

## HELMINTH PARASITES OF SEVEN ANURAN SPECIES FROM NORTHWESTERN MEXICO

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**ABSTRACT.**—One hundred eighty-three specimens representing 7 anuran species were examined for helminth parasites: *Bufo kelloggi*, *B. mazatlanensis*, *Leptodactylus melanonotus*, *Pachymedusa dacnicolor*, *Rana forreri*, *R. magnaocularis*, *Smilisca baudini*. The following species were found: 8 species of Trematoda, *Cephalogonimus americanus*, *Clinostomum attenuatum* (larva), *Glythelminis poncedeleoni*, *G. quieta*, *Gorgoderina attenuata*, *Haematoloechus complexus*, *H. longiplexus*, and *Megalodiscus temperatus*; 2 species of Cestoda, *Cylindrotaenia americana* and *Nematotaenia dispar*; 13 species of Nematoda, *Aplectana incerta*, *A. itzocanensis*, *Cosmocerca podicipinus*, *Cosmocercella haberi*, *Cosmocercoides variabilis*, *Foleyellides striatus*, *Oswaldocruzia pipiens*, *Rhabdias americanus*, *R. ranae*, *Subulascaris falcaustriformis*, *Physaloptera* sp. (larva), *Phyocephalus* sp. (larva), and *Spiroxys* sp. (larva); and 1 species of Acanthocephala (cystacanth). Helminth species richness was  $6.4 \pm 2.4$  s. Thirty-five new host records are reported.

**Key words:** *Anura*, *helminths*, *Trematoda*, *Cestoda*, *Nematoda*, *Acanthocephala*, *Bufo kelloggi*, *Bufo mazatlanensis*, *Leptodactylus melanonotus*, *Pachymedusa dacnicolor*, *Rana forreri*, *Rana magnaocularis*, *Smilisca baudini*, *Mexico*.

Although some 198 anuran species occur in Mexico (Flores-Villela 1993), reports of helminth parasite infections exist for only 13 species: *Bufo marinus* Linnaeus, 1758, *B. marmoratus* Wiegmann, 1833, *B. valliceps* Wiegmann, 1833, *Leptodactylus melanonotus* (Hallowell, 1861), *Rana berlandieri* Baird, 1854, *R. dunni* Zweifel, 1957, *R. forreri* Boulenger, 1883, *R. trilobata* (Mocquard, 1899) = *R. megapoda* Taylor, 1942, *R. montezumae* Baird, 1854, *R. neovolcanica* Hillis and Frost, 1985, *R. vaillanti* Brocchi, 1877, *Spea multiplicata* (Cope, 1863) = *Scaphiopus multiplicatus* (Cope, 1863), and *Smilisca baudini* (Duméril and Bibron, 1841) (Baker 1987, Pérez-Ponce de León et al. 2000). The purpose of this paper is to report for the first time helminths harbored by 4 anuran species: *Bufo kelloggi* Taylor, 1938, *B. mazatlanensis* Taylor, 1940, *Pachymedusa dacnicolor* (Cope, 1864), and *Rana magnaocularis* Frost and Bagnara, 1976. Additional helminth records for *Leptodactylus melanonotus*, *Rana forreri*, and *Smilisca baudini* are also reported. Four of these anurans are endemic to Mexico (Flores-Villela 1993): *Bufo kelloggi*, north central Sonora through Sinaloa to Nayarit; *B. mazatlanensis*, northern Sonora to Colima; *Rana magnaocularis*, east central Sonora through Sinaloa and Nayarit to central

Jalisco; *Pachymedusa dacnicolor*, southern Sonora to the Isthmus of Tehuantepec. Three have Neotropical distribution: *Leptodactylus melanonotus*, Sonora through Central America to central Ecuador; *Rana forreri*, southern Sonora along the Pacific coast to northwestern Costa Rica; *Smilisca baudini*, southern Texas (USA) and southern Sonora to Costa Rica (Frost 1985).

### MATERIALS AND METHODS

One hundred eighty-three specimens collected 1959–1987 from the herpetological collections at the University of Arizona (UAZ) or Arizona State University (ASU) were examined. Number and mean snout-vent length (SVL) in mm for each species examined are given in Table 1. Museum accession numbers are listed in Appendix 1. With the exception of *Rana forreri* and 8 specimens of *R. magnaocularis* from Sinaloa, the anurans examined were from the Mexican state of Sonora (Fig. 1). All anurans were from region 2, “tierra seca extra-tropical” of Flores-Villela (1993).

