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Occurrence of digeneans in open sea fishes off the South Shetland Islands and South Georgia, and a list of fish digeneans in the Antarctic

ABSTRACT: A total of 704 fishes representing 39 species were examined. Twenty five digenean species were recognized. Only one species previously found by the present author in a fiord of this area was absent in the material. Pelagic species were usually not parasitized by digeneans, while demersal fishes were normally found to be infected. Results of the present study are compared to those from fiords. Seven species were found to be widely distributed. Two of them, *Macvicaria pennelli* and *Genolinea bowersi*, were associated with an inshore fiord environment and could be used as biological tags indicating the association of hosts with this kind of environment. Three of widely distributed species, *Lepidapedon garrardi*, *Elytrophalloides oatesi* and *Lecithaster macrocotyle*, were not clearly associated with any environment. *Gonocerca phycidis*, *Neolebouria antarctica* and other less widely distributed species, with the exception of *Postmonorchis variabilis*, were associated with deep part of fiords and/or open sea shelf environment. The level of infection of open sea fish at the South Shetlands was low. Many fish species living at South Georgia were massively infected; the dominant species in this area is *E. oatesi*, which was rare off the South Shetland Islands.

A total of 45 digenean species occurring in the Antarctic fish were listed. Eleven of them were not endemic.

Key words: Antarctic, digeneans, fish infection, open sea.

Introduction

According to Rodjuk (1985), 14 digenean species were reported from fishes of the Atlantic part of the Antarctic; 11 species occurring off Elephant Island (South Shetlands) and 10 off South Georgia. However, only 7 species were listed. Fish digeneans in this area have been the subject of some morphological and faunistical investigations (Szidat 1965, Szidat and Graefe 1967, 1968, Tomo and Stadler 1973, Kovaljova and Gaevskaja 1974, Paruchin and Sysa 1975, Gaevakaja and Kovaljova 1976, Gibson 1976, Zdzitowiecki 1979, 1987, Reimer

1987, Gaevskaja and Rodjuk 1988a). Metacercariae of one species were found in a mysid crustacean (Gaevskaja 1982). Occurrence of digeneans in fishes at the South Shetland Islands (11 species; most of the data concerned fish infections in Admiralty Bay) was reported by the present author (Zdzitowiecki 1988), who has also investigated infection of inshore fiord fishes at South Georgia and has found 9 digenean species (Zdzitowiecki, White and Coggan, in press). Recently, the present author (Zdzitowiecki 1989, 1990a, b, c, d) described 9 new species and redescribed some others, including redescrptions of the type specimens of two species originally described by Szidat and Graefe (1967). The number of species reported from Admiralty Bay has increased to 13. Digeneans of fishes in the East Antarctic, including the Kerguelen Subregion, have been the subject of fewer morphological and faunistical investigations (Leiper and Atkinson 1914, 1915, Byrd 1963, Holloway and Bier 1968, Prudhoe and Bray 1973, Paruchin and Lyadov 1979, 1982, Holloway and Spence 1980). Lyadov (1985) prepared a list of parasitic worms of Antarctic fishes containing 31 species of digeneans.

The present paper describes investigations on the occurrence of digeneans in fishes caught off the South Shetland Islands and South Georgia, and the comparison with those from fiords of the same areas. A comprehensive list of digeneans reported from Antarctic fishes is included.

Material and methods

Material was collected from the same host specimens that were used for similar investigations on Acanthocephala (Zdzitowiecki 1990e). The list of fish species examined is shown in table 1. Most of these fishes were collected during a cruise of R/V "Profesor Siedlecki" at the South Shetland Islands and around South Georgia during the austral summer 1986/87. These investigations were part of BIOMASS III programme. In addition, materials from 26 fishes collected in the open sea off the South Shetland Islands in 1979 and previously discussed in the author's paper on digenetic trematodes of the Admiralty Bay (Zdzitowiecki 1988) are now included. Materials from 10 fishes caught in the open sea at South Georgia in 1977 are also included. Numbers of fishes collected in 1977 and 1979 are indicated in parentheses in table 1.

Demersal fish species were caught on shelves at various depths (50—500 m). Shelf at Elephant Island was investigated in the South Shetland Islands area and samples from closely related parts of Bransfield Strait (for example Joinville Island shelf) were added. Most of demersal fish species investigated at South Georgia were collected around this island, but three species (marked in table 1) were caught at Shag Rocks. Size and weight of fishes examined were shown in the author's previous paper (Zdzitowiecki 1990e, tab. 1).

Table 1

List of open sea fishes examined. Numbers of fishes collected in 1977 and 1979 in parentheses.
¹ fishes collected at the Shag Rocks. Behaviour: D — demersal, P — pelagic

