A C T A P A R A S I T O L O G I C A P O L O N I C A
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Helminths of certain *Clupeidae*, mainly of the herring *Clupea harengus* L., in South Baltic

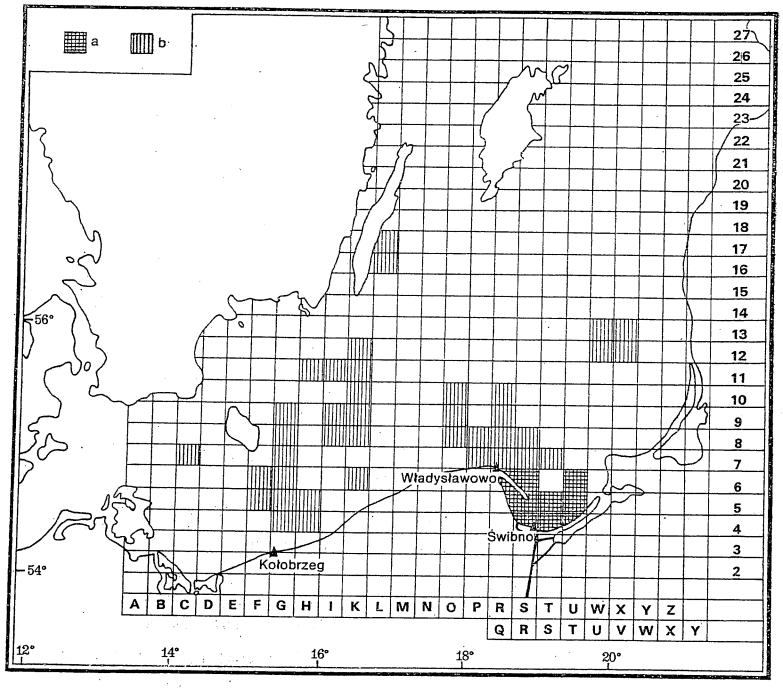
Helmintofauna ryb śledziowatych, głównie śledzia, *Clupea harengus* L. południowego Bałtyku

The helminth fauna of the Baltic herring fish is as yet imperfectly known. To extent the knowledge of its distribution in the sea, fish of the family *Clupeidae*, mainly *Clupea harengus* L., living in the Gdańsk Bay and South Baltic were investigated for helminths in an annual cycle. For technical reasons *Monogenoidea* were ignored. Examination of 923 herrings *Clupea harengus* L., 178 *Sprattus sprattus* (L.) specimens and one (?) *Alosa fallax* (Lac.) specimen revealed 5 trematode, 1 cestode, 2 nematode and 3 acanthocephalan species. An annotated list of these species is given below, including a discussion of the helminth fauna recorded.

Material and methods

Three main basins are distinguished in the Baltic: the Bornholm Basin stretching from the Sound Strait and the Gedser-Darss Shoal in the west to the line linking Utkipan near Karlskrona and the Rozewie Cap in the east; the Gotland Basin — the largest and the deepest, reaching the Aland Islands; and the Bothnia Basin, encompassing the Gulf of Bothnia. South Baltic includes the Bornholm Basin and the southern part of the Gotland Basin. The salinity of the Baltic depends on the inflow of salt waters from the North Sea and it varies in superficial waters from 10‰ in south-west to 2.4‰ in the north; in deep waters it oscillates from 20‰ in south-west to about 12‰ in the Gotland Basin; the mean salinity is 7.8‰. The depths of basins in South Baltic are as follows: Arcona Basin 55 m, Bornholm Basin 105 m, Rynna Słupska 95 m, the Gotland Basin 250 m.

The distribution of the grounds where the fish were caught is seen in Map. 1. In autumn, 1968 the present author made three cruises of South Baltic lasting three days each, aboard the MS "Michał Siedlecki", a research vessel of the Marine Fisheries Institute (M.I.R.), Gdynia. Apart from this, investigation was conducted in selected localities at the seacoast: Kołobrzeg, Władysławowo and Świbno, advantage being taken of fish supplied by fishermen. Fish caught in the most distant fishing



Map 1. Distribution of the investigating areas of the Baltic: a — collecting regions for clupeid fish in the Gdańsk Bay; b — collecting regions for clupeid fish in other waters of the Baltic.

ground were kept on ice for about 15 h before autopsy. This did not reduce the value of the collected material owing to good storage conditions. Most parasites were alive when located.

The fish species were determined according to the key of Gąsowska 1962. Autopsies were performed by examining all internal fish organs, including muscles. The laboratory techniques used here for preparation, staining and examination of helminths collected are described elsewhere (Rokicki 1970). All measurements are in microns, unless otherwise stated.

Trematoda

Hemiuridae Lühe, 1901

Hemiurus luehei Odhner, 1905

Syn.: *Distomum appendiculatum* (Rudolphi, 1802) sensu Olsson, 1868; *Hemiurus ocreatus* (Rudolphi, 1802) Looss, 1899.

Hosts: *Clupea harengus* L.; *Sprattus sprattus* (L.).

Location: stomach.

Localities: the Gdańsk Bay (for the herring); South Baltic (for the herring and the sprat).

The incidence and intensity of infestation are shown in Tables I, II and III.