All specimens were originally fixed in 10% formalin and stored in 70% alcohol. The body cavity was opened by a longitudinal incision from vent to throat, and the gastrointestinal

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TABLE 1. Number, mean snout-vent length (SVL) and range in mm, comparison of SVL (Kruskal-Wallis test), number infected, and comparison of infection rate between female and male specimens (chi-square test) for 7 anuran species from northwestern Mexico.

Anuran species	N	SVL, range	Kruskal-Wallis test	Number infected (%)	Chi-square test
<i>Bufo kelloggi</i>	female, 14 male, 15	38.9 ± 5.2, 30–41 33.6 ± 2.9, 32–49	8.96, $P < 0.001$	8 (57) 10 (66)	0.27, $P > 0.05$
<i>Bufo mazatlanensis</i>	female, 6 male, 14	67.7 ± 8.0, 59–80 59.8 ± 5.1, 50–68	4.95, $P < 0.05$	6 (100) 14 (100)	0
<i>Leptodactylus melanonotus</i>	female, 10 male, 20	34.3 ± 5.5, 24–42 31.6 ± 3.3, 27–39	2.72, $P > 0.05$	10 (100) 20 (100)	0
<i>Pachymedusa dacnicolor</i>	female, 11 male, 13	77.4 ± 11.2, 57–92 65.7 ± 2.9, 61–70	7.57, $P < 0.001$	9 (82) 9 (69)	0.50, $P > 0.05$
<i>Rana forreri</i>	female, 22 male, 17	101.1 ± 17.7, 72–130 88.5 ± 11.1, 73–114	5.79, $P < 0.05$	19 (86) 10 (59)	3.81, $P > 0.05$
<i>Rana magnaocularis</i>	female, 13 male, 13	65.0 ± 7.8, 44–78 51.3 ± 7.3, 40–67	11.28, $P < 0.001$	13 (100) 12 (92)	1.04, $P > 0.05$
<i>Smilisca baudini</i>	female, 5 male, 14	69.8 ± 7.7, 59–80 59.1 ± 3.5, 50–65	6.24, $P < 0.05$	3 (40) 9 (64)	0.02, $P > 0.05$

tract was removed by cutting across the esophagus and rectum. The lungs, esophagus, stomach, small intestine, large intestine, body cavity, liver, and urinary bladder of each specimen were examined separately. Each helminth was removed and placed on a microscope slide in a drop of undiluted glycerol, a coverslip added, and the slide set aside until the helminth became transparent. Nematodes and acanthocephalans were identified from these slides. Trematodes and cestodes were stained with hematoxylin and mounted in balsam for further examination. Voucher helminths were deposited in the United States National Parasite Collection (USNPC; Appendix 2).

## RESULTS

We found the following species: 8 species of Trematoda, *Cephalogonimus americanus* Stafford, 1902, *Clinostomum attenuatum* Cort, 1913 (larvae in cysts), *Glypthelmins poncedeleoni* Razo-Mendivil and León-Règagnon, 2001, *G. quieta* (Stafford, 1900), *Gorgoderina attenuata* (Stafford, 1902), *Haematoloechus complexus* (Seely, 1906), *H. longiplexus* Stafford, 1902, *Megalodiscus temperatus* (Stafford, 1905); 2 species of Cestoda, *Cylindrotaenia americana* Jewell, 1916 and *Nematotaenia dispar* (Goeze, 1782); 13 species of Nematoda, *Aplec-*

*tana incerta* Caballero, 1949, *A. itzocanensis* Bravo-Hollis, 1943, *Cosmocerca podicipinus* Baker and Vaucher, 1984, *Cosmocercella haberi* Steiner, 1924, *Cosmocercoides variabilis* (Harwood, 1930), *Foleyellides striatus* (Ochoterena and Caballero, 1932), *Oswaldocruzia pipiens* Walton, 1929, *Rhabdias americanus* Baker, 1978, *R. ranae* Walton, 1929, *Subulascaris falcaustriformis* Freitas and Dobbin, 1957, *Physaloptera* sp. (larvae), *Physocephalus* sp. (larvae in cysts), and *Spiroxyis* sp. (larvae in cysts); and 1 species of Acanthocephala (cystacanth larva in cyst). Although in all anuran species except *Leptodactylus melanonotus* the SVL of female specimens was significantly greater than in male specimens, there was no difference in the infection rate between female and male hosts (Table 1). Because there was no difference in infection rates between female and male individuals of a host species, data for male and female individuals were combined. Mean helminth species richness (summation of number of helminth species per particular host species divided by number of host species) was  $6.4 \pm 2.4$  s (range 4–10; Table 2). Prevalence (number of hosts infected by a helminth species divided by the total number of hosts examined and expressed as a percentage), mean intensity (number of individuals of a parasite species in a host species

