

Community structure of metazoan parasites of the yellow Cururu toad, *Bufo ictericus* (Anura, Bufonidae) from Rio de Janeiro, Brazil

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Abstract

Thirty-two specimens of *Bufo ictericus* (Spix, 1824), 22 males and 10 females, collected in Miguel Pereira, State of Rio de Janeiro, Brazil, from April 2002 to August 2003, were examined for presence of metazoan parasites. Thirty-one (97%) specimens of *B. ictericus* were parasitized by one or more metazoan species. Sixteen species of parasites were collected: 2 digeneans, 13 nematodes, and 1 ixodid tick. The endoparasites represented 82.3% of the total number of parasite specimens collected. *Bufo ictericus* is a new host record for: *Gorgoderina parvicava* Travassos, 1922, *Oswaldocruzia lopesi* Freitas et Lent, 1938, *O. mazai* Travassos, 1935, *O. subauricularis* (Rudolphi, 1819), *Oxyascaris* sp., *Parapharyngodon alvarengai* Freitas, 1957, *Rhabdias elegans* Gutierrez, 1945 and *R. sphaerocephala* Goodey, 1924. The digenean *Mesocoelium monas* (Rudolphi, 1819) was the most abundant species and the ixodid *Amblyomma rotundatum* (Koch, 1844) was the most prevalent in the parasite community of *B. ictericus*. The metazoan parasite species of *B. ictericus* showed the typical aggregated pattern of distribution of most parasite systems. There was no influence of host weight on parasite abundance and prevalence. Only one parasite species, *M. monas*, showed an influence of host sex on its abundance and prevalence. One pair of endoparasite species, *O. lopesi* and *M. monas*, showed an association in the infracommunities of *B. ictericus*. As in other parasite communities of *Bufo* species, the parasite community of *B. ictericus* was dominated by nematodes.

Key words

Parasite ecology, metazoan parasites, Anura, Bufonidae, *Bufo ictericus*, Brazil

Introduction

The parasite communities of amphibians are considered highly variable, depauperate, and non interactive (Aho 1990, Barton 1997). Since the review by Aho (1990), several other studies have been conducted on the parasite community structure of amphibians, however, the majority of these were conducted on Nearctic and Australasian host species (Barton 1999; Bolek and Coggins 2000, 2001, 2003; Paredes-Calderón *et al.* 2004). The Neotropical region has the highest biodiversity of amphibian species (Frost 1985, Izecksohn and Carvalho-Silva 2001), yet the majority of papers dealing with their parasites are taxonomic descriptions and only a few examine parasite populations and community structure (Goldberg *et al.* 1995b; Linzey *et al.* 1998; Puga and Torres 1999; Boquimpani-Freitas *et al.* 2001; Bursey *et al.* 2001; Goldberg and Bursey 2003; Iannaccone 2003a, b).

The yellow Cururu toad, *Bufo ictericus* (Spix, 1824) is a large terrestrial anuran in the *Bufo marinus* group of Martin, 1972, living in woods and being adapted to an urban environment (Izecksohn and Carvalho-Silva 2001). Commonly used breeding sites for this species are next to roads, in puddles, pasture ponds, and slow moving pasture streams (Heyer *et al.* 1990). This species is widely distributed along southeastern and southern Brazil, eastern Paraguay and Argentina (Kwet and Di-Bernardo 1999). Although there are reports of trematodes (Kloss 1971, Rodrigues and Rodrigues 1971, Faria 1978, Rodrigues *et al.* 1978), nematodes (Rodrigues *et al.* 1982, Vicente *et al.* 1990) and ixodid ticks (Woehl 2002) from *B. ictericus* in Brazil, no studies exist on the parasite community structure of this toad. In the present study we report the metazoan parasites of the yellow Cururu toad, *B. ictericus* at the component and infracommunity level from Rio de Janeiro, Brazil.