Fish species	Behaviour	Infection	S. Shetlands	S. Georgia
<i>Notothenia rossii</i> Richardson	D	+		23 (3)
<i>Notothenia gibberifrons</i> Lönnberg	D	+	12	21 (1)
<i>Notothenia squamifrons</i> Günther	D	+	2 (2)	20
<i>Nototheniops larseni</i> (Lönnberg)	D	+		20
<i>Nototheniops nudifrons</i> (Lönnberg)	D	+		20
<i>Nototheniops nybelini</i> (Balushkin)	D	+	20	
<i>Pagothenia brachysoma</i> (Pappenheim)	P	—	20	
<i>Pagothenia hansonii</i> (Boulenger)	D	+		20
<i>Trematomus eulepidotus</i> Regan	D	+	20	
<i>Patagonotothen brevicauda guntheri</i> (Norman)	D	+		20 ¹
<i>Dissostichus eleginoides</i> Smitt	D	+	2 (1)	20 ¹
<i>Dissostichus mawsoni</i> Norman	D	+	6	
<i>Harpagifer antarcticus</i> Nybelin	D	+	6	
<i>Artedidraco mirus</i> Lönnberg	D	+		20
<i>Parachaenichthys georgianus</i> (Fischer)	D	+		20
<i>Parachaenichthys charcoti</i> (Vaillant)	D	+	15	
<i>Psilodraco breviceps</i> Norman	D	+		3
<i>Gymnodraco acuticeps</i> Boulenger	D	—	1	
<i>Racovitzia glacialis</i> Dollo	D	+	1	
<i>Chaenocephalus aceratus</i> Lönnberg	D	+	13 (1)	23 (3)
<i>Chaenodraco wilsoni</i> Regan	D	—	3 (3)	
<i>Chamsocephalus gunnari</i> Lönnberg	D	+	27 (7)	20 ¹
<i>Chionodraco rastrospinosus</i> DeWitt et Hureau	D	+	21 (9)	
<i>Cryodraco antarcticus</i> Dollo	D	+	15 (3)	
<i>Neopagetopsis ionah</i> Nybelin	P, D	+	2	
<i>Pseudochaenichthys georgianus</i> Norman	D	+	10	23 (3)
<i>Muraenolepis microps</i> Lönnberg	D	+		21
<i>Ophthalmolycus concolor</i> (Roulé et Despax)	D	+	5	
<i>Paradiplospinus antarcticus</i> Andrijašev	P	—	20	
<i>Notolepis coatsi</i> Dollo	P	—	13	
<i>Electrona antarctica</i> (Günther)	P	—	40	
<i>Electrona carlsbergi</i> Taning	P	—		20
<i>Gymnoscopelus nicholsi</i> (Gilbert)	P	—	23	20
<i>Gymnoscopelus</i> sp.	P	—	5	
<i>Protomyctophum bolini</i> (Fraser-Brunner)	P	—	20	
<i>Bathyraja eatoni</i> (Günther)	D	+	6	
<i>Bathyraja maccaini</i> Springer	D	—	20	
* <i>Bathyraja</i> sp. 2 Stehmann	D	—	3	
<i>Raja georgiana</i> Norman	D	—		20
Total number of species (specimens)				
39 (704)			28 (351)	18 (353)

* According to Stehmann (1985).

All fishes were examined for parasites soon after capturing; digeneans were collected alive and examined using a stereomicroscope. They were found exclusively in the digestive tract: stomach, pyloric caeca, small and large intestine. A few parasites belonging to species that normally occur in the stomach were also found in the buccal cavity and on the gills. It can be assumed that almost all digenean specimens present in bony fishes examined were collected and recognized. However, this may not be true for one species. Two specimens provisionally determined as *Fellodistomum* sp. were found during the examination of gills preserved in formaldehyde solution for monogeneans. This species was not found during the examination of the digestive tract of the same host specimen. Both parasites were much smaller than other digeneans recognized during the investigations. Their atypical habitat indicates the possibility of the presence of other specimens of this species being overlooked in fishes examined. Batoid fishes were not fully examined. Parasites were collected only from the intestine; very numerous cestodes, few nematodes and one digenean specimen were found.

Digeneans were killed either by heat or by putting into fresh water, counted, provisionally identified and fixed in 75% ethyl alcohol with 5% glycerine. All specimens of most species, as well as samples of some common, very abundant and easily identified species, were stained in alum carmine after washing in distilled water, dehydrated in a graded series of ethyl alcohol, cleared and examined as whole mounts in beechwood creosote.

Comparative data from the Admiralty Bay and South Georgian fiords are based on re-examination of materials previously used for two former papers (Zdzitowiecki 1988, Zdzitowiecki, White and Coggan, in press). Data from Admiralty Bay were corrected by the exclusion of material from open sea fishes and the addition of sample from 6 notothenioid fishes, *Neopagetopsis ionah* (1), *Parachaenichthys charcoti* (3) and *Gymnodraco acuticeps* (2), collected in November 1986. Only *P. charcoti* were infected with digeneans.

Prevalence (% of infected fishes), intensity (number of digeneans in one host specimen) and density (mean number of digeneans in fishes examined) were used as indices of infection. Distribution of parasites in hosts is usually over-dispersed, so frequency data from each host specimen were transformed, according to the formula $y = \log(x+1)$, for comparative studies. However, statistical methods were not used, because fish examined were of various sizes and they were collected in various periods of the year.

Results

Fish examined belonged to 35 species of bony fishes and 4 species of batoid ones (Tab. 1). Digeneans were found in 25 bony fish species, and one digenean specimen occurred in the intestine of a batoid fish, *Bathyraja eatoni*. However,

the data from batoid fishes are not of real significance, because only the intestines were examined, whilst, according to Gibson (1976), digeneans were reported from the stomach and body cavity of subantarctic species of this fish group. Pelagic fishes were usually not infected by digenean parasites. The single *Neopagetopsis ionah* infected was caught in mid-water using a krill net, but two specimens collected in Admiralty Bay were caught at the bottom. The parasite found in the pelagic fish specimen mentioned is common in various demersal fishes and the infection seems to be of a demersal origin.

Almost all demersal bony fish species were infected. Lack of infection of *Gymnodraco acuticeps* and *Chaenodraco wilsoni* is probably a result of too few fish examined and the feeding of these fish mainly on krill. The Antarctic krill has been reported as not infected with parasitic worms (Kagei, Asano and Kihata 1978).

In all 26 digenean species (Tab. 2) were recorded by the present author at the South Shetland Islands and South Georgia; 25 species were found during the present investigations and *Derozenes varicus* exclusively in Admiralty Bay (Zdzitowiecki 1987, 1988). Six species occurred mainly in the stomach, rarely in the buccal cavity and intestine. According to Gibson (1976), *Otodistomum cestoides* is also a parasite of the stomach, although the present author has found the single specimen in the intestine. The normal habitat of *Fellodistomum* sp. is not known (parasites were found on the gills). All other 18 species occurred in the intestine.

