Parasites of the round goby, *Neogobius melanostomus* (Pallas, 1811), an invasive species in the Polish fauna of the Vistula Lagoon ecosystem

OCEANOLOGIA, 48 (4), 2006.
pp. 545–561.

KEYWORDS
Parasites
Round goby
Neogobius melanostomus
Poland
Vistula Lagoon

Leszek Rolbiecki

Department of Invertebrate Zoology,
University of Gdańsk,
al. Marszałka Piłsudskiego 46, PL–81–378 Gdynia, Poland;

e-mail: lrolbiecki@ocean.univ.gda.pl

Received 16 May 2006, revised 13 November 2006, accepted 16 November 2006.

Abstract

The round goby, *Neogobius melanostomus* (Pallas, 1811) was introduced into southern Baltic waters (including the Vistula Lagoon) from the Black Sea and Sea of Azov in the early 1990s. This study describes the parasites of the round goby in its new environment. In 2004, 486 round goby specimens from the Vistula Lagoon were examined for parasites. The following taxa were identified: *Dermocystidium* sp.; Protozoa: *Trichodina domerguei domerguei* (Wallengren, 1897); Digenea: *Cryptocotyle concavum* (Creplin, 1825), *Diplostomum* spp., *Tylodelphys clavata* (Nordmann, 1831), *Bunodera luciopercae* (Müller, 1776); Cestoda: *Bothriocephalus scorpii* (Müller, 1776), *Eubothrium crassum* (Bloch, 1779), *Paradilepis scolecina* (Rudolphi, 1819), *Proteocephalus filicollis* (Rudolphi, 1802), *P. gobiorum* Dogel et Bychovsky, 1939, *Proteocephalus* sp.; Nematoda: *Anguillicola crassus* Kuwahara, Niimi et Itagaki, 1974, *Camallanus truncatus* (Rudolphi, 1814), *Contracaecum* spp., *Cystidicoloides ephemeridarum* (Linstow, 1872), *Dichelyne minutus* (Rudolphi, 1819), *Hysterothylacium aduncum* (Rudolphi, 1802); Acanthocephala: *Echinorhynchus gadi* Müller, 1776, *Pomphorhynchus laevis* (Müller, 1776). The parasites found were all local species, already reported from Poland. Except for *Dermocystidium* sp., *C. concavum*, *P. gobiorum*, and *D. minutes*, they have already been recorded in other fish species in the Vistula Lagoon. The prevalence and mean intensity of infection was low (18.3%; 4.0 indiv. – this value does not include ciliates). The most frequent parasites included *H. aduncum* (9.9%, 1.2 indiv.) and *A. crassus* (9.1%, 1.2 indiv.). In

addition, *Dermocystidium* sp., *B. luciopercae*, *E. crassum*, *P. scolecina*, *P. filicollis*, *C. truncatus* and *C. ephemeridarum* are reported from the round goby for the first time. As the fish has only recently appeared in the Vistula Lagoon, its parasitic fauna has not yet developed to the full.

1. Introduction

Until recently, the southern Baltic area supported 5 gobiid species (Gąsowska 1962). The round goby (*Neogobius melanostomus*) was recorded for the first time in Polish waters in 1990 (Skóra & Stolarski 1993, Kuczyński 1995) and in the Vistula Lagoon for the first time in 1999 (Borowski 1999). Most probably, this fish reached the Baltic in the ballast tanks of ships travelling via an inland route connecting the Black Sea and Sea of Azov (the round goby's native range) with the Baltic (Skóra & Stolarski 1993, Leppäkoski & Olenin 2000, Sapota 2005). Since that first appearance in the southern Baltic, the round goby has increased its abundance there and has become a new and important link in the trophic structure of these waters, disturbing their dynamic biocoenotic equilibrium. The round goby is a second-order consumer, feeding mainly on annelids, crustaceans, chironomids, molluscs and small fish. Being larger (20–25 cm) than the native gobiids and other local fish species, however, it competes strongly with them for food; it also forages on the eggs of commercially important fish species. Moreover, it has become a new diet item for third-order consumers, e.g., fish-eating birds like the black cormorant (Bzoma 1998) and predatory fish like the cod (Wandzel 2003).

This study is an introduction to research into the qualitative and quantitative characteristics of the parasitic fauna of the round goby in the Vistula Lagoon. It also attempts to determine the role of the species in the transmission of parasites in a new environment.

