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ONTOGENY OF THE DIET IN ANURANS (AMPHIBIA) COLLECTED AT LA VIEJA RIVER BASIN IN THE DEPARMENTO OF QUINDIO (COLOMBIA)

Ontogenia de la dieta de anuros (Amphibia) colectados en la rivera del río La Vieja en el departamento de Quindio (Colombia)

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ABSTRACT

The diet of three anuran species, *Rhinella marina* (Bufonidae), *Pristimantis achatinus* (Strabomantidae) and *Dendropsophus columbianus* (Hylidae), that inhabit agroecosystems at the Rio La Vieja Basin (Quindio, Colombia) was examined. The goal of this study was to establish if there is an ontogenetic change in the diet of all species. Gastrointestinal contents were preserved in 70% ethanol and identified to the lowest possible taxonomic level. Identified prey portions were classified into 20 types. Hymenoptera, Coleoptera and Hemiptera were the most frequent preys. Considerable dietary overlap among three different body-size classes of all species show some differences. However the ANOVA analysis showed that there was no significant difference (P=0.05) in diets at different ontogenetic sizes.

Key words. Diet, ontogenetic change, anurans, preys, Quindío

RESUMEN

Se analizó la dieta de tres especies de anuros: *Rhinella marina* (Bufonidae), *Pristimantis achatinus* (Strabomantidae) y *Dendropsophus columbianus* (Hylidae) que habitan en los agroecosistemas de la cuenca del rio La Vieja (Quindío, Colombia) con el fin de determinar si existe cambio ontogénico en la dieta de estas especies. Todos los individuos fueron colectados y sacrificados para la obtención de los contenidos gastrointestinales e identificados hasta el menor nivel taxonómico posible siendo preservados en etanol al 70%. Las proporciones de las presas fueron clasificadas en 20 tipos, mostrando que los taxones más frecuentes son Hymenoptera, Coleoptera y Hemiptera.Considerando la superposición de la dieta entre los diferentes grupos de tamaños de todas las especies se sugiere que una pequeña parte de los recursos alimenticios se encuentran divididos. Sin embargo con el ANOVA no se encontraron diferencias significativas (P=0.05) en las presas de ninguna de las especies.

Palabras clave. Dieta, cambio ontogénico, anuros, presas, Quindío

INTRODUCTION

Amphibians are important components of ecosystems because they transfer energy from invertebrates, mainly detritivores, to higher trophic levels (Cogalniceanu *et al* 2000). Several studies show the importance of food to the assemblages, evolution, and organization of anuran communities in both young and adult specimens in different ecosystems (Caldwell 1996).

Ontogenetic changes in anuran diet have been documented in several species (Hirai & Matsui 1999, Biavati *et al* 2004, Whitfield & Donnelly 2006). These studies have shown that type of ontogenetic change is associated with the size in *Epipedobates flavopictus* (Dendrobatidae), where the volume and the prey number were greatest in larger individuals; this finding is interpreted as a mechanical consequence due to larger frogs having larger heads, which enable them to hunt for larger prey. The ontogenetic shift in prey sizes is often associated with shifts in prey types, simply because the mean size of individuals differ among arthropod taxa (Biavati *et al* 2004).Some frogs also exhibit ontogenetic changes in prey types independent of changes in the sizes of prey and, at least for some species, this may be partially explained by ontogenetic changes in foraging activity. Among dendrobatid frogs, small individuals often consume primarily mites and collembolans, whereas ants are preferred by larger individuals (Biavati et *al* 2004).

In natural conditions amphibians have numerous food sources (Zug *et al* 2001), although diet composition of many amphibians depends on how they search for food (Lima & Magnusson 2000). Some general conclusions can be drawn about anuran feeding behavior. Toft (1980, 1981) identified two main diet patterns in tropical anurans: the “ant specialists” that eat more chitinous, slow-moving arthropods such as ants and mites, and the “non-ant specialists”, that eat larger, less chitinous and more mobile arthropods, such as orthopterans and large spiders. These diet specializations are intrinsically linked to foraging strategies (sit-and-wait or active searching behavior), nocturnal or diurnal activity patterns, the nature of defense mechanisms, the type of habitat occupied, and the seasonal variability in resource abundance (Santos *et al* 2004).

