

# Parasite community similarity between four Irish lakes

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## Abstract

A total of 140 trout were examined from four lakes in north west Ireland, Loughs Craghy, Waskel, Meela and Owennamarve. Eleven species of metazoan parasite were recorded, ten of which were of freshwater origin and *Anisakis* sp. was the only marine species. No acanthocephalan species were found. *Diphyllbothrium ditremum*, *D. dendriticum* and *Anisakis* sp. were the only allogenic species. Lough Owennamarve had the largest component community with nine species recorded. Lough Meela, the only brackish water lake had the smallest component community with six species recorded. Lough Waskel and Craghy had intermediate component community values. Lough Meela showed the lowest levels of similarity to any of the other lakes. Values for the Shannon-Wiener diversity index were highest for Lough Owennamarve and lowest for Lough Meela and intermediate for the other two lakes. Lough Meela had the highest values for the Simpson's dominance index and the Berger-Parker index. Lough Owennamarve had the highest Brillouin's index and Lough Meela had the lowest. The use of multiple regression techniques to control for the potentially confounding effect of geographical distance as a predictor of community similarity was discussed. No parasite species found could be considered as regionally and locally abundant and therefore described as a core species. The helminth community appears to have some degree of predictability, but chance colonization events are also important.

## Introduction

The patterns of occurrence of freshwater fish parasites has received considerable attention over the last number of years (Kennedy, 1978a,b; Bailey & Margolis, 1987; Esch *et al.*, 1988; Marcogliese & Cone 1991; Hartvigsen & Halvorsen, 1993; Hartvigsen & Kennedy, 1993). It is apparent from these studies that two differing theories exist on the occurrence and predictability of parasite communities in freshwater fish. Kennedy (1978b) examined the distribution and zoogeographical characteristics of the parasite fauna of char *Salvelinus alpinus* from Arctic Norway, Bear Island and Jan Mayen Island and found parasite communities with low diversity dominated by one species whose identity changed from one location to

another. He concluded that there was no pattern in the occurrence or predictability of parasites and that the composition of the parasite community was the result of stochastic events and chance colonization. In contrast, Hartvigsen & Halvorsen (1993) examined the parasites of brown trout from a number of closely located lakes in North Norway. They identified common species which were locally abundant and regionally widespread, and rare species which were regionally and locally scarce and concluded that the parasite community had some degree of predictability. More recently Poulin & Morand (1999) using multiple regressions of one or more independent variable over one dependent variable demonstrated the importance of closeness between localities in explaining parasite species communities, and hence predictability. They suggest that geographical distances between lakes are likely to mask the effects of other variables, and over time are likely to become the best predictors of parasite

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community similarity in fish populations. They suggest that in order to account for this we must try to control for the confounding effect of geographical distances.

The principle aim of this study was to assess the patterns of occurrence and similarities of parasite communities in trout between four lakes in north west Ireland. The analytical methodology adopted was based upon that of Kennedy *et al.* (1997) who compared the structure of helminth communities in eels from four coastal lagoons in Italy. A particular focus of the present study was to assess whether common species were contributing a degree of predictability to the parasite community or whether the parasite community was a result of chance colonization.

### Materials and methods

The study site is a geographically distinct group of lakes called the Rosses, located in north west Ireland. The area consists of large expanses of Atlantic blanket peat overlying an undulating mass of weathered igneous rocks. Lakes have formed in the hollows of these undulations. Samples of fish were taken from four lakes which range in size from 5 to 54 ha and contain resident brown trout and migratory sea trout in various proportions. The characteristics of the lakes are described in table 1. The smallest lake, Lough Owennamarve, although only 5 ha in area is part of a complex of lakes which are drained by the Owennamarve river. The sea trout fishery is particularly important in Lough Meela, formerly a brackish or saltwater lake containing marine algae, mysid shrimps and mullet. Installation of a one way swinging sluice gate which partially closes during incoming tides has lessened the marine influence on the lake. However, the continued presence of large number of flounder and mysid shrimp indicate that some tidal influence still persists. Samples of trout were taken from each lake on one occasion only between February and March 1997 using a collection of gill nets of light monofilament mesh with 1-inch stretch diameter. A single 1 inch sinking gill net was set in deep water to fish from the lake bottom to 3 m above it, and a pair of floating gill nets were set perpendicular to the shore in shallow bays to fish the surface 3 m of water. Fish were transported back to the laboratory and frozen before examination.

