

Helminth communities of European eels *Anguilla anguilla* (Linnaeus, 1758) from the Vistula Lagoon and Puck Bay, Poland

Zofia Bystydzińska¹ Leszek Rolbiecki² and Jerzy Rokicki²

¹Sea Fisheries Institute, ul. Kołłątaja 1, 81-332 Gdynia

²Department of Invertebrate Zoology, University of Gdańsk, Al. Marsz. Piłsudskiego 46, 81-378 Gdynia;
E-mail: rokicki@ocean.univ.gda.pl

ABSTRACT. Within 2001-2002 a total of 621 eel *Anguilla anguilla* (L., 1758) (488 from the Vistula Lagoon and 133 from the Puck Bay) were examined. Fifteen parasite taxa were recovered: *Pseudodactylogyrus anguillae* (Yin et Sproston, 1948), *Brachyphallus crenatus* (Rudolphi, 1802), *Deropristis inflata* (Molin, 1859), *Diplostomum* spp., *Bothriocephalus claviceps* (Goeze, 1782), *Proteocephalus macrocephalus* (Creplin, 1825), *Anguillicola crassus* (Kuwahara, Niimi et Itagaki, 1974), *Camallanus lacustris* (Zoega, 1776), *Cystidicola farionis* Fischer, 1798, *Hysterothylacium aduncum* (Rudolphi, 1802), *Raphidascaris acus* (Bloch, 1779), *Acanthocephalus anguillae* (Müller, 1780), *A. lucii* (Müller, 1776), *Echinorhynchus gadi* Müller, 1776, and *Pomphorhynchus laevis* (Müller, 1776), representing Monogenea, Digenea, Cestoda, Nematoda, and Acanthocephala, respectively. Ten of these taxa occurred in the Vistula Lagoon, while fourteen were noted in the Puck Bay. *P. anguillae*, *Diplostomum* spp., *C. lacustris*, *C. farionis* and *P. laevis* were not found in the lagoon eels, while *B. crenatus* did not occur in the bay. *Anguillicola crassus* was the most frequently found parasite (Vistula Lagoon: prevalence 75%, mean intensity 6.9 specimens; Puck Bay: 74.4%, and 8.3 specimens, respectively). *Pseudodactylogyrus anguillae* was recorded for the first time in the Puck Bay.

Key words: eel, helminth community, Poland, Puck Bay, Vistula Lagoon.

Introduction

Eel is one of the most valuable commercial fish species of the Vistula Lagoon and the Puck Bay [1, 2]. This fish is diadromous and catadromous, although it is also capable of migrations between different bodies of water e.g. Vistula Lagoon adjacent rivers (Nogat River), Drużno Lake, the Gulf of Gdańsk (including the Puck Bay), and the Baltic Sea). Eel is a predatory fish; reaching 60 cm in length and 1 kg in weight, although specimens as long as 2 m and weighing as much as 6 kg have also been noted.

There has been a large number of parasitological surveys, of this fish species in Polish waters [3-23]. On the other hand, very few studies focused on eel from the Puck Bay and the Vistula Lagoon, and they were usually limited to individual parasite groups (e.g. Puck Bay tapeworms [10]; Vistula Lagoon co-

pepods [3, 9], nematode *Anguillicola crassus* [16, 21], as well as Microsporea and Myxozoa [22]). The parasites of eel from the Russian zone of the Vistula Lagoon have also been studied [24-27]. Appearance of non-indigenous parasites such as *Pseudodactylogyrus anguillae*, *P. bini*, and, especially, *Anguillicola crassus*, prompted an increased interest in parasite fauna of the eel.

The present study focuses on the helminth communities of eel from two basins – the Vistula Lagoon and the Puck Bay. The Vistula Lagoon is one of the largest lagoons in the southern Baltic Sea area with the surface area of 838 km² (of which 328 km² is located within Polish borders) and the depth of 2.6 m (maximum 5.1 m). The Puck Bay is a part of the Gulf of Gdańsk with a surface area of 115 km² and an average depth of 15.5 m (maximum 54 m) [28, 29]. Both of these basins are impacted by inflows of fresh water from rivers (the lagoon – pri-

marily from the Vistula through the Nogat, Elbląg, Pasłęka, Pregola; the bay – from the Reda River) as well as by the brackish waters of the Baltic, which is apparent in variations in salinity. In the Vistula Lagoon the salinity is at the level of 0.5-7‰, while in the Puck Bay it ranges from 3.8 to 8‰ [30, 31].