Twelve digenean species occurred in fishes other than Notothenioidea (Tab. 3). *O. cestoides* is a specific parasite of skates and rarely sharks (Gibson and Bray 1977). One of the two species recorded in a zoarcid fish *Ophthalmolycus concolor*, namely *Macvicaria ophthalmolyci* was found also in a nototheniid fish, *Nototheniops nudifrons*, in Admiralty Bay (Zdzitowiecki 1990b); *Lepidapedon tertius* seems to be specific for zoarcid fish. Three of nine species occurring in a gadiform fish, *Muraenolepis microps*, (*Elytrophalloides oatesi*, *Gonocerca phycidis* and *Lecithaster macrocotyle*) are common parasites of notothenioids; six species seem to be specific for *M. microps*. However, small immature *Discoverytrema gibsoni* and *D. markowskii* were found in *Notothenia rossii* (Zdzitowiecki, White and Coggan, in press) and in *N. nudifrons* (present investigations). Habitats of these specimens were atypical (stomach and pyloric caeca) and their presence in nototheniid fish is considered occasional. Probably parasites were not established in the hosts mentioned, but just liberated from other hosts ingested. *M. microps* was the only host species not belonging to Notothenioidea, which was found to be heavily infected with digeneans.

Eleven digenean species occurred in notothenioid fishes in the open sea off the South Shetland Islands. Six of these are rather widely distributed and they were found in not less than four host species each (Tab. 4). Several parasites were usually present in each host specimen, with exceptions of *L. macrocotyle* in *P. charcoti* and *Cryodraco antarcticus*, as well as *G. phycidis* in *C. antarcticus*

Table 2

Occurrence of digeneans — parasites of fishes at the South Shetland Islands and South Georgia. The data from fiords according to Zdzitowiecki (1988) corrected and Zdzitowiecki, White and Coggan (in press). Habitat: I — intestine, S — stomach

Digenean species	Habitat	S. Shetlands		S. Georgia	
		open sea	fiords	open sea	fiords
<i>Macvicaria antarctica</i> (Kovaljova et Gaevskaja, 1974)	I	—	—	+	—
<i>Macvicaria muraenolepidis</i> Zdzitowiecki, 1990	I	—	—	+	—
<i>Macvicaria ophthalmolyci</i> Zdzitowiecki, 1990	I	+	+	—	—
<i>Macvicaria pennelli</i> (Leiper et Atkinson, 1914)	I	+	+	+	+
<i>Neolebouria antarctica</i> (Szidat et Graefe, 1967)	I	+	+	+	+
<i>Discoverytrema gibsoni</i> Zdzitowiecki, 1990	I	—	—	+	—
<i>Discoverytrema markowskii</i> Gibson, 1976	I	—	—	+	+
<i>Stenakron glacialis</i> Zdzitowiecki, 1989	I	+	—	—	—
<i>Lepidapedon garrardi</i> (Leiper et Atkinson, 1914)	I	+	+	+	+
<i>Lepidapedon notogeorgianus</i> Zdzitowiecki, 1990	I	—	—	+	—
<i>Lepidapedon paralebouri</i> Zdzitowiecki, 1990	I	—	—	+	—
<i>Lepidapedon tertius</i> Zdzitowiecki, 1990	I	+	—	—	—
<i>Neolepidapedon magnatestis</i> (Gaevskaja et Kovaljova, 1976)	I	—	+	+	—
<i>Neolepidapedon opisthobifurcatus</i> Zdzitowiecki, 1990	I	—	—	+	—
<i>Neolepidapedon trematomi</i> Prudhoe et Bray, 1973	I	+	+	+	—
<i>Muraenolepitrema magnatestis</i> Gaevskaja et Rodjuk, 1988	I	—	—	+	—
<i>Fellodistomum</i> sp.	?	—	—	+	—
<i>Otodistomum cestoides</i> (Beneden, 1871)	?!	+	—	—	—
<i>Postmonorchis variabilis</i> Prudhoe et Bray, 1973	I	—	—	+	+
<i>Derogenes varicus</i> (Müller, 1784)	S	—	+	—	—
<i>Elytrophaloides oatesi</i> (Leiper et Atkinson, 1914)	S	+	+	+	+
<i>Genolinea bowersi</i> (Leiper et Atkinson, 1914)	S	+	+	+	+
<i>Glomericirrus macrouri</i> (Gaevskaja, 1975)	S	+	+	—	—
<i>Gonocerca phycidys</i> Manter, 1925	S	+	+	+	+
<i>Lecithaster macrocotyle</i> Szidat et Graefe, 1967	I	+	+	+	+
<i>Lecithophyllum champsocephali</i> Zdzitowiecki, 1989	S	+	+	—	—
Total number of species — 26 (16 and 19 in every area)		14	13	19	9

and *Pseudochaenichthys georgianus*. Five digenean species were found in a few host species (Tab. 5). However, the only case of massive infection recognized in a fish in the South Shetland Islands open sea area concerned *Neolepidapedon trematomi* in *Dissostichus eleginoides*. It should be noted that this fish specimen

Table 3

Digenean infection of open sea fishes other than notothenioids

Host species	n	Locality	Parasite species	Prevalence	Intensity	Density
<i>B. eatoni</i>	6	S. Shetlands	<i>O. cestoides</i>	16.7%	1	0.17
<i>O. concolor</i>	5	S. Shetlands	<i>M. ophthalmolyci</i>	20.0%	2	0.40
			<i>L. tertius</i>	20.0%	3	0.60
			Total	40.0%	2—3	1.00
<i>M. microps</i>	21	S. Georgia	<i>M. muraenolepidis</i>	38.1%	1—38	3.05
			<i>D. gibsoni</i>	81.0%	1—36	8.48
			<i>D. markowskii</i>	23.8%	1—18	2.76
			<i>L. paralebouri</i>	4.8%	3	0.14
			<i>N. opisthobifurcatus</i>	4.8%	5	0.24
			<i>M. magnatestis</i>	33.3%	1—95	5.86
			<i>E. oatesi</i>	4.8%	2	0.10
			<i>G. phycidis</i>	28.5%	1—5	0.52
			<i>L. macrocotyle</i>	33.3%	1—18	1.29
			Total	100 %	1—114	22.43

was the largest examined in the area (length 65 cm, weight 4,87 kg) and it was collected in 1979. Other parasites listed in table 5 are rare in open sea fish species (*Genolinea bowersi* is common in the Admiralty Bay) in the area.