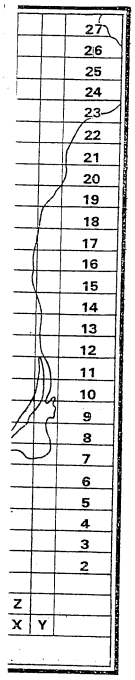


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Table I

Helminth fauna of *Clupea harengus* L., in the South Baltic (except the Bay of Gdańsk)

Helminth species	Infestation	
	incidence (%)	intensity
Brachyphallus crenatus	25	1–37
Hemiurus luehei	6	1–77
Hemiurus raabei	0.1	2
Parahemiurus merus	0.1	1
Lecithaster gibbosus	0.1	1
Bothriocephalus scorpii, larva	2	1–27
Anisakis sp., larva	1	1–10
Contracaecum aduncum, larva	2	1–2
Echinorhynchus gadi	10	1–27
Corynosoma semerme	0.1	2
Pomphorhynchus kostylewi	0.2	1

Table II

Helminth fauna of *Clupea harengus* L., in the Bay of Gdańsk

Helminth species	Infestation	
	incidence (%)	intensity
Brachyphallus crenatus	14	1–6
Hemiurus luehei	8	1–4
Bothriocephalus scorpii, larva	7	1–18
Anisakis sp., larva	2	1–10
Contracaecum aduncum, larva	3	1–2
Echinorhynchus gadi	19	1–27
Corynosoma semerme	1	1

Table III

Helminth fauna of *Sprattus sprattus* (L.) in the South Baltic (except the Bay of Gdańsk)

Helminth species	Infestation	
	incidence (%)	intensity
Hemiurus luehei	1	1–3
Bothriocephalus scorpii	2	1–6 larvae
Contracaecum aduncum	1	1 larva

This is a typical parasite of sea fish: *Clupeidae* and *Salmonidae* living in the North Sea, North Atlantic, Pacific and the Baltic Sea. In Poland the species was found by Ślusarski 1958, in *Salmo salar* and *Salmo trutta* m. *trutta* caught in the Baltic. Trematodes which Markowski 1933 found in *Clupea harengus* and determined as *H. luehei* are actually representatives of genus *Brachyphallus* Odhner, 1905. *Clupea harengus* and *Sprattus sprattus* were found new hosts of this parasite in Poland. Morphological characters of this trematode species coincide with those described by Odhner 1905 and Ślusarski 1958.

Hemiurus raabei Ślusarski 1958 (Fig. 1 a)

Host: *Clupea harengus* L.
Location: stomach.
Localities: The Gdańsk Bay, fishing ground R-S-6.
The incidence and intensity of infestation: two specimens were found in one herring. Ślusarski 1958 only once determined this species in *Salmo salar* in the Baltic, so herring is a new host record for this species.

Morphology: Body length including evaginated ecsoma 2.8 mm, body width 310. Oral sucker 100 × 100, ventral sucker 150 × 170; pharynx 40 × 50. The cuticle finely striped on the whole body length including the ecsoma. The intestinal caeca end in the ecsoma which they enter together with uterus. The hermaphroditic pore opens near the oral sucker. The seminal vesicle has three follicles and strong wall musculature. Eggs measure 20 × 11.

Parahemiurus merus (Linton, 1910) Woolcock, 1935

Syn.: *Hemiurus merus* Linton, 1910; *Parahemiurus platichthyi* Lloyd, 1937.

Host: *Clupea harengus* L.
Location: stomach.
Locality: South Baltic, fishing ground G-5.
Incidence and intensity of infestation: a single specimen was found in one herring. This trematode is rare; formerly found in the Pacific and Atlantic Oceans in the coastal regions of both Americas. The present investigation has revealed its presence in the Baltic for the first time. Herring is a new host record.

Morphology: Body length 1.9 mm, width 240. Oral sucker 80 × 90; ventral sucker 130 × 150; pharynx 50 × 60; eggs 23 × 11. Seminal vesicle 80 × 100. The prostate duct arising from the seminal vesicle forms a slight expansion, measuring 10 × 12, in the latter's direct neighbourhood. But it does not like as another seminal vesicle. Nevertheless the

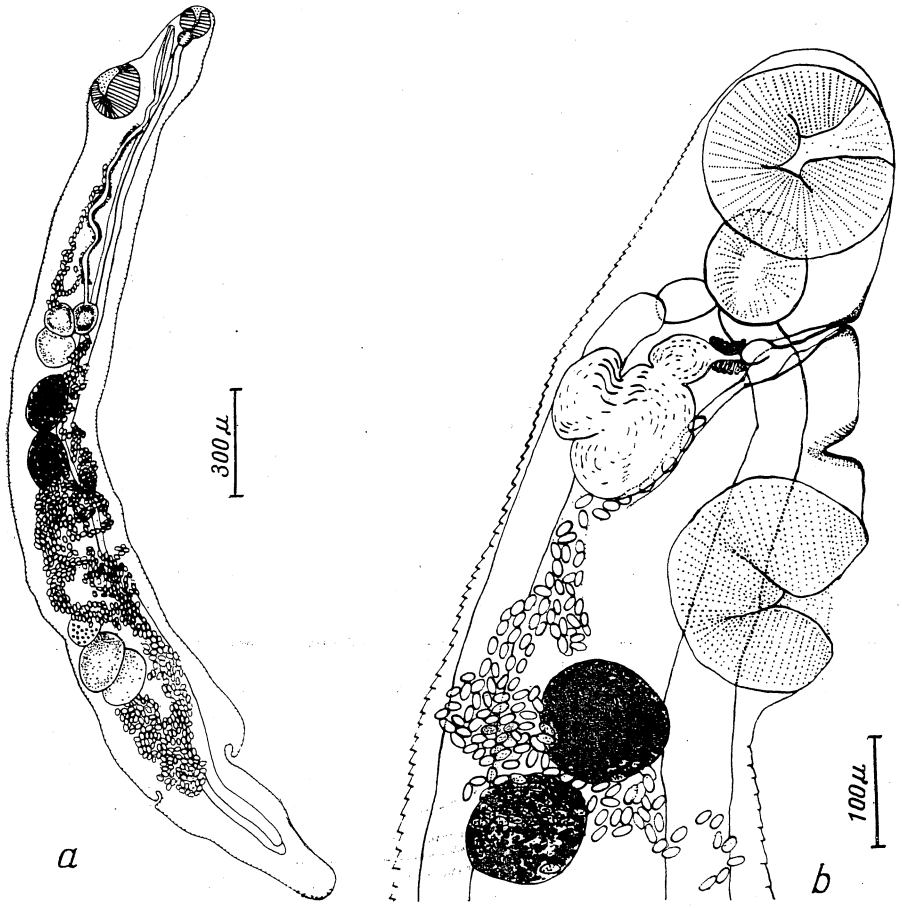

Fig. 1. a — *Hemiurus raabei* from *Clupea harengus* of the Gdańsk Bay; b — *Brachyphallus crenatus* from *Clupea harengus* of the Baltic Sea.

very existence of such a possibility reveals the weakness of genus *Parahemiurus* based on the suggested existence of only one seminal vesicle. This trematode fits best in the description given by Lloyd 1938 of *Parahemiurus platichthyi*, ranked by Manter 1940 into synonyms of *Parahemiurus merus*.

