Phyllomedusa 2(1):3-8, **2003**

ISSN 1519-1397

Observations on the ecology of *Pseudis bolbodactyla* (Anura, Pseudidae) in central Brazil

Reuber A. Brandão[1,2], Adrian Garda[2,3], Vívian Braz[2], and Bárbara Fonseca[4]

[1] Coordenação de Assuntos Fundiários (DICRI), Diretoria de Ecossistemas (DIREC), Instituto Brasileiro do Meio Ambiente (IBAMA), Avenida L4 Norte, 70 910-900, Brasília, DF, Brazil). E-mail: reuberbrandao@yahoo.com.br.

[2] Departamento de Zoologia, Universidade de Brasília, 70910-900 Brasília, DF. Brazil.

[3] Current address: Department of Zoology and Sam Noble Oklahoma Museum of Natural History, University of Oklahoma, Norman, Oklahoma, 73072-7029, USA. E-mail: garda@ou.edu.

[4] Instituto de Botânica, Seção de Ecologia. Universidade de São Paulo. Av. Miguel Stéfano 3687, Água Funda, 04301-012, São Paulo, SP, Brazil. E-mail: bm_fonseca@yahoo.com.br.

Abstract

Observations on the ecology of *Pseudis bolbodactyla* (Anura, Pseudidae) in central Brazil. Data on diet, activity, habitat use, and anti-predator behavior are presented for a population of *Pseudis bolbodactyla* in central Brazil. The most common diet items were diurnal plant-associated insects. *Pseudis bolbodactyla* shows both diurnal and nocturnal activity and uses mainly areas with aquatic vegetation (submerged and emergent). Individuals detect predators visually and through vibrations in the water.

Keywords: Anura, Pseudidae, *Pseudis bolbodactyla*, anti-predator behavior, diet, cerrado, central Brazil.

Introduction

The family Pseudidae Savage and Carvalho, 1953 is composed of two genera and nine species restricted in distribution to South America, east of the Andes (Frost 2002). Pseudids occur in aquatic habitats in river flood plains in Venezuela, Guyana, Colombia, Peru, Bolivia, Paraguay, Uruguay, Argentina, and Brazil (Duellman and Trueb 1986, Morales and Chandler 1992, Frost 2002) with the exception of *Pseudis cardosoi*, which is found above 900 m in the Planalto das Araucárias, Brazil (Kwet 2000).

Received 14 February 2003
Accepted 29 May 2003
Distributed 31 October 2003

The phylogenetic position of Pseudidae has long been a matter of debate. Savage and Carvalho (1953), when erecting the family, considered these frogs closely related to Leptodactylidae. Currently, Pseudidae is suggested to form a clade with Hylidae and Centrolenidae based primarily on the presence of intercalary elements between phalanx II and III (Burger 1954, Cochran 1955, Gallardo 1961, Griffiths 1963, Cei 1980). Using morphological characters to reconstruct the phylogeny of the subfamilies of Hylidae, Duellman (2001) found Pseudidae to cluster within the Hylidae; however, this placement should be taken with caution because no leptodactylid was included in this analysis. Haas (2003) suggested that Pseudidae is paraphyletic with respect to

Hylidae (Hylinae). While no specific analysis regarding this question is presented, we prefer to consider Pseudidae as a separate clade.

Adults of the six species of the genus *Pseudis* vary between 24.5 and 61.7 mm in snout-vent length (SVL) and are considerably smaller than their tadpoles. For example, *P. paradoxa* tadpoles can reach 270 mm in total length (Bokermann 1967). No other anuran species have tadpoles of a comparable size (Emerson 1988). In a recent revision of the genus *Pseudis*, Caramaschi and Cruz (1998) recognized *P. bolbodactyla* Lutz 1925 and *P. fusca* Garman 1883 as valid species and described a third species, *P. tocantins*, based on specimens from the middle Tocantins river flood plain, Brazil. *Pseudis tocantins* is known only from the type locality in Porto Nacional Municipality, Tocantins state, Brazil (Caramaschi and Cruz 1998, Frost 2002). *Pseudis fusca* is referred to the Jequitinhonha river basin on the northeast part of Minas Gerais state and South of Bahia state, Brazil (Caramaschi and Cruz 1998). *Pseudis bolbodactyla* occurs in flood plains of the São Francisco, Doce, and Paraguai rivers (Caramaschi and Cruz 1998, Feio *et al*. 1998).

