Trabajo

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# Diet of the Cuban giant frog, *Eleutherodactylus zeus* (Anura: Eleutherodactylidae) in Viñales National Park, Cuba

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ABSTRACT
*Eleutherodactylus zeus* is an endemic frog of the family Eleutherodactylidae from Western mountains of Cuba, that inhabits in rocky karstic caves and tropical forest adjacent to caves. Here, we report the first approach to the diet of a Cuban cave-rock dwelling amphibian. We surveyed seven cave-karstic habitats and tropical forest habitats adjacent to those caves from May to July. The samples (N = 70) of stomach content were obtained using the stomach-flushing method. Preys were present in 68.6% of stomachs: 76.9% in the forest and 44.4% in the cave samples. The most represented preys in *E. zeus* stomach were Aranae, Orthoptera, Lepidoptera larvae, Blattodea, and Gasteropoda. In addition, we report the presence of an anuran (*Eleuthorodactylus*), a lizard (*Anolis*) and a plathyhelminth in the stomach content of this species. In this species, larger frogs consumed larger and fewer prey, but difference in prey length and number of prey consumed depends on the habitat they temporary exploited.

Key Words: Feeding Ecology, Cuba, *Eleutherodactylus zeus*, Conservation, Caves.

RESUMEN
*Eleutherodactylus zeus* es una rana endémica de las montañas de la parte más occidental de Cuba, que habita en áreas cársicas, dentro de cuevas y en el bosque adyacente a estas cavidades. Aquí reportamos el primer acercamiento a la dieta de un anfibio petrícola-cavernícola Cubano. Muestreamos siete cuevas cársicas y cuatro áreas de bosque tropical adyacentes a estas cavidades, desde mayo hasta julio. Las muestras (N = 70) del contenido estomacal fueron obtenidas mediante el método de lavado estomacal. Se observaron presas en el 68.6% de los estómagos analizados: el 76.9% en el bosque, y el 44.4% en las cuevas. Esta especie depredó principalmente arañas, grillos, larvas de lepidópteros, cucarachas y moluscos terrestres. Se reporta la presencia de un anuro, un lagarto y un platelminto en el contenido estomacal de esta especie. En *E. zeus*, los individuos más grandes consumieron por lo general presas más grandes, aunque esto varió entre los sexos dependiendo del hábitat donde se encuentren forrajeando.

Palabras claves: Ecología Alimentaria, Cuba, *Eleutherodactylus zeus*, Conservación, Cuevas.

## Introduction

Trophic interactions are important to understand the population dynamics of a species because the acquisition of prey resources could affect some factors, such as population densities and individual fecundity (Mahan and Johnson, 2007). In general, anuran´s adults feed on invertebrate community (Duellman and Trueb, 1986), being the rest of species specialist predators (Pertel *et al.*, 2010).

*Eleutherodactylus zeus* is an endemic species of the family Eleutherodactylidae in Cuba, with a notorious longitude variation between females (127.4 mm, García, 2012) and males (63.7 mm, Schwartz, 1958). This species has a local distribution in rocky karstic areas of Cordillera de Guaniguanico (Henderson and Powell, 2009) where it is reproduce in caves (Alonso *et al.*, 2015). In addition, it also fre-

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quent in the tropical forest habitat adjacent to caves-kartic habitats (Henderson and Powell, 2009). This species is included in the IUCN red list as Endanger B1ab (iii), threatened by habitat loss or fragmentation (Hedges and Díaz, 2004). The foraging behavior and diet of *E. zeus* is unknown as it also for other Cuban *Eleutherodactylus* species. Anecdotal data reported a large roach (*Eurycotis* spp.) disgorged by an adult female (Schwartz, 1958), and a juvenile mollusk in a male (Alonso and Rodríguez, 2003) from Moncada, Viñales. We studied the diet composition of *E. zeus* inside caves-karstic habitats and in the adjacent tropical forest habitat. We expected that *E. zeus* feeds mostly in the forest adjacent to the cave, were there are more prey available that in the cave, as we observed in previous studies (García-Padron, *unpubl. data*).

## Materials and methods

*Sampling and study sites*

We carried out field samples on the cave-karstic habitats on Santo Tomás Great Cavern (STGC), and in the adjacent tropical forest habitat, El Moncada, Viñales, Pinar del Río, Cuba (83º50937.0240 W; 22º32942.8630 N; WGS 84; 130-300 m a.s.l.). Two consecutive nights (21:30-01:00 h) were monitored during each of three months on the rainy season (May, June and July) in 2018. The seven sites in the cave-karstic habitat (CKH hereafter) were Puñales, Incógnita, Increíble, Rivero, Lechuza, Dos Dolinas, and Magalognus. The tropical forest habitat (TFH hereafter) were three karst depressions (*Hoyos*) (Hoyo de Fanía, Hoyo del Yagrumón, and Hoyo de la Palma) and the northeastern slope of Sierra de Quemados. In each TFH and in the CKH, we surveyed one 100 m transect with 3 m each side from the middle of the track; each site (forest or gallery) was at least 150 m apart from any other. The sampled area then was calculated, in both CKH and TFH, as 100 x 6 m in each site surveyed.