Materials and methods

The materials for the study comprised 488 fish specimens from the Vistula Lagoon (290 collected in September 2001 and 198 collected in August 2002), and 133 fish specimens collected from the Puck Bay in 2002 (June – 43, July – 31, August – 30, September – 29). The material from the Vistula Lagoon consisted exclusively of frozen viscera, while the Puck Bay was represented by fresh eels (length: 520-1000 mm, weight: 210-1600 g). Only in the case of two specimens, the gills of the Puck Bay fish were obtained.

A dissecting microscope was used to locate parasites in the viscera (alimentary tract, swim bladder, pancreas, gonads, liver, and kidneys) and also in the eyes and on the gills.

The helminths collected were fixed in a mixture of glacial acetic acid and formalin (19:1) and preserved in 70% ethanol. In order to facilitate the

species identification, the flukes and nematodes were cleared in lactophenol, the tapeworms and acanthocephalans were stained with carmine borax, placed in glacial acetic acid and cleared in benzyl alcohol.

Results

Fifteen helminth species were recovered from the eels studied, including one taxon of the generic level (*Diplostomum*). Ten taxa (2 digeneans – one determined at the genus level only, 2 cestodes, 3 nematodes, and 3 acanthocephalans) were noted in the Vistula Lagoon, while 14 taxa (1 monogenean, 2 digeneans, 2 cestodes, 5 nematodes, and 4 acanthocephalans) were noted in the Puck Bay. Nine species were common for both bodies of water (1 digenean, 2 cestodes, 3 nematodes, and 3 acanthocephalans). One digenean species was recorded only in the Vistula Lagoon, while 5 taxa (1 monogenean, 1 digenean, 2 nematodes, and 1 acanthocephalan) were recorded only in the Puck Bay (Table 1).

Except the tapeworms *Bothriocephalus claviceps* and *Proteocephalus macrocephalus* in the Puck Bay and *Anguillicola crassus*, *Camallanus lacustris*, and *Raphidascaris acus* in the Vistula Lagoon, the remaining parasites were recorded in

Table 1. Prevalence (%)/ mean intensity (ind.)/ and range of intensity (ind.) of parasites in the eel from the Vistula Lagoon and the Puck Bay in the 2001-2002 period

Parasite	September 2001	Vistula Lagoon August 2002	Total	Puck Bay VI-IX 2002
Monogenea				
<i>Pseudodactylogyrus anguillae</i> *	–	–	–	100 / 11 / 6-16
Digenea				
<i>Brachyphallus crenatus</i>	0.3 / 1 / 1	0	0.2 / 1 / 1	0
<i>Deropristis inflata</i>	0.3 / 1 / 1	0.5 / 1 / 1	0.4 / 1 / 1	0.7 / 1 / 1
<i>Diplostomum</i> spp., met.	–	–	–	51.1 / 6.8 / 1-88
Cestoda				
<i>Bothriocephalus claviceps</i>	0	2 / 1.5 / 1-2	0.8 / 1.5 / 1-2	30.1 / 2.8 / 1-11
<i>Proteocephalus macrocephalus</i>	4.8 / 2.9 / 1-15	13.7 / 4.2 / 1-22	8.4 / 3.8 / 1-22	23.3 / 4.8 / 1-42
Nematoda				
<i>Anguillicola crassus</i>	72.2 / 6.8 / 1-53	79.2 / 7.1 / 1-58	75 / 10 / 1-58	74.4 / 8.3 / 1-62
<i>Camallanus lacustris</i>	0	0	0	3.8 / 2 / 1-7
<i>Cystidicola farionis</i>	0	0	0	0.7 / 7 / 7
<i>Hysterothylacium aduncum</i>	0	0.5 / 1 / 1	0.2 / 1 / 1	0.7 / 1 / 1
<i>Raphidascaris acus</i>	51.6 / 3.9 / 1-39	63.5 / 7.5 / 1-92	56.1 / 5.6 / 1-92	4.5 / 5 / 1-12
Acanthocephala				
<i>Acanthocephalus anguillae</i>	0.7 / 4.5 / 1-8	0.5 / 1 / 1	0.6 / 3.3 / 1-8	1.5 / 1 / 1
<i>Acanthocephalus lucii</i>	0.3 / 14 / 14	0	0.2 / 14 / 14	0.7 / 14 / 14
<i>Echinorhynchus gadi</i>	0	0.5 / 1 / 1	0.2 / 1 / 1	3 / 3.2 / 1-10
<i>Pomphorhynchus laevis</i>	0	0	0	6.0 / 2.8 / 1-10
Total	84.5 / 8.5 / 1-53	94.9 / 11.6 / 1-92	88.7 / 9.8 / 1-92	86.5 / 10.3 / 1-88