Fifteen digenean species (including two occasional ones — *D. gibsoni* and *D. markowskii*) occurred in notothenioid fishes in the open sea off South Georgia. Each of six widely distributed species were found in 4—12 fish species (Tab. 6). The most common was *E. oatesi*; especially strong infection of *Pseudochaenichthys georgianus* and *N. rossii* was recognized. Surprisingly, this species was rare in fish material collected at Shag Rocks. *Patagonotothen brevicauda guntheri* and *Champscephalus gunnari* were not infected and the infection of *D. eleginoides* was low. It is not clear whether *E. oatesi* is really rare in these hosts or its presence depends upon the locality. The present author examined the stomach of one large *C. gunnari* (length 53 cm) and found 296 *E. oatesi*. Strong infections with *Neolebouria antarctica* in three host species and with *G. phycidis* in *Chaenocephalus aceratus* were also found. The level of infection with other parasites listed in table 6 was low with exceptions of *Genolinea bowersi* in *N. rossii* and *Lepidapedon garrardi* in *Notothenia gibberifrons*. Nine digenean species were found in less than four host species (Tab. 7). Their prevalences were not high (never exceeding 50%), but infections were sometimes of massive character (circa 300 in two cases).

Discussion

The abundance of various digenean species in notothenioids in three kinds of environment in both areas of investigations is shown in Fig. 1. Data from

Table 4

Prevalence (%), density and intensity (in parentheses) of widely distributed digenean species in notothenioid fishes caught in the open sea off the South Shetland Islands

Host species	n	Parasite species								Total
		<i>M. pennelli</i>	<i>N. antarctica</i>	<i>L. garrardi</i>	<i>E. oatesi</i>	<i>G. phycidis</i>	<i>L. macrocotyle</i>	Others		
<i>N. gibberifrons</i>	12	50.0% 0.67 (1-2)		25.0% 0.25 (1)		25.0% 0.42 (1-3)				75.0% 1.33 (1-3)
<i>N. nybelini</i>	20						10.0% 0.10 (1)			10.0% 0.10 (1)
<i>T. eulepidotus</i>	20	5.0% 0.15 (3)	5.0% 0.15 (1)							10.0% 0.20 (1-3)
<i>D. eleginoides</i>	2		50.0% 1.00 (2)	50.0% 1.00 (2)	50.0% 0.50 (1)	100.0% 4.50 (1-8)		50.0% 811 (1622)		100.0% 818 (9-1627)
<i>D. mawsoni</i>	6	16.7% 0.33 (2)					16.7% 0.17 (1)			33.3% 0.50 (1-2)
<i>H. antarcticus</i>	6	16.7% 0.83 (5)								16.7% 0.83 (5)
<i>P. charcoti</i>	15		53.3% 0.73 (1-3)	26.7% 0.47 (1-3)	20.0% 0.20 (1)		73.3% 15.47 (2-83)	26.7% 0.73 (2-4)		86.7% 17.60 (1-84)
<i>C. aceratus</i>	13		23.1% 0.23 (1)			23.1% 0.83 (1-3)				38.5% 0.62 (1-4)
<i>C. gunnari</i>	27	7.4% 0.07 (1)	11.1% 0.15 (1-2)			3.7% 0.04 (1)		7.4% 0.67 (6-12)		22.2% 0.93 (1-13)
<i>C. rastrospinosus</i>	21		4.8% 0.05 (1)	9.5% 0.24 (1-4)	4.8% 0.05 (1)	4.8% 0.10 (2)	23.8% 0.52 (1-7)			38.1% 0.95 (1-7)
<i>C. antarcticus</i>	15		40.0% 0.60 (1-3)		6.7% 0.07 (1)	73.3% 4.60 (1-42)	73.3% 3.33 (1-14)	26.7% 0.67 (1-5)		86.7% 9.27 (1-46)
<i>N. ionah</i>	2		50.0% 0.50 (1)							50.0% 0.50 (1)
<i>P. georgianus</i>	10		10.0% 0.10 (1)			20.0% 2.10 (4-17)				30.0% 2.20 (1-17)

Table 5
Occurrence of less abundant digenean species in notothenioid fishes caught in the open sea off South Shetland Islands

Digenean species	Host species	Prevalence	Intensity	Density
<i>N. trematomi</i>	<i>D. eleginoides</i>	50.0%	1622	811.00
<i>S. glacialis</i>	<i>R. glacialis</i>	+	2	
<i>G. bowersi</i>	<i>P. charcoti</i>	26.7%	2—4	0.67
	<i>C. antarcticus</i>	6.7%	1	0.07
<i>G. macrouri</i>	<i>P. charcoti</i>	6.7%	1	0.07
	<i>C. gunnari</i>	3.7%	1	0.04
	<i>C. antarcticus</i>	26.7%	1—4	0.60
<i>L. champsocephali</i>	<i>C. gunnari</i>	7.4%	6—11	0.63