Fish were defrosted at room temperature and the general condition of the fish and any external lesions were noted. Viscera were removed and washed in 0.9% saline solution, the rinse was kept and separately examined for

parasites. The gills, eyes, liver, heart, spleen, gonads and swimbladder were examined for parasites. All parasites were preserved in 70% alcohol. For identification, parasites were first cleared in lactophenol and where necessary were stained with polyvinyl acetate and lignin pink.

The helminth community structure was examined at both infra and component community levels. The measures of component community richness used were percentage prevalence, mean abundance and mean intensity, all calculated according to Bush *et al.* (1997). The Shannon-Wiener index, Shannon-Wiener evenness, Simpson's Dominance index and Berger-Parker index were also calculated.

The measures of infracommunity richness used were mean number of species, mean number of individuals, maximum number of species per fish and Brillouin's index which was calculated for all fish and for infected fish only. Similarities between lakes were measured using Sorenson's index at the component level. All indices used were as defined and calculated in Magurran (1988). Analyses were carried out on total helminth communities.

### Results

#### *Composition of communities*

Summary data on the composition of the parasite community of trout from the four lakes is presented in table 2. A total of 11 species were recovered, ten species were helminths and one species, *Salmincola salmoneus*, was a copepod. No acanthocephalan species were recorded. The nematode *Anisakis* sp. was of marine origin. *Anisakis* sp. and the cestodes *Diphyllobothrium dendriticum* and *D. ditremum* are allogenic and mature in vertebrate hosts other than fish. Five species (*Crepidostomum metoecus*, *C. farionis*, *D. dendriticum*, *Eubothrium crassum* and *Raphidascaris acus*) were common to all lakes. *Diphyllobothrium ditremum* and *Discocotyle sagittata* were present in three lakes. *Anisakis* sp. was present in two lakes, and three species (*Cystidicoloides tenuissima*, *Cystidicola farionis* and *Salmincola salmoneus*) were present in one lake. The distance between each lake in the study and the other three lakes in the study are indicated in table 3. The nearest lake on the map is also indicated in this table. The largest distance between any two lakes in this study was 21 km, between Loughs Waskel and Owennamarve. The shortest distance between any two lakes in this study was 2 km, between Loughs Meela and

Table 1. Summary characteristics of the four sample lakes.

	Craghy	Waskel	Meela	Owennamarve
Lake status	Freshwater	Freshwater	Brackish	Freshwater
Area (ha)	46	32.4	54	5
Altitude (m.a.s.)	14	3	3	48
Nearest lake (km)	7	2	2	7
pH	6.19	6.29	6.61	6.32
Alkalinity (mg CaCO <sub>3</sub> l <sup>-1</sup> )	1.43	1.89	1.89	1.01
No. of trout examined	40	32	45	23
% Migratory trout in sample	32.5	18.8	2.2	Not available
No. of parasite species	8	8	6	9

Table 2. Component community data for the parasites of trout in the four sample lakes.