Anuran feeding ecology can be particularly useful in explaining patterns within multispecies communities; however previous studies have not considered intraspecific diet variation, including ontogenetic diet change. It has been suggested that results based on analyses that do not include intraspecific diet variation, may lead to partial and possibly erroneous conclusions regarding to community structure. Therefore, examination of ontogenetic diet change is necessary before community structure can be analyzed on the basis of food utilization (Hirai 2002). In Colombia some studies have been done on anuran feeding (*e.g.,*Daza-Vaca and Castro-Herrera 1999, Botero-Trujillo 2006, Muñoz-Guerrero *et al* 2009, Isaacs & Hoyos 2010, Hoyos *et al* 2012) but there are not studies on ontogenetic change in prey composition for any Colombian frog. The goal of this study is to identify and compare frog diet at different sizes, in order to establish if there are ontogenetic changes in the diet.

MATERIALS AND METHODS

Frog specimens used in this study were collected in the Departmento of Quindío (Colombia) at La Vieja river basin in different farms in June 2006, September 2006, and June 2007 (**Table 1**).The weather shows a bimodal distribution of rains, with two periods of rainfall in the months of March-May and September-November, and two periods of lowest rainfall between December-February and June-August, with an average annual rainfall of 2436 mm (Rodríguez 1999). This zone is dominated by a landscape of flat areas and undulating lands that have crops of coffee, extensive pastures for livestock, and vegetation dominated by guadua (*Guadua angustifolia)*.

Anuran species were capture using the searching method VES (Visual Encounter Surveys) (Crump & Scott 1994). Collecting permits were issued by the Ministerio del Medio Ambiente, Vivienda y Desarrollo Territorial of Colombia. All frogs were euthanized in the field as soon as possible to avoid that the digestive process continued (Parmelee 1999). Specimens were fixed in 10% formalin and later transferred to 70% ethanol. Specimens and gastrointestinal contents were deposited in the herpetological collection of the Museo de Historia Natural Lorenzo Uribe of the Pontificia Universidad Jeveriana in Bogotá, Colombia

Dietary analyses

Dietary data was obtained from samples of three species *Rhinella marina* (Bufonidae), *Pristimantis achatinus* (Strabomantidae) and *Dendropsophus columbianus*. Specimens were captured both in the morning (0900-1200 hrs) and in the afternoon (1500-1800 hrs) and were sacrificed immediately, but those captured at night (1900-2400 hrs) were killed 8-12 hours after their capture. Gastrointestinal contents were preserved in 70% ethanol and identified to the lowest possible taxonomic level, mainly to Order. The frequency of prey occurrence was taken in the gastrointestinal contents; this frequency is a measure of the number of times in which a type of prey appeared in of a predator species (Parmelee 1999).

Ontogenetic change

To detect ontogenetic change in diet, we have chosen specimens of *R. marina*, *D. colombianus* and *P. achatinus* because these are the most common species in the research area. We divided frogs into three body-size classes for each species (**Table 2**) based on reports on adult size: adult size of *R. marina* is 90 mm or more, as snout-vent length (SVL) (Zug &Zug 1979); adult size of *D. columbianus* is 25 mm SVL (Duellman & Trueb 1983), and adult size of *P. achatinus* is 23 mm SVL (Lynch & Duellman 1997). Then we compared these categories into each species to establish differences based on the type and quantity of prey. Using R program version 2.10.0, we performed an ANOVA of one way with a α of 0.01 in order to test whether there were

Table 1. Collection sites (farms) in the Quindio department (Colombia).