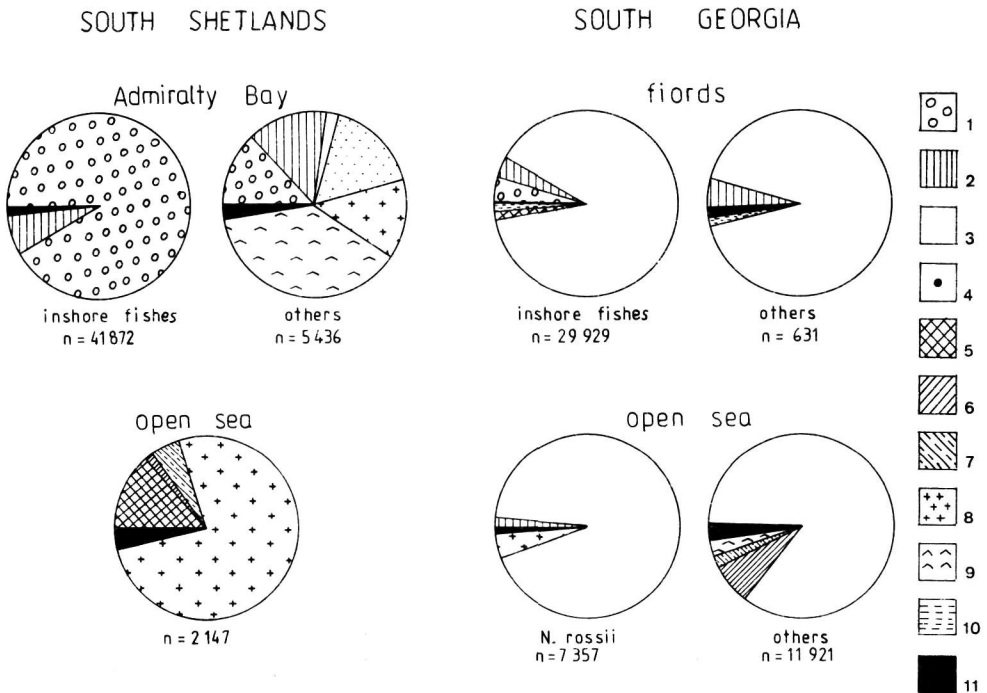


Fig. 1. Structure of infection of notothenioid fishes in various areas and environments. Inshore fishes — *N. neglecta*, *N. rossii*, *N. angustifrons* and *H. antarcticus*; n — numbers of digeneans 1 — *M. pennelli*, 2 — *G. bowersi*, 3 — *E. oatesi*, 4 — *L. garrardi*, 5 — *L. macrocotyle*, 6 — *N. antarctica*, 7 — *G. phycidis*, 8 — *N. trematomi*, 9 — *N. magnatestis*, 10 — *P. variabilis*, 11 — various species, less numerous than 1% each

fiords are based on re-elaborated results of earlier investigations (Zdzitowiecki 1988, Zdzitowiecki, White and Coggan, in press). Data from *N. rossii* caught in the open sea off South Georgia were presented separately because of the especially strong association of this fish with the fiord environment during the

Table 6

Prevalence (%), density and intensity (in parentheses) of widely distributed digenean species in notothenioid fishes caught in the open sea off South Georgia

Host species	n	Parasite species												Total			
		<i>N. antarctica</i>		<i>L. garrardi</i>		<i>E. oatesi</i>		<i>G. bowersi</i>		<i>G. phycidis</i>		<i>L. macrocotyle</i>			Others		
<i>N. rossii</i>	23	8.7%	0.22	4.4%	0.26	100.0%	297.3	65.2%	4.61	8.7%	0.09	4.4%	0.09	39.1%	17.35	100.0%	319.9
		(1—4)		(6)		(3—1305)		(1—29)		(1)		(2)		(2—338)		(19—1310)	
<i>N. gibberifrons</i>	21			61.9%	3.62	19.1%	0.76	28.6%	0.90	9.5%	0.14					81.0%	5.43
				(1—29)		(3—5)		(1—10)		(1—2)						(1—29)	
<i>N. squamifrons</i>	20	70.0%	1.50			80.0%	7.90					5.0%	0.05	45.0%	18.25	95.0%	27.70
		(1—5)				(1—37)						(1)		(1—287)		(1—300)	
<i>N. larseni</i>	20	75.0%	2.85	5.0%	0.05	70.0%	1.40									80.0%	4.30
		(1—8)		(1)		(1—3)										(1—11)	
<i>N. nudifrons</i>	20					35.0%	1.05	5.0%	0.05	5.0%	0.75	20.0%	0.50	60.0%	3.05	80.0%	5.40
						(1—9)		(1)		(15)		(1—7)		(1—15)		(1—26)	
<i>P. hansonii</i>	20					95.0%	5.40			10.0%	0.10			5.0%	0.05	95.0%	5.55
						(1—13)				(1)				(1)		(1—13)	
<i>P. b. guntheri</i>	20			10.0%	0.25							5.0%	0.05	50.0%	3.05	55.0%	3.35
				(2—3)								(1)		(1—17)		(1—17)	
<i>D. elegendoides</i>	20					35.0%	0.65			35.0%	0.60			10.0%	0.15	55.0%	1.40
						(1—4)				(1—3)				(1—2)		(1—5)	
<i>A. mirus</i>	20					20.0%	0.25	5.0%	0.05					5.0%	0.10	20.0%	0.40
						(1—2)		(1)						(2)		(1—4)	
<i>Par. georgianus</i>	20	95.0%	11.50			85.0%	18.60	15.0%	0.25	15.0%	0.25	25.0%	0.35			100.0%	30.95
		(1—44)				(1—132)		(1—2)		(1—3)		(1—3)				(3—139)	
<i>P. breviceps</i>	3	100.0%	2.00			100.0%	8.00					33.3%	1.00			100.0%	11.00
		(2)				(3—12)						(3)				(8—14)	
<i>C. aceratus</i>	23	100.0%	15.82			100.0%	27.91	4.4%	0.04	87.0%	5.35	30.4%	0.74			100.0%	49.87
		(1—80)				(2—79)		(1)		(1—42)		(1—6)				(2—125)	
<i>C. gunnari</i>	20	10.0%	0.10													10.0%	0.10
		(1)														(1)	
<i>Ps. georgianus</i>	23	70.0%	8.74			100.0%	383.6			21.7%	0.78	8.7%	0.09			100.0%	393.2
		(1—62)				(87—884)				(1—9)		(1)				(87—941)	

Table 7

Occurrence of less abundant digenean species in notothenioid fishes caught in the open sea off South Georgia

