New and 'visiting' fish species collected off the western coast of Poland (Baltic Sea) in 2007–2008 with a description of their parasite fauna

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Abstract

The first occurrence of striped red mullet *Mullus surmuletus* in the Pomeranian Bay (in 2007) and the occurrence of three very rarely noted species (tub gurnard *Chelidonichthys lucerna*, Atlantic horse mackerel *Trachurus trachurus*, thicklip grey mullet *Chelon labrosus*) collected in 2007–2008 in the Pomeranian Bay, Szczecin Lagoon and Lake Dąbie are reported. Their expansion is probably due to increased sea temperatures resulting from climate change, as well as the inflow of saline water. The 'visitors' hosted eight pathogens from four taxonomic groups: Protozoa, Nematoda, Acanthocephala and Mollusca. Nematodes, the most numerous ones, were found in three host species. All the parasite species were new for the hosts examined; only the larvae of the acanthocephalan *Corynosoma strumosum* had already been recorded in one of the hosts (*Chelidonichthys lucerna*). The stomachs of almost all the fish examined were empty, but the species composition of the parasite fauna found showed that the fish must have ingested some food in the Pomeranian Bay.

1. Introduction

In recent years both rare (or visiting) and exotic species have been recorded in the southern Baltic and its estuaries, e.g. sea bass *Dicentrarchus labrax* (L., 1758), saithe *Pollachius virens* (L., 1758), ballan wrasse *Labrus bergylta* (Ascanius, 1767), snake pipefish *Entelurus aequoreus* (L., 1758), Atlantic mackerel *Scomber scombrus* L., or swordfish *Xiphias gladius* L., 1758 (Krzykawski et al. 2001, Bacevičius & Karalius 2005, Grygiel & Trella 2007, Lampart-Kałużniacka et al. 2007, Czerniejewski et al. 2008).

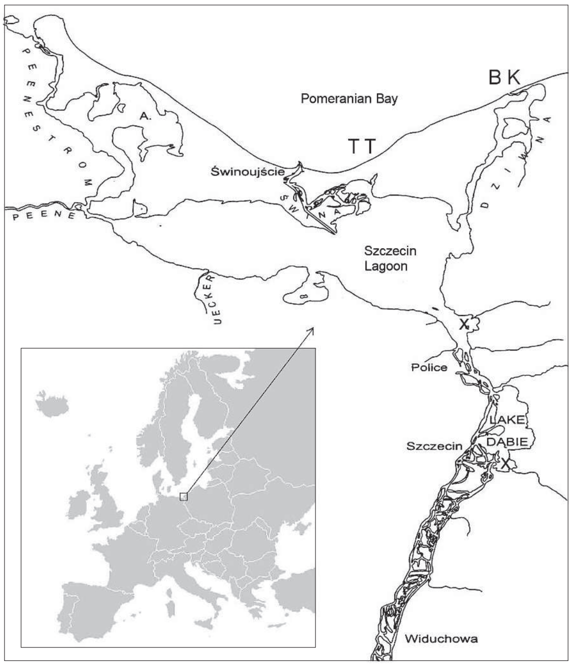
The present paper reports the first occurrence of striped red mullet (or surmullet) *Mullus surmuletus* L., 1758, in the Pomeranian Bay in 2007 and the occurrence of three very rarely noted species – tub or yellow gurnard *Chelidonichthys lucerna* (L., 1758), Atlantic horse mackerel *Trachurus trachurus* L., 1758 and thicklip grey mullet *Chelon labrosus* (Risso, 1827) – caught in the Pomeranian Bay, Szczecin Lagoon and Lake Dąbie in 2007 –2008.

