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Monogenean parasites from fishes of the Vaal Dam, Gauteng Province, South Africa II. New locality records

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Abstract

Baseline information on parasitic infections, including monogenean infections on wild fishes, may aid in implementation of proactive measures as opposed to reactive research aimed at crisis control with reference to future aquaculture applications. The aim of this project was to examine the freshwater monogenean fauna of the Vaal Dam, Vaal River system, South Africa. This short communication reports on infection statistics for monogenean species, some representing new locality records. Parasites were collected from host species other than *Labeo* spp. from the Vaal Dam, during a summer (January 2010) survey. Fish collected using gill nets of varying mesh sizes were weighed and measured. Mucous smears were prepared from the skin and fins with the aid of microscope slides. Fish were killed humanely by severing the spinal cord behind the head. Gills were carefully removed and divided into areas which were separately scraped to investigate potential parasite site preference. The areas examined were dorsal, median and ventral positions on both the anterior and posterior hemibranch. Both mucous smears and gill scrapings were examined with the aid of a stereo microscope. More parasites were collected from the first or second gill arches, the medial position on the gill, and the anterior hemibranch. Preference for either left or right gill set was inconclusive. Spatial distribution of parasites is thought to result from water flow over the gills during respiration. This paper reports a new locality record for the following monogenean species: *Quadriacanthus aegypticus*, *Dactylogyrus extensus*, *Dactylogyrus minitus*, *Gyrodactylus kherulensis* and *Dactylogyrus lamellatus.*

Keywords

Vaal Dam, *Quadriacanthus aegypticus*, *Dactylogyrus extensus*, *Dactylogyrus minutus*, *Dactylogurus lammelatus*, *Gyrodactylus kherulensis*

Introduction

Despite a low-level intensity of aquaculture in sub-Saharan Africa, Hecht and Endemann (1998) argue that generation of baseline data on wild fish parasites may be useful. Such information may be used to draft and implement proactive measures as opposed to reactive research aimed at crisis control. A point in case is *Labeo umbratus* (Smith, 1841), a prospective aquaculture species (Crafford *et al.* 2014). Fletcher and Whittington (1998) and Jianying *et al.* (2003), with reference to Australia and China respectively, postulated that a very large percentage of monogenean parasite species still remain undiscovered. Given that many South African freshwater host species and localities still need to be examined with specific reference to monogeneans, the situation in South Africa may be similar. Results presented here were derived from a project aimed at examining the freshwater monogenean fauna of the Vaal Dam, Vaal River system, South Africa. New species descriptions from *Labeo* spp. have been published (Crafford *et al.* 2012), while seasonal aspects (infection statistics and site preference) from the same hosts were also described (Crafford *et al.* 2014). This paper reports on infection statistics for monogenean species, with emphasis on new locality records, from host species other than *Labeo* spp. from the Vaal Dam, as recorded during a summer (January 2010) survey.

Materials and Methods

The study site was an area of the Vaal Dam (26°52.249′S, 28°10.249′E) surrounding the University of Johannesburg Island (previously RAU Island), Vaal River system, Gauteng Province, South Africa (as illustrated by Crafford *et al.* 2014).

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Table I. Data (number, gender, weight and length) on host species collected from the Vaal Dam during a summer (January 2010) survey