We analyzed N = 70 *Eleutherodactylus zeus* individuals (Figure 1A and B), 52 (20 males and 32 females) in TFH and 18 in CKH. Each frog was measured snout–vent length (SVL) with a caliper (to the nearest 0.05 mm), and sexed (following Massip, 2016) *in situ*. All individuals were stomach-flushed following Mahan and Johnson (2007); two different catheter tubes were used (with 4 mm for males and 5.5 mm for females) of outer diameter because of the size difference between sexes. The stomach content was preserved in vials with 75% ethanol for further analysis. After stomach-flushed, each individual was released at the site of capture. In the laboratory we measured the body length of each item (only unbroken items) using a digital caliper (to the nearest 0.01 mm), and classified them to order level when possible using a stereoscope; also data of some samples identified at genus and/or species level are given (Espinosa and Ortea, 2009; Mancina and Cruz, 2017).

We calculate the volume of each item using the ellipsoid formula (Magnusson *et al*., 2003): V = 4/3π (lenght/2) (breadth/2)2. In addition, we calculated the number of consumed items ($N$) and its percent ($N_{\%}$); the frequency of occurrence ($F$, number of stomachs in which a given prey category was found), and it's percent ($F_{\%}$), and the volume percent ($V_{\%}$) for each prey category. The Index of Relative Importance (IRI) was calculated for every prey category by IRI=$N_{\%} + V_{\%} + F_{\%}$ / 3. We used the Levins´ index ($B´$) (Krebs 1989) to calculate the trophic niche breadth:

were Pi = fraction of items in the food category i; for standardization of niche breadth ($B_A$), we use

$$ß = \frac{1}{\sum_{i=1}^{n} P_i^2}$$

the Hurlbert (1978) proposal: dividing $B´$ by the total number of resource states after correcting for a finite number of resources; range = 0 (no diversity, exclusive use of a single prey type, specialist) to 1 (highest diversity, prey items of all categories, generalist). In addition, we calculated niche overlap between juveniles and adults, and males and females, using Pianka's overlap index (*POI* hereafter) (Pianka 1973), which varies from 0 (no overlap) to 1 (complete overlap).

*Karst and forest characteristic*

More than 65% of the soil in Cuba is karst (Molerio, 2004), and the typical morphology of the karstic hills of Sierra de los Órganos is conic karst (*mogotes*) with internal karstic valleys (poljes) locally known as *hoyos* (Acevedo-González, 1967). The forest in these karstic hills is named "*complejo de vegetación*" (vegetation complex) because it has a mesophyll semi-deciduous forest distributed in strip-shape at the base of the *mogotes*; a mesophyll evergreen forest in their internal valleys (*hoyos*), and a xerophytic thicket in the upper part in the karstic hill (Luis,

