Pentastomid parasites in fish in the Olifants and Incomati River systems, South Africa

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ABSTRACT

LUUS-POWELL, WILMIEN J., JOOSTE, ANTOINETTE & JUNKER, KERSTIN. 2008. Pentastomid parasites in fish in the Olifants and Incomati River systems, South Africa. *Onderstepoort Journal of Veterinary Research*, 75:323–329

During parasitological field surveys of freshwater fish, sebekiid and subtriquetrid pentastome larvae were recovered from the body cavity or swim bladder of several fish species from various localities in Limpopo and Mpumalanga Provinces, South Africa. *Sebekia wedli* was recovered from the body cavity of *Marcusenius macrolepidotus* (Mormyridae) from Flag Boshielo Dam, Limpopo Province, and *Alofia* sp. and *Subtriquetra rileyi* were found in the swim bladder of *Oreochromis mossambicus* (Cichlidae) from the Phalaborwa Barrage, Limpopo Province. The latter species was also collected from the swim bladder of *O. mossambicus* in dams in the Phalaborwa region and the Ga-Selati River, Limpopo Province. A single specimen of *Sebekia okavangoensis* was present in the body cavity of *Clarias gariepinus* (Clariidae) in a dam on a sugarcane farm in the Komatipoort region, Mpumalanga Province. Pentastomid infections in the Mormyridae and Clariidae represent new host records.

Keywords: *Alofia* sp., *Clarias gariepinus*, *Marcusenius macrolepidotus*, *Oreochromis mossambicus*, Pentastomida, *Sebekia okavangoensis*, *Sebekia wedli*, South Africa, *Subtriquetra rileyi*

INTRODUCTION

The Pentastomida represent an ancient taxon, comprising some 131 species in seven families (Almeida & Christoffersen 1999). Adults of most species inhabit the nasal passageways and lungs of snakes, lizards and crocodilians, while others are found in the air sacs of gulls and terns, and in the nasopharynx and sinuses of canids and felids (Bakke 1972; Banaja, James & Riley 1975; Riley 1986). Two species, *Raillietiella bufonis* and *Raillietiella indica*, use amphibians as final hosts (Ali, Riley & Self 1982). The pentastomid life cycle usually includes a vertebrate intermediate host in which larvae undergo several moults to reach the infective stage (Riley 1986; Winch & Riley 1986a; Riley & Huchzermeyer 2000), but insects have been reported as intermediate hosts of some raillietiellid parasites, while *Reighardia sternae*, a parasite of gulls, has a direct lifecycle (Banaja *et al*. 1975; Riley 1986).

Two families of pentastomids, Sebekidae and Subtriquetridae, use various freshwater fish species as intermediate hosts (Fain 1961; Overstreet, Self & Vliet 1985; Winch & Riley 1986a, b; Junker, Boomker & Booyse 1998). The sebekiid genera, *Agema*, *Alofia*, *Leiperia* and *Selfia*, have to date only been recorded from crocodilian final hosts, but a single *Sebekia* species is also thought to mature in a che-

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Accepted for publication 22 August 2008—Editor

lonian host (Dukes, Shealy & Rogers 1971; Riley, Spratt & Winch 1990). The sebekiids *Diesingia* and *Pelonia*, on the other hand, have hitherto been reported exclusively from chelonian final hosts (Sambon 1922; Overstreet *et al*. 1985; Junker & Boomker 2002). Adults of the Subtriquetridae are known from crocodilians only (Riley *et al*. 1990).

In South Africa infective larvae of *Sebekia wedli*, *Leiperia cincinnalis* and *Subtriquetra rileyi* have been reported from the cichlids *Tilapia rendalli* (redbreast tilapia) and *Oreochromis mossambicus* (Mozambique tilapia) from the Phabeni Dam in the Kruger National Park (KNP) (Junker *et al.* 1998). Junker, Boomker & Bolton (1999) recorded the Nile crocodile, *Crocodylus niloticus*, as the definitive host of *S. wedli* and *L. cincinnalis*, as well as of *Alofia nilotici*, *Alofia simpsoni*, *Sebekia cesarisi* and *Sebekia okavangoensis* in South Africa. The final host of *S. rileyi* is as yet unknown. The pentastomid parasites included in this publication are products of a number of parasitological studies on freshwater fish from several localities in two provinces of South Africa.

