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Jadwiga GRABDA

Parasitology

THE DYNAMICS OF THE NEMATODE LARVAE, *ANISAKIS SIMPLEX* (RUD.) INVASION IN THE SOUTH-WESTERN BALTIC HERRING (*CLUPEA HARENGUS* L.)

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The analysis of an infestation level of the Baltic herring (*Clupea harengus* L.) with *Anisakis simplex* (Rud.) larvae as well as otoliths and gonad maturity examinations allowed to distinguish, among the Pomeranian Gulf and adjacent area herrings, 4 herring stocks appearing succesively in the region investigated. The seasonal occurrence of *Anisakis* larvae in herring from the examined fishing regions is related to the sequence of arrival of the different stocks. Suspected sources of invasion are discussed, the *Anisakis* invasion being related to the North Sea herring migrations.

INTRODUCTION

In spite of the vast literature, larvae of *Anisakis* commonly found in many marine fish species still attract attention of many workers on account of a possible infestation of man.

Until recently, larvae of this nematode species have been regarded as absent from the Baltic fishes. **Šul'man and Šul'man Al'bova** (1953) contributed to support this view as

they were of opinion that *Anisakis* was very sensitive to the salinity conditions and could occur only in waters of sufficient salt concentrations. They based their opinion on the fact that the frequency and invasion intensity were at their greatest in the Kandalaksha Firth, the most saline part of the White Sea in which *Anisakis* was encountered in many fish species. The Onega Firth fishes were infested to a smaller extent, whereas the lowest degree of fish infestation was recorded in the most diluted Dwina Firth with only 14 larvae found in 145 fishes examined.

Also the results of studies carried out on the Baltic fishes, presented in many papers (**Markowski**, 1933; **Janiszewska**, 1938; **Kahl**, 1939; **Popiel**, 1951; **Engelbrecht**, 1958; **Studnicka**, 1965; the author's unpublished data from the period 1961–1962), have influenced the establishment of this opinion. The authors mentioned have not succeeded to find the *Anisakis* larvae in any fish species from the Baltic, usually referred to as the parasite hosts in the other seas, e.g., herring, cod, mackerel, plaice, salmon, and others.

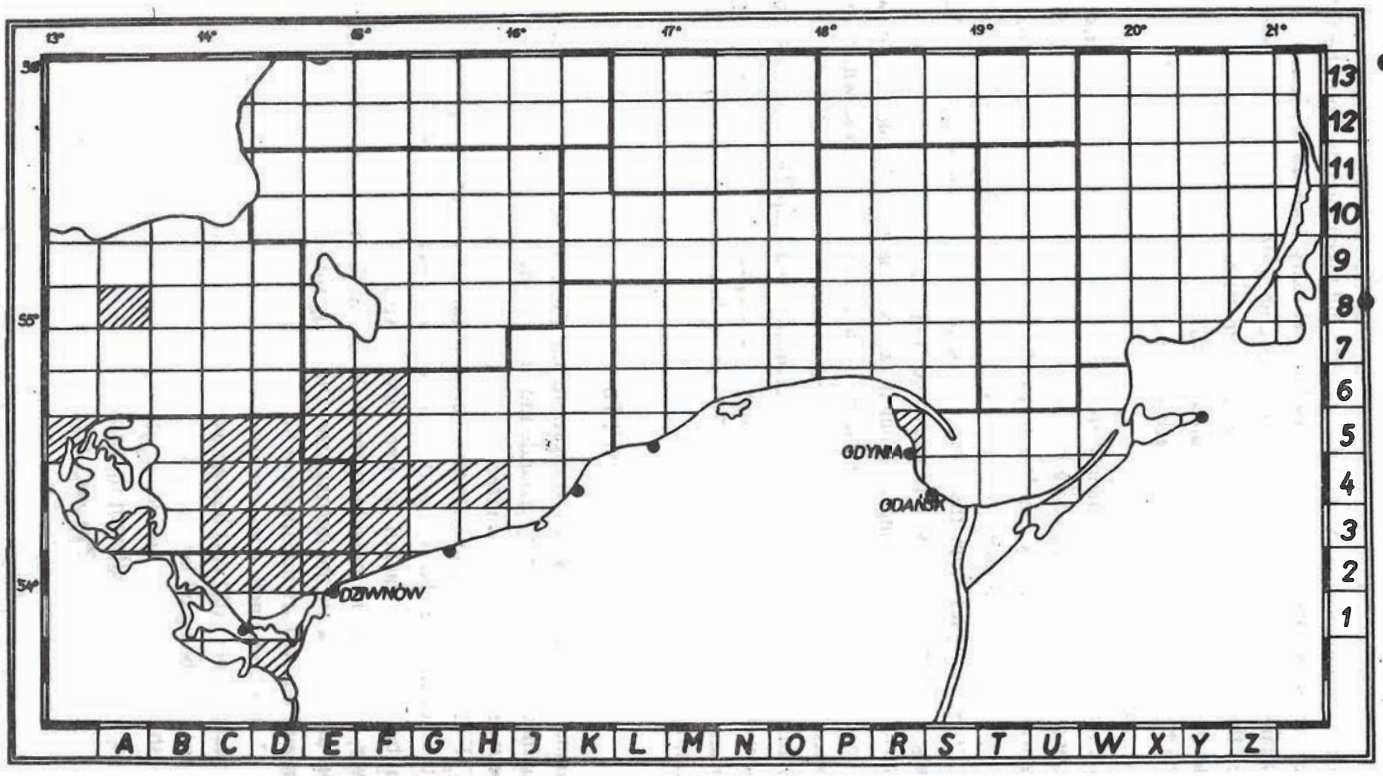
Only as late as in 1972 the first reports on the *Anisakis* larvae findings in the Baltic herring were presented (**Rokicki**, 1972, 1973; **Lubieniecki**, 1972).

Rokicki (1972) examined, in February 1970, 100 herring individuals of body length 15–28 cm, caugth from F, G-5, and G-9 Baltic fishery grounds, and found 31% herring infestation with the invasion intensity 1–15, most frequently 4–6 larvae per one fish individual.