Digenean species	Host species	Prevalence	Intensity	Density
<i>M. antarctica</i>	<i>N. nudifrons</i>	25.0%	1	0.25
<i>M. pennelli</i>	<i>N. rossii</i>	21.7%	2—24	2.30
<i>D. gibsoni</i>	<i>N. nudifrons</i>	5.0%	2	0.10
<i>D. markowskii</i>	<i>N. nudifrons</i>	5.0%	1	0.05
<i>L. notogeorgianus</i>	<i>N. squamifrons</i>	30.0%	1—34	2.85
	<i>N. nudifrons</i>	35.0%	1—13	1.15
	<i>P. b. guntheri</i>	50.0%	1—17	3.05
<i>N. magnatestis</i>	<i>N. squamifrons</i>	20.0%	2—287	15.40
	<i>D. eleginoides</i>	10.0%	1—2	0.15
<i>N. trematomi</i>	<i>N. rossii</i>	17.4%	2—338	15.04
	<i>P. hansonii</i>	5.0%	1	0.05
<i>P. variabilis</i>	<i>N. nudifrons</i>	25.0%	1—13	1.50
<i>Fellodistomum</i> sp.	<i>A. mirus</i>	5.0%	2	0.10

immature stage (see also Zdzitowiecki 1990e). Percentage contribution of ten parasite species exceeded 1% in one or more environments. Unfortunately, only ten fish specimens other than inshore ones were collected in South Georgian fiords and this sample was scarce.

Seven digenean species are widely distributed in notothenioid open sea fishes in either one (2 species) or both (5 species) areas of the present investigations. *Macvicaria pennelli* was found in 5 host species off the South Shetland Islands (Tab. 4) and in one host species (*N. rossii*) off South Georgia (Tab. 7). It is the dominant digenean species in Admiralty Bay (Zdzitowiecki 1988) and the subdominant one in South Georgian fiords (Zdzitowiecki, White and Coggan, in press). Out of its open sea hosts, *N. rossii* and *N. gibberifrons* stay in fiords as in its immature stage (according to the present author's observations the former occurs in shallow waters, and the latter in a deeper zone); *Harpagifer antarcticus* is known as a typical inshore species. Infections of other hosts were purely occasional. Thus *M. pennelli* is considered to have the biology associated with the inshore, mainly fiord, environment. The same is true for *Genolinea bowersi*. This species was found in two host species off the South Shetland Islands (Tab. 5) and in six host species off South Georgia (Tab. 6). *G. bowersi* is relatively common in *N. rossii* and *N. gibberifrons* off South Georgia and only occasionally present in other open sea fishes. It is the subdominant digenean species in fiord fishes in both areas investigated. Therefore these two digenean species could be used as biological indicators of the fish association with the fiord environment.

According to Zdzitowiecki, White and Coggan (in press) *Lepidapedon garrardi*, *Elytrophalloides oatesi* and *Lecithaster macrocotyle* are common in inshore fiord fishes at South Georgia. The same was observed in Admiralty Bay

(Zdzitowiecki 1988). However, *E. oatesi* is not numerous in the latter area, but it is much more common here than in the open sea environment off the South Shetland Islands. These three species are not clearly associated with any kind of demersal environment. The same is true for *Postmonorchis variabilis* in the South Georgia area. This species was found in *Nototheniops nudifrons* and *Notothenia angustifrons* in Stromness Harbour and the infection of the latter was of massive character (Zdzitowiecki, White and Coggan, in press).

The last two widely distributed digenean species, *Neolebouria antarctica* and *Gonocerca phycidis*, and almost all remaining less widely distributed species, including parasites of fishes other than notothenioids, seem to be associated with open sea and/or deep parts of fiord's environments.

Comparison between infections of notothenioid fishes occurring in each open sea area (Tab. 8) indicated that digeneans are not numerous in fishes off

Table 8

Comparison between levels of digenean infection, based on frequency data transformed to $\log(x+1)$, of the same or closely related fish species caught in various areas and localities. *Dissostichus* spp. = *D. eleginoides* and/or *D. mawsoni*. *Nototheniops* spp. = *N. larseni* or *N. nybelini*. *Parachaenichthys* spp. = *P. charcoti* or *P. georgianus*. 1 — small samples (2—7 fishes); 2 — single fish examined

Host species	South Shetland Islands		South Georgia	
	Admiralty Bay	open sea	fiords	open sea
<i>N. rossii</i>	1.79 ± 0.38		2.21 ± 0.52	2.25 ± 0.46
<i>N. gibberifrons</i>	0.66 ± 0.48	0.31 ± 0.22		0.61 ± 0.43
<i>N. nudifrons</i>	1.32 ± 0.46		1.54 ± 0.17 ¹	0.59 ± 0.44
<i>Nototheniops</i> spp.		0.03 ± 0.09		0.59 ± 0.38
<i>P. hansonii</i>	1.26 ± 0.73		+ ²	0.72 ± 0.32
<i>Dissostichus</i> spp.	+ ²	0.62 ± 1.10 ¹		0.28 ± 0.29
<i>Parachaenichthys</i> spp.	1.10 ± 0.23	0.90 ± 0.61	1.68 ± 0.81 ¹	1.29 ± 0.44
<i>C. aceratus</i>	1.06 ± 0.52	0.15 ± 0.22		1.60 ± 0.33
<i>C. gunnari</i>	0.27 ± 0.38	0.13 ± 0.29	+ ²	0.03 ± 0.09
<i>C. rastrospinosus</i>	0.69 ± 0.63 ¹	0.19 ± 0.28		
<i>P. georgianus</i>		0.23 ± 0.43		2.52 ± 0.27

the South Shetland Islands, whereas the same or closely related host species are much more infected off South Georgia, with the only exception of *C. gunnari*. It is mainly due to the massive infections with *E. oatesi*, the dominant parasite species in open sea and fiord fishes at South Georgia. This parasite is very rare in open sea fishes at the South Shetland Islands and only two specimens were collected from fish caught at the Elephant Island shelf and five specimens at the Joinville Island shelf. *E. oatesi* was less numerous there than such rare species as *Glomericirrus macrouri* and *Lecithophyllum champsocephali*. Rodjuk (1985) did not find *E. oatesi* at Elephant Island. Fiord fishes were more strongly infected with digeneans at South Georgia than at the South Shetland Islands,

although the difference was less conspicuous than in the case of open sea fishes (see also Zdzitowiecki, White and Coggan, in press). The high level of infection of fishes in Admiralty Bay is mainly due to the mass infection of *Notothenia neglecta* and *N. rossii* with *Macvicaria pennelli* (Zdzitowiecki 1988). *Neolebouria antarctica* is the second most widely distributed species that is much more common at South Georgia than at the South Shetland Islands. The dominance of *Neolepidapedon trematomi* in the open sea environment at the South Shetland Islands (Fig. 1) seems to be an artifact due to the presence of one massively infected host specimen. *Lecithaster macrocotyle* and *Gonocerca phycidis* seem to be the most common species in this area and environment.