Host	***Clarias gariepinus* (Burchell, 1822)**				***Cyprinus carpio* Linnaeus, 1758**				***Ctenopharyngodon idella* (Valenciennes, 1844)**			
Variable	**Number**	**Average weight (g)** [SD]	**Average length (cm)** [SD]	**Average condition factor*** [SD]	**Number**	**Average weight (g)** [SD]	**Average length (cm)** [SD]	**Average condition factor*** [SD]	**Number**	**Average weight (g)** [SD]	**Average length (cm)** [SD]	**Average condition factor*** [SD]
Male	6	1266.67 [475.04]	56.67 [5.80]	0.67 [0.08]	11	450.00 [456.62]	30.31 [8.35]	1.22 [0.49]	7	450.00 [239.79]	37.27 [4.57]	0.79 [0.22]
Female	5	1100.00 [778.62]	53.18 [9.15]	0.64 [0.11]	2	100.00 [0.00]	25.50 [0.99]	0.61 [0.07]	5	780.00 [822.04]	42.18 [11.55]	0.78 [0.20]
Combined	11	1190.91 [602.42]	55.08 [7.32]	0.65 [0.09]	13	396.15 [437.06]	29.57 [7.84]	1.13 [0.50]	12	587.50 [553.14]	39.32 [8.14]	0.79 [0.20]
Host	***Labeobarbus kimberleyensis* (Gilchrist and Thompson, 1913)**				***Labeobarbus aeneus* (Burchell, 1822)**							
Male	1	950.00 [N/A]	47.60 [N/A]	0.88 [N/A]	5	470.00 [120.42]	36.66 [3.30]	0.94 [0.03]				
Female	3	841.67 [390.78]	45.67 [7.48]	0.83 [0.05]	10	492.50 [233.35]	37.35 [4.63]	0.88 [0.18]				
Combined	4	868.75 [323.63]	46.15 [6.19]	0.85 [0.04]	15	485.00 [198.16]	37.12 [4.12]	0.90 [0.14]				

* = Fulton's condition factor: $K = 100 \times W/L^3$ (calculated individually for each fish with calculated arithmetic average reflected here);
SD = Standard deviation;
Average length = Total length.

Table II. Infection statistics for monogenean parasites collected from *Clarias gariepinus* (Burchell, 1822) and *Cyprinus carpio* Linnaeus, 1758 from the Vaal Dam during January 2010

Host species		***Clarias gariepinus* (Burchell, 1822)**			***Cyprinus carpio* Linnaeus, 1758**					
Monogenean species		***Q. aegypticus***	**?***	**CC**	***D. extensus***	***D. minutus***	***Dact.* spp.**	***G. kherulensis***	**?***	**CC**
Distribution										
Total		182	24	206	39	3	4	3	2	51
Gill arch number	**1**	53	7	60	13	0	3	Not applicable: Found on skin	0	16
	2	46	10	56	5	0	1		1	7
	3	43	5	48	6	0	0		1	7
	4	30	2	32	5	0	0		0	5
	Unknown	10	0	10	10	3	0		0	13
Gill set (side of head)	**Left**	92	9	101	14	0	2		1	17
	Right	80	15	95	15	0	2		1	18
	Unknown	10	0	10	10	3	0		0	13
Gill arch region	**Dorsal**	45	6	51	5	0	0		1	6
	Medial	65	5	70	19	0	4		0	23
	Ventral	62	12	74	5	0	0		1	6
	Unknown	10	1	11	10	3	0		0	13
Gill orientation	**Anterior**	94	13	107	15	0	2		1	18
	Posterior	77	11	88	14	0	2		1	17
	Unknown	11	0	11	10	3	0		0	13
Infection levels										
Prevalence (%)		90.91	54.55	90.91	76.92	7.69	15.38	7.69	15.38	76.92
Mean intensity		18.2	4.0	20.6	3.9	3.0	2.0	3.0	1.0	5.1
Intensity range: Minimum		1.0	1.0	2.0	1.0	3.0	1.0	3.0	1.0	1.0
Intensity range: Maximum		37.0	6.0	43.0	10.0	3.0	3.0	3.0	1.0	14.0
Mean abundance		16.55	2.18	18.73	3.0	0.23	0.31	0.23	0.15	3.92

Key (species codes used)

Q. aegypticus = *Quadriacanthus aegypticus* El-Naggar and Serag, 1986

* = ? = Specimens that could not be identified to genus level (damaged/ lost during mounting)

CC = Component community

D. extensus = *Dactylogyrus extensus*

D. minutus = *Dactylogyrus minutus*

G. kherulensis = *Gyrodactylus kherulensis*

Dact. spp. = *Dactylogyrus* spp. that could not be identified to species level (damaged during mounting)