More comprehensive studies, although also at random, were carried out by **Lubieniecki** (1972). In 1969–1972 he examined 4233 herring individuals of body length 16–35 cm from various fishery grounds and found the *Anisakis* larvae for 4 grounds only (R-11, S-4, S-4 and J-7). The infestation extent appeared to be relatively small. The greatest infestation (12%) was recorded in April 1972 in R-4 area with an average intensity of 3.6 larvae per 1 fish. The fishes had been caught during their spawning at a distance of about 1 Nm from teh shore. The author believed these herrings to belong to a local stock spawning within the Gdańsk Bay. The fishes from the other regions showed a slight infestation (0.5–1.8%) observed only in four samples: in November 1969, May 1970, and twice in June 1972.

The present author's own observations (**J. Grabda**, 1974) made in 1972 showed, on the 6 th of May, 93.4% infestation with the invasion intensity 1–43, averaging to 11.3 larvae per 1 herring individual (The observations were carried out on the Pomeranian Gulf herrings of body length 26–30 cm). This value is regarded as a surprisingly high invasion extent. In view of this fact, three monitoring inspections were made on the Pomeranian Gulf herrings in June 1972, with negative results obtained. During the same time (June) **Lubieniecki** (1972) carried out his investigations on various Baltic fishery grounds and only twice found a slight infestation (1.8% and 0.5% in R-11 and J-7, respectively).

The discrepancy of the results quoted above has made the author to undertake detailed studies on the dynamics of the *Anisakis* larvae invasion in the Baltic herrings throughout the annual cycle.



Fishery ground investigated

Fig. 1. The regions of Baltic Sea under examination in a period from February 1973 to February 1974. Data obtained of 2850 herrings from 29 samples

MATERIAL AND METHODS

The herrings were supplied by commercial catches and taken directly from the fishing vessels throughout the year (February 17th, 1973 – February 16th, 1974) at approximately two weeks'intervals, except for October and November 1973 when strong winds and storms stopped the fishing activities and caused a longer pause in the investigations.

One sample from a fishery ground amounted to 100 herring individuals. Totally 2850 individuals of 17.5–31.5 cm total body length were examined. Most often the 23–26 cm specimens were found in the samples.

The fishes examined were taken mainly from the Pomeranian Gulf, Odra Bank, and western Kołobrzeg – Darłowo fishery grounds exploited by boats belonging to SPRM „Belona", Dziwnów Additionally, in March 1973, the samples were taken from the Szczecin Firth, Greifswalder Bodden, and a fishery ground off Hiddensee. In September and October 1973 2 samples from the Arkona ground were examined, while in March 1974 50 herrings from the Puck Bay were inspected (Fig. 1).

Only the larvae present in herring abdominal cavities, visible with naked eye, were taken into account when determining the extent of infestation. The larvae which might have been in muscles or gonads were not considered.

The gonad maturity stage was determined according to a simplified three-level scale (gonad non-developed – I, gonad moderately developed – II, gonad well-developed – III). From April 1973 till February 1974 the otoliths were taken from the fishes under examination.

RESULTS

Table 1 summarizes the results of investigations and presents the infestation extents of the fishes examined in various fishing grounds and in different time.

Correlation between the incidence of infection and the body length

The graph (Fig. 2) reflects a relationship between the extent of the *Anisakis* larvae invasion and the herring size. To follow this relationship, 1141 spring herring individuals of 19–30 cm body length, caugth in February – April 1973, were examined. No nematode larvae were found in individuals below 20 cm. Both the incidence and intensity of the invasion increased with the herring size. Originally slow infection increase became rapid at 27 cm and reached its maximum of 96.5% with 30 cm body length. The smallest herrings (20–22 cm) contained a few nematode larvae (average 1.6 larvae per 1 fish), whereas the greatest ones (30 cm) had an average invasion intensity of 14.6 larvae per fish, the extremal cases being 67 larvae per fish.

The relationship between the incidence of invasion and the herring body size in the Baltic, presented here, agrees well with the other authors results for various areas (**Bishop** and **Margolis**, 1955; **Hodder** and **Parsons**, 1971; **Parsons** and **Hodder**, 1971; **Reimer** and **Jessen**, 1972; **Thiel** et al., 1960; and others).

All the authors mentioned also quote 20 cm body length as a lower limit for the *Anisakis* larvae infection, only **Khalil** (1969) scarcely found the larvae in fishes below

Table 1

Infestation of Anisakis larvae in herring from various fisheries of Baltic Sea in years 1973–1974

Number of sample	Fishery	Date of fishing	Length of herring (cm)	Incidence (%)	Intensity of infection	Total number of larvae
1	E – 5	17 II 1973	21–30	40	1–23	138
2	C,D– 4,5	1 III 1973	23–29.5	54	1–17	248
3	D – 2	8 III 1973	22–30.5	56	1–33	287
4	C,D – 3	8 III 1973	22–30	40	1–50	158
5	G,H – 4	10 III 1973	22–31.5	23	1–19	131
6	Greifswald	14 III 1973	24–30.5	54	1–31	157
7	Hiddensee	15 III 1973	20.5–28.5	58	1–27	172
8	C,D – 2	23 III 1973	23–29	51	1–22	211
9	Szczec. Bay	6 IV 1973	19–30	30	1–20	137
10	C,D – 2,3	13 IV 1973	21–30	45	1–18	213
11	C – 4	4 V 1973	20–25	12	1–10	28
12	E,F – 4	24 V 1973	19–29	3	1–20	25
13	E – 5	6 VI 1973	22–30	0	0	0
14	E – 5	20 VI 1973	21–27	0	0	0
15	E – 5	5 VII 1973	22 – 27.5	0	0	0
16	E – 4,5	19 VII 1973	20.5–26	0	0	0
17	E,F – 5	15 VIII 1973	20–29	0	0	0
18	E,F – 5,6	29 VIII 1973	21–27	1	5	5
19	F – 6	18 IX 1973	20.5–28	0	0	0
20	Arkona Depth	25 IX 1973	17.5–25	0	0	0
21	E – 5	5 X 1973	21–28	6	2–18	47
22	Arkona Depth	20 X 1973	18–26	0	0	0
23	E – 4	30 XI 1973	22–26	60	1–40	701
24	E,F – 2,3	21 XII 1973	21–29	42	1–29	396
25	E – 5,6	5 I 1974	22–29	50	1–28	463
26	E – 6	24 I 1974	23–29	69	1–32	690
27	F – 6	7 II 1974	22.5–26	51	1–15	377
28	D – 5	16 II 1974	22–30	80	1–67	802

12 cm length. a steady increase in both the invasion incidence and intensity being noted above 12 cm.

