A C T A I C H T H Y O L O G I C A E T P I S C A T O R I A
Vol. XXXII, Fasc. 2 2002

ON THE ROLE OF PARATENIC HOSTS IN THE LIFE CYCLE OF THE NEMATODE *ANGUILLICOLA CRASSUS* IN THE VISTULA LAGOON, POLAND

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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 (2): 109–116.

Anguillicola crassus is an Asian nematode accidentally introduced to Europe and parasitising the swim bladder of European eels. Planktonic copepods are the major intermediate hosts but the success of this parasites depends on small fishes, acting as paratenic hosts and transmitting the nematode to eels. The role played by cyprinids and percids in the life cycle of *A. crassus* in the Vistula Lagoon was analysed. A total of 2398 fish specimens (1091 percids and 1307 cyprinids) were examined within December 1994–March 1997. The presence of the nematode was recorded in zander (*Sander lucioperca*), European perch (*Perca fluviatilis*), ruffe (*Gymnocephalus cernuus*), carp bream (*Abramis brama*), ziege (*Pelecus cultratus*), and roach (*Rutilus rutilus*), the ruffe being the most heavily infected fish species. The present findings advance our knowledge on the biology *A. crassus* and will help to predict its spread to other bodies of water.

Key words: parasite, fish, *Anguillicola crassus*, eel, *Anguilla anguilla*, paratenic host, *Gymnocephalus cernuus*, Poland, Vistula Lagoon

INTRODUCTION

Nematodes of the genus *Anguillicola* parasitise the swim bladder of eel. Among the five *Anguillicola* species described so far, two (*Anguillicola crassus* Kuwahara Niimi et Itagaki, 1974 and *Anguillicola novaezelandiae* Moravec et Taraschewski, 1988) have been found in Europe. They were brought to this continent with eels in the early 1980s. *A. novaezelandiae* has remained rare (Paggi et al. 1982, Moravec et al. 1994), while *A. crassus*, known earlier from East Asia, in a short time attacked natural populations of the European eel to become known, at present, almost throughout the continent (Neumann 1985, Peters and Hartmann 1986, Moravec and Taraschewski 1988, Belpaire et al. 1989a, b, Kennedy and Fitch 1990, Własow 1991, Rolbiecki et al. 2000).

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Although the parasite is harmless for its typical host (the Japanese eel, *Anguilla japonica*), while in the European eel its infection level attains higher parameters and induces deterioration of the fish condition and may even lead to the host's death (Hartmann 1987, Molnár 1993, Molnár et al. 1991).

The life cycle of *A. crassus* usually involves intermediate hosts, predominantly various copepod species, housing stage 3 larvae which infect the definitive host, i.e. the eel (De Charleroy et al. 1990, Kennedy and Fitch 1990, Petter et al. 1990). Paratenic (transport) hosts play an important role in the nematode's life cycle as well. They accumulate the parasites, thus increasing their potential for dispersal and infection of the eel. Such hosts are usually various fish species belonging to many families (Haenen and Van Banning 1990, Thomas and Ollevier 1992, Székely 1994). They are the principal source of infection for the large eels that are predominantly piscivorous.

The eel is one of the most commercially important fish species in the Vistula Lagoon. In addition, the lagoon is inhabited by 39 other fish species belonging to additional 16 families. The most abundant among them are cyprinids and percids, a food source for eel. For this reason, an attempt was made to investigate the role of those fishes as paratenic hosts in the life cycle of *A. crassus*.

MATERIAL AND METHODS

The fish obtained within the period of December 1994–March 1997 from fishermen operating in the Vistula Lagoon from a fishing harbour at Tolkmicko near Elbląg were examined.

A total of 2398 fish specimens belonging to two families and 16 species were examined. The sample consisted of 1091 fishes belonging to 3 percid species (390 × zander, *Sander lucioperca*, 6.5–72 cm; 371 × European perch, *Perca fluviatilis*, 11.7–31 cm; 330 × ruffe, *Gymnocephalus cernuus*, 6.5–18 cm) and 1307 fishes belonging to 13 cyprinid species (389 × roach, *Rutilus rutilus*, 10–32.5 cm; 376 × carp bream, *Abramis brama*, 9–59.2 cm; 322 × ziege, *Pelecus cultratus*, 15.5–44 cm; 101 × Prussian carp, *Carassius gibelio*, 10–33 cm; 39 × tench, *Tinca tinca*, 13.8–27 cm; 31 × white bream, *Abramis bjoerkna*, 20–32.2 cm; 29 × bleak, *Alburnus alburnus*, 11.5–15 cm; 7 × asp, *Aspius aspius*, 28–36.5 cm; 5 × Baltic vimba, *Vimba vimba*, 25–26 cm; 4 × rudd, *Scardinius erythrophthalmus*, 19–25 cm; 2 × common carp, *Cyprinus carpio*, 16 cm; 1 × common dace, *Leuciscus leuciscus*, 16 cm; 1 × ide, *Leuciscus idus*, 32 cm).