Farm	Date	Municipality	Vereda	Departmento	Coordinates	Altitude
La Ramada	June 14-17 2006	Quimbaya	El Laurel	Quindío	04°35’33” N 75°49’84.6” O	1203 m
La Floresta	June 19-23 2006	Quimbaya	El Laurel	Quindío	04°35’47.7” N 75°50’20.4” O	1186 m
La Comarca	September 23-25 2006	Alcalá	Playas Verdes	Quindío	04°41’45.4”N 75°46’20”O	1237 m
Tesalia Baja	September 27-28 2006	Circasia	Llanadas	Quindío	04°35’08.5” N 75°40’01.2” O	1616 m
La Floresta	June 15-18 2007	Quimbaya	El Laurel	Quindío	04°35’47.7” N 75°50’20.4” O	1186 m
Lusitania	June 19-23 2007	Alcalá	Playas Verdes	Quindío	04°41’50.2” N 75°50’05.2” O	1197 m

significant differences among different sizes in each species. The dietary overlap was also quantified among these three size classes in each species by calculating simple similarity indices (Schoener, 1968):

$$C_{XY} = 1 - 0.5 \sum \left| P_{IX} - P_{IY} \right|$$

based on the proportion of prey taxa (i) in diets of two different frog size classes (x and y). Overlap values vary from 0 (total dissimilarity) to 1 (identical diets).

Table 2. Body-size classes for each species.

Species	First class	Second class	Third class
R marina	(SVL <70 mm)	(SVL 70 mm - 89mm)	(SVL ≥ 90 mm)
P achatinus	(SVL <16 mm)	(SVL 16 mm - 22mm)	(SVL ≥ 23 mm)
D columbianus	(SVL <20 mm)	(SVL 20 mm - 24mm)	(SVL ≥ 25mm)

RESULTS

Diet of species

Rhinella marina: Of the 32 individuals examined, only one had a completely empty gastrointestinal tract. We found 13 prey types; Coleoptera and Hymenoptera were the most frequent preys; vegetal material was the second most common (**Table 3**).

Pristimantis achatinus: We examined 57 specimens; nine of them had completely empty gastrointestinal tracts. We found 14 prey types, Coleoptera the most frequent, followed by Hymenoptera; this was the only species where both Isoptera and Pseudoescorpionida were found (**Table 3**).

Dendropsophus columbianus: We examined 109 specimens, 22 had completely empty gastrointestinal tracts. We found 15 types of preys; Coleoptera and Hymenoptera were the most frequent, and it was the only species in which Dermapterans remains were found (**Table 3**).

Table 3. Prey frequency of the anuran collected.

PREYS	*R marina* N(32) Frequency	*D columbianus* N(109) Frequency	*P achatinus* N(57) Frequency
Acari	0	1	1
Araneae	7	24	9
Blatodea	1	1	2
Crustacea	0	1	2
Coleoptera	20	25	20
Collembola	0	1	1
Diptera	2	12	6
Gastropoda	1	0	0
Hemiptera	8	25	10
Hymenoptera	20	18	18
Isoptera	0	0	1
Lepidoptera	4	5	4
Miriapoda	5	0	2
Nematoda	9	7	5
Odonata	0	1	0
Orthoptera	2	6	0
Pseudoescorpiones	0	0	1
Psocoptera	1	1	0
Dermaptera	0	1	0
Vegetal material	16	28	17

Ontogenetic change

Diet comparison among the three size classes of *R. marina, P. achatinus* and *D. columbianus,* revealed that they consume similar prey but species specific composition of other preys was identified.

Rhinella marina: Coleoptera, Hymenoptera, and vegetal material were the most frequent contents among the three sizes classes (**Table 4**); the third class (SVL ≥ 90 mm) showed the greatest count of prey types (11), whereas the first class (SLV <70.0 mm) showed the lowest count of prey types (six). According to the ANOVA test ($F = 2.3684$, $p = 0.1070$), there were no significant differences among the three size classes. Dietary overlap of the first class (SLV <70.0 mm) and of the second class (SLV 70 mm- 89mm), showed the greatest similarity (0.86), followed by both the second and the third classes that had a diet similarity of 0.81.The lowest was found between the first class and the third class (0.77).

