Oceanological and Hydrobiological Studies
International Journal of Oceanography and Hydrobiology
Vol. XXXV, Supplement 1

Institute of Oceanography (121-136) University of Gdańsk
2005

ISSN 1730-413X

ANGUILLICOLA CRASSUS - AN ALIEN NEMATODE SPECIES FROM THE SWIM BLADDERS OF EEL (*ANGUILLA ANGUILLA*) IN THE POLISH ZONE OF THE SOUTHERN BALTIC AND IN THE WATERS OF NORTHERN POLAND

LESZEK ROLBIECKI[1], JERZY ROKICKI

University of Gdańsk, Department of Invertebrate Zoology
Al. Marszałka Piłsudskiego 46, 81-378 Gdynia, Poland

Key words: *Anguillicola crassus*, alien nematode, southern Baltic, northern Poland, review

Abstract

The dispersal and distribution of the alien nematode *Anguillicola crassus* parasitizing the European eel (*Anguilla anguilla*) in the southern Baltic and in waters of northern Poland is analyzed. The parasite's presence in eel was first recorded in 1988 in the Vistula Lagoon when the prevalence of infection and intensity ranges were 63.3-75% and 1-25 parasites per infected eel, respectively. In 2000-2002, as many as 73.6-76.2% of the eel were affected at an intensity range of 1-53 parasites. In addition to the Vistula Lagoon, *A. crassus* was recorded in the Szczecin Lagoon, the Gulf of Gdańsk, and the Puck Bay as well as in lakes Drużno, Łebsko, Przywłoka, Skąpe, Wielewickie, Miedwie, Ińsko, Łętowskie, Niegocin, Mamry Północne, Strażyn, Raduńskie, and a lake in the village of Gaj as well as in the rivers Rega, Radew, Wieprza, and Dead Vistula. The prevalence of infection was reported to be between 26.4% and 100%. It can be assumed that the colonization of the eel by *A. crassus* and the parasite's dispersal in European waters, including Poland, will increase.

[1] Corresponding author: *rolbieck@sat.ocean.univ.gda.pl*

TAXONOMY AND ORIGIN

Parasitic nematodes of the genus *Anguillicola* are represented by the following five species: *Anguillicola globiceps* Yamaguti, 1935 parasitizing *Anguilla japonica* in Japan and China; *Anguillicola australiensis* Johnston et Mawson, 1940 from *Anguilla reinhardtii* in southern Australia; *Anguillicola crassus* Kuwahara, Niimi et Itagaki, 1974 from *Anguilla japonica* in east Asia and from *Anguilla anguilla* in Europe; *Anguillicola novaezelandiae* Moravec et Taraschewski, 1988 from *Anguilla australis* and probably *Anguilla diffenbachii* in New Zealand and Australia and from *Anguilla anguilla* in Italy; and *Anguillicola papernai* Moravec et Taraschewski, 1988 from *Anguilla mossambica* in the Republic of South Africa (Moravec and Taraschewski 1988, Moravec 1994).

Table 1

First published records of the presence of *Anguillicola crassus* in various European countries.

Country	First published report
Austria	Konecny and Wais (1993)
Belgium	Balpaire et al. (1989)
Belarus	Bauer (1998)
Czech Republic	Moravec (1992)
Denmark	Koie (1988)
Estonia	Kangur et al. (1994)
France	Dupont and Petter (1988)
Germany	Neumann (1985)
Greece	Balpaire et al. (1989
Hungary	Szekely et al. (1991)
Ireland	Evans and Matthews (1999)
Latvia	Vismanis et al. (1999)
Italy	Canesti-Trotti (1987)
Macedonia	Cakic et al. 2002
Netherlands	Van Banning et al. (1985)
Norway	Mo and Stein (1994)
Poland	Własow et al. (1991)
Portugal	Cruz et al. (1992)
Russia	Zaostrovceva (1993)
Spain	Belpaire et al. (1989)
Sweden	Hellström et al. (1988)
United Kingdom	Kennedy and Fitch (1990)
Yugoslavia	after Höglung and Thomas (1992)

Anguillicola crassus was accidentally introduced to Europe (northern Germany) in 1982, most probably with imported infested Japanese eel from a culture in Taiwan (Neumann 1985, Koops and Hartmann 1989, Koie 1991). Subsequently, the species spread very rapidly by attacking cultured and wild eel populations. At present, *A. crassus* occurs in almost all European countries (Table 1), in north Africa in Egypt (Koops and Hartmann 1989), Marocco (El

Hilali et al. 1996), and Tuniesia (Maamouri et al. 1999), in the American eel in the United States (Fries et al. 1996, Barse and Secor 1999), and in Taiwan (Ooi et al. 1996).

In addition, *Anguillicola novazelandiae*, initially identified as *A. australiensis*, has been recorded locally in Europe. Its presence was first reported in Lake Bracciano in Italy where it was introduced in 1975 with *Anguilla australis* (Paggi et al. 1982, Moravec and Taraschewski 1988). The presence of the nematode was confirmed in subsequent studies carried out in 1988-1993 (Moravec et al. 1994).