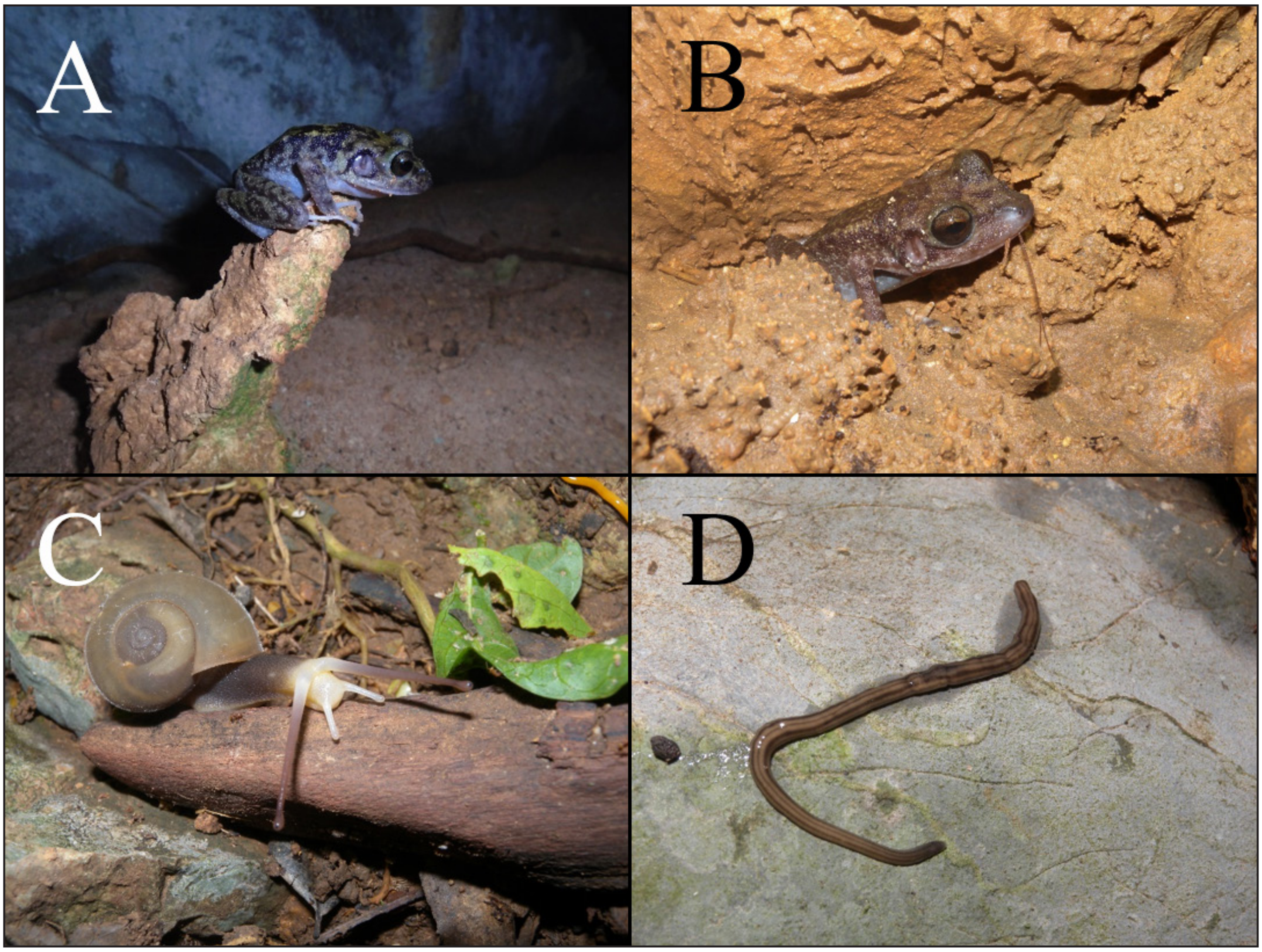


**Figure 1.** Female of *E. zeus* in hunting attitude inside a gallery (A), a male consuming an *Otteius thoracicus* (B), an adult of the land snail *Satipellis stigmatica* (Stylommatophora) (C), a plathyhelminth in the study area (D). (Photographed by LYGP).

2000). The typical vegetation is composed of *Oxandra lanceolata, Pachira emarginata*, *Spathelia brittonii*, large trees, as *Ficus* spp., had many bromeliads (genus *Tillandsia, Hohenbergia, Guzmania*, etc.).

*Statistical analysis*

We applied the Kolmogorof-Smirnof normality test and the Levene variance homogeneity test, and for both tests *a*>0.05. We analyzed the ratio of maximum prey size (MPS)/SVL of all individuals with prey in the stomach. We used t-test comparing both cave and forest samples for number of prey/sex, and prey length/sex for independent samples of stomach content. In addition, one factor ANOVA was calculated for the observed differences for prey per stomach.

## Results

Were captured 37 females of *E. zeus* (SVL = 90.5±13.54; mean ± 1 SD; range 73.25-127.7 mm), and 33 males (SVL = 68.15±4.08; mean ± 1 SD; range 63.1 to 75.1 mm). Difference were found in abundance in TFH with respect to CKH (*a*=0.008; *df*=9). The tropical forest habitat had with 0.03 frog/m$^2$, meanwhile, the cave-karstic habitat had 0.004 frog/m$^2$. The male/female ratio was 0.63/1 in the forest, and 2.6/1 in the galleries.

Forty-eight *E. zeus* (68.6%) had stomach content, and only 22 had empty stomach (31.4%). In the forest, most of frogs (76.9%) had prey in the stomach, only three males and nine females had an empty stomach; on the contrary, in the galleries, most frogs had an empty stomach (seven males and three females), six males and two females were found with prey consumed (44.4%). We observed 131 prey items (2.93 mean prey items per stomach, range= 1-10), representing 26 prey categories, plus plant material and dirt/rock (Table 1). Males consumed more and smaller prey items than females in forested areas; in the galleries, females consumed more prey items at smaller size than males (Table 2).

