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Fish parasitology

INTERNAL HELMINTH FAUNA OF BALTIC HERRING, *CLUPEA HARENGUS MEMBRAS* L. (CLUPEIFORMES) FROM SOUTHERN BALTIC

WEWNĘTRZNA HELMINTOFAUNA ŚLEDZIA BAŁTYCKIEGO *CLUPEA HARENGUS MEMBRAS* L. (CLUPEIFORMES) Z POŁUDNIOWEGO BAŁTYKU

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In the years 1994–1996, a total of 592 specimens of herring *Clupea harengus membras* L., caught in southern Baltic, were examined. The investigations revealed four species of trematodes: *Hemiurus lühei*, *H. raabei*, *H. levinseni*, *Brachyphallus crenatus*, two species of nematodes: *Hysterothylacium auctum* (syn. *H. aduncum*), and *Anisakis simplex* and three acanthocephalans: *Echinorhynchus gadi*, *Metechinorhynchus salmonis* and *Pomphorhynchus* sp. The finding of *H. levinseni* constitutes the first record of this species in Polish waters. The infection parameters of herring (prevalence, intensity and abundance) were compared in relation to different capture areas and seasons of the year. Possible affects of the feeding ground, fish body length and the spawning group of herring on the infection levels were also examined.

No relation was observed between the place and the season of catch and the infection level of herring. The fish representing different feeding grounds (Baltic, Danish Straits) and sequential length classes showed variable parameters of infection.

INTRODUCTION

Herring is one of the most common species of fish in the Baltic Sea and owing to its consumption value it is caught in great amounts. It is considered to be a subspecies of the Atlantic herring *Clupea harengus* L., and its full name is *C. harengus membras* L. 1761. This group of fish is not homogeneous, exhibiting considerable intraspecific variation. Based on the differences in the structure of otoliths, herring belonging to three spawning stocks can be encountered in the Polish zone of the Baltic Sea (Wyszyński 1997):

1. Spring coastal herring (denoted by letter "W") which spawn in spring in shallow coastal waters between the Pomeranian Bay and the Gulf of Gdańsk, as well as in the Vistula Lagoon. After the spawning period, a large part of this stock commences trophic migrations towards the Danish Straits, reaching the North Sea, and the reminder have their feeding grounds in open waters of the southern Baltic.
2. Spring open sea herring ("WM") reproduce in spring close to the coasts of Sweden, Latvia, and Estonia, and after the spawning they migrate to distant feeding grounds of the southern Baltic where they mix with spring coastal herring and autumn spawning herring.
3. Autumn herring ("J") reproduce in the western and southern Baltic from September to October, and in the central and northern Baltic from August to September. Their spawning grounds stretch farther off the coast than those of herring "W", frequently at the open sea. This herring, likewise herring "WM", does not undertake trophic migrations beyond the Baltic.

Each of the three groups of herring consists of many local stocks.

The parasites of herring in the southern Baltic and Gulf of Gdańsk were so far studied sporadically. Markowski (1933) found trematodes *Brachyphallus crenatus* (determinated as *Hemiurus lühei*), nematode *Contracaecum aduncum* (larvae) and acanthocephalans *Echinorhynchus gadi*, and *Corynosoma strumosus*. Grabda (1971) found only acanthocephalans

E. gadi, and *Corynosoma semerme*. Rokicki (1973, 1975) noted trematodes *B. crenatus*, *H. lühei*, *H. raabei*, cestode *Bothriocephalus scorpii* (larvae), nematodes *Anisakis* sp. (larvae), and *C. aduncum* (larvae), and acanthocephalans *E. gadi* and *C. semerme*; apart from this, author found single specimens of trematodes *Parahemiurus merus*, and *Lecithaster gibbosus*, and acanthocephalan *Pomphorhynchus kostylewi*.

MATERIAL AND METHODS

The present study was carried out from 1994 to 1996 in spring (from March to May) and autumn (October). Based on the structure of otoliths (they were analysed in the majority of the herring examined) the per cent shares of the individual spawning groups (W, WM and J) in each capture site were estimated. Totally, 592 herring were examined, 373 of which (W, WM and J) were caught in waters of the open Baltic, 36 (W and J) in the transitional zone, 128 (W and WM) in the Gulf of Gdańsk, and 55 (W) in the Vistula Lagoon (Fig. 1, Table 1). The herring from the open sea waters were caught during the cruises of the research vessel "Baltica" owned and operated by the Sea Fisheries Institute and the Institute of Meteorology and Water Management in Gdynia, Poland. The herring from the Gulf of Gdańsk and the Vistula Lagoon were caught by small offshore fishing.

