Oceanological and Hydrobiological Studies

International Journal of Oceanography and Hydrobiology

Volume 44, Issue 4, December 2015

pages (520-529)

ISSN 1730-413X
eISSN 1897-3191

Species richness and the diversity of parasite communities of eelpout *Zoarces viviparus* (Linnaeus, 1758) in the Oder River estuary, Poland

by

Ewa Sobecka*, Ewa Łuczak

Abstract

A parasitological study was carried out on 330 eelpouts from two fishing grounds of the Polish fishing zone off the Oder estuary (Pomeranian Bay and Dziwna Mouth). A total of 11 species and genera of parasites from six higher taxa were recorded: 1 monogenean, 1 digenean, 5 nematodes (eelpout was a new host for *Ascarophis morhuae* and *Capillaria gracilis*), 2 acanthocephalans, 1 mollusk and 1 protist (a fungus-related pathogen). A total of 4284 autogenic countable parasites were identified. These included parasites of eight species and two genera (six higher taxa) from Pomeranian Bay, and five species (two higher taxa) from the Dziwna Mouth. The abundance of parasites per host was higher in fish from the Dziwna Mouth, while the parasitic biodiversity index was almost two times lower than in Pomeranian Bay. *Pomphorhynchus laevis* dominated among the eelpout parasites in both fishing grounds, but the parasite communities from the Dziwna Mouth consisted of a larger number of dominating classes. The high intensity of infection of *Hysterothylacium auctum* and the relative density affect more the dimensions of the dominant parasite (*P. laevis*) in the Dziwna Mouth than the crowding of parasites. Infection by more abundant large parasites have an important influence on the value of Fulton's coefficient.

Key words: eelpout *Zoarces viviparous*, Oder River estuary, parasite fauna, *Ascarophis morhuae*, *Capillaria gracilis*, *Pomphorhynchus laevis*

DOI: **10.1515/ohs-2015-0049**
Category: **Original research paper**
Received: **April 22, 2015**
Accepted: **June 18, 2015**

Department of Hydrobiology, Ichthyology and Biotechnology of Breeding,
West Pomeranian University of Technology,
ul. Kazimierza Królewicza 4, 71-550 Szczecin, Poland

* Corresponding author: *ewa.sobecka@zut.edu.pl*

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Introduction

Eelpout *Zoarces viviparus* (L., 1758), which inhabits the littoral and sublittoral, and sporadically moves to depths exceeding 30 m, is a near-bottom, coastal predatory fish. The fish occurs in shallower waters in summer and in deeper waters in winter. It is also observed in estuaries, but it avoids waters with salinity below 5 PSU (Rutkowicz 1982). It is the only viviparous fish species in the Baltic Sea, which is why it is an exceptionally valuable component of the Baltic ichthyofauna. It moves slowly within a small area, hence it is considered to be a good bioindicator of water pollution (Bergek et al. 2012).

Significant declines in eelpout abundance of more than 50% have been observed during the last 20 years in Swedish surveys (HELCOM 2013). Also Polish fishermen report that catches of eelpout have declined over the past fifteen years; the species is usually caught with herring.

The parasite fauna of eelpout has probably not yet been thoroughly investigated. Until 1938, nine parasite species belonging to four higher taxonomic orders were observed in the Baltic Sea: digeneans (Trematoda), tapeworms (Cestoda), nematodes (Nematoda), and acanthocephalans (Acanthocephala). The first comprehensive work on the parasite fauna of the Baltic eelpout in the vicinity of Hel and the Gulf of Gdańsk was published by Markowski (1933, 1938). Other authors focusing on the parasites of eelpout in the southern Baltic include Möller (1975) in the Bay of Kiel, Rokicki (1975) in the Gulf of Gdańsk , Graś-Wawrzyniak et al. (1979) in the Bay of Puck, Sulgostowska et al. (1990) in the vicinity of Hel peninsula and Zander (1991) who studied fish from the south-western Baltic. This prompted further studies of the abundance and species composition of the parasite fauna of eelpout, the possible impact of parasites on the condition of the fish and the value of the Fulton coefficient, commonly used to assess the condition of the fish. This study is the first of its kind in the Oder River estuary.