TABLE 2. Prevalence (P), mean intensity  $\pm s$  (I  $\pm s$ ) and site of infection for helminths from 7 anuran species from northwestern Mexico.

Helminth Site of infection	<i>Bufo kellyi</i>		<i>Bufo mazatlanensis</i>		<i>Leptodactylus melanotus</i>		<i>Pachymedusa daenicolor</i>		<i>Rana forreri</i>		<i>Rana magnaocularis</i>		<i>Smilisca baudini</i>	
	P	I $\pm s$	P	I $\pm s$	P	I $\pm s$	P	I $\pm s$	P	I $\pm s$	P	I $\pm s$	P	I $\pm s$
TREMATODA														
<i>Cephalogonimus americanus</i> small intestine	—	—	—	—	—	—	—	—	*23	8.4 $\pm$ 12.5	—	—	—	—
<i>Clonostomum attenuatum</i> cysts in muscle, skin	—	—	—	—	—	—	—	—	*31	34.3 $\pm$ 46.2	—	—	—	—
<i>Glyphthalmus poncedeleoni</i> small, large intestines	—	—	—	—	7	6.0 $\pm$ 7.1	—	—	—	—	—	—	—	—
<i>Glyphthalmus quieta</i> small intestine	—	—	—	—	—	—	—	—	—	—	*12	8.7 $\pm$ 10.7	—	—
<i>Gorgoderina attenuata</i> urinary bladder	—	—	—	—	*3	2	—	—	—	—	—	—	—	—
<i>Haematoloechus complexus</i> lung	—	—	—	—	—	—	—	—	—	—	*4	2	—	—
<i>Haematoloechus longiplexus</i> lung	—	—	—	—	*3	2	—	—	—	—	—	—	—	—
<i>Megalodiscus temperatus</i> large intestine	—	—	—	—	*3	2	—	*13	3.7 $\pm$ 2.1	*31	1.7 $\pm$ 0.9	—	—	—
CESTODA														
<i>Cylindrotaenia americana</i> small intestine	*3	1	—	—	*7	4.5 $\pm$ 0.7	—	—	—	—	—	—	—	—
<i>Nematotaenia dispar</i> small intestine	—	—	*40	3.5 $\pm$ 1.7	—	—	—	—	—	—	—	—	—	—
NEMATODA														
<i>Aplectana incerta</i> small, large intestines	—	—	*90	342 $\pm$ 197	—	—	—	—	—	—	—	—	*5	53
<i>Aplectana itzacensis</i> small, large intestines	*34	7.4 $\pm$ 9.8	*25	59.6 $\pm$ 46.8	*7	2	*42	11.6 $\pm$ 22.8	—	—	*8	3.0 $\pm$ 1.4	*58	26.8 $\pm$ 23.9