Table III. Infection statistics for monogenean parasites collected from *Ctenopharyngodon idella* (Valenciennes, 1844), *Labeobarbus kimberleyensis* (Gilchrist and Thompson, 1913) and *Labeobarbus aeneus* (Burchell, 1822) from the Vaal Dam during January 2010

Host species		***Ctenopharyngodon idella* (Valenciennes, 1844)**			***Labeobarbus kimberleyensis* (Gilchrist and Thompson, 1913)**			***Labeobarbus aeneus* (Burchell, 1822)**		
Monogenean species	***D. lamellatus***	**?***	**CC**	***P. ichthyoxanthon***	***Dact.* G**	**CC**	***P. ichthyoxanthon***	**?***	**CC**	
Distribution										
Total		73	10	83	6	3	9	60	2	62
Gill arch number	**1**	16	7	23	3	2	5	22	2	24
	2	29	3	32	1	0	1	12	0	12
	3	21	0	21	1	0	1	9	0	9
	4	7	0	7	1	1	2	17	0	17
	Unknown	36	9	45	0	0	0	0	0	0
Gill set (side of head)	**Left**	37	1	38	1	2	3	34	2	36
	Right	28	3	31	5	1	6	26	0	26
	Unknown	31	2	33	0	0	0	0	0	0
Gill arch region	**Dorsal (D)**	13	5	18	6	2	8	21	0	21
	Medial (M)	1	0	1	0	0	0	33	2	35
	Ventral (V)	51	2	53	0	1	1	6	0	6
	Unknown	22	8	30	0	0	0	0	0	0
Gill orientation	**Anterior**	16	7	23	0	3	5	0	2	2
	Posterior	29	3	32	0	0	0	0	0	0
	Unknown	21	0	21	6	0	4	60	0	60
Infection levels										
Prevalence (%)		83.33	8.33	83.33	50.0	25.0	50.0	73.3	13.3	80.00
Mean intensity		7.3	10.0	8.3	3.0	3.0	4.0	5.5	1.0	5.2
Intensity range: Minimum		1.0	10.0	1.0	3.0	3.0	3.0	1.0	1.0	1.00
Intensity range: Maximum		31.0	10.0	31.0	3.0	3.0	6.0	14.0	1.0	14.0
Mean abundance		6.08	0.83	6.92	1.5	0.0	2.3	4.0	0.1	4.1

Key (species codes used)

D. lamellatus = *Dactylogyrus lamellatus* Achmerow, 1952

* = ? = Specimens that could not be identified to genus level (damaged/lost during mounting)

CC = Component community

Dact G = Undescribed species apparently belonging to the "*Dactylogyrus varicorhini* Bychowsky, 1958 species group/type".

P. ichtyoxanthon = *Paradiplozoon ichthyoxanthon* Avenant-Oldewage, 2012

Table IV: Summary results (p-values) following statistical comparison of gill site preference: monogenean species collected from various host species (other than *Labeo* Cuvier, 1817 spp.) during a summer (January 2010) survey. Statistically significant values (i.e. $p \leq 0.05$) are indicated in shaded blocks

Host	Gill arch		Gill set		Position		Hemibranch	
	Pref.	P-value	Pref.	P-value	Pref.	P-value	Pref.	P-value
C. gariepinus	1st and 2nd	0.001	Left	0.133	Ventral	0.227	Anterior	0.239
C. carpio	1st	0.186	Right	0.282	Medial	0.755	Anterior	0.282
C. idella	2nd	0.587	Left	0.139	Medial	0.353	Anterior	0.042
***Labeobarbus* spp.**	1st and 2nd	0.630	Inconclusive	0.176	Dorsal/Medial	0.032	Anterior	0.083

Pref. = Preference; *C. gariepinus* = *Clarias gariepinus* (Burchell, 1822); *C. carpio* = *Cyprinus carpio* Linnaeus, 1758; *C. idella* = *Ctenopharyngodon idella* (Valenciennes, 1844); *Labeobarbus* spp. = *Labeobarbus aeneus* (Burchell, 1822) and *Labeobarbus kimberleyensis* (Gilchrist and Thompson, 1913) data combined.