Parasites	Site	Craghy			Waskel			Meela			Owennamarve		
		%	A	I	%	A	I	%	A	I	%	A	I
<i>Crepidostomum metoecus</i>	IN	50	8.65 (33)	17.3 (45.6)	81.3	23.56 (32.9)	29 (34.3)	6.7	0.13 (0.6)	2 (1.7)	17.4	5.65 (14.8)	32.5 (21.22)
<i>C. farionis</i>	IN	12.5	0.98 (3.5)	78 (7.5)	37.5	1.81 (3.1)	4.8 (3.2)	2.2	0.04 (0.3)	2	56.5	11.35 (22)	20.07 (26.5)
<i>Diphyllobothrium dendriticum</i>	V	22.5	1.6 (5.2)	10.6 (9.6)	18.8	1.53 (3.9)	8.16 (5.3)	2.2	0.04 (0.3)	2	69.6	27.86 (36.7)	40.06 (38.1)
<i>D. ditremum</i>	V	47.5	14.92 (26.8)	31.42 (31.8)	31.3	4.71 (11.2)	15.1 (16.1)	24.4	0.42 (0.8)	1.73 (0.8)	0	0	0
<i>Eubothrium crassum</i>	IN	60	2 (2.4)	3.3 (2.3)	3.1	0.09 (0.5)	3	73.3	2.66 (2.77)	3.63 (2.6)	73.9	1.91 (2.2)	2.59 (2.1)
<i>Raphidascaris acus</i>	IN	2.5	0.65 (4.1)	26	21.9	0.78 (1.9)	3.57 (2.8)	6.7	0.31 (1.3)	4.66 (2.5)	17.4	1.26 (5.4)	7.25 (12.5)
<i>Cystidicola farionis</i>	S	0	0	0	0	0	0	0	0	0	8.7	0.17 (0.7)	2 (1.4)
<i>Anisakis</i> sp.	SB	0	0	0	9.4	0.5 (1.7)	5.33 (2.5)	0	0	0	0	0	0
<i>Discocotyle sagittata</i>	IN	12.5	0.48 (1.7)	3.8 (3.6)	0	0	0	0	0	0	8.67	0.09 (0.3)	1
<i>Salmincola salmoneus</i>	G	5	0.18 (1)	3.5 (3.5)	12.5	0.34 (1.1)	2.75 (1.7)	0	0	0	43.5	0.93 (1.3)	2.1 (1.1)
	G	0	0	0	0	0	0	0	0	0	17.4	0.3 (0.9)	1.75 (1.5)

IN, intestine; V, viscera; S, swimbladder; SB, swimbladder; G, gills; %, prevalence; A, mean abundance ( $\pm$  S.D.); I, mean intensity ( $\pm$  S.D.).

Table 3. Matrix of the distances measured in km, of each lake from the other three lakes in this study, and also the nearest lake on the map (presented in italics along the diagonal).

	Craghy	Waskel	Meela	Owennamarve
Craghy	<i>500 m</i>	11	7	7
Waskel		<i>700 m</i>	2	21
Meela			<i>1 km</i>	18
Owennamarve				<i>500 m</i>

Waskel. Lough Craghy lies approximately half-way between Lough Owennamarve and Loughs Meela and Waskel. At the component community level, using Sorenson's index of similarity, Lough Meela was the lake which showed the lowest levels of similarity to any of the other lakes (table 4). Loughs Craghy, Waskel and Owennamarve showed a high degree of similarity to each other.

#### Component community structure

Nine species were found in Lough Owennamarve, the smallest lake. This lake also had the highest Shannon-Wiener diversity value (table 5). Shannon-Wiener diversity values for Loughs Craghy and Waskel were similar, but were substantially lower for Lough Meela. Evenness values were highest for Lough Meela, lowest for Lough Owennamarve and intermediate for Loughs Craghy and Waskel. The Simpson's dominance index and the Berger-Parker index are in broad agreement, with the highest values reported for Lough Meela. This corresponds with the lakes low diversity index, and is probably related to the low mean parasite abundance and mean species richness values. Loughs Craghy and Owennamarve had similar values for the Berger-Parker Index, they were lower than the values reported for Loughs Waskel and Meela. Simpson's dominance index showed almost identical values for Loughs Craghy, Waskel and Owennamarve that were lower than the value for Lough Meela. *Eubothrium crassum* has the highest prevalence in three lakes, and the highest mean abundance in Lough Meela. *Diphyllobothrium ditremum* had the highest mean abundance in Lough Craghy and Lough Owennamarve, and *Crepidostomum farionis* dominated in Lough Waskel (table 2).