<i>Cosmoecera podicipinus</i>	—	—	*97	7.6 ± 6.5	—	—	*13	2.0 ± 1.2	—	—
small, large intestines	—	—	—	—	—	—	—	—	—	—
<i>Cosmoecercella haberi</i>	—	—	—	—	*54	287 ± 381	—	—	—	—
small, large intestines	—	—	—	—	—	—	—	—	*15	1
<i>Cosmoecercoides variabilis</i>	—	—	—	—	—	—	—	—	—	—
large intestine	—	—	—	—	—	—	*8	1.0 ± 0.0	*4	1
<i>Foleyellides striatus</i>	—	—	—	—	—	—	—	—	—	—
under peritoneum	—	—	—	—	—	—	—	—	—	—
<i>Oscaldocruzia pipiens</i>	—	*5	1	*17	3.4 ± 3.7	—	—	—	*15	2.0 ± 0.8
stomach, small intestine	—	*5	2	—	—	—	—	—	—	—
<i>Rhabdias americanus</i>	*34	10.0 ± 18.7	—	—	—	—	—	—	—	*11
lungs	—	—	—	*7	2	—	—	—	*85	9.7 ± 11.7
<i>Rhabdias ranae</i>	—	—	—	—	—	—	—	—	*8	2.5 ± 0.7
lungs	—	—	—	—	—	—	—	—	—	—
<i>Subulascaris falcaustriformis</i>	—	—	—	—	—	—	—	—	—	—
small intestine	3	1	35	3.0 ± 1.7	—	—	15	35.2 ± 72.6	8	5.5 ± 6.4
<i>Physaloptera</i> sp. (larva)	—	—	40	9.6 ± 17.1	—	—	—	—	—	—
stomach	—	—	—	—	—	—	—	—	—	—
<i>Physocephalus</i> sp. (larva)	—	—	—	—	—	—	—	—	—	—
cysts in peritoneum	—	—	—	—	—	—	—	—	—	—
<i>Spiroxys</i> sp. (larva)	—	—	—	—	—	—	—	—	—	—
cysts in peritoneum	—	—	23	2.6 ± 1.9	—	—	—	—	—	—
ACANTHOCEPHALA	—	—	—	—	—	—	—	—	—	—
oligacanthorhynchid cystacanth	—	—	—	—	—	—	4	1	—	—
cyst in peritoneum	—	—	—	—	—	—	—	—	—	—

\*New host record

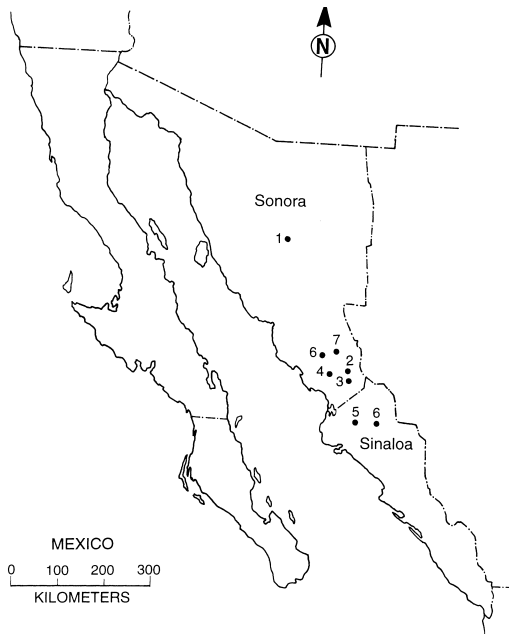


Fig. 1. Approximate collection areas for 7 anuran species from northwestern Mexico: 1 = *Bufo kelloggi*, 2 = *B. mazatlanensis*, 3 = *Leptodactylus melanonotus*, 4 = *Pachymedusa dacnicolor*, 5 = *Rana forreri*, 6 = *R. magnaocularis*, 7 = *Smilisca baudini*.

divided by the number of infected hosts), range, and site of infection are given in Table 2. Thirty-five new host records are reported (Table 2).

#### DISCUSSION

Pérez-Ponce de León et al. (2000) have recently reviewed digenean fauna of some selected amphibians of central Mexico. They distinguished 3 categories: helminths of anurans that have Nearctic or Neotropical distributions and helminths of anurans endemic to Mexico. Of the trematode species found in this study, all have been previously reported from Mexico. All have Nearctic distributions with the exception of *Glypthelmins ponce-deleoni*, currently known only from Mexico (Razo-Mendivil and León-Règagnon 2001) and considered a Mexican endemic by Pérez-Ponce de León et al. (2000). All of these trematodes are generalists with the exception of *Clinostomum attenuatum*, a bird parasite (bitterns) that utilizes frogs as transport hosts (Schell 1985). *Cephalogonimus americanus* has

been reported from bufonids, ranids, and salamanders; *Glypthelmins quieta* from bufonids, hylids, and ranids; *Gorgoderina attenuata* from bufonids, ranids, and salamanders; *Haematoloechus complexus* from ranids; *H. longiplexus* from bufonids and ranids; *Megalodiscus temperatus* from bufonids, hylids, ranids, and salamanders (Prudhoe and Bray 1982, Pérez-Ponce de León et al. 2000). *Clinostomum attenuatum* and *Megalodiscus temperatus* are additions to the list provided by Pérez-Ponce de León et al. (2000). Etges (1991) reported that *Bufo marinus* from northern Mexico (precise location not given) harbor *Clinostomum attenuatum*. This is the 2nd report of *C. attenuatum* from Mexico. *Megalodiscus temperatus* was originally reported as *M. montezumae* Travassos, 1934 from *Rana montezumae* collected in the state of Mexico (Bravo-Hollis 1941). Additional information on the life history of digenean trematodes of Mexican amphibians is in Pérez-Ponce de León et al. (2000).

