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A PRELIMINARY COMPARISON OF THE SPECIFIC COMPOSITION OF THE PARASITE FAUNA OF THE FISH OF LLYN PADARN, CAERNARVONSHIRE, AN OLIGOTHROPHIC LAKE, AND LLYN TEGID (BALA LAKE), MERIONETSHIRE, A LATE OLIGOTHROPHIC OR ERALY MESOTROPHIC LAKE

by

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As was shown by Professor W. L. Wiśniewski and his colleagues in 1958 it is possible to characterise the parasite fauna of lakes. Some of the factors involved in such characterizations were discussed by Chubb (1963); it was suggested that as a free living animal is dependent on the external environment, so a species of parasite is additionally dependent upon the presence of the range of species of hosts it is able to enter, survive and reproduce in. This was regarded as the most important factor which will determine the distribution of parasites. In other words, the host specificity of a parasite at all stages of its life cycle will tend to determine its distribution. Thus, owing to the development of a high degree of host specificity by many species of parasites, if a species of host is regarded as typical for an environment, then its associated parasites may also be regarded as typical for this same environment.

At the present time in the British Isles the parasite faunas of a very limited number of freshwater habitats have been investigated. It is not possible therefore to arrive at a really definite solution to the problem of the characterization of the parasite faunas. Currently several investigations are in progress at Liverpool: Dr J. B. E. Awachie of Nigeria has completed a very thorough investigation of the parasites of a small trout stream, the Afon Terrig, Wales, and his observations are in process of publication. Mr. S. S. H. Rizvi of Pakistan

is working on the parasite fauna of fish of Rostherne Mere, England, and eutrophic lake, whilst Miss E. H. Davies is working on the parasites of the fish of the river Wye, England. Mrs. A. M. Powell and I are working on the parasites of the fish of Llyn Padarn, an oligotrophic lake in North Wales, and I propose to present our preliminary findings on the specific composition of the parasite fauna of this lake, and compare them with previous observations made on Llyn Tegid (Chubb, 1963). It should be noted that these observations are preliminary, and may be subject to additions in the future; the completed investigation will be reported in full elswhere.

TABLE 1

A comparison of the features of Llyn Padarn and Llyn Tegid

Item	Llyn Padarn	Llyn Tegid
Geographical location	North Wales, 9 km from Caernarvon	Mid-Wales, 1 km from Bala
Size of lake	3 km by 4 km	6 km by 1 km
Depht of lake	maximum 30 m	much of lake 20 to 40 m
Water supply	fed by small mountain streams from rocky valley	fed by small mountain streams from sheep pasture
Lake bottom	rocky shores, mud bottom	rocky and muddy shores, mud bottom
Vegetation	sparse, submerged	sparse, submerged
Zones in lake	littoral sub-littoral profundal	littoral sub-littoral profundal
Character of lake	oligotrophic	late oligotrophic or early mesotrophic
Fish fauna (dominant)	*Salmonidae*	*Salmonidae* and coarse fish
Source of data	Powell and Chubb, investigation in progress	Dunn, 1961 Chubb, 1963

Llyn Padarn (Table 1) is an oligotrophic lake at the foot of the Snowdonia range of mountains in North Wales. The lake is 3 km long by 4 km wide, and has a maximum depth of about 30 m. Small mountain streams feed the lake with water collected from bare rock slopes and mountain grassland. The dominant fish species are the trout *Salmo trutta* and the Welsh char *Salvelinus alpinus perisii.*

Llyn Tegid (Table 1) is a late oligotrophic or early mesotrophic lake in mid-Wales, about 45 km from the west coast. The lake

is 6 km long and 1 km wide, with a maximum depth of 40 m. The streams flowing into the lake originate on mountain sheep pasture. The dominant fish species are trout *Salmo trutta*, gwyniad, a species of whitefish *Coregonus clupeoides pennantii*, grayling *Thymallus thymallus*, pike *Esox lucius*, roach *Rutilus rutilus* and perch *Perca fluviatilis*. The mixed populations of salmonoid and coarse fishes are characteristic of a lake in an intermediate phase, although Dunn (1961) described Llyn Tegid as an oligotrophic lake. On the basis