Materials and methods

Sampling

Pomeranian Bay (PB), part of the Oder River estuary, is characterized by varying hydrochemical conditions resulting from the interactions between sea and inland waters. With its relatively small volume, the amount of river waters flowing through PB is relatively large. However, the water circulation in Pomeranian Bay has been reported to be driven mainly by winds (Majewski 1974, Masłowski 2010).

The Dziwna Mouth (DM) is the smallest part of the water area of the Western Pomeranian coast, and includes the part of PB where the impact of water flowing into the Baltic Sea through the strait is very strong. There is a fairway in this area running to the marine port, the fishing harbor, and the marina in *Dziwnów*. In accordance with the Water Framework Directive (2000), this area is classified as a transitional water area under a strong anthropogenic pressure from both the pollution coming from the DM and the Dziwnów town – a popular tourist destination.

The herring fishing has been monitored in different seasons throughout most Polish fishing grounds. However, eelpouts were obtained only in PB (vicinity of 54°02'N, 14°30'E; 297 fish) and in the fresh and sea water mixing zone at the mouth of the Dziwna strait (DM) (vicinity of 54°01'N, 14°42'E; 33 fish) at a depth of up to 10-12 m with trawls in several catches carried out from early spring until winter in the period of 2008-2011 (Fig. 1). The total length of fish from PB ranged from 11 to 52 cm ($\bar{x}$ – 27.23, SD – 6.61), and the weight ranged from 33 to 295 g ($\bar{x}$ – 120.31, SD – 46.05); the total length of fish from DM ranged from 14 to 36.5 cm ($\bar{x}$ – 24.56, SD – 5.47), and the weight ranged from 44 to 238 g ($\bar{x}$ – 112.55, SD – 67.92).

Parasitological studies

Parasitological examinations focused on the skin, vitreous humor, eye lens, mouth and nasal cavities, gills, heart, gonads, spleen, gastrointestinal tract, kidneys, gallbladder, urinary bladder, and peritoneum. The parasites found in the fish were identified by viewing the specimens immersed in glycerin or lactic acid under transient light, or preserved in 75% ethyl-alcohol. The acanthocephalan *Pomphorhynchus laevis* (Zoega in Müller, 1776) larvae were observed using a confocal microscope. Helminths (in addition to nematodes) were stained using alum carmine and mounted in Canada balsam.

