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PARASITE COMMUNITY OF EUROPEAN EEL, *ANGUILLA ANGUILLA* (L.), IN THE RIVER ESTE, NORTHERN PORTUGAL

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ABSTRACT: Parasites of the European eel, *Anguilla anguilla* (L.) in a section of the river Este, northern Portugal, were studied monthly for two years. A total of seventeen species of parasites, seven protists (*Trypanosoma granulosum, Myxidium giardi, Myxobolus portucalensis, Zschokkella stettinensis, Hoferellus gilsoni, Ichthyophthirius multifiliis* and *Trichodina jadranica*) and ten metazoans (*Pseudodactylogyrus anguillae, P. bini, Bothriocephalus claviceps, Paraquimperia tenerrima, Cucullanus truttae, Pseudocapillaria tomentosa, Raphidascaris acus* larvae, *Anisakis simplex* larvae, *Acanthocephalus clavula* and *Ergasilus gibbus*), were detected. Almost all parasite species occurred throughout the year, but prevalences and abundances of *P. tenerrima* and *C. truttae* were highest in spring/summer and those of *Pseudodactylogyrus* spp. and *E. gibbus* were highest in autumn. This parasite community shares similar membership as well as similar seasonal dynamics with communities observed in other European eel populations. Differences in the community involved the commonness of *C. truttae* and the absence of *Acanthocephalus anguillae* and *A. lucii*.

KEY WORDS: European eel, *Anguilla anguilla*, parasite community, seasonality, Portugal.

INTRODUCTION

Few studies are available on parasites of European eels *Anguilla anguilla* in Portuguese freshwaters. Most have dealt with one parasite species (PELETEIRO & MARTINS MENDES, 1980; VENTURA & PAPERNA, 1984; EIRAS, 1988; AZEVEDO, LOM & CORRAL, 1989; SARAIVA & MOLNAR, 1990; CRUZ E SILVA, GRAZINA FREITAS & CARVALHO-VARELA, 1992); only three (CARVALHO VARELA *et al.*, 1984; SARAIVA & CHUBB, 1989; SARAIVA, 1994) provide information on the membership and structure of parasite communities. The present study describes the seasonal dynamics of the parasite community of eels caught in a section of the river Este, northern Portugal.

MATERIAL AND METHODS

Study area: The river Este is the last downstream tributary of the right margin of the river Ave (Fig. 1). Samples were obtained approximately 1 km upstream from the confluence with the river Ave and 5.5 km from the sea. The Ave catchment has an area of 1390 km^2 and is located at 41°15' - 41°40' N and 8°00' - 8°45' W. This catchment has an Atlantic-Mediterranean climate with a mean annual precipitation of 1800 mm and a mean annual sunlight of 2400 hours. Mean temperature in the warmest months (July-August) is 20° C and in the coldest months (December-January) is 7 to 8° C (LOUREIRO & MACHADO, 1986).

The river Ave fish community, excluding the estuary, is composed of eight fish species: brown trout (*Salmo trutta*), chub (*Leuciscus cephalus*), Iberian nase (*Chondrostoma polylepis*), barbel (*Barbus barbus bocagei*), eel (*Anguilla anguilla*), largemouth bass (*Micropterus salmoides*), spined loach (*Cobitis taenia*) and crucian carp (*Carassius carassius*).

The macroinvertebrate community is dominated by Chironomidae and Oligochaeta. There are some Ephemeroptera, Coleoptera and Mollusca (predominantly *Physa* sp.); Odonata and Hemiptera are scarce; Cladocera and Copepoda are very rare (MACHADO CRUZ *et al.*, 1989; SARAIVA, 1994).

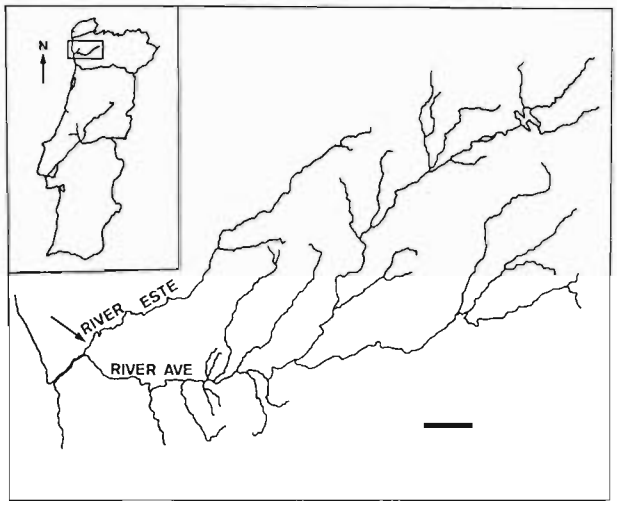

Fig. 1.– River Ave catchment showing the study site (arrow). Insert shows the location of river Ave catchment in Portugal. Scale bar = 5 km.