Seasonal occurrence of the Anisakis larvae

The herring infection was not stable throughout the year, but varied to a great extent, as presented on a graph (Fig. 3), following the variations in the herring infestation during the annual cycle. The curve was derived from 2200 herring individuals from the Pomeranian Gulf, Odra Bank and western Kołobrzeg – Darłowo grounds restricted to the fishery squares C-F – 2-6.

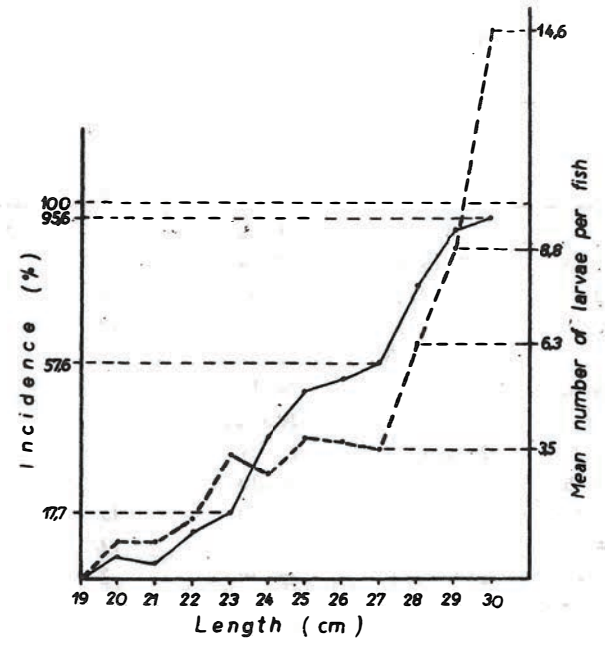


Fig. 2. Relationship between the length of *Clupea harengus*, the incidence of infection and mean number of *Anisakis simplex* larvae per fish. Data obtained of 1141 herrings caugth in South-West Baltic in February – April 1973

As it has been mentioned above, the body length range of the fishes examined was 17.5–31.5 cm, the greatest number of fishes (50–99%) being found within 23–26 cm, and the number of fishes both below 23 cm and above 26 cm were almost equal. Only the May sample compositions differed in this respect a considerabele amount of fishes below 23 cm (21–76%) and a lack of individuals above 26 cm which would balance the infestation percentage. These two samples could be appropriately interpreted only from otoliths and ascribed in this way to the proper herring group (Table 1 and 2), i.e., to the spring herring spawning off the Pomeranian Gulf coasts.

A clear seasonal occurrence of the *Anisakis* larvae is marked here with two periods that can be distinguished. One of them (autumn – winter – spring) begins in November and is finished in May next year. The second one (summer – autumn) covers the period from June till October. The former showed a high percentage of the herring infestation with the *Anisakis* larvae: in spring 1973 it ranged within 40–56%, in autumn – winter 1973/1974 – 42–80%. On the other hand, the latter (June – October) did not yield any larvae or they occurred in negligible numbers.

In spring 1973 the herring individuals were caught mainly from the squares C,D–2,3, the Greifswalder Bodden, off Hiddensee, and from the Szczecin Firth (Fig. 4). It was the spawning period; the fishes exhibited well-developed gonads filling the entire abdominal cavity.