#### Infracommunity structure

A total of 16 trout harboured no metazoan parasites, the remainder harboured between two and four species. Lough Owennamarve had the highest mean species richness and mean number of individuals, Lough Meela

Table 4. Sorenson's index of similarity indices between the four lakes at the component community level.

	Craghy	Waskel	Meela	Owennamarve
Craghy	*	0.95	0.24	0.98
Waskel		*	0.27	0.97
Meela			*	0.25
Owennamarve				*

Table 5. Dominance and diversity indices for the helminth communities of trout from the four lakes.

	Craghy	Waskel	Meela	Owennamarve
Shannon-Wiener Index	0.49	0.51	0.23	0.6
Shannon-Wiener Evenness	0.69	0.67	0.85	0.57
Simpson's Dominance Index	0.71	0.7	0.85	0.67
Berger-Parker Index	0.51	0.71	0.74	0.56

had the lowest (table 6). Lough Craghy and Waskel had similar intermediate values. Brillouin's index was calculated for all fish in each lake and for infected fish only. Lough Owennamarve had the highest Brillouin's index, Lough Meela had the lowest index, Lough Craghy and Lough Waskel had similar intermediate values (table 5). As only a small proportion of fish from three lakes and none from Lough Owennamarve were uninfected, the Brillouin's index for all fish did not differ significantly from the Brillouin's index for infected fish only.

### Discussion

The parasite community was dominated by autogenic species. This finding is in agreement with other studies on the parasite communities of trout (Esch *et al.*, 1988; Molloy *et al.*, 1993; Byrne *et al.*, 1999). *Anisakis* sp. was the only marine parasite species found. It occurred in Lough Craghy and Lough Owennamarve, both of which have a migratory trout component. Conneely & McCarthy (1988) also recorded *Anisakis* sp. from trout in a freshwater lake in the west of Ireland. The occurrence of this species whose adults are parasites of marine mammals is evidence that trout have spent time at sea. It was interesting to note that no acanthocephalan species were recorded from any lake in this study. Molloy *et al.* (1993) recorded acanthocephalans from resident and migratory trout in the west of Ireland and Conneely & McCarthy (1988) recorded acanthocephalans from resident trout in the west of Ireland.

There is a tendency for a negative relationship between lake size, altitude and the number of species of trout parasites, but in all cases relationships were not significant. This is contrary to the findings of Kennedy (1978a) and Hartvigsen & Halvorsen (1993).

Multivariate analysis on the determinants of community richness and similarity of composition was performed using permutations of distance matrices. The method used was described in Poulin & Morand (1999). Multiple regressions of two independent variables over one dependent variable were performed on the values in the matrices, and repeated for 999 random permutations of the dependent variable matrix. Partial regression

coefficients were obtained for each independent variable and their significance tested. A backward elimination procedure was then used to identify the independent variable that contributed significantly to the explanation of the dependent variable. The independent variable whose partial regression coefficient had the highest *P* value was dropped (provided that it was equal to, or greater than 0.100). As there were only two independent variables in each analysis, the regression was repeated on the remaining variable to assess whether its contribution to the explanation of the dependent variable was significant. The results of the multivariate analysis were inconclusive for this study. One of the limitations of this multivariate approach is that the number of lakes studied must be greater than the number of variables in the analysis, otherwise there are not enough degrees of freedom to test for relationships (Poulin & Morand, 1999). In this study there were four lakes, which allowed a maximum of three variables to be tested. As it was not possible to test all independent variables (lake altitude, lake area, geographical distance) against the one dependent variable (either species richness or similarity between pairs of lakes using Sorenson's index of similarity) simultaneously, the data could not be satisfactorily analysed using permutation of distance matrices. Therefore it was not possible to control for the possible confounding effect of geographical distance as a predictor of community similarity in this case.