We observed that *E. zeus* consumed more

**Table 1.** Diet composition of *Eleutherodactylus zeus* from El Moncada, Viñales, given by Classes and Orders. F, frecuency of occurrence (percent), N, number of consumed items (percent), V, volume of each item (percent), given in mm3, and IRI, is the index of relative importance.

| Class | Order | Females (n=25) | | | | Males (n=23) | | | | Total (n=48) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F | N | V | IRI | F | N | V | IRI | F | N | V | IRI |
| Diplopoda | Spirobolida | 2 (4.26) | 2 (3.77) | 32.83 (0.37) | 2.8 | 1 (2.33) | 1 (1.89) | 39.86 (0.74) | 1.65 | 3 (3.37) | 3 (2.83) | 36.35 (0.42) | 2.21 |
| | Polydesmida | 1 (2.13) | 1 (1.89) | 172.69 (1.96) | 1.99 | 0 | 0 | 0 | 0 | 1 (1.12) | 1 (0.94) | 172.69 (1.99) | 1.35 |
| Arachnida | Amblypygi | 1 (2.13) | 1 (1.89) | 420.15 (4.77) | 2.93 | 2 (4.65) | 2 (3.77) | 90.51 (1.67) | 3.36 | 3 (3.37) | 3 (2.83) | 255.33 (2.94) | 3.05 |
| | Uropygi | 2 (4.26) | 2 (3.77) | **2533.81 (28.78)** | 12.27 | 1 (2.33) | 1 (1.89) | **2253.05 (41.69)** | 15.3 | 3 (3.37) | 3 (2.83) | 2393.43 (27.56) | **11.25** |
| | Aranae | 4 (8.51) | 5 (9.43) | 18.09 (0.21) | 6.05 | 7 (16.28) | 7 (13.21) | 5.64 (0.1) | 9.86 | **11 (12.36)** | **12 (11.32)** | 11.87 (0.14) | 7.94 |
| | Opiliones | 0 | 0 | 0 | 0 | 1 (2.33) | 1 (1.89) | 6.09 (0.11) | 1.44 | 1 (1.12) | 1 (0.94) | 6.09 (0.07) | 0.71 |
| | Scorpiones | 2 (4.26) | 2 (3.77) | **2546.01 (28.92)** | 12.32 | 1 (2.33) | 1 (1.89) | 378.22 (7.0) | 3.74 | 3 (3.37) | 3 (2.83) | 1462.12 (16.84) | 7.68 |
| Hexapoda | Orthoptera | 2 (4.26) | 2 (3.77) | 149.41 (1.7) | 3.24 | 7 **(16.28)** | 7 **(13.21)** | **856.44 (15.85)** | **15.11** | **9 (10.11)** | **9 (8.49)** | 502.93 (5.79) | 8.13 |
| | Hymenoptera | 2 (4.26) | 4 (7.55) | 0.06 (0.0007) | 3.94 | 1 (2.33) | 6 (11.32) | 0.38 (0.01) | 4.55 | 3 (3.37) | 10 (9.43) | 0.22 (0.003) | 4.27 |
| | Diptera | 0 | 0 | 0 | 0 | 4 (9.3) | 7 (13.21) | 2.48 (0.05) | 7.52 | 4 (4.49) | 7 (6.6) | 2.48 (0.03) | 3.71 |
| | Lepidoptera (larvae) | 5 (10.64) | 5 (9.43) | 37.89 (0.43) | 6.83 | 4 (9.3) | 5 (9.43) | 59.33 (1.1) | 6.61 | **9 (10.11)** | **10 (9.43)** | 48.61 (0.56) | 6.7 |
| | Blattodea | 5 (10.64) | 5 (9.43) | 262.76 (2.98) | 7.68 | 4 (9.3) | 4 (7.55) | 42.16 (0.78) | 5.88 | **9 (10.11)** | **9 (8.49)** | 152.46 (1.76) | 6.79 |
| | Coleoptera | 3 (6.38) | 3 (5.66) | 95.02 (1.08) | 4.37 | 3 (6.98) | 4 (7.55) | 82.89 (1.53) | 5.35 | 6 (6.74) | 7 (6.6) | 88.96 (1.02) | 4.79 |
| | Zygentoma | 0 | 0 | 0 | 0 | 1 (2.33) | 1 (1.89) | 106.94 (1.98) | 2.07 | 1 (1.12) | 1 (0.94) | 53.47 (0.62) | 0.89 |
| | Hemiptera | 1 (2.13) | 1 (1.89) | 554.52 (6.3) | 3.44 | 0 | 0 | 0 | 0 | 1 (1.12) | 1 (0.94) | 554.52 (6.39) | 2.82 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Not-identified insect | 1 (2.13) | 1 (1.89) | 0.46 (0.01) | 1.34 | 1 (2.33) | 1 (1.89) | 0.02 (0.0004) | 1.41 | 2 (2.25) | 2 (1.89) | 0.24 (0.03) | 1.39 |
| Chilopoda | Scolopendromorpha | 1 (2.13) | 1 (1.89) | 26.4 (0.3) | 1.44 | 1 (2.33) | 1 (1.89) | 13.54 (0.25) | 1.49 | 2 (2.25) | 2 (1.89) | 19.97 (0.23) | 1.46 |
| Clitellata | Haplotaxida | 0 | 0 | 0 | 0 | 1 (2.33) | 1 (1.89) | 488.28 (9.03) | 4.42 | 1 (1.12) | 1 (0.94) | 488.28 (5.62) | 2.56 |
| Turbellaria | Tricladida | 2 (4.26) | 2 (3.77) | 57.18 (0.65) | 2.89 | 0 | 0 | 0 | 0 | 2 (2.25) | 2 (1.89) | 57.18 (0.66) | 1.6 |
| Gastropoda | Stylommatophora | **6 (12.77)** | 7 (13.21) | **1445.91 (16.42)** | **14.13** | 0 | 0 | 0 | 0 | **6 (6.74)** | **7 (6.6)** | 1445.91 (16.65) | **10.0** |
| | Littorinimorpha | 2 (4.26) | 2 (3.77) | 93.2 (1.06) | 3.03 | 0 | 0 | 0 | 0 | 2 (2.25) | 2 (1.89) | 93.2 (0.11) | 1.42 |
| | Cycloneritimorpha | 2 (4.26) | 4 (7.55) | 22.81 (0.26) | 4.02 | 1 (2.33) | 1 (1.89) | 11.39 (0.21) | 1.48 | 2 (2.25) | 5 (4.72) | 17.1 (0.02) | 2.33 |
| | Not-identified gasteropod | 1 (2.13) | 1 (1.89) | 0.41 (0.005) | 1.34 | 0 | 0 | 0 | 0 | 1 (1.12) | 1 (0.94) | 0.41 (0.005) | 0.69 |
| Crustacea | Isopoda | 1 (2.13) | 1 (1.89) | 267.87 (3.04) | 2.35 | 0 | 0 | 0 | 0 | 1 (1.12) | 1 (0.94) | 267.87 (3.09) | 1.72 |
| **VERTEBRATA** | | | | | | | | | | | | | |
| Reptilia | Squamata | 0 | 0 | 0 | 0 | 2 (4.65) | 2 (3.77) | 967.43 (17.9) | 8.77 | 2 (2.25) | 2 (1.89) | 483.72 (5.57) | 3.24 |
| Amphibia | Anura | 1 (2.13) | 1 (1.89) | 67.48 (0.77) | 1.6 | 0 | 0 | 0 | 0 | 1 (1.12) | 1 (0.94) | 67.48 (0.78) | 0.95 |
| Plant material | | 13 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 19 | 0 | 0 | 0 |
| dirt/rocks | | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |