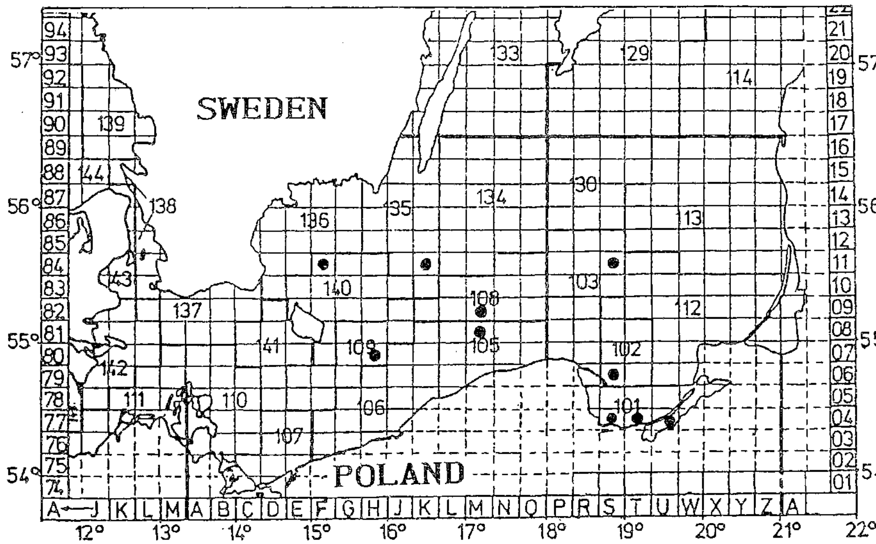

Fig. 1. Localisation of fishing sites

Because the sample material was stored frozen, only the internal parasites were examined; the external ones, being damaged by freezing, could not be identified.

The total body length of fish varied from 16.5 to 26.5 cm, amounting to 21.0 cm on the average. On this base nine groups were distinguished within the fish sample.

The infection of herring was analysed in relation to:

- place of catch (Table 1)
- season (Table 1)[1]
- feeding ground (Table 2)[2]
- fish body length (Table 3)
- spawning group (Table 4)

Internal organs of herring were examined under a dissecting microscope. These were contents of outer and inner surface of the alimentary tract, peritoneum, liver, spleen, air bladder, surface of gonads, and muscles. Trematodes were fixed and stained in alume carmine dehydrated in graded series of ethanol, cleared in creosote, and mounted on microscope slides in Canada balsam. The acanthocephalans fixed in 75% ethanol with 5% glyc-

[1] Since herring occurs only in spring in the coastal waters of the Gulf of Gdańsk and adjacent areas, the infection parameters of herring caught in different seasons of year were compared only for fish caught in the open sea fishing grounds.

[2] In this work two groups of herring were distinguished, i.e. the first one feeding in the Baltic: herring WM, J and part of W, and the second one feeding outside the Baltic: part of herring W. Such a distinction of two groups was based on the presence of larvae *A. simplex*. As proved by earlier investigations (Grabda 1974, confirmed also by many other authors), only herring that migrate trophically outside the Baltic are infected with this nematode.

erol were dehydrated in 96% ethanol and cleared in creosote (Sulgostowska et al. 1998). Taxonomic position was established after obtaining microscopic preparations. Nematodes, following the liberation from the capsule (in the case of specimens found outside the alimentary tract), were placed in a 9:1 mixture of 70% ethanol and glycerol. After evaporation of alcohol, the cleared parasites were identified microscopically based on morphological descriptions given by Berland (1961, 1989) and Fagerholm (1982).

RESULTS

The present survey yielded four trematode species, two nematodes, and three acanthocephalans. A total of 171 out of 592 herring examined (28.9%) were infected. Detailed data on the prevalence, intensity, and abundance of herring infection in individual areas are summarised in Table 1.

The infections of fish varied depending on the area of capture (Fig. 1). According to Table 1, when taking into account the infection with all parasites, the highest infection parameters were observed in the Gulf of Gdańsk. The lowest prevalence and abundance were noted in the Vistula Lagoon, the intensity of infection in this region being close to that in other areas.

The comparison of the infection of herring caught in the open sea in spring and autumn (see: Material and methods, footnote 1) indicates that the prevalence and abundance in spring were about twice as high as those in autumn, while the intensity levels were similar (Table 1).

