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Digenean Trematoda infection of inshore fish at South Georgia

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Abstract: A sample of 111 fish of eight species caught in two fjords at South Georgia were examined for digenean trematode parasites. The alimentary tracts of all specimens were infected with digeneans. The dominant species was *Elytrophalloides oatesi* (Leiper & Atkinson) which was found in all fish, with a maximum number of 1961 specimens per fish. Other common species were; *Macvicaria pennelli* (Leiper & Atkinson), *Lepidapedon garrardi* (Leiper & Atkinson), *Lecithaster macrocotyle* Szidat & Graefe, *Genolinea bowersi* (Leiper & Atkinson) and *Postmonorchis variabilis* Prudhoe & Bray. Three further species, *Neolebouria antarctica* (Szidat & Graefe), *Discoverytrema markowskii* Gibson and *Gonocerca phycidis* Manter, were rare. Infection of the most commonly caught fish at South Georgia, *Notothenia rossii* Richardson, is compared with that of *N. rossii* at Admiralty Bay, South Shetland Islands. The species composition of common parasites was similar in both areas but conspicuous differences in the frequency of individual digenean species were found.

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Introduction

Digenean trematodes are common parasites in marine fish. The first five species in Antarctic fish were described from specimens caught in McMurdo Sound (Leiper & Atkinson 1914, 1915). Several additional species have been described more recently (Byrd 1963) but descriptions of the majority of currently known species have been published only during the past 20 years. According to Lyadov (1985) 31 digenean species occur in Antarctic fish; however seven of these species were recorded only from the Kerguelen sub-region. Digeneans from fish at South Georgia have been the subject of a small number of reports (Gibson 1976, Zdzitowiecki 1979, Rodjuk 1985, Reimer 1987, Gaevskaya & Kovaljova 1976, Gaevskaya & Rodjuk 1988). A total of 12 digenean species were reported from fish in the area, with six of these occurring in fish from the Cumberland Bay fjord (Gibson 1976).

The present study describes the digenean infection of inshore fish from two fjords at South Georgia. Most of the fish were collected during research by the British Antarctic Survey in 1988. Data on the digenean infection of some fish caught by the senior author in 1977 at Cumberland Bay are also included.

Materials and methods

A total of 111 fish of eight notothenioid species were collected from two fjords at South Georgia (Table I). These were identified according to Fischer & Hureau (1985). Juvenile *Notothenia rossii* Richardson are common in coastal habitats (Burchett *et al.* 1983) and comprised the larger part of the sample (92). Apart from immature *N. rossii*, other typical inshore species were *Notothenia neglecta* Nybelin and *Notothenia angustifrons* Fischer. The other species listed (Table I) are also distributed in deeper parts of fjords and over open continental shelf.

Most fish (105) were caught using a set trammel net in Stromness Harbour at a depth of 15–20 m between 6–8 April 1988. A further six fish were caught at a similar depth in Cumberland Bay between 1–4 April 1977 using a hand line. Fish collected in 1977 were examined immediately after capture. Digenean trematodes were collected alive, killed by heat, counted, fixed in 75% ethanol, stained in alum carmine, dehydrated and identified after clearing in beechwood creosote. Fish caught in 1988 were fixed and stored in 4% formaldehyde solution and examined one year after collection. They were dissected in fresh water and the digeneans were identified and counted using a dissecting microscope. Samples of specimens of all species identified, together with all specimens of doubtful identification were transfered to ethanol, stained, cleared and examined using whole preparations in beechwood creosote. This re-examination

Table I. Species, number and size of fish examined at South Georgia

Species	*n*	Standard length (cm) range	mean
Notothenia rossii Richardson	92	10.2–38.0	22.0
Notothenia neglecta Nybelin	3	36.0–46.0	39.5
Notothenia angustifrons Fischer	6	9.7–11.8	10.7
Nototheniops nudifrons (Lönnberg)	3	11.5–16.0	13.2
Pagothenia bernacchii (Boulenger)	2	15.5–25.5	20.5
Pagothenia hansoni (Boulenger)	1	30.0	
Parachaenichthys georgianus (Fischer)	3	47.5–50.0	48.3
Champsocephalus gunnari Lönnberg	1	19.5	

confirmed the provisional identifications.