Lecithochiriidae Skrj. et Gusch., 1954

Brachyphallus crenatus (Rudolphi, 1802) Odhner, 1905
Host: *Clupea harengus* L.
Location: stomach.
Localities: The Gdańsk Bay, South Baltic.

Incidence and intensity of infestation are shown in Tables I and II.

It is common in the coastal and pelagic zone of seas of the Northern Hemisphere, particularly in *Clupeiformes*. It was found in Poland by Markowski 1933 in *Hyperoplus lanceolatus* and by Ślusarski 1958 in *Salmo salar* and *Salmo trutta* m. *trutta*. The individuals found by the present author fit in the description of this species given by the above two authors.

The seminal vesicle of these trematodes is bipartite. In one specimen a tri-partite vesicle was observed (Fig. 1 b) with the following dimensions: the smallest anterior part 61 × 46, the lateral part 93 × 79, the hind part 144 × 107. Unfortunately, the place in which vasa deferentia reach the seminal vesicle was not found, so it was impossible to find what part of the vesicle is the first. Probably the hind largest follicle with relatively thick walls is the main part, and the lateral is the result of a teratological case probably caused by the swelling of the wall of the largest follicle. The prostate duct surrounded by the ducts of prostate cells passes into the vesicle 23 in diameter. This vesicle was observed by Lloyd 1938, and Ślusarski 1958, and determined as a "prostatic vesicle" because of prostate glands occurring in its hind part.

Lecithasteridae Skrj. et Gusch., 1954

Lecithaster gibbosus (Rudolphi, 1802) Lühe, 1901

Syn.: *Fasciola gibbosa* Rudolphi, 1802.

Host: *Clupea harengus* L.
Location: stomach.
Locality: South Baltic, fishing ground K-8.

Incidence and intensity of infestation: a single specimen was found in one herring.

This is a common species known from coastal waters of the Scandinavian Peninsula, Great Britain, North America, Asia (Sea of Japan, White and Barents seas). The known hosts are mainly *Clupeiformes* and *Perciformes*. In Poland it was earlier found by Ślusarski 1958 in *Salmo trutta* m. *trutta*. It has not been found earlier in *Clupea harengus*. Some morphological data on the present material: body length 1.3 mm, width 370. Oral sucker 115 × 110, ventral sucker 180 × 180, pharynx 70 × 70; seminal vesicle 150 × 190 with strong musculature of walls, situated in front of the ventral sucker and not exceeding its hind edge. Testes are small, behind the ventral sucker. Eggs 23 × 24.

Cestoda

Bothriocephalidae Blanchard, 1849

Bothriocephalus scorpii Müller, 1776

Syn.: *Bothriocephalus punctatus* Rudolphi, 1810; *Bothriocephalus bipunctatus* Lühe, 1899; *Bothriocephalus* sp. Markowski 1933.

Hosts: immature forms of the parasite were found in *Clupea harengus* L. and *Sprattus sprattus* (L.) The latter is a new host record for this species, the cestode being found for the first time in the herring in South Baltic.

Location: intestine.

Localities: South Baltic (herring and sprat) and the Gdańsk Bay (herring).

Incidence and intensity of infestation are shown in Tables I, II and III.

Previously found in fish caught in the Baltic, Mediterranean, Black and White seas, Arctic, Atlantic and Pacific Oceans. It was reported from Poland by various authors.

Nematoda

Heterocheilidae Railliet et Henry, 1915

Anisakis sp., third stage larva

Host: *Clupea harengus* L.

Location: larvae of this nematode curled into flat spirals were found most often in the body cavity on the peritoneum, and along the blind portion of the stomach. Some of larvae were found in the adipose tissue covering the intestine. Single individuals were also recorded in the liver, between pyloric appendices and on the surface of gonads. A certain number of larvae were found in the muscular tissue. Contrary to larvae found in the body cavity, nematodes found in muscles were never curled into spirals and their position in the muscles was rather straight suggesting migration.

Localities: The Gdańsk Bay; the fishing grounds in the South Baltic: F-G-5-6. This is the first record of *Anisakis* sp. larvae in the Baltic, being reported earlier by the present author (Rokicki 1972).

Incidence and intensity of infestation are shown in Tables I and II.

Apart form this, autopsies of 100 herrings from the Darłowo fishing ground F-G-5-6 and G-6 were made only to find larvae *Anisakis* sp.

The larvae were recorded in 31% of examined herrings, the intensity of infestation ranged from 1 to 15, and most frequently from 4 to 6 per one fish.

These larvae are known from the North Sea, the White and Barents seas, the Atlantic Ocean and the western regions of the Pacific. Larvae found by the present author were 1.8–2.4 cm long and about 0.4 cm in diameter. They are classified in the genus *Anisakis* Dujardin, 1845, on the ground of criteria proposed by van Thiel 1962, and van Thiel and van Houten 1966. The following characters were used as generic discriminants: (1) location of the ventriculus between the pharynx and the intestine (a characteristic feature of *Heterocheilidae* Railliet et Henry, 1915), (2) an oblique connection between the ventriculus and the intestine, (3) a ventral position of the excretory pore in relation to the anterior penetration tooth, and (4) the presence of three anal glands near the excretory pore. The present larvae and the specimens from herrings of the North Sea, classified as *Anisakis* sp., kindly placed of the disposal of the present author by Dr. Sluiters of the National Institute of Public Health, Netherlands, appeared to be completely identical. Larvae with similar morphological features were also found in imported herrings caught in the western region of the Pacific and in the North Sea.

Contracaecum aduncum (Rudolphi, 1802) Baylis, 1920

Syn.: *Ascaris adunca* Rudolphi, 1802; *Porrocaecum adunca* (Rudolphi, 1819).