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Materials and methods

From April 2002 to August 2003, 32 specimens of *Bufo ictericus* were examined from the locality of Miguel Pereira (22°27'S, 43°28'W), State of Rio de Janeiro, Brazil; and were identified according to Heyer *et al.* (1990). The toads had been collected by hand and were killed by freezing and weighed 50–450 (237.5 ± 85.9) g; the average wet weights of male (236.5 ± 50.8 g, $N = 10$) and female (300 ± 105.4 g, $N = 22$) specimens were significantly different ($t = -2.538$, $p = 0.031$). The analysis included only parasite species with prevalence higher than 10% (Bush *et al.* 1990). The variance-to-mean ratio of parasite abundance (index of dispersion) was used to determine distribution patterns and its significance was tested using d statistical test, if values of d are higher than 1.96, an aggregated distribution is likely (Ludwig and Reynolds 1988). The dominance frequencies of each parasite species were cal-

culated according to Rohde *et al.* (1995); also, the Berger-Parker index of dominance was calculated for each parasite infracommunity (Magurran 1988). Spearman's rank correlation coefficient r_s was calculated to determine possible correlations between the total weight of hosts and the abundance of parasites. Pearson's correlation coefficient r was used as an indication of the relationship between the host's weight and the prevalence of parasites, following arcsine transformation of the prevalence data (Zar 1996) and the splitting of the host sample into four 50 g intervals. The effect of host sex on abundance and prevalence of parasites was tested using the Z_c normal approximation to the Mann-Whitney test and the Fisher exact test, respectively. Parasite species diversity was calculated using the Brillouin index (H) (Zar 1996). The probable variation of diversity and species richness in relation to host sex (Mann-Whitney test) and to host total weight (Spearman's rank correlation coefficient) was tested. The possible inter-

Table I. Prevalence, intensity range, mean intensity, mean abundance, and site of infection of metazoan parasites found in 32 specimens of *Bufo ictericus* from Miguel Pereira, State of Rio de Janeiro, Brazil

Parasites	Prevalence (%)	Intensity range	Mean intensity $\pm$ SD	Mean abundance $\pm$ SD	Site of infection
Digenea					
<i>Gorgoderina parvicava</i> [§] CHIOC 36434, 36435, 35436	6.2	1–32	16.5 $\pm$ 21.9	1 $\pm$ 5.6	urinary bladder
<i>Mesocoelium monas</i> CHIOC 36437, 36438	18.7	6–3700	694.3 $\pm$ 1478.7	130.1 $\pm$ 654.5	intestine
Nematoda					
<i>Aplectana membranosa</i> CHIOC 35291	37.5	1–61	11.5 $\pm$ 17.2	4.3 $\pm$ 11.7	rectum
<i>Aplectana</i> sp. (larval) CHIOC 35292	18.7	1–13	4.8 $\pm$ 4.3	0.9 $\pm$ 2.5	rectum
<i>Falcaustra mascula</i> CHIOC 35293	15.6	1–3	1.2 $\pm$ 0.4	0.1 $\pm$ 0.4	small intestine
<i>Oswaldocruzia lopesi</i> [§] CHIOC 35294	47	1–31	6.8 $\pm$ 8.7	3.2 $\pm$ 6.8	small intestine
<i>Oswaldocruzia mazzai</i> [§] CHIOC 35295	6	1–2	1.5 $\pm$ 0.7	<0.1	small intestine
<i>Oswaldocruzia subauricularis</i> [§] CHIOC 35296	12.5	1–9	4.5 $\pm$ 4.1	0.5 $\pm$ 1.9	small intestine
<i>Oswaldocruzia</i> sp. CHIOC 35297	15.6	1–8	3.6 $\pm$ 3.2	0.5 $\pm$ 1.7	small intestine
<i>Oxyascaris</i> sp. [§] CHIOC 35298	3	–	1	<0.1	rectum
<i>Parapharyngodon alvarengai</i> [§] CHIOC 35299	3	–	1	<0.1	rectum
<i>Rhabdias elegans</i> [§] CHIOC 35300	3	–	1	<0.1	lung
<i>Rhabdias fuelleborni</i> CHIOC 35301	53.1	1–31	8 $\pm$ 8.8	4.2 $\pm$ 7.5	lung
<i>Rhabdias sphaerocephala</i> [§] CHIOC 35302	3	–	1	<0.1	lung
<i>Strongyloides</i> sp. CHIOC 35303	3	–	1	<0.1	small intestine
Acari					
<i>Amblyomma rotundatum</i> IBSP 8726	63	1–234	50.2 $\pm$ 71.4	31.4 $\pm$ 61.1	body surface