2. Material and methods

The study involved a total of 486 specimens (98–186 mm; 19.9–189 g) caught in the Vistula Lagoon from March to December 2004.

To locate parasites, skin, gills, mouth cavity, eyes and viscera (intestine, mesentery, spleen, gonads, liver and kidneys) were examined under a stereomicroscope. Additionally, to find larval nematodes, the intestinal walls were examined with the aid of a compressor.

The helminths collected were fixed in a 19:1 glacial acetic acid-formalin mixture and preserved in 70% ethanol. *Dermocystidium* were fixed and preserved in 70% ethanol. Taxonomic identification followed appropriate procedures: the ciliates were impregnated with 2% silver nitrate; *Dermocystidium* were embedded in glycerol-gelatine; nematodes were cleared in

lactophenol and embedded in glycerol-gelatine; the remaining helminths were stained in borax carmine, dehydrated in the alcohol series, cleared in benzyl alcohol and embedded in Canada balsam.

3. Results

Full parasitological examination revealed the presence of 20 parasitic taxa. The most frequent taxa were the nematodes *Hysterothylacium aduncum* (9.9%) and *Anguillicola crassus* (9.1%). The remaining ones were found in less than 6% of the fish examined (Table 1). Owing to the high morphological similarity between metacercariae within the genus *Diplostomum*, their identification to the species level is very difficult (Niewiadomska 1996), for which reason only the generic name is used in this paper. Also, larvae of *Contracaecum* spp. could be identified only to the generic level because no detailed descriptions of the larvae of various species in this genus have been published (Moravec 1994). Moreover, some tapeworms of the genus *Proteocephalus* could not be identified as to species either, as they had no fully developed, mature genital segments.

The specimens of *Bunodera luciopercae*, *Proteocephalus filicollis*, *P. gobiorum*, and *H. aduncum* (32 nematodes, the remainder were larvae) were ovigerous. On the other hand, *Camallanus truncatus*, *Cystidicoloides ephemeridarum*, and *Dicheline minutus* did not contain eggs. *Echinorhynchus gadii* and *Pomphorhynchus laevis* were represented only by males.

4. Discussion

A total of 20 parasitic taxa were found in the round gobies from the Vistula Lagoon. Round gobies caught in the nearby Gulf of Gdańsk (Table 2) were found to host as few as 11 parasitic taxa (Kvach 2002, Rokicki & Rolbiecki 2002, Rolbiecki & Kvach 2005) and, with the exception of trematodes of the genus *Diplostomum* (20%, 1–56 indiv.; Kvach 2002), the level of infection was low, too. On the other hand, there were far fewer parasitic species in the round gobies from the Vistula Lagoon than in the same species in its native range. As many as 71 taxa have been recorded in the Black Sea (Table 2), some species with a level of infection of 80%, 400 indiv. (Naydenova 1974, Gaevskaya et al. 1975, Machkevsky et al. 1990, Özer 2003, Kvach 2005), and 43 taxa have been reported from the Sea of Azov (Table 2), with a level of infection of 96%, 250 indiv. (Naydenova 1974, Gaevskaya et al. 1975). This discrepancy is most likely because the round goby is a recent immigrant to the Baltic and is only gradually being colonised by local parasites. The round gobies caught in the Vistula Lagoon

Table 1. Parasites of the round goby from the Vistula Lagoon

Parasites	Prevalence [%]	Mean intensity	Range of intensity	Site
1	2	3	4	5
Dermocystidium sp., cysts	0.4	42.5	34–51	gills
CILIOPHORA				
Trichodina domerguei domerguei (Wallengren, 1897)	5.6	few	few	skin
DIGENEA				
Cryptocotyle concavum, met. (Creplin, 1825)	1.6	2.9	2	skin
Diplostomum spp., met.	5.8	1.1	1-2	lens
Tylodelphys clavata, met. (Nordmann, 1831)	2.9	1.4	1–3	vitreous body
Bunodera luciopercae (Müller, 1776)	0.2	3	3	intestine
CESTODA				
Bothriocephalus scorpii, pl. (Müller, 1776)	0.6	1.7	1–2	intestine
Eubothrium crassum, pl. (Bloch, 1779)	1.6	1.5	1–3	intestine
Paradilepis scolecina, pl. (Rudolphi, 1819)	0.6	2.7	2–4	intestine
Proteocephalus filicollis (Rudolphi, 1802)	0.5	2.0	1–3	intestine
Proteocephalus gobiorum Dogel et Bychovsky, 1939	1.2	1.5	1–3	intestine
Proteocephalus sp.	2.7	1.5	1–4	intestine
NEMATODA				
Anguillicola crassus, L3 Kuwahara, Niimi et Itagaki, 1974	9.1	1.2	1–4	intestinal wall and mesentery
Camallanus truncatus (Rudolphi, 1814)	0.4	1	1	intestine
Contracaecum spp., L3	0.4	1	1	on intestine

