

Seasonal zooplankton patterns in a shallow oligotrophic lake : Loch Rusky (Scotland)

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Keywords : Zooplankton, seasonal succession, lake, Scotland.

The zooplankton taxa and their seasonal distribution are described for Loch Rusky, a shallow oligotrophic lake in the central region of Scotland. 15 species were identified : 11 Rotifera, 2 Cladocera and 2 Copepoda. Only 5 species *Polyarthra remata*, *Keratella cochlearis*, *Filinia terminalis*, *Trichocerca* sp. and *Eudiaptomus gracilis* occurred in sufficient numbers to facilitate a description of their seasonal pattern. The annual zooplankton variation was dominated by rotifers for most of the year, but copepods (*E. gracilis*, *Cyclops* sp.) only were dominant in the epilimnion during summer. It is presumed that this pattern was the result of the rotifers faster rate of reproduction and higher grazing efficiency under oligotrophic conditions, as well as the decrease of larger zooplankton by the continuous programme of fish stocking in the lake.

Evolution saisonnière du zooplancton dans le lac Rusky (Ecosse)

Mots clés : Zooplancton, succession saisonnière, lac, Ecosse.

La composition et l'évolution annuelle du zooplancton ont été étudiées dans le Loch Rusky, un petit lac oligotrophe de l'Ecosse centrale. 15 espèces ont été identifiées : 11 Rotifères, 2 Cladocères et 2 Copépodes. 5 espèces seulement *Polyarthra remata*, *Keratella cochlearis*, *Filinia terminalis*, *Trichocerca* sp. et *Eudiaptomus gracilis* sont apparues en nombre suffisant pour décrire leur évolution saisonnière.

Les Rotifères sont dominants durant la majeure partie de l'année tandis que les Copépodes *E. gracilis*, *Cyclops* sp. dominent seulement dans l'épilimnion en été. Le taux de reproduction plus rapide des Rotifères, leur plus grande efficacité de broyage dans des conditions oligotrophes et la diminution du grand zooplancton consécutive au programme suivi d'alevinage du lac conditionnent probablement ce schéma.

Introduction

The plankton of small lakes has been hitherto poorly documented, especially in Scotland (May 1983), where recent research has been focussed on the characteristic larger lakes of this region (Maitland 1981). Nevertheless, the increasing interest in the study of small water bodies makes the gathering of information in this latitude more important for further comparative studies on zooplankton distribution. The present study includes a taxonomic list of species and the annual zooplankton pattern described in Loch Rusky, a shallow oligotrophic lake in Scotland (Maulood 1974, Romo 1987).

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1. Study area, material and methods

Loch Rusky lies in the central part of Scotland (National Grid Reference NN615035), just to the south of the Highland Boundary Fault. The surface area of the lake is about 0.2 km², with a maximum length of roughly 800 m and mean width of 400 m. It has a maximum depth of 15 m. 86 % of the catchment area (about 3 km²) is covered with softwood forestry plantations and the rest by moorland.

The observations covered the period October 1985 to September 1986. One sampling point was situated in the northern part of lake, in a site of the maximum depth. Sampling was carried out fortnightly, except between December to February where sampling was monthly. Water samples were taken with a 6 litres Van Dorn bottle at five depths :

surface, 1, 3, 5 and 10 m. Zooplankton subsamples were sedimented and counted using inverted microscope (Edmonson & Winberg 1971). Temperature and oxygen were measured in the field using a Macchereth Mark II temperature/oxygen probe.

2. Results

2.1. Temperature and Oxygen

The lake was seen to be monimictic with only an annual stratification period occurring in summer, from June to August (fig. 1). During this period, the hypolimnion with a more or less constant temperature of 11° C was only well defined in the depth 9 m. The epilimnion was comprised in the top 6 m and extended deeper during the summer. The maximum temperature of 20° C was reached in July in the top 2 m. Isothermal conditions prevailed during the remaining year, with a thermal range between 3.5 to 13° C. Icecover was not observed on any sampling date but it is probable that occasional surface freezing occurred during winter. Oxygen had similar seasonal and vertical distribution to temperature. Saturated oxygen levels (135-90 % saturation)

remained throughout the whole year and only during summer stagnation did the oxygen fall to 21 % in the hypolimnion.

2.2. Zooplankton

A total of 15 species were identified from the zooplankton (Table I), but only five species occurred in sufficient numbers to permit the description of the seasonal pattern.