The prevalence (number of fish containing parasites) and density (mean number of digeneans per host examined) were used as indices of infection for *N. rossii*. In addition, analysis of variance was used to evaluate the relationship between the intensity (number of parasites per host) of digeneans in relation to size of host for *N. rossii*. The numbers of parasites from other fish examined were insufficient to justify similar calculations. The distribution of parasites in hosts was over-dispersed; the frequency data from each host specimen were therefore transformed according to the formula $y=\log(x+1)$. The transformed data were used for comparison (Student's *t* test) between the infection of *N. rossii* in fjords at South Georgia and Admiralty Bay, King George Island, South Shetland Islands. However, the results should be interpreted with caution as the investigations at Admiralty Bay were undertaken throughout a whole year, whereas those at South Georgia were completed during a few days. Seasonal changes in the occurrence of one digenean species in *N. neglecta* in Admiralty Bay were observed by Zdzitowiecki (1988).

Results

All fish examined were infected with digenean trematodes. The total number of parasites was 30 560 specimens, belonging to nine species, all of which had been previously reported from the South Georgia area. These species were:

1) *Macvicaria pennelli* (Leiper & Atkinson, 1914).
   Synonyms: *Plagioporus pennelli* (Leiper & Atkinson, 1914); *P. pennelli georgianus* Kovaljova & Gaevskaya, (1974); *Allocreadium fowleri* Leiper & Atkinson, (1914).
2) *Neolebouria antarctica* (Szidat & Graefe, 1967).
   Synonyms: *Crassicutis antarcticus* Szidat & Graefe, (1967); *Opegaster synodi* in Szidat (1965) not Manter, (1947); *Neolebouria georgiensis* Gibson, (1976); *Plagioporus lobatus georgianus* Gaevskaya & Kovaljova, (1976).
3) *Discoverytrema markowskii* Gibson, 1976.
4) *Lepidapedon garrardi* (Leiper & Atkinson, 1914).
   Synonyms: *L. antarcticum* Byrd, (1963); *Lepocreadium trullaeforme* in Szidat (1965) and Szidat & Graefe (1967) not Linton, (1940).
5) *Postmonorchis variabilis* Prudhoe & Bray, 1973.
6) *Lecithaster macrocotyle* Szidat & Graefe, 1967.
   Synonym: *L. australis* Prudhoe & Bray, (1973).
7) *Elytrophalloides oatesi* (Leiper & Atkinson, 1914).
   Synonym: *E. merluccii* Szidat, (1955).
8) *Genolinea bowersi* (Leiper & Atkinson, 1914).
   Synonyms: *G. leiperi* Byrd, (1963); *Genarches lintoni* Szidat & Graefe, (1967); *Derogenes parvus* in Szidat (1955) not Szidat, (1950).
9) *Gonocerca phycidis* Manter, 1925.
   Synonym: *G. trematomi* Byrd, (1963).

It should be noted that several authors have incorrectly identified various Antarctic digenean species as *Lepocreadium trullaforme*. According to Zdzitowiecki (1990) *L. trullaforme* of Gaevskaya & Kovaljova (1976) and probably of Parukhin & Lyadov (1982) is not identical with *L. garrardi*, but with *Neolepidapedon trematomi* Prudhoe & Bray, 1973.

The number of fish infected with each species is shown on Table II. All nine digenean species are parasites of the alimentary tract. Two species, *E. oatesi* and *G. bowersi* occur mainly in the stomach, while the other species are recorded as intestinal parasites. Both specimens of *D. markowskii* were found in stomachs of fish. This species is more commonly known as an intestinal parasite of the gadiform fish *Muraenolepis microps* Lönnberg. However, both specimens of *D. markowskii* were very small and immature and so it is probable they had just been liberated from tissues of intermediate hosts eaten by the fish. The presence of *D. markowskii* in stomachs of nototheniid fish is therefore considered incidental and it suggests the presence of intermediate hosts infected with *D. markowskii* in the inshore zone of fjords at South Georgia.