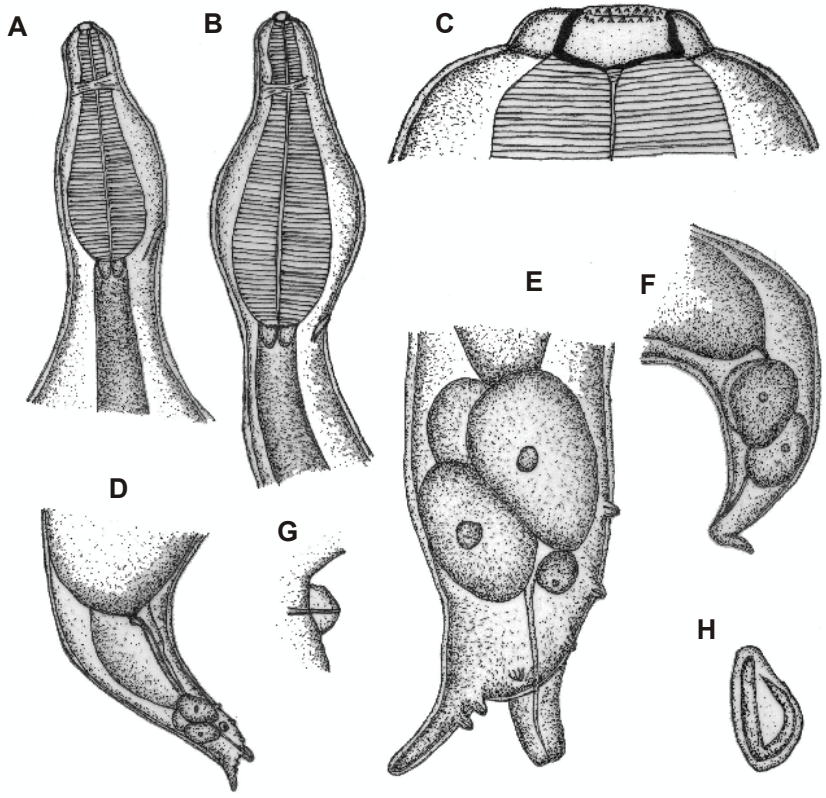

Fig. 1. *Anguillicola crassus* Kuwahara, Niimi et Itagaki, 1974. A, B – head end of male and female, C – buccal capsule of female, D – posterior end of male, E – tail of male, F – caudal end of female, G – vulva, H – larva from uterus. (After Moravec and Taraschewski 1988 and Moravec 1994).

MORPHOLOGY (AFTER MORAVEC AND TARASCHEWSKI 1988 AND MORAVEC 1994), BIOLOGY, AND LIFE CYCLE

The *Anguillicola crassus* body is fusiform, usually plump, and tapers at both ends. The buccal capsule is well sclerotized, and has one row of 21-28 circumoral teeth. As the nematode feeds on blood, the body has a dark brown coloration (Fig. 1).

Adult females measure 13.08-44.74 mm in length and 1.22-5.0 mm in maximum width. The buccal capsule measures 0.024-0.027 mm in length and 0.054-0.063 mm in width. The esophagus is 0.775-1.09 mm long, with a maximum width of 0.204-0.381 mm. The esophagus length to total body length ratio is 1:15-40. The nerve ring is located 0.258-0.299 mm from the anterior end of the body, and the excretory pore is situated 0.857-1.142 mm away from it. The prominent vulva is conical and located 3.40-7.01 mm from the posterior end of the body. Most of the body is occupied by the uterus filled with eggs containing developing embryos as well as fully developed and molting larvae measuring 0.244-0.258 mm in length and 0.015 mm in width. The conical tail measures 0.136-0.448 mm.

Males measure 5.77-23.12 mm in length and 0.340-1.77 mm in maximum width. The male buccal capsule length and maximum width ranges are 0.021-0.027 and 0.048-0.063 mm, respectively. The esophagus length and maximum width are 0.571-0.843 and 0.135-0.258 mm, respectively. The esophagus length to body length ratio is 1: 9-29. The nerve ring is 0.210-0.286 mm from the anterior end of the body, and the excretory pore is located 0.694-0.924 mm from it. The cloacal duct opens onto a prominent process that is 0.048-0.090 mm long. There are six pairs of caudal papillae - two to three of which are preanal, one adanal, and two to three postanal. The conical tail measures 0.109-0.286 mm.

Females are ovoviviparous and expel eggs containing stage II larvae which, via the pneumatic duct and intestine, exit to the external medium - water. A single female is able to produce up to 150,000 eggs (Thomas and Ollevier 1993). The life span of the free-living larvae depends on salinity and temperature. At 30, 21, and 4ºC the larvae survive for 15, 23, and 42 days, respectively (De Charleroy et al. 1987). When swallowed by an intermediate host (mainly a cyclopoid copepod, more seldom an ostracod or an amphipod), the stage II larvae move to the haemocoel where, after 10-12 days at 21 ºC (De Charleroy et al. 1990) they molt into a stage III larva, a fish invader. The *A. crassus* life cycle involves paratenic hosts, mainly various small fish which, by feeding on copepods carrying stage III larvae, become infected, but the larvae remain at the same developmental stage. Paratenic hosts are particularly important for large eel that, more often than not, feed on other fish (Fig. 2).