Although the phylogenetic and biogeographic knowledge of the group has recently increased, there is little information about the ecology of *Pseudis* and nothing is known regarding *P. bolbodactyla*. Herein we present data on diet, habitat use, and antipredator behavior from a population of *P. bolbodactyla* in central Brazil.

Material and Methods

Our study site was a ca. 180 m^2 artificial pond (max. depth = 3 m) located 6 km west of the city of Pirenópolis, state of Goiás, Brazil (15°15'13" S, 48°57'48" W; 720 m). About 40% of the pond surface was covered with aquatic vegetation composed mainly of plants from the families Cyperaceae, Poaceae, and Xyridaceae. Macrophytes were also abundant. The pond was formed by the damming of a small creek that flows into the Almas river, a tributary of the left margin of the Tocantins river.

We made four visits of two to four days each to the study site in April, June, and December 1998, and January 1999. To quantify the activity of *P. bolbodactyla*, we marked 44 2 x 2 m squares in the pond with bamboo sticks, 36 partially or totally covered with vegetation and 8 in open water. For each individual observed, we recorded the point of observation, behavior (vocalizing, foraging, or motionless), body position in the water, and time. We collected 18 individuals throughout the study period for use in morphological and dietary analyses. Specimens were preserved in 10% formalin, transferred to 70% ethanol, and deposited in the herpetological collection of the Universidade de Brasília (CHUNB). Using digital calipers, we measured the following variables to the nearest 0.01 mm for each individual: snout-vent length, tibia length, foot length, arm length, hand length, mouth length, head length, head width, and head height, following Heyer *et al*. (1990) (Table 1).

Fourteen of the 18 stomachs analyzed contained prey items. We identified prey items to the lowest taxonomic level possible and measured their length and width to the nearest 0.01 mm with digital calipers. For each prey category, we also calculated frequency, numerical importance, and volumetric importance. Prey volume was estimated through the ellipsoid formula:

$$V = \pi \text{ (length x width}^2)/6.$$

Niche breadth was calculated through Simpson's diversity index according to the formula:

$$1/ \Sigma p_i^2$$

where *pi* is the proportion of records of category *i*.

Duré and Kehr (2001) studied the diet of *P. paradoxa* in Corrientes, Argentina. For comparison purposes, the table of prey types presented by these authors was used to calculate Simpson's niche breadth for *P. paradoxa*. We then used t tests (two tailed) to test for differences in niche breadth, prey number, and prey volume between *P. bolbodactyla* and *P. paradoxa* (Brower and Zar 1984, Zar 1996). For all tests, α was set at 0.05.

Results

The occurrence of *Pseudis bolbodatyla* at Pirenópolis represents a considerable species' range extension, and one of the highest altitudes recorded for a pseudid.

The diet of *Pseudis bolbodactyla* consisted of 10 prey categories (Table 2). Coleoptera, Heteroptera (Hemiptera), Homoptera (Hemiptera), Orthoptera, and Plecoptera were eaten in equal numbers. The most frequent diet items were non-aquatic true bugs (Heteroptera), beetles (Coleoptera), grasshoppers (Orthoptera, Acrididae), and small cicadas (Homoptera). In volume, the most important items were grasshoppers, bees (Hymenoptera), spiders (Aranae), and true bugs (Heteroptera).

Niche breadth of *Pseudis paradoxa* (4.588) was smaller than niche breath of *P. bolbodactyla* (8.007); however, this difference was not significant (t = -0.571; p > 0.05). Differences in prey number (t = -0.793; p = 0.437) and volume (t = -0.654; p = 0.520) detected between species were not significant, although *P. paradoxa* ingested a large number of Diptera and larger prey, such as Anura.

Pseudis bolbodactyla vocalized and foraged during both day and night. During the day, individuals remained in the vegetated area of the pond, congregating in the area with denser vegetation. At night, individuals were more dispersed throughout the pond, but the number of individuals observed in the vegetated area (76) was much larger than in the open water (4).

