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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*, *Balantidium*; 2 species of Monogenea, *Protopolyctena*; 2 species of Digenea, *Clinostomum*; 3 species of Acanthocephala, *Acanthocephalus*; 2 species of Monogenea, *Contracaecum*; 2 species of Cestoda, *Protopolystoma*; 1 species of Nematoda, *Eustrongylides*; 1 species of Acanthocephala, *Acanthocephalus*. Of these, the protozoans *P. xenopus* and *B. xenopodis* have an African origin. The monogenean *Protopolyctena xenopus* (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*.

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, *Nyctotherus*, *San Diego*), with most species unique to this host. Twenty-five genera from 7 taxonomic groups (Protozoa, Monogenea, Digenea, Cestoda, *Xenopus laevis*). In contrast, little is known about the parasites of *X. laevis* outside Africa. The monogenean *Protopolyctena xenopus* (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-
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, *Protoopalinia xenopodus* Metcalf, 1923; 2 species of Monogenea, *P. xenopodis*, *Gyridicotylus gallieni* Vercammen-Grandjean, 1960; 1 species of Digenea, *Clinostomum* sp. (as metacercariae); 1 species of Cestoda, *Cephalochlamys 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. xenopodis*, HWML 16620; *P. xenopodus*, 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

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

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Prevalence (%)</th>
<th>Range</th>
<th>Infection Site*</th>
<th>Present in Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RJS</td>
<td>DCS</td>
<td>SAR</td>
<td>RJS</td>
</tr>
<tr>
<td>Protozoa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Nyctotherus</em> sp.</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>R</td>
</tr>
<tr>
<td><em>Balantidium xenopodis</em></td>
<td>81</td>
<td>79</td>
<td>77</td>
<td>R</td>
</tr>
<tr>
<td><em>Protoopalinia xenopodus</em></td>
<td>45</td>
<td>44</td>
<td>40</td>
<td>R</td>
</tr>
<tr>
<td>Monogenea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Protopolystoma xenopodis</em></td>
<td>48</td>
<td>46</td>
<td>47</td>
<td>1–24</td>
</tr>
<tr>
<td><em>Gyridicotylus gallieni</em></td>
<td>10</td>
<td>18</td>
<td>10</td>
<td>1–13</td>
</tr>
<tr>
<td>Digenea</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Clinostomum</em> sp.</td>
<td>0</td>
<td>72</td>
<td>0</td>
<td>1–4</td>
</tr>
<tr>
<td>Cestoda</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cephalochlamys namaquensis</em></td>
<td>51</td>
<td>46</td>
<td>30</td>
<td>1–55</td>
</tr>
<tr>
<td>Nematoda</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Contracaecum</em> sp.</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>1–3</td>
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<tr>
<td><em>Eustrongylides</em> sp.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1–2</td>
</tr>
<tr>
<td>Acanthocephala</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Acanthocephalus</em> sp.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

* 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.

‡ Neither African nor California specimens identified beyond genus.

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

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/C224
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 filarial 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 hammondii*, 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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