Sampling of parasites: Eels were examined monthly for parasites over a two-year period (January 1988 to December 1989). Whenever possible 15 specimens were collected each month; sampling was impossible in February and September 1988. A total of 290 eels were examined. Eels were caught by electric fishing and were transported alive to the laboratory where they were maintained in aerated containers before being examined as soon as possible. Recently killed eels were necropsied for parasites as outlined by BYLUND, FAGERHOLM & WILGREN (1980).

Data analysis: Ecological terms follow MARGOLIS *et al.* (1982). The significance of temporal changes in metazoan parasite prevalence and intensity in each year was tested by using the Kruskal-Wallis one-way analysis of variance by ranks. If significant differences were detected Mann-Whitney U-tests were employed (GRÉMY & SALMON, 1969; SIEGEL & CASTELLAN, 1988). The sta-

tistical analysis of the intensity of gill parasites showed that there were no significant differences between left and right gill arches. Therefore, the intensity of gill parasites was determined in left gills only. Prevalence and mean intensity of *P. anguillae* and *P. bini*, on the one hand, and *R. acus* and *A. simplex* larvae, on the other, were determined together. This was done because in the first samples *P. anguillae* and *P. bini* were identified only to genus level, while *R. acus* and *A. simplex* larvae were treated as anisakids as a whole.

RESULTS

Seventeen species of parasites were found, including seven protists [*Trypanosoma granulosum* Laveran et Mesnil, 1902; *Myxidium giardi* Cépède, 1882; *Myxobolus portucalensis* Saraiva et Molnár,1990; *Zschokkella stettinensis* Wierbicka, 1987; *Hoferellus gilsoni* (Debaiseux, 1925) Lom, Molnár et Dyková, 1986; *Ichthyophthirius multifiliis* Fouquet, 1876; and *Trichodina jadranica* Haider, 1964] and ten metazoans [*Pseudodactylogyrus anguillae* (Yin et Sproston, 1948) Gussev, 1965; *P. bini* (Kikuchi, 1929) Gussev, 1965; *Bothriocephalus claviceps* (Goeze, 1782) Rudolphi, 1809; *Paraquimperia tenerrima* (Linstow, 1878) Baylis, 1934; *Cucullanus truttae* Fabricius, 1794; *Pseudocapillaria tomentosa* (Dujardin, 1843) Freitas, 1959; *Raphidascaris acus* (Bloch, 1779) Railliet et Henry, 1915 larvae; *Anisakis simplex* (Rudolphi, 1809, det. Krabbe, 1878) larvae; *Acanthocephalus clavula* (Dujardin, 1845) Grabda-Kazsubska et Chubb, 1968; and *Ergasilus gibbus* von Nordmann, 1832].

The overall percentage of infected eels was 100% and the number of parasite species per eel varied between 1 and 9 species, with the majority (70%) infected with 3 (21,72%), 4 (24,14%) or 5 (24,14%) species.

Monthly prevalence values of protozoan species, prevalence of metazoan species and mean intensity are shown in Tables 1, 2 and 3 respectively.

Prevalence of *Pseudodactylogyrus* spp. was highest in November 1988 ($p<0,001$) and October 1989 ($p<0,05$) and lowest in April 1988 ($p<0,05$) and May 1989 ($p<0,01$) (Table 2). Intensity varied between 1 and 265 specimens and showed no significant seasonal change (Table 3).

Prevalence of *P. tenerrima* was highest in July 1988 ($p<0,01$) and May 1989 ($p=0,01$) (Table 2). The lowest prevalence was observed from September to December in both years (excluding November, 1989). Intensity varied between 1 and 20 specimens and showed no significant seasonal change (Table 3).