At rest, individuals of *P. bolbodactyla* float on the water surface and anchor themselves to the vegetation by holding branches and leaves with their hands, in a characteristic manner (Figure 1). Like other species of the genus, the polex is opposable (Burguer 1954), allowing the animal to hold on to branches while remaining motionless with only the eyes, nostrils, and tympanum out of the water. This position not only ensures a visual perception of the outer environment, but also allows individuals to monitor the water through vibrations on the branches to which they are anchored. When a certain level of undulation in the water is sensed in one of the branches, the animal promptly flees by sinking in the water and swimming away.

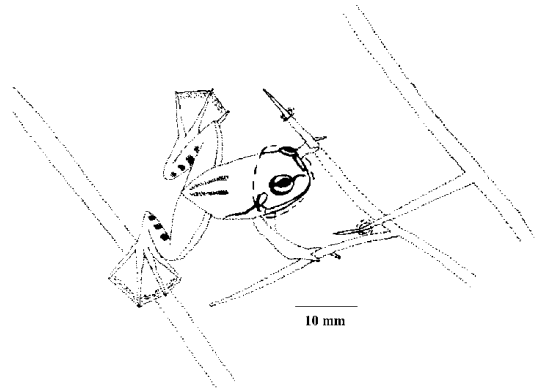

Figure 1 - Adult male of *Pseudis bolbodactyla* anchored to leaves of aquatic plants. Drawing based on a colored photograph by RAB.

Discussion

According to Cei (1980), the diet of *Pseudis paradoxa* consists of aquatic insects and amphibians. In Corrientes, Argentina, the diet of *P. paradoxa* was dominated numerically by Diptera and volumetrically by Anura (Duré and Kehr 2001). In *P. cardosoi* feces, Kwet (2000) found several insects such as Orthoptera, Homoptera, Coleoptera, Odonata, and Heteroptera (Naucoridae). Although the populations of *P. bolbodactyla* and *P. paradoxa* compared herein showed no significant difference in niche breadth, prey size and prey volume, their diets differ qualitatively. In *P.*

Table 1 - Morphological measurements (in mm) of 18 individuals of *Pseudis bolbodactyla* from Pirenópolis, Goiás, Brazil.

Measurements	Mean ± Standard deviation	Range
Snout-vent length	37.53 ± 4.75	29.45-46.19
Leg length	77.17 ± 8.55	63.39-92.52
Foot length	23.11 ± 2.40	18.78-27.42
Arm length	23.81 ± 3.21	18.60-31.13
Hand length	13.51 ± 1.64	10.82-16.72
Head length	14.21 ± 1.69	11.79-16.48
Head width	14.37 ± 1.61	10.89-17.11
Head height	8.37 ± 1.20	6.64-10.81
Jaw length	11.60 ± 1.11	9.13-13.49

Table 2 - Diet of *Pseudis bolbodactyla* in an artificial pond in Pirenópolis Municipality, Goiás, Brazil (n = 14). The total number of items for each category (N), the number of stomachs containing each category (Frequency), and volume for each category are presented.

Category	N	Frequency	Volume (cm^3)	Volume (%)
INSECTA				
Homoptera	6	4	0.0303	0.0283
Cercopidae	6	4	0.0303	0.0283
Hemiptera	5	5	0.1011	0.0943
Orthoptera	4	4	0.5958	0.5559
Acrididae	3	3	0.4156	0.3878
Tettigoniidae	1	1	0.1801	0.1681
Plecoptera	4	2	0.0041	0.0038
Coleoptera	4	4	0.0336	0.0314
Curculionidae	1	1	0.0019	0.0018
Hymenoptera	2	2	0.1579	0.1473
Apidae				
Apis mellifera	1	1	0.1259	0.1174
Meliponinae	1	1	0.0321	0.0299
Diptera	3	2	0.0054	0.0050
Tricoptera	2	2	0.0141	0.0132
ARACHNIDA				
Araneae	3	2	0.1201	0.1121
Acari	1	1	0.0001	< 0.0001
Plant material (*)	1	1	0.0092	0.0086
TOTAL	**33**	**14**	**1.0717**	**1.0000**

(*) Accidental ingestion.

bolbodactyla, diurnal plant-associated insects such as Orthoptera, Hymenoptera, and Homoptera were more represented numerically than Diptera, which was common in *P. paradoxa*. Also, although 17 other anuran species were observed in our study site, there were no frogs in the stomachs of *P. bolbodactyla*.