TABLE 2

The species of fish found in Llyn Padarn and Llyn Tegid

Fish species	Family	Occurrence	
		Llyn Padarn	Llyn Tegid
Salmo salar L.	*Salmonidae*	p	p
Salmo trutta L.		p	p
Salvelinus alpinus perisii (Günther)		p	—
Coregonus clupeoides pennantii Cuv. et Val.		—	p
Thymallus thymallus (L.)	*Thymallidae*	—	p
Esox lucius L.	*Esocidae*	—	p
Gobio gobio (L.)	*Cyprinidae*	—	p
Phoxinus phoxinus (L.)		p	p
Rutilus rutilus (L.)		—	p
Nemacheilus barbatula (L.)	*Cobitidae*	—	p
Anguilla anguilla (L.)	*Anguillidae*	p	p
Perca fluviatilis L.	*Percidae*	—	p
Cottus gobio L.	*Cottidae*	—	p
Gasterosteus aculeatus L.	*Gasterosteidae*	p	—
Lampetra planeri (Bloch)	*Petromyzonidae*	p	p
Total number of species		7	13

of the aquatic vegetation the lake may be regarded as being in a mesotrophic condition (Pearsall, 1921).

The characteristic features of the two lakes are given in Table 1, whilst Table 2 compares the fish faunas. From Table 2 it may be seen that the lakes are similar in possessing salmonoid species, but in addition Llyn Tegid has the coarse fish species, pike, roach and perch, more characteristic of eutrophic waters.

Table 3 compares the over-all composition of the parasite fauna of the lakes. It may be seen that in general terms there is a remarkable similarity. The following exceptions may be noted: no *Myxosporidia* have so far been found in Llyn Padarn; the percentage representation of adult *Digenea* in Llyn Tegid is lower than in Llyn

TABLE 3

A comparison of the prasite fuana of the fish of Llyn Padarn and Llyn Tegid

Parasite group	Species							
	Llyn Padarn				Llyn Tegid			
	Adult		Larval		Adult		Larval	
	No.	%	No.	%	No.	%	No.	%
Myxosporidia	0	0	0	0	2	6.6	0	0
Monogenea	2	11.7	0	0	4	13.3	0	0
Digenea	4	23.5	1	5.9	4	13.3	0	0
Cestoda	3	17.6	3	17.6	5	16.6	4	13.3
Nematoda	1	5.9	1	5.9	6	20.0	0	0
Acanthocephala	2	11.7	0	0	3	10.0	0	0
Crustacea parasitica	0	0	0	0	2	6.6	0	0
Total	12	70.5	5	29.4	26	86.6	4	13.3
Total number of species	17				29			
Number of fish species examined	5				8			
Mean number of parasite species per fish species examined	3.4				3.6			
Data from	Powell and Chubb, investigation in progress				Chubb, 1963 and unpublished data			

Note: *Triaenophorus nodulosus* was found as larva and adult in Llyn Tegid and is shown separately in each column, but is counted as one species for the total number of species occurring in the lake.

Padarn, and the representation of *Nematoda* higher in Llyn Tegid. The reasons for these differences are not known. However, it is the similarity which is noteworthy, rather than the differences. The mean number of parasite species per fish species examined is close in each case, Llyn Padarn 3.4, Llyn Tegid 3.6.