Table 1. (*continued*)

1	2	3	4	5
Cystidicoloides ephemeridarum (Linstow, 1872)	1.0	1.6	1–3	intestine
Dichelyne minutus (Rudolphi, 1819)	0.2	1	1	intestine
Hysterothylacium aduncum, L3, L4, ad. (Rudolphi, 1802)	9.9	1.2	1–4	body cavity (L3), intestine (L4, ad.)
ACANTHOCEPHALA				
Echinorhynchus gadi Müller, 1776	0.4	1.5	1–2	intestine
Pomphorhynchus laevis (Müller, 1776)	1.6	1.8	1–3	intestine
Total	18.3	4.0*	1–51*	

* the value does not include *Trichodina domerguei domerguei.*

Table 2. Parasites of the round goby in native (Black Sea and Sea of Azov) and invaded areas (USA, Slovakia, southern Baltic), as reported by various authors (Naydenova (1974), Gaevskaya et al. (1975), Machkevsky et al. (1990), Pronin et al. (1997), Camp et. al. (1999), Kvach (2002, 2005), Rokicki & Rolbiecki (2002), Özer (2003), Ondračková et al. (2005), Rolbiecki & Kvach (2005)) and present study

Parasite	Black Sea	Sea of Azov	St. Clair River, Lake St. Clair (USA)	Southern Lake Michigan (USA)	River Danube (Slovakia)	Southern Baltic Sea	
						Gulf of Gdańsk	Vistula Lagoon, present
1	2	3	4	5	6	7	8
Dermocystidium sp.							+
MICROSPORA							
Glugea anomala	+						
Glugea sp.	+	+					
CILIOPHORA							
Apiosoma sp.			+				
Dipartiella sp.	+						
Trichodina domerguei	+						
Trichodina domerguei domerguei	+	+				+	+
Trichodina jadranica (=*T. domerguei gobii*)	+	+					
Trichodina fultoni	+	+					
Trichodina inversa	+	+					
Trichodina rectuncinata	+	+					
MYXOZOA							
Kudoa quadratum	+	+					
Myxidium melanostomi	+						

Table 2. (*continued*)

1	2	3	4	5	6	7	8
Sphaeromyxa sevastopoli			+				
MONOGENEA							
Gyrodactylus proterorhini (=*G. najdenovae*)	+	+					
DIGENEA							
Acanthostomum imbutiformie, met	+						
Acanthostomum sp., met	+	+					
Acanthostomatidae gen. sp., met	+	+					
Apatemon sp., met		+					
Aspidogaster limacoides	+						
Asymphylodora demeli	+	+					
Asymphylodora pontica	+						
Bacciger melanostomus	+	+					
Bucephalus marinus, met	+						
Bucephalus polymorphus, met	+						
Bucephalus sp.	+	+					
Bunodera luciopercae							+
Cardiocephalus longicollis, met	+	+					
Clinostomum complanatum, met			+				
Cryptocotyle concavum, met	+	+					+
Cryoptocotyle jejuna, met	+						
Cryptocotyle lingua, met	+	+					
Diplostomum spathaceum, met	+	+	+			+	

Table 2. (*continued*)

1	2	3	4	5	6	7	8
Diplostomum sp., met				+	+	+	
Diplostomum spp., met						+	+
Fellodistomatidae gen. sp., met	+						
Galactosomum lacteum, met	+	+					
Helicometra fasciata	+						
Heterophyidae gen. sp., met	+	+					
Ichthyocotylurus pileatus, met	+	+	+				
Lecithaster gibbosus confusus	+	+					
Magnibursatus skrjabini	+						
Maritrema subdolum, met	+						
Metadena pauli (=*Achoreus pauli*), met	+	+					
Metagonimus yokogawai, met	+*						
Microphallus papillorobustus		+					
Microphallidae gen. sp., met	+						
Monorchidae gen. sp., met	+*	+*					
Nicolla skrjabini (=*Crowcrocaecum skrjabini*)	+				+		
Pronoprymna ventricosa	+						
Pseudopentagramma petrowi (=*Pentagramma petrowi*)	+						
Pygidiopsis genata, met	+						
Rhipidocotyle sp., met			+				