Diurnal plant-associated insects like true bugs, grasshoppers, and small cicadas, were the main prey categories of *Pseudis bolbodactyla*, both numerically and volumetrically. Bees found in the stomachs (*Apis mellifera* and one Meliponinae) where probably ingested when getting water on the pond surface or after falling into the water. Only winged adults of aquatic insects (Plecoptera and Tricoptera) were ingested, corresponding to a small fraction in volume (1.83%) and frequency (20.7%). An aquatic species of Acari was also recovered. *Pseudis bolbodactyla* has a generalist and opportunistic diet, which may be related to its sit-and-wait predatory behavior.

Nocturnal and diurnal activity seems to be common in the genus *Pseudis*. Similar to *P. bolbodactyla*, other species such as *P. cardosoi* (Kwet 2000) and *P. tocantins* (Brandão and Péres Jr. 2001) also are active during day and night. Male *P. paradoxa* start calling in late afternoon and early evening, but also call during the day after rains (Dixon *et al*. 1995).

Our data show that the presence of aquatic vegetation is essential for the occupation of the pond by *Pseudis bolbodactyla*. Aquatic vegetation is used for foraging (as seen by the volumetric and numerical importance of vegetation-associated insects in the diet) as well as protection against predators. Other *Pseudis* also appear to depend on the presence of aquatic vegetation to colonize ponds (Savage and Carvalho 1953, Gallardo 1961, Morales and Chandler 1992, Dixon *et al.* 1995, Bosch *et al.* 1996, Sá and Lavilla 1997, De la Riva 1999, Kwet 2000, Brandão and Péres Jr. 2001, Duré and Kehr 2001, Arias *et al*. 2002). Our field site had four ponds in total, two with vegetation and the two without. *P. bolbodactyla* were only found in the ponds with aquatic vegetation.

The behavior of anchoring to the vegetation described herein has also been observed in *Pseudis tocantis* (Brandão and Peres Jr. pers. obs.). The movements of stems can be caused by predators approaching the frog from both the surface and underwater. *Pseudis bolbodactyla* can therefore sense not only terrestrial and aerial predators, but also aquatic ones such as snakes, turtles, caimans and fishes. Hence, observers studying this species should move with extreme caution in order to disturb the water as little as possible. During the day, *P. bolbodactyla* is less tolerant to approach thus making capture difficult. Potential predators of adults and tadpoles observed in the study pond were wolf fish (*Hoplias* sp.), water opossum (*Chironectes minimus*), herons (*Syrigma sibilatrix*, *Casmerodius albus*, *Nycticorax nycticorax*), buff-necked ibis (*Theristicus caudatus*), water snakes (*Liophis reginae*), and side-necked turtle (*Phrynops gibbus*).

The study pond also had a high abundance of leeches (*Oxyptycus brasiliensis* and *Hementaeria lutzi*) that attacked several other anurans and were even able to predate small species, such as *Scinax fuscomarginatus* (Brandão and Garda 2000). In spite of living in the water, none of the observed *P. bolbodactyla* showed signs of attack by leeches.

Acknowledgments

We would like to acknowledge Marcelo Bagno (*in memorian*), Gláucia Zerbini, Mariana Zatz, and Frederico França for field assistance. Marcelino Boaventura and Mark Siddal helped on the identification of insects and leeches. We also would like to thank Donald B. Shepard and Guarino R. Colli for critical reading of the manuscript, and Bernardo Brito help us with the map. Eli Medeiros and Evandro Ayer kindly allowed us to work in their properties.

References

Arias, M. M., P. M. Peltzer and R. C. Lajmanovich. 2002. Diet of the giant tadpole *Pseudis paradoxa platensis* (Anura, Pseudidae) from Argentina. *Phyllomedusa 1*: 97-100.

Bokermann, W. C. A. 1967. Girinos de anfíbios brasileiros - 3: Sobre um girino gigante de *Pseudis paradoxa* (Amphibia: Pseudidae). *Revista Brasileira de Biologia 27*: 209-212.

Bosch, J., I. De la Riva and R. Márquez. 1996. The calling behaviour of *Lysapsus limellus* and *Pseudis paradoxa* (Amphibia: Anura: Pseudidae). *Folia Zoologica 45*: 49-55.

