



Larval stages of helminths in fish from the Vistula Lagoon and the Gulf of Gdańsk in relation to bird occurrence

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Abstract. A total of 5, 835 specimens of fish belonging to three families, Cyprinidae, Percidae and Gasterosteidae, were examined from January 1993 to March 1997. Sixteen species of parasites in the larval stage were observed and identified. The parasite species included: *Digenea* (*Diplostomum helveticum*, *Diplostomum spathaceum*, *Diplostomum paracaudum*, *Tylodelphys clavata*, *Ichthyocotylurus platycephalus*, *Ichthyocotylurus variegatus*, *Apatemon annuligerum*, *Posthodiplostomum cuticola*, *Posthodiplostomum brevicaudatum*); *Cestoda* (*Diphyllobothrium ditremum*, *Ligula intestinalis*, *Schistocephalus solidus*, *Paradilepis scolecina*); *Nematoda* (*Eustrongylides mergorum*) and *Acanthocephala* (*Corynosoma strumosum*, *Corynosoma semerme*). Based on the results which were obtained and on data regarding the occurrence of birds in the investigated areas, it can be stated that birds of the Laridae family play the greatest role in helminth circulation followed by those from the Podicipedidae, Phalacrocoracidae and Anatidae families.

Key words: helminths, fish, birds, the Vistula Lagoon, the Gulf of Gdańsk

INTRODUCTION

A comparatively large body of knowledge concerning the helminths of fish from the waters of the Vistula Lagoon and the Gulf of Gdańsk exists. However, there is not much data concerning the parasites of other vertebrates.

In the present work, it was decided to use data regarding larval stage helminths in fish to determine the potential bird species which are the most numerous final hosts of these parasites. Ichthyophagous birds are an indispensable link in the life cycle of many helminth species.

MATERIALS AND METHODS

A total of 5,835 fish, 3,431 from the Gulf of Gdańsk and 2,404 from the Vistula Lagoon, were examined from January 1993 to March 1997. The fish belonged to three families: Cyprinidae, Percidae and Gasterosteidae (Table 1). In the Vistula Lagoon, these families were represented

Table 1. Numbers fish species examined

Fish species	Gulf of Gdańsk	Vistula Lagoon
<i>Gasterosteus aculeatus</i> / stickleback	2880	8
<i>Rutilus rutilus</i> / roach	34	389
<i>Pelecus cultratus</i> / sichel	-	322
<i>Abramis brama</i> / common bream	47	376
<i>Carassius auratus gibelio</i> / german carp	-	101
<i>Tinca tinca</i> / tench	-	39
<i>Alburnus alburnus</i> /bleak	-	29
<i>Blicca bjoercna</i> / white bream	-	31
<i>Vimba vimba</i> / vimba bream	-	5
<i>Aspius aspius</i> /asp	-	7
<i>Scardinius erythrophthalmus</i> / rudd	-	4
<i>Leuciscus idus</i> / ide	-	1
<i>Leuciscus leuciscus</i> /dace	-	1
<i>Stizostedion lucioperca</i> / pikeperch	189	390
<i>Perca fluviatilis</i> / perch	281	371
<i>Acerina cernua</i> / ruffe	-	330
Total	3,431	2,404

by the common species of bream, roach, sichel, pike-perch, perch and ruffe and in the Gulf of Gdańsk by stickleback.

The fish originated from different regions of the Gulf of Gdańsk and the Vistula Lagoon (Fig. 1).

Both bodies of water are estuarine water reservoirs which are constantly influenced by the inputs of fresh and salty waters. According to data from the State Institute of Meteorology and Water Management in Gdynia, during the investigation period the average salinity in the Gulf of Gdańsk was 7‰ and in the Vistula Lagoon it was 2.7 ‰.

Cyprinid and percoidean fish were supplied by fishermen and Gasterosteidae were caught using minnow nets.