Gill arch = First, second, third or fourth gill arch; Gill set= Left or right; Position = Dorsal, medial or ventral (see Crafford *et al.,* 2014); Hemibranch = Anterior or posterior.

Fish collection, parasite recovery, calculation of condition factors and statistical methods were employed as described by Crafford *et al.* (2014).

Results

Host data

Numbers collected, gender, weight and length data for the fish species collected are presented in Table I. Using length measurements, approximate age ranges could be inferred by referencing age/length graphs as discussed later.

Parasite species collected

Parasite species collected from the various fish hosts are summarized in Table V. With the exception of parasites collected from *Labeobarbus* spp., all parasite species listed in Table V are known species but represent new locality records.

Infection statistics and site preference

Infection statistics are summarized in Tables II and III with significance of apparent site preference on the gills summarized in Table IV.

More monogeneans were collected from the first or second gill arches (only significantly so for parasites from *Clarias gariepinus*), the medial position on the gill (only significantly so for parasites from *Labeobarbus* spp. for which a preference for both the dorsal and medial positions were evident) and the anterior hemibranch (only significantly so for parasites from *Ctenopharyngodon idella*) (Table IV). Preference for either left or right gill set was inconclusive (Table IV).

Table V: List of all host (with the exception of *Labeo* spp.) and parasite species collected during a summer survey (January 2010) in the Vaal Dam

Survey: Summer (January 2010)	
List of all host species	**List of parasite species**
Clarias gariepinus (Burchell, 1822)	***Quadriacanthus aegypticus*** El-Naggar and Serag, 1986
	Dactylogyrus extensus Mueller and Van Cleave, 1932
Cyprinus carpio Linnaeus, 1758	***Dactylogyrus minutus*** Kulwiec, 1927
	Gyrodactylus kherulensis Ergens, 1974
Ctenopharyngodon idella (Valenciennes, 1844)	***Dactylogyrus lamellatus*** Achmerow, 1952
Labeobarbus aeneus (Burchell, 1822)	***Dactylogyrus* sp.** (belonging to the *Dactylogyrus varicorhini* Bychowsky, 1958 species group/type)
Labeobarbus kimberleyensis (Gilchrist and Thompson, 1913)	***Paradiplozoon ichthyoxanthon*** Avenant-Oldewage, 2012

Note: *Q. aegypticus, D. extensus, D. minitus, G. kherulensis* and *D. lamellatus* all constitute new locality records (Vaal Dam, South Africa)

The parasites of *Labeobarbus* spp. warrants further investigation and description (if required)

Discussion

Host data

Based on the mean length/year class tables (i.e. age at length correlations), the age range of fishes collected could be estimated. Following the guide by Yalçin *et al.* (2002), *C. gariepinus* specimens were estimated to be approximately 2 years to more than 5 years of age. Using correlations published by Karataş *et al.* (2007) for *C. carpio*, specimens were estimated to be approximately 1 year to more than 4 years old. Based on correlations by Cudmore and Mandrak (2004), *C. idella* specimens were approximately 4 to 6 years old.

Following guides by Mulder (1973), the age range for *L. kimberleyensis* was estimated to be approximately 6 to 11 years whilst that for *L. aeneus* was 5 to 8 years.