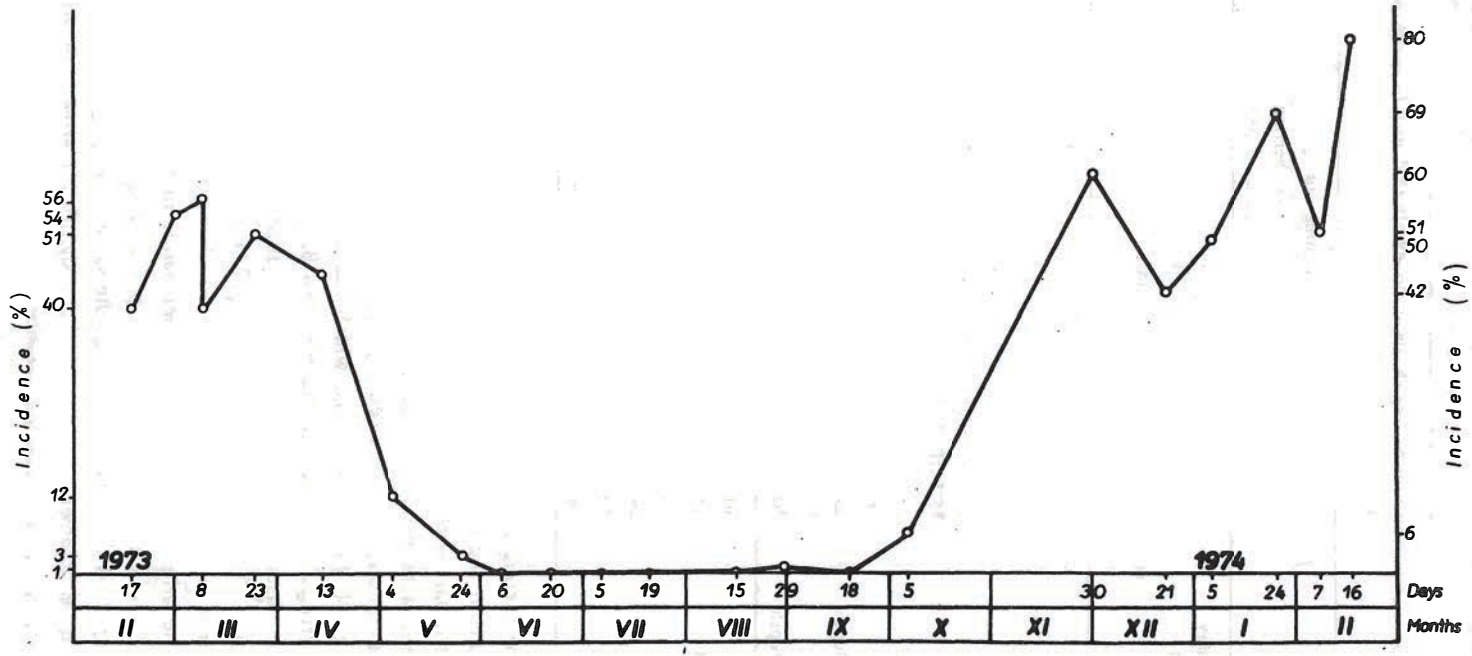


Fig. 3. Incidence of *Anisakis simplex* larvae in *Clupea harengus* in a period from February 1973 to February 1974. Data obtained of 2200 herrings from 22 samples caugth in South-West Baltic Sea

Table 2

Seasonal appearence of various herring shoals in the investigated areas of Baltic Sea, based on the analysis of otoliths

Number of sample	Fishery	Date of fishing	Spring spawning coastal herring (%)	Spring spawning sea herring (%)	Autumn spawning herring (%)
9	Szczecin Bay	6 IV 1973	100	–	–
10	C,D – 2,3	13 IV 1973	99	1	–
11	C – 4	4 V 1973	100	–	–
12	E,F – 4	24 V 1973	90	6	4
13	E – 5	6 VI 1973	14	54	32
14	E – 5	20 VI 1973	18	78	4
15	E – 5	5 VII 1973	28	68	4
16	E – 4,5	19 VII 1973	28	62	8
17	E,F – 5	15 VIII 1973	14	70	16
18	E,F – 5,6	29 VIII 1973	6	70	22
19	F – 6	18 IX 1973	14.5	85.5	–
20	Arkona Depth	25 IX 1973	–	100	–
21	E – 5	5 X 1973	38	34	24
22	Arkona Depth	20 X 1973	20	80	–
23	E – 4	30 XI 1873	88	10	2
24	E,F – 2,3	21 XII 1973	100	–	–
25	E – 5,6	5 I 1974	94	4	2
26	E – 6	24 I 1974	98	2	–
27	F – 6	7 II 1974	100	–	–
28	D – 5	16 II 1974	98	–	2

In summer, the herring individuals were fished mainly south of Bornholm (E,F–5,6 fishing regions) and in the Arkona fishery grounds (Fig. 5). These are the main feeding areas in the western part of the Baltic Sea as it is evidenced also by a considerable herring stomach fulfillment with plankton. According to **Rutkowicz** and **Klimaj** (1962), the Bornholm feeding grounds are attained by spring spawning sea herring after their spawning in spring off the Swedish coast which has been proved by Swedish taggings. Also the spring herrings spawning off the southern Baltic coasts as well as the autumn ones feed in the area discussed, according to the same authors.

At the beginning of October (5th October 1973) a slight increase in the invasion incidence, amounting to 6%, was noted, but the population structure of this sample did not differ from the other samples. On the other hand, an examination at the end of November revealed a very high percentage of infestation of herring (60%).

From November 1973 till February 1974 in the same areas (Fig. 6) the situation was different than that in summer. Herring showed a significant growth of gonads, their stomachs were less filled, whereas the invasion incidence appeared to be very high (42–80%).