To detect the presence of the nematodes, temporary mounts were prepared from the intestinal wall, liver, spleen, swim bladder, and gonads. Some of the parasites collected were fixed in a 95 : 5 mixture of glacial acetic acid and formalin, cleared in lactophenol, and mounted in glycero-gelatin.

The ruffe were divided into several length classes. The division was based on the fish growth rate and the number of fish specimens examined.

RESULTS

The nematode was recorded in fishes of 6 species, the heaviest infection being typically observed in ruffe (Table 1). The parasites were located in the intestinal wall (80.4%), liver (14.8%), gonads (3.9%), and the swim bladder wall (0.9%).

The ruffe parasites revealed a seasonality in their occurrence and a correlation between the level of infection and fish length: the heaviest infection was observed in summer (Fig. 1), the fish smaller than 8 cm being most heavily infected (Fig. 2).

Table 1

The occurrence of L_3 *Anguillicola crassus* in cyprinids and percids in the Vistula Lagoon

Fish species	No. of larvae	Prevalence [%]	Mean int.	Relative density
Rutilus rutilus, roach	7	1.3	1.4	0.02
Abramis brama, carp bream	1	0.3	1	0.003
Pelecus cultratus, ziege	1	0.3	1	0.003
Carassius gibelio, Prussian carp	0	0	0	0
Tinca tinca, tench	0	0	0	0
Abramis bjoerkna, white bream	0	0	0	0
Alburnus alburnus, bleak	0	0	0	0
Aspius aspius, asp	0	0	0	0
Vimba vimba, Baltic vimba	0	0	0	0
Scardinius erythrophthalmus, rudd	0	0	0	0
Cyprinus carpio, common carp	0	0	0	0
Leuciscus leuciscus, common dace	0	0	0	0
Leuciscus idus, ide	0	0	0	0
Sander lucioperca, zander	1	0.3	1	0.003
Perca fluviatilis, European perch	2	0.5	1	0.005
Gymnocephalus cernuus, ruffe	320	11.8	8.2	1

The remaining infected fishes included: one ziege, measuring 18.5 cm; 5 roach, measuring 14–23 cm; one carp bream, 32 cm long; two perch specimens, measuring 12–17.5 cm; and one zander, 12 cm long.

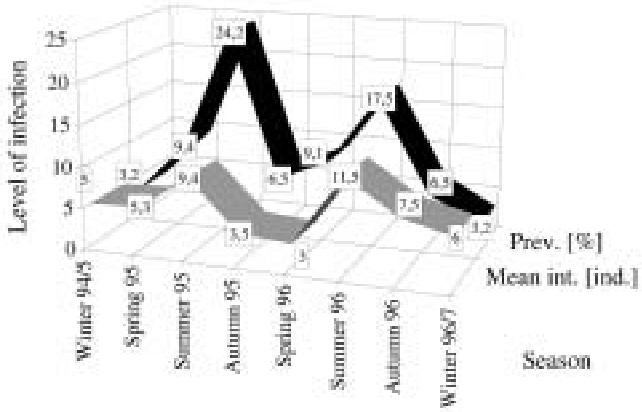

Fig. 1. Seasonality of infection of ruffe from the Vistula Lagoon with *Anguillicola crassus*

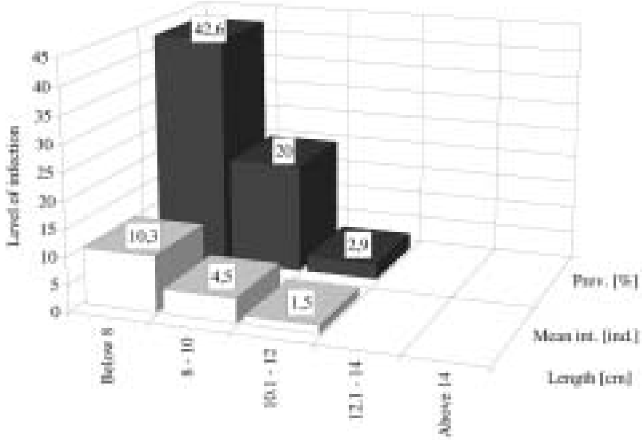

Fig. 2. Infection of ruffe with *Anguillicola crassus* in individual length classes

DISCUSSION

As shown by the present study, 6 cyprinid and percid species of the Vistula Lagoon fish fauna are paratenic hosts of *A. crassus* (Table 1). The third stage larvae of the nematode had earlier been recorded in the lagoon in the ruffe, perch, and zander (Rolbiecki et al. 1996, Własow et al. 1996, 1997, 1998). Those studies, however, involved examination of a lower number of fish specimens during a period as short as several months.

