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Research Note

Parasites of the African Clawed Frog, *Xenopus laevis*, in Southern California, U.S.A.

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ABSTRACT: A total of 230 feral African clawed frogs, *Xenopus laevis*, from 3 localities in southern California were examined for parasites. The following species were found: 3 species of Protozoa, *Nyctotherus* sp., *Balantidium xenopodis*, *Protoopalina xenopodus*; 2 species of Monogenea, *Protopolystoma xenopodis*, *Gyrdicotylus gallieni*; 1 species of Digenea, *Clinostomum* sp. (as metacercariae); 1 species of Cestoda, *Cephalochlamys namaquensis*; 2 species of Nematoda, *Contracaecum* sp. (as larvae), *Eustrongylides* sp. (as larvae); and 1 species of Acanthocephala, *Acanthocephalus* sp. (as cystacanth). Of these, the protozoans *P. xenopodus* and *B. xenopodis*, both monogeneans, and the cestode have an African origin. *Contracaecum* sp., *Eustrongylides* sp., and *Acanthocephalus* sp. have not been previously reported from *X. laevis*.

KEY WORDS: Protozoa, Monogenea, Digenea, Cestoda, Nematoda, Acanthocephala, survey, African clawed frog, *Xenopus laevis*, southern California.

The African clawed frog, *Xenopus laevis* (Daudin, 1802), is a pipid anuran native to sub-Saharan Africa (Tinsley et al., 1996). *Xenopus laevis* was used for pregnancy assays in humans, and beginning in the 1930s, thousands of these frogs were exported from Africa to other continents, mainly Europe and the Americas. Specimens of feral *X. laevis* were recorded in the early 1960s in U.K., Germany, and the United States (Tinsley and McCoid, 1996) and in the early 1970s in southern California, U.S.A., in Los Angeles, Orange, Riverside, San Diego, and Ventura counties (Marhdt and Knefler, 1972; St. Amant et al., 1973; McCoid and Fritts, 1980). Now the African clawed frog can be found in most ponds, rivers, and streams in southwestern California (Tinsley and McCoid, 1996).

In South Africa, *X. laevis* harbors a diverse parasite fauna, with most species unique to this host. Twenty-five genera from 7 taxonomic groups (Protozoa, Monogenea, Digenea, Cestoda, Nematoda, Hirudinea, Acari) have been reported from *X. laevis* over some 60 yr of study (see Tinsley, 1996). In contrast, little is known about the parasites of *X. laevis* outside Africa. The monogenean *Protopolystoma xenopodis* (Price, 1943) has been reported from populations of *X. laevis* in Wales, U.K., and southern California, U.S.A., and the pseudophyllidean cestode *Cephalochlamys namaquensis* (Cohn, 1906) from populations on the Isle of Wight, U.K., and southern California (Lafferty and Page, 1997; Tinsley and Jackson, 1998; Jackson and Tinsley, 2001a, b). This note presents parasites of *X. laevis* collected in southern California and compares them with those found in African populations of *X. laevis*.

A total of 230 *X. laevis* (mean snout–vent length, 61 ± 25 mm SD, range 16–90 mm) were collected in 1999–2001 from 3 localities in southern California, U.S.A.: 132 from ponds of the Rancho Jamul System (32°40′03″N; 116°51′48″W), San Diego County; 68 from ponds of the Dulzura Creek System (32°37′30″N; 116°46′34″W), San Diego County; 30 from a backwater of the Santa Ana River (33°58′00″N; 117°38′43″W), Riverside County. The frogs were trapped using Gee® minnow traps or seines, transported to San Diego State University, and killed with an overdose of MS-222. After snout–vent measurement and external examination, each frog was examined internally. The body was opened by an incision from vent to throat and the gastrointestinal tract, kidney, urinary bladder, lungs, liver, heart, gonads, and body cavity were examined separately using a dissection microscope. Helminths were collected, counted, and selected specimens fixed for light microscopy (LM) or scanning electron micros-

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Table 1. Prevalence, range, and infection sites of parasites of *Xenopus laevis* from 3 localities in southern California, U.S.A., 1999–2001.