Tables 4 to 11 give comparative data for the occurrence and

TABLE 4

Myxosporidia of the fish of Llyn Padarn and Llyn Tegid

Parasite species	Occurrence	
	Llyn Pedarn	Llyn Tegid
Henneguya psorospermica Thelohan, 1895	—	*Esox lucius* *Perca fluviatilis*
Henneguya tegidiensis Nicholas et Jones, 1959	—	*Coregonus clupeoides pennantii*
Data from	Powell and Chubb, investigation in progress	Chubb, 1963

host specificity of the parasites in the two lakes. The following points deserve mention:

1. Table 4, *Myxosporidia*. No species of *Myxosporidia* have so far been found in Llyn Padarn.

TABLE 5

Monogenea of the fish of Llyn Padarn and Llyn Tegid

Parasite species	Occurrence	
	Llyn Padarn	Llyn Tegid
Gyrodactylus sp.	*Gasterosteus aculeatus*	—
Tetraonchus monenteron (Wagener, 1857)	—	*Esox lucius*
Ancyrocephalus paradoxus (Creplin, 1839)	—	*Perca fluviatilis*
Discocotyle sagittata (Leuckart, 1842)	*Salmo trutta*	*Salmo trutta*
		Coregonus clupeoides pennantii
		Thymallus thymallus
Diplozoon paradoxum Nordmann, 1832	—	*Rutilus rutilus*
Data from	Powell and Chubb, investigation in progress	Chubb, 1963 and unpublished data

TABLE 6

Adult *Digenea* of the fish of Llyn Padarn and Llyn Tegid

Parasite species	Occurrence	
	Llyn Padarn	Llyn Tegid
Allocreadium isoporum (Looss, 1894)	*Phoxinus phoxinus*	—
Crepidostomum metoecus (Braun, 1900)	*Salmo trutta*	*Salmo trutta*
		Thymalus thymallus
Crepidostomum farionis (Müller, 1784)	*Salmo trutta*	*Thymalus thymallus*
Bunodera lucioperca (Müller, 1776)	—	*Perca fluviatilis*
Phyllodistomum folium (Olfers, 1816)	*Salmo trutta*	*Coregonus clupeoides pennantii*
	Salvelinus alpinus perisii	
	Phoxinus phoxinus	
	Gasterosteus aculeatus	
Data from	Powell and Chubb investigation in progress	Chubb, 1963 and unpublished data

2. Table 5, *Monogenea*. The species of *Monogenea* fall into two groups, *Discocotyle sagittata* associated with salmonoid fish, and *Tetraonchus monenteron, Ancyrocephalus paradoxus* and *Diplozoon paradoxum* associated with pike, perch and roach respectively, the coarse fish element.

3. Table 6, Adult *Digenea*. As with *Monogenea*, there is a division: *Crepidostomum metoecus* and *Crepidostomum farionis* are associated with salmonoid species, and *Bunodera lucioperca* with perch. *Allocreadium isoporum* and *Phyllodistomum folium* are also reported from eutropic waters (Kozicka, 1959).

4. Table 7, Adult *Cestoda*. *Proteocephalus* sp. of *Coregonus, Eubothrium salvelini* are specific to salmonoid fish, whilst *Caryophyllaeides fennica* and *Triaenophorus nodulosus* are associated with roach and pike respectively. *Bothriocephalus claviceps* is specific to the eel, as may also be the species of *Proteocephalus* found in the eel.

TABLE 7

Adult *Cestoda* of the fish of Llyn Padarn and Llyn Tegid

Parasite species	Occurrence	
	Llyn Padarn	Llyn Tegid
Proteocephalus sp.	—	*Coregonus clupeoides pennantii*
Proteocephalus sp.	*Anguilla anguilla*	*Anguilla anguilla*
Proteocephalus filicollis (Rudolphi, 1802)	*Gasterosteus aculeatus*	—
Caryophyllaeides fennica (Schneider, 1902)	—	*Rutilus rutilis*
Bothriocephalus claviceps (Goeze, 1782)	—	*Anguilla anguilla*
Triaenophorus nodulosus (Pallas, 1781)	—	*Esox lucius*
Eubothrium crassum (Bloch, 1779)	*Salmo trutta*	*Salmo salar* *Salmo trutta*
Eubothrium salvelini (Schrank, 1790)	*Salvelinus alpinus perisii*	—
Data from	Powell and Chubb, investigation in progress	Chubb, 1963 and unpublished data