According to Lyadov (1985) 31 digenean species were recorded in Antarctic fishes, including data from the Kerguelen sub-region. However, Lyadov (1985) omitted five species previously reported by Prudhoe and Bray (1973) (*Steringophorus* sp., *Helicometra* sp. and *Derogenes johnstoni* Prudhoe et Bray, 1973), by Holloway and Bier (1968) (*Helicometra antarcticae* Holloway et Bier, 1968) and by Byrd (1963) (*Gonocerca lobata* Byrd, 1963). According to Zdzitowiecki (1987) *Lepidapedon antarcticus* Byrd, 1963 is identical with *L. garrardi* and digeneans wrongly identified as *Lepocreadium trullaforme* Linton, 1940 reported by Szidat (1965), Szidat and Graefe (1967), Gaevskaja and Kovaljova (1976) and Paruchin and Lyadov (1982) are identical partially with *L. garrardi*, partially with *N. trematomi* (see also Zdzitowiecki 1990c). Thus 34 species of digeneans have been reported until 1985. Recently 10 new species were described (Gaevskaja and Rodjuk 1988a, Zdzitowiecki 1990a, b, c). With addition of one undescribed species, provisionally assigned to the genus *Fellodistomum* (present data), the number of species increased to 45 and they are listed in Table 9. However, the identity of some species with other ones listed is still possible.

It should be noted that some species listed here were previously reported using names now considered junior synonyms. *Neolebouria antarctica* was usually reported as *N. georgiensis* Gibson, 1976 and *Lecithaster macrocotyle* as *L. australis* Prudhoe et Bray, 1973 (see Zdzitowiecki 1990d).

Lyadov (1985) did not divide the Antarctic Region into provinces, but only into sub-regions: Glacial sub-region and Kerguelen sub-region. It is not clear whether he has included the South Georgian province in the former one, or only two subcontinental provinces (East Glacial province and West Glacial province) were included there by him. The data available in all papers known to the present author, including those preceding the Lyadov's list, were used for preparing the present list of digeneans occurring in fishes in the Antarctic (Tab. 9). The sign "?" in this table indicates that the species was listed by Lyadov (1985) as occurring in "Glacial sub-region", but it was not reported in any former paper and it is not clear in which province this species was found.

The number of digenean species reported from fishes is lower in the Antarctic than in the subantarctic and austral temperate regions. For example

Table 9

The list of digeneans occurring in the Antarctic fishes

Digenean species	W.Glacial Province	E.Glacial Province	S.Georgian Province	Kerguelen Subregion
1. <i>Macvicaria antarctica</i> (Kovaljova et Gaevskaja)	?	?	+	+
2. <i>Macvicaria muraenolepidis</i> Zdzitowiecki	—	—	+	—
3. <i>Macvicaria ophthalmolyci</i> Zdzitowiecki	+	—	—	—
4. <i>Macvicaria pennelli</i> (Leiper et Atkinson)	+	+	+	—
5. <i>Plagioporus</i> (s.l.) sp. Lyadov	—	—	—	+
6. <i>Neolebouria antarctica</i> (Szidat et Graefe)	+	—	+	—
7. <i>Discoverytrema gibsoni</i> Zdzitowiecki	—	—	+	—
8. <i>Discoverytrema markowskii</i> Gibson	—	—	+	+
9. <i>Helicometra antarcticae</i> Holloway et Bier	—	+	—	—
10. <i>Helicometra</i> sp. Prudhoe et Bray	—	+	—	—
11. <i>Stenakron glacialis</i> Zdzitowiecki	+	—	—	—
12. <i>Stenakron kerguelense</i> Prudhoe et Bray	—	—	—	+
13. <i>Stenakron</i> sp. Prudhoe et Bray	—	+	—	—
14. <i>Lepidapedon garrardi</i> (Leiper et Atkinson)	+	+	+	—
15. <i>Lepidapedon notogeorgianus</i> Zdzitowiecki	—	—	+	—
16. <i>Lepidapedon paralebouri</i> Zdzitowiecki	—	—	+	—
17. <i>Lepidapedon tertius</i> Zdzitowiecki	+	—	—	—
18. <i>Lepidapedon</i> sp. Rodjuk	+	—	—	—
19. <i>Paralepidapedon antarcticus</i> (Prudhoe et Bray)	—	+	—	+
20. <i>Paralepidapedon dubius</i> (Prudhoe et Bray)	—	+	—	—
21. <i>Neolepidapedon magnatestis</i> (Gaevskaja et Kovaljova)	+	—	+	+
22. <i>Neolepidapedon opisthobifurcatus</i> Zdzitowiecki	—	—	+	—
23. <i>Neolepidapedon trematomi</i> Prudhoe et Bray	+	+	+	+
24. <i>Muraenolepitrema magnatestis</i> Gaevskaja et Rodjuk	—	—	+	—
25. <i>Benthotrema melanostigni</i> Paruchin et Lyadov	—	—	—	+
26. <i>Lomasoma kergueleni</i> Paruchin et Lyadov	—	—	—	+
27. <i>Steganodermatoides kergueleni</i> Paruchin et Lyadov	—	—	—	+
28. <i>Fellodistomum</i> sp. Zdzitowiecki	—	—	+	—
29. <i>Steringophorus</i> sp. Prudhoe et Bray	—	—	—	+
30. <i>Otodistomum cestoides</i> (Beneden)	+	?	?	—
31. <i>Otodistomum</i> sp. Lyadov	?	?	?	—
32. <i>Postmonorchis variabilis</i> Prudhoe et Bray	—	—	+	+
33. <i>Derogenes varicus</i> (Müller)	+	?	?	+
34. <i>Derogenes johnstoni</i> Prudhoe et Bray	—	+	—	—
35. <i>Elytrophalloides oatesi</i> (Leiper et Atkinson)	+	+	+	+
36. <i>Genolinea bowersi</i> (Leiper et Atkinson)	+	+	+	+
37. <i>Glomicirrus macrouri</i> (Gaevskaja)	+	—	—	+
38. <i>Gonocerca lobata</i> Byrd	—	+	—	—
39. <i>Gonocerca medius</i> Lyadov	—	—	—	+
40. <i>Gonocerca muraenolepisi</i> Paruchin et Lyadov	—	—	—	+
41. <i>Gonocerca phycidis</i> Manter	+	+	+	+
42. <i>Lecithaster macrocotyle</i> Szidat et Graefe	+	—	+	+
43. <i>Lecithocladium cristatum</i> (Rudolphi)	?	?	?	—
44. <i>Lecitophyllum anteroporum</i> Margolis	?	?	?	—
45. <i>Lecitophyllum champsocephali</i> Zdzitowiecki	+	—	—	—