Parasite	Prevalence (%)			Range			Infection Site*	Present in Africa
	RJS	DCS	SAR	RJS†	DCS†	SAR†		
Protozoa								
Nyctotherus sp.	100	100	100				R	Uncertain‡
Balantidium xenopodis	81	79	77				R	Yes
Protoopalina xenopodus	45	44	40				R	Yes
Monogenea								
Protopolystoma xenopodis	48	46	47	1–24	1–31	1–12	UB	Yes
Gyrdicotylus gallieni	10	18	10	1–13	1–20	1–9	M, E, S	Yes
Digenea								
Clinostomum sp.	0	72	0		1–4		LC, P, BC	Uncertain‡
Cestoda								
Cephalochlamys namaquensis	51	46	30	1–55	1–37	1–18	SI	Yes
Nematoda								
Contracaecum sp.	3	4	0	1–3	1–2		BC	No
Eustrongylides sp.	1	0	0	1–2			ST	No
Acanthocephala								
Acanthocephalus sp.	1	0	0	1			L	No

* BC, body cavity; E, esophagus; L, liver; LC, lymph cavities; M, mouth cavity; P, pericardium; R, rectum; SI, small intestine, ST, subcutaneous tissue; UB, urinary bladder.

† RJS, Rancho Jamul System ($n = 132$); DCS, Dulzura Creek System ($n = 68$); SAR, Santa Ana River ($n = 30$).

‡ Neither African nor California specimens identified beyond genus.

copy (SEM) for precise identification. Helminths for LM were fixed in 70% ethanol, AFA (alcohol, formalin, acetic acid), or 5% formalin, stained with hematoxylin, and examined using a compound microscope. Protozoans for LM were collected by pipetting from rectal contents and examined alive or fecal smears were fixed in Schaudinn's fixative and stained with iron hematoxylin. Both helminths and protozoans selected for SEM were fixed in Karnovsky's solution, processed by standard methods, and examined with a Hitachi S-2700 scanning electron microscope. Voucher frogs were deposited in the herpetology collection of the California Academy of Sciences (CAS), San Francisco, California, U.S.A. (CAS 220089-220108).

Ten species of parasites were found: 3 species of Protozoa, *Nyctotherus* sp., *Balantidium xenopodis* De Puytorac and Grain, 1965, *Protoopalina xenopodus* Metcalf, 1923; 2 species of Monogenea, *P. xenopodis*, *Gyrdicotylus gallieni* Vercammen-Grandjean, 1960; 1 species of Digenea, *Clinostomum* sp. (as metacercariae); 1 species of Cestoda, *C. namaquensis*; 2 species of Nematoda (as larvae), *Contracaecum* sp. and *Eustrongylides* sp; and 1 species of Acanthocephala, *Acanthocephalus* sp. (as cystacanth). Selected specimens were deposited in the Harold W. Manter Laboratory of Parasitology (HWML), University of Nebraska State Museum, Lincoln, Nebraska, U.S.A.: *Nyctotherus* sp., HWML 16618; *B. xenopodis*, HWML 16619; *P. xenopodus*, HWML 16620; *P. xenopodis*, HWML 16130; *G. gallieni*, HWML 16623; *Clinostomum* sp., HWML 16622, *C. namaquensis*, HWML 16132; *Contracaecum* sp., HWML 16733; *Eustrongylides* sp., HWML 16734; and *Acanthocephalus* sp., HWML 16732. Prevalence and infection sites for each parasite and ranges of infection for helminths are given in Table 1.