5. Table 8, Larval *Cestoda*. The plerocercoids of the two species of *Diphyllobothrium* are associated with salmonoid fish, whilst *Ligula*

TABLE 8

Larval *Cestoda* of the fish of Llyn Padarn and Llyn Tegid

Parasite species	Occurrence	
	Llyn Padarn	Llyn Tegid
Schistocephalus solidus (Müller, 1776)	*Gasterosteus aculeatus*	—
Ligula intestinalis (L., 1758)	—	*Rutilus rutilus*
Diphyllobothrium sp. CC	*Salmo trutta* *Salvelinus alpinus perisii* *Gasterosteus aculeatus*	*Salmo trutta* *Coregonus clupeoides pennantii* *Thymallus thymallus*
Diphyllobothrium sp. N	*Salmo trutta* *Salvelinus alpinus perisii*	*Thymallus thymallus*
Triaenophorus nodulosus (Pallas, 1781)	—	*Perca fluviatilis* *Esox lucius*
Data from	Powell and Chubb investigation in progress	Chubb, 1963

intestinalis and *Triaenophorus nodulosus* are typical of roach and perch respectively.

6. Table 9, *Nematoda*. *Cystidicola farionis* is characteristic of salmonoid fish, and *Camallanus lacustris* is of the perch. *Raphidascaris cristata*, *Haplonema tenerrimum* and *Spinitectus inermis* are specific to the eel. *Cucullanus truttae* is normally associated with salmonoid fish, as in Llyn Padarn, but in Llyn Tegid is associated with the eel.

7. Table 10, *Acanthocephala*. The *Acanthocephala* infect a wide range of fish, especially in Llyn Tegid. Other evidence (see Chubb, 1964) suggests the invertebrate intermediate host may be an important limiting factor in the distribution of the *Acanthocephala*, rather than the definitive host.

8. Table 11, *Crustacea parasitica*. *Salmincola salmonea* may well occur in Llyn Padarn, for as yet salmon have not been examined. *Argulus coregoni* may also be present, as owing to its active mode of life, it may have been missed.

From the above Tables it may have been seen that the parasites tended to fall into two categories, those associated with the salmonoid fish species, and those associated with the coarse fish species, the pike, roach and perch. In addition the parasites of the eel tend to be separate.

TABLE 9

Nematoda of the fish of Llyn Padarn and Llyn Tegid

Parasite species	Occurrence	
	Llyn Padarn	Llyn Tegid
Raphidascaris cristata (v. Linstow, 1872)	—	*Perca fluviatilis*[1] *Anguilla anguilla*
Haplonema tenerrimum (v. Linstow, 1878)	—	*Anguilla anguilla*
Cystidicola farionis Fischer von Waldheim 1798	—	*Salmo trutta*
Cystidicola sp.	—	*Thymallus thymallus*
Spinitectus inermis (Zeder, 1800)	—	*Anguilla anguilla*
Camallanus lacustris (Zoega in Müller, 1776)	—	*Perca fluviatilis*
Cucullanus truttae Fabricius, 1794	*Salmo trutta*	*Esox lucius* *Anguilla anguilla*
Data from	Powell and Chubb, investigation in progress	Chubb, 1963

[1] as juvenile worms only

Tables 12, 13 and 14 compare the occurrence of the parasites of the *Salmonoidei*, the coarse fish species and the eel respectively in the two lakes. As may be noted from Table 12, 9 species of parasites occurred in the salmonoid fish of the two lakes. *Cucullanus truttae* although occurring in both lakes, hat not so far been found infecting salmonoids in Llyn Tegid. *Eubothrium salvelini* is specific to the char, and thus does not occur in Llyn Tegid where this fish is also absent. Equally *Henneguya tegidiensis* and *Proteocephalus* sp. seem to be specific to *Coregonus* spp., and thus do not occur in Llyn Padarn. Further investigation at Llyn Padarn may well reveal the occurrence of *Cystidicola farionis, Salmincola salmonea* and *Argulus coregoni* in this lake. The status of *Echinorhynchus truttae* remains uncertain, for it was rare in Llyn Tegid, and not found in Llyn Padarn, but is a common parasite of stream trout in North Wales. But in general terms, there is good agreement between the specific composition of the parasite fauna of the salmonoid fish of Llyn Padarn and Llyn Tegid, and as has been stated earlier (Chubb, 1963), the

Salmonoidei are characteristic of oligotrophic lakes in Europe, thus their parasite fauna may by regarded as the oligotrophic element of the parasite fauna of the two lakes.