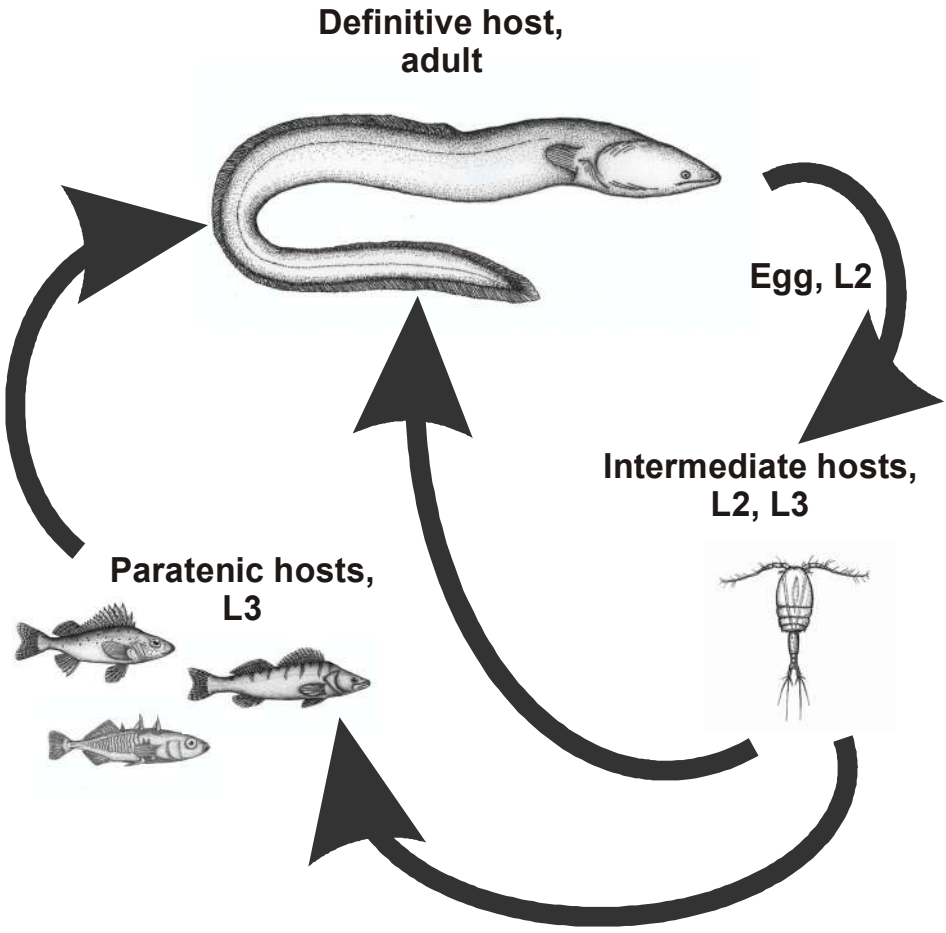

Fig. 2. Life cycle of *Anguillicola crassus*

Stage III larvae were reported from numerous fish species, *i.e*., carp bream, *Abramis brama*; roach, *Rutilus rutilus*; perch, *Perca fluviatilis*; ruffe, *Gymnocephalus cernuus*; zander, *Sander lucioperca* (*e.g.*, Thomas and Ollevier 1992, Székely 1994, 1995, Rolbiecki 2002, 2003a); ziege, *Pelecus cultratus* (Rolbiecki 2002, 2003a); bleak, *Alburnus alburnus*; asp, *Aspius aspius*; white bream, *Abramis bjoerkna*; gibel carp, *Carassius auratus*; gudgeon, *Gobio albipinnatus*; common carp, *Cyprinus carpio*; tench, *Tinca tinca*; pumpkinseed, *Lepomis gibbosus*; pike, *Esox lucius*; European catfish, *Silurus glanis*; river goby, *Neogobius fluviatilis* (*e.g*., Székely 1994, 1995); smelt, *Osmerus eperlanus* (*e.g*., Haenen and van Banning 1990, Rolbiecki 2003b); stickleback,

Gasterosteus aculeatus (Belpaire et al. 1989, Thomas and Ollevier 1992, Rolbiecki 2003c); three-spined stickleback, *Pungitius pungitius* (Rolbiecki 2003c); round goby, *Neogobius melanostomus* (Rolbiecki 2004a); and dab, *Limanda limanda* (Rolbiecki 2004b). The role of paratenic host can also be assumed by amphibians: tadpoles of the frog, *Bombina bombina*, and the newt, *Triturus vulgaris* (Moravec and Skorikova 1998), and even snails, *e.g.*, *Galba corvus* (Moravec 1996), or aquatic insects, *e.g.*, larvae of the alderfly *Sialis lutaria* (Megaloptera), the dragonflies *Sympetrum sanguineum* and *Coenagrion puella* (Odonata), and the caddisfly *Oligotrichia striati* (Trichoptera) (Moravec and Skorikova 1998).

The role of paratenic hosts in various water bodies can differ depending on the food preferences of the eel. For example, the main *A. crassus* paratenic host in Lake Balaton is bleak (Székely 1994) as it accounts for as much as 93.5% of the eel food (Paulovits and Bíró 1987). Thus, eel become infected either via intermediate or paratenic hosts, the latter increasing the possibility of the parasite life cycle being completed. Stage III larvae move from the definitive host's intestinal lumen through the intestinal walls and the body cavity to the swim bladder where, two to three weeks later, they molt to become stage IV larvae. These larvae feed on the host's blood, molt once again, mature, and begin to reproduce. Under laboratory conditions, at 20˚C, the life cycle is completed in 2 months (De Charleroy et al. 1990).

PATHOGENICITY, CLINICAL SYMPTOMS, AND ANATOMOPATHOLOGICAL CHANGES PRODUCED

Anguillicola crassus has proved more dangerous to the European than to the Japanese eel (type host). In Japan, 10-40% of the eel are infected by the nematode. Although it lives in the swim bladder and feeds on blood, the nematode does not harm the host in any substantial manner. As reported by Egusa (1979), the Japanese eel has been evolutionarily immunized to any damage the parasite could induce. On the other hand, the nematode's prevalence in the European eel may be as high as 100%, the infection intensity reaching several tens of nematodes per infected fish, which cannot leave the host's condition unaffected.