The parasites obtained were fixed in Berland fluid (acetic acid and formalin, 95:5) and then preserved in 70% alcohol. In order to determine the taxonomic classification of the parasites total preparations were made. Digenea, Cestoda and Acanthocephala were later colored in carmine alun acid and dehydrated successively in 50%, 70%, 85% alcohol, then twice in 96% alcohol, cleared in beechwood creosote and mounted in Canada balsam. The nematodes were exposed to lactophenol and placed in glycerin jelly.

RESULTS

Sixteen parasite species were identified. Digenea dominated over Cestoda, Nematoda and Acanthocephala.

The morphological and anatomical similarities of metacercariae of the genus *Diplostomum* can make identification and classification difficult (Graczyk 1992, Laskowski 1996, Niewiadomska 1996, Niewiadomska and Szymański 1991). The *Diplostomum* specimens were identified to the genus level, and some of the metacercariae were identified to the species level, including *Diplostomum helveticum*, *D. spathaceum* and *D. paracaudum*. These

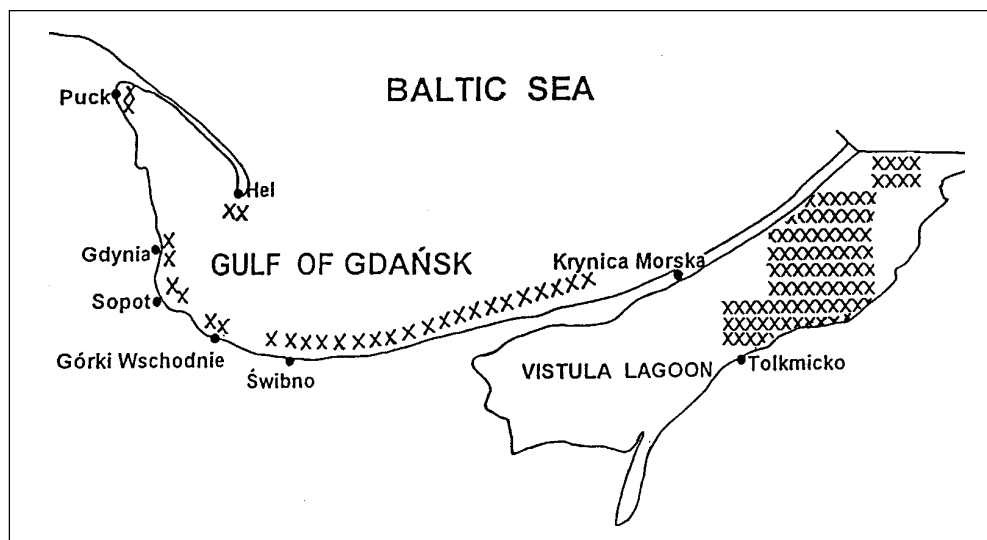


Fig. 1. Capture areas of fish for investigations (x)

Table 2. Prevalence [%] and mean intensity [ind.] of parasitic infestation of fish from Gulf of Gdańsk

Parasite/fish	Stickle-back	Common Bream	Roach	Pike perch	Perch
DIGENEA					
<i>Diplostomum spp.</i>	3.9/3.3	25.5/4.7	23.5/2.5	2.6/3.8	7.1/14.9
<i>Tylodelphys clavata</i>	-	12.8/2.2	52.9/1.7	2.1/3	32.4/45.2
<i>Ichthyocotylurus platycephalus</i>	-	-	-	1.6/3.7	1/3
<i>Apatemon annuligerum</i>	15.4/2.6	-	-	-	1.7/1.6
CESTODA					
<i>Diphyllobothrium ditremum</i>	0.7/2.9	-	-	-	-
<i>Ligula intestinalis</i>	-	17/1.1	-	-	-
<i>Schistocephalus solidus</i>	6.3/1.2	-	-	-	-
NEMATODA					
<i>Eustrongylides mergorum</i>	0.07/1.5	-	-	-	-
ACANTHOCEPHALA					
<i>Corynosoma strumosum</i>	-	-	-	0.5/1	-
<i>Corynosoma semerme</i>	-	-	-	1/1	-

-: no infested fish

three species were from roach, bream, sichel and perch. The presence of other species of metacercariae cannot be ruled out. Due to the more than 20,000 parasite specimens which were collected, it was very difficult to identify all the species.