The striped red mullet is a new species found in the Pomeranian Bay, whereas the other three species are known from single finds and apparently belong to the category of accidentally occurring fish. The presence of these species in the Pomeranian Bay and adjacent waters (Szczecin Lagoon, Lake Dąbie) is probably due to strong inflows of saline water from the North Sea through the Danish Straits, as well as to climate changes (Nausch et al. 2007, 2008, Matthäus et al. 2008). The Baltic Sea's environmental conditions and their variability are closely linked to the hydrological and meteorological processes and their interactions, among other things (Grygiel & Trella 2007), while the climate and hydrology of the Baltic Sea region is influenced by the winter intensity of the North Atlantic Oscillation NAO (Lehmann et al. 2002).

The main objectives of the present study were to report on the occurrence of new and 'visiting' fish species in the Pomeranian Bay, Szczecin Lagoon and Lake Dąbie during 2007–2008, and to characterize the stomach contents and the parasite fauna of the fish caught.

2. Material and methods

Two specimens of Atlantic horse mackerel were collected in 2007–2008 during the annual monitoring of fish, carried out by the research vessel SNB-AR-1 (University of Agriculture, Szczecin) in a network of areas along the western Polish coasts of the Baltic Sea with the aim of following the development of coastal fish stocks. All monitoring areas were located close to the coast. The other fish species were caught by accident by local fishermen



legend:
X – thicklip grey mullet
T –Atlantic horse mackerel
B – striped red mullet
K – tub gurnard

Figure 1. Locations where the fish were caught

with flounder gillnets or fyke nets (Figure 1). In 2007–2008 representatives of the following species were captured and examined:

1. two juveniles [(1) and (2)] of Atlantic horse mackerel *Trachurus trachurus* L., 1758; Fam. Carangidae, Order: Perciformes; location: Pomeranian Bay, depth: 12 m; bottom trawl; date of capture: 30 September 2007; both individuals immature;
2. tub gurnard *Chelidonichthys lucerna* (L., 1758); Fam. Triglidae, Order: Scorpaeniformes; location: Pomeranian Bay, depth: 10 m; flounder gillnet; date of capture: 12 October 2007;
3. striped red mullet *Mullus surmuletus* L., 1758; Fam. Mullidae, Order:

Perciformes; location: Pomeranian Bay, depth: 10 m; flounder gillnet; date of capture: 12 October 2007;

4. thicklip grey mullet *Chelon labrosus* (Risso, 1827); Fam. Mugilidae, Order: Perciformes; 2 specimens: 1st location (1): Lake Dąbie, depth: 2 m; fyke net (with perch-pike and eel); date of capture: 17 June 2008; 2nd location (2): Szczecin Lagoon, depth: 3 m; fyke net; date of capture: 19 June 2008.

All the specimens were examined morphologically following Krzykawski et al. (2001), Turan (2006) and Uiblein & Heemstra (2010). Species were identified with the aid of available keys (Whitehead et al. 1986). Table 2 lists detailed taxonomic data of the striped red mullet in order to rule out any doubts about the species' taxonomic status.

In addition, the stomach contents of the fish were analysed.

Parasitological examination focused on the skin, vitreous humour, eye lens, mouth and nasal cavities, gills, gonads, spleen, gastrointestinal tract, kidneys, swim bladder, peritoneum and muscles. The parasites found in the fish were prepared for species determination by viewing the specimens in transient light, immersed in glycerine or preserved in 70% ethanol so that the procedure could be continued the next day.

3. Results

Table 1 presents biological descriptions (total length, weight and stomach contents) of the fish examined. The stomachs of all the fish were empty, except that of the thicklip grey mullet from the first location – (1), in which two specimens of *Gammarus pulex* (L., 1758) (Gammaridae) were found.