The qualitative structure of the parasite

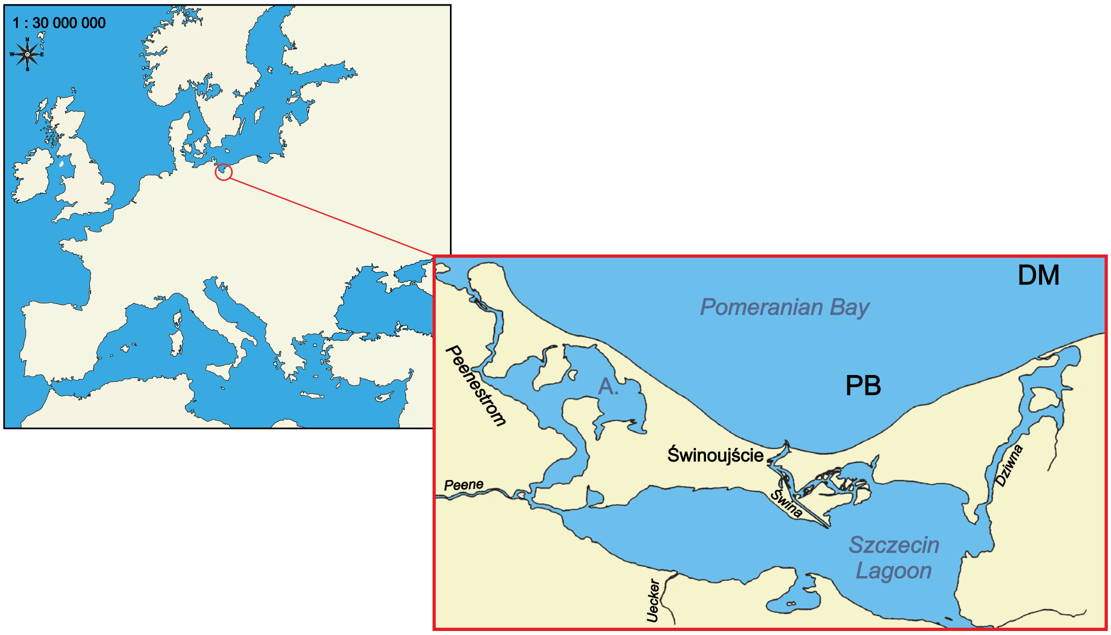

Figure 1

Location of the study area

communities was estimated taking into consideration their taxonomic position (based on their morphological features) and species diversity, and using the following sources: Bauer (1987), Anderson (1992), Moravec (1994), Niewiadomska (2003), Gibson et al. (2005), Grabda-Kazubska & Okulewicz (2005). Other original works with species descriptions were also consulted. The parasite nomenclature follows the above-mentioned sources as well as Fauna Europea, WoRMS (World Register of Marine Species) and Shinn et al. 2010.

The nomenclature used to describe the structure of the parasite communities was based on the studies by Margolis et al. (1982) and Bush et al. (1997).

The following indicators were used to analyze the species diversity of the communities: species richness as the number of parasite species; Margalef's biodiversity index and the Berger-Parker dominance index that indicates the share of species with the highest abundance in a given community. Similarities and differences between the communities from the two fishing grounds were determined using the Sørensen index based on qualitative data, i.e. presence or absence of species in samples (Czachorowski 2006).

The quantitative structure was analyzed by determining the quantitative composition of each of the qualitative groups (species or higher taxa). The following parameters were evaluated: prevalence (% of fish infected); mean intensity of infection (the mean number of parasites found in the infected hosts), crowding, which indicates the place of the parasite within the infrapopulation of a single host; relative density (the average number of parasites per one host in a sample); the dominance ratio which defines the role of the parasite in the community. Habitat preferences (topical structure) and co-occurrence of parasite species were also studied.

To determine whether the crowding and relative density affect the size of a dominant parasite, a morphometric study of the acanthocephalan *P. laevis* was also carried out using a microscope with a measuring apparatus and 10/0.25 and 40/0.65 magnification. The study included 120 individuals of both sexes (in the same proportions), collected from the most infected fish caught in the two fishing grounds (PB and DM). Only parasites with the spiny proboscis fully everted were selected (Fig. 2).

Spearman rank correlations were used to assess the relationships between Fulton's coefficient (K) and the parasite abundance in the fish.

The results were analyzed using the PQStat ver. 1.4.2.324 and Quantitative Parasitology (QP30 statistics packages), and the results were interpreted based on the principles presented in Rózsa et al. (2000), Reiczigel et al. (2005a,b).