Based on the presence of larvae *Anisakis simplex*, recognised as indicators whether or not the herring undertake trophic migrations beyond the Baltic or have their feeding grounds within the Baltic (see: Material and methods, footnote 2), it was found that from among the rest of parasite species, three, i.e. *H. raabei*, *H. levinseni*, *Pomphorhynchus* sp. and *Metechinorhynchus salmonis*, occur locally, while *B. crenatus*, *H. lühei*, *H. auctum* and *E. gadi* have wider range of occurrence. Detailed data are summarised in Table 2.

The level of infection with *B. crenatus*, *H. lühei*, and *A. simplex* increased with fish body length (Table 3). Acanthocephalans *M. salmonis* and *E. gadi* were present in similar numbers in the majority of fish length classes. In 24.0 cm class the prevalence attained the highest value, while in longer individuals the infection decreased. Two trematods, *H. raabei* and *H. levinseni* more frequently occurred in smaller herring than in other length classes. They were not found at all in the biggest individuals. The infection with *H. auctum* was low and not dependent on herring length. Acanthocephalan *Pomphorhynchus* sp. was sporadically found and therefore will not be considered in further discussion.

Table 1

The occurrence of internal parasites in herring in different fishing grounds and seasons*

		Open sea	Open sea	Transitional zone	Gulf of Gdańsk	Vistula Lagoon	Total
Season →		spring	autumn	spring	spring	spring	
Number of fishes →		n = 92	n = 281	n = 36	n = 128	n = 55	n = 92
Average length (cm) →		21.05	19.6	20.2	23.3	20.8	20.8
Parasite species ↓							
Hemiurus lühei	a	8.7%	4.3%	25.0%	46.9%	5.4%	15.5%
	b	6.4; 1–17	9.6; 2–30	9.5; 1–32	5.3; 1–28	1.0; 1–1	6.2; 1–32
	c	0.55	0.41	2.39	2.48	0.05	0.97
Hemiurus raabei	a	—	2.5%	—	0.8%	—	1.3%
	b	—	1.9; 1–3	—	1.0; 1–1	—	1.7; 1–3
	c	—	0.05	—	0.01	—	0.02
Hemiurus levinseni	a	—	1.8%	—	1.6%	—	1.2%
	b	—	1.0; 1–1	—	1.0; 1–1	—	1.0; 1–1
	c	—	0.02	—	0.02	—	0.01
Brachyphallus crenatus	a	2.2%	1.4%	—	19.5%	—	5.2%
	b	1.5; 1–2	1.5; 1–2	—	3.5; 1–14	—	3.1; 1–14
	c	0.03	0.02	—	0.68	—	0.16
Hysterothylacium auctum	a	—	1.1%	8.3%	2.3%	—	1.5%
	b	—	1.0; 1–1	1.0; 1–1	1.0; 1–1	—	1.0; 1–1
	c	—	0.01	0.08	0.02	—	0.01
Anisakis simplex	a	2.2%	0.4%	2.8%	43.7%	3.6%	10.5%
	b	12.0; 1–23	1.0; 1–1	1.0; 1–1	7.5; 1–50	17.0; 12–22	7.8; 1–50
	c	0.26	0.004	0.03	3.3	0.62	0.82
Pomphorhynchus sp.	a	—	0.7%	—	—	—	0.3%
	b	—	1.0; 1–1	—	—	—	1.0; 1–1
	c	—	0.01	—	—	—	0.003
Echinorhynchus gadi	a	12.0%	0.4%	—	0.8%	—	2.2%
	b	2.1; 1–8	1.0; 1–1	—	1.0; 1–1	—	1.9; 1–8
	c	0.25	0.004	—	0.01	—	0.04
Metechinorhynchus salmonis	a	4.3%	2.5%	—	0.8%	3.6%	2.4%
	b	1.0; 1–1	1.3; 1–3	—	2.0; 2–2	1.0; 1–1	1.2; 1–3
	c	0.04	0.03	—	0.02	0.04	0.03
All parasites	a	29.4%	13.2%	33.3%	68.7%	12.7%	28.9%
	b	3.9; 1–23	4.2; 1–30	7.5; 1–32	9.5; 1–57	5.6; 1–22	7.2; 1–57
	c	1.14	0.55	2.50	6.54	0.71	2.07
Per cent share of spawning stocks	W	37.4	37.8	97.2	94.0	100.0	59.9
	WM	57.1	54.6	—	6.0	—	35.5
	J	5.5	7.6	2.8	—	—	4.6

a, prevalence; b, intensity (mean; range); c, abundance (Margolis et al. 1982)

* See: Material and methods, footnote 1.