Hosts: *Clupea harengus* L., *Sprattus sprattus* (L.)

Location: liver.

Localities: The Gdańsk Bay and many fishing grounds outside the Bay, for *Clupea harengus*; the Bay of Gdańsk and only the R-10 fishing ground outside the Bay, for *Sprattus sprattus*.

Incidence and intensity of infestation are shown in Tables I, II and III.

It is a very common and well-known parasite occurring in Boreal Europe, Asia and North America. In Poland, it has been reported from many fish species.

Acanthocephala

Echinorhynchidae (Cobbold, 1879) Hamann, 1892

Echinorhynchus gadi Zoega et Müller, 1776

Syn.: *Echinorhynchus acus* Rudolphi, 1802.

Host: *Clupea harengus* L.

Location: intestine.

Localities: The Gdańsk Bay and the South Baltic.

Incidence and intensity of infestation are shown in Tables I and II.

A common parasite in many sea fish species of the northern Holarctic zone. It has many times been found in Poland.

Pomphorhynchidae Yamaguti, 1939

Pomphorhynchus kostylewi Petročenko, 1956

Host: *Clupea harengus* L.

Location: intestine.

Localities: South Baltic, fishing grounds R-7-8-10.

Incidence and intensity of infestation: see Table I.

In Poland this parasite was also recorded by Rokicki (in press) in *Platichthys flesus* from the Bay of Gdańsk. These are the first records of *P. kostylewi* in this country. So far it was only found in *Varicorhinus capoeta sevangi* in the U.S.S.R.

Polymorphidae Meyer, 1931

Corynosoma semerme (Forssell, 1904) Lühe, 1905, larva

Syn.: *Echinorhynchus semermis* Forssell, 1904; *Echinorhynchus strumosus* Rudolphi, 1802.

Host: *Clupea harengus* L.

Location: body cavity.

Localities: The Gdańsk Bay, catching fishing grounds in South Baltic K-J-11.

Incidence and intensity of infestation: see Tables I and II.

This species has several times been reported from the Baltic: Markowski 1933 found it in *Osmerus eperlanus*, Janiszewska 1938 in *Platichthys flesus*, and Studnicka 1965 in *Gadus callarias*. Morphological characters of the present specimens correspond to the description of Looss 1911 quoted by Petročenko 1958 for this species.

Tentative analysis of the dynamics of the helminth fauna recorded

The catches of *Clupeidae* in the Baltic have considerably increased during the recent few years (Strzyżewska 1971). In spite of this the technological value of fish caught was not the best because most

of them were medium-size or small herrings. Also the forecasts for 1971 (Strzyżewska 1971) did not envisage an increase in abundance of older age groups in the herring herds. Many authors regard this crisis as an effect of excessive exploitation of fishing grounds. Although an analysis of this situation goes beyond the scope of the present study, it seems reasonable to direct attention to the quantitative and qualitative distribution of helminths in relation to the horst age, the seasonal dynamics of the helminth fauna recorded, and vertical distribution of fishing grounds.

The *Clupeidae* in the Baltic include three genera: *Clupea, Sprattus* and *Alosa*. The representatives of the latter genus, quite frequent in South Baltic a few years ago, are a rarity at present.

Clupea harengus L. is a pelagic sea fish. It resides near the bottom during the day and in the night in the medium-depht or superficial waters. Plankton crustaceans are the principal food of the herring. The oldest fish individuals are partly prey animals which is revealed by the contents of their stomach, including fish larvae, small fish and larger crustaceans. In winter and during spawning they do not feed much. They migrate either for searching food or for reproduction aims. Migration falling into the former type are subjected to considerable variations in time and space, but reproduction migrations are similar every year. In the Baltic, the autumn herrings are distinguished, which spawn in autumn, and spring herrings whose spawning period falls early in the spring in the brackish Polish coastal waters.

Herrings from the Gdańsk Bay and other regions of the Baltic have not been regularly examined for the presence of parasites. Markowski, 1933, who examined fish of the Gdańsk Bay and other Baltic waters, made autopsies of 46 herrings and 62 sprats and found four parasite species in them. Popiel 1951, who studied the diet of herrings in the Gdańsk Bay and neighbouring areas, took this opportunity to make a record of the parasites he found on this occasion, but he only determined the acanthocephalan *Echinorhynchus gadi* and referred its life-cycle to the presence of the crustacean *Pontoporeia femorata*.

The present author examined the clupeid fish in the years 1968-1969 in an annual cycle, taking into consideration their total length, sex, and age determined from the examination of otoliths. The degree of development of gonads was determined and this allowed to distinguish representatives of spring and autumn herrings. All in all, 923 herrings and 178 sprats from the Gdańsk Bay and the South Baltic were examined. Endohelminths found in those fish belonged to trematodes, cestodes, nematodes and acanthocephalans; 11 species were distinguished (cf. Tables I, II and III). Only helminths specific of sea fish species were found in her-

rings. Individuals caught in the Gdańsk Bay did not contain as many helminths as those caught outside the Bay (Tables I and II). Perhaps this is due to the fact that herrings caught in the Gdańsk Bay came there for spawning and their stomachs were empty or only filled with a small amount of food. Table IV shows the incidence of helminth infection in

Table IV

Occurrence of helminths of *Clupea harengus* L. in four fishing areas of the South Baltic, incl. the Bay of Gdańsk (cf. Map 1)

		Area A	Area B	Area C	Area D
No. of fish examined		306	556	15	25
Incidence of infestation in %	Helminths (total)	47	36	53	36
	Trematoda	44	19.4	20	4
	Cestoda	1.6	3.2	26	—
	Nematoda	2.6	2.7	6.7	12
	Acanthocephala	7.8	12.4	6.7	20

For explanation:
Area A includes fishing grounds: F-5-6; G-4-5-6-7-8-9; H-4-5-11; J-8-9-11; K-6-8-9--10-11-12.
Area B includes fishing grounds: 0-8-9-10; P-7; R-5-6-7-8-9-10; S-6-7-8; T-7; U-6.
Area C includes fishing grounds: L-16-17.
Area D includes fishing grounds: W-12-13; X-12-13.
The following fishing grounds are distributed in the Bay of Gdańsk: R-5-6; S-6; U-6.

herrings from 4 Baltic fishing areas. The water of the A and C fishing areas which are situated westward and north-westward of areas B and D (Map 1) shows a higher degree of salinity (cf. chapter dealing with material and methods); also the composition of the helminth fauna in the mentioned areas was different. In the region A the incidence of trematodes was the highest and that of cestodes the lowest. The incidence of nematodes was similar in regions. A and B, and acanthocephala were found much more frequent in region B than in A.