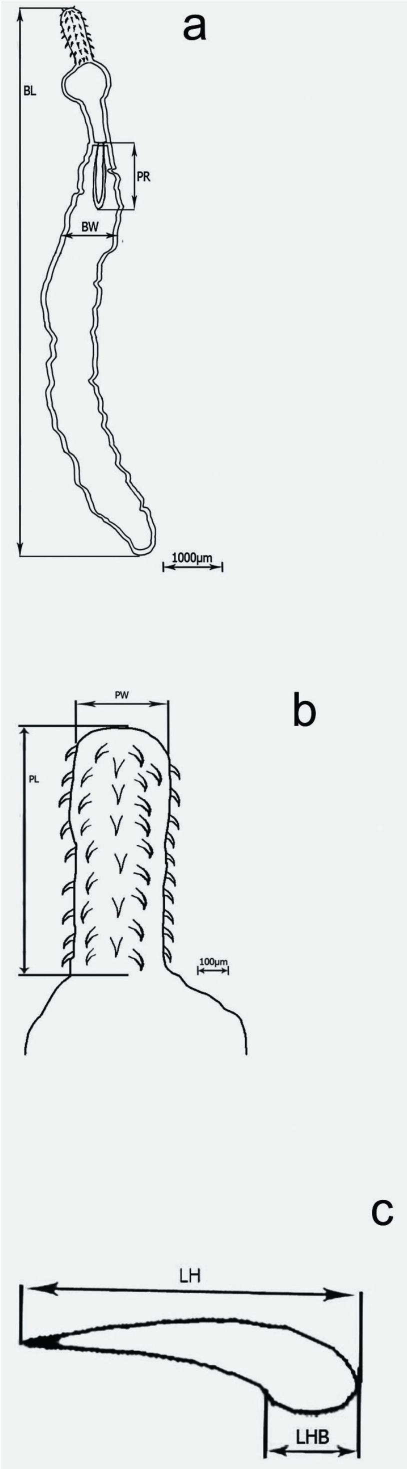

Figure 2

Morphometric features of *P. laevis*: BL – body length; BW – maximum body width; PL – proboscis length; PW – proboscis width; LH – length of the largest hook; LHB – length of the base of the largest hook; PR – length of the proboscis sheath

Results

The examination of 330 eelpouts resulted in the identification of 11 species (or genera) of parasites from six higher taxa, including 4284 countable parasites. A total of 3426 parasites of eight species and two genera (six higher taxa) were identified in the fish from PB, while 858 parasites of five species (two higher taxa) were identified in the eelpout from DM.

The identified species were the fluke *Asymphylodora kubanicum* (Issaitschikoff, 1923) (Trematoda: Digenea), *Gyrodactylus perlucidus* Bychowsky et Polyansky, 1955 (Monogenea), larval (L3 and L4) and adult forms of *Hysterothylacium auctum* (Rudolphi, 1802), adult *Ascarophis arctica* Polyansky, 1952, *Ascarophis morrhuae* van Beneden, 1871, *Ascarophis* sp., and *Capillaria gracilis* (Bellingham, 1840) (Nematoda), *Echinorhynchus gadi* Zoega in Müller, 1776 and *P. laevis* (Acanthocephala). *Pomphorhynchus laevis* occurred in both larval and adult forms. The larval stage (glochidia) of *Unio* sp. (Mollusca: Bivalvia) as well as *Ichthophonus hoferi* (Plehn and Mulsow, 1910) (Neomonada: Mesomycetozoea) were also identified.

The nematode *C. gracilis* was found in the fish caught in PB, and this was the first record of this species in the fish host. All of the parasites identified in the examined eelpouts were autogenic species that complete the full developmental cycle in one environment.

The biodiversity index value of the parasitic fauna in PB (0.9829) was almost twice as high as in DM (0.5907). Values of the Berger-Parker dominance index were similar at the two fishing grounds (PB = 49.97, DM = 54.35) and the Sørensen species similarity index was 53%.

The average number of parasite species in a single host was higher in fish from DM (0.151, 1-5) than from PB (0.037, 1-10); however, values of this index were low in the fish from both fishing grounds. The average number of the parasite per host was higher in fish from DM (26.00, range 3-61) than from PB (11.53, range 1-135).

Among the higher taxa, the class Acanthocephala was most abundantly represented (a total of 2410 helminths), while only 2 specimens of parasitic Bivalvia were found.

The prevalence of parasites in all the fish examined was 92.61%. The acanthocephalan *P. laevis* occurred most frequently and abundantly (from 1 to 135 parasites per fish). The highest prevalence was noted for *P. laevis* from PB, for which also the crowding value was the highest (Table 1).