The cestode species found in this study cannot be placed in the categories constructed above. *Nematotaenia dispar* is a variable species with a broad geographical range extending to all but the Australian and Ethiopian biogeographical realms (Jones 1987). Host records suggest that *N. dispar* is primarily a parasite of bufonids, but hylids, ranids, salamanders, and a varanid lizard have also been reported as hosts (Jones 1987). *Cylindrotaenia americana* is restricted to the Western Hemisphere, where it is a parasite of bufonids, ranids, hylids, and leptodactylids (Jones 1987). This is the 1st report of *C. americana* from Mexico. *Nematotaenia dispar* and *C. americana* are members of the Nematotaeniidae, which are considered by Joyeux (1927) to have direct life cycles, that is, without intermediate hosts. Infection of a new host occurs through ingestion of cestode eggs. Reports of cestodes in Mexican anurans are given in Table 3.

The nematode species represented by mature individuals found in this study can be placed in the categories of Pérez-Ponce de León et al. (2000). The Nearctic species include *Aplectana incerta*, *A. itzacanensis*, *Cosmocercella haberi*, *Cosmocercoides variabilis*, *Oswaldocruzia pipiens*, *Rhabdias americanus*, and *R. ranae*. Neotropical species include *Cosmocerca podicipinus* and *Subulacaris falcaustriformis*. *Foleyellides striatus* is

TABLE 3. Cestoda and Nematoda of species of Mexican anurans.

Helminth	Locality (State)	Reference
CESTODA		
<i>Cylindrotaenia americana</i> Jewell, 1916		
<i>Leptodactylus melanonotus</i>	Sonora	this study
<i>Nematotaenia dispar</i> (Goeze, 1782) Lühe, 1899		
<i>Bufo marinus</i>	Nuevo León	Martínez 1969
<i>Bufo mazatlanensis</i>	Sonora	this study
<i>Ophiotaenia magna</i> Hannum, 1925		
<i>Rana tarahumarae</i>	Sonora	Bursey and Goldberg 2001
NEMATODA		
<i>Aplectana incerta</i> Caballero, 1949		
<i>Bufo marinus</i>	Puebla	Bravo-Hollis 1943
	Chiapas	Caballero 1949, 1954
<i>Bufo marmoratus</i>	Jalisco	Galicia-Guerrero et al. 2000
<i>Bufo mazatlanensis</i>	Sonora	this study
<i>Smilisca baudini</i>	Sonora	this study
<i>Aplectana itzocanensis</i> Bravo-Hollis, 1943		
= <i>Aplectana hoffmani</i> Bravo-Hollis, 1943		
<i>Bufo kelloggi</i>	Sonora	this study
<i>Bufo marinus</i>	Veracruz	Caballero Deloya 1974
<i>Bufo mazatlanensis</i>	Sonora	this study
<i>Leptodactylus melanonotus</i>	Sonora	this study
<i>Pachymedusa dacnicolor</i>	Sonora	this study
<i>Rana magnaocularis</i>	Sonora	this study
<i>Spea multiplicata</i>	Puebla	Bravo-Hollis 1943
<i>Smilisca baudini</i>	Sonora	this study
<i>Aplectana</i> sp.		
<i>Bufo marinus</i>	Veracruz	Guillén-Hernández 1992
<i>Cosmocerca podicipinus</i> Baker and Vaucher, 1984		
<i>Leptodactylus melanonotus</i>	Sonora	this study
<i>Rana forreri</i>	Sinaloa	this study
<i>Cosmocerca</i> sp.		
<i>Bufo marinus</i>	Veracruz	Guillén-Hernández 1992
<i>Cosmocercella haberi</i> Steiner, 1924		
<i>Pachymedusa dacnicolor</i>	Sonora	this study
<i>Cosmocercoides variabilis</i> (Harwood, 1930) Travassos, 1931		
<i>Rana magnaocularis</i>	Sonora	this study
<i>Cruzia morleyi</i> (Pearse, 1936) Chabaud, 1978		
<i>Bufo marinus</i>	Yucatan	Pearse 1936
	Veracruz	Caballero Deloya 1974
<i>Falcaustra caballeroi</i> Chabaud and Golvan, 1957		
= <i>Dibulgiber longispiculis</i> Caballero, 1935		
<i>Rana montezumae</i>	Mexico	Caballero 1935
<i>Falcaustra inglisi</i> (Anderson, 1964) Baker, 1980		
<i>Rana tarahumarae</i>	Sonora	Bursey and Goldberg 2001
<i>Falcaustra lowei</i> Bursey and Goldberg, 2001		
<i>Rana tarahumarae</i>	Sonora	Bursey and Goldberg 2001
<i>Foleyellides striatus</i> Caballero, 1935		
= <i>Chandlerella striata</i> Ochoterena and Caballero, 1932		
<i>Rana forreri</i>	Sinaloa	this study
<i>Rana magnaocularis</i>	Sonora	this study
<i>Rana montezumae</i>	Mexico	Caballero 1935
<i>Rana tarahumarae</i>	Sonora	Bursey and Goldberg 2001
<i>Ochoterenella caballeroi</i> Esslinger, 1987		
<i>Bufo marinus</i>	Chiapas	Esslinger 1987
<i>Ochoterenella chiapensis</i> Esslinger, 1988		
<i>Bufo marinus</i>	Chiapas	Esslinger 1988a
<i>Ochoterenella digiticauda</i> Caballero, 1944		
<i>Bufo marinus</i>	Oaxaca	Caballero 1944
	Chiapas	Caballero 1948
	Chiapas	Esslinger 1986
	Jalisco	Galicia-Guerrero et al. 2000