The distribution and composition of the helminth of parasites and the fauna in different age groups of fish is shown in Table V. As the sample material was taken at random there is a relatively small percentage of older fish and, as a result, the Table does not give a clear picture in this respect. One-year old herring individuals were only infected with the trematode *Brachyphallus crenatus*. The most variegated helminth fauna was recorded in the age group 2–6 years inclusive.

Diagrams 1, 4, 5 present the incidence of helminth infection in herrings, depending on the depth of waters in which it was caught, the

Table V

Composition of the helminth fauna and the age of the host *Clupea harengus* (the incidence of infestation within age groups)

Fish age group	No. of fish determined	*Hemiurus luehei* (%)	*Hemiurus raabei* (%)	*Brachyphallus crenatus* (%)	*Parahemiurus merus* (%)	*Bothriocephalus scorpii* (%)	*Anisakis* sp. (%)	*Contracaecum aduncum* (%)	*Echinorhynchus gadi* (%)
I	20	—	—	10	—	—	—	—	—
II	81	3.7	1.2	25.9	—	1.2	—	1.2	6.1
III	118	5	—	5.9	—	1.7	—	0.8	7.7
IV	69	1.4	—	33.3	1.4	—	4.3	2.9	16
V	50	—	—	16	—	2	2	—	18
VI	26	—	—	19.2	—	—	3.8	—	7.7
VII	22	9	—	45.4	—	4.5	—	9	27
VIII	20	—	—	20	—	5	—	—	10
IX	21	—	—	33.3	—	—	—	4.7	23.8
X	22	—	—	22.7	—	—	—	4.5	27.4
XI	12	—	—	—	—	—	—	8.3	8.3
XII	10	—	—	—	—	—	—	—	40
All groups	471	—	—	—	—	—	—	—	—

Table VI

Occurrence of four helminth classes in *Clupeidae* of the South Baltic (except the Bay of Gdańsk)

Host species	No. of fish					
	examined	infested with				
		helminths (total)	trematodes	cestodes	nematodes	acanthocephalans
Clupea harengus L.	795	318	220	18	30	83
Sprattus sprattus L.	173	8	4	3	2	—
Clupeidae (total)	968	326 (33.6%)	224 (23.1%)	21 (2.1%)	32 (3.3%)	83 (8.5%)

length of the fish, and the season of the year in which the fishes were caught. The infestation with trematodes and cestodes was found to decrease with the depth of fishing grounds. This suggests that shallow waters abundant in zooplankton offer an environment in which trematodes and cestodes find better developmental conditions than do other

Table VII

Occurrence of four helminth classes in *Clupeidae* of the Bay of Gdańsk

Host species	No. of fish					
	examined	infested with				
		helminths (total)	trematodes	cestodes	nematodes	acantho-cephalans
Clupea harengus L.	128	48	28	9	4	25
Sprattus sprattus (L.)	5	—	—	—	—	—
(?) *Alosa fallax* (Lacepede)	1	1	—	1	1	—
Clupeidae (total)	134	49 (36.5%)	28 (20.8%)	10 (7.4%)	5 (3.7%)	25 (18.6%)

helminth groups. The number of fish infested with nematodes increases at a depth exceeding 80 m (Diagram 1). The Diagram does not, however, reflect the fact that *Echinorhynchus gadi* which accounts for the major part of *Acanthocephala* in herring, was found in fish caught in shallow and deep waters as well, but always in the direct vicinity of the shore.

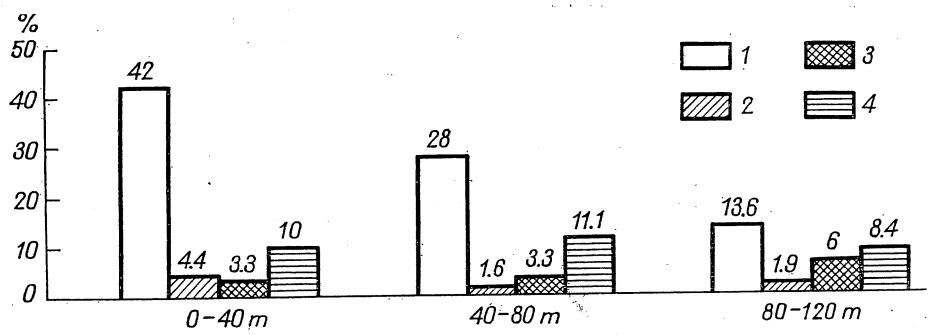

Diagram 1. The incidence of infestation with helminths in *C. harengus*, and the depth of the catching areas: 1 — trematodes, 2 — cestodes, 3 — nematodes, 4 — acanthocephala.

This would coincide with Popiel's 1951 suggestion that *Pontoporeia femorata* is involved as an intermediate host of *E. gadi*. This host was found by Popiel in waters up to 40 m deep.

The incidence of infestation with *Nematoda* and *Acanthocephala* was higher in spring herrings than in autumn herrings (Diagram 2). On the other hand, the autumn herring was more infected with trematodes and cestodes than spring herring. This suggests that the mode of life of the two groups is different to such an extent that it brings about differences in the incidence of infestation with helminths.