— ROTIFERA

The Rotifers were the most common and abundant species represented in the zooplankton (fig. 2). The maximum biomass was the spring phytoplankton increase (mainly represented by small diatoms). The dominance of Rotifera remained throughout the year except in summer, where Copepoda became dominant in the epilimnion.

Polyarthra remata Skorikov (fig. 3) was the most frequent (84 % occurrence) and represented up to 20 % of the total zooplankton biomass (Table I). The seasonal pattern showed three distinct peaks: the first occurred between April and June with values up to 40 ind/l; the second attained the

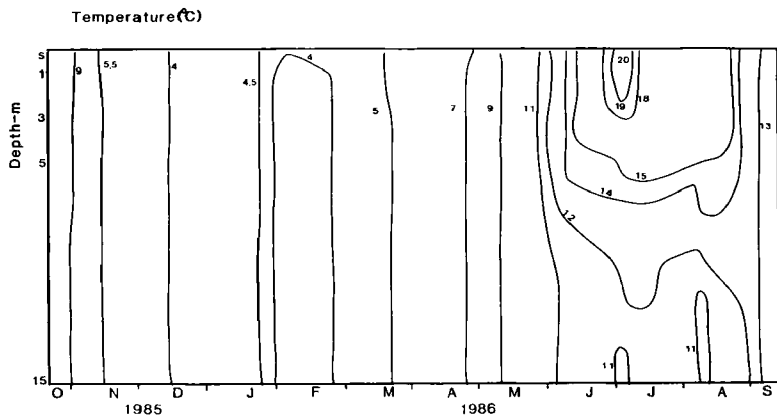


Fig. 1. Isoleths of water temperature from October 1985 to September 1986, expressed in degree centigrade.

Table 1. Occurrence and relative abundance of the zooplankton species in Loch Rusky, during the period October 1985 to September 1986.

	OCCURENCE	REL. ABUNDANCE
CLADOCERA		
<i>Daphnia hyalina</i> Leydig	+	..
<i>Daphnia longispina</i> Muller	-	-
ROTIFERA		
<i>Ascomorpha ecaudis</i> Perty	-	...
<i>Asplanchna priodonta</i> Gosse	-	.
<i>Brachionus angularis</i> Gosse	-	.
<i>Euchlanis dilatata</i> Ehrb	-	.
<i>Filinia terminalis</i> Plate	++	..
<i>Kellicottia longispina</i> Kellicott	+	.
<i>Keratella cochlearis</i> Gosse	++	..
<i>Keratella quadrata</i> Muller	-	.
<i>Polyarthra remata</i> Skorikov	+++	...
<i>Trichocerca similis</i> Wierzejski	-	-
<i>Trichocerca</i> spp.	+	...
COPEPODA		
<i>Cyclops</i> sp.	-	.
<i>Etudiaptomus gracilis</i>	++	..
Nauplius	+++	...
CILIATES		
	+++	.
Occurrence :		
100 - 75 %	+++	
75 - 50 %	++	
50 - 25 %	+	
< 25 %	-	
Rel. Abundance :		
25 - 10 %	...	
10 - 5 %	..	
5 - 1 %	.	
< 1 %	-	

maximum population levels (about 50 ind/l) during August and September; and thereafter population numbers decreased to 25 ind/l in the peak of autumn and remained stable at about 10 ind/l in winter. The vertical distribution was more or less uniform during the periods of water mixing but at the starting of stratification in June, *P. remata* tended to concentrate behind the thermocline and in July only occurred at 10 m. This distribution was reversed in late summer, where it was restricted to the upper 3 m of the epilimnion.

Keratella cochlearis Gosse (fig. 3) showed lower occurrence (72 %) and abundance (9 %) than

P. remata. Similar seasonal pattern with less pronounced peaks than those described for *P. remata* was observed for this species under water mixing conditions. During water stagnation *K. cochlearis* showed different vertical distribution in time and space than *P. ramata*, reaching maximum population numbers of 40 ind/l in July at the thermocline level. Uniform vertical distribution was the pattern during the rest of the other seasons.

Filinia terminalis Plate (fig. 3) had an occurrence of 53 % and 6 % of relative frequency. During summer months it was only present in the hypolimnion. Uniform profiles were observed for the rest of

year, although slightly higher population values were always present at 10 m.