E. oatesi was the dominant digenean (88.6% of all parasite specimens), and occurred in all specimens examined. The other species, *M. pennelli, L. garrardi, L. macrocotyle, G. bowersi* and probably *P. variabilis*, also seem to be facultatively or obligatorily associated with hosts inhabiting the nearshore environment. *N. antarctica* and *G. phycidis* were absent in typical inshore fish and these species appear to be associated with fish from deeper waters in the fjords and continental shelf.

Infection of immature *N. rossii* by digenean parasites was correlated with fish size (Table III); both the parasite species diversity and total number of parasites increased with host size. An exception to this trend occurred in *L. macrocotyle* where the density increased but prevalence decreased with fish size. The relatively high density of infection with *L. garrardi* in the smaller fish was a result of the large infection (52 digeneans) of a single host. The relationship between the intensity of each species of digenean and the size of individual *N. rossii* was analysed (ANOVA) and the most common species of digeneans, *E. oatesi, G boweri* and *M. pennelli*, were found to be significantly correlated with an increase in size of the host (Table IV).

Discussion

Eight of the digenean trematode species found (with exception of *N. antarctica*) had previously been recorded from the East Antarctic (Leiper & Atkinson 1914, 1915, Byrd 1963, Holloway & Spence 1980, Parukhin & Lyadov 1982). *M. pennelli, L. garrardi, E. oatesi, G. bowersi* and *G. phycidis* occur in fish at high latitudes around the Antarctic Continent and have been found at McMurdo Sound. However, these earlier data are insufficiently detailed to allow quantitative comparison with the present observations.

Table II. Infection of South Georgia inshore fish by digenean trematodes.

Fish Species	Number of fish infected (intensity range)									
	M. pennelli	*N. antarctica*	*D. markowskii*	*L. garrardi*	*P. variabilis*	*L. macrocotyle*	*E oatesi*	*G. bowersi*	*G. phycidis*	Total
N. rossii	50 (1–558)		2 (1)	12 (1–52)		76 (1–34)	92 (2–1655)	83 (1–64)		92 (3–1961)
N. neglecta	3 (1–11)					2 (2–3)	3 (68–735)	3 (3–35)		3 (87–739)
N. angustifrons				2 (1–13)	1 (426)		6 (3–13)	4 (1–4)		6 (4–437)
N. nudifrons	1 (5)				1 (9)		3 (19–25)	2 (1–26)		3 (25–54)
P. bernacchii							2 (20–34)			2 (20–34)
P. hansoni							1 (67)			1 (67)
P. georgianus		2 (2)					3 (5–335)	2 (1–4)	1 (1)	3 (7–336)
C. gunnari							1 (20)			1 (20)

Table III. Prevalence and density of digenean trematodes in immature *Notothenia rossii* (total and in 10cm size classes) caught in fjords at South Georgia

	Size classes							
	10.2–20.0 $n = 34$		20.2–30.0 $n = 47$		30.5–38.0 $n = 11$		Total $n = 92$	
Species	Prevalence (%)	Density	Prevalence (%)	Density	Prevalence (%)	Density	Prevalence (%)	Density
M. pennelli	20.6	3.71	68.1	12.19	100	80.82	54.4	16.17
D. markowskii	-	-	2.1	0.02	9.1	0.09	2.2	0.02
L. garrardi	2.9	1.53	14.9	0.60	36.4	1.09	13.0	1.00
L. macrocotyle	94.1	3.32	80.9	3.91	54.5	5.36	82.6	3.87
E. oatesi	100	122.26	100	333.62	100	501.73	100	275.61
G. bowersi	82.4	4.75	93.6	14.28	100	16.64	90.2	10.73
Total	100	135.57	100	364.62	100	605.73	100	307.40

The accumulated data from the South Shetland Islands area (Zdzitowiecki 1979, 1987, 1988) and from South Georgia provide an opportunity for the distribution from the two areas to be compared. Eleven digenean species were found in fish in Admiralty Bay and nine digenean species were found parasitizing fish at South Georgia. Seven species are common to both localities. *D. markowskii* and *P. variabilis* have not been reported from the South Shetland Islands area.