Table 2

Comparison of infection of herring migrating and not migrating to feeding grounds beyond the Baltic

Parasite species→		*Hemiurus lühei*	*Hemiurus raabei*	*Hemiurus levinseni*	*Brachyphallus crenatus*	*Hysterothylacium auctum*	*Anisakis simplex*	*Pomphorhynchus* sp.	*Echinorhynchus gadi*	*Metechinorhynchus salmonis*	All parasites (without *A. simplex*)
Migrating herring	a	53.2%	—	—	20.1%	3.2%	100%	—	1.6%	—	64.5%
n = 62	b	5.8; 1–28	—	—	4.8; 1–14	1.0; 1–1	7.8; 1–50	—	1.0; 1–1	—	6.4; 1–28
(av. length 25.1 cm)	c	3.08	—	—	1.0	0.03	7.8	—	0.02	—	4.13
Not migrating	a	11.1%	1.5%	1.32%	3.4%	1.32%	—	0.4%	2.3%	2.6%	20.6%
herring, n = 530	b	6.5; 1–32	1.7; 1–3	1.0; 1–1	2.6; 1–12	1.0; 1–1	—	2.0; 2–2	2.0; 1–8	1.2; 1–3	4.6; 1–32
(av. length 20.3 cm)	c	0.72	0.03	0.01	0.09	0.01	—	0.004	0.04	0.03	0.94

Table 3

Infection parameters of herring in individual length classes (separately for each parasite).

Parasite species ↓		Fish body length								
		<17 n = 60	18 n = 61	19 n = 99	20 n = 115	21 n = 85	22 n = 49	23 n = 30	24 n = 32	>25 n = 61
Hemiurus lühei	a	5.0%	9.8%	11.1%	16.5%	5.9%	8.2%	16.7%	28.1%	49.2%
	b	12.0; 2–30	12.8; 1–25	3.4; 1–15	5.3; 1–24	13.4, 1–32	10.5; 1–26	4.6; 1–8	7.3; 2–28	4.1; 1–25
	c	0.60	1.26	0.37	0.88	0.79	0.86	0.77	2.06	2.03
Hemiurus raabei	a	3.3%	3.3%	—	0.9%	1.2%	2.0%	3.3%	—	—
	b	1.0; 1–1	2.5; 2–3	—	2.0; 2–2	3.0; 3–3	1.0; 1–1	1.0; 1–1	—	—
	c	0.03	0.08	—	0.02	0.03	0.02	0.03	—	—
Hemiurus levinseni	a	5.0%	—	—	2.6%	0.0%	2.0%	—	—	—
	b	1.0; 1–1	—	—	1.0; 1–1	0.0	1.0; 1–1	—	—	—
	c	0.05	—	—	0.03	0.0	0.02	—	—	—
Brachyphallus crenatus	a	—	1.6%	2.0%	5.2%	2.3%	2.0%	—	15.6%	22.9%
	b	—	2.0; 2	1.5; 1–2	2.8; 1–7	1.0; 1–1	3.0; 3–1	—	4.2; 1–14	3.4; 1–12
	c	—	0.03	0.03	0.15	0.02	0.06	—	0.66	0.79
Hysterothylacium auctum	a	—	3.3%	2.0%	—	—	4.1%	3.3%	—	3.3%
	b	—	1.0; 1–1	1.0; 1–1	—	—	1.0; 1–1	1.0; 1–1	—	1.0; –1–1
	c	—	0.03	0.02	—	—	0.04	0.03	—	0.03
Anisakis simplex	a	—	—	1.0%	0.9%	—	2.0%	23.3%	25.0%	72.1%
	b	—	—	1.0; 1–1	7.0; 7–7	—	1.0; 1–1	9.7; 1–23	7.4; 1–19	7.9; 1–50
	c	—	—	0.01	0.06	—	0.02	2.27	1.84	5.69
Pomphorhynchus sp.	a	—	—	—	0.9%	—	2.0%	—	—	—
	b	—	—	—	1.0; 1–1	—	1.0; 1–1	—	—	—
	c	—	—	—	0.01	—	0.02	—	—	—
Echinorhynchus gadi	a	—	1.6%	—	0.9%	4.7%	4.1%	—	9.4%	3.3%
	b	—	1.0; 1–1	—	1.0; 1–1	2.2; 1–4	4.5; 1–8	—	1.0; 1–1	1.0; 1–1
	c	—	0.02	—	0.01	0.11	0.18	—	0.09	0.03
Metechinorhynchus salmonis	a	3.3%	—	3.0%	3.5%	2.3%	—	—	9.4%	0.0%
	b	1.0; 1	—	1.0; 1	1.0; 1	2.0; 1–3	—	—	1.3; 1–2	0.0
	c	0.03	—	0.03	0.03	0.05	—	—	0.12	0.0
All parasites	a	15.0%	16.4%	17.2%	25.2%	14.1%	22.4%	36.7%	50.0%	91.8%
	b	4.8; 1–30	8.7; 1–28	2.7; 1–16	4.7; 1–28	7.1; 1–32	5.4; 1–30	8.4; 1–23	9.6; 1–38	8.5; 1–57
	c	0.72	1.43	0.46	1.18	1.0	1.22	3.1	4.78	7.79

In addition, the infection of herring was compared for different spawning groups (Table 4). The data, however, do not represent all individuals examined (otoliths were read for 559 specimens) and are not included in the results but only mentioned in the discussion.