Table 2. (*continued*)

1	2	3	4	5	6	7	8
Stephanostomum bicoronatum, met	+						
Strigeidae gen. sp., met	+	+					
Tylodelphys clavata, met		+					+
CESTODA							
Bothriocephalus scorpii, pl						+	+
Caryophyllaeidae gen. sp, L	+	+					
Eubothrium crassum, pl							+
Grillotia sp., pl	+						
Ligula pavlovski, pl	+	+					
Paradilepis scolecina, pl							+
Proteocephalus ambloplitis, pl			+				
Proteocephalus filicollis							+
Proteocephalus gobiorum	+	+					+
Proteocephalus sp.							+
Scolex pleuronectis, pl	+	+	+				
NEMATODA							
Agamonema sp. L3	+**	+**					
Anguillicola crassus, L3						+	+
Ascarophis sp., L3	+**						
Camallanus truncatus							+
Contracaecum microcephalum, L3	+						
Contracaecum rudolphii, L3	+						

Table 2. (*continued*)

1	2	3	4	5	6	7	8
Contracaecum sp., L3	+**	+**					
Contracaecum spp., L3							+
Cucullanus heterochrous	+						
Cystidicoloides ephemeridarum							+
Dichelyne minutus (=*Cucullanellus minutus*)	+	+					+
Eustrongylides excisus, L3	+						
Eustrongylides tubifex, L3			+**				
Eustrongylides sp., L3				+**			
Hysterothylacium aduncum, L3, L4, ad.	+**					+	+
Raphidascaris sp., L3	+						
Raphidascaris acus L3			+**		+		
Streptocara crassicauda, L3	+	+					
Tetrameres fissispina, L3		+					
ACANTHOCEPHALA							
Acanthocephaloides incrassatus	+	+					
Acanthocephaloides propinquus	+						
Acanthocephalus lucii	+					+	
Acanthocephalus dirus				+			
Echinorhynchus gadi						+	+
Pomphorhynchus laevis					+	+	+
Telosentis exiguus	+	+					

Table 2. (*continued*)

1	2	3	4	5	6	7	8
COPEPODA							
Ergasilus nanus	+	+					
Ergasilus gibbus	+***	+***					
Ergasilus sieboldi	+	+				+	
Lernaea cyprinacea	+	+					
Paraergasilus rylovi borysthenicus	+						
BIVALVIA							
Anodonta, glochidium	+*	+*					
Anodonta anatina, glochidium					+		
Total number of taxa	71	43	10	3	5	11	20

* species entered in a general list of round goby parasites, but absent from the detailed part of the monograph (Gaevskaya et al. (1975));
** the authors (Gaevskaya et al. (1975), Machkevsky et al. (1990), Pronin et al. (1997), Camp et. al. (1999)) gave no information as to the larval stage; it was, most probably, L3;
*** the authors (Gaevskaya et al. (1975)) placed a question mark next to the fish name; perhaps the record needs checking/confirmation.

contained no parasitic species typical of the fish's native range. Those parasites may have been unable to adapt to the new habitat, for instance, for lack of suitable hosts. Likewise, some 'native' parasitic species may have perished during the fish's migration. It has been hypothesised that the round goby was transported to Europe in the egg stage (Moskalikova 1996), which would preclude the introduction of host-specific parasitic species. Round gobies introduced to Slovakia (Ondračkova et al. 2005, Table 2), for example, were found to host only local parasite species. Similarly, round gobies introduced to the USA were also found, on examination there, to contain (Table 2) exclusively local parasite species (Camp et al. 1999); nonetheless, Pronin et al. (1997) did report *Sphaeromyxa sevastopoli* (from other gobiid species), an alien species endemic to the Black Sea and Sea of Azov.