TABLE 3. Continued.

Helminth	Locality (State)	Reference
NEMATODA (continued)		
<i>Ochoterenella figueroai</i> Esslinger, 1988		
<i>Bufo marinus</i>	Chiapas	Esslinger 1988b
<i>Ochoterenella lamothei</i> Esslinger, 1988		
<i>Bufo marinus</i>	Chiapas	Esslinger 1988b
<i>Ochoterenella nanolarvata</i> Esslinger, 1987		
<i>Bufo marinus</i>	Chiapas	Esslinger 1987
<i>Ochoterenella</i> sp.		
<i>Bufo marinus</i>	Veracruz	Guillén-Hernández 1992
<i>Oswaldocruzia pipiens</i> Walton, 1929		
<i>Bufo marinus</i>	Nuevo León	Martínez 1969
<i>Bufo mazatlanensis</i>	Sonora	this paper
<i>Leptodactylus melanonotus</i>	Sonora	this paper
<i>Rana magnaocularis</i>	Sonora	this paper
<i>Rana tarahumarae</i>	Sonora	Bursey and Goldberg 2001
<i>Oswaldocruzia subauricularis</i> (Rudolphi, 1819) Travassos, 1917		
<i>Bufo marinus</i>	Chiapas	Caballero 1949, 1954
<i>Oswaldocruzia</i> sp.		
<i>Bufo marinus</i>	Veracruz	Guillén-Hernández 1992
<i>Physaloptera</i> sp. (larva)		
<i>Bufo kelloggi</i>	Sonora	this study
<i>Bufo marinus</i>	Jalisco	Galicia-Guerrero et al. 2000
<i>Bufo mazatlanensis</i>	Sonora	this study
<i>Pachymedusa dacnicolor</i>	Sonora	this study
<i>Rana forreri</i>	Sinaloa	this study
<i>Rana magnaocularis</i>	Sonora	this study
<i>Rana tarahumarae</i>	Sonora	Bursey and Goldberg 2001
<i>Smilisca baudini</i>	Sonora	this study
<i>Physocephalus</i> sp. (larva)		
<i>Bufo marinus</i>	Jalisco	Galicia-Guerrero et al. 2000
<i>Bufo mazatlanensis</i>	Sonora	this study
<i>Rhabdias americanus</i> Baker, 1978		
<i>Bufo kelloggi</i>	Sonora	this paper
<i>Bufo mazatlanensis</i>	Sonora	this paper
<i>Smilisca baudini</i>	Sonora	this paper
<i>Rhabdias fuelleborni</i> Travassos, 1926		
<i>Bufo marinus</i>	Jalisco	Galicia-Guerrero et al. 2000
<i>Bufo marmoreus</i>	Jalisco	Galicia-Guerrero et al. 2000
<i>Rhabdias ranae</i> Walton, 1929		
<i>Leptodactylus melanonotus</i>	Sonora	this study
<i>Rana magnaocularis</i>	Sonora	this study
<i>Rana tarahumarae</i>	Sonora	Bursey and Goldberg 2001
<i>Rhabdias sphaerocephala</i> Goodey, 1924*		
<i>Bufo marinus</i>	Veracruz	Bravo-Hollis and Caballero 1940
	Chiapas	Caballero 1949, 1954
	Nuevo León	Martínez 1969
	Veracruz	Caballero Deloya 1974
	Veracruz	Guillén-Hernández 1992
<i>Spiroxys corti</i> Caballero, 1935		
<i>Rana montezumae</i>	Mexico	Caballero 1935
<i>Spiroxys</i> sp. (larva)		
<i>Leptodactylus melanonotus</i>	Sonora	this study
<i>Subulascaris falcaustriformis</i> Freitas and Dobbin, 1957		
<i>Rana magnaocularis</i>	Sonora	this study
<i>Rana tarahumarae</i>	Sonora	Bursey and Goldberg 2001