MATERIALS AND METHODS

During fish health surveys, a total of 1 047 fish, belonging to 14 species were collected at nine localities in South Africa and examined for parasites (Tables 1 and 2).

Fish were captured using gill nets of stretched mesh sizes, ranging from 30–120 mm, and transported live to the field laboratory where they were kept in containers with well aerated water. Immediately before dissection, fish were killed by decapitation. Encysted larvae were removed from their cysts and placed in water to unfold. In order to prevent them from contracting, they were fixed by adding small quantities of 70 % ethanol to the water over a period of approximately 1 h, after which they were transferred to 70 % ethanol.

Pentastomids were mounted and cleared in Hoyer's medium for identification. Measurements were taken from whole mounted specimens according to the schematic layout proposed by Riley *et al*. (1990). Hook and oral cadre morphology, combined with the number of annuli, were used as identification criteria.

The ecological terms prevalence, mean intensity and abundance are used in accordance with Bush, Lafferty, Lotz & Shostak (1997). Standard deviation was not calculated, since too few specimens were collected which renders standard deviation values meaningless (Rózsa, Reiczigel & Majoros 2000).

RESULTS

Pentastomid larvae were encountered at four localities in the Olifants River drainage system in Limpopo Province (Table 2). Eight encysted infective *S. wedli* larvae were collected from the body cavity of five of 29 *Marcusenius macrolepidotus* (Mormyridae) (bulldog) in Flag Boshielo Dam, constituting a new intermediate host record for this parasite. While a single cyst was located on the swim bladder, the remainder were found between fat deposits on the mesenteries. Cysts had a yellowish colour and closely resembled those of *Clinostomum* metacercariae, although slightly smaller in size. No free-living larvae were detected in the swim bladder. The prevalence of infection was 17.2 %, with a mean intensity of 1.6 (range 1–3) and an abundance of 0.3.

Subtriquetra rileyi was free-living in the swim bladder of *O. mossambicus* from dams in the PIC region. The prevalence of infection was 6.3 %, the mean intensity 1.9 (range 1–6) and the abundance 0.1. No pentastomid larvae were recovered from sharptooth catfish, *Clarias gariepinus* (Clariidae), the only other host examined at these sites at the time (Table 2).

At the Phalaborwa Barrage, *S. rileyi*, and a total of three infective larvae of an *Alofia* sp. were recovered from *O. mossambicus*. Concurrent infections of *S. rileyi* and *Alofia* sp. occurred in two hosts, with the former moving freely in the swim bladder while the *Alofia* sp. was encapsulated. Combined, the two species had a prevalence of 30 %, a mean intensity of 2.4 (range 1–5) and an abundance of 0.7. *Clarias gariepinus* and *Labeo rosae* (Cyprinidae) examined at this site harboured no pentastomid larvae (Table 2). This is the first published record of an *Alofia* species from fish intermediate hosts in South Africa.

In the Ga-Selati River, three *S. rileyi* larvae were recovered from one *O. mossambicus* of 36 examined, resulting in a prevalence of 2.7 %, and an abundance of 0.08. Larvae were moving freely in the swim bladder. No pentastomid larvae were found in *C. gariepinus* at this site (Table 2).

With respect to the Incomati River drainage system, Mpumalanga Province, a single infective larva of *S. okavangoensis* was encysted on the mesenteries of *C. gariepinus*, from a dam on a sugarcane farm in the Komatipoort region. This is the first report of *C. gariepinus* as intermediate host of a pentastomid.