The parasites found in the Vistula Lagoon round gobies were all local species, already recorded in Poland. Except for *Dermocystidium* sp., *Cryptocotyle concavum*, *P. gobiorum* and *D. minutus*, the parasites found were previously recorded in other fish species in the Vistula Lagoon (e.g., Wegener 1909, Evdokimova et al. 1994, Rolbiecki 2003, Avdeeva & Evdokimova 2004). The parasites found have usually a wide array of hosts and are common in the Lagoon. Some of them do have typical/main hosts, e.g., *P. gobiorum* is specific to gobiids, *D. minutus* inhabits mostly the flounder, and *E. gadi* lives in the cod. The parasites new to gobiids were *Dermocystidium* sp., *B. luciopercae*, *Eubothrium crassum*, *Paradilepis scolecina*, *P. filicollis*, *C. truncatus*, and *C. ephemeridarum*. It has to be added, however, that Sołtyńska (1964) was not convinced that her identification of *P. gobiorum* collected from the black goby in Puck Bay was correct. Moreover, Koter (1962) found tapeworms of the genus *Proteocephalus* in Puck Bay gobiids. This author did not identify the species, but – as reported later by Scholz & Hanzelová (1998) – they most probably represented *P. gobiorum*. It is possible that the tapeworms found by Sołtyńska (1964) and identified only as *Proteocephalus* belonged to this species as well.

The following parasites have been reported in round gobies from the Black Sea: *Trichodina domerguei domerguei*, *C. concavum*, *Diplostomum* spp. (*Diplostomum spathaceum*), *P. gobiorum*, *Contracaecum* spp. (*C. microcephalum*, *C. rudolphii*, *Contracaecum* sp.), *D. minutus*, and *H. aduncum* (Naydenova 1974, Gaevskaya et al. 1975, Machkevsky et al. 1990, Özer 2003, Kvach 2005), and from the Sea of Azov: *T. domerguei domerguei*, *C. concavum*, *Diplostomum* spp. (*D. spathaceum*), *Tylodelphys clavata*, *P. gobiorum*, *Contracaecum* spp. (*Contracaecum* sp.), and *D. minutus* (Naydenova 1974, Gaevskaya et al. 1975). In addition, *Bothriocephalus*

scorpii, *B. luciopercae*, *C. truncatus*, *E. crassum*, *P. scolecina*, and *P. laevis* have been found in other fish from the Black Sea and Sea of Azov which, however, hosted no *Dermocystidium* sp., *P. filicollis*, *A. crassus*, *C. ephemeridarum* or *E. gadi*.

Salinity is a factor important for the presence of parasites. Owing to its geographic location, the Vistula Lagoon is an estuarine one fed by the sea and river discharges. Consequently, the Lagoon may be inhabited by typically marine, typically freshwater, and brackish-water species. The round goby parasitic fauna in the Vistula Lagoon included as few as 6 marine taxa (*B. scorpii*, *C. concavum*, *Contracaecum* spp., *D. minutus*, *H. aduncum*, and *E. gadi*); they could have been introduced with the fish migrating to brackish, or even fresh, waters. Among the 10 *Contracaecum* nematode species known from Europe, the southern Baltic may support – in addition to the typically marine *C. osculatum* (Rokicki et al. 1993) – freshwater species known to occur in brackish waters: *C. rudolphii* (Kanarek et al. 2002) and *C. micropapillatum* (Okulewicz & Rokicki 1998). The proximity of the Gulf of Gdańsk and the Baltic Sea to the Vistula Lagoon facilitates fish migrations. However, because of the low salinity of the Lagoon (an average of 2.4 PSU, Łomniewski 1958), marine parasites are not frequent, although they are common in typical hosts, e.g., *H. aduncum* in the eelpout and *E. gadi* in the cod (Rolbiecki, in preparation). The remaining parasites are considered to be freshwater species which may be brought by their hosts to brackish waters. It is worth mentioning that the trematodes *Diplostomum* spp. and *T. clavata* have already been classified as brackish-water species (Rolbiecki 2003).

The finding of stage III larvae of the nematode *A. crassus*, the adults of which parasitise the swim bladder of the eel, is of particular interest. Until the 1980s, this parasite was recorded in eels from Japan and China (Moravec & Taraschewski 1988), from where it was brought to Europe (Neumann 1985, Moravec 1994) and North America (Fries & Williams 1996, Barse & Secor 1999). Once in Europe, it soon attacked natural populations of the European eel and produced symptoms of anguillicolosis, a dangerous and frequently fatal condition. Importantly, the life cycle of *A. crassus* involves paratenic (transmissive) hosts which, by accumulating the parasites, enhance the nematode's dispersal potential and infection of the definitive host, the eel. Paratenic hosts of *A. crassus* include various fish species feeding on invertebrates (mostly crustaceans), the intermediate hosts of the nematode (De Charleroy et al. 1990, Haenen & van Banning 1990). The eel becomes infected with *A. crassus* by ingesting crustaceans or paratenic hosts supporting the invasive third-stage larvae. As shown by the present data, the round goby in the Vistula Lagoon may participate in the