Table 4

Infection of herring belonging to different spawning stocks

Spawning group → Parasite species ↓		Herring W n = 327 av. length 21.1 cm	Herring WM n = 205 av. length 20.05 cm	Herring J n = 27 av. length 19.4
Hemiurus lühei	a	20.2%	4.4%	18.5%
	b	7.1; 1–32	6.0; 1–20	2.4; 1–7
	c	1.44	0.26	0.44
Hemiurus raabei	a	1.5%	—	7.4%
	b	2.0; 1–3	—	1.5; 1–2
	c	0.03	—	0.11
Hemiurus levinseni	a	0.9%	1.9%	—
	b	1.0; 1–1	1.0; 1–1	—
	c	0.01	0.02	—
Brachyphallus crenatus	a	7.0%	1.5%	—
	b	3.2; 1–14	1.0; 1–1	—
	c	0.23	0.01	—
Hysterothylacium auctum	a	2.1%	1.0%	—
	b	1.0; 1–1	1.0; 1–1	—
	c	0.02	0.01	—
Anisakis simplex	a	19.0%	—	—
	b	7.8; 1–50	—	—
	c	1.48	—	—
Pomphorhynchus sp.	a	0.3%	0.5%	—
	b	1.0; 1–1	1.0; 1–1	—
	c	0.003	0.005	—
Echinorhynchus gadi	a	1.2%	4.4%	—
	b	1.5; 1–3	2.1; 1–8	—
	c	0.02	0.09	—
Metechinorhynchus salmonis	a	0.9%	4.4%	3.7%
	b	1.0; 1–1	1.2; 1–3	1.0; 1–1
	c	0.01	0.05	0.04
All parasites	a	34.9%	16.6%	29.6%
	b	9.3; 1–57	2.8;1–20	2.0; 1–7
	c	3.23	0.46	0.59

Trematoda

Four trematode species were found, 3 of which belonged to Hemiuridae and 1 to Lecithochiriidae. They occurred in the stomach and pyloric caeca of the fish.

Hemiurus lühei Odhner, 1905

The specimens found were mature. They were present in herring of all fishing grounds studied. The highest prevalence was observed in the Gulf of Gdańsk. In the fish caught in the open sea this parasite occurred in both seasons analysed but the prevalence in spring was twice as that observed in autumn, while the intensity was higher in autumn (Table 1). These trematodes were found in both the migrating herring and the herring confined to the Baltic. In that former group the prevalence was markedly higher (Table 2). This parasite was found in all fish length classes, being most abundant in the specimens exceeding 23 cm (Table 3).

Hemiurus raabei Ślusarski, 1958

Mature specimens of this fluke were found sporadically in two areas only: in the Gulf of Gdańsk in spring and in the open sea in autumn (Table 1). This species was considerably less frequently found than *H. lühei*, occurring only in herring not migrating beyond the Baltic (Table 2). In specimens up to 23 cm, the infection with this parasite was similar. It was not observed in longer fish (Table 3).

Hemiurus levinseni Odhner, 1905

These parasites were found in 7 herring: in the open sea (autumn) and in the Gulf of Gdańsk (spring) (Table 1). They were only found in the fish confined to the Baltic (Table 2). In the Polish Baltic zone this trematode was found for the first time.

Brachyphallus crenatus (Rudolphi, 1802) Odhner, 1905

This species commonly occurred both in the open sea and in the Gulf of Gdańsk. The prevalence and intensity of infection with this parasite was markedly higher in the Gulf of Gdańsk. In the open sea, the prevalence was higher in spring than in autumn (Table 1). The infection was much more intensive in herring migrating beyond the Baltic (Table 2) and was most frequently observed in specimens with body length exceeding 23.0 cm (Table 3).