TABLE 1 Localities at which fish were collected in Limpopo and Mpumalanga Provinces, South Africa

Locality	Co-ordinates	Sampling dates	Comments
Limpopo Province: Olifants River system			
Flag Boshielo Dam	24°49′ S, 29°24′ E	Dec 1998; Nov 1999; Feb, Sept and Dec 2000	Formerly known as Arabie Dam; previously part of Mpumalanga Province
Ga-Selati River	23°92′ S, 23°92′ E	April, July, Oct 2002; Jan, April, Jul and Oct 2003; Jan 2004	–
PIC: phosphate mine	24°01′ S, 31°05′ E	April, July and Oct 2002; Jan, April, July and Oct 2003; Jan 2004; June, Oct 2005; Jan and April 2006	Part of the Phalaborwa Industrial Complex (PIC). Pentastomid data from the PIC were combined for the calculation of infection statistics
PIC: fertilizer plant	23°59′ S, 31°05′ E	June and Oct 2005; Jan and April 2006	
PIC: copper mine	24°00′ S, 31°05′ E	June and Oct 2005; Jan and April 2006	
Phalaborwa Barrage	24°04′ S, 31°08′ E	June and Oct 2005; Jan and April 2006	Water source for the PIC
Nwanedi-Luphephe Dam	22°39′ S, 30°25′ E	April and Oct 1996; March 1997; March, May and Oct 1998; March, May, July and Oct 1999; June 2001	–
Tzaneen Dam	23°48′ S, 30°10′ E	June 1997; Nov 1998; Jan, March, May, Aug, Nov and Dec 1999; Jan, April, July and Nov 2000; Feb, May and Oct 2001	–
Mpumalanga Province: Incomati River system			
Komatipoort	24°30′ S, 31°30′ E	July 2006	Sampling site was a sugar cane farm dam
Loskop Dam	25°22′ S, 29°10′ E	May 2001	–
Blyde Canyon Dam	24°32′ S, 30°48′ E	July and Nov 1999	–

TABLE 2 The prevalence of pentastomid infections in fish collected at various localities in South Africa

Drainage system	No. of infected hosts/hosts examined								
	Limpopo Province						Mpumalanga Province		
	Olifants River						Incomati River		
Fish species	**Flag Boshielo Dam**	**Ga-Selati River**	**Phalaborwa Industrial Complex**	**Phalaborwa Barrage**	**Nwanedi-Luphephe Dam**	**Tzaneen Dam**	**Komatipoort**	**Loskop Dam**	**Blyde Canyon Dam**
Alestidae									
Hydrocynus vittatus	nc	nc	nc	nc	nc	nc	0/12	nc	nc
Micralestes acutidens	nc	nc	nc	nc	0/33	nc	0/2	nc	nc
Cichlidae									
Oreochromis mossambicus	0/12	1/36	13/207	12/40	0/45	0/18	nc	0/3	nc
Tilapia rendalli	0/3	nc	nc	nc	nc	nc	nc	nc	nc
Clariidae									
Clarias gariepinus	0/5	0/19	0/45	0/20	0/15	0/3	1/4	0/3	0/2
Cyprinidae									
Barbus matozzi	0/2	nc	nc	nc	nc	nc	nc	nc	nc
Cyprinus carpio	nc	nc	nc	nc	nc	nc	nc	0/1	nc
Labeobarbus marequensis	nc	nc	nc	nc	0/21	nc	nc	0/3	nc
Labeobarbus polylepis	nc	nc	nc	nc	nc	nc	nc	nc	0/3
Labeo rosae	0/2	nc	nc	0/15	nc	nc	nc	0/3	nc
Mochokidae									
Synodontis zambezensis	0/5	nc	nc	nc	nc	nc	nc	nc	nc
Mormyridae									
Marcusenius macrolepidotus	5/29	nc	nc	nc	0/163	0/74	nc	0/4	0/8
Petrocephalus wesselsi	nc	nc	nc	nc	0/135	0/27	nc	nc	nc
Schilbeidae									
Schilbe intermedius	0/4	nc	nc	nc	0/17	0/4	nc	nc	nc

nc Not collected

DISCUSSION

The fact that *S. wedli*, *S. okavangoensis* and the *Alofia* sp. had reached the final larval stage, as evidenced by double hooks and rows of annular spines typical for infective sebekiid larvae (Winch & Riley 1986a), confirms that *M. macrolepidotus*, *C. gariepinus* and *O. mossambicus* are indeed the respective true intermediate hosts for these pentastomids. Similarly, Winch & Riley (1986a) found only the infective stage of *Sebekia* to be encysted.