There were 12 helminth species from the Gulf of Gdańsk and 15 from the Vistula Lagoon (Tables 2, 3a and 3b). These were larvae which occur in the adult stage in the digestive tracts of ichthyophagous birds. The exceptions are *Corynosoma semerme* and *C. strumosum*, which usually live in the intestines of sea mammals. Birds act only as paratenic hosts for these acanthocephalans.

DISCUSSION

About 80 species of breeding birds, both migratory and non-migratory, live in the Gulf of Gdańsk and the Vistula Lagoon regions. Seventeen are birds of prey, of which fifteen are ichthyophagous and five are polyphagous species (Table 4). The other species are phytophagous, benthophagous and entomophagous, which occasionally feed on fish. A significant role in the circulation of helminths in the waters of the Gulf of Gdańsk and the Vistula Lagoon is played by ichthyophagous birds.

Until now, only a few parasite species which occur in the larval stage in fish have been identified in birds inhabiting the Gulf of Gdańsk. These include *Diplostomum commutatum* (Digenea) in common terns, *Diplostomum spathaceum* (Digenea) in common gulls (Markowski 1933a) and black-headed gulls (Cichowlas 1961), *Apatemon gracilis* (Digenea) in long-tailed ducks, *Cryptocotyle concavum* (Digenea) in long-tailed ducks (Sulgostowska and Grytner-Zięcina 1973 and 1974), velvet scoters and eiders (Grytner-Zięcina and Sulgostowska 1978) and *Diphyllobothrium dendriticum* (Cestoda) in common terns (Markowski 1933a). The helminths noted in the birds from the Vistula Lagoon were *Diplostomum baeri* (Digenea) in black-headed gulls, *Diplostomum spathaceum*, *Apophallus muhlingi* and *Mesorchis pseudoechinatus* (Digenea) in great black-backed gulls, lesser black-backed gulls, common gulls and black-headed gulls, and *Cryptocotyle concavum* (Digenea) in common gulls, great black-backed gulls and black-headed gulls (Malczewski 1964). Okulewicz and Rokicki (1998) found the nematod *Contracaecum micropapillatum* in cormorants from the Gulf of Gdańsk and the Vistula Lagoon. However, only metacercariae *Cryptocotyle concavum* in deepsnouted pipefish (*Syngnathus typhle*) and sand goby (*Pomatoschistus minutus*) were confirmed in the Gulf of Gdańsk (Markowski 1933b and 1935). The presence of Digenea from the genus *Diplostomum* spp. was noted.

It was revealed that Digenea from the genus *Diplostomum* and *Tylodelphys clavata* most often appear in the cyprinid, percoidean and Gasterosteidae fish of the Gulf of Gdańsk and the Vistula Lagoon (Tables 2, 3a and 3b). *Diplostomum* were observed in all the examined species of fish, and the most infested were bream, roach and stickleback. According to the literature, *Diplostomum* spp. has a wide range of hosts which includes over 125 species of fish belonging to many families, including, among others, Cyprinidae, Percidae and Gasterosteidae (McKeown and Irwin 1995). Specimens of adult *Diplostomum* were noted in four bird orders and Charadriiformes, mainly from the suborder Larii, were most often infested (Niewiadomska 1996, Shigin 1996). The metacercariae *Tylodelphys clavata* settle in the corpus vitreum of percoidean fish, mostly perch (Kennedy and Burrough 1977, Pojmańska *et al.* 1980); many authors also report high infestation levels in some cyprinids (Kozicka 1959, Pojmańska *et al.* 1980). In the current work, the highest infestation values were noted in roach and perch in the Gulf of Gdańsk and in the Vistula Lagoon. Adult specimens of *T. clavata* were noted in birds from the genus *Podiceps* (Kozicka and Niewiadomska 1960). High infestation coefficients of these species in the fish in Gulf of Gdańsk and the Vistula Lagoon result from their wide occurrence in, among others, their final hosts. *Diplostomum* spp. infest birds of the genus *Larus* and *Phalacrocorax*, and *Tylodelphys clavata* infest birds of the genus *Podiceps podiceps*. From the observations of Kozakiewicz *et al.* (1997), Meissner and Goc (oral information, University of Gdańsk) it appears that the above mentioned genera of birds represent only several species of the great number which occur in the Gulf of Gdańsk and Vistula Lagoon regions. It should also be added, that the fish which are intermediate parasite hosts belong to species commonly occurring in the waters of the Gulf of Gdańsk and the Vistula Lagoon.