\*Considered to be a Palearctic species only (Baker 1987).

endemic to Mexico. Previous records of these nematodes from Mexican anurans are given in Table 3.

The above nematodes are generalists: *Aplectana incerta* is a common parasite of bufonids; *A. itzacanensis* of bufonids and a pelobatid; *Cosmocercella haberi* of hylids and ranids; *Cosmocercoides variabilis* of frogs, toads, salamanders, lizards, turtles, and snakes; *Oswaldocruzia pipiens* of frogs, toads, a salamander, lizards, and turtles; *Rhabdias americanus* of bufonids; *R. ranae* of hylids and ranids (Baker 1987). *Cosmocerca podicipinus* has been reported from South American leptodactylids and *Subulascaris falcaustriformis* from a Brazilian ranid (Baker 1987). *Foleyellides striatus* is currently known only from Mexican ranids (Baker 1987). *Aplectana*, *Cosmocerca*, *Cosmocercella*, *Cosmocercoides*, *Oswaldocruzia*, and *Rhabdias* have direct life cycles; *Foleyellides* are transmitted to new hosts by haematophagous arthropods; and the life cycle of *Subulascaris* is not known (Anderson 2000).

Adults of *Physaloptera* sp. occur in the stomachs of mammals, snakes, and a few lizard species; larvae are common in amphibians and some lizard species (Anderson 2000). Adults of *Physocephalus* occur in the stomachs of swine, horses, cattle, and rabbits; infective larvae have been recovered from dung beetles and are found encapsulated in the tissues of amphibians, reptiles, birds, and mammals (Anderson 2000). Adults of *Spiroxys* sp. are common parasites of the gastric mucosa of turtles in North America; larvae are found encapsulated in the tissues of snails, fish, frogs, and newts (Anderson 2000). The life cycle is similar for species in these 3 genera: embryonated eggs are passed with the feces of the definitive host and hatch when eaten by intermediate hosts, various species of insects; infection is acquired by ingesting insects containing infective third-stage larvae (Anderson 2000). Because larvae of *Physocephalus* sp. and *Spiroxys* sp. were found in cysts and are not known to mature in anurans, the possibility of anurans as paratenic hosts must be considered. Since larvae of *Physaloptera* sp. were found in the digestive tract and do not mature in anurans, we consider them to be pseudoparasites, a by-product of diet.

Acanthocephalan cystacanths have been found in amphibians (Moore 1946), reptiles (Goldberg et al. 1998), and mammals (Radomski

et al. 1991). Elkins and Nickol (1983) and Bolette (1997) consider reptiles in these instances to be paratenic hosts. For those acanthocephalans parasitic in terrestrial animals, the intermediate hosts are usually insects (Nickol 1985); thus, their occurrence in insectivores could be anticipated. Because these larvae occur in cysts, the possibility of frogs as paratenic hosts must be considered.

Our knowledge of anuran helminths of Mexico is far too incomplete to make generalizations about distribution patterns. But, as more hosts are studied, we believe they will be shown to harbor generalist helminths and these generalists will fall into 1 of the 3 categories erected by Pérez-Ponce de León et al. (2000), i.e., Nearctic, Neotropical, endemic.