Nematoda

Two anisakid nematode species were found in the herring examined:

Hysterothylacium auctum (Rudolphi, 1802)[3] [syn. *H. aduncum* (Rudolphi, 1802)] – larvae L_3 and L_4

Nine specimens of this species were found (five L_3 larvae and four L_4 larvae). One L_3 larva was isolated form the peritoneum, and the remaining ones were located in the lumen of the small intestine. The infection of herring was small and the prevalence was the lowest in open waters, slightly higher in the Gulf of Gdańsk (excluding the Vistula Lagoon, where it was not found), and the highest in the transitional zone. The intensity of infection was always low (Table 1). This parasite occurred both in herring migrating beyond the Baltic and in non-migrating herring. In local fish, the prevalence of infection was twice as low and intensity the same as those in the migrating herring (Table 2). No relation between the infection with this parasite and fish body length was observed (Table 3).

Anisakis simplex (Rudolphi, 1809) – larvae L_3

These nematodes were located mostly along the mesentery and the intestine, and also between the pyloric caeca, rarely on the surface of the liver and gonads, sometimes piercing the peritoneum and penetrating the muscular tissue. These nematoda were in most cases arranged in characteristic flat encapsulated spirals, in general forming greater agglomerations. Single individuals located on the peritoneum and piercing into the peritoneum or muscles were extended and devoid of the capsule. This parasite was mostly observed in the Gulf of Gdańsk and less frequently in the open sea (Table 1). The infection increased with fish body length (Table 3). It was found exclusively in spring coastal herring W (Table 4).

Acantocephala

Three species of Acanthocephala were found, including 2 representing the family Echinorhynchidae and 1 of the family Pomphorhynchidae.

Echinorhynchus gadi (Zoega in Müller, 1776)

[3] *H. auctum* (syn. *H. aduncum*) is a common nematode occurring in many regions of the world in the fish of sea and brackish waters. Hartwich (1975) noticed certain differences in the morphology of nematodes isolated from different fishes, and described the following three species: *H. aduncum,* typically occurring in eel pout but also in several flatfishes, *H. gadi,* which is a parasite of gadids, and *H. aduncum* found in clupeids. However, most of authors recognise one species, assigning it to *H. aduncum* or *H. auctum*. The name *H. aduncum* is more frequently encountered in the literature than *H. auctum* (Fagerholm 1987, 1989; Zander 1991; Køie 1992). The name *H. auctum* seems better justified for the Baltic nematodes in view of molecular investigations (multilocus allozyme electrophoresis and PCR-based techniques) of Szostakowska et. al. (2000), who found that Baltic *Hysterothylacium* belong to one species which the main host is eel pout.

This parasite was found in the small intestine. It occurred in herring caught in the open sea and in the Gulf of Gdańsk, much more frequently in the open sea than in other areas; primarily in spring (Table 1). The infection of herring which do not migrate beyond the Baltic was more severe (Table 2) and distinctly greater in the specimens longer then 20.0 cm. The infection was weakening in the longest specimens (Table 3).

Metechinorhynchus salmonis (Müller, 1780)

This parasite also occurred in the small intestine, being however less abundant than *E. gadi*. It was found in almost all fishing grounds. In the open sea in spring the prevalence of infection was higher compared to that observed in the autumn, whereas the intensity was similar (Table 1). This acanthocephalan was found in herring, which do not migrate beyond the Baltic (Table 2). The infection was the highest in fish with body length of 24.0 cm, but was not observed in the longest herring (Table 3).

Pomphorhynchus sp.

The parasites were located in the terminal portion of the fish intestine. Only two specimens (male) were found in fish caught in the open sea in autumn (Table 1). They occurred only in herring that do not migrate beyond the Baltic (Table 2), in fish with body lengths 20 and 22 cm (Table 3). Insufficient material and the lack of females enabled the identification to the genus level only.

Measurements: trunk: 10.0–11.0 × 1.2–1.3 mm; proboscis: 1.4 × 0.5 mm; there are 16 rows of hooks on the proboscis, 10 hooks in each. On the top of the proboscis the hooks are bigger than those at its base. The spike of larger hooks is 0.049–0.051 mm, and of the smaller ones 0.027–0.029 mm. The length of the collum is 4.9 × 0.2 mm, its extension at the base (bulbus) is 2.0 mm. Lemniscs do not reach the edge of the first testis. Both testes are big and oval: 1.2–1.3 × 0.7–0.8 mm. The data on morphology and anatomy of the male individual correspond to the description of *P. perforator* Linstow, 1908, observed so far in fresh-water fishes.