The protozoans *B. xenopodis* and *P. xenopodus* were previously recorded for *X. laevis* in Africa (Thurston, 1970). The morphology of *Nyctotherus* sp. from California is similar to that reported for the African specimens only identified to generic level by Thurston (1970). Further study is required to identify the species of this parasite and to determine whether our material represents the same species as the African material. Both species of monogeneans have been reported from Africa (Tinsley, 1996). In addition, *P. xenopodis* has been recorded in *Xenopus* from U.K. and the United States (Tinsley and Jackson, 1998; Jackson and Tinsley, 2001a). Metacercariae of *Clinostomum* sp. have previously been

reported from *X. laevis* in Africa (Macnae et al., 1973) as well as ranid and hylid frogs in the United States (Ingles, 1936; Goldberg et al., 1998; Goldberg and Bursey, 2001). However, it is unknown whether the same species of *Clinostomum* infects *X. laevis* in Africa and in California. *Cephalochlamys namaquensis* is the only cestode known to infect *X. laevis*. It has been reported from Africa, U.K., and United States (Thurston, 1967; Ferguson and Appleton, 1988; Tinsley, 1996; Lafferty and Page, 1997; Jackson and Tinsley, 2001b). In Africa, *Xenopus* harbors 2 camallanid, 1 capillarid, and 1 filariid species of nematode (Thurston, 1970; Wade, 1982; Jackson and Tinsley, 1995). We did not find any of these species but did find juvenile stages of 2 other species, *Contracaecum* sp. and *Eustrongylides* sp., which have not been reported in Africa. Acanthocephala is the only parasite phylum that has not been reported from *X. laevis* in Africa (see Tinsley, 1996). Our specimen was located in the liver and was assigned to *Acanthocephalus* sp. based on the structure of its trunk and proboscis.

In California, *X. laevis* harbors parasite species of African origin that apparently were carried by the frog to its new environment as well as species acquired after introduction. Introduced African species include the protozoans *B. xenopodis* and *P. xenopodus*, the monogeneans *P. xenopodis* and *G. gallieni*, and the cestode *C. namaquensis*, all species unique to *X. laevis* (see Tinsley, 1996). Neither did we find them in other frogs, i.e., *Hyla regilla*, *Hyla cadaverina*, *Rana catesbeiana*, *Bufo boreas*, or *Spea hammondi*, that we collected in the same localities as *X. laevis* (Kuperman, unpublished data) nor have they been reported in frogs of other areas of North America (Ingles, 1936; Baker, 1987; Goldberg et al., 1995; Goldberg, Bursey, Gergus et al., 1996; Goldberg, Bursey, Sullivan, et al., 1996; Goldberg et al., 1998).

African species with direct life cycles (protozoans and monogeneans) dominate the list of parasites carried to new environments. Of 13 African parasites with indirect life cycles unique to *Xenopus* (see Tinsley, 1996), only the cestode *C. namaquensis* seems to have found a suitable intermediate host, a cyclopoid copepod, that allowed its survival in California. Newly acquired parasites of *X. laevis* in California are predominantly bird parasites that use fish as an intermediate host, i.e., the nematodes *Contracaecum* sp. and *Eustrongylides* sp. and the acanthocephalan *Acanthocephalus* sp. (Yamaguti, 1961, 1963). Because *X. laevis* has a fully aquatic life history, it is perhaps more similar to fish than to semiterrestrial frogs and may serve as a paratenic host. Species of *Clinostomum* are known to use both fish and amphibians as intermediate hosts (Yamaguti, 1961; Levine, 1980).

Populations of *X. laevis* in California harbor fewer species of parasites than African populations. The number of protozoan species is reduced from 9 to 3, digeneans from 10 to 1, nematodes from 5 to 2, and parasites of Hirudinea and Acari are missing. These data are in accord with a major principle of ecological parasitology (Dogiel, 1938; Kennedy and Bush, 1994): a host species with a particular parasite fauna in its native range will lose a number of parasite species as a result of introduction to a new environment and will acquire additional non–host-specific parasites in the new habitat.

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