The most frequently occurring parasite among the fish from DM was the nematode *H. auctum* (from 1 to 32 specimens per fish). The prevalence of all parasites ranged from 6.1 to 93.9% (DM) and 0.03 to 84.2% (PB) (Table 1). Parasites occurred more abundantly in eelpout from PB, where *P. laevis* from DM was observed with the highest relative density. Among the parasite community in the fish from DM, *H. auctum* was also characterized by a high relative density (in addition to *P. laevis*).

Pomphorhynchus laevis was the dominant eelpout parasite at both fishing grounds. However, the dominating classes of the parasite communities from DM had higher values (Table 2).

All larval nematodes, some acanthocephalan larvae and all adult helminths were found in the stomach and the intestinal lumen of the host. These included the trematodes (*A. cubanicum*), adult (*C. gracilis*, *H. auctum*, *A. arctica*, *A. morhue*, *Ascarophis* sp.) and larval nematodes (*H. auctum*), and adult (*E. gadi*, *P. laevis*) and larval (cystacanth *P. laevis*) acanthocephalans. The remaining topical communities were less abundant and comprised both larval and adult parasites. *G. perlucidus* and *Unio* sp. (the only ectoparasites) were noted only on the gill filaments of eelpout from PB, and *I. hoferi* was identified on the internal wall of the urinary bladder. Low organ specificity was indicated; thus, encysted larval *P. laevis* was present at most localities (in the gastrointestinal tract, coelom, beneath the gonadal serosa, on the urinary bladder). Adult acanthocephalans were located predominantly in the posterior part of the intestine (PB – $\bar{x}$ = 68.67, SD = 37.70; DM – $\bar{x}$ = 81.63, SD = 28.37).

Parasites infecting the eelpout from PB occupied more sites in the fish than both larval and adult parasites from the DM locality – only the gastrointestinal tract. The 144 nematodes (*H. auctum* and *C. gracilis*) noted in the atypical locations of the mouth and the gill cavities were disregarded in further analyses.

The co-occurrence in a single host of at least two parasite species was recorded in 43.9% (107 specimens) of the fish (*H. auctum* and *P. laevis* in the stomach and the anterior and posterior parts of the intestines). Much less common (in 12 cases) was the co-occurrence of *E. gadi* and *P. laevis* located in the posterior, and less frequently in the middle or anterior parts of the intestines, as well as *A. kubanicum* and *P. laevis* in the anterior part of the

Table 1

Quantitative characteristics of eelpout parasites from DM and PB: 1 – *P. laevis*, 2 – *H. auctum*, 3 – *C. gracillis*, 4 – *E. gadi*, 5 – *A. arctica*, 6 –*A. morhue*, 7 – *Ascarophis* sp., 8 – *A. kubanicum*, 9 – *G. perlucidus*, 10 – *Unio* sp., Ci – confidence interval