Table 3a. Prevalence [%] and mean intensity [ind.] of parasitic infestation of cyprinids from Vistula Lagoon

Parasite/fish	Common bream	Roach	Sichel	German carp	Tench	Bleak	White bream	Vimba bream	Asp	Rudd	Ide	Dace
DIGENEA												
<i>Diplostomum spp.</i>	84.3/35.4	8.3/17.9	24.7/11.7	28.7/11.7	7.7/2	*/2	9.7/84	*/32	*/6.8	*/51.7	*/90	*/190
<i>Tylolephys clavata</i>	14.9/7.8	69.9/27.6	-	1/2	2.6/1	-	3.2/7	-	*/5	-	*/41	-
<i>Ichthyocotylurus platycephalus</i>	6.1/3.7	0.5/2.5	-	-	-	-	-	*/1	-	-	*/3.0	-
<i>Posthodiplostomum cuticola</i>	17.8/8.6	26.5/6.7	0.6/1	3/1.7	-	-	9.7/4.0	-	-	-	-	*/6
CESTODA												
<i>Ligula intestinalis</i>	9.3/1.5	1/1	6/1.3	-	-	-	19.4/1.2	-	-	-	-	-
<i>Paraditleps scolecina</i>	0.3/1	0.8/5.7	-	-	5.1/2.5	-	-	-	-	-	-	-
NEMATODA												
<i>Eustrongylides mergorum</i>	-	-	-	-	-	-	-	-	*/1	-	-	-

Table 3b. Prevalence [%] and mean intensity [ind.] of parasitic infestation of stickleback and percoids from Vistula Lagoon

Parasite/fish	Stickleback	Pikeperch	Perch	Ruffie
DIGENEA				
<i>Diplostomum spp.</i>	*/7	5.4/4.3	11.6/5	8.8/3.6
<i>Tylolephys clavata</i>	*/2	2.8/1.8	53/44	0.6/8.5
<i>Ichthyocotylurus platycephalus</i>	-	4.4/2.1	1.3/2	2.1/9.4
<i>Ichthyocotylurus variegatus</i>	-	-	3.8/2.4	0.3/1
<i>Apatemon annuligerum</i>	*/2	-	5.1/3.7	-
<i>Posthodiplostomum brevicaudatum</i>	-	-	3.8/5.7	-
CESTODA				
<i>Ligula intestinalis</i>	-	-	-	-
<i>Schistocephalus solidus</i>	*/1	-	-	-
NEMATODA				
<i>Eustrongylides mergorum</i>	*/2	-	-	22.1/1.1
ACANTHOCEPHALA				
<i>Corynosoma strumosum</i>	-	0.8/1	-	-
<i>Corynosoma semerme</i>	-	0.5/1	-	-

*: due to low specimen numbers (<30)prevalence disregarded, -: no infested fish

Of the six cyprinid species in the Vistula Lagoon in which *Posthodiplostomum cuticola* was found, the most infested were bream and roach (Table 3a). Similarly, Kozicka (1958 and 1963) and Kennedy (1974) observed these metacercariae mostly in cyprinids. The final hosts of this parasite are birds from the Ardeidae family, which occur in the Vistula Lagoon (Goc and Iliszko 1993, Tomiałojć 1990). The lack of parasites in the fish of the Gulf of Gdańsk may result from the sporadic occurrence of their final hosts and of the hosts of parthenogenetic generations of freshwater *Gastropoda* from the genus *Planorbis*. For the sake of comparison, Grabda-Kazubska and Batro-Warszawska (1987) obtained a prevalence of over 60% in bream, roach, rudd and white bream in the freshwater Lake Dgaj.