The prevalence of *C. truttae* in 1988 was highest in July ($p<0.05$). In 1989 the highest prevalences occurred in April and May ($p<0,01$ and $p<0,001$, respectively) (Table 2). Intensity varied between 1 and 36 specimens with no evident seasonal change (Table 3). The prevalence of E. gibbus was highest in September and October 1989 ($p<0,001$ in both months). No specimens were detected between February and May. Intensity varied between 1 and 179 with a significant increase in October 1989 ($p<0,001$) (Table 3)

No. eels	Year	Month	*Trypanosoma granulosum*	*Trichodina jadranica*	*Ichthyophthirius multifiliis*	*Myxidium giardi*[a]	*Myxidium giardi*[b]	*Hoferellus gilsoni*	*Zschokkella stettinensis*	*Myxobolus portucalensis*
11		JAN	90,9	9,1	27,3	100,0	63,6	ND[c]	ND	27,3
–		FEB								
15		MAR	86,7	6,7	6,7	86,7	66,7	ND	ND	66,7
15		APR	100,0	6,7	0,0	100,0	73,3	ND	ND	80,0
12		MAY	83,3	0,0	8,3	91,7	66,7	ND	ND	75,0
14	1988	JUN	100,0	7,1	0,0	100,0	64,3	ND	ND	35,7
6		JUL	100,0	33,3	0,0	100,0	50,0	ND	ND	100,0
15		AUG	100,0	60,0	0,0	100,0	60,0	ND	ND	33,3
–		SEP								
15		OCT	93,3	46,7	0,0	100,0	60,0	ND	ND	40,0
14		NOV	78,6	0,0	0,0	92,9	78,6	ND	ND	28,6
15		DEC	100,0	6,7	0,0	100,0	80,0	ND	ND	60,0
14		JAN	100,0	14,3	14,3	92,9	78,6	0,0	21,4	57,1
3		FEB	100,0	0,0	0,0	100,0	100,0	0,0	66,7	0,0
15		MAR	93,3	0,0	6,7	86,7	73,3	6,7	13,3	33,3
15		APR	93,3	0,0	20,0	100,0	40,0	40,0	40,0	53,3
15		MAY	100,0	33,3	20,0	93,3	40,0	66,7	33,3	6,7
14	1989	JUN	100,0	28,6	21,4	92,9	50,0	71,4	50,0	14,3
15		JUL	100,0	46,7	0,0	93,3	73,3	46,7	66,7	60,0
15		AUG	93,3	60,0	20,0	66,7	53,3	53,3	60,0	26,7
15		SEP	100,0	20,0	13,3	66,7	60,0	46,7	26,7	20,0
14		OCT	92,9	7,1	7,1	71,4	64,3	28,6	35,7	28,6
15		NOV	80,0	46,7	6,7	100,0	73,3	40,0	46,7	46,7
8		DEC	75,0	12,5	0,0	75,0	50,0	25,0	25,0	25,0

Table 1.– Prevalence (%) of protozoan species found in Anguilla anguilla in the river Este, Portugal. [a] = cysts from gills; [b] = cysts from organs other than gills; [c] = no data (ND).

Year	Month	*Pseudodactylogyrus* spp.	*Bothriocephalus claviceps*	*Paraquimperia tenerrima*	*Cucullanus truttae*	*Pseudocapillaria tomentosa*	Anisakid larvae	*Acanthocephalus clavula*	*Ergasilus gibbus*
	JAN	36,4	9,1	45,5	18,2	9,1	9,1	0,0	9,1
	FEB								
	MAR	26,7	6,7	20,0	0,0	0,0	0,0	0,0	13,3
	APR	6,7[c]	6,7	33,3	6,7	13,3	0,0	0,0	26,7
	MAY	25,0	16,7	25,0	33,3	0,0	0,0	0,0	8,3
1988	JUN	21,4	14,3	35,7	21,4	0,0	0,0	7,1	35,7
	JUL	33,3	16,7	83,3[b]	50,0[b]	0,0	0,0	0,0	16,7
	AUG	46,7	0,0	40,0	33,3	6,7	0,0	0,0	0,0
	SEP								
	OCT	26,7	6,7	6,7	0,0	0,0	0,0	0,0	40,0
	NOV	85,7[a]	7,1	7,1	14,3	0,0	7,1	0,0	21,4
	DEC	40,0	0,0	13,3	13,3	0,0	6,7	6,7	6,7
	JAN	42,9	14,3	21,4	0,0	0,0	0,0	0,0	14,3
	FEB	0,0	33,3	33,3	33,3	0,0,	0,0	0,0	0,0
	MAR	60,0	13,3	40,0	6,7	0,0	0,0	26,7	0,0
	APR	40,0	20,0	46,7	53,3[b]	6,7	0,0	46,7	0,0
	MAY	13,3[b]	13,3	60,0[b]	93,3[c]	6,7	6,7	0,0	0,0
1989	JUN	57,1	14,3	42,9	28,6	7,1	7,1	14,3	14,3
	JUL	40,0	20,0	33,3	20,0	0,0	0,0	0,0	20,0
	AUG	53,3	6,7	13,3	20,0	6,7	6,7	0,0	26,7
	SEP	33,3	6,7	0,0	13,3	6,7	0,0	0,0	66,7[a]
	OCT	78,6[c]	7,1	21,4	21,4	14,3	0,0	0,0	100,0[a]
	NOV	66,7	0,0	40,0	0,0	13,3	0,0	0,0	40,0
	DEC	62,5	12,5	12,5	0,0	0,0	0,0	0,0	50,0