Fishing ground	Parasite	Prevalence		Intensity of infection		Relative density		Crowding	
		%	Ci	$\bar{x}$	Ci	$\bar{x}$	Ci	$\bar{x}$	Ci
DM	1.	66.7	0.4817 – 0.8204	21.55	17.50 – 24.77	14.36	10.21 – 18.55	25	22.11 – 27.69
	2.	93.9	0.7977 – 0.9926	11.29	8.45 – 14.61	10.61	7.88 – 14.18	18.5	14.33 – 23.49
	3.	12.1	0.0340 – 0.2821	3.5	3.00 – 3.75	0.42	0.09 – 0.91	3.57	3.00 – 3.80
	4.	15.2	0.0510 – 0.3190	3	0.00 – 0.00	0.45	0.09 – 0.82	3	0.00 – 3.00
	5.	6.1	0.0074 – 0.2023	3	0.00 – 0.00	0.18	0.00 – 0.45	3	0.00 – 3.00
PB	1.	84.2	0.7952 – 0.8814	13.52	11.45 – 16.43	11.38	9.52 – 13.71	43.55	29.31 – 62.42
	2.	27.3	0.2228 – 0.3272	2.58	2.10 – 3.54	0.7	0.53 – 0.98	6.29	3.51 – 10.58
	4.	5.7	0.0336 – 0.0901	2.82	2.00 – 3.88	0.16	0.08 – 0.26	3.96	2.00 – 5.21
	5.	0.03	0.0000 – 0.0187	3	0.00 – 0.00	0.01	0.00 – 0.03	3	0.00 – 3.00
	6.	2	0.0074– 0.0435	5.33	2.33 – 7.76	0.11	0.03 – 0.26	7.88	3.86 – 9.55
	7.	2	0.0074 – 0.0435	1	0.00 – 0.00	0.02	0.01 – 0.04	1	0.00 – 1.00
	8.	35.6	0.0446 – 0.1009	3	2.25 – 3.83	0.98	0.63 – 1.41	3.34	2.70 – 4.01
	9.	0.9	0.0304 – 0.0242	4	0.00 – 0.07	0.03	0.00 – 0.07	4	0.00 – 4.00
	10.	0.7	0.0008 – 0.0242	1	0.00 – 0.00	0.01	0.00 – 0.02	1	0.00 – 1.00

Table 2

Dominance index of the elements of parasite communities [%]

Species	Fishing grounds		
	PB	DM	Total
G. perlucidus	0.23		0.18
A. kubanicum	2.04		1.63
A. arctica	8.99	0.69	7.3
Ascarophis sp.	10.18		8.14
A. morhue	1.19		0.95
H. auctum	6.94	42.30	14.00
C. gracillis		1.63	0.32
E. gadi	20.37	1.74	8.49
P. laevis	49.97	55.24	51.02
Unio sp.	0.05		0.04

intestines. These parasite species also occurred in multi-component communities (twenty four times + two species, two times + three species, four times + four species).

Results of the morphometric study of *P. laevis* showed that the species had larger size in DM, although helminths from PB had a longer proboscis (Table 3).

A statistically significant positive correlation between Fulton's coefficient and the abundance of *P. laevis* (0.1180, $p<0.05$) and *H. auctum* (0.0458) as well as a negative relationship between K and the abundance of *A. arctica* (-0.1433, $p<0.01$), *A. morhuae* (-0.0392) and *C. gracilis* (-0.0728) were determined.

Table 3

Mean measurements and standard deviations of *P. laevis* from PB and DM: BL – body length; BW – maximum body width; PL – proboscis length; PW – proboscis width; LH – length of the largest hook; LHB – length of the base of the largest hook; PR – length of the proboscis sheath (mm)

Feature	PB		DM	
	$\bar{x}$	SD	$\bar{x}$	SD
BL	7.211	3.743	8.699	3.594
BW	0.740	0.187	0.856	0.142
PL	0.711	0.106	0.656	0.133
PW	0.052	0.036	0.070	0.028
LH	0.032	0.013	0.052	0.027
LHB	0.007	0.003	0.008	0.004
PR	0.912	0.179	1.044	0.404

Discussion

The analysis of the obtained results indicated that the majority of parasites of *Zoarces viviparus* are generalists with an Arctic-Boral distribution. Included are parasites that are characteristic of both fresh water and brackish water, as well as of marine species. Different acanthocephalans were the most abundant group, including *E. gadi* which is a typical marine parasite occurring frequently and abundantly in the Baltic and a dominant parasite of cod (Sobecka et al. 2012). *E. gadi* is also observed in eelpout from the Barents Sea (Polyansky 1955), the White Sea (Šulman & Šulman-Albova 1953), and the southern Baltic (Markowski 1938, Möller 1975, Sulgostowska et al. 1990). *P. laevis* occurs only in eelpout from the southern Baltic (Markowski 1938, Möller 1975, Graś-Wawrzyniak et al. 1979, Sulgostowska et al. 1990), because it is a parasite occurring in many freshwater fish species (Grabda 1971); in the Baltic Sea, it is most common in the European flounder *Platichthys flesus* (Linnaeus, 1758) (Chibani et al. 2001).