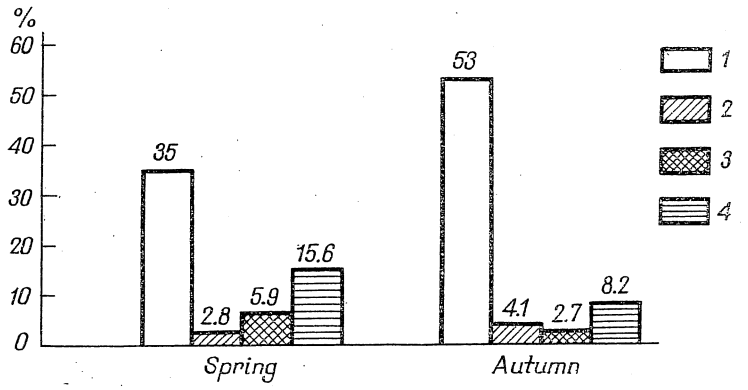

Diagram 2. Helminth fauna of the spring and autumn *C. harengus* forms. For explanation see Diagram 1.

The stomach of the herring is composed of three parts. It may be supposed that the conditions afforded by each of the three parts are not similarly favourable for the establishment of parasites. There is, however, no clear division into a group of species parasitizing the stomach and that inhabiting the intestine; there are only differences in the incidence and intensity of infestation. The highest infestation was noted in the pyloric part of the stomach, while the blind part showed the lowest intensity of the helminth infestation (Diagram 3). Despite lack of com-

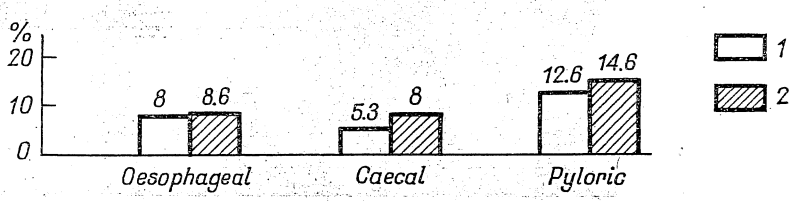

Diagram 3. The incidence of infestation in the *C. harengus* stomachs. 1 — *Brachyphallus crenatus*, 2 — *Hemiurus luehei*.

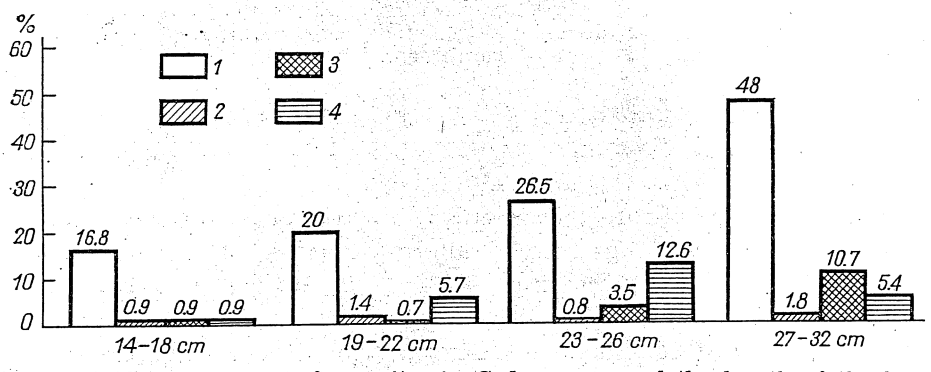

Diagram 4. The occurrence of parasites in *C. harengus*, and the length of the host. For explanation see Diagram 1.

plete data for each age group, it seems, judging by the present findings, that the helminth infestation increases with the growth of the fish length, this being true for all groups of helminths (Diagram 4). Sure enough, older herrings eat more and larger organisms (they eat more fish) and thus are more exposed to infection with certain parasites. Popiel 1951 stated that in the stomachs of herring specimens over 25 cm long, the fish *Gobius* sp. specimens and their larvae were found. Markowski 1935, considers that *Gobius minutus* is the main second intermediate host of the cestode *Bothriocephalus scorpii* (incidence: 41%) in the Gdańsk Bay. Larger fish can eat larger organisms and this is an explanation of the growing incidence of infestation with cestodes in larger herring specimens (Diagram 1). Smaller herrings, on the other hand, become infested by eating *Eurytemora hirudo*, also an intermediate host of *Bothriocephalus scorpii* (Markowski 1936). Popiel 1951, found few copepods in stomachs of examined herrings caught in the coastal waters.

According to Popiel 1951, *Pontoporeia femorata* is the first intermediate host of *Echinorhynchus gadi*. It results from his Diagram V that herring feeds on *Mysidacea*, to which this crustacean belongs, and that the amount of food increases in proportion to the growth of the length of fish up to 25 cm. In fish exceeding 25 cm in length, the consumption of those crustaceans drops nearly by half. The analysis of the occurrence of *Acanthocephala* in fish, according to the host's length (Diagram 4),

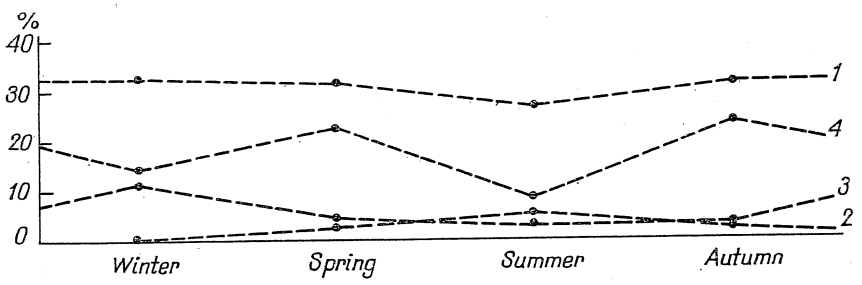

Diagram 5. The incidence of the helminth infestation in *C. harengus*, and the season of the year. For explanation see Diagram 1.

clearly shows a relationship between the presence of parasites in the fish and the amount of food consisting of organisms in which immature forms of these parasites develop.

Infestation with cestodes reached its peak in summer; it was somewhat lower in the spring and autumn, and in winter it nearly disappeared. Infestation with nematodes was the highest in winter, and in the remaining seasons of the year it was more or less at the same level. The

high mean incidence in winter is due to the fact that larvae *Anisakis* sp. were found in herrings only in that season. Spring and autumn were found to be the optimum seasons for *Acanthocephala*, the incidence with those helminths considerably decreased in summer and winter.