Five digenean species were common in immature *N. rossii* in both areas (Table V). Only data on the infection of fish of similar size classes (>25cm) at Admiralty Bay and South Georgia were analysed (Table V). Infection with *E. oatesi* and *L. macrocotyle* as well as total infection was much more common in fish from South Georgia; while infections with *M. pennelli* and *L. garrardi* were more prevalent in fish from Admiralty Bay. Mean intensity data (log transformed) were compared and the differences found to be significant ($P<0.001$). The infection with *G. bowersi* was similar in both areas and not found to be statistically different ($P>0.10$).

Table IV. Statistics of digenean trematode infection in relation to size of *N. rossii* (n= 92) at South Georgia (ANOVA).

Species	r^2	F	P	Total	x	±sd
M. pennelli	7.0	6.81	*	1488	16.2	67.8
D. markowskii	1.3	1.61	NS	2	-	-
L. garrardi	0.1	0.05	NS	92	1.0	5.7
L. macrocotyle	0.4	0.39	NS	356	3.9	5.6
E. oatesi	13.3	14.08	***	25356	275.6	338.5
G. bowersi	9.9	9.89	**	987	10.7	12.9
Total digeneans	17.4	19.02	***	28281	297.6	336.5

The structure of infection of juvenile *N. rossii* for all areas is shown in Fig. 1, using data from all specimens. It is clear, that *E. oatesi* was the dominant (in terms of prevalence and intensity) digenean species in *N. rossii* inhabiting fjords at South Georgia (89.7% specimens); while *M. pennelli* dominated this fish in Admiralty Bay (78.9% specimens).

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Table V. Comparison between infections of *Notothenia rossii* with common digenean trematodes in two fjords at South Georgia, (Stromness Harbour and Cumberland Bay); (SL=20.2–38.0 cm) and at Admiralty Bay, South Shetland Islands; (SL=23.5–34.5 cm).

	South Georgia n = 58			South Shetland Islands n = 50		
Species	Prevalence (%)	Density	Mean Log(x+1)	Prevalence (%)	Density	Mean Log (x+1)
M. pennelli	74.1	25.21	0.73 ± 0.65	98.0	66.80	1.62 ± 0.47
L. garrardi	19.0	0.69	0.10 ± 0.25	58.0	2.14	0.33 ± 0.34
L. macrocotyle	75.9	4.19	0.50 ± 0.41	20.0	0.26	0.07 ± 0.15
E. oatesi	100	365.50	2.25 ± 0.62	16.0	0.22	0.06 ± 0.14
G. bowersi	94.8	14.72	1.00 ± 0.45	92.0	15.16	0.93 ± 0.49
Total	100	410.34	2.34 ± 0.55	100	84.68	1.79 ± 0.38