Anguillicola crassus causes anguillicolosis. The nematodes feeding within the eel produce acute and chronic inflammations as well as edemas and fibrosis of the swim bladder walls which become opaque and thickened (*e.g.*, Van Banning and Haenen 1990, Molnár et al. 1993). Occasionally, the adjacent organs may become fibrotic as well (Van Banning and Haenen 1990). The feeding nematodes mechanically damage the swim bladder epithelium. The epithelial cells become hyperaemic, hypertrophic, hyperplasic, and dysplasic,

which frequently results in collapse of the swim bladder (Würtz and Taraschewski 2000). When the swim bladder holds a high number of the nematodes, the fish abdomen is swollen (Kirk et al. 2000). Frequently, the eel swim bladder contains a thick, black liquid that resembles blood - a remnant of dead nematodes (*e.g.*, Rolbiecki et al., 2000). As the larvae migrate in the swim bladder wall, they damage it and cause hemorrhages. The walls of the intestine and swim bladder often have tumors containing dead larvae and their remains (Molnár 1994). *A. crassus* impairs swim bladder gas secretion. The gas content in a healthy eel's swim bladder is 70% oxygen, about 25% carbon dioxide, with argon and nitrogen as the remaining gases. In fish infested by as few as 10 adult nematodes, the volume of oxygen in the swim bladder is reduced by as much as 60% (Würtz and Taraschewski 2000). In addition, the swimming speed of such fish is reduced by 18% (Kirk 2003), making them easy prey for large predators (Barse and Secor 1999). Moreover, Koie (1988) contends that anguillicolosis impairs the ability of eel to undertake spawning migrations to the western Atlantic. Tesch (1995) adds that a properly functioning swim bladder is indispensable in long-distance oceanic migrations as, among other functions, it helps fish maintain the appropriate depth during the day (500 m) and at night (250 m).

As reported by Lefebvre et al. (2002), danger from swim bladder damage increases as eel grow; this is most probably related to the accumulation of pathological changes.

In the presence of additional stressors (*e.g.*, bacterial infection, oxygen deficiency in the water, high fish density, transport), the afflicted fish affected may die. Mortality of this kind was reported in Lake Balaton in Hungary in 1991 (Molnár et al. 1991) and in the Czech Republic in 1994 and 1995 (Baruš 1994, 1995).

DISPERSAL AND DISTRIBUTION OF *ANGUILLICOLA CRASSUS* IN THE EEL IN THE SOUTHERN BALTIC AND ADJACENT WATERS

Most of the data on the occurrence of *A. crassus* in the eel in Poland come from northern Poland and the Baltic Sea. In this region, the presence of *A. crassus* has been reported from the Vistula and Szczecin Lagoons, the Gulf of Gdańsk, the Puck and Pomeranian Bays, and from the lakes Drużno, Łebsko, Przywłoka, Skąpe, Wielewickie, Miedwie, Ińsko, Łętowskie, Niegocin, Mamry Północne, Strażyn, Raduńskie, a lake in the village of Gaj, and in the rivers Rega, Radew, Wieprza, and Dead Vistula (Table 2). Most nematode studies were conducted in the Vistula and Szczecin lagoons. The first record of the parasite dates to 1988 when it was identified in the Vistula Lagoon (Grawiński 1988, Rolbiecki et al. 1996) in 75% (Grawiński 1994) and 63.3% of the eel

Table 2

The occurrence of *Anguillicola crassus* in the eel in the Polish zone of the southern Baltic and northern Poland.

Reservoir	Sampling date	No. of fish examined	Prevalence [%]	Mean intensity [ind.]	Range of intensity [ind.]
Vistula Lagoon					
[Grawiński 1994]	1988	-	75[1]	12[1]	-
[Rolbiecki et al. 1996]	1988-1990	117	63.3	-	1-25
[Własow et al. 1997]	1996	10	100	8.3	1-24
	1997	14	92.9	6.9	1-17
	1997	18	94.4	10.3	1-30
	1997	12	91.7	4.3	1-11
	1997	1[2]	100	2,0	2
[Rokicki et al. 2002]	2000	288	73.6	7.0	1-53
[Bystydzieńska et al. 2003]	2001-2002	488	76.2	7.0	-
Jezioro Druzno					
[Rolbiecki and Rokicki 1997, unpubl.]	1997	16	37.5	7.3	5-16
Jezioro Raduńskie					
[Rolbiecki 2004, unpubl.]	2004	2	100	12	6-18
Dead Vistula					
[Rolbiecki 1996, unpubl]	1996	8	37.5	5.0	3-8
[Rolbiecki 2004, unpubl]	2004	12	58.3	6.0	2-12
Łebsko Lake					
[Morozińska 2004]	2001-2003	60	78	6.2	1-26
Jeziora Przywłoka, Skąpe, Wielewickie					
[Grawiński 1994]	1989	-	about 80	-	-
Lake Miedwie					
[Sobecka and Piasecki 2002]	1997-99	20	100	-	3-44
Lake Ińsko					
[Orecka-Grabda et all. 1994]	1993	84	88.7	-	1-15
[Rząd 1998]	1993-1996	136[3]	88.7	-	1-15
Szczecin Lagoon					
[Rząd 1998]	1993-1996	136[3]	65.0	-	1-35
[Garbacik-Wesołowska and Szkudlarek 1994]	1993	106	26.4	-	0-12
	1994	19	68.4	-	0-11
	1994	16	37.5	-	0-36
[Sobecka 1995]	1993	106	24.5	-	-
	1994	-	68.4		1-29
Pomeranian Bay					
[Garbacik-Wesołowska and Szkudlarek 1994]	1994	10	30.0	-	0-10
Pomeranian rivers:					
Rega	1999-2003	198	59.1	1.7	1-11
Radew	2000-2001	64	65.6	2.1	1-12
Wieprza	1999-2001	60	41.7	1.3	1-8
[Pilecka-Rapacz and Sobecka 2004]					
Lake Łętowskie					
[Garbacik-Wesołowska and Szkudlarek 1994]	1994	29	69.0	-	0-22
[Sobecka 1995]	1994	29	69.0	-	-30[4]
Lake Niegocin					
[Własow et al. 1991]	1989	15	27.7	-	1-2
Lake Mamry Północne					
[Własow et al. 1991]	1990	15	27.7	-	2-33
Lake Strażyn					
[Własow et al. 1994]	1993	55[5]	78.3	-	1-204 600
Lake in the town Gaj					
[Własow et al. 1994]	1993	55[5]	25.0	-	1-102
Gulf of Gdańsk					
[Rolbiecki et al. 2000]	1997-1998	372	41.9	3.0	-
Gulf of Puck					
[Bystydzieńska et al. 2003]	2001-2002	133	74.4	8.3	-