Pristimantis achatinus: Coleoptera was the most frequent among the three size classes (**Table 5**); the third class (SLV ≥ 23 mm) showed the greatest number of prey types (11), and the first class (SLV < 16mm) showed the lowest number of prey types (five). According to the ANOVA test (F=0.3475 p=0.7086), there was not significant differences among the three size classes. Dietary overlap showed the third (SLV ≥ 23 mm) and the second class (SLV 16 mm-22 mm) with the greatest diet similarity (0.74), dietary overlap among the third class and the first class was about 0.54 which was the same between the second and the first classes (0.54).

Table 4. Frequency (F) and Proportions (P) of prey types found in three classes of size of *R. marina.*

PREYS	First class N (8) (SLV <70.0 mm)		Second class N (13) (SLV 70 mm-89mm)		Third class N (11) (SVL ≥90mm)	
	F	P	F	P	F	P
Coleoptera	3	0.21	10	0.23	7	0.24
Hymenoptera	4	0.29	10	0.23	6	0.23
Hemiptera	2	0.14	5	0.11	1	0.03
Araneae	1	0..07	4	0.09	2	0.07
Lepidoptera	1	0.07	2	0.05	1	0.03
Diptera	0	0	1	0.02	1	0.03
Miriapoda	0	0	3	0.07	2	0.07
Orthoptera	0	0	1	0.02	1	0.03
Gastropoda	0	0	0	0	1	0.03
Blattodea	0	0	0	0	1	0.03
Psocoptera	0	0	0	0.02	0	0
Vegetal material	3	0.21	7	0.16	6	0.21

Table 5. Frequency (F) and Proportions (P) of prey types found in three classes of size of *P. achatinus.*

PREYS	First class N (18) (SLV < 16mm)		Second class N (14) (SLV 16mm-22mm)		Third class N (25) (SVL ≥23mm)	
	F	P	F	P	F	P
Coleoptera	8	0.33	5	0.24	7	0.22
Hymenoptera	11	0.46	3	0.14	4	0.13
Hemiptera	3	0.13	3	0.14		0.13
Araneae	0	0	2	0.10	7	0.22
Lepidoptera	0	0	2	0.10	2	0.06
Diptera	1	0.04	3	0.14	2	0.06
Miriapoda	0	0	0	0	2	0.06
Seudoescorpiones	1	0.04	0	0	0	0.03
Blattodea	0	0	1	0.05	1	0.03
Isoptera	0	0	1	0.05	0	0
Acari	0	0	1	0.05	0	0
Crustacea	0	0	0	0	2	0.06
Collembola	0	0	0	0	1	0.03

Dendropsophus columbianus: Coleoptera was the most frequent prey among the three size classes (**Table 6**); the second class (SLV 20 mm – 24 mm) showed the greatest number of prey types (11), and the first class (SLV <20 mm) showed the lowest number of prey types, (three). According to the ANOVA test (F=3.906 p=0.02843), there was not significant differences among the three size classes. Dietary overlap showed that third (SLV ≥ 25 mm) and the second class (SLV 20 mm – 24 mm) had the greatest similarity (0.70), followed by the diet similarity (0.53) between the first and the second classes. The lowest similarity was found between the first and the third class (0.45).

DISCUSSION

Diet is a complex phenomenon that is affected by both body size and head shape, phylogeny, microhabitat and foraging behavior (Parmelee 1999). Because of frog position in the trophic network is extremely important, many studies describing the diet of amphibians have been done, but few general conclusions emerge from these studies owing to large differences in sample sizes, time of analysis, age class, and lack of information on food availability (Cogalniceanu *et al* 2000).