[§]New host records.

specific association between gastrointestinal concurrent species was determined using the χ^2 test. Possible covariation among the abundance of concurrent species was analyzed using the Spearman's rank correlation coefficient. Ectoparasite and endoparasite larval stages were not included in this analysis because only one species of each group was collected. Ecological terminology follows Bush *et al.* (1997). Statistical significance level was set at $p \leq 0.05$. Voucher specimens of parasite species were deposited in the Coleção Helmintológica do Instituto Oswaldo Cruz (CHIOC), Rio de Janeiro and in the Coleção Acarológica do Instituto Butantã (IBSP), São Paulo, Brazil.

Results

Component community

Sixteen species of metazoan parasites were collected (Table I). *Mesocoelium monas* (Rudolphi, 1819) was the most abundant species with 4166 specimens collected (73.6% of all parasites) and the tick *Amblyomma rotundatum* Koch, 1844 was the species with the highest frequency of dominance (16%) following by *Oswaldocruzia lopesi* (7%) and *Aplectana membranosa* (6%). All parasites of *B. ictericus* showed the typical aggregated pattern of distribution observed in many parasite systems (Table II). The mean abundance and prevalence of all parasite species were not significantly correlated with host's weight. Both mean abundance and prevalence of *M. monas* were significantly different, being higher in females (412.5, 40%, $N = 10$) than in male toads (1.9, 9.1%, $N = 22$) ($Z_c = -2.2$, $p = 0.02$; Fisher exact test = 0.04).

Table II. Values of dispersion index (DI) and d test for the metazoan parasites of *Bufo ictericus* from Miguel Pereira, State of Rio de Janeiro, Brazil

Parasites	DI	d
<i>Mesocoelium monas</i>	3291.38	443.9
<i>Aplectana membranosa</i>	31.85	36.6
<i>Aplectana</i> sp.	7.42	13.6
<i>Falcaustra mascula</i>	1.98	3.7
<i>Oswaldocruzia lopesi</i>	14.42	22.1
<i>Oswaldocruzia subauricularis</i>	6.98	13
<i>Oswaldocruzia</i> sp.	5.49	10.6
<i>Rhabdias fuelleborni</i>	13.37	20.9
<i>Amblyomma rotundatum</i>	118.98	78.1

Infracommunities

Ninety-seven percent of *B. ictericus* specimens were parasitized by at least one parasite species. A total of 5661 individual parasites were collected with a mean of 176.5 ± 651.6 parasites/toad. Total parasite abundance was not significantly correlated with weight or sex of toads examined. Infections

with multiple species were common with 0, 1, 2, 3, 4, 5, and 6 species occurring in 1 (3.1%), 2 (6.3%), 9 (28.1%), 7 (21.8%), 9 (28.1%), 2 (6.3%), and 2 (6.3%) individual toads, respectively; only one host (3.1%) was not parasitized. The Berger-Parker index of dominance for the infracommunities was 0.713 ± 0.228 , and 0.690 ± 0.279 when *A. rotundatum* was not included in the infracommunities. The mean value of the Brillouin index of diversity (H) was 0.379 ± 0.499 and individual values were not significantly correlated with host total weight, but differences were observed between male and female toads ($Z_c = -2.197$, $p = 0.027$). Parasite species richness (3.1 ± 1.4 , 1–6) was not significantly correlated with weight of the host and no significant differences were observed between male and female hosts. Only one pair of gastrointestinal species showed significant positive association: *Oswaldocruzia lopesi*-*Mesocoelium monas* ($\chi^2 = 5.58$; $p = 0.018$). No pair of species showed significant positive covariation between their abundances.