Table 2.– Prevalence (%) of metazoan species found in *Anguilla anguilla* in the river Este, Portugal. [a]: $p \leq 0,001$; [b]: $p \leq 0,01$; [c]: $p \leq 0,05$.

Year Month	*Myxidium giardi*	*Myxobolus portucalensis*	*Pseudodactylogyrus* spp.	*Bothriocephalus claviceps*	*Paraquimperia tenerrima*	*Cucullanus truttae*	*Pseudocapillaria tomentosa*	Anisakid larvae	*Acanthocephalus clavula*	*Ergasilus gibbus*
1988										
JAN	49,1 ± 86,3	11,7 ± 18,5	1,0 ± 0	1,0 ± 0	2,0 ± 1,2	1,0 ± 0	1,0 ± 0	1,0 ± 0		1,0 ± 0
FEB										
MAR	11,9 ± 18,0	7,7 ± 8,0	2,5 ± 1,2	1,0 ± 0	2,7 ± 2,1					7,5 ± 7,8
APR	45,3 ± 64,2	14,9 ± 14,7	12,0 ± 0	1,0 ± 0	1,8 ± 0,8	1,0 ± 0	3,0 ± 1,4			6,0 ± 5,0
MAY	61,8 ± 136,5	5,2 ± 4,0	3,3 ± 2,5	1,0 ± 0	1,3 ± 0,6	1,5 ± 1,0				2,0 ± 0
JUN	57,6 ± 111,7	16,6 ± 16,2	2,3 ± 0,6	3,0 ± 2,8	1,8 ± 1,1	1,3 ± 0,6			1,0 ± 0	2,4 ± 1,9
JUL	70,8 ± 45,1	21,3 ± 32,3	18,5 ± 0,7	1,0 ± 0	1,4 ± 0,9	2,0 ± 1,0				1,0 ± 0
AUG	57,4 ± 47,7	20,6 ± 22,5	3,4 ± 2,6		2,0 ± 0,9	1,6 ± 0,9	1,0 ± 0			
SEP										
OCT	28,0 ± 29,6	14,2 ± 18,1	23,5 ± 45	1,0 ± 0	1,0 ± 0					1,5 ± 0,8
NOV	42,8 ± 61,0	13,8 ± 12,2	14,1 ± 20,1	1,0 ± 0	1,0 ± 0	2,5 ± 2,1		2,0 ± 0		3,0 ± 2,6
DEC	62,2 ± 96,5	6,7 ± 4,4	4,5 ± 4,7		1,5 ± 0,7	2,0 ± 0		1,0 ± 0	1,0 ± 0	1,0 ± 0
1989										
JAN	42,2 ± 56	14,0 ± 16,3	6,0 ± 8,6	1,0 ± 0	2,0 ± 1,7					3,0 ± 2,8
FEB	20,3 ± 5,68			1,0 ± 0	2,0 ± 0	1,0 ± 0				
MAR	34,5 ± 36,3	13,0 ± 12,5	5,4 ± 4,9	2,0 ± 1,4	6,8 ± 6,7	1,0 ± 0			15,0 ± 26,7	
APR	33,1 ± 52,8	30,4 ± 37,1	2,5 ± 2,1	1,0 ± 0	2,9 ± 2	6,5 ± 9	6,0 ± 0		7,9 ± 9,4	
MAY	23,3 ± 39,7	4,0 ± 0	1,5 ± 0,7	1,0 ± 0	3,1 ± 1,9	6,9 ± 9,4	1,0 ± 0	3,0 ± 0		
JUN	52,1 ± 61,5	26,0 ± 32,5	32,6 ± 68,4	1,5 ± 0,7	4,2 ± 3,5	7,5 ± 9,8	1,0 ± 0	1,0 ± 0	13,5 ± 17,7	4,0 ± 4,2
JUL	26,1 ± 34,2	8,3 ± 15,3	4,3 ± 1	1,0 ± 0	1,8 ± 0,4	1,7 ± 0,6				1,3 ± 0,6
AUG	29,1 ± 19,6	1,5 ± 1	58,9 ± 98,3	1,0 ± 0	3,5 ± 2,1	1,3 ± 0,6	3,0 ± 0	1,0 ± 0		3,5 ± 3,8
SEP	15,1 ± 10,4	1,7 ± 1,2	2,2 ± 1,6	1,0 ± 0		2,5 ± 0,7	2,0 ± 0			18,4 ± 26,0
OCT	15,5 ± 14,1	15,8 ± 13,1	4,4 ± 4,8	1,0 ± 0	3,3 ± 4,0	4,7 ± 3,2	2,0 ± 1,4			64,4 ± 65,8[a]
NOV	147,7 ± 39,1	23,6 ± 28	39,0 ± 69		1,5 ± 0,5		1,0 ± 0			6,5 ± 5,3
DEC	55,2 ± 71,9	5,0 ± 0	10,4 ± 12,1	1,0 ± 0	1,0 ± 0					17,0 ± 17,9