**Table 2.** Number of stomachs with prey and prey length between sexes of *E. zeus*.

| | Males | | Females | |
|---|---|---|---|---|
| | Galleries | Forest | Galleries | Forest |
| Prey/stomach | 1,5 (1-2)<br>(N=6) | 2,59 (1-10)<br>(N=17) | 2,5 (1-4)<br>(N=2) | 2,13 (1-4)<br>(N=23) |
| N items | 9<br>(N=6) | 44<br>(N=17) | 5<br>(N=2) | 49<br>(N=23) |
| Prey length (mm) | 20,97 (7,53-54,0)<br>(N=7) | 11,62 (0,78- 64,58)<br>(N=28) | 5,92 (1,17- 6,42)<br>(N=4) | 14,30 (2,35- 40,6)<br>(N=35) |

amounts of prey, and types of prey ($\alpha \leq 0.05$) in the forest than in galleries (Table 3). No difference were found in number of prey per stomach ($\alpha$=0.928), and prey length ($\alpha$=0.998), in males and females. Aranae was the most abundant prey in the stomachs ($F_{\%}$=12.36; *IRI*=7.94), detected in 27.5% of frogs in the forest, followed by Lepidoptera larvae ($F_{\%}$=10.11; *IRI*=6.7), Orthoptera ($F_{\%}$=10.11; *IRI*=8.13), Blattodea ($F_{\%}$=10.11; *IRI*=6.79), and Gasteropoda ($F_{\%}$=6.74; *IRI*=10.0) (Table 1). Females consumed more type of preys ($B_A$=0.55) than males ($B_A$=0.39) ($\alpha$<0.05). In the forest, individuals consumed more type of preys (females, $B_A$=0.53; males, $B_A$=0.39) than in the galleries (females, $B_A$=0.12; males, $B_A$=0.17) ($\alpha$<0.05). Difference was observed in prey preference was observed between males and females: Females consumed mainly Gasteropoda ($F_{\%}$=12.77; *IRI*=14.13), meanwhile males preferred Orthoptera ($F_{\%}$=16.28; *IRI*=15.11) and Aranae ($F_{\%}$=16.28; *IRI*=9.86). We observed high overlap between males and females (*POI*=0.65): in Aranae, Lepidoptera (larvae), Blattodea, and Coleoptera (Table 1). The higher overlap occur in the forest (*POI*=0.64), but no overlap was detected in the gallery (*POI*=0.00).