Manter (1954) described 66 species from marine fishes collected at New Zealand and Gaevskaja, Kovaljova and Rodiuk (1985) recognized 50 species in the Falkland-Patagonian shelf waters. Both totals are likely to be lower than the actual number of digenean species; recently further species have been reported (Gaevskaja and Rodjuk 1988a, b).

According to Manter (1954) some subantarctic digenean species have either bipolar or cosmopolitan distribution. It is true also for Antarctic digenean species. Five species, *Gonocerca phycidis*, *Derogenes varicus*, *Glomericirrus macrouri*, *Lecithocladium cristatum* and *Otodistomum cestoides*, were originally described from fishes living in the northern hemisphere and later found in the Antarctic. According to Gaevskaja and Kovaljova (1978), Gaevskaja, Kovaljova and Rodjuk (1985) and Gaevskaja and Rodjuk (1988b) five further Antarctic digenean species, *Elythrophalloides oatesi*, *Genolinea bowersi*, *Lecithaster australis* (= *L. macrocotyle*), *Lepidapedon antarcticus* (= *L. garrardi*) and *Opechona* (= *Neolepidapedon*) *magnatestis*, occur in fishes of the Falkland-Patagonian shelf. According to the present investigation *Macvicaria antarctica* should be added to this list as the sixth species. However, most of the Antarctic digenean species occurring in fishes seem to be endemic.

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Additional note

Recently the present author re-examined digeneans of the genus *Lecithaster*. Two closely related separate species (one undescribed) were identified in the material from South Georgian open sea fishes. The description of a new species occurring in *Muraenolepis microps*, as well as in some notothenioids, and corrections to faunistic data are in preparing for press.

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Streszczenie

Zbadano 704 ryby występujące na pełnym morzu w okolicach Południowych Szetlandów i Południowej Georgii. Należały one do 39 gatunków (Tab. 1), w tym 35 gatunków ryb kostnoszkieletowych i 4 chrzęstnoszkieletowe (płaszczki). Zebrano prawie wszystkie przywry digenetyczne występujące w rybach kostnoszkieletowych, natomiast tylko jedną przywrę znaleziono w płaszczce. Stwierdzono występowanie 25 gatunków tych pasożytów zasiedlających żołądek i jelito (Tab. 2), przy czym pasożyty żołądkowe występowały niekiedy w jamie gębowej i na skrzelach. Tylko jeden gatunek, *Derogenes varicus* Müller, stwierdzony przez autora wcześniej w fiordzie (Zatoka Admiralicji) Południowych Szetlandów, nie został znaleziony u ryb na pełnym morzu. Ryby pelagiczne były, z jednym wyjątkiem, niezarażone. Natomiast większość gatunków i osobników ryb przydennych była zarażona (Tabele 3—7). Rezultaty omawianych badań porównano z wynikami wcześniejszych badań autora, prowadzonych w fiordach Południowych Szetlandów (Zatoka Admiralicji) i Południowej Georgii (Zatoka Cumberland i Stromess Harbour) (Tab. 8; Rys. 1). Siedem gatunków przywr występuje u wielu różnych żywicieli na obu terenach badań. Dwa z nich, *Macvicaria pennelli* (Leiper et Atkinson) i *Genolinea bowersi* (Leiper et Atkinson), są związane z przybrzeżnym środowiskiem fiordowym i mogą być wykorzystane jako biologiczne wskaźniki powiązań żywicieli z tym środowiskiem. Trzy spośród szeroko rozpowszechnionych

szechnionych gatunków, *Lepidapedon garrardi* (Leiper et Atkinson), *Elytrophalloides oatesi* (Leiper et Atkinson) i *Lecithaster macrocotyle* Szidat et Graefe oraz stwierdzony tylko koło Południowej Georgii *Postmonorchis variabilis* Prudhoe et Bray, występują pospolicie zarówno w fiordach, jak i na pełnym morzu. *Gonocerca phycidis* Manter, *Neolebouria antarctica* (Szidat et Graefe) i prawie wszystkie mniej rozpowszechnione gatunki są związane ze środowiskiem przydennym szelfu pełnego morza oraz ewentualnie głębszymi niż 100 m częściami fiordów. Poziom zarażenia ryb jest niski na pełnym morzu w okolicach Południowych Szetlandów (wyjątkiem był jeden masowo zarażony *Dissostichus eleginoides*), natomiast bardzo wysoki na pełnym morzu w okolicach Południowej Georgii, podobnie jak w fiordach w obu rejonach badań. W okolicach Południowej Georgii gatunkiem dominującym był *E. oatesi*, który w okolicach Południowych Szetlandów występował nielicznie, szczególnie rzadko na pełnym morzu.

W pracy zamieszczono listę 45 gatunków przywr digenetycznych występujących u ryb w całej Antarktyce (Tab. 9). Większość z nich jest endemiczna, ale 5 gatunków występuje kosmopolitycznie, a 6 dalszych znaleziono w Subantarktyce.