Parasites from the genus *Ichthyocotylurus* were noted in perch and pike-perch in the Gulf of Gdańsk (Table 2) and in bream, roach, vimba bream, ide and in all the percoids in the Vistula Lagoon (Table 3a, 3b). They have a wide range of intermediate hosts among various species of freshwater fish (Bauer 1987). Attention should also be drawn to the fact that the host of the parthenogenetic generation of this parasite is the fresh-water snail *Valvata piscinalis*, a species which is rare in both the gulf and the lagoon in spite of the commonness of its final host, the gull. Thus, the infestation level of fish here is lower than is typical in freshwater reservoirs. For example, in the Vistula River near Warsaw, the infestation of bream was 83% (Reda 1987) and in the Konin lake complex it was over 50% (Pojmańska *et al.* 1980).

The next parasite, *Apatemon annuligerum*, occurred in perch, which is convergent with the observations of Kozicka (1972), and in stickleback (Table 2, 3b). This parasite is classified as a freshwater species since it inhabits mainly freshwater. This is why the level of infestation in the brackish waters of the Gulf of Gdańsk and Vistula Lagoon regions is clearly lower than that in freshwater reservoir, where infestation can even reach 100% (Lukyantseva 1976). It must be mentioned that *A. annuligerum*'s final host is Anatidae, which occur widely in the area under investigation (Goc and Iliszko 1993, Meissner and Skakuj 1990, Tomiałojć 1990, Zyska *et al.* 1990).

Ligula intestinalis plerocercoids were observed in the bream of the Gulf of Gdańsk (Table 2) and in the bream, roach, sichel and white bream of the Vistula Lagoon (Table 3a). This tapeworm is a common parasite in cyprinids (Kennedy and Burrough 1981, Sweeting 1976). In Poland it occurs most frequently in bream, roach and rudd (Kwiatkowski and Pokora 1995). In freshwater, the degree of fish infestation often reaches 100% (Bryliński 1970). The final hosts of this tapeworm include Laridae, Podicipedidae, Anatidae, all of which occur on a massive scale in the investigated region. This is also why a lowered infestation level is observed in the fish in the brackish waters of the Gulf of Gdańsk and the Vistula Lagoon; this may result from the rare occurrence of this tapeworm's first intermediate host, namely, freshwater crustacean species.

The plerocercoid *Schistocephalus solidus* occurred only in stickleback (Table 2, 3b), which, in the opinion of Solonchenko (1982), is its main host. The adult stages of this tapeworm were found, similarly to *Ligula intestinalis*, mostly in Podicipedidae, Laridae and Anatidae (Bezubik 1956), which, as has been mentioned previously, are common species in the Gulf of Gdańsk and Vistula Lagoon regions. As was the case with *L. intestinalis*, the *S. solidus* tapeworms achieved higher levels of infestation in freshwater, where these levels often reach several tens of percents (Haitlinger and Wolańska 1965).