Discussion

In the present report, nematodes represented 81.3% of the total species in the component community of *B. ictericus*. The composition of the majority of parasite communities of bufonid amphibians shows a higher number of nematode species (Goldberg and Bursey 1991a, b, 1992; Goldberg *et al.* 1995a, b; Galicia-Guerrero *et al.* 2000; Bolek and Coggins 2000, 2003; Iannaccone 2003a; Ragoo and Omah-Maharaj 2003) than trematodes as observed for several ranid hosts (McAlpine 1997, Gilliland and Muzzall 1999, Bolek and Coggins 2000, Muzzall *et al.* 2001, Paredes-Calderón *et al.* 2004). Terrestrial toads predominantly feed on ants, beetles and other terrestrial invertebrates, therefore preventing them from becoming infected with a high species richness of trematodes which commonly infect aquatic amphibians such as ranids. *M. monas* is an exception in this case because it is a trematode that uses terrestrial gastropods as the first and second intermediate host (Wong and Bundy 1985), but again it makes the point that these amphibians feed on terrestrial invertebrates (Brandt 1936, Campbell 1968, Bolek and Coggins 2003).

Some species of ticks are considered to play an important role in regulating the population density of toads (Oba and Schumaker 1983, Lampo and Bayliss 1996). The majority of bufonids have terrestrial habitats (Duellman and Trueb 1986) and some, as *B. ictericus*, are species with a high level of aggregation (Izecksohn and Carvalho-Silva 2001); this characteristic would favor high levels of tick infestations (Santos *et al.* 2002). Lampo and Bayliss (1996) analyzed distribution patterns of *Amblyomma* species on *Bufo marinus* from Venezuela and Brazil, showing that aggregation levels of ticks decrease with the mean intensity of infection and higher prevalence and intensity of infection on male hosts. Nevertheless, in the present paper, the infection by *A. rotundatum* on *B. ictericus* showed higher values of prevalence and abundance,

and showed no correlation with the sex of the hosts. As stated by Lampo and Bayliss (1996) this situation might be attributed to differences in susceptibility and life-history parameters among *Bufo* species.

In the present paper a correlation between parasite prevalence and abundance with host weight (body mass) was not observed. This pattern is the opposite of that in other amphibian species (Bolek and Coggins 2000, 2001, 2003; Iannacone 2003a, b). An increase of parasite species richness, prevalence and abundance could be expected in the largest host specimens that present a larger surface area and ingest a more diverse diet. The absence of this pattern for *B. ictericus* has no clear explanations, but might be related with possible ontogenetic changes in the feeding behavior or other unknown aspects of the biology of *B. ictericus*.

In a general way, parasite abundance and prevalence were not affected by host sex, however, the abundance of the digenean *M. monas* differed between male and female hosts. Host sex is not considered to be important in structuring parasite communities (Poulin 2001), and this is applicable to anurans (Yoder and Coggins 1996; Joy and Bunten 1997; McAlpine 1997; Goldberg *et al.* 2002; Iannacone 2003a, b). Differences in the parasite prevalence and intensity of *M. monas* between female and male host specimens might be the result of ecological or behavioral differences between male and female toads (Gilliland and Muzzall 1999), nevertheless, these differences are still unrecorded for *B. ictericus*.

One theoretical framework which influenced much of the research on parasite community ecology, including several studies, is the interactive versus isolationist classification of parasite communities, now viewed as extremes of a continuum rather than a dichotomy. The interactive-versus-isolationist view of parasite communities remains the only conceptual template available to interpret the huge variability observed in natural assemblages of parasites (Poulin and Luque 2003). Barton (1999) mentioned various factors to explain the depauperate parasite fauna typical of amphibians, including a generalized opportunistic diet, simple intestinal system, low vagility and ectothermic metabolism. Bufonid amphibians are terrestrial species restricted to the ground, congregating in large groups within day shelters and are generally active for a large part of the year. In the present paper, the parasite community of *B. ictericus* is dominated by nematodes but has no core species and evidence of interspecific interactions (only one pair of associated species), confirming its proximity to the isolationist extremity of the continuum, typical of amphibian and reptile parasite communities (Aho 1990).