Lough Owennamarve, the smallest lake at the highest altitude, had the largest component community, with eight freshwater and one marine species found. This lake is part of a system of 12 lakes which are drained by the Owennamarve river. It is likely that trout move freely between the various lakes along the river, therefore we feel it would be more accurate to group all of the lakes in this system together as one unit, the Owennamarve system. The Owennamarve system has a combined area greater than Lough Meela.

Lough Meela has both resident brown trout and a large population of sea trout. Only six freshwater parasite species were found. It is significant that the lake with the largest sea trout fishery only had freshwater parasite species, and the poorest parasite component community.

Table 6. Infracommunity parameters for the parasites of trout in the four sample lakes.

	Craghy	Waskel	Meela	Owennamarve
Mean species richness (S.D.)	2 (1.3)	2.2 (1.4)	1.2 (0.77)	3.1 (1.5)
Max species per fish	3	3	2	4
Mean no. individuals (S.D.)	29.5 (43.9)	33.3 (42.2)	3.6 (3.7)	49.5 (40.4)
Brillouin's index (S.D.)	0.38 (0.4)	0.38 (0.37)	0.14 (0.32)	0.48 (0.32)
BI for infected fish only (S.D.)	0.41 (0.4)	0.43 (0.36)	0.16 (0.35)	0.48 (0.32)



The brackish water status of this lake could mean that many entirely freshwater species such as *Discocotyle sagittata* could not survive there. All of the fish caught in Lough Meela were either resident brown trout or pre-smolts, trout which were preparing to go to sea for the first time. Molloy *et al.* (1993) showed that sea trout kelts (those which had previously been to sea) had the richest component community. As the pre-smolts had not yet migrated they could not have developed such a rich component community, this also explains the lack of marine parasite species. Kennedy *et al.* (1997) demonstrated that as the salinity of a lake increased the parasite fauna of eels changed from freshwater species to marine species at the component community level. Trout in Lough Meela appear to be undergoing a similar process, the number of freshwater species being reduced but not yet replaced by marine species. The component communities of Lough Craghy and Lough Waskel represent intermediate positions between the communities of Lough Meela and the Owennamarve system. Diversity values were very similar for three lakes. Lough Meela had the lowest range of values and Owennamarve had the highest. Values for the Berger-Parker dominance index ranged from 0.51 to 0.74 and are comparable with those of Esch *et al.* (1988).

At the infracommunity level, the difference between Lough Meela and the other lakes persists, all infracommunity parameters examined were lower for Lough Meela. Similarity values for Lough Meela with other lakes range from 0.24 to 0.27, compared with similarity values which range between 0.95 and 0.98 for the other lakes. Values for mean species richness and mean number of individuals for Loughs Craghy, Waskel, and Owennamarve are comparable with those reported by Byrne *et al.* (1999) for sea trout from the west coast of Ireland, whereas values for Lough Meela are more comparable with those of Molloy *et al.* (1995) for resident brown trout from the west of Ireland. Brillouin's index ranged from 0.14 to 0.48, and for infected trout only from 0.16 to 0.48. These values are significantly higher than those reported by Molloy *et al.* (1995) for brown trout yet similar to those reported by Byrne *et al.* (1999) for sea trout.

Five species were found in all lakes, two species were found in three lakes, one species was found in two lakes and three species were found in one lake only. The regionally rare species were rarely as abundant as the regionally common species, although in Lough Waskel *Cystidicola farionis* had a higher abundance value than *Eubothrium crassum*, a regionally common species. No species could be defined as a core species, both regionally widespread and locally abundant, whereas *Crepidostomum farionis*, *C. metoecus*, *Diphyllobothrium dentriticum*, *Eubothrium crassum* and *Raphidascaris acus* were intermediate, being regionally widespread but not locally abundant.

In conclusion it appears that there is a degree of predictability to the parasite community of trout from north-west Ireland, but chance colonization plays a role in structuring the helminth community. Five of the 11 species found were regionally common but not locally

abundant, and four species were regionally and locally rare, and none could be considered as core species.

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