[1]: the author published the maximum prevalence and intensity values only
[2]: a single eel regurgitated by a black cormorant in Kąty Rybackie
[3]: the number of fish examined was a pooled sample from the Szczecin Lagoon and Lake Ińsko
[4]: the author published the maximum intensity values only
[5]: the number of fish examined was a pooled sample from lakes Strażyn and Gaj
-: no value reported

examined (the latter value was calculated based on the prevalence in the fish caught in 1988-1990) (Rolbiecki et al. 1996). It is worth adding that Grawiński (1994) did not mention the number of fish examined, and the prevalence of infection he reported, which was calculated from a small number of fish examined, could have been overestimated. Additionally, Grawiński (1994) only reported the maximum prevalence and intensity. Subsequent studies on Vistula Lagoon eel indicated that there was an increase in the extent of infection. In 2000, the prevalence and mean intensity were 73.6% and 7.0 parasites, respectively; in 2001-2002, the prevalence was observed to increase to 76.2%, while the mean intensity remained at an unchanged level (Bystydzieńska et al. 2003). It should be mentioned here that the Vistula Lagoon eel were examined for parasites in 1996-1997 as well, but the study involved as few as 1–18 fish specimens (Własow et al. 1997). In the Szczecin Lagoon, *A. crassus* was first identified in 1993 (Garbacik-Wesołowska and Szkudlarek 1994, Sobecka 1995, Rząd 1998). The prevalence and maximum intensity reported by Garbacik-Wesołowska and Szkudlarek (1994) were 26.4% and 12 parasites, respectively; the authors did not mention the value at the lowest intensity. Sobecka (1995) reported an infestation prevalence of 24.5%, but did not report the intensity level, while Rząd (1998) reported prevalence and intensity of 65% and 1-35 parasites, respectively. The differences in infection could have resulted from the fact that Rząd (1998) reported prevalence of infection pooled over the 1993-1996 period, while Garbacik-Wesołowska and Szkudlarek (1994) and Sobecka (1995) referred only to 1993 values. Additionally, Rząd (1998) did not state the number of fish examined. Garbacik-Wesołowska and Szkudlarek (1994) reported two eel samples, examined in 1994 (with prevalences of 37.5% and 68.4%), consisting of as few as 16 and 19 specimens. In the same year, Sobecka (1995) reported higher prevalence (68.4%), but did not mention the number of fish examined.

There were usually only single samples from the remaining areas. The proportion of infected fish ranged from 30% in the Pomeranian Bay (Garbacik-Wesołowska and Szkudlarek 1994), 41.9% in the Gulf of Gdańsk (Rolbiecki et al. 2000), to 74.4% in the Puck Bay (Bystydzieńska et al. 2003). Among the eel caught in lakes, the prevalence of infection varied from 25% in the lake in the village of Gaj (Grawiński 1994) to, for example, 88.7% in Lake Ińsko (Orecka-Grabda et al. 1994, Rząd 1998) and even to 100% (based on as few as 20 fish examined) in Lake Miedwie (Sobecka and Piasecki 2002). The prevalence in rivers ranged from 41.7% in the Wieprza to 65.6% in the Radew (Pilecka-Rapacz and Sobecka 2004).

The differences in the infection level in various water bodies could have resulted from a number of factors. These can be biotic including the presence of intermediate hosts (mainly copepods), paratenic hosts, or the opportunity the

fish have to migrate from one reservoir to another. They can also be abiotic and include factors such as salinity or temperature, or they can be anthropogenic. The presence of a high number of species that are potential intermediate and paratenic hosts increases the chance of the definitive host, the eel, to become infected. Migrations of both paratenic hosts and eel are an important factor enhancing dispersal of the parasite both on a local and global scale. Water temperature is an important factor accelerating the parasite's development. On the other hand, salinity may be a factor limiting the distribution of *A. crassus*. The parasite is commonly regarded as a freshwater species, but, as reported by numerous authors (including those referred to in this paper), it is highly tolerant to salinity changes. Human activities, particularly uncontrolled stocking, may play a role as well. Each batch of stocking material should be examined for the presence of parasites, including *A. crassus*, and the infected fish should be eliminated. The water infected fish were transported in should not be poured into clean reservoirs, as it may contain stage II larvae.