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APPENDIX 1  
ZOOLOGY MUSEUM ACCESSION NUMBERS

Anurans examined from the herpetology collections of Arizona State University (ASU) or the University of Arizona (UAZ).

*Bufo kelloggi* ( $N = 29$ ): Sonora UAZ 4457–4459, 10192, 10289, 10290, 10293–10295, 11258, 11313, 11314, 23437, 31553, 31554, 31664, 31668–31670, 31674, 31686, 32036, 32037, 32040, 32043, 32044, 42822, 45212, 47068.

*Bufo mazatlanensis* ( $N = 20$ ): Sonora ASU 6109, 6111–6113, 6115–6117, 6119–6121, 6123, 6126, 6128–6134, 6194.

*Leptodactylus melanonotus* ( $N = 30$ ): Sonora UAZ 8215, 8216, 8219, 8223, 8225, 8229, 11301, 11302, 33324, 33351, 36389, 38733, 39449, 39540, 42833, 42835, 44815, 45228–45230, 45232–45236, 45966, 50886, 50888–50890.

*Pachymedusa dacnicolor* ( $N = 24$ ): Sonora UAZ 12877, 31597, 31717, 39250, 39251, 39451, 39452, 44787, 44788, 45217, 45220, 45222, 45226, 45915, 45916, 45962, 46558, 46688, 46689, 47423, 47493, 47777, 47778, 51577.

*Rana forreri* ( $N = 39$ ): Sinaloa UAZ 49726–49758, 49760–49765.

*Rana magnaocularis* ( $N = 26$ ): Sinaloa UAZ 51035, 51037–51043; Sonora UAZ 44740, 45103, 45941, 45949, 51031–51033, 51044–51047, 51049, 51051, 51053–51056, 51058.

*Smilisca baudini* ( $N = 19$ ): Sonora UAZ 31416, 31550, 31659–31661, 31840, 31998, 32020, 39247–39249, 45214, 45242–45244, 46691, 47424, 47491, 47492.

APPENDIX 2  
PARASITOLOGY MUSEUM  
ACCESSION NUMBERS

Helminths deposited in the United States National Parasite Collection (USNPC).

*Bufo kelloggi*: *Cylindrotaenia americana* 89794; *Aplectana itzacanensis* 89795; *Rhabdias americanus* 89796; *Physaloptera* sp. (larvae) 89797.

*Bufo mazatlanensis*: *Nematotaenia dispar* 89798; *Aplectana incerta* 89799; *Aplectana itzacanensis* 89800; *Oswaldocruzia pipiens* 89801; *Rhabdias americanus* 89802; *Physaloptera* sp. (larvae) 89803; *Phyocephalus* sp. (larvae) 89804.

*Leptodactylus melanonotus*: *Glypthelmins poncedeleoni* 89805; *Gorgoderina attenuata* 89806; *Haematoloechus longiPLEXUS* 89807; *Megalodiscus temperatus* 89808; *Cylindrotaenia americana* 89809; *Aplectana itzacanensis* 89810; *Cosmocerca podicipinus* 89811; *Oswaldocruzia pipiens* 89812; *Rhabdias ranae* 89813; *Spiroxys* sp. (larvae) 89814.

*Pachymedusa dacnicolor*: *Megalodiscus temperatus* 89815; *Aplectana itzacanensis* 89816; *Cosmocercella haberi* 89817; *Physaloptera* sp. (larvae) 89818; oligacanthorhynchid acanthocephalan cystacanth 89819.

*Rana forreri*: *Cephalogonimus americanus* 90728, 90729; *Clinostomum attenuatum* 90730, 90731; *Megalodiscus temperatus* 90732, 90733; *Cosmocerca podicipinus* 90734; *Foleyellides striatus* 90735; *Physaloptera* sp. 90736;

*Rana magnaocularis*: *Glypthelmins quieta* 89820; *Haematoloechus complexus* 89821; *Aplectana itzacanensis* 89822; *Cosmocercoides variabilis* 89823; *Foleyellides striatus* 89824; *Oswaldocruzia pipiens* 89825; *Rhabdias ranae* 89826; *Subulascaris falcaustriformis* 89827; *Physaloptera* sp. (larvae) 89828.

*Smilisca baudini*: *Aplectana incerta* 89829; *Aplectana itzacanensis* 89830; *Rhabdias americanus* 89832; *Physaloptera* sp. (larvae) 89833.