It is well known that ontogenetic shifts in diet occur in postmetamorphic anurans, and that body size or mouth size are thought to be important factors in determining the size of prey consumed (Hirai & Matsui 1999, Flowers & Brent 1995). However, our results show that there were no significant difference among the three size classes of *R. marina, P. achatinus*, and *D. columbianus*, indicating high values of dietary overlap and similar diet composition among the three size classes. Our results suggest that food resources are not strongly partitioned ontogenetically in these species. Although there were no significant differences in diet, the smallest individuals of *R. marina*, *D. colombianus* and *P. achatinus* have less prey types; they also consumed smaller prey such as ants, mites and small beetles, whereas largest individuals of all species consumed larger preys such as crickets and roaches. In this way, smaller individuals tend to exploit small preys more heavily, avoiding competition with larger individuals, and

Table 6. Frequency (F) and Proportions (P) of the prey type found in three classes of size of *D. columbianus.*

PREYS	First class N (15) (SLV < 20mm)		Second class N(58) (SLV 20mm-24mm)		Third class N(36) (SVL ≥25mm)	
	F	P	F	P	F	P
Coleoptera	0	0	11	0,19	14	0,25
Hymenoptera	1	0,17	7	0,12	10	0,18
Hemiptera	1	0,17	17	0,29	7	0,12
Araneae	3	0,5	12	0,2	9	0,16
Lepidoptera	0	0	2	0,03	3	0,05
Diptera	1	0,17	3	0,05	8	0,14
Psocoptera	0	0	1	0,02	0	0
Odonata	0	0	0	0	1	0,03
Blattodea	0	0	1	0,02	0	0
Orthoptera	0	0	3	0,05	3	0,05
Acari	0	0	1	0,02	0	0
Crustacea	0	0	1	0,02	0	0
Collembola	0	0	0	0	1	0.03
Dermaptera	0	0	0	0	1	0,02

extending the domain of the trophic resource exploited by the population. The high values of dietary overlap could be explained by the high similarity of morphology of the frogs, thus constraining food choice to a smaller subset of the available prey assemblage (Doan 2008). However, this results also could be influenced by the level of the taxonomic identification of the prey (order level only), thus dietary overlap may appear artificially higher in the species.

Clearly, we can conclude that diet is a complex phenomenon that is affected by different factors, and to establish which of these factors is the most important, could give us the tools for making strategies of conservation in the future.

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LITERATURE CITED

Biavati G.M., H.C. Wiederhecker & G.R. Colli. 2004. Diet of *Epipedobates flavopictus* (Anura: Dendrobatidae) in a Neotropical Savanna. Journal of Herpetology 38: 510-518.

Botero-trujillo, R. 2006. Anuran predators of scorpions: *Bufo marinus* (Linnaeus, 1758) (Anura: Bufonidae), first known natural enemy of *Tityus nematochirus* Mello-Leitão, 1940 (Scorpiones: Buthidae). Revista Ibérica de Aracnología 13: 199-202.

Caldwell, J. 1996. The evolution of myrmecophagy and its correlates in poison frogs (Family Dendrobatidae). Journal of Zoology 240: 75-101.

Cogalniceanu, D., M.W. Palmer & C. Ciubuc. 2000. Feeding in anuran communities on islands in the Danube floodplain. Amphibia-Reptilia 22: 1-19.

Crump, M.L. & J.R. Scott. 1994. Visual Encounter Surveys. In: Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L. Hayek & M.S. Foster (eds.). Measuring and Monitoring Biological Ddiversity, Standard Methods for Amphibians. 84-92 Smithsonian Institution Press, Washington and London.

Daza-Vaca, J., D. & F. Castro-Herrera. 1999. Hábitos alimenticios de la rana toro (*Rana catesbeiana*) Anura: Ranidae, en el Valledel Cauca, Colombia. Revista de la Academia Colombiana de Ciencias 23: 265-274.

Doan, T. 2008. Dietary varition within the Adean Lizard Clade Protoporus (Squmata: Gymnopthalmidae). Journal of Herpetology 42 (1): 16-21.