Trichocerca sp. (fig. 3) was an occasional species in the zooplankton distinguished by a rapid development (108 ind/l) in the middle waters during May and July.

— COPEPODA

It was mainly represented by *Eudiaptomus gracilis* Sars. *Cyclops* sp. only appear in low numbers when *E. gracilis* was absent at the beginning of August.

Eudiaptomus gracilis (fig. 4) showed two seasonal population peaks from April to September, both registered in the upper waters. The latter summer increase represented the maximum population numbers of 50 ind/l. Naupliar populations showed two seasonal increases prior to or coinciding with, those observed for adults. The first peak was mainly achieved in the upper 3 m while the second one in summer was evenly distributed throughout the depths. Similarly low populations (10 ind/l) in both *E. gracilis* and nauplii remained during autumn-winter.

— CLADOCERA were numerically rare, mainly represented by *Daphnia hyalina* Leybig in the epilimnion in July.

— CILIATES were not identified in this study and their biomass was bulked together. The occurrence was high but was gathered with a low abundance during summer and November.

3. Discussion

The rotifers seasonal pattern in Loch Rusky was similar to that shown by the phytoplankton (Romo 1989). The faster rate of reproduction of rotifer over all temperature ranges and higher grazing efficiency under the oligotrophic conditions (Allan 1976) prevailing in the lake, would enable to this group to respond quickly to increasing phytoplankton biomass (mainly represented by nanoplanktonic species). It would also contribute to the dominance of this group for most of the year. The three

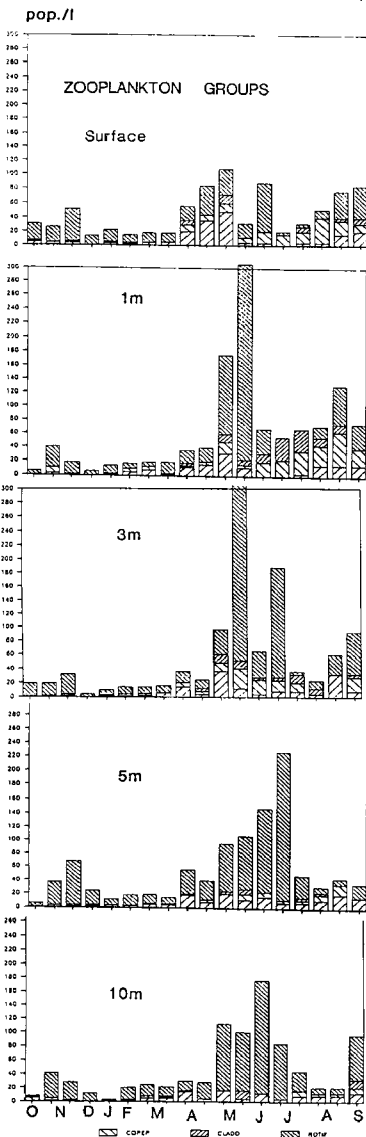


Fig. 2. Seasonal and vertical changes of the major zooplankton groups in Loch Rusky, from October 1985 to September 1986.