DISCUSSION

The composition of internal parasite fauna of organisms depends on the composition of their diet. The feed of herring consists mostly of planktonic crustacea as well as larval and preadult forms of fishes (Popiel 1951). The feeding of herring is affected by many factors which are frequently closely related with each other and therefore it is not possible to analyse them separately. First of all these are biology of herring (maturity of gonads, migrations related with reproduction and feeding), their body size, as well as external factors such as season of a year (affecting both herring and composition of their feed) or geographical area, influencing the specific composition of crustacea. It is in general considered that intensive feeding of herring occurs outside the spawning period which for individual spawning stocks takes place at different times and in different regions. However, the feeding grounds of these fish in the Baltic often overlap. In view of seasonal migrations of herring and periodic changes in the intensity of their feeding it is difficult to analyse the parasite fauna of the Baltic herring stocks in relation to the place of catch and season, since in most cases the survival period of parasites in fish organisms is not known. There is an opinion that parasites in the alimentary tract do not stay there longer than one year, while those located outside alimentary tract can live there longer (Hemmingsen et al. 1991).

The size of fish is the factor that, independent of the other ones, influences the type of herring's feed and, as a result, the internal parasites. Irrespective of the season, region or development stage (trophic or spawning period) the composition of feed is different in particular fish length classes, which is probably determined by the size of the fish mouth. This phenomenon was described in detail by Popiel (1951) who found that the growth of fish body length is accompanied by the drop in the content of copepods and the increase in the share of large crustacea of the family Mysidacea and fish larvae in the feed. In the case of the longest herring (above 25 cm), the feed contents markedly differs from that ingested by smaller specimens, and consists mostly of small fishes and their larvae, crustacea being less abundant.

Except for *H. levinseni*, all the parasite species found were earlier observed in the Baltic herring (Grabda 1971; Rokicki 1973; Valtonen and Crompton 1990; Turovsky et al. 1992). H. raabei was originally described by Ślusarski (1958) based on specimens found in *Salmo salar* L., which were examined after their trophic season in the Baltic. The author discussed in detail specific features differentiating *H. raabei* from *H. lühei*. Among other things, in the trematoda examined he found narrow folds of external layer of tegument (named "cuticular folds" in the original text) over the whole body. In *H. lühei* such folds do not occur on the rear part of the body. Therefore Ślusarski even suggested erecting a new subgenus *Neohemiurus* within the genus *Hemiurus* to acomodate *H. raabei*. In the present material this species was distinguish among individuals of the genus *Hemiurus*. The presence of *H. raabei* in herring should not raise doubts since Clupeidae are related with Salmonidae and in a number of taxonomic systems the latter are assigned to Clupeiformes.

By comparing the infection of herring migrating and not migrating to feeding grounds beyond the Baltic (the former group including fish infected with *A. simplex* larvae), a conclusion can be drawn that some parasites: *B. crenatus*, *H. lühei*, *H. auctum*, and *E. gadi* are cosmopolitan and the remaining parasites: *H. raabei*, *H. levinseni*, *M. salmonis*, and *Pomphorhynchus* sp. were only found in herring that do not migrate trophically outside the Baltic. Nonetheless, one cannot maintain based on the material analysed that they have a local range only, since the number of migrating fish investigated was several times lower that of the specimens from local stocks (besides, infection of these last with these parasites was low). It was also found that these four parasite species are more abundant in small individuals, whereas average body length of herring feeding outside the Baltic exceeded 25 cm. Based on the presence of *H. levinseni*, a trematode found earlier in Atlantic fishes (Arthur and Arai 1980) and observed by us in not migrating herring, it can only be inferred that the range of its occurrence expands. It was found already in fish samples in 1994 and 1995, thus rather ruling out its accidental presence in the Baltic waters. Markedly higher prevalence of the infection with trematodes *B. crenatus* and *H. lühei* (the most common species of trematoda in Baltic herring), together with lower prevalence of infection with acanthocephalan *E. gadi* of herring migrating beyond the Baltic compared with the local stocks, probably results from a marked difference in body lengths of the groups compared. Higher prevalence of infection with *H. auctum* of herring undertaking trophic migrations beyond the Baltic may be ascribed to a higher number of species of intermediate hosts, including euphausiid (Crustacea: Malacostraca) - a common intermediate host of this nematode in the North Sea. The comparison of the number of parasite species found in herring belonging to particular spawning stocks implies that only *A. simplex* occurred exclusively in herring W, thus confirming its off-Baltic origin. It is brought into the Baltic by spring coastal herring (W), spawning in shallow coastal waters mainly of southern Baltic, and feeding in the North Sea and Danish Straits rich in euphausiids. These crustacea are the fundamental feed of herring in that region and the main source of infection with *A. simplex* larvae. In view of to low salinity euphausiids are not present in the Baltic. Therefore, herring that do not migrate beyond the Baltic are not infected with this nematode.