* = the gills of only two fish were examined, – = not examined, 0 = not found

eel from these basins for the first time. Additionally, *Pseudodactylogyrus anguillae* has not been previously noted in the Puck Bay.

Discussion

Among the combined total of fifteen parasite taxa recovered (Table 1), one species (*Brachyphallus crenatus*) was found only in the Vistula Lagoon, and 5 taxa were found only in the Puck Bay (*Pseudodactylogyrus anguillae*, *Diplostomum* spp., *Camallanus lacustris*, *Cystidicola farionis*, *Pomphorhynchus laevis*). The species commonly occurring in both the Vistula Lagoon and the Puck Bay were *Deropristis inflata*, *Bothriocephalus claviceps*, *Proteocephalus macrocephalus*, *Anguillicola crassus*, *Hysterothylacium aduncum*, *Raphidascaris acus*, *Acanthocephalus anguillae*, *A. lucii*, and *Echinorhynchus gadi*. It is worth mentioning that five species were specific to eel. These include *Pseudodactylogyrus anguillae*, *Deropristis inflata*, *Bothriocephalus claviceps*, *Proteocephalus macrocephalus*, and *Anguillicola crassus* [32-35]. The overall infection rate was high and was only slightly higher in the fish from the Vistula Lagoon (88.7%) than in those from the Puck Bay (86.5%), at a mean intensity of 10.3 specimens in the bay and 9.8 specimens in the lagoon.

The dominant species in both the Vistula Lagoon and the Puck Bay was the nematode *Anguillicola crassus*. In the Puck Bay, the metacercariae *Diplostomum* spp. (however, only the eyes of fish from the Puck Bay were examined), tapeworms *Bothriocephalus claviceps* and *Proteocephalus macrocephalus* also occurred frequently, while in the lagoon these two species were not frequent: *P. macrocephalus* occurred in fewer than 10% of the fish, and *B. claviceps* – in less than 1%. Additionally in the Vistula Lagoon the nematode *Raphidascaris acus* was the common species. It is worth to mention that the freshwater crustacean cyclopoids (*Macrocyclus albidus*, *M. fuscus*, *Eucyclops macruroides*, *E. macrurus*, and *Cyclops insignis*), which normally play a role as intermediate host for *B. claviceps* and *P. macrocephalus* [33] were not present in the Vistula Lagoon. Instead in both the Vistula Lagoon [36-41] and in the Puck Bay [42, 43] some others species belonging to the same genus were present, and possibly served as intermediate hosts of these cestodes. For *R. acus* the higher infection level in eel from the Vistula Lagoon might be connected with the frequent occurrence of the intermediate hosts, i.e. various copepods, aquat-

ic oligochaetes, molluscs, insects, and fish – its paratenic hosts (second intermediate hosts?) [44], upon which eel, the definitive host, feed. It is worth mentioning that *R. acus* is often found in pike, salmonids, eel, gadids, and cyprinids [44]. *Diplostomum* spp. metacercariae had been described as occurring in over 125 different fish species as well as in Cyclostomata and the amphibians [45, 46, 47].

The remaining parasites (*Pseudodactylogyrus anguillae*, *Brachyphallus crenatus*, *Deropristis inflata*, *Camallanus lacustris*, *Cystidicola farionis*, *Hysterothylacium aduncum*, *Acanthocephalus anguillae*, *A. lucii*, *Echinorhynchus gadii*, and *Pomphorhynchus laevis*) were found rarely in eel and exhibited low infection parameters. The prevalence oscillated between 0.2 and 6%, and the mean intensity ranged from 1 to 14 specimens.