Morphological examination of the specimens showed that they fit within the ranges given in Whitehead et al. (1986) and Krzykawski et al. (2001),

Table 1. Biological descriptions of the fish studied

Species	Total length TL [cm]	Weight [g]	Stomach contents
Trachurus trachurus	(1) 13.0	(1) 16.5	empty
	(2) 11.6	(2) 10.3	empty
Chelidonichthys lucerna	35.3	519.0	empty
Mullus surmuletus	23.1	196.8	empty
Chelon labrosus	(1) 42.5	(1) 803.4	2 specimens of *Gammarus pulex* (Gammaridae)
	(2) 40.8	(2) 709.5	empty

with the exception of the striped red mullet (Figure 2), which also exhibited some features characteristic of *Mullus barbatus* L. (shape and length of head, barbel length, gill raker count). Table 2 lists the detailed morphological characteristics of the specimen of *M. surmuletus* examined, including the metric characters expressed as a proportion of total length (TL), standard length (SL) and head length (HL), and meristic features.

Figure 2. The specimen of striped red mullet collected in the Pomeranian Bay (12 October 2007)

The 'visiting' fishes hosted eight pathogens from four taxonomic groups: Protozoa (two species), Nematoda (three species), Acanthocephala (two species) and Mollusca (one species) (Table 3). The most numerous were nematodes (Secernentea: Anisakidae), recorded in fishes of three species.

Two larvae of the nematode *Contracaecum osculatum* (Rudolphi, 1802) L3 were found to have perforated the intestinal wall of one Atlantic horse mackerel. They were the only parasites recorded in this host species.

Four L3 larvae of *Pseudoterranova decipiens* (Krabbe, 1878) (Nematoda) were noted in the stomach of *M. surmuletus*, and three young acanthocephalans *Pomphorhynchus laevis* (Zoega, in Muller, 1776) in the intestinal lumen. Neither of these parasite species has yet been found in the striped red mullet.

Three species of parasite were recorded in the thicklip grey mullet. The ciliates *Epistylis colisarum* (Foissner and Schubert, 1977) and *Chilodonella*

Table 2. Morphological characteristics of the specimen of *Mullus surmuletus* caught in the Pomeranian Bay

Metric character	[%] TL	[%] SL
TL – total length	–	124.19
SL – standard (or body) length	80.52	–
FL – fork length	89.61	111.29
HEADL – length of head	23.25	28.87
HEAD1	19.42	24.13
BARBL – length of barbel	18.14	22.53
pD – predorsal length	30.30	37.63
pV – preventral length	24.16	30.00
pA – preanal length	51.13	63.41
lP – length of pectoral fin	19.65	24.41
lPbs – length of pectoral fin base	5.63	6.99
lV – length of pelvic fin	17.45	21.67
lVbs – length of pelvic fin base	3.98	4.95
P-A – distance between P-A fin bases	32.81	40.75
P-V – distance between P-V fin bases	9.74	12.10
V-A – distance between V-A bases	28.74	35.70
hD_1 – depth of first dorsal fin	16.54	20.54
hD_2 – depth of second dorsal fin	11.82	14.68
D1-D2 – distance between fins	7.23	8.98
lD_1 – length of first dorsal fin base	15.80	19.62
lD_2 – length of second dorsal fin base	13.12	16.29
hA – depth of anal fin	12.42	15.43
lA – length of anal fin base	9.26	11.51
H – maximum body depth	21.13	26.24
h – minimum body depth	7.97	9.89
lpc – length of caudal peduncle	20.26	25.16
laco – width of body	16.67	20.70

Head characters	[%] HEADL	
HEAD1 – max. head depth (at ventral edge of operculum)	85.60	
HEAD2 – head depth across vertical midline through eye	67.73	
SUBORB – suborbital depth	43.36	
INTORB – interorbital length	32.74	
SNOUTL – snout length	42.07	
SNOUTW – snout width		
PORBL – postorbital length	40.39	
ORBITL – orbit length	24.47	
ORBITD – orbit depth	19.22	
UJAWL – upper-jaw length	33.35	
LJAWL – lower-jaw length	34.84	
BARBL – barbel length	74.66	
BARBW – maximum barbel width	3.15	
Meristic characters		
D_1 – ray count in first dorsal fin	VIII	
D_2 – ray count in second dorsal fin	I 8	
A – ray count in anal fin	I 6	
P – ray count in pectoral fin	17	
V – ray count in ventral fin	I 5	
Gill raker count on first (GR1) and second (GR2) gill arches	GR1	GR2
GrUud – rudimentary gill rakers on upper limb	1	2
GrUd – developed gill rakers on upper limb	5	2
GrLd – developed gill rakers on lower limb	13	9
GrLud – rudimentary gill rakers on lower limb	2	1
GrU – total gill rakers on upper limb	6	4
GrL – total gill rakers on lower limb	15	10
Gr – total gill rakers (including rudiments)	21	14