In summary, the distribution range of *A. crassus* in northern Poland and the Baltic is increasing as is the extent of infection. Perhaps the process will level off with time as a result of a stabilizing effect exerted by constraints imposed by interspecific interactions and habitat saturation.

REFERENCES

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

Baruš V., 1994, *Uhořům hrozi smrt,* Rybářstvi, 11, 328-329

Baruš V., 1995, *First record of* Anguillicola crassus *(Nematoda) in the Morava River drainage basin,* Helminthologia, 32, 89

Bauer O.N., 1998, *Novaya paraziticheskaya nematoda roda Anguillicola (Dracunculoidea: Anguillicolidae) v rybakh Palearktiki*, Parazitologiya, 32, 59-65

Belpaire C., De Charleroy D., Grisez L., Ollevier F., 1989, *Spreading mechanisms of the swimbladder parasite* Anguillicola crassus *in the European eel* Anguilla anguilla*, and its distribution in Belgium and Europe,* European Inland Fisheries Advisory Commission EIFAC - Working Party on Eel, , 29 May - 3 June, Porto, Portugal, Porto, 1-13.

Bystydzieńska Z., Rolbiecki L., Rokicki J., 2003, *Nicienie węgorza europejskiego,* Anguilla anguilla *z wód Zatoki Gdańskiej i Zalewu Wiślanego,* Materiały konferencyjne Zjazdu Polskiego Towarzystwa Zoologicznego „Zoologia na progu XXI wieku", September, 2003, Toruń, Poland, 18

Cakic P., Stojanovski S., Kulišić Z., Hristovski N., Lenhardt M., 2002, *Occurence of* Anguillicola crassus *(Nematoda: Dracunculoidea) in eels of Lake Ohrid, Macedonia,* Acta Vet., 52, 163-168

Canestri-Trotti G., 1987, *Occurrence of the nematode* Anguillicola crassus *Kuwahara, Niimi & Itagaki, 1974 in eels from the Po delta, Italy*, Bull. Eur. Ass. Fish Pathol., 7, 109-111

Cruz E., Silva P., Grazina Freitas M.S., Carvalho-Varela M., 1992, *First report of* Anguillicola crassus *in the European eel in Portugal,* Bull. Eur. Ass. Fish Pathol., 12, 154-156

De Charleroy D., Thomas K., Belpaire C., 1987, *Problems concerning the species determination, biology and diagnostical methods of Anguillicola, a swim-bladder nematode in the European eel (*Anguilla anguilla *L.),* European Inland Fisher, Adv. Commission, EIFAC Working Party on Eel, April, 1987, Bristol, UK, 1-7

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

Dupont F., Petters A., 1988, *Anguillicola, un épizootie plurispécifigue en Europe. Apparition d'* Anguillicola crassa *(Nematoda, Anguillicolidae) chez l'anguille européenne (*Anguilla anguilla*) en Camargue*, Sus de la France, Bull. Fr. Pech. Pisci., 308, 38-41

Egusa S., 1979, *Notes on the culture of the european eel (*Anguilla anguilla *L.) in japanese eel - farming ponds,* Rapp. P. v. Réun. Cons. int. Explor. Mer., 174, 51-58

El Hilali M., Yahyaoui A., Sadak A., Maachi M., Taghy Z., 1996, *Première donnèes èpidemiologiques sur l'anguillicolose au Maroc,* Bull. Fr. Pěche Pisci., 340, 57-60

Evans D.W., Matthews M.A., 1999, Anguillicola carssus *(Nematoda: Dracunculoidea): first documented record of this swimbladder parasite of eels in Ireland*, J. Fish Biol., 55: 665-668

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

Garbacik-Wesołowska A., Szkudlarek A., 1994, *Nematode* Anguillicola crassus *in eels from the Szczecin Lagoon and Lake Łętowskie,* Bull. Sea Fish. Inst., 2,34-37

Grawiński E., 1994, *Occurrence of* Anguillicola crassa *nematode in eel (*Anguilla anguilla*) from Vistula Lagoon and Pomeranian lakes,* The 17th Congress of the Polish Parasitological Society, September, 1994, Poland. Biul. Met. Org., 27, 55

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

Hellström A., Ljungberg O., Bornstein S., 1988, *Anguillicola, en ny ålparasit i Sverige*, Sven. Vet., 40, 211-213

Höglund J., Thomas K., 1992, *The black goby* Gobius niger *as a potential paratenic host for the parasitic nematode* Anguillicola crassus *in a thermal effluent of the Baltic*, Dis. Aquat. Org., 13, 175-180

Kangur A., 1994, *Uus liik Vortsjärve kalaparasiitide hulgas,* Eesti Loodus, 6, 189

Kennedy C.R., Fitch D.J., 1990, *Colonization, larval survival and epidemiology of the nematode* Anguillicola crassus*, parasitic in the eel,* Anguilla anguilla*, in Britain*, J. Fish Biol., 36, 117-131

Kirk R.S., 2003, *The impact of* Anguillicola crassus *on European eels*, Fish Manag. Ecol., 10, 385-394

Kirk R.S., Lewis J.W., Kennedy C.R., 2000, *Survival and transmission of* Anguillicola crassus *Kuwahara, Niimi & Itagaki, 1974 (Nematoda) in seawater eels*, Parasitology, 120, 289-295

Koie M., 1988, *Parasites in eels,* Anguilla anguilla *(L.), from eutrophic Lake Esrum (Denmark),* Acta Parasitol. Pol., , 33, 89-100