Compared with the helminth communities of other *Bufo* species from America, *B. ictericus* showed a higher species richness at the component community level (see Table III). Although parasite communities of amphibians from Neotropical areas like South America have been scarcely documented, the present study showed that at least in species richness of helminths in bufonids, this region has the highest num-

Table III. Helminth species richness at component community level of some species of *Bufo* from North and South America

Host	N	Species richness	Nematode species richness	Locality	Reference
<i>Bufo alvarius</i>	95	6	4	Arizona, U.S.A.	Goldberg and Bursey (1991a)
<i>Bufo americanus</i>	47	6	3	Wisconsin, U.S.A.	Bolek and Coggins (2000)
<i>Bufo americanus</i>	30	9	5	Wisconsin, U.S.A.	Bolek and Coggins (2003)
<i>Bufo boreas</i>	255	5	3	California, U.S.A.	Koller and Gaudin (1977)
<i>Bufo cognatus</i>	21	5	4	Arizona, U.S.A.	Goldberg and Bursey (1991a)
<i>Bufo cognatus</i>	36	4	3	New Mexico, U.S.A.	Goldberg <i>et al.</i> (1995a)
<i>Bufo debilis</i>	49	5	4	New Mexico, U.S.A.	Goldberg <i>et al.</i> (1995a)
<i>Bufo debilis</i>	27	2	1	Texas U.S.A.	McAllister <i>et al.</i> (1989)
<i>Bufo fowleri</i>	62	13	5	North Carolina, U.S.A.	Brandt (1936)
<i>Bufo fowleri</i>	29	11	7	Virginia, U.S.A.	Campbell (1968)
<i>Bufo hemiophrys</i>	40	4	3	Alberta, Canada	Bursey and Goldberg (1998)
<i>Bufo houstonensis</i>	17	6	4	Texas, U.S.A.	Thomas <i>et al.</i> (1984)
<i>Bufo ictericus</i>	32	15	13	Rio de Janeiro, Brazil	Present paper
<i>Bufo marinus</i>	167	5	3	Bermuda	Linzey <i>et al.</i> (1998)
<i>Bufo marinus</i>	49	5	4	Jalisco, Mexico	Galicia-Guerrero <i>et al.</i> (2000)
<i>Bufo marinus</i>	59	6	3	Trinidad and Tobago	Ragoo and Omah-Maharaj (2003)
<i>Bufo marmoratus</i>	19	4	3	Jalisco, Mexico	Galicia-Guerrero <i>et al.</i> (2000)
<i>Bufo marmoratus</i>	77	7	5	Arizona, U.S.A.	Goldberg <i>et al.</i> (1996)
<i>Bufo punctatus</i>	21	3	2	Arizona, U.S.A.	Goldberg and Bursey (1991b)
<i>Bufo quercicus</i>	35	5	4	Florida, U.S.A.	Goldberg and Bursey (1996)
<i>Bufo typhonius</i> *	27	7	6	Cuzco, Peru	Bursey <i>et al.</i> (2001)
<i>Bufo valiceps</i>	23	2	1	Texas, U.S.A.	McAllister <i>et al.</i> (1989)
<i>Bufo woodhousii</i>	20	2	0	Texas, U.S.A.	McAllister <i>et al.</i> (1989)
<i>Bufo woodhousii</i>	61	6	4	Arizona, U.S.A.	Goldberg <i>et al.</i> (1996)

*Only intestinal parasites.

ber of species reported from any toad. In a general way, this might be attributed to possible differences in the local availability of helminth species and aggregation of host populations, nevertheless, additional parasitological surveys of amphibians from the Neotropical region will be necessary to confirm this.

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