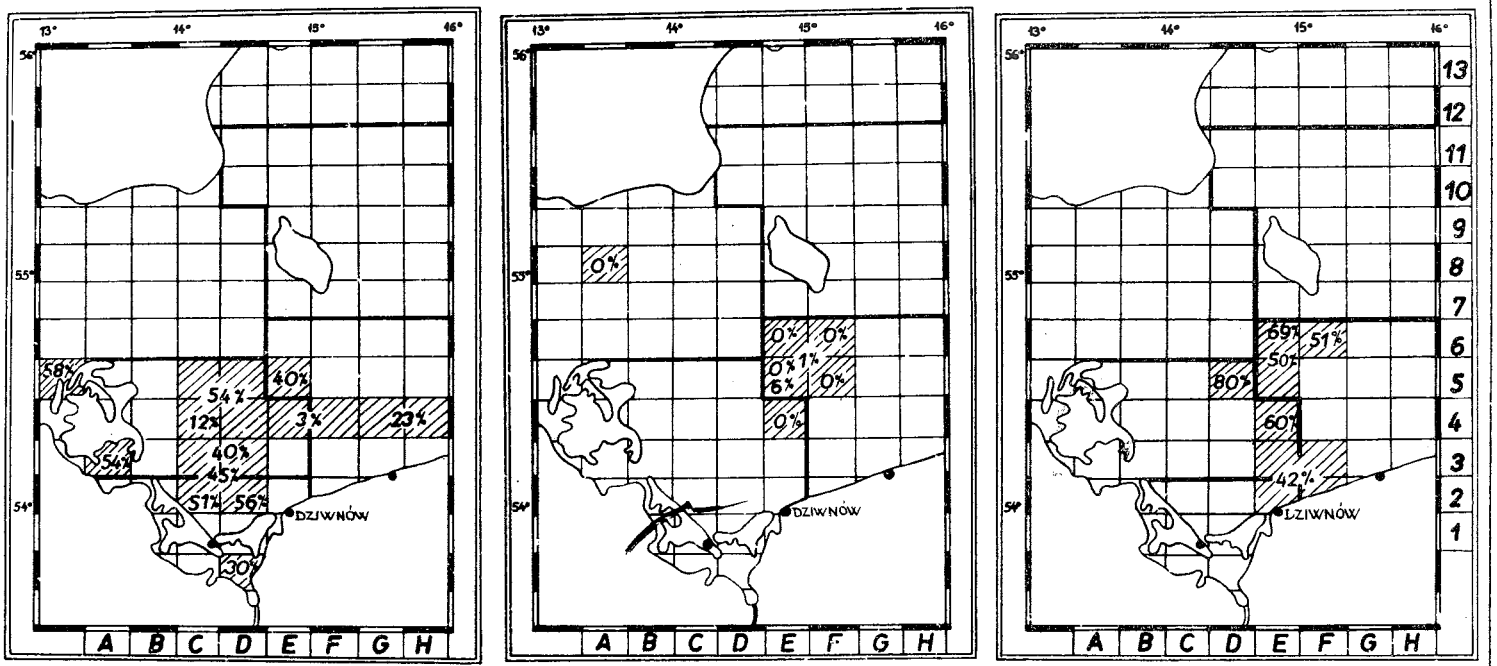


Fig. 4. Incidence of *Anisakis simplex* larvae in fisheries of South-West Baltic Sea in a period from February to May 1973

Fig. 5. Incidence of *Anisakis simplex* larvae in fisheries of South-West Baltic Sea in a period from Juni 1973 to October 1973

Fig. 6. Incidence of *Anisakis simplex* larvae in fisheries of South-West Baltic Sea in a period from November 1973 to February 1974

Analysis of otoliths

I am very much indebted to Prof. dr Józef Popiel and in this place I would like to express my gratitude to him for reading the otoliths collected.

Basing on the otolith readings, 3 groups of herring were distinguished within the studied area of the Baltic, namely:

1. Spring coastal herring spawning in the Pomeranian Gulf in spring (March – May). These fishes enter also the Szczecin Firth in spring. They appear in the fishery grounds in autumn (November) and remain there till spring next year. After having completed their spawning, most of them swim away in an unknown direction, only a small fraction remains in the Bornholm feeding grounds.
2. Spring sea herring spawning in spring off the Swedish coasts. After having completed their spawning they migrate to the southern regions of the Baltic to feed and stay there from June till October. The Swedish taggings have permitted to elucidate the spring sea herring migrations (quoted after Rutkowicz and Klimaj, 1962).
3. Autumn herring which spawn further off the southern Baltic coasts than to the spring ones, from August till November. After having completed their spawning they sink towards deeper layers of the water.

Table 2 summarizes the results of the otoliths analysis.

In spring 1972, the spring herrings occurred almost exclusively in the investigated areas (90–100%). Scandinavian herrings were present in negligible quantities (1% and 6% in two samples), equally rare were the autumn herrings (4% in a single sample).

From June till October the number of spring herring dropped rapidly down to 6–38%, while the spring spawning sea herring group markedly increased in its abundance (34–100%), the autumn herring being noted also fairly frequently (4–32%).

Thus in the same feeding grounds three different herring groups stay in summer, the predomination of the spring sea herring group being clearly marked.

Eventually from November till February, the spring herrings tend to be abundant again in the fishery grounds (88–100%), while the spring sea and autumn ones are present in small quantities, the former only in three samples (2–10%) and the latter in three samples with 2% each.

When comparing the period of presence of the different herring groups in the fishing grounds investigated (Table 2) with the herring infestation in the same areas (Table 1) it can be stated that the Anisakis larvae invasion is noted only in spring herring, while Scandinavian and autumn fish only exceptionally subject to infection. Of the total amount of 297 spring sea herring individuals whose otoliths had been examined, only 3 specimens aging 6–7 years showed an infection (1,0%), while out of 62 autumn herring two individuals 2–4 years old, contained the *Anisakis* larvae (3,2%).

DISCUSSION

After having completed their spawning, most of the herrings swim away in an unknown direction, only a small quantity of them remaining in the Bornholm feeding

area. It is of interest that the remaining fishes show no sign of infection. The spring herring which spawn off the Pomeranian Gulf shores are suggested to form no homogenous group but at least two different populations are present here. One of them consists of quantitatively prevailing, strongly parasitized herring which presumably undertake long-range migrations since in summer they are encountered neither in nearby Bornholm Deep feeding areas nor in the Arkona Deep. The other one probably forms a local stock of Baltic herring with migrations limited to the near-shore spawning and nearby feeding areas, the Bornholm Deep in this case.

This stock remains non-parasitized. Out of 86 spring herring individuals, otoliths of which were examined, only 3 were infested (3.5%), and they had probably parted from their home stock.

The fact that strongly parasitized spring herring disapear in summer is worth consideration.

It has been assumed so far that the Baltic herrings are grouped into distinct local stocks translocating only within the Baltic area boundaries (**Popiel**, 1951; **Popiel** in **Gąsowska**, 1962). These stocks differ from the North Sea and Atlantic ones as well as from one another in their vertebrae, keel scale, fin ray, and filtering processes numbers. spawning season, scale and otolith nature, etc. Certain authors have gone as far as to separate a distinct group of Baltic herring under the name of *Clupea harengus membras*.

Two spring herring stocks have been determined to occur off the Polish coasts: the Pomeranian Gulf and Rugen one, entering also the Szczecin Firth, and the Gdańsk Bay one, spawning in the Puck and Gdańsk Bays, and in the Vistula Firth.

The stocks, according to **Popiel** in **Gąsowska** (1962), differ in their vertebrae numbers and growth rates.

The periodic occurrence of parasitized spring herring indicates to a possibility that herring from more distanced areas of the Danish Sounds or of the North Sea, of permanently high *Anisakis* larvae invasion frequently recorded by different authors as well as the present author (**J. Grabda**, 1974), could enter the investigated feeding grounds.

In the northern Baltic herring no *Anisakis* larvae have been found. The Soviet researches maintain the opinion that the Baltic water salinity is too low to create a suitable environment for *Anisakis* (**Šul'man, Šul'man-Al'bova**, 1953),thus the parasitized herrings could not be expected to come from there.