transmission of *A. crassus* to the eel. *A. crassus* larvae of this stage have been previously recorded in the Vistula Lagoon from the ruffe, perch, zander (Własow et al. 1997, 1998, Rolbiecki 2002, 2003), carp bream, and ziege (Rolbiecki 2002, 2003), smelt, stickleback (Rolbiecki 2004a), dab (Rolbiecki 2004b), and eel (Bystydzieńska et al. 2005, Rolbiecki & Rokicki 2006). Nevertheless, only the ruffe (11.8%, 8.2 indiv., Rolbiecki 2002), smelt (8.6%, 2.3 indiv., Rolbiecki 2004a) and stickleback (8.9%, 1.2 indiv., Rolbiecki 2004a) can be regarded as being involved as paratenic hosts in the life cycle of *A. crassus*. The level of infection in the round goby (9.1%, 1.2 indiv.) in the Vistula Lagoon was similar to that found in the smelt and stickleback. Unlike the ruffe and stickleback, the sharp fin rays of which could injure the eel, the round goby – in addition to the smelt (Rolbiecki 2004a) – may be a prey that definitive hosts find easier to catch.

As an invasive species in the trophic web, the round goby may be very important in parasite transmission in the new ecosystem. As it adapts to the new environment, it acquires new, local parasites. It is contended that, because of the recent immigration of the round goby, the qualitative and quantitative structure of its parasitic fauna in the Vistula Lagoon (Baltic) has not yet developed to the full. This is evidenced by the low level of prevalence and intensity, the absence (except from 9 specimens of *P. gobiorum*) of host-specific species, and the presence, in the case of some parasites, of only males (*E. gadi*, *P. laevis*) or immature females (*C. ephemeridarum*, *C. truncatus*, *D. minutus*). The development of new parasite-host systems may prove to be a long-term process.

References

Avdeeva E. V., Evdokimova E. B., 2004, *Results of ecological-parasitological study of fishes of some reservoirs in Kaliningrad district: an overview*, Modern problems of parasitology, zoology and ecology, Contributed papers to I and II international readings dedicated to the memory and 85th anniversary of birthday of S. S. Shulman (March 2002 and February 2003, Kaliningrad), Izd. Kaliningrad. Gos. Tekhn. Univ., 188–200, (in Russian).

Barse A. M., Secor D. H., 1999, *An exotic nematode parasite of the American Eel*, Fisheries, 24, 6–10.

Borowski W., 1999, *Round goby in the Vistula Lagoon*, Mag. Przem. Ryb., 4, 39, (in Polish).

Bystydzieńska Z., Rolbiecki L., Rokicki J., 2005, *Helminth communities of European eels Anguilla anguilla (Linnaeus, 1758) from the Vistula Lagoon and Puck Bay, Poland*, Wiad. Parazytol., 51 (2), 145–150.

Bzoma S., 1998, *The contribution of round goby (Neogobius melanostomus Pallas, 1811) to the food supply of cormorants (Phalacrocorax carbo Linnaeus, 1758) feeding in the Puck Bay*, Bull. Sea Fish. Inst., 2, 39–47.

Camp J. W., Blaney L. M., Barnes D. K., 1999, *Helminths of the round goby, Neogobius melanostomus (Perciformes: Gobiidae), from Southern Lake Michigan, Indiana*, J. Helminthol. Soc. Wash., 66, 70–72.

De Charleroy D., Grisez L., Thomas K., Belpaire C., Ollevier F., 1990, *The life cycle of Anguillicola crassus*, Dis. Aquat. Organ., 8, 77–84.

Evdokimova E. B., Avdeeva E. V., Zaostrovceva S. K., 1994, *Anthropogenic influence on parasitic fauna of some fish from the Kaliningrad Lagoon*, Vodnye bioresursy i akvakultura, Sb. Nauchn. Trud. Kaliningrad. Gos. Tekhn. Univ., 71–74, (in Russian).

Fries L. T., Williams D. J., 1996, *Occurrence of Anguillicola crassus, an exotic parasitic swim bladder nematode of eels, in the Southeastern United States*, Trans. Am. Fish. Soc., 125, 794–797.