The ruffe is probably the most common paratenic host of *A. crassus*, as suggested by the high (even up to 100%) prevalence and the mean infection intensity exceeding 20 nematodes (Haenen and Van Banning 1990, Thomas and Ollevier 1992, Székely

1994). It proved the most heavily infected species in this study as well, although the infection parameters were relatively low. Such substantial differences in the extent of infection could have resulted from the fact that the Vistula Lagoon fish, compared to those in other European water bodies, were being infected by the parasite at a lower rate. Salinity seems to play a significant role in the occurrence of *A. crassus*, as fish dwelling in freshwater habitat were more affected by the nematode than those inhabiting mixo- and euhaline water bodies. The Vistula Lagoon is a brackish reservoir; over the period of study, the average salinity was 2.5‰ (according to the Institute of Meteorology and Water Management in Gdynia), while the salinity in freshwater habitats does not exceed 0.5‰ (Żmudziński and Pęczalska 1984).

The relationship between the ruffe infection level and season, points to the summer months (Fig. 1) as offering the most favourable thermal and ecological conditions (availability of infected crustaceans) for the *A. crassus* development. In the opinion of Thomas and Ollevier (1992), the paratenic hosts recruit most parasites in summer. On the other hand, the winter decline in the infection level is a result of autumn feeding of eel and stems also from the fact that copepods (intermediate hosts) are much less abundant in winter. Feeding of the definitive host, the eel, may be an important factor affecting the occurrence of *A. crassus* in the ruffe. Most eel appear in the Vistula Lagoon in autumn (Borowski and Dąbrowski 1996). In that season, *Anguilla anguilla* has to considerably reduce the population of infected ruffe which, as infected, may be an easy prey for the eel.

A clear-cut reverse correlation between the body length and degree of infection was observed in ruffe, the infection prevalence and mean intensity decreasing as the fish length increased (Fig. 2). The heaviest infection was recorded in the smallest ruffe, i.e. those measuring less than 8 cm. No nematodes were found in ruffe specimens longer than 12 cm. The L_3 larvae are restricted in their occurrence to the small fish only because, on the one hand, the small ruffe feeds predominantly on copepods, intermediate hosts of *A. crassus* (the adult ruffe feeds mainly on chironomids and *Asellus* spp. isopods) (Brylińska 1986); on the other hand, the already infected fish are eliminated by predators, including the eel.

Not all the infected hosts contribute to completing of the parasite’s life cycle. In the present study, the L_3 larvae were found in large (longer than 20 and even 30 cm) fish (roach, carp bream). When evaluating the role of a paratenic host, the feeding ecology of the definitive host should be taken into account. As it is only the larger eel that feed on fish, and select—as a rule—small individuals (Paulovits and Biró 1987), larger ones are a “dead end” in the life cycle of *A. crassus*.

The eel feeding selectivity is an important issue as well. This was pointed out by Székely (1994) who regarded the bleak as the major paratenic host of *A. crassus* in Lake Balaton, as that fish accounted for more than 90% of the eel diet there. As reported by Żelepień and Wilkońska (1995), the food of the Vistula Lagoon eel includes, in addition to invertebrates, also small fish, i.e. herring larvae, smelt (6–7 cm long), ruffe (5–6 cm), single specimens of zander, ziege, and goby. The likelihood that herring larvae will become infected is low because at that stage the fish take up very little food or do not feed at all. On the other hand, the ruffe—the species most infected among those examined and accounting for 30.8% of the eel diet (a mean value calculated from data collected over 5 months)—should be regarded as an important link in the *A. crassus* cycle in the Vistula Lagoon. In contrast, the role of smelt (37.8% of the eel food) as a paratenic host in the lagoon is not clear. The literature evidence allow to presume that the smelt can be a paratenic host for *A. crassus* (cf. Haenen and Van Banning 1990).

CONCLUSIONS

1. Among the Vistula Lagoon cyprinids and percids, the *Anguillicola crassus* stage three larvae were recorded in carp bream, ziege, roach, zander, European perch, and ruffe, the latter species being the principal paratenic host of the nematode.
2. The most favourable conditions for the parasite's development prevail in summer, which is evident by the highest level of infection in fish.
3. The level of infection in ruffe decreased with fish length. The heaviest infection (42.6%, 10.3 ind.) was recorded in the ruffe smaller than 8 cm.
4. It is most likely that more and more paratenic hosts will be acquired by the parasite, thereby increasing the proportion of infected eel in the lagoon. It should be added that paratenic hosts can transfer the parasite to other water bodies connecting with the Vistula Lagoon, and thus extend the distribution range of the parasite.

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Received: 12 June 2002
Accepted: 14 November 2002