Parasitized herring enter the southern Baltic as early as in November and remain there till the end of May. After having finished their spawning, they swim back westwards. Their greatest amount spawn in the Pomeranian Gulf and off Rugen, which is evidenced through their high degree of infestation with nematode larvae. A considerable quantity of them, however, moves further eastwards and reaches the Gdańsk Bay (Fig. 7). Lubieniecki showed in his studies 1.3% infestation in S-4 fishing region in May 1970, and 12% in R-4 region in April 1972. On the other hand, the author's own investigations resulted in 27% (26.9%) infection in March 1974 in the Puck Bay coastal waters.

The *Anisakis*-parasitized spring herring group has been denominated as western spring herring opposite to the *Anisakis*-free local herring stock which is suggested to be named

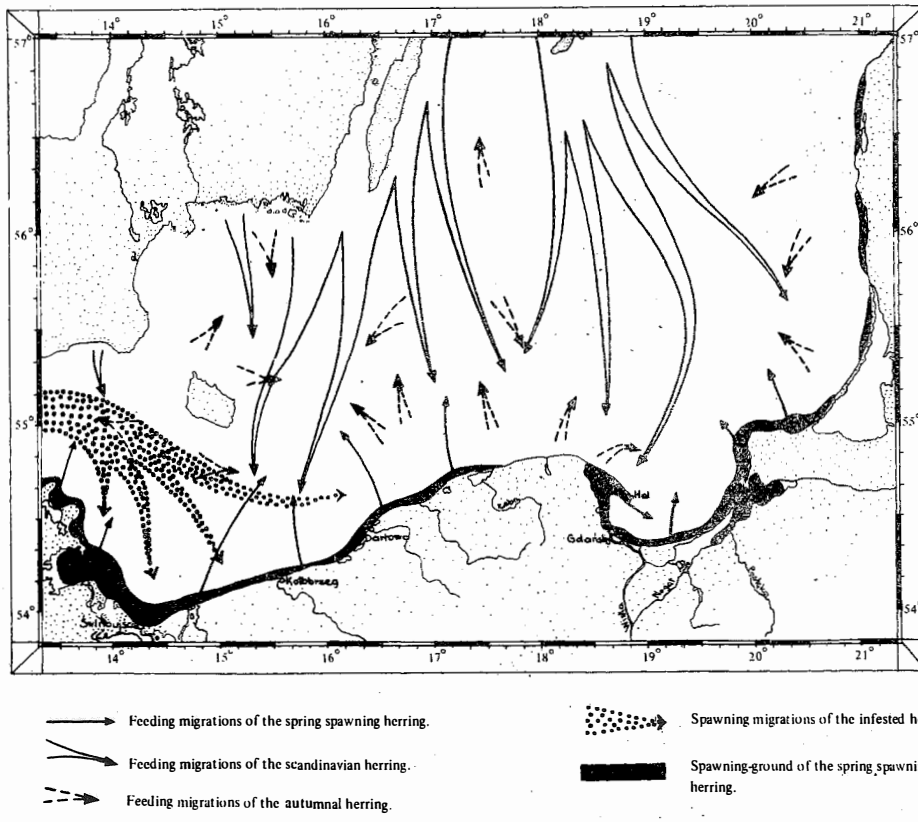


Fig. 7. Migrations of the herring in Southern Baltic (according to Rutkowicz and Klimaj, 1962, supplemented by author)

the southern Baltic spring herrings. They, in turn, can diverge into the Pomeranian Gulf and Gdańsk Bay stocks.

The long-distance spawning migrations of western spring herring are also evidenced by their poor feeding (or a complete cease of feeding) during their pre-spawning and spawning periods; their absence from the Baltic feeding grounds in summer has made them unable to become infested in the Baltic Sea. The spring sea autumn herring, feeding in summer off Bornholm, do not become infested as well.

The individual parasitized specimens found at that time cannot be taken into account as they can be dispersed all over the Baltic area having parted from the western herring stock.

A similar attempt to explain the occurrence of various herring groups in the western Baltic as well as their migrations basing on the parasitologic studies, is given by Reimer (1970).

Basing on the herring infestation with trematodes and cestodes the author mentioned separates 3 herring groups present in the vicinity of Rugen, namely: 2 groups of spring and 1 groups of autumn herring. One of the spring herring groups and the autumn one from a local stock recruited from the western Baltic herrings, while the other spring herring group exhibits long-range migrations. In spring they migrate from the Rugen spawning ground to the Pomeranian Gulf and then come back westwards through the Danish Sounds to Kattegat. During the autumn-winter months the herrings belonging to this group return again to the Rugen coasts.

The present author's own investigations based upon the Baltic herring infestation with the *Anisakis* larvae indicate to much more extended migrations. The parasitized herrings belonging to the so-called western spring herring group migrate much more further eastwards entering the Puck and Gdańsk Bays. After having completed their spawning, they return to the Sounds, and perhaps even to the North Sea, where they become infested.

Additionally, around Bornholm and Arkona Deep one more herring group has been found, the so-called spring spawning sea herring, spawning in spring off the Swedish coasts and migrating to the southern Baltic to feed.

Lubieniecki (1972), when investigating various Baltic fishery grounds, only in June found a negligible infestation of 1.8% and 0.5% in two regions, R-11 and J-7, respectively, while the other regions contained *Anisakis*-free herring. Thus his results are in accordance with those presented above. **Rokicki's** studies carried out in the Baltic Sea (1973) revealed 2% infestation with 1–10 larvae for the Gdańsk Bay, and for the southern Baltic fishery grounds F,G-5, 6–1% infestation with 1–10 larvae per one fish. He did not state the months of sample-taking, but one can suppose they had been taken in summer on account of an insignificant in only a few of the regions examined. Earlier he had recorde 31% infestation in February in the Darłowo fishery area, and this also conforms with our results.