Morphological characteristics of infective larvae of *S. wedli* from *M. macrolepidotus* correspond well with those recorded from *O. mossambicus* and *T. rendalli* (Junker *et al*. 1998). Ranging from 73–77, the number of annuli in infective larvae from *M. macrolepidotus* was similar to that observed in the latter hosts, namely 71–76 (Junker *et al*. 1998). Other characteristics that support the identification of *S. wedli* were the single row of chloride cell pore caps on the anterior border of the annuli and the overall appearance of the oral cadre. The latter is readily distinguished from congeneric African species by appearing open anteriorly and having a less pronounced ovoid profile (Riley & Huchzermeyer 1995).

The arrangement of the chloride cell pore caps in an irregular field at the anterior border of the annuli, about 2–3 cells deep, and the mitre-shaped appearance of the oral cadre, observed in the specimen from *C. gariepinus* confirm its identification as *S. okavangoensis* as described by Riley & Huchzermeyer (1995).

All infective *Sebekia* and *Alofia* larvae found during this study were encysted, the cysts being attached to either the swim bladder or the mesenteries. Conversely, Junker *et al*. (1998) recorded encysted as well as free-living infective *S. wedli* larvae from *T. rendalli* and *O. mossambicus*. The majority were, however, encysted and the authors speculated that free-living infective larvae had only recently moulted into this developmental stage. Junker *et al*. (1998) recovered *S. wedli* from the swim bladder only, and not from the mesenteries. They did, however, collect encysted infective larvae of another sebekiid, *L. cincinnalis* from this site in *T. rendalli* and *O. mossambicus.*

The literature suggests that sebekiids may occupy a number of sites in their intermediate hosts, and Overstreet *et al*. (1985) reported infective larvae of *Sebekia mississippiensis* under the connective tissues lining muscle, kidney, liver and swim bladder of a variety of fish intermediate hosts.

Sebekia wedli larvae appear to be host specific in Flag Boshielo Dam, as none of the other seven fish species examined at the time, including 12 *O. mossambicus* and three *T. rendalli*, harboured pentastomid larvae (Table 2). *Sebekia wedli* had a relatively high prevalence of 40.5 % in *T. rendalli* in the KNP, but only three of 119 *O. mossambicus* harboured this pentastome (Junker *et al.* 1998). Hence, it is possible that the sample size with respect to the other hosts in Flag Boshielo Dam was too small to detect infection.

Although mormyrids were studied intensively at Nwanedi-Luphephe and Tzaneen Dams, Limpopo Province, and Loskop and Blyde Canyon Dams, Mpumalanga Province (Table 2), pentastomid larvae were only recovered from *M. macrolepidotus* from Flag Boshielo Dam.

Flag Boshielo Dam has a large population of Nile crocodiles. These crocodilians have long been established as a final host of *S. wedli* (Sambon 1922), and Junker *et al*. (1999) reported this pentastomid from Nile crocodiles in South Africa. Mormyrids are bottom feeders, favouring the muddy bottomed margins of rivers and floodplains (Skelton 2001), and are thus likely to ingest pentastome eggs, which are shed in crocodile faeces, and settle onto the bottom substrate. It remains a matter of speculation as to why *S. wedli* was not observed in intermediate hosts at any of the other dams, since both Loskop and Blyde Canyon Dams, as well as Tzaneen Dam also support crocodile populations. Possibly sample sizes at all these Dams were too small to detect pentastome infections. Prevalence data on pentastomids in Nile corocodiles in any of the above dams, including Flag Boshielo, are lacking.