Gaevskaya A. V., Gusev A. V., Delyamure S. L. et al., 1975, *Key to the parasites of vertebrates of the Black Sea and Sea of Azov. Parasitic invertebrates of fishes, fish-eating birds and marine animals*, Nauk. Dumka, Kiev, 552 pp., (in Russian).

Gąsowska M., 1962, *Keys to identification of vertebrates of Poland, Part 1. Cyclostomi and fish*, PWN, Warszawa, 240 pp., (in Polish).

Haenen O. L. M., van Banning P., 1990, *Detection of larvae of Anguillicola crassus (an eel swimbladder nematode) in freshwater fish*, Aquaculture, 87, 103–109.

Kanarek G., Rolbiecki L., Sitko J., Baruš V., Rokicki J., 2002, *The occurrence of Contracaecum rudolphii Hartwig, 1964 in the cormorant (Phalacrocorax carbo sinensis) in northern Poland*, Slovenské a české parazitologické dni, 28–31 May 2002, Stará Lesná, Slovenská Republika, 22 pp.

Koter M., 1962, *Helminth parasites in Gobiidae of the Puck Bay*, Acta Parasitol. Pol., 10, 217–230.

Kuczyński J., 1995, *Round goby Neogobius melanostomus (Pallas, 1811) – immigrant from Pontocaspian Basin – in the Gulf of Gdańsk*, Bull. Sea Fish. Inst., 2, 68–71, (in Polish).

Kvach Y., 2002, *The round goby's parasites in native habitats and in a place of invasion*, Oceanol. Stud., 31 (1–2), 51–57.

Kvach Y., 2005, *A comparative analysis of helminth faunas and infection parameters of ten species of gobiid fishes (Actinopterygii: Gobiidae) from the North-Western Black Sea*, Acta Ichthyol. Piscat., 35, 103–110.

Leppäkoski E., Olenin S., 2000, *Non-native species and rates of spread: lessons from the brackish Baltic Sea*, Biol. Invasions, 2, (2), 151–163.

Łomniewski K., 1958, *The Vistula Lagoon*, PWN, Warszawa, 106 pp., (in Polish).

Machkevsky V. K., Mordvinova T. N., Parukhin A. M., 1990, *Helminthofauna of bullheads in the Egorlytsian Bay and Lake Donuzlav, places for arrangement of mussel farms*, Ekol. Morya, 36, 69–75, (in Russian).

Moravec F., 1994, *Parasitic nematodes of freshwater fishes of Europe*, Kluwer, Dordrecht; Boston; London, 473 pp.

Moravec F., Taraschewski H., 1988, *Revision of the genus Anguillicola crassus Yamaguti, 1935 (Nematoda: Anguillicolidae) of the swimbladder of eels, including descriptions of two new species, A. novaezelandiae sp. n. and A. papernai sp. n.*, Folia Parasitol., 35, 125–146.

Moskalikova K. I., 1996, *Ecological and morphophysiological prerequisites to range extension in the round goby Neogobius melanostomus under conditions of anthropogenic pollution*, J. Ichthyol., 36, 584–590.

Naydenova N. N., 1974, *Parasite fauna of fishes of the goby family from the Black Sea and Sea of Azov*, Nauk. Dumka, Kiev, 182 pp., (in Russian).

Neumann W., 1985, *Schwimmblasenparasit Anguillicola bei Aalen*, Fisch. Teichwirt, 11, 322.

Niewiadomska K., 1996, *The genus Diplostomum – taxonomy, morphology and biology*, Acta Parasitol., 41, 55–66.

Okulewicz A., Rokicki J., 1998, *Contracaecum micropapillatum (Stossich, 1890) (Nematoda) – new species to the parasitofauna in Poland*, Bull. Scan. Soc. Parasitol., 8, 74.

Ondračková M., Dávidová M., Pečínková M., Blažek R., Gelnar M., Valová Z., Černý J., Jurajda P., 2005, *Metazoan parasites of Neogobius fishes in the Slovak section of the River Danube*, J. Appl. Ichthyol., 21, 345–349.

Özer A., 2003, *Trichodina domerguei Wallengren, 1897 (Ciliophora: Peritrichia) infestations on the round goby, Neogobius melanostomus Pallas, 1811 in relation to seasonality and host factors*, Comp. Parasitol., 70, 132–135.

Pronin N. M., Fleischer G. W., Baldanova D. R., Pronina S. V., 1997, *Parasites of the recently established round goby (Neogobius melanostomus) and tubenose goby (Proterorhinus marmoratus) (Cottidae) from the St. Clair River and Lake St. Clair, Michigan*, Folia Parasitol., 44, 1–6.