Brandão, R. A. and A. A. Garda. 2000. *Scinax fuscomarginatus* (Anura: Hylidae). Predation. *Herpetological Review 30*: 171.

Brandão, R. A. and A. K. Péres Jr. 2001. Levantamento da herpetofauna na área de influência do Aproveitamento Hidroelétrico da UHE Luís Eduardo Magalhães (Palmas, TO). *Humanitas 3*: 35-50.

Brower, J. E. and J. H. Zar. 1984. *Field and Laboratory Methods for General Ecology* (2nd ed.). Dubuque. Wm. C. Brown. 226 pp.

Burger, W. L. 1954. Two family-groups of Neotropical frogs. *Herpetologica 10*: 194-196.

Caramaschi, U. and C. A. G. Cruz. 1998. Notas taxonômicas sobre *Pseudis fusca* Garman e *P. bolbodactyla* A. Lutz, com descrição de uma nova espécie correlata (Anura: Pseudidae). *Revista Brasileira de Zoologia 15*: 929-944.

Cei, J. M. 1980. Amphibians of Argentina. *Monitore Zoologico Italiano (N.S.) 2*: 1-609.

Cochran, D. M. 1955. *Frogs of Southeastern Brazil*. United States Natural Museum Bulletin 206. Washington. Smithsonian Institution. 423 pp.

De la Riva, I. 1999. Notes on the paradox frog, *Pseudis paradoxa*, in Bolivia. *British Herpetological Society Bulletin 68*: 14-19.

Dixon, J. R., C. Mercolli and A. A. Yanosky. 1995. Some aspects of the ecology of *Pseudis paradoxa* from northeastern Argentina. *Herpetological Review 26*: 183-185.

Duellman, W. E. 2001. *The Hylid Frogs of Middle America*. Ithaca, NY. Society for the Study of Amphibians and Reptiles. 1159 pp.

Duellman, W. E. and L. Trueb. 1986. *Biology of Amphibians*. New York. McGraw-Hill. 670 pp.

Duré, M. I. and A. I. Kher. 2001. Differential exploitation of trophic resources by two pseudid frogs from Corrientes, Argentina. *Journal of Herpetology 35*: 340-343.

Emerson, S. B. 1988. The giant tadpole of *Pseudis paradoxa*. *Biological Journal of the Linnean Society 34*: 93-104.

Feio, R. N., U. M. L. Braga, H. Wiederhecker, and P. S. Santos. 1998. *Anfíbios do Parque Estadual do Rio Doce (Minas Gerais)*. Viçosa. IEF/UFV. 32 pp.

Frost, D. R. (ed.). 2002. *Amphibian Species of the World – an on line reference*. URL: *http://research.amnh.org – herpetology/amphibia/index.html*. Captured on 2 February 2003.

Gallardo, J. M. 1961. On the species of Pseudidae (Amphibia, Anura). *Bulletin of the Museum of Comparative Zoology 125*: 111-134.

Griffithis, I. 1963. The phylogeny of the Salientia. *Biological Review 38*: 241-292.

Haas, A. 2003. Phylogeny of frogs as inferred from primarily larval characters (Amphibia: Anura). *Cladistics 19*: 23-89.

Heyer, W. R., A. S. Rand, C. A. S. Cruz, O. L. Peixoto, and C. E. Nelson. 1990. Frogs of Boracéia. *Arquivos de Zoologia, São Paulo 31*: 231-410.

Kwet, A. 2000. The genus *Pseudis* (Anura: Pseudidae) in Rio Grande do Sul, southern Brazil, with description of a new species. *Amphibia-Reptilia 21*: 39-55.

Morales, V. C. and M. Chandler. 1992. First record of *Pseudis paradoxa* (Anura: Pseudidae) in Peru, with notes on its distress call and habitat. *Caribbean Journal of Science 28*: 224-226.

Sá, R. O. and E. O. Lavilla. 1997. The tadpole of *Pseudis minuta* (Anura: Pseudidae), an apparent case of heterochrony. *Amphibia-Reptilia 18*: 229-240.

Savage, J. M. and A. L. Carvalho. 1953. The family position of neotropical frogs currently referred to the genus *Pseudis*. *Zoologica 38*: 193-200.

Zar, J. H. 1996. *Biostatistical Analysis*. (3rd ed.). Englewood Cliffs, New Jersey, Prentice Hall. 988 pp.