Some taxa were able to be identified to genus or species: amblypygid (*Phrynus* sp.), uropygid (*Mastigoproctus* sp.), cockroaches (*Eurycotis* sp., *Euthlatoblatta diaphana*, and *Nauphoeta cinerea*), scorpion (*Centruroides* cf. *guanensis*), crickets and grasshoppers (*Otteius thoracicus* and *Gryllodes* sp.), land snails (*Setipellis stigmatica* [Fig. 1C], *Alcadia* sp., *Zachrysia* cf. *guanensis*, and *Chondropometes* sp.), a partially digested individual of *Eleutherodactylus*, an egg and a juvenile of *Anolis* sp.

## Discussion

In the present study the diet of *E. zeus* was first described from two different habitats. A higher number of empty stomachs (55.5%) and a lower dietary richness of frogs from the CKH of frogs from the CKH when compared with TFH indicate that this species forage mostly in the later habitat. Limitation in prey abundance carry to a high number of individuals without prey in their stomachs, whereas a lower dietary diversity is indicative of a greater resource availability (Toft, 1980; Whitfield and Donnelly, 2006; Luría-Manzano and Ramírez-Bautista, 2017). However, some studies pointed out that the abundance and diversity of arthropods are lower inside caves than in surroundings (Prous *et al.*, 2004; Tobin *et al.*, 2013). The higher richness of prey consumed by *E. zeus* in the forest, seems to reveal that total prey availability, independent of prey taxa, is lower in the caves of STGC. However, an adequate abundance or density research of invertebrate fauna in this area is required to corroborate this hypothesis.

In this study, most *E. zeus* were observed in the TFH adjacent to CKH of STGC during the study (May to July). We observed that females leave the galleries after hatching, but males apparently stay much longer and can feed upon the cave resources (García-Padrón, *unpubl. data*). This could explain why males were more abundant than females in galleries (2.6/1, male/female rate), in spite of the small sample size, whereas in the forest the opposite occurred (0.63/1) during the study time. High density of frogs, less empty stomachs, and more dietary taxa consumed in the TFH may indicate that *E. zeus* leave the CKH after reproduction, as observed Alonso *et al.* (2015). The migration to adjacent forest to feed may be explained in terms of high diversity of arthropods (Prous *et al.*, 2004; Tobin *et al.*, 2013).

Despite high overlap between males and females of *E. zeus* (*POI*=0.65), females preferred gastropods ($F_{\%}$=23.4; $IRI_{\%}$=22.52), and males, Orthoptera and Aranae ($F_{\%}$=32.56; $IRI_{\%}$=24.96, combined). Large preys are also consumed (females: Uropygi and scorpions; Males: Uropygi), but no preference for these type of prey seems to occur because of its

**Table 3.** Percent of prey categories in the stomach content of *E. zeus* in forest and galleries. The "% total" represents the percent from the total of prey category in both ecosystems.

| Class | Order | Galleries (N=8) | | Forest (N=40) | |
|---|---|---|---|---|---|
| | | N | % total | N | % total |
| Diplopoda | Spirobolida | 0 | 0 | 3 | 7.5 |
| | Polydesmida | 0 | 0 | 1 | 2.5 |
| Arachnida | Amblypygi | 1 | 12.5 | 2 | 5 |
| | Uropygi | 0 | 0 | 3 | 7.5 |
| | Aranae | 1 | 12.5 | 11 | 27.5 |
| | Opiliones | 0 | 0 | 1 | 2.5 |
| | Scorpiones | 1 | 12.5 | 2 | 5 |
| Hexapoda | Orthoptera | 2 | 25 | 8 | 20 |
| | Hymenoptera | 2 | 25 | 8 | 20 |
| | Diptera | 0 | 0 | 7 | 17.5 |
| | Lepidoptera | 2 | 25 | 8 | 20 |
| | Blattodea | 2 | 25 | 7 | 17.5 |
| | Coleoptera | 1 | 12.5 | 6 | 15 |
| | Zygentoma | 0 | 0 | 1 | 2.5 |
| | Hemiptera | 0 | 0 | 1 | 2.5 |
| | NI 1 | 0 | 0 | 2 | 5 |
| Chilopoda | Scolopendromorpha | 0 | 0 | 2 | 5 |
| Annelida, Class Clitellata | Haplotaxida | 0 | 0 | 1 | 2.5 |
| Phyllum Nemertina | NI 2 | 0 | 0 | 2 | 5 |
| Gastropoda | Stylommatophora | 1 | 12.5 | 6 | 15 |
| | Littorinimorpha | 1 | 12.5 | 1 | 2.5 |
| | Cycloneritimorpha | 0 | 0 | 5 | 3.47 |
| | NI 3 | 0 | 0 | 1 | 2.5 |
| Crustacea | Isopoda | 0 | 0 | 1 | 2.5 |
| VERTEBRATA | | | | | |
| Reptilia | Squamata | 0 | 0 | 2 | 5 |
| Amphibia | Anura | 0 | 0 | 1 | 2.5 |
| | | | | | |
| Plant material | | 2 | 25 | 17 | 42.5 |
| dirt/rocks | | 1 | 12.5 | 4 | 10 |
| TOTAL | 17 | | 144 | | |

low frequency (Table 1). In the five cases (see Table 1), no more than a single (large) prey per stomach was observed. Seems that large prey, besides occupy most of its stomach capacity, can fulfill its nutritious needs in this species. No overlap in the galleries were observed, maybe because most of *E. zeus* had empty stomach, and the number of frogs with prey in the stomach were too low.