The suggestion, expressed by **Lubieniecki** (1972) and **Rokicki** (1972), of eggs, larvae, and *Anisakis*-parasitized plankton being carried into the Baltic with the North Sea influx waters, thus enabling the Baltic herrings to become infested, does not hold true when confronted with our studies. If it was so, both the southern Baltic spring herring and sea herring group as well as the autumn herring would have to get parasitized during feeding and this was not the case. Apart from that, no *Euphausiidae* acting as the main first intermediate hosts for *Anisakis*, have been found in the Baltic. Recently **Reimer** et al. (1971) and **Reimer** and **Jessen** (1972) have found the *Anisakis* larvae in the North Sea *Chaetognatha*, particularly in *Sagitta*. According to **Różańska** (1971), both *Sagitta setosa* and *S. elegans* are carried into the Baltic with the influx waters and most often they appear in the Arkona region. *Sagitta setosa* appears to be particularly frequent and abundant, and during the strong influxes it is present in the Bornholm Basin, reaching even the Gdańsk Deep.

According to **Popiel** (1951), Sagitta elegans is an insignificant component of the Baltic herring food. This species individuals have been found only in one sample from Novem-

ber, in a few herring specimens from the Słupsk Trough. The *Sagitta* are seldom encountered in the herring food as evidenced by the fact that in spite of their abundant occurrence in the Gdańsk Bay they have not been found in herring of that area.

Similarly, the studies of **Cięglewicz** and co-workers (1972) on the food of herring of the Puck Bay, Gdańsk Bay, Słupsk Trough, Bornholm Basin, and Kołobrzeg – Darłowo fishing grounds, carried out in 1971, exhibited no *Sagitta* in the herring stomach contents. According to the same authors (personal communication) no *Sagitta* were found in herring from the same areas in 1972 and 1973.

The earlier works on the Baltic herring infestation recorded no *Anisakis* larvae in the Baltic Sea (**Markowski**, 1933; **Kahl**, 1939; **Popiel**, 1951; **Engelbrecht**, 1958). **Markowski**, however, examined only 45 herring specimens in 1930, and 1931, most of them in June and July. **Engelbrecht** made his investigations on 15 specimens only, whereas **Kahl's** researches concerned relatively high amount, i.e., 200 specimens. These authors, however, did not include investigated months in presenting their data; probably they carried on their studies also in summer, when the parasitized western herring shoal had disappeared and only the *Anisakis*-free stocks remained. Therefore it could be stated, basing on their data, that *Anisakis* was absent from the Baltic during those years. However, the work by **Popiel** (1951) indicates, that it was not the case. He examined 2356 herring individuals from the Gdańsk Bay and Słupsk Trough throughout the entire annual cycle. His main interest concentrated on the food and feeding of herring, but parasites were also taken into account and he could not omit the nematode larvae if they were really present on the herring stomachs.

Undoubtedly the *Anisakis* larvae invasion in the Baltic herrings becomes more and more stronger. Simultaneously the herring population has been greatly enlarged during the recent years which is evidenced by the increase in catches.

CONCLUSIONS

1. Both the incidence and intensity of the *Anisakis simplex* invasion in herring from the Baltic as well as from the other seas increase with the herring body size starting from 20 cm body length. Herrings below this length remain unaffected. 30 cm-herring group is almost entirely parasitized.
2. The invasion incidence fluctuate seasonally throughout the annual cycle. The highest infestation is observed from November till May. In summer, from June till October, the fishes are *Anisakis*-free.
3. Basing on the infestation level as well as on the otoliths structure and gonad maturity, four groups of herring have been distinguished in the Pomeranian Gulf and adjacent regions:

   a. *western spring herring*, coming from the North Sea and Belts to the Pomeranian Gulf to spawn and penetrating along the southern Baltic coast to the Puck and Gdańsk Bays. This group is strongly parasitized with the *Anisakis* larvae. The fishes appear in the souhtern Baltic in November and remain till May, their spawning extends from

March till May in the Pomeranian Gulf. After having finished the spawning they swim away to the North Sea and become infected there.

b. *southern-Baltic spring herring,* a local Pomeranian Gulf herring stock, undertaking only short migrations. Their spawning proceeds in the Pomeranian Gulf coastal waters from March till May, afterwards they migrate to the Bornholm feeding grounds. The fishes are *Anisakis*-free.

c. *spring sea herring,* spawning in spring in the Swedish coastal waters. After having completed their spawning they migrate to the Bornholm feeding grounds and stay there from June till October. The *Anisakis* larvae are absent from herring of this group, only sporadically single parasitized specimens are found.

d. *autumn herring,* spawning further offshore than the spring group from August till November. They appear in small quantities on Bornholm feeding grounds, mainly in summer from June till October. They are *Anisakis*-free; only sporadically the parasitized specimens are found.

4. On the Bornholm feeding grounds as well as presumably within the whole Baltic Sea the herrings have no possibilities of becoming infested with the *Anisakis* larvae, the lack of infection during 5 months of their occurrence on these areas supporting this finding.

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Jadwiga Grabda

Dynamika inwazji larw nicieni *Anisakis simplex* (Rud.) w śledziach (*Clupea harengus* L.) południowo-zachodniego Bałtyku

Streszczenie

W związku z niebezpieczeństwem zarażenia człowieka larwami *Anisakis simplex*, bytującymi w śledziach, dokładne poznanie występowania tego pasożyta w Bałtyku posiada duże znaczenie.

Dotychczas poza stwierdzeniem występowania larw *Anisakis* w śledziach bałtyckich Lubieniecki 1972, Rokicki 1972, 1973) brak było szczegółowych badań nad dynamiką inwazji pasożyta w cyklu rocznym, oraz stopnia zarażenia w zależności od wielkości ryb.

Celem wyjaśnienia tych zagadnień zbadano ogółem 2850 śledzi bałtyckich, pochodzących głównie z Zatoki Pomorskiej i łowisk przyległych, pobieranych w próbach po 100 sztuk z połowów przemysłowych co dwa tygodnie w czasie od lutego 1973 do lutego 1974. Badano stopień zarażenia ich przez larwy *Anisakis*, stopień dojrzałości gonad oraz otolity.

Stwierdzono, że wraz ze wzrostem śledzi zwiększa się zarówno ekstensywność jak i intensywność zarażenia. Śledzie mniejsze niż 20 cm długości całkowitej nie zawierały zupełnie larw nicieni natomiast w śledziach większych zarażenie sukcesywnie wzrastało, osiągając prawie 100% u śledzi długości 30 cm. Zwiększała się również liczba larw w jednej rybie, dochodząc do średniej wartości 14 pasożytów w śledziu.