Table 13 shows the species of parasites infecting the coarse fish species dominant in Llyn Tegid. The pike, perch and roach are more typical of eutrophic lakes than of oligotrophic waters in Europe.

TABLE 10

Acanthocephala of the fish of Llyn Padarn and Llyn Tegid

Parasite species	Occurrence	
	Llyn Padarn	Llyn Tegid
Neoechinorhynchus rutili (Müller, 1780)	*Salmo trutta*	*Salmo trutta* *Thymallus thymallus* *Esox lucius* *Rutilus rutilus*
Echinorhynchus clavula Dujardin, 1845	*Salmo trutta* *Anguilla anguilla* *Gasterosteus aculeatus*	*Coregonus clupeoides pennantii* *Thymallus thymallus* *Esox lucius* *Rutilus rutilus* *Anguilla anguilla* *Perca fluviatilis*
Echinorhynchus truttae Schrank, 1788	—	*Thymallus thymallus*
Data from	Powell and Chubb investigation in progress	Chubb, 1963

TABLE 11

Crustacea parasitica of the fish of Llyn Padarn and Llyn Tegid

Parasite species	Occurrence	
	Llyn Padarn	Llyn Tegid
Salmincola salmonea (L., 1761)	—	*Salmo salar*
Argulus coregoni [1] Thorell, 1864	—	*Thymallus thymallus*
Data from	Powell and Chubb, investigation in progress	Chubb, 1963

[1] mistakenly reported as *Argulus foliaceus* in Chubb, 1963

TABLE 12

Parasite species infecting *Salmonoidei* (*Salmonidae* and *Thymallidae*) in Llyn Padarn and Llyn Tegid

Infecting *Salmonoidei*		
in both lakes	in Llyn Padarn only	in Llyn Tegid only
Discocotyle sagittata	*Eubothrium salvelini*	*Henneguya tegidiensis*
Crepidostomum metoecus	*Cucullanus truttae* [2]	*Proteocephalus* sp.
Crepidostomum farionis		*Cystidicola farionis*
Phyllodistomum folium		*Cystidicola* sp.
Eubothrium crassum		*Echinorhynchus truttae*
Diphyllobothrium sp. CO		*Salmincola salmonea* [3]
Diphyllobothrium sp. N		*Argulus coregoni*
Neoechinorhynchus rutili [1]		
Echinorhynchus clavula [1]		

[1] these species also paratise coarse fish in Llyn Tegid
[2] so far found in non-salmonoid fish in Llyn Tegid
[3] *Salmo salar* from Llyn Padarn not yet examined

TABLE 13

Parasite species infecting pike *Esox lucius*, *roach Rutilus rutilus* and perch *Perca fluviatilis* in Llyn Tegid

Parasite species	
not also found in Llyn Padarn	also found in Llyn Padarn
Esox lucius:	*Esox lucius*:
Henneguya psorospermica	*Cucullanus truttae* [2]
Tetraonchus monenteron	*Neoechinorhynchus rutili* [2,3]
Triaenophorus nodulosus	*Echinorhynchus clavula* [2,3]
Rutilus rutilus:	*Rutilus rutilus*:
Diplozoon paradoxum	*Neoechinorhynchus rutili* [3]
Caryophyllaeides fennica	*Echinorhynchus clavula* [3]
Ligula intestinalis	
Perca fluviatilis:	*Perca fluviatilis*:
Henneguya psorospermica	*Echinorhynchus clavula* [3]
Ancyrocephalus paradoxus	
Bunodera lucioperca	
Triaenophorus nodulosus	
Raphidascaris cristata [1]	
Camallanus lacustris	