Sprat was infected with helminths to a small extent. *Hemiurus luehei*, *Bothriocephalus scorpii* and *Contracaecum aduncum* were the only helminth species recorded. In a fish determined as *Alosa fallax* (Lac.) (the determination is not certain) the cestode *Proteocephalus macrocephalus* was found.

The above data indicate that the investigated *Clupeidae* in the Baltic were infested with a small number of helminth species if compared to the complete list of parasites of this fish family found in other seas. By the way, these complete lists are also poor in helminth species as compared to the helminth fauna of other fish groups. It may be supposed that the pelagic mode of life of these fishes and occurrence in large fish herds as well as a great selection (probably also by means of elimination of weak and ill fish) results in such a picture of their helminth fauna.

Remarks on the occurrence of *Aniskis* sp. larvae

The third larval stage mentioned here was known so far from sea fish, above all *Clupea harengus* L., *Salmo salar* L., *Scomber scombrus* L. and *Osmerus eperlanus* L., in the North Sea and the Atlantic Ocean (van Thiel 1966, Vik 1966 etc.). There are also data pointing to the presence of these larvae in the White Sea and the Barents Sea (Šulman and Šulman-Albova 1953) and in the western region of the Pacific Ocean (Yokogawa and Yoshimura 1965, 1967, and the present author's material, unpublished findings).

Sure enough, adults of this nematode are unknown. Many adults of the genus *Anisakis* were found by various authors in the stomach and intestine of sea mammals, such as *Halichoerus grypus* (Fabr.), *Phoca vitulina* L., *Lagenorhynchus albirostris* Gray, *Phocaena phocaena* (L.), *Tursiops truncatus* (Montagu), *Hyperoodon amullatus* (Forst), *Delphinapterus leucas* (Pall.), *Balaenoptera acutorostrata*, in numerous collecting places in the Atlantic Ocean and the North Sea (Baylis 1920, Baylis and Daubney 1926, van Thiel 1966, and others). Van Thiel (op. cit.), who based his opinion on his own investigations, maintained that *Anisakis* nematodes found in mammals of the South Atlantic and the North Sea represent the same species. He also considered that the *Anisakis* larvae, common in herrings, are identical with larvae described from herrings in 1767 by Linnaeus as *Gordius marinus*. Creating a new

combination *Anisakis marina* (Linnaeus, 1767), the mentioned author came from the assumption that this well-known larval form was a larva of nematodes found in the sea mammals mentioned earlier. However, his stand has not yet been supported by detailed studies consisting in the comparison of larvae for identifying with adult forms, which can only be made by an experiment. Moreover not a single life cycle of nematodes of the genus *Anisakis* has been known. In addition, Baylis 1944 puts in doubt the value of description of Linnaeus which, according to Baylis, is so scant and insufficient that it cannot serve as a basis to determine not only a species but even a genus. In this situation all the *Anisakis* larvae found in sea fishes should be determined only as *Anisakis* sp. as long as their adults are not identified. Khalil 1969 took a similar stand in this matter.

There are no reports on the occurrence of *Anisakis* in the Baltic. Up to now investigation of Baltic fish was mainly conducted in bays and gulfs where the herring, probably the main host of the third larval stage of *Anisakis* sp., occurs occasionally, so that it was of marginal value for the investigation. There is no mention in relevant literature about the occurrence of *Anisakis* larvae in the Baltic. Nor is there any mention about adults of this nematode in sea mammals living in the Baltic. Šulman and Šulman-Albova 1953, are of the opinion that representatives of *Anisakis* do not occur in the Baltic because of a low degree of salinity of this sea. The mean salinity of the Baltic is 8 g of salt per 1 litre, as against 34 g per litre in the North Sea. As a result the flora and fauna are different in each of the two seas, and many organism species which constitute the trophic base of the herring in the North Sea are almost unknown in the Baltic. Professor R. Ph. Dollfus of the Museum National d'Histoire Naturelle, Paris, expressed the presumption (personal information) that *Anisakis* nematodes probably occurred in the Baltic. The present findings support his suggestion which had been made before the present author discovered these nematodes in the Baltic Sea. A single nematode which Creplin 1839, found in the intestine of a herring caught in the Baltic, was ranked into *Ascaris gracilescens* Rud., 1819. Its description is too short and one should examine it again at the Zoological Museum in Greifswald where it is kept, to take a stand as to its specific status. According to Löliger-Müler (fide Roskam 1960), *Eustoma rotundatum* (Rud., 1819) is found in larval stage in the Baltic herring. This nematode is known at present as *Pseudoanisakis rotundata*, whose adults parasitize certain *Chondrichthyes* (sharks and rays).

As mentioned earlier, the life cycle of the mentioned nematodes, whose larvae are commonly found in marine fish, and whose adults certainly parasitize at least one of the known species of marine mammals,

is unknown. No *Anisakis* larvae have been found in the sea plankton. Van Thiel et al. 1960, regard *Copepoda* and other zooplankton organisms as the first intermediate host of these nematodes. Banning 1967, who examined 700 samples of plankton from the North Sea, did not mention these larvae. Berland 1961, quotes Polianski who allegedly found *Anisakis* sp. larvae in a pelagic crustacean of the genus *Thysonoësa* in the Baltic. But no more detailed data are available in this matter. This does not exclude that one of van Thiel's 1966 hypotheses may be correct. According to him plankton crustaceans can be involved as intermediate hosts of early larval stages of *Anisakis*. This view is supported by the composition of the contents of herring stomach. In the Baltic, young herrings feed almost exclusively on *Copepoda,* and older herrings on larger *Mysidacea*. Herrings of the most advanced age group are partly prey fishes and eat fish larvae, small fish and large crustaceans. The food of the herring differs in various regions of the Baltic, but *Copepoda, Schizopoda,* fish larvae and young fish constitute the main food of these fishes.