Stwierdzono również wyraźną zmienność sezonową zarażenia śledzi. W okresie letnim (czerwiec – październik) śledzie były zupełnie wolne od pasożytów, natomiast w pozostałych miesiącach roku zarażenie było bardzo silne, wahając się na różnych łowiskach od 40% do 80%.

Zjawisko sezonowego pojawu larw *Anisakis* wiąże się z występowaniem różnych stad śledzi w Bałtyku i ich wędrówek tarłowych i żerowiskowych. Badania otolitów wykazały, że śledzie zarażone należą do odrębnego stada śledzi wiosennych, trących się w Zatoce Pomorskiej na wiosnę (marzec – maj). Śledzie te skupiają się na pobliskich łowiskach już na jesieni.

Wśród śledzi nie zarażonych można wyróżnić śledzie skandynawskie, trące się przy wybrzeżach Szwecji na wiosnę a przebywające na żerowiskach w południowej części Bałtyku w lecie. Ponadto na badanych żerowiskach pod Bornholmem występują śledzie jesienne, trące się od końca sierpnia do listopada pod wybrzeżem polskim a także w okolicach Bornholmu. Wreszcie lokalne stado śledzi wiosennych, trących się przy wybrzeżach polskich na wiosnę i odbywających ograniczone wędrówki w Bałtyku z tarlisk na pobliskie żerowiska.

Badania porównawcze śledzi wiosennych z Zatoki Greifswaldzkiej i z łowisk przy Hiddensee w marciu 1973 wykazały podobne nasilenie inwazji jak w śledziach Zatoki Pomorskiej, co świadczy o należeniu ich do tego samego stada.

Brak śledzi zarażonych na łowiskach Bałtyku w lecie nasuwa przypuszczenie, że śledzie wiosenne, silnie zarażone larwami *Anisakis* odpływają po tarle na żerowiska położone dalej na zachód, prawdopodobnie do Cieśnin Duńskich a być może nawet do Morza Północnego, gdzie ulegają dalszemu zarażeniu.

W świetle powyższych badań pogląd, że śledzie bałtyckie stanowią lokalne stada, odbywające wędrówki tarłowe i żerowiskowe tylko w obrębie Bałtyku, powinien ulec rewizji.

ДИНАМИКА ИНВАЗИИ ЛИЧИНОК НЕМАТОД ANISAKIS SIMPLEX (RUD.) В СЕЛЬДИ (CLUPEA HARENGUS L.) ЮГО-ЗАПАДНЫХ РАЙОНОВ БАЛТИЙСКОГО МОРЯ

Р е з ю м е

В связи о опасностью заражения человека личинками Anisakis simplex, живущими в организме сельди, тщательное изучение вопроса, связанного с обитанием этого паразита в Балтийском море, имеет большое значение.

До сих пор, кроме констатирования наличия личинок Anisakis в балтийской сельди (Лубенецки, 1972; Рокицки, 1972, 1973) не имелось основательных исследований по изучению динамики инвазии этого паразита в годовом цикле, а также степени заражения им в зависимости от величины рыбы.

С целью выяснения этих вопросов было исследовано 2800 экземпляров балтийской сельди, выдовленной главным образом из Поморской бухты и прилежащих районов промысла. Пробы, состоящие из 100 экземпляров, брали из промысловых уловов через каждые две недели в период с февраля 1973 г. до февраля 1974 г. Исследовали степень заражения личинками Anisakis, стадии зрелости гонад, а также отолиты.

Установлено, что одновременно с ростом сельди увеличивается как экстенсивность, так и интенсивность заражения. В сельди, общая длина которой составляла меньше, чем 20 см, абсолютно не имелось личинок нематод, в то время как в сельди больших размеров заражение последовательно увеличивалось, достигая почти 100% у рыб, длиной 30 см. Увеличивалось также количество личинок в одной рыбе, достигая среднего числа, равного 14 паразитам в одной рыбе.

Установлена также отчётливая сезонная изменчивость заражения сельди. В летний период (июнь - октябрь) сельдь была совершенно свободна от паразитов, в то время как в остальные месяцы года заражение было более сильным и колебалось в разных районах промысла от 40 до 80%.

Явление сезонного появления личинок Anisakis связывается с появлением разных стад сельди в Балтийском море и их нерестовыми и кормовыми миграциями. Исследования отолитов показали, что заражённая сельдь принадлежит к отдельному стаду весенней сельди, нерестящейся в Поморской бухте весной (март - май). Эта сельдь концентрировалась в близлежащих районах лова уже осенью.

Среди незаражённой сельди можно выделить сельдь скандинавскую нерестящуюся у побережья Швеции весной и нагуливающуюся в южной части Балтийского моря в летнее время. Кроме того, в исследуемых местах нагула в районе Борнхольма встречается осенняя сельдь, нерестящаяся с конца августа до ноября у польских побережий, а также в районе Борнхольма. И, наконец, местное стадо весенней сельди, нерестящееся у побережий Польши весной и совершающей ограниченные миграции в Балтийском море от нерестилищ к близлежащим местам нагула.

Сравнительные исследования весенней сельди из залива Грейфсвальдер-Бодден и из районов лова у о. Хиддензе в марте 1973 г. выявили подобное усиление инвазии, как и в сельди из Поморской бухты, что свидетельствует о принадлежности их к одному и тому же стаду.

Отсутствие заражённой сельди в промысловых районах Балтики в летнее время заставляет предположить, что весенняя сельдь, в значительной степени заражённая личинками Anisakis, уходит после нереста для нагула далеко на запад, вероятно в Датский пролив, а может быть даже в Северное море, где подвергается дальнейшему заражению.

В свете вышеописанных исследований точка зрения, что балтийская сельдь представляет собой местное стадо, совершающее нерестовые и кормовые миграции только в районе Балтийского моря, должна быть пересмотрена.

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