Rokicki J., Rolbiecki L., 2002, *Colonization of the round goby, Neogobius melanostomus (Gobiidae) by parasites in the new environment of the Gulf of Gdańsk (Southern Baltic)*, Wiad. Parazytol., 48 (2), 197–200.

Rokicki J., Valter E. D., Myjak P., 1993, *Contracaecum osculatum (Nematoda, Anisakidae) in cod, Gadus morhua L. from the Polish coast of the Baltic*, Acta Parasitol., 38, 33–35.

Rolbiecki L., 2002, *On the role of paratenic hosts in the life cycle of the nematode Anguillicola crassus in the Vistula Lagoon, Poland*, Acta Ichthyol. Piscat., 32, 109–116.

Rolbiecki L., 2003, *Diversity of the parasite fauna of cyprinid (Cyprinidae) and percid (Percidae) fishes in the Vistula Lagoon, Poland*, Wiad. Parazytol., 49 (2), 125–164.

Rolbiecki L., 2004a, *Larvae of Anguillicola crassus (Nematoda, Dracunculoidea) in stickleback (Gasterosteus aculeatus) and smelt (Osmerus eperlanus) from the Gulf of Gdańsk and the Vistula Lagoon*, Zool. Pol., 49, 29–35.

Rolbiecki L., 2004b, *Can the dab (Limanda limanda) be a paratenic host of Anguillicola crassus (Nematoda; Dracunculoidea)? The Gulf of Gdańsk and Vistula Lagoon (Poland) example*, Wiad. Parazytol., 50 (2), 317–322.

Rolbiecki L., Kvach Y., 2005, *The round goby Neogobius melanostomus (Pallas, 1811) as a new paratenic host of the parasitic nematode Anguillicola crassus Kuwahara, Niimi et Itagaki, 1974 in the Gulf of Gdańsk (Poland)*, Nauk. Zapiski, 4 (Ser. Biol.), 195–196, (in Ukrainian).

Rolbiecki L., Rokicki J., 2006, *Parasite fauna of the eel, Anguilla anguilla (Linnaeus, 1758), from the Polish part of the Vistula Lagoon*, Wiad. Parazytol., 52 (2), 115–119.

Sapota M. R., 2005, *Biology and ecology of round goby Neogobius melanostomus (Pallas 1811), invasive species in the Gulf of Gdańsk*, Wyd. Uniw. Gdańsk., Gdańsk, 117 pp., (in Polish).

Scholz T., Hanzelová V., 1998, *Tapeworms of the genus Proteocephalus Weinland, 1858 (Cestoda: Proteocephalidae), parasites of fishes in Europe*, Acad. Sci. Czech Republic, Praha, 118 pp.

Skóra K., Stolarski J., 1993, *New fish species in the Gulf of Gdańsk Neogobius sp. [cf. Neogobius melanostomus (Pallas, 1811)]*, Bull. Sea Fish. Inst., 1, 83.

Sołtyńska M., 1964, *Fish tapeworms in Puck Bay (South Baltic)*, Acta Parasitol. Pol., 12, 13–26.

Wandzel T., 2003, *The food and feeding of the round goby (Neogobius melanostomus Pallas, 1811) from the Puck Bay and the Gulf of Gdańsk*, Bull. Fish. Inst., 1, 23–39.

Wegener G., 1909, *Die Ektoparasiten der Fische Ostpreußens*, Phys.-ökon. Gesellsch. Königsb., 50, 194–286.

Własow T., Gomułka P., Martyniak A., Hliwa P., 1998, *Ruffe Gymnocephalus cernua L. the main paratenic host of the nematode Anguillicola crassus in Vistula Lagoon waters*, Wiad. Parazytol., 44, 365.

Własow T., Gomułka P., Ziomek E., Martyniak A., Hliwa P., Wziątek B., Szymańska U., Kozłowski J., 1997, *Parasites of cormorant fish prey in the cormorant nesting colony at Kąty Rybackie*, [in:] *Assessment of the cormorant (Phalacrocorax carbo sinensis) pressure on the Vistula Lagoon fish fauna*, L. Stempniewicz (ed.), Uniw. Gdańsk.; Akad. Rol.-Techn., Olsztyn; Mor. Inst. Ryb., Gdynia, Rap. No 3, 1–12, (in Polish).