Analysing the infection of herring within individual length classes it was found that the data on the infection with trematodes are diversified. The infection with *H. lühei* and *B. crenatus* increases, and with *H. raabei* and *H. levinseni* decreases. However, based on the material collected it is difficult to interpret the results. In the case of *H. auctum*, the infection of large herring is similar to that of smaller individuals. This may be due to a wide variety of species of intermediate hosts of this nematode among invertebrates (mainly crustacea) both beyond and within the Baltic. Earlier investigations imply that the prevalence of the extra-intestinal infection of herring with *H. auctum* is low (0.05%). It was, however, noted in all herring spawning stocks (Myjak et al. 1996). In our study, this nematode was found in herring W and WM and was absent in herring J. This should probably be due to a small number of examined individuals belonging to this spawning stock. *A. simplex* larvae were found in herring with body length exceeding 18 cm. The degree of infection increased with fish size. The increase of herring infection with *A. simplex* larvae with growing fish size may be accounted for by a greater amount of feed (euphausiids) assimilated by bigger individuals and by the cumulation of parasites as successive infected crustacea are eaten. Distinctly greater infection of coastal herring and its increase with the growing body length observed by us confirm earlier findings of other authors (Grabda 1974; Myjak et al. 1996; Rokicki et al. 1997) who also demonstrated the seasonal character of the occurrence of this parasite in the Baltic herring.

The analysis of infection with acanthocephalans *E. gadi* and *M. salmonis* revealed the drop in the infection of big individuals. This is in agreement with earlier observations of Popiel (1951) who noticed the connection between the occurrence of *E. gadi* in herring and the presence of amphipod *Pontoporeia femorata* in its food. The author analysed the food of herring depending on herring size, concluding that Amphipoda are components of food of smaller specimens.

The fact that 6 out of 9 parasite species were not found in herring J is probably due to insufficient number of fish of this group examined (27). In the case of *B. crenatus* small fish size was the additional reason, while the in the case of *H. levinseni*, *H. auctum* and *Pomphorhynchus* sp. the level of infection with these parasites was in general low.

Not even one *C. osculatum* (Anisakidae) was found in herring examined, although earlier investigations (Myjak et al. 1996) proved its presence in 0.17% of herring W. Over 30.000 fish were examined at that time and the lack of this species in our study is probably caused by insufficient sample size.

CONCLUSIONS

1. Trematode *H. lühei* was the most common internal helminth of Baltic herring.
2. The presence of *H. levinseni* in herring which do not migrate beyond the Baltic indicates the expansion of the range of its occurrence.
3. The size of herring mouth, determining the composition of food, is the factor which independly of remaining ones influences the composition of internal parasites fauna of herring. The importance of other factors (e.g. fishing site) is difficult to estimate and probably not possible to considerate singly.

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WEWNĘTRZNA HELMINTOFAUNA ŚLEDZIA BAŁTYCKIEGO *CLUPEA HARENGUS MEMBRAS* L. (CLUPEIFORMES) Z POŁUDNIOWEGO BAŁTYKU

STRESZCZENIE

W latach 1994-1996 badaniom w kierunku obecności helmintofauny wewnętrznej poddano 592 śledzie *Clupea harengus membras* L., odłowione w południowym Bałtyku. Stwierdzono, że u badanych ryb występują cztery gatunki przywr: *Hemiurus lühei*, *H. raabei*, *H. levinseni*, *Brachyphallus crenatus*, dwa gatunki nicieni (oba z rodziny Anisakidae): *Hysterothylacium auctum* (syn. H. *aduncum*) i *Anisakis simplex* oraz trzy gatunki kolcogłowów: *Echinorhynchus gadi*, *Metechinorhynchus salmonis* i *Pomphorhynchus* sp. Obecność przywry *H. levinseni* stwierdzono w polskich wodach po raz pierwszy. Analizowano zarażenie śledzi (ekstensywność, intensywność i liczebność) odłowionych w różnych miejscach połowowych (morze otwarte i Zatoka Gdańska) i porach roku (wiosna i jesień). Badano także wpływ miejsc żerowania (bałtyckie i pozabałtyckie), przynależności do grup tarłowych i długości ciała ryb na poziom zarażenia. Stwierdzono, że parametry zarażenia śledzi są różne u ryb podejmujących wędrówki troficzne poza Bałtyk w porównaniu z lokalnymi stadami śledzi oraz u ryb różniących się długością ciała. Nie zaobserwowano natomiast wpływu miejsca i sezonu połowowego na zarażenie śledzi – wydaje się, że czynniki te nie mogą być analizowane oddzielnie.

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