Clarias gariepinus constitutes an important component of the diet of Nile crocodiles (Guggisberg 1972; Whitfield & Blaber 1979), and its own feeding habits would readily expose it to ingesting pentastome eggs. Riley & Huchzermeyer (2000) noted that *Clarias* spp. were common in swamp forest pools in the northern Congo Republic and postulated that it might serve as intermediate host for the pentastomids, *Agema silvaepalustris*, *Alofia parva* and *S. okavangoensis*, that were recovered from swamp forest dwarf crocodiles, *Osteolaemus tetraspis*, in that region. However, no proof of the role of *Clarias* in the transmission of pentastomids has so far been presented. The prevalence of infection in *C. gariepinus* is low and only one of four hosts at the Komatipoort locality was infected, while a total of 112 collected at eight additional localities did not habour the parasite (Table 2). Ten *C. gariepinus* from the KNP also harboured no pentastomids (Junker, unpublished data 1996). Winch & Riley (1986b) concluded that the absence of *Subtriquetra subtriquetra* in bottom-feeding *Tilapia* spp. in Trinidad, despite its presence in *Aequidens pulcher*, another bottom-feeder in the same reservoir, was probably due to an immune response. This could also be an explanation for the low prevalence of pentastomids in *C. gariepinus*.

To date, several fish species belonging to a number of families world-wide have been recorded as intermediate hosts of sebekiids, namely *Sebekia oxycephala* in *A. pulcher* (Cichlidae) (blue acra) and *Tilapia* sp. (Cichlidae) in Trinidad and *Gambusia affinis* (Poeciliidae) (mosquitofish) in Florida (Boyce, Cardeilhac, Lane, Buergelt & King 1984; Winch & Riley 1986a). *Fundulus grandis* (Fundulidae) (gulf killifish), *Lepomis macrochirus* (Centrarchidae) (bluegill), *Micropogonias undulatus* (Sciaenidae) (Atlantic croaker), *Micropterus salmoides* (Centrarchidae) (largemouth bass) and *Xiphophorus helleri* (Poeciliidae) (swordtail) are confirmed intermediate hosts for *Sebekia mississippiensis* (*Overstreet et al.* 1985). Fain (1961) lists *Alestes macrophthalmus* (Alestidae) (torpedo robber), *Bathybates ferox* (Cichlidae), *Chrysichthys brachynema* (Claroteidae) (salmontail catfish), *Chrysichthys mabusi* (Claroteidae), *Lates microlepis* (Latidae) (forktail lates), *Lates niloticus* (Latidae) (Nile perch), *Mastacembelus* sp. (Mastacembelidae) and *Oreochromis niloticus* (= *Tilapia nilotica*) (Cichlidae) (Nile tilapia) as intermediate hosts of *L. cincinnalis* in Central Africa. The latter was also present in *Serranochromis meridianus* (Cichlidae) (Lowveld largemouth) in South Africa (Junker 2002). Few data exist on the intermediate hosts of *Subtriquetra*, which has sofar been recovered from *A. pulcher*, *O. mossambicus* and *T. rendalli* (Winch & Riley 1986b; Junker *et al.* 1998). Fain (1961) reports *S. subtriquetra* from Brazilian fish in general.

While *S. rileyi* has now been reported from intermediate fish hosts from several localities in South Africa, its final host has not been identified. According to Riley *et al*. (1990) adult subtriquetrids are exclusive to crocodilians, but adult *S. rileyi* were absent in crocodiles harbouring other pentastome infections in the KNP, suggesting the involvement of a different final host, perhaps piscivorous terrapins or birds (Junker 2002).

ACKNOWLEDGEMENTS

The Division for Research Development and Administration, University of Limpopo, is thanked for financial assistance. The research at Phalaborwa was supported by a grant from the National Research Foundation of South Africa (Thuthuka Programme; TTK2004081000029). We are grateful to the Department of Biodiversity, University of Limpopo, for infrastructure and Messrs H.E. Hattingh and J. Theron for technical assistance during some of the field surveys.

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