Koie M., 1991, *Swimbladder nematodes (*Anguillicola *spp.) and gill monogeneans (*Pseudodactylogyrus *spp.) parasitic on the European eel* Anguilla anguilla*,* J. Cons. Int. Explor. Mer, 47, 391-398

Konecny R., Wais A., 1993, *Occurence of* Anguillicola crassus *in eels of :Lake Neusiedl, Austria,* International Workshop "*Anguillicola* and Anguillicolosis of Eels", October, 1993, České Budějovice, Czech Republic, 327

Koops H., Hartmann F., 1989, Anguillicola-*infestations in Germany and in German eel imports,* J. Appl. Ichthyol., 5, 41-45

Lefebvre F., Contournet P., Crivelli A.J., 2002, *The helth state of the eel swimbladder as a measure of parasite pressure by* Anguillicola crassus*,* Parasitology, 124, 457-463

Maamouri F., Gargouri L., Ould Daddah M., Bouix G., 1999, Occurrence of *Anguillicola crassus* (Nematoda, Anguillicolidae) in the Ichkeul Lake (Northern Tunisia), Bull. Eur. Ass. Fish Pathol., 19, 17-19

Mo. T.A., Steien S.H., 1994, *First observation of the eel swimbladder nematode* Anguillicola crassus *in Norway,* Bull. Eur. Ass. Fish Pathol., 14, 163

Molnár K., 1994, *Formation of parasitic nodules in the swimbladder and intestinal walls of the eel* Anguilla anguilla *due to infections with larval stages of* Anguillicola crassus*,* Dis. Aquat. Org., 20, 163-170

Molnár K., Székely Cs., Baska F., 1991, *Mass mortality of eel in Lake Balaton due to* Anguillicola crassus *infection,* Bull. Eur. Ass. Fish Pathol., 11, 211-212

Molnár K., Baska F., Csaba G., Glávits R., Székely Cs., 1993, *Pathological and histopathological studies of the swimbladder of eels* Anguilla anguilla *infected by* Anguillicola crassus *(Nematoda: Dracunculoidea),* Dis. Aquat. Org., 15, 41-50

Moravec F., 1992, *Spreading of the nematode* Anguillicola crassus *(Dracunculoidea) among eel populations in Europe*, Folia Parasitol., 39, 247-24

Moravec F., 1994, *Parasitic nematodes of freshwater fishes of Europe,* Kluwer Academic publishers, Dordrecht, Boston, London, 273pp.

Moravec F., 1996, *Aquatic invertebartes (snails) as new paratenic hosts of* Anguillicola crassus *(Nematoda: Dracunculoidea) and the role of paratenic hosts in the life cycle of this parasite,* Dis. Aquat. Org., 27, 237-239

Moravec F., Taraschewski H., 1988, *Revision of the genus* Anguillicola *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

Moravec F., Di Cave D., Orecchia P., Paggi L., 1994, *Present occurrence of* Anguillicola novaezelandiae *(Nematoda: Dracunculoidea) in Europe and its development in the intermediate host,* Folia Parasitol., 41, 203-208

Moravec F., Škoriková B., 1998, *Amphibians and larvae of aquatic insects as new paratenic hosts of* Anguillicola crassus *(Nematoda: Dracunculoidea), a swimbladder parasite of eels,* Dis. Aquat. Org., 34, 217-222

Morozińska-Gogol J., 2004, *Occurence of Asiatic nematode* Anguillicola crassus *in European eel from the Łebsko Lagoon (Middle Coast),* Konference: Baltic – the Sea of aliens, August, Gdynia, Poland, 36-37

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

Ooi Hong-Kean, Wang Way-Shyan, Chang Hong-You, Wu Chwen-Herng, Lin Cheng-Chung, Hsieh Meng-Tong, 1996, *An epizootic of Anguillicolosis in cultured American Eels in Taiwan,* J. Aquat. Anim. Health, 8, 163-166

Orecka-Grabda T., Pilecka_Rapacz M., Cisek I., 1994, *Invasion of* Anguillicola crassus*, asiatic nematoid in European eel from Lake Ińsko (district of Szczecin),* The 17th Congress of the Polish Parasitological Society, September, Poland. Biul. Met. Org. 27, 57

Paggi L., Orecchia P., Minervini R., Mattiucci S., 1982, *Sulla comparsa di* Anguillicola australiensis *Johnston et Mawson, 1940 (Dracunculoidea: Anguillicolidae) in* Anguilla anguilla *del Lago di Bracciano*, Parassitologia, 24, 130-144

Paulovits G., Biró P., 1987, *Feeding and growth of the eel in Lake Balaton*, Proceedings of the 29th "Georgikon" Days, August 1987, Keszthely, Hungary, 213-226

Pilecka-Rapacz M. Sobecka E., 2004, *Nematodes of the intestine and swim bladder of the European eel* Anguilla anguilla *(L.) ascending Pomeranian rivers*, Wiad. Parazytol., 50, 19-28

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

Rolbiecki L., 2003b, *Udział stynki Osmerus eperlanus w cyklu życiowym* Anguillicola crassus *w wodach Zalewu Wiślanego*, Zjazd Polskiego Towarzystwa Zoologicznego – Zoologia na progu XXI wieku, September, 2003, Toruń, Poland, 223-224

Rolbiecki L., 2003c, Anguillicola crassus *(Nematoda: Dracunculiodea) stage III larvae in gasterosteid (Gasterosteidae) fish of the Gulf of Gdańsk (Baltic Sea),* XIV Wrocławska Konferencja Parazytologiczna - Parazytologia XX/XXI wieku, October 2002 Wrocław, Wiad. Parazytol., 49, 96