Table 3. Parasites recorded in the fish species examined

Pathogen	*Trachurus trachurus* L. n = 2	*Mullus surmuletus* L. n = 1	*Chelon labrosus* (Risso, 1827) n = 1	*Chelidonichthys lucernus* (L.) n = 1
Epistylis colisarum (Foissner and Schubert, 1977)			1 specimen	
Chilodonella hexasticha (Kiernik, 1909) Kahl, 1931			1 specimen	
Contracaecum osculatum (Rudolphi, 1802)	2 specimens			5 specimens
Pseudoterranova decipiens (Krabbe, 1878)		4 specimens		7 specimens
Hysterothylacium aduncum (Rudolphi, 1802)				1 specimen
Corynosoma strumosum (Rudolphi, 1802)				1 specimen
Pomphorhynchus laevis (Zoega in Muller, 1776)		3 specimens		
Unio sp.			single specimens	

hexasticha (Kiernik, 1909) Kahl, 1931 were found in the mucus covering the gill filaments, from one to two in the field of view. Small numbers of larvae of *Unio* sp. (Mollusca) were also recorded – they were attached to the gill filaments.

In the tub gurnard one L3 larva of *P. decipiens* was found in a pyloric caecum; additionally, five larvae of this nematode were recorded on pyloric caeca, and one under a liver connective tissue capsule. Five encysted L3 larvae of *C. osculatum* and one of *Hysterothylacium aduncum* (Nematoda) were noted there as well. One larva of the acanthocephalan *Corynosoma strumosum* was found in the body cavity.

4. Discussion and summary

The classification of a fish species as 'rare' requires the adoption of clear criteria (see Draganik (1996)). According to this author, the utility of the feature of rarity of a species population in respect of its abundance and distribution within a defined area is considered to be the main criterion for species conservation. Similarly, the HELCOM (2007) definition of rarity refers to a species with a small total population. In the case of a species that is sessile or of restricted mobility at any time in its life cycle, a species is rare if it occurs in a limited number of locations; in the case of a highly mobile species, the total population size will determine its rarity. According to Ehrich et al. (2006), rare species are those with a mean abundance of less than 0.5 individual per hectare – that is to say, they are continually recorded in catches but their abundance is not significant.

On the other hand, some authors use the term 'rare' or 'very rare' with regard to fish species that are come across very seldom in the southern Baltic, occurring as single individuals, sometimes as representatives of a typical migrant species or of a species passively moving with the sea currents or inflows (Skóra 1996, Krzykawski et al. 2001). Most authors, however, use terms like 'visiting', 'occurring accidentally', 'occasional visitors', 'strays', or 'vagrants' with respect to such fish species, whereas those expanding their distribution range are called 'non-indigenous', 'invasive' or 'alien' species and could be potential pests in the environment they have freshly colonized (Skóra 1996, Grygiel & Trella 2007, Lampart-Kałużniacka et al. 2007, Piatkowski & Schaber 2007, Pinnegar et al. 2008).