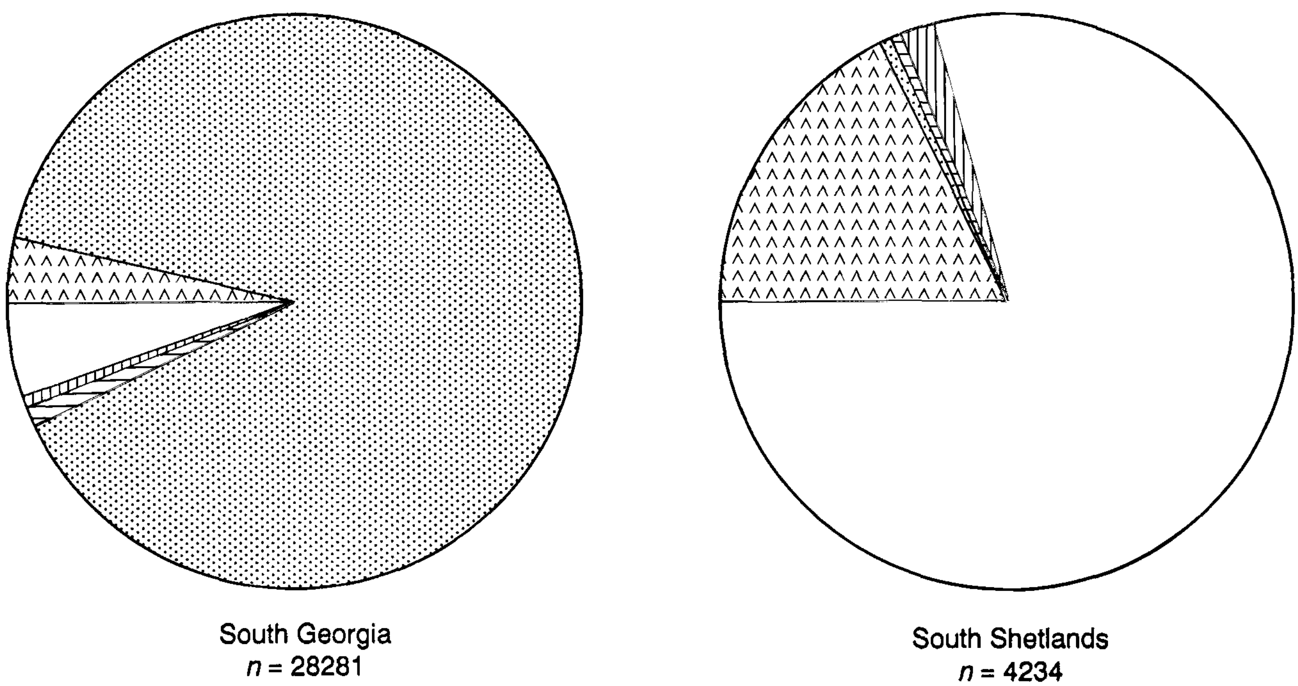
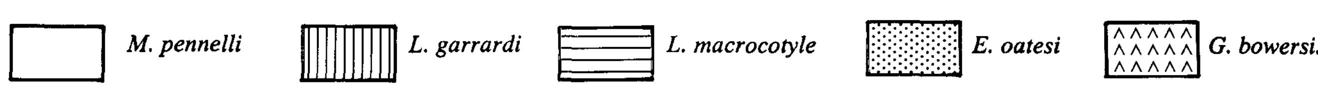


Fig. 1. Comparison of digenean trematode infection of immature *Notothenia rossii* from fjords at South Georgia and the South Shetland Islands.



M. pennelli was the next most frequently occurring species at South Georgia (5.3% specimens), while *E. oatesi* occurred rarely in fish from Admiralty Bay (0.3% specimens). *G. bowersi* occurred in both areas (3.5% and 17.9% specimens respectively). These data are in agreement with those of Rodjuk (1985), who reported that *E. oatesi* was a very common parasite of fish from South Georgia but it was rare at the South Shetland Islands. According to Gibson (1976) this species is widely known from both the Antarctic and subantarctic waters, and has little definitive host specificity. It seems probable that *E. oatesi* is a highly successful parasite of fish at South Georgia because of the abundance of suitable intermediate hosts (molluscs and copepods) in the coastal habitats occupied by the juvenile fish but this alone does not explain the marked differences in occurrence between the parasite species composition in different parts of the range of *N. rossii*.

Differences in parasite burden have been used as indicators of the separation of fish stocks and this technique has been applied to some species of Antarctic fish (Siegel 1980). The marked difference in parasite burden in *N. rossii* at the South Shetland Islands and South Georgia are likely to reflect a strong geographical isolation between stocks of these fish.

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