Table 3.– Mean intensity of parasite species (means ± standard deviation) found in *Anguilla anguilla* in the river Este, Portugal. [a]: $p \leq 0,001$.

Specimens of *A. clavula* were obtained in June and December 1988, and March, April and June 1989 only (Table 2).

All other metazoan species (*B. claviceps*, *P. tomentosa* and anisakid larvae) did not have significant changes in prevalence and intensity.

DISCUSSION

Most of the previous studies of the European eel parasites dealt with metazoan parasites or digestive tract helminths only. As far as we know only KØIE (1988), SARAIVA & CHUBB (1989), SARAIVA (1994), ORTS *et al.* (1995) OUTEIRAL, PERIS & SANMARTIN (1995) and GRACIA *et al.* (1995) carried out studies on European eel parasites, including protozoan, in particular habitats. In those studies species richness of protozoan parasites varied between 3 and 7 species.

In freshwater localities, species of metazoan parasites of European eels detected by most authors varied between 3 and 20 species, but mostly between 6 and 12, the nematodes being the group of parasites that usually contributed more to richness (SARAIVA, 1994). In our study we found similar results (10 metazoan species, five being nematodes).

Excluding *A. simplex* larvae, all other parasite species detected have previously been reported in *Anguilla anguilla*. The occurrence of *A. simplex*, a generalist parasite of marine fish, may indicate either that these eels acquired the infection during their estuarine glass eel phase, or that they continue to feed in estuarine waters. This larva has been detected in other freshwater/migratory fishes (BYKHOVSKAYA-PAVLOVSKAYA *et al.*; 1964; WOOTTEN & SMITH, 1975; MORAVEC, NAGASAVA & URAWA, 1985).

The present study reveals that the parasite community of eels in Portugal is similar to other European regions. Furthermore, the overall seasonal dynamics observed in individual species resemble those described by several authors for different locations (JEACOCK, 1968; CONNEELY & MCCARTHY, 1986; KOIE, 1988; NIE & KENNEDY, 1991, 1992). Nevertheless, some supply characteristics appear in Portuguese populations. For example, KENNEDY (1990) concluded that *C. truttae* was an accidental parasite of the European eel, yet the present study identifies *C. truttae* as a common parasite. This observation could be related with the occurrence of lamprey larvae, probably the natural reservoir or intermediate host of *C. truttae* (MORAVEC, 1976), in the river. Otherwise, scarcity of the acanthocephalan *A. clavula* seems to be related to localized scarcity of its intermediate host, *Proasellus meridianus*. Interestingly *Asellus aquaticus*, the intermediate host of *Acanthocephalus anguillae* and *A. lucii*, does not exist in the Iberian Peninsula (HENRY & MAGNIEZ, 1977), which explains the principle difference in membership absence of these acanthocephalans.

Finally the parasite transmission or capture of parasites from ichtyofauna had a minor effect on eel. Most of the parasites were eel specialists. Only the generalist *P. tomentosa* seems to occur because of the presence of the cyprinids fish, the dominant fish in the river.

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