The Baltic Sea is characterized by a closed circulation in the central basin, low salinities, and low biodiversity. The Baltic Sea biota consists of four types of natural immigrants of different origin: freshwater, marine-boreal, cold-water, and glacial relicts of freshwater and marine origin (Elmgren 1984). Fish species from other regions (like the Mediterranean or North Sea) are non-indigenous immigrants, occurring sporadically, and which should be regarded as merely an enrichment of the Baltic fish community (Grygiel & Trella 2007). Some authors, like Elmgren & Hill (1997) and Elmgren (1984), regard the Baltic Sea, in comparison with other basins, as a unique example of an ecosystem inhabited by few species, functioning at a low level of biodiversity, whereas Grygiel & Trella (2007) consider the Baltic fish community to be of relatively high biodiversity. Be that as it may, there are some 120 marine fish species in the North Sea but only 69 in the western Baltic Sea (ICES subdivisions 22–24) (Aro 2000). There are well-documented reports on over 20 non-indigenous marine fish species (NIS), including just one typically invasive species – *Neogobius melanostomus* (Pallas, 1814) (Skóra 1996, Krzykawski et al. 2001, Bacevičius & Karalius 2005, Grygiel & Trella 2007, Lampart-Kałużniacka et al. 2007, Czerniejewski et al. 2008). The occurrence of NIS has been reported not only from the Baltic Sea, but also from the Mediterranean, considered to be one of the main hotspots for marine bioinvasions and is, among European seas, by far the major recipient of NIS, including macrophytes, invertebrates and fish. The most important vectors of NIS in this region are shipping, aquaculture and direct immigration via the Suez Canal. In recent decades, the rate of introductions into the Mediterranean Sea has increased, which has had both ecological and economic impacts (Kalogirou et al. 2010).

Some species occur unexpectedly in new regions after an expansion of their natural distribution range (Mohr 1988, Nehring 2002); one of these is the thicklip grey mullet, which occurs in the North Atlantic. Its range extends northwards to the Faroes and the British Isles, Iceland and southern Norway. Since the mid-1960s, the species has evidently been spreading from the North Sea into the western Baltic (Mohr 1988). Single specimens were caught in Flensburg Fjord and the Fehmarnsund in the mid-1970s, and in Kiel Fjord and the Trave estuary in the 1980s (Czerniejewski et al. 2008). Ehrich et al. (2006) put *Chelon labrosus* on the list of fish species occurring in German waters in the North Sea and western Baltic, but the frequency of occurrence in the total number of hauls was extremely low in the former region (0.01%), and zero in the latter one (studies conducted from 1958 to 2005).

There are only three well-documented 20th century records of the thicklip grey mullet from the central and eastern Baltic: one specimen was caught off Pori (Finland) in 1958, and another in the Gulf of Riga (Latvia) in 1980; the third Baltic record comes from fish catches in Puck Bay in 1998 (Skóra 2000). In 2007, the first thicklip grey mullet was caught with a fyke net in the northern part of Lake Dąbie (Polish estuarine waters) (Czerniejewski et al. 2008). According to Fricke (HELCOM 2007) *Ch. labrosus* is a rare species.

Lampart-Kałużniacka (2007) found another member of the Mugilidae family, identified as a flathead grey mullet *Mugil cephalus* L. in Polish coastal waters (in 2004, between the Kołobrzeg and Łeba fishing grounds).

The tub gurnard *Chelidonichthys lucerna* is more commonly recorded in the Baltic Sea. On the HELCOM (2007) List of Species not threatened in the Baltic its status is DD (data deficient); its region of distribution is given as the Skagerrak, Kattegat and Western Baltic. Ehrich et al. (2006) placed *Ch. lucerna* on the list of fish species occurring in German waters in the North Sea and western Baltic Sea; in the former waters the frequency of occurrence in the total number of hauls amounted to 14.86%, in the latter it was very low – 0.39% (studies from 1977 to 2005). The tub gurnard was found as far east in the Baltic as the Gulf of Gdańsk in 1990 and 1991 (Skóra 1996). Detailed descriptions of two individuals recorded in the Pomeranian Bay in 1998 and 1999 are given in Krzykawski et al. (2001). Lampart-Kałużniacka et al. (2007) noted the occurrence of 24 individuals of *Ch. lucerna* in Polish coastal waters (2000–2004, between the Kołobrzeg and Łeba fishing grounds). Also, one specimen of tub gurnard was reported in catches from the Gdańsk Deep in 2008 (Grygiel 2009) and one from the Czołpino area (Draganik 2004, after Grygiel 2009).