Among the numerous nematode species encountered, *C. gracilis* was noted only in eelpout from DM. It is a typical marine nematode found in gadids inhabiting the European Atlantic and Danish Straits (Køie 2001). It is noteworthy that *C. gracilis* has not been previously identified in eelpout in the Polish region of the Baltic Sea.

Nematodes of the genus *Ascarophis* were identified in eelpout from the Barents Sea (*A. arctica* – Polyansky 1955, Fagerholm & Berland 1988), the western Baltic (*Ascarophis* sp. and *A. arctica* – Möller 1975), and the southern Baltic (*A. scrjabini* (Layman, 1933) – Markowski 1938). However, neither *Ascarophis* sp. nor *A. morhue* occurred in the eelpout from DM. The latter was found in the eelpout for the first time. *Hysterothylacium auctum* was confirmed in the Baltic eelpout only in the adult stage (Markowski 1938, Myjak et al. 1996). Eelpout is one of the definitive hosts recorded for this nematode. Adult worms occur in the gastrointestinal tract, and encapsulated nematode larvae are noted in the liver and coelom, rarely in the muscle tissues. Larval location (Grabda-Kazubska & Okulewicz 2005) is one of the characteristics, based on which *H. auctum* can be distinguished from *Hysterothylacium aduncum* (Rudolphi, 1802), also described in the

Baltic fish hosts.

Asymphylodora kubanicum, the only species of the Trematoda identified in the current study, was previously noted only once in eelpout (Rokicki 1975). The remaining fluke species, with the exception of *Diplostomum* spp. metacercariae, were confirmed in this host from waters with higher salinity (Zander 1991). The digenean complex of the genus *Diplostomum* was noted in fresh and brackish waters, but the species compositions were different (Cavaleiro et al. 2012).

The monogenean *G. perlucidus* is a species with a very narrow host specificity. It has been previously identified in eelpout, which is its primary host, from the Gulf of Riga (Kirjušina & Vismanis 2004) and the Barents Sea (Polyansky 1955). Another monogenean species collected by Markowski (1938) from the Baltic eelpout is *Gyrodactylus medius* Kathariner, 1895; it has not been observed more than once.

The fungus-like pathogen *I. hoferi* is observed in various fish species, in both fresh and sea waters (Rahimian 1998); in addition to the present study, it has been reported only once in eelpout (Graś-Wawrzyniak et al. 1979).

The fauna inhabiting brackish waters is characterized by fewer species compared to sea waters (Różańska 1999). Under such conditions, fish parasites exhibit lower host specificity and have adapted to new conditions (Remene & Schlieper 1971, Zander & Reimer 2002).

The number of parasite species in the eelpout from both fishing grounds studied differed substantially. The number of parasite species in DM was half the number of parasite species in PB, but the parasite mean infection intensity and relative density were significantly higher in DM. The DM waters are transitional, and their current health status has been assessed as poor (REIWP Report 2010). Environmental conditions are likely to affect the hosts by impairing their natural defense mechanisms. The disadvantageous environmental conditions, even though their impact may be indirect, are also an obvious cause of the low diversity in the parasite species richness in eelpout from this fishing ground. This was also described by Kreitsberg et al. (2012) who reported that the number of eelpout parasite species decreased with the increasing water pollution. Similar observations were made by Kuperman (1992) in a study of the parasite fauna of bream *Abramis brama* (Linnaeus, 1758) from the Rybinsk Reservoir that was contaminated with petroleum compounds and communal sewage. Poor environmental conditions also impact the abundance and species composition of parasites with complex life cycles by eliminating or limiting the abundance of suitable intermediate host species (Voigt 1991).