Larvae of the nematode *Eustrongylides mergorum* were found in the Vistula Lagoon in ruffe (22.1%) and in one specimen each of stickleback and asp (Table 3a, 3b). In the Gulf of Gdańsk this nematode occurred only in stickleback and its infestation level was very low at just 0.07% (Table 2). In spite of the wide-spread occurrence of its final host (including Laridae,

Table 4. Bird species occurrence in Gulf of Gdańsk and Vistula Lagoon (Goc and Iliszko 1993; Goc – pers. comm., University of Gdańsk; Meissner – pers. comm., University of Gdańsk; Tomiałojć 1990; Zyska *et al.* 1990)

Predators/Icthyophags	Poliphags	Others
<i>Gavia arctica</i> / black-throated diver	<i>Larus ridibundus</i> / black-headed gull	<i>Cygnus olor</i> / mute swan
<i>Gavia stellata</i> / red- throated diver	<i>Larus canus</i> / common gull	<i>Cygnus cygnus</i> / whooper swan
<i>Tachybaptus ruficollis</i> / little grebe	<i>Larus argentatus</i> / herring-gull	<i>Anser albifrons</i> / white-fronted goose
<i>Podiceps cristatus</i> / great crested grebe	<i>Larus fuscus</i> / lesser black-backed gull	<i>Tadorna tadorna</i> / sheldrake
<i>Podiceps griseigena</i> / red-necked grebe	<i>Larus marinus</i> / great black-backed gull	<i>Anas platyrhynchos</i> / wild duck
<i>Podiceps nigricollis</i> / black-necked grebe		<i>Anas penelope</i> / wigeon
<i>Podiceps auritus</i> / slavoianian grebe		<i>Anas crecca</i> / teal
<i>Ardea cinerea</i> / common heron		<i>Anas acuta</i> / pintail
<i>Mergus merganser</i> / goosander		<i>Aythya ferina</i> / pochard
<i>Mergus albellus</i> / smew		<i>Aythya fuligula</i> / tufted duck
<i>Mergus serrator</i> / red-breasted		<i>Bucephala clangula</i> / goldeneye
<i>Chlidonias niger</i> / black tern		<i>Clangula hyemalis</i> / long-tailed duck
<i>Sterna albifrons</i> / little tern		<i>Melanitta fusca</i> / velvet scoter
<i>Sterna hirundo</i> / common tern		<i>Melanitta nigra</i> / common scoter
<i>Phalacrocorax carbo</i> / cormorant		<i>Somateria mollissima</i> / eider
<i>Alcedo atthis</i> / kingfisher		<i>Fulica atra</i> / coot
<i>Haliae'tus albicilla</i> / white-tailed eagle		and others

Podicipedidae, Anatidae) and intermediate hosts (*Oligochaeta*), the level of infestation of this parasite in the fish of the gulf and the lagoon is considerably lower than that in the fish of freshwater reservoirs. This is concurrent with the observations of Fagerholm (1982), who observed that 45% of the ruffe in freshwater Finnish lakes were infested.

The remaining helminth larval species (*Diphyllobothrium ditremum*, *Posthodiplostomum brevicaudatum*, *Paradilepis scolecina*, *Corynosoma semerme* and *C. strumosum*) were noted less frequently. It must be added that their final hosts are the following birds: *Phalacrocorax* (for *P. scolecina*), Laridae, Anatidae (for *D. ditremum*) and Ardeidae (for *P. brevicaudatum*). All of these, with the exception of Ardeidae, commonly inhabit the Gulf of Gdańsk and Vistula Lagoon regions. With respect to acanthocephalans, it should be added that the birds act only as paratenic hosts (Petrochenko 1958); thus, these parasites do not reach reproductive maturity in this host. It is improbable that birds, in comparison with other paratenic hosts, are the source of infestation for this parasite's final host, the seal. Therefore, it must be acknowledged that these birds do not provide these acanthocephalans with a link for further development and, as a result, they die.

On the basis of the analysis of larval stages occurring in Cyprinidae, Percidae and Gasterosteidae fish and by relating to this the occurrence of birds in the investigated reservoirs, it was ascertained that in the waters of the Gulf of Gdańsk and the Vistula Lagoon the greatest role in the circulation of parasitic helminths was played by birds from the Laridae, Phalacrocoracidae, Podicipedidae and Anatidae families, of which gulls are one of the most important final hosts for water helminths.

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