Šulman and Šulman-Albova 1953, report that the maximum incidence of infection with *Anisakis* larvae in the White Sea was recorded in the Kandalaksha Bay. Khalil 1969, reports that the intensity of infestation with this parasite of herring in the North Sea is even higher near the British coast than in the deep sea. It is considered that the plankton infested with *Anisakis* sp. larvae exists in the North Sea but this suggestion has not yet been supported by detailed studies. It is possible that the plankton is drifted by the water current through the Danish Straits, from the North Sea to the western regions of the Baltic. Hence the conclusion may be drawn that this parasite can occur in the western Baltic, if the hypothesis of Šulman and Šulman-Albova 1953 about the influence of salinity on the possible presence of *Anisakis* larvae is recognized as correct. The salinity of the Baltic increases towards the Danish Straits, and the greater the distance from the North Sea, i.e. from the connection with the open sea, the lower degree of salinity, as a result of inflow of fresh river water. Also the size of herrings in western regions of the Baltic is better adapted to the requirements of *Anisakis* larvae than in other regions of that sea. Medium-size herrings occur in the Belts, in the western part of the Baltic and in its central part between Rügen, Bornholm and Gotland. In the eastern regions of the Baltic small herring occurs, called strömling or salaka.

As is known, *Cetacea* and *Pinnipedia* are the final hosts of *Anisakis* nematodes in the Atlantic and the North Sea. It is supposed (van Thiel 1966), that *Halichoerus grypus* is the largest source of infestation of herrings in the North Sea. According to Ropelewski 1952, *H. grypus*

is mainly concentrated in eastern region of the Baltic, and *Phoca vitulina* is only found in western Baltic. *Delphinus delphis* and *Phocaena phocaena* only occasionally occur in the Baltic. Hence, from the point of view of the presence of final hosts of *Anisakis* sp., eastern Baltic seems to provide more favourable conditions for its development. On the other hand, the majority of arguments are in favour of western region of the Baltic as the possible main centre of *Anisakis* larvae in that sea But these are only theoretical dissertations based on to-date studies of that parasite in other geographical regions, and the results of these studies are far from being complete.

The fact that *Anisakis* larvae have been found in herrings living in the Baltic is important not only from the point of view of our knowledge of parasite fauna of the Baltic, but also for the aspect of the human health. From the moment *Anisakis* larvae were found in man for the first time (S t r a u b 1955) in the Netherlands, and severe pathological disturbances were found in human intestine as a result of its penetration by this parasite (van T h i e l et al. 1960, K u i p e r s et al. 1960 a, b), interest in this nematode has considerably increased. It has been proved that larvae found in man are identical with *Anisakis* larvae which are common in herrings. More reports were made on frequent infestation of men with *Anisakis* larvae in Britain, Denmark and Japan. The pathogenesis, pathology and clinical treatment of this parasitic disease in men have been worked out and regulations have been issued to prevent the spreading of infection by eating raw herring or incorrectly prepared herring pickles.

Summary

Examination of 923 herrings *Clupea harengus* L. and 178 sprats *Sprattus sprattus* (L.) from the Gdańsk Bay and South Baltic, revealed 5 trematode, a cestode, 2 nematode, and 3 acanthocephalan species. *Clupeidae* were examined during an annual cycle in 1968–1969, and classified according to their total length, sex and age. Two categories of fishes: the spring and the autumn herrings were distinguished according to development degree of gonads. On the ground of data obtained this way a tentative analysis was made of the dynamics of the helminth fauna formation in *Clupeidae*. As regards the number of species, trematodes predominated in the Baltic herrings; *Brachyphallus crenatus* was the predominant species, and *Echinorhynchus gadi* the subdominant. In the herrings from the Gdańsk Bay there was no clear predominance of any helminth class, but as regards individual species, *Echinorhynchus*

gadi predominated, *Brachyphallus crenatus* being the subdominant species. *Clupea harengus* appeared to be a new host record for *Hemiurus raabei* Ślusarski, 1958 and *Pomphorhynchus kostylewi* Petročenko, 1956. The particular importance attached to the presence of *Anisakis* sp. larvae in *Clupeidae* and the fact that these nematodes have for the first time been recorded in the Baltic, are discussed.

Acknowledgements

The author wishes most sincerely to thank Professor Dr. J. Popiel of the Marine Fisheries Institute, Gdynia, whose advice helped a great deal to get the fish for the present study. He wishes also to extend his warm thanks to the Management and fishermen of Fisheries Enterprises "Barka", Kołobrzeg, "Szkuner", Władysławowo, "Dalmor" Gdynia and "Wyzwolenie", Świbno, for supplying much of the fish material on which this paper is based.

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STRESZCZENIE

W wyniku zbadania 923 śledzi, *Clupea harengus* L. i 178 szprotów, *Sprattus sprattus* (L.) łowionych w Zatoce Gdańskiej i południowym Bałtyku, autor stwierdził 5 gatunków *Trematoda*, 1 *Cestoda*, 2 *Nematoda* i 2 spośród *Acanthocephala*. Poszukiwania prowadzone były w latach 1968–1969 w cyklu rocznym, przy uwzględnieniu długości całkowitej, płci ryb, a także ich wieku, określonego na podstawie badania otolitów. Określony był też stopień rozwoju gonad, przy czym autorowi udało się wyróżnić przedstawicieli stada śledzi wiosennych i jesiennych. W oparciu o uzyskane wyniki autor podjął próbę analizy dynamiki kształtowania się helmintofauny *Clupeidae*. Pod względem liczby gatunków pasożytów

u tych ryb przeważała gromada przywr (*Trematoda*), zaś gatunkiem dominującym była przywra *Brachyphallus crenatus*, a subdominantem kolcogłów *Echinorhynchus gadi*. Śledź okazał się nowym żywicielem dla *Hemiurus raabei* Ślusarski, 1958 i *Pomphorhynchus kostylewi* Petročenko, 1956. Ponadto, w związku ze szczególnym znaczeniem, jakie przywiązuje się do występowania larw *Anisakis* sp. u ryb śledziowatych, a także wobec faktu pierwszego stwierdzenia tych nicieni w Bałtyku, omówienie ich objęte jest osobnym rozdziałem. Autor snuje też rozważania na temat przynależności gatunkowej tych larw.