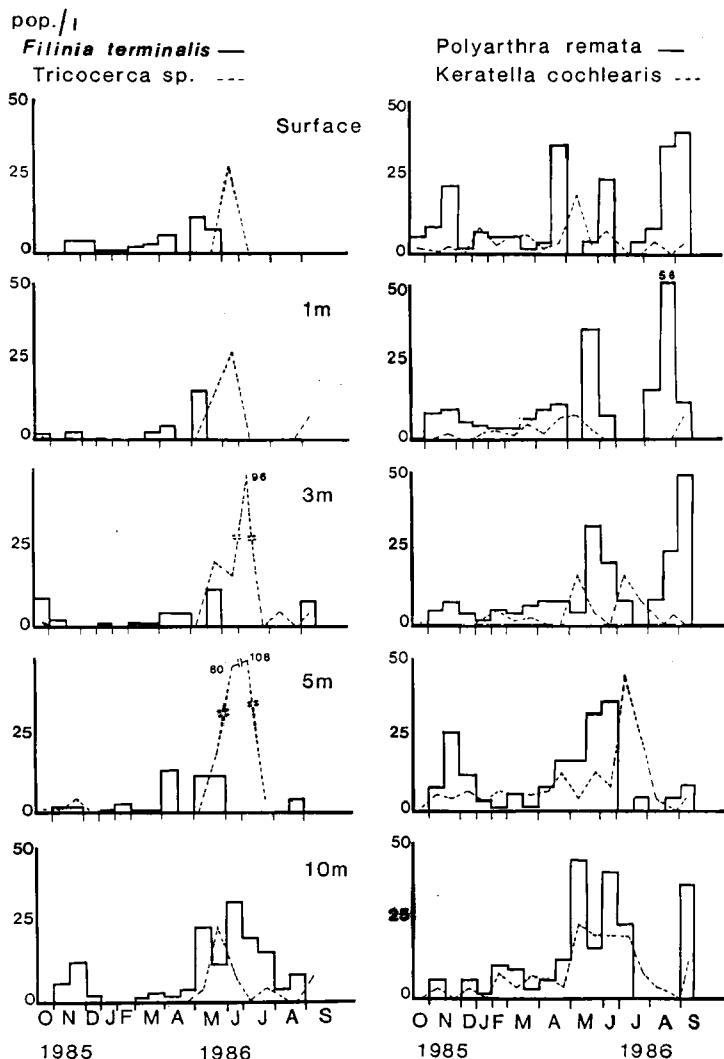


Fig. 3. Depth-time distribution of the rotifers *Polyarthra remata* Shor., *Filinia terminalis* Plate, *Keratella cochlearis* Goss. and *Tricocerca* sp. in the zooplankton of Loch Rusky during 1985-86, expressed as number of individuals per litre.

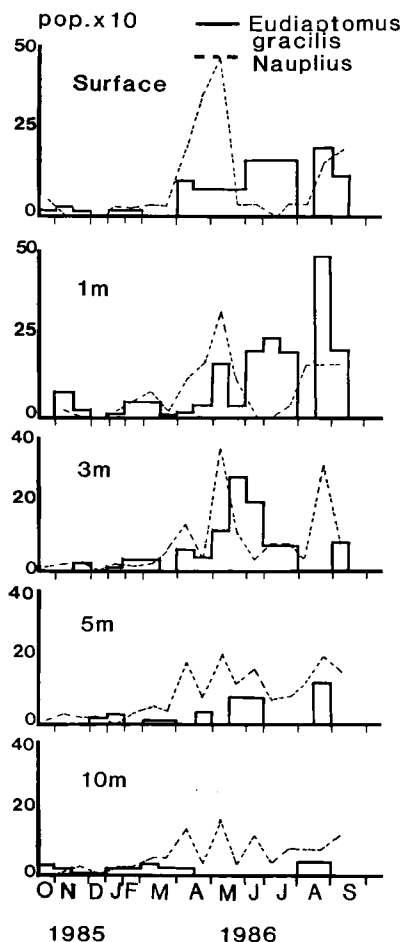


Fig. 4. Depth-time distribution of nauplius and *Eudiaptomus gracilis* Sars. in Loch Rusky, expressed as number of individuals per litre.

main identified rotifer species (*P. remata*, *K. cochlearis* and *F. terminalis*) co-occurred in the lake for the whole study period. *E. terminalis* had preference to bottom waters, which agrees with the general niche characteristics described for this species (Ruttner-Kolisko 1974). *P. remata* and *K. cochlearis* overlap time and depth presence during the water mixing seasons but showed segregation in depth at the time of water stratification. It is possible that competition with *Daphnia* (Neill 1984) and intraspecific niche partitioning under stratified waters (Makarewicz and Likens 1975) conditioned this pattern.

The continuous programme of fish stocking in the lake (rainbow trout, *Salmo gairdneri*), could strongly influence the abundance of Cladocera (mostly represented by *D. hyalina*) due to feeding relations described for both species in small lakes (Stenson 1972) favouring rotifer dominance.

The long cycle of reproduction of *Eudiaptomus gracilis*, determined a single season of abundance in the zooplankton in summer. There was coexistence in time and depth between this copepod and *P. remata* (Neill 1984) in late summer and with *D. hyalina* Lampert & Muck (1985) in July. It seems plausible that niche differentiation and nonequilibrium mechanisms were critical to interactions between these species.

It is likely that temperature and other environmental variables could also influence zooplankton succession by affecting feeding rates and metabolic demands (Hebert 1978).

Loch Rusky showed in general a zooplankton community similar in species composition to that described in the small oligotrophic lakes of Pyrenees (Miracle 1978) and in oligotrophic temperate lakes (Margalef 1983).

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