With these results, we reinforced previous unpublished data regarding to ethology of *E. zeus*. This species remain into forest for feeding and gaining energy after reproduction, whereas males spend more time in the caves exploiting the food resources available. The cockroaches were an important component in the diet of *E. zeus* (see Tables 1 and 2). Schwartz (1958) observed a large roach (*Eurycotis*) disgorged by an adult female; we observed and identified three species of roaches: *Eurycotis* sp., *Euthlatoblatta diaphana* and *Nauphoeta cinerea*. Alonso and Rodríguez (2003) report a mollusk in a juvenile of the Cuban Giant Frog. In this study, four species of land snails (*Setipellis stigmatica* [Figure 1C], *Alcadia* sp., *Zachrysia* cf. *guanensis*, and *Chondropometes* sp.), plus one not identified specimen were observed in *E. zeus* stomach content. From all organisms identified in the cave samples, the cave cricket (*Otteius thoracicus*) (Figure 1B) was the most common prey observed in the stomach of this species. Rodríguez-Cabrera and Torres (2019) reported the presence of the exotic land platyhelminth *Bipalium kewense* for central and western Cuba. We detected the presence of a Platyhelminthes (order Tricladida, family Geoplanidae), probably *B. kewense* (see Rodríguez-Cabrera and Torres, 2019), consumed by two females (91.6mm and 94.4mm SVL) in the forest; this is the first record of a non-parasitic land Plathyhelminthes consumed by an anuran (Figure 1D). Here, we report the presence of an *Eleutherodactylus* frog in the stomach of a female (74.35mm) in the forest; this item was partially digested, but according to the size of it (8.26mm of maximum length) could be a neonate of *E. zeus* or an adult of *E. klinikowskii*, both very common on the forest floor. Also in the forest we found a male (67.9mm SVL) with a partially digested individual (probably female) and an egg of *Anolis*; could be *A. homolechis* or *A. mestrei,* because both species seek refuge on the forest floor in that area during nighttime.

Difference exploitation of dietary resources in each habitat was detected. Females consumed more type of prey than males in the TFH; on the contrary, in the CKH males had broaded diet than females. In *E. zeus* no significant difference was observed in prey length between sexes, but larger individual consumed larger preys; although, this role apparently can change between sexes, and depends on the habitat they temporarily exploited. We observed that males of *E. zeus* consumed more and smaller prey than females in the forest; meanwhile females, on the contrary, consumed more prey items at smaller size than males in the caves (Table 2).

We can classify properly *Eleutherodactylus zeus* as a "non-ant specialist" and a "sit-and-wait" predator according to Toft (1981): because of the type of prey consumed (large and solitary prey, such as spiders, mollusks, crickets, roaches, and caterpillars), its crypticity, its wide mouth, and the lower number of prey consumed (2.93 prey/stomach). We observed that this frog forages from the ground to 2 m above ground level, on rocks, walls of galleries, or trunks of bushes, ambushing its prey. This ambushed attitude is largely known for anurans (Pertel *et al*., 2010).

The generalized diet of *Eleutherodactylus zeus* seems to have contributed to its success in both caves and forest, but the growing modification and/or destruction of the habitat, and consequently the disturbance in the food web, may determinate the future, survival and emergence of morphological abnormalities (García-Padrón and Alonso, 2019; García-Padrón *et al*., 2020) of this local endemic and ecologically restricted frog.

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## Literature cited

Acevedo-González, M. 1967. Clasificación general y descripción del carso Cubano. *Instituto Nacional de Recursos Hidráulicos, Publicación Especial* 4: 33-67.

Alonso, R. & Rodríguez, A. 2003. Insospechados habitantes de las penumbras, *In* Rodríguez Schettino, L. (Ed.). *Anfibios y reptiles de Cuba*. UPC Print, Vaasa, Finlandia, p. 20-29.

Alonso Bosch, R., García, L.Y., del Castillo Domínguez, S. & Torres Martínez, E.L. 2015. Clutches, nest attendance, and hatching in a rock-cave-dwelling frog, *Eleutherodactylus* (Syrrophus) *zeus*, from Cuba. *Journal of Cave and Karst Studies* 77 (2): 83-86.

Duellman, W.E. & Trueb, L. 1986. *Biology of Amphibians*. McGraw-Hill Publishing Company, USA.