A significant factor in the occurrence of fish parasites is the water salinity. The location of the Vistula Lagoon and the Puck Bay cause that these basins are impacted by marine waters and fresh river water. Due to this, they are inhabited by typically marine, freshwater or brackish water species. Only four marine parasite species (*Bothriocephalus crenatus*, *Deropristis inflata*, *Hysterothylacium aduncum* and *Echinorhynchus gadii*) were present in the parasite communities in the Vistula Lagoon and the Puck Bay. The remaining parasites are regarded as freshwater species. A special emphasis should be given to three taxa, namely a digenean metacercariae of *Diplostomum* spp. and the nematodes *Anguillicola crassus* and *Raphidascaris acus*. Due to their high frequency in eel and the fact that mature ovigerous nematode females were noted, it can be acknowledged that these are species with a wide salinity tolerance. It was suggested in an earlier study [48] that *Diplostomum* spp. prefer brackish waters.

The diversified infection level of eel might also result from the specifics of the feeding of these fish in the bay and the lagoon. Unfortunately, the eel food composition has only been studied in the Vistula Lagoon [49-51].

An interesting issue have been alien species of parasites brought into European waters by eel, especially the nematode *Anguillicola crassus*. Until the 1980s this parasite occurred only in eel from Japan and China [33], and from there it was introduced into Europe [44, 52] and North America [53-55]. In a very short time period this nematode attacked the natural population of European eel causing symp-

toms of anguillicolosis, a serious disease that, in conjunction with other stressors, such as low oxygen content or transport, is often fatal. The European eel turned out to be more sensitive to infection than the Japanese eel. According to Egusa [56], throughout co-evolution, the Japanese eel developed resistance to the adverse effects of the parasite, which is exhibited, among other factors, by the low intensity of infection. The European eel has not yet developed resistance to *A. crassus*, as is manifested in the high infection rate of the fish and its tendency for consistent increase. The first available data on the occurrence of *A. crassus* in the Polish part of the Vistula Lagoon are from the 1988-1990 period, when the prevalence was 68.3% and the intensity 1-25 specimens [21]. In 1996 and 1997 the infection of eel was 100% with mean intensity of 8.3 specimens (only 10 fish examined), 92.9% with 6.9 specimens (14 fish examined), 94.4% with 10.3 specimens (18 fish examined), and 91.7% with 4.3 specimens (12 fish examined) [22]. Grawiński [16] also studied the occurrence of *A. crassus* in eel from the Polish zone of the Vistula Lagoon, but unfortunately, he only reports the maximum infection rate (75%) and intensity (12 specimens). The first available data on the occurrence of *A. crassus* in the Russian part of the Vistula Lagoon come from the early 1990s, when fish infection was at a level of 6.6% and 1-3 specimens [25]. Although earlier studies were not conducted on the *A. crassus* from the Puck Bay, data is available on the occurrence of this parasite in the Gulf of Gdańsk near Rewa from 1997-98, where eel infection was noted at 41.9% and 3 specimens [57]. The present results indicate an increased infection on a similar level in both basins (Vistula Lagoon - 75%, 10.0, 1-58 and Puck Bay - 74.4%, 8.3, 1-62). Another new species for European fauna is the branchial parasite *Pseudodactylogyrus anguillae*, which, similarly to *A. crassus*, originally occurred only in *Anguilla japonica* and *Anguilla reinhardti* in Japan, China, Taiwan, and Australia, and, along with a second species, *P. bini*, came to Europe from these regions [58, 59]. Some researchers believe, however, that *P. anguillae* is endemic to Europe and North America [60, 61]. In Poland to date this species has only been recorded in Lake Strazyn near Toruń [62], in rivers in Western Pomerania (Radew, Rega, Wieprza) [63] and in the Vistula Lagoon (Rolbiecki unpublished data).

Generally the overall infection parameters of the eel from the Vistula Lagoon and Puck Bay are si-

milar. For some species, however, the differences observed arise from the differences in the lagoon and bay habitats (including the presence of potential hosts, eel diet, salinity). It was interesting that the presence of species that are alien to the fauna of Poland and Europe, namely the branchial parasites *Pseudodactylogyrus anguillae* and the nematode *Anguillicola crassus*, was confirmed, and that these species, especially the nematode, exhibit widening distribution and increasing infection rates.

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