Rolbiecki L., 2004a, *Preliminary results of studies on parasites of the round goby* Neogobius melanostomus *(Pallas, 1811) from the Vistula Lagoon, a species new for Poland, and potential biological consequences,* Wiad. Parazytol., 50 (supplement), 106-107

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, 317-322

Rolbiecki L., Grawiński E., Rokicki J., 1996, *The occurrence of nematod* Anguillicola crassus *Kuwahara, Niimi et Itagaki 1974 in the swimbladder of eel (*Anguilla anguilla *(L.)) from the Vistula Lagoon,* Land-Ocean

Interactions in the Coastal Zone, Second International Symposium on: Functioning of Coastal Ecosystems in Various Geographical Regions, 1996, Sopot, Poland, 55-56

Rolbiecki L., Rokicki J., Wojtkiewicz D., 2000, *The first record of the nematode* Anguillicola crassus *(Nematoda: Dracunculoidea) in eel of the Gulf of Gdańsk (Poland),* Oceanol. Studies 24, 75-81

Rząd I., 1998, Anguillicola crassus*, asiatic nematoid imperil European eel (*Anguilla anguilla *L.),* XVIII Congress of the Polish Parasitological Society, Wiad. Parazytol., 44, 355

Sobecka E., 1995, Anguillicola crassus – *parasitic nematode of eels from Western Pomeranian (Poland),* IVth International Symposium of Fish Parasitology, October, 1995, Munich, Germany, 39

Sobecka E, Piasecki W., 2002, *Parasite fauna of selected fish species of Lake Miedwie,* Wiad. Parazytol., 48, 207-215

Székely Cs., 1994, *Paratenic hosts for the parasitic nematode* Anguillicola crassus *in Lake Balaton, Hungary,* Dis. Aquat. Org., , 18, 11-20

Székely Cs., 1995, *Dynamics of* Anguillicola crassus *(Nematoda: Dracunculoidea) larval infection in paratenic host fishes of lake Balaton, Hungary*, Acta Vet. Hung., 43, 401-422

Székely Cs., Láng M., Scaba Gy., 1991, *First occurence of* Anguillicola crassus *in Hungary*, Bull. Eur. Ass. Fish Pathol., 11, 162

Tesch F.W., 1995, *Vertical movements of migrating silver eels (*Anguilla anguilla*) in the sea*, Bull. Sea Fish. Inst., 2, 23-30

Thomas K., Ollevier F. 1992, *Paratenic hosts of the swimbladder nematode* Anguillicola crassus*,* Dis. Aquat. Org., 13, 165-174

Thomas K., Ollevier F., 1993, *First estimate of the egg production of* Anguillicola crassus *(Nematoda: Dracunculoidea),* Folia Parasitol., 40, 104

Van Banning P., Heermans W., Van Willigen J.A., 1985, Anguillicola crassa*, een nieuwe aalparasiet in Nederlandse wateren,* Visserij, 38, 237-240

Van Banning P., Haenen O.L.M., 1990, *Effects of the swimbladder nematode Anguillicola crassus in wild and farmed eel,* Anguilla anguilla, [in:] *Pathology in Marine Science*, Perkins F.O., Cheng T.C. (eds.), New York, Academic Press, 317-330

Vismanis K., Kirjusina M., Rodzins R., 1999, *An eel nematode* Anguillicola crassus *Kuwahara, Nimii et Itagaki, 1974 (Nematoda: Dracunculoidea) in Latvia*, Proceedings of the Fifth International Symposium on Fish Parasites, August, 1999, Czech Republic, 160

Własow T., Kujawa R., Bernard A., Zielonka M., 1991, *Występowanie pasożytów u* Anguilla anguilla *(L.) na podstawie imortowanego materiału obsadowego i wegorzy żerujących w wodach polskich*, XVI Zjazd Polskiego Towarzystwa Parazytologicznego, September, Poznań, 1991, Poland, 35

Własow, T., Gomułka, P., Martyniak, A., Boroń, S., Hliwa, P., Terlecki, J., Szymańska, U., 1997, *Pasożyty ryb ofiar kormoranów z koloni lęgowej w Kątach Rybackich,* [in:] *Ocena presji kormorana czarnego* Phalacrocorax carbo sinensis *na ichtiofaunę Zalewu Wiślanego*, Stempniewicz L. (ed.), Uniwersytet Gdański, Akademia Rolniczo-Techniczna w Olsztynie, Morski Instytut Rybacki w Gdynia, Raport, 2, 1-7

Własow T., Gomułka P., Dzika E., 1994, *Nematodes* Anguillicola crassus *and* Daniconema anguillae *in swim-bladder of eel from selected water-bodies of Toruń District*, XVII Congress of the Polish Parasitological Society, September, Poland. Biul. Met. Org., 27, 51

Würtz J., Taraschewski H., 2000, Histopathological changes in the swimbladder wall of the European eel *Anguilla anguilla* due to infections with *Anguillicola crassu,* Dis. Aquat. Org., 39, 121-134

Zaostrovceva S.K., 1993, *Ekologo-faunisticheskij obzor gelmintofauny ryb Kaliningradskogo Zaliva,* Nauchno-tekhnicheskaja Konferencija Professorsko-Prepodavatel'skogo Sostava, Aspirantov i Sotrudnikov Kaliningradskogo Tekhnicheskogo Instituta Rybnoj Promyshlennosti i Khozjajstva, Tezisy dokladov, 18