On the HELCOM (2007) List of Species not threatened in the Baltic *Trachurus trachurus* has the status of LC (least concern) in in the Skagerrak, Kattegat but is rare (RA) in the Western Baltic. *T. trachurus* is listed as a species occurring in German North Sea and western Baltic waters (Ehrich et al. 2006); the frequency of occurrence in the total number of hauls in the former region was 26.74% and in the latter one quite high at 22.44 % (studies were conducted between 1977 and 2005). Lampart-Kałużniacka et al. (2007) reported the occurrence of 17 individuals of *T. trachurus* in Polish coastal waters (from 1998 to 2000, between the Kołobrzeg and Łeba fishing grounds). All individuals recorded were sexually immature, like those reported in the present paper. Grygiel & Trella (2007) recorded the occurrence of the Atlantic horse mackerel during the autumn-winter periods of 1976–2004 in the near-bottom waters of the southern Baltic Sea (within the Polish EEZ), as one of nine visiting fishes, mainly between Kołobrzeg and Darłowo (average proportion 0.987 per mille of the species in bottom research catches). It was described as a 'newcomer' from the North Sea and adjacent regions for a limited time and reached southern Baltic waters in a natural way as a result of changes in the hydrological regime.

The red striped mullet is an extremely rare fish species in the Baltic Sea. The specimen collected in the Pomeranian Bay was identified as *Mullus surmuletus*, although some characters were typical of *M. barbatus*. Nonetheless, the specimen's identity was confirmed by Franz Uiblein (personal communication) as a 'North-Sea' form of *M. surmuletus*. There is a considerable lack of basic systematic and taxonomic knowledge on goatfishes, intraspecific morphological variation and genetic differentiation, and further detailed studies are required (Uiblein 2007). There is considerable variation in the *Mullus* genus, even among populations from neighbouring habitats, which to some extent may reflect phenotypic plasticity (Uiblein et al. 1998). Much more information may still be hidden behind morphological differentiation, if a specimen of *Mullus* from the Skagerrak exhibiting a head shape intermediate between red mullet *M. barbatus* and striped red mullet *M. surmuletus* is anything to go by.

Fage (1909, after Uiblein 2007) distinguished southern and northern forms of striped red mullet based mainly on head shape. There have also been problems with the correct identification of *Mullus* spp. during regular bottom trawls in the North Sea. Additional confusion may arise from the continued usage of the common name 'red mullet' for both species. Recently, a detailed comparison of *Mullus* specimens from the North Sea was started as part of an intended revision of the genus (Uiblein 2007).

Mullus surmuletus has the status of RA (rare) on the HELCOM (2007) List of Species not threatened in the Baltic, its region of distribution being in the Skagerrak, Kattegat and western Baltic. *M. surmuletus* is on the list of fish species occurring in German North Sea and western Baltic waters (Ehrich et al. 2006); the frequency of occurrence in the total number of hauls in the former region is 6.05%; in the latter one it is low (0.98%). Lampart-Kałużniacka et al. (2007) reported the occurrence of 3 individuals of *Mullus*, identified as *M. barbatus* in Polish coastal waters (between 1998 and 2000, between the Kołobrzeg and Łeba fishing grounds). Grygiel (2009) reported the presence of one specimen of striped red mullet in catches from open Baltic waters (56°N, 17°30′E) in 2007, and Skóra (2007) also reported one specimen from the Gulf of Gdańsk.