Pomphorhynchus laevis occurred with the highest prevalence and crowding in eelpout from PB. The relative density and the mean intensity of infection were also the highest. Therefore, its mean total length was smaller than in DM except for the mean length of the proboscis (Table 3). The size of the infrapopulation of a single host is an indication of significance for the parasite. This affects both their parasite morphology and the interaction between the parasite and the host, and which differs among different species.

The species composition of nematodes from PB differed from that of nematodes noted in the fish from DM. *Capillaria gracilis* was not observed in fish from PB but occurred most frequently in cod *Gadus morhua* Linnaeus, 1758 and other gadids. Chironomid larvae and oligochaetes are intermediate hosts of these nematodes, and they are also used as food by juvenile eelpouts (Køie 2001). In the current study, these nematodes were found in the gastrointestinal tract but also accidentally in the esophagus and on the gill arches of eelpout from DM. The reason for the atypical location of these nematodes was, as in the case of *H. auctum*, the regurgitation of worms from the stomach during or immediately after the catch.

Species diversity indicates the number of species and the uniformity of individual distribution of specimens among the species. Thus, if one species dominates and the other species are represented by low individual abundance, species diversity is lower compared to the situation when all of the species occur with a similar abundance (Czachorowski 2006). The parasite communities from DM were dominated by two species occurring with high abundance, *P. laevis* and *H. auctum*, resulting in low species diversity and lower numbers of other species.

The parasites encountered were mainly located in the gastrointestinal tract. This tendency suggested that the greatest competition for food and habitat among the parasites in the fish from PB occurred in the anterior section of the intestines. Five parasite species were identified in the stomachs of fish from PB and DM. However, *H. auctum* was "replaced" by *C. gracilis* in the eelpout from DM. The most frequent co-occurrence of parasites in the habitats (organs) was the combination of *P. laevis* and *H. auctum*. Such an abundant co-occurrence has not been observed previously in eelpout. The co-occurrence of the two identified acanthocephalan species occurs rarely in other Baltic fish species. The dominance of *P. laevis* in communities of the two species of acanthocephalans was observed in brown trout *Salmo trutta* Linnaeus, 1758 (Byrne et al. 2003) and eel (Kennedy & Hartvigsen 2000) in fresh waters of England.

Pomphorhynchus laevis occurred in the examined eelpout both as adults and larvae (cystacants). Some of the mature helminths were located outside the intestine, encysted in the internal organs (they produce proteolytic enzymes – Polzer & Taraschewski 1994). When parasite abundance was high in the examined fish, those located outside of the gastrointestinal tract also either formed collagen capsules around the proboscis or were closed in hard, white cysts. Adult *P. laevis* specimens were observed to be attached to the peritoneum of the European flounder from the Thames estuary, but they were always adult individuals and they were not encysted (Munro et al. 1989). Encapsulated specimens were found in the Baltic flounder near the rectum. These were old, dead individuals that had been expelled from the intestines (Køie 1999). Cystacants were observed on the gonads and in the coelom. The presence of cystacants and their location in the fish is very rare.

Helminths in cysts decompose over time, leaving behind the hardest parts of their bodies, which are the proboscis and hooks (Køie 1999). Fish infected with live, juvenile, encysted *P. laevis* can also serve as a transport host; however, cysts with larval acanthocephalans of the genus *Pomphorhynchus* are usually found in the hemocoel of Gammaridae (Amphipoda), which are the intermediate hosts, while flounder and eelpout have been regarded to date as definitive hosts of these parasites (Sulgostowska et al. 1987, 1990).

Despite high abundance and relatively large size, *P. laevis* did not have a negative impact on the fish condition measured with Fulton's coefficient, while the small size of the nematodes *A. arctica, A. morhue* and *C. gracilis* had a statistically significant negative impact. This indicates that the high biomass of large and abundant parasites (such as *P. laevis*, and probably large tapeworms) could increase the weight of fish, thus leading to the false increased condition of fish.

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