Duellman, E. & L. Trueb. 1983. Frogs of the *Hyla columbiana* Group: Taxonomy and Phylogenetic relationships. *In:* A.G.J. Rhodin and K. Miyata (eds.). Advances in Herpetology and Evolutionary Biology 33-51. Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, U.S.A.

Flowers, M. & M.G. Brent.1995.Prey Selectivity and Size-Specific Diet Changes in *Bufo cognatus* and *B. woodhousii* during Early Postmetamorphic Ontogeny Journal of Herpetology 29: 608-612.

Hirai, T. & M. Matsui. 1999. Feeding Habits of the Pond Frog, Rana nigromaculata, Inhabiting Rice Fields in Kyoto, Japan Copeia 4: 940-947.

Hirai, T. & M. Matsui. 2002. Feeding ecology of *Bufo japonicas formosus* from the montane region of Kioto, Japan. Journal of Herpetology 36: 719-723.

Hirai, T. 2002. Ontogenetic change in the diet of the pond frog, *Rana nigromaculata.* Ecological Research 17: 639-644 .

Hoyos, H., P. Isaacs. N. Devia. D. Galindo. & R. Acosta. 2012. An approach to the ecology of the herpetofauna in agroecosystems of the Colombian coffee zone. Journal of South American Herpetology 7: 25-34.

Isaacs, P. & H. Hoyos.2010. Diet of the cane toad in productive systems in the coffee region of Colombia. Journal of South American Herpetology 5: 45-50.

Lima, A.P. & E. Magnusson. 2000. Does foraging activity change with ontogeny? An assessment for six sympatric species of postmetamorphic litter anurans in central Amazonica. Journal of Herpetology 33: 192-200.

Lynch, D. & W. Duellman.1997 *Frogs of the genus Eleutherodactylus (Leptodactylidae) in western Ecuador : Systematics, Ecology, and Biogeography*. Natural HistoryMuseum The university of Kansas. 263 pp

Muñoz-Guerrero, J., V.H. Serrano. & M.P. Ramirez-Pinilla. 2007. Uso de microhábitat, dieta y tiempo de actividad encuatro especies simpátricas de ranas hílidas neotropicales (Anura: Hylidae). Caldasia 29: 413-425.

Parmelee, J.R. 1999. Trophic ecology of a tropical anuran assemblage. Scientific Papers Natural History Museum The University of Kansas 11: 1-59.

Rodríguez, C.T. 1999. Biodiversidad del relicto “Cedro Rosado” de la Universidad del Quindío. Biología y Educación 9: 17-18.

Santos, M.E., A.V. Argus & S.D. Vasconcelos. 2004. Feeding habits of six anuran (Amphibia: Anura) species in a rainforest fragment in Northeastern Brazil. Iheringia, Sér. Zool., Porto Alegre 94: 433-438.

Schoener, W. 1968. The *Anolis* lizards of Bimini:resource partitioning in a complex fauna. Ecology 49: 704-726

Toft, C.A. 1980a. Feeding ecology of thirteen syntopic species of anurans in a seasonal tropical enviroment. Oecologia 45: 131-141.

Toft, C.A. 1981. Feeding ecology of Panamanian litter anurans: patterns in diet and foraging mode. Journal of Herpetology 15: 139-144.

Whitfield, S.M. & M.A. Donnelly. 2006. Ontogenetic and seasonal variation in the diets of a Costa Rican leaf-litter herpetofauna. Journal of Tropical Ecology 22: 409-417.

Zug, G.R. & P.B. Zug.1979. The marine toad, *Bufo marinus*: a natural history resumé of native populations. Smithsonian Contributions to Zoology 284**:** 1-58.

Zug, R., J. Vitt. & P. Caldwell. 2001. *Herpetology An introductory biology of amphibians and reptiles*. Segunda edición. Academic Press. New York U.S.A 630 pp

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