Temperature increases and longer warming up periods may induce *M. surmuletus* to migrate to higher latitudes in the North Sea. Isolated occurrences of this species in the Norwegian Sea at 60°N have been documented (Uiblein 2007). In the North Sea it was not caught by international bottom trawl surveys before 1988, but an ongoing northward shift in its distribution has been demonstrated since, with steadily increasing abundance in south-western areas (Beare et al. 2004). This change in distribution and abundance has happened during a phase when temperature rises have taken place as a result of global climate change (Hulme et al. 2002).

Among the parasites noted in the fishes examined, the most numerous were nematodes, found in three host species. All the parasite species were new to the hosts examined, except the larvae of the acanthocephalan *Corynosoma strumosum*.

Chelon labrosus was the only host of exopathogens. *Epistylis colisarum* is a sessile peritrichous ciliate that attaches itself to the gills of the fish directly by its scopula equipped with short immobile cilia. It is not a primary disease agent, but a heavy growth signifies that the fish has been predisposed by some debilitating factor. In very large numbers *E. colisarum* may impair respiration and cause surface irritation (Lom 1995). It was one of three pathogens of the grey mullet sporadically observed on the gills. *Chilodonella hexasticha* is a free-living ectoparasite, which may occur in both freshwater and also estuarine and brackish water fish. The gills and skin are infected, and under favourable conditions the parasites may cover the body surface and the gills in a continuous layer. They feed on cell debris; if the gills are seriously infected, moribund fish may show signs of hypoxia (Lom 1995). Neither of these two parasite species nor *Unio* sp. larvae have yet been noted in the grey mullet. *Contracaecum osculatum* larvae occur mainly in various marine fishes (cod and other Gadidae, Clupeidae) but also in freshwater species (usually recorded in the liver) (Moravec 1994).

Marine mammals are the definitive hosts, while planktonic copepods are the first intermediate hosts. Only larvae L3 of *Contracaecum* sp. and *C. multipapillatum* (Drasche, 1882) were found in *T. trachurus* (Sanmartin Duran et al. 1989, Moravec 1998). The parasite has yet to be recorded in *Ch. lucerna*.

The third-stage larvae of *Pseudoterranova decipiens* parasitize the internal organs of Gadidae, Clupeidae, Pleuronectidae, Cottidae and Salmonidae (Grabda-Kazubska & Okulewicz 2005). Marine mammals, especially *Phoca* sp., are the definitive hosts. Various species of marine invertebrates serve as its first intermediate hosts. *M. surmuletus* and *Ch. lucerna* have not yet been recorded as hosts of these parasites. *Hysterothylacium aduncum* is a cosmopolitan nematode with planktonic crustaceans (*Acartia bifilosa*, *Eurytemora affinis*) as obligate intermediate hosts and both invertebrate and fish as paratenic hosts, where they are located in the body cavity, liver and muscles. L4 larvae and adults of nematodes have been reported in the intestines of many predatory fish host species. These fish may become second intermediate hosts and definitive hosts (Grabda-Kazubska & Okulewicz 2005). The nematode *H. aduncum* has not yet been recorded in *Ch. lucerna*. The acanthocephalan *Corynosoma strumosum* is a parasite of seals and cormorants (Wülker 1933); the first intermediate hosts are amphipods *Pontoporeia*, which ingest the cystacanth larvae. Once ingested, the cystacanth encysts in the body cavity of several fish species (paratenic hosts) and waits for seals to prey on these fish. *C. strumosum* is recorded in *T. trachurus* from different fishing grounds as well (MacKenzie et al. 2008). *Pomphorhynchus laevis* is a parasitic acanthocephalan whose definitive hosts are numerous freshwater and estuarine fishes. In the Baltic Sea *P. laevis* is most often come across in the flounder, in which it perforates all the layers of the intestinal wall with its proboscis; it therefore never changes its position in the intestine, giving rise to inflammation. Amphipods are the usual intermediate hosts, but fish are not often paratenic hosts. The parasite has not been noted in *M. surmuletus* before.