[1] found in perch as juvenile worms only, otherwise in eel (see Table 14)
[2] infections probably secondarily acquired by pike from fish eaten
[3] also parasitise *Salmonoidei* in Llyn Tegid

TABLE 14

Parasites of the eel *Anguilla anguilla* in Llyn Padarn and Llyn Tegid

Infecting the eel		
in both lakes	in Llyn Padarn only	in Llyn Tegid only
Proteocephalus sp. *Echinorhynchus clavula*	—	*Bothriocephalus claviceps* *Raphidascaris cristata* *Haplonema tenerrimum* *Spinitectus inermis* *Cucullanus truttae* [1]

[1] infects *Salmonoidei* in Llyn Padarn, see Table 9

Intermediate types of lakes may contain mixed populations of salmonoids and coarse fish species, as Llyn Tegid, Windermere, England and Loch Lomond in Scotland. As may be seen from Table 13 each of the three species of fish has its own specific complement of parasites, and as would be expected these were found in Llyn Tegid and not Llyn Padarn. *Cucullanus truttae*, *Neoechinorhynchus rutili* and *Echinorhynchus clavula* in the pike are probably acquired secondarily with fish taken as food. The finding of *Neoechinorhynchus rutili* and *Echinorhynchus clavula* in roach and perch may also have little significance, for as commented earlier (Chubb, 1964) the limiting factor for some *Acanthocephala* may be the occurrence of the intermediate host. Thus the specific parasites of the pike, roach and perch in Llyn Tegid may be regarded as representing the eutrophic element of the parasite fauna.

Finally the parasites of the eel are considered in Table 14. The occurrence of *Echinorhynchus clavula* in the eel may be explained as in the previous paragraph, although this parasite matured most successfully in the eel, if the production of shelled acanthors is taken as the criterion (see Chubb, 1964). *Bothriocephalus claviceps*, *Raphidascaris cristata* (adults), *Haplonema tenerrimum* and *Spinitectus inermis* were specific to the eel in Llyn Tegid. *Cucullanus truttae* is probably typical of the salmonoids, although found in the eel in Llyn Tegid. Apart from the exceptions noted, the parasites of the eel may be regarded as a separate component of the parasite fauna, as was stated earlier (Chubb, 1963), although as the four typical species have not so far been found in Llyn Padarn, this concept may require revision.

The following conclusions are confirmed:

1. The parasites of the *Salmonoidei* may be regarded as the oligotrophic element of parasite faunas.

2. The parasites of the pike, roach and perch may be regarded as the eutrophic element of parasite faunas.

A third conclusion requires further investigation:

3. The parasites of the eel may be regarded as a separate component of the parasite fauna of lakes.

This conclusion is probably valid, but owing to the absence of the typical eel parasites from Llyn Padarn, requires confirmation.

It will have been noted that the parasites of the gudgeon *Gobio gobio,* minnow *Phoxinus phoxinus,* stone loach *Nemacheilus barbatula,* bull head *Cottus gobio,* three spined stickleback *Gasterosteus aculeatus* and the lamprey *Lampetra planeri* have been largely omitted from consideration. These species require further investigation before any statement can be made regarding their parasite faunas.

Of what importance are the conclusions noted above? At first sight they may seem self-evident, but if extensive programmes of re-stocking of lakes, or introduction of new species of fish are planned it is very important that the parasite fauna both of the existing fish populations and of the species to be introduced are clearly defined. If on further investigation the conclusions noted above are found to hold, then it should be possible to postulate, at least in outline, the expected parasite fauna for a given water once the species of fish inhabiting it are known. It should then be possible to avoid bad stocking programmes and the accidental introduction of parasites of harmful nature with acclimatized fish. It is important to realise that the present investigations must be repeated and extended upon other waters and species of fish, before forecasts of this type can be made with certainty.

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