Parasite species collected

As mentioned previously, the monogenean parasites collected from all host species except *Labeobarbus* spp., could be identified from available literature. Mashego (1983) described a number of *Dactylogyrus* spp. from barbs (*Barbus paludinosus* Peters, 1852, *Barbus neefi* Greenwood, 1962 and *Barbus trimaculatus* Peters, 1952) and identified another (*Dactylogyrus spinicirrus* (Paperna and Thurston, 1967)) from largescale yellowfish (*Labeobarbus marequensis* (Smith, 1841)). Price *et al.* (1969) reported *Dactylogyrus varicorhini* Bychowsky, 1958 from *L. kimberleyensis* (largemouth yellowfish). These are also the only two records of monogenean parasites from South African yellowfishes as listed by Khalil and Polling (1997). Hempel *et al.* (2001), however, also reported an unidentified *Paradiplozoon* Akhmerov, 1974 species from *L. aeneus* (smallmouth yellowfish) in the Vaal Dam whilst two *Paradiplozoon* species were recently described from the Vaal River (Avenant-Oldewage *et al.* 2014 and Dos Santos *et al.* in press). Furthermore Matla *et al.* (2010) reported dactylogyrids on *Labeobarbus*, *Labeo* and *Barbus* spp. from Lake Tzaneen, while Mbokane *et al.* (2010) reported dactylogyrids from *Labeobarbus* and *Barbus* spp. from Nwanedi-Luphephe Dams. The dactylogyrid collected from *L. kimberleyensis* as reported on in this paper, most definitely has the "*varicorhini*-type" anchor Price *et al.* (1969) referred to. However, few specimens were collected and none could be unequivocally identified as being *D. varicorhini.* For the purposes of the paper, this parasite was thus simply identified as belonging to the *D. varicorhini* species group or type.

The presence of the two dactylogyrid parasites (*Dactylogyrus minitus* and *Dactylogyrus extensus*) collected from *Cyprinus carpio*, emphasise the global distribution of their host. This is not surprising, as monogenean parasites of commonly cultured cyprinids (including *C. carpio*) and tilapiae are often the same, even in countries as diverse as Syria, Israel and Hungary (Al-Samman *et al.* 2006). *Dactylogyrus extensus* have thus also been collected from *C. carpio* in the Australian Capital Territory (Dove and Ernst, 1998), Israel (Paperna, 1964) and Germany (Dzika *et al.* 2009), amongst others. Kir and Özan (2007) found *D. minitus* to be the most common monogenean parasite species infecting common carp in Kovada Lake, Turkey. This parasite was also collected during all months of the year, with the exception of April, from the same host and country by Tekin-Özan *et al.* (2008). However, both these parasites (*D. minitus* and *D. extensus*) do not occur only on common carp, but have also been recorded from the koi variety (Dzika *et al.* 2009). It is thought that carp were already introduced in South Africa in the 1700's, with many introductions recorded in the 1800's (Skelton 2001). Importation of the ornamental *koi* variety is still ongoing (Mouton *et al.* 2001).

Infection statistics and site preference

Spatial distribution (of glochidial larval stages on fish gills) does not result from an active choice of attachment site, but is considered the result of respiratory current (Blažek and Gelnar 2006). Molnár (1971) confirms that this is also the case for many monogeneans, as infection of *C. idella* with *D. lamellatus* most frequently takes place by passive infection as larvae are swept through the gills with water.

Paling (1968) demonstrated that most of the respiratory current flows through the third pair of gill arches. He continues to say that smaller amounts flow through the second and fourth pairs of slits. With the first and last gill slits carrying comparatively little of the water flow, one might thus expect higher infection rates on the second and third gill arches.

Turgut *et al.* (2006) confirmed that differences in water volume influence both available attachment surface area and aerobic conditions. Second and third arch gill preferences have been demonstrated by Anderson *et al.* (1993) for *Dactylogyrus banghami* Mizelle and Donahue, 1944, by Blažek and Gelnar (2006) for glochidial larval stages, by Le Roux *et al.* (2011) for *Cichlidogyrus philander* Douëllou, 1993, and by Crafford *et al.* (2014a) for *Labeo* spp. The fact that a gill arch preference for the first (and to a lesser extend the second) gill arches were recorded for the other species, is thus somewhat surprising. This preference was, however, not significant in the majority of cases. Furthermore the large number of unknown cases (e.g. *C. carpio*, Table II) may confound general trends. This most probably explains the surprising result obtained with regard to gill arch preference (i.e. most parasites found on the first gill arch). The preference for the medial position and anterior gill hemisphere is also considered a result of water flow over the gills (Crafford *et al.* 2014).

Summary and Conclusion

This short communication reports a new locality record (Vaal Dam, Vaal River system, South Africa) for the following

monogenean species (see Table V): *Q. aegypticus*, *D. extensus*, *D. minitus*, *G. kherulensis* and *D. lamellatus.*

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