All the parasites found have a cosmopolitan distribution; they are also generalists, having been reported in many fish species in the Pomeranian Bay and Szczecin Lagoon (Sobecka & Słomińska 2007). However, although these parasites have not been recorded elsewhere in the natural distribution ranges of the fish examined, they have colonized the new accidental hosts, making them part of their life cycle (Rohde 2005). Both species of ciliates found, as well as *Unio* sp. larvae (Bivalvia), actively settle on their hosts; the other parasites enter their hosts passively with ingested food.

As juveniles, the fish examined consume small invertebrates, including molluscs and crustaceans (Blaber 1976, Muller 2004, Eryilmaz & Meriç 2005). They are also the first intermediate hosts of the nematode and acanthocephalan larvae, recorded the most commonly in the present study. As part of their diet, older fish eat small fish, which may lead to an accumulation of parasites, especially nematodes. However, their small number and the lack of stomach contents suggest that the Baltic Sea specimens fed mainly on invertebrates, this kind of food allowing the passive transmission of parasites. This is the case with young fish and parasites with a complex life cycle (Pilecka-Rapacz & Sobecka 2004).

Neither specific parasites (especially monogeneans), characteristic of a single host species, nor copepods were found in the 'visiting' fish species. These are especially sensitive to changes in external environmental conditions, principally salinity. With such a considerable salinity difference between oceanic and Baltic waters, the parasites die or abandon their host species. All the fish species examined became hosts to local parasites.

Nothing is known about the origin and stock structure of the 'visitors' to the Baltic Sea. But their expansion is probably due to elevated sea temperatures resulting from climate change, as well as the inflow of saline water. Deep water renewal processes can be divided into two types: the 'classical' barotropic Major Baltic Inflows (MBIs) and the 'new' baroclinic inflows (Matthäus et al. 2008). MBIs occurring in winter and spring lead to higher salinities, lower temperatures and elevated oxygen levels in the deep basins, while those of either type in summer and autumn increase the salinity along their route and raise water temperatures, but carry only small amounts of oxygen. In the last two decades, however, MBIs have become rather scarce: the last three major inflows took place in 1993, 1997 and 2003, along with a minor one in 2001 (Matthäus et al. 2008).

According to Nausch et al. (2007, 2008) the inflow activity of recent years from the Kattegat into the Baltic Sea was initiated by a quite unusual sequence of events: a warm inflow in summer 2002 was followed by a cold, gale-forced one in January 2003, and again by a warm inflow in summer 2003; together they terminated the period of stagnation in Baltic deep water that had lasted since 1995. In the subsequent period inflow activities were weak, only intensifying slightly after 2006. Except in the southern Baltic, the stagnation lasting since 2004–2005 is strengthening further. A baroclinic inflow in summer 2006, followed by small barotropic inflows in 2007 again caused very high temperatures to be recorded in central Baltic deep water. The decreasing inflow activity in 2008 caused the previously fairly good oxygen conditions in the Bornholm Basin to deteriorate in 2009.

All the individual fish were collected in the warm season of the year (June–October), but nothing is known about their abilities to overwinter in Baltic waters. Moreover, very little is known about their diet, because the stomachs of almost all the fish examined were empty. Nevertheless, the species composition of the parasite fauna found showed that the fish must have ingested some food in the Pomeranian Bay.

The 'visiting' fish species can be considered an important example of interannual changes in the ichthyofauna and hydrology regime, and the relatively wide biodiversity of the Baltic fish community (given the poor salinity conditions for marine fish species) (Grygiel & Trella 2007). An understanding of the impacts, drivers of propagation and effects of the possible establishment of a highly migratory 'invasive' fish species (Piatkowski & Schaber 2007) or just a non-indigenous 'visiting' fish on Baltic ecosystem dynamics will improve our ability to predict further impacts of climate change and other human-induced or natural pressures.

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