Espinosa, J., & J. Ortea. 2009. Moluscos terrestres de Cuba. UCP Print, Vaasa, Finland.

García, L.Y. 2012. *Eleutherodactylus zeus* (Cuban Giant Frog). Record Size. *Herpetological Review* 43 (4): 631.

García-Padrón, L.Y. & Alonso Bosch, R. 2019. Anomalous colour in a Cuban cave-dwelling frog: First record of piebaldism in *Eleutherodactylus zeus* (Anura: Eleutherodactylidae). *The*

*Herpetological Bulletin* 147: 1-3.
García-Padrón, L.Y., Torres, J. & Boligán Expósito, M. 2020. Aberrant body markings in the Cuban banded dwarf boa, *Tropidophis feicki* (Squamata: Tropidophiidae). *The Herpetological Bulletin* 152: 38-39.
Hedges, B. & Díaz, L. 2004. *Eleutherodactylus zeus*: The IUCN Red List of Threatened Species 2004: e.T57065A11576165. http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T57065A11576165.en. (Accessed on 17 November 2020).
Henderson, R.W. & Powell, R. 2009. Natural history of West Indian reptiles and amphibians: University Press of Florida, Gainesville.
Hurlbert, S.H. 1978. The measurement of niche overlap and some relatives. *Ecology* 59 (1): 67-77.
Krebs, C.J. 1989. *Ecological Methodology*. 2nd Edition. Menlo Park. Addison-Wesley Educational Publishers.
Luis López, M. 2000. Evaluación para la protección de los mogotes de la Sierra de los Órganos y el Pan de Guajaibón. Ph.D. Dissertation, Universidad de La Habana, Cuba, p. 167+4 anexes.
Luría-Manzano, R. & Ramírez-Bautista, A. 2017. Diet comparison between rainforest and cave populations of *Craugastor alfredi* (Anura: Craugastoridae): does diet vary in contrasting habitats? *Journal of Natural History* 51 (39-40): 2345-2354.
Magnusson, W.E., Lima, A.P., Silva W.A. & Araújo M.C. 2003. Use of geometric forms to estimate volume of invertebrates in ecological studies of dietary overlap. *Copeia* 2003: 13-19.
Mahan, R.D. & Johnson, J.R. 2007. Diet of the gray treefrog (*Hyla versicolor*) in relation to foraging site location. *Journal of Herpetology* 41 (1): 16-23.
Mancina, C.A., & D.D. Cruz Flores (Eds). 2017. Diversidad biológica de Cuba: métodos de inventario, monitoreo y colecciones biológicas. Editorial AMA, La Habana.
Massip Veloso, Y. 2016. Dimorfismo sexual y propagación de las llamadas en un anfibio cavernícola-petrícola cubano, *Eleutherodatylus zeus* (Anura: Eleutherodactylidae). Degree Dissertation, Universidad de la Habana, Cuba, p. 93.
Molerio León, L. (Ed.). 2004. Mundo Subterráneo. Tabloide Universidad para Todos, La Habana, Cuba.
Pertel, W., Teixeira, R.L. & Ferreira, R.B. 2010. Comparison of diet and use of bromeliads between bromelicolous and a bromeligenous anuran at an inselberg in the southeast of Brazil. *Caldasia* 32 (1): 149-159.
Pianka, E. R. 1973. The structure of lizard communities. *Annual Review of Ecology and Systematics* 4: 53-74.
Prous, X., Lopes Ferreira, R. & Parentoni Martins, R. 2004. Ecotone delimitation: epigean-hypogean transition in cave ecosystems. *Austral Ecology* 29: 374-382.
Rodríguez-Cabrera, T. M. & Torres, J. 2019. New locality records of *Bipalium kewense* (Platyhelminthes: Tricladida: Geoplanidae) in Cuba. *Poeyana* 508: 76-79.
Schwartz, A. 1958. Another new large *Eleutherodactylus* (Anura: Leptodactylidae) from Western Cuba. *Proceedings of the Biological Society of Washington* 71: 37-42.
Tobin, B.W., Hutchins, B.T. & Schwartz, B.F. 2013. Spatial and temporal changes in invertebrate assemblage structure from the entrance to deep-cave zone of a temperate marble cave. *International Journal of Speleology* 42: 203-214.
Toft, C.A. 1980. Feeding ecology of thirteen syntopic species of Anurans in a seasonal tropical environment. *Oecologia* 45: 131-141.
Toft, C.A. 1981. Feeding ecology of Panamanian litter anurans: patterns in diet and foraging mode. *Journal of Herpetology* 15 (2): 139-144.
Whitfield, S.M. & Donnelly, M.A. 2006. Ontogenetic and seasonal variation in the diets of a Costa Rican leaf-litter herpetofauna. *Journal of Tropical Ecology* 22: 409-417.

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