Zooplanktic indicators of trophy and their food

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Abstract

Regarding specific food requirements zooplankters in oligotrophic forest lakes are compared with indicators of other trophic conditions.

Most zooplanktic indicators of eutrophic conditions feed on very small particles, to a large extent on bacteria, while the indicators of oligotrophy may be filtrators of courser particles. Both categories comprise raptors as well. In both extremes of lake types, hypertrophy and ultraoligotrophy, feeders on minute particles increase in relative importance, while moderate eutrophy or oligotrophy render a higher diversity of species and feeding categories.

Introduction

When trying to characterize the specific food requirements of zooplankters in oligotrophic forest lakes, one approach is to focus the interest on its indicative species and to compare these with indicators of other trophic conditions. For this reason an analysis, based on the literature, was performed concerning the food of oligotrophic as well as eutrophic indicators.

Pertinent problems of this type were treated by Gliwicz (1969, 1974, 1977, 1980), Hillbricht-Ilkowska & Węgleńska (1970), Hillbricht-Ilkowska (1977), Nilssen (1978) and Geller & Müller (1981). The feeding conditions of the dominant zooplankters, especially those of crustaceans, were discussed, and comparisons were made between different lakes as well as between different seasons within the same lake. In the present paper the results have been complemented, especially by data on rotifers, previously not discussed in this connection. The attention is drawn to species regarded as indicators of eutrophic or oligotrophic conditions, mainly according to Pejler (1965). The Swedish lakes in question represent a much broader spectrum of the trophic continuum than the Polish lakes investigated by the above authors.

Food of oligotrophic indicators

There are strong reasons to include *Asplanchna herricki* de Guerne (see Pejler 1957b; Hakkari 1972) and *Cyclops scutifer* Sars (cf. Elgmork 1967; Kiefer 1978) with the species enumerated by Pejler (1965, p. 503).

Three of the rotifers indicative of oligotrophy may be designated as 'raptorial forms' (according to the terminology in Hutchinson 1967; called 'Greifer' by Naumann 1923; 'snatchers' by Pejler 1965, p. 477; 'seizers' by Nilssen 1976; 'grasping species' by Pourriot 1977), viz. *Asplanchna herricki* (see Monakov 1972; Gilbert 1980), *Synchaeta grandis* Zacharias (Koste 1978) and *Ploesoma hudsoni* (Imhof) (see Dumont 1977; Pourriot 1977; Guiset 1977).

Among the cladocerans *Holopedium gibberum* Zaddach has a varying and broad filtering range,

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with a probable filtering optimum at a larger particle size than in *Bosmina* and *Daphnia* (Johansson *et al.* 1976). This assumption is corroborated in the SEM studies performed by Geller & Müller (1981), who consider its range of high filtering efficiency to reach from 4 to at least 15, and perhaps more than 20 μm. Regarding the genus *Daphnia* it has been shown that different species can utilize different food as regards quality (Burns 1968; Infante 1973), and Geller & Müller (1981) have found there are differing ranges of high filtering efficiency, that of *D. galeata* Sars reaching from about 1 to 20 μm.

According to Naumann (1923) and Monakov (1972) the copepod *Heterocope appendiculata* Sars feeds at least in the adult stage as a raptor, which is considered to be the case in all cyclopoids as well (Fryer 1957). This means that both animals and bigger algae can be utilized. The omnivorous character of *H. appendiculata* and *Cyclops scutifer* is stressed by Langeland & Reinertsen (1982) as well, basing themselves on own analyses of stomach contents. Regarding *C. scutifer* the following circumstances are of interest in this connection: in lake Kuoblatjåkkojaure, which is probably the highest situated lake in all Sweden, only two zooplankters were found, viz. the rotifer *Keratella hiemalis* Carlin and the copepod *Cyclops scutifer* (Pejler 1962). In this lake and in similar lakes the most important groups of the phytoplankton are chrysomonads and cryptomonads, often also dinoflagellates (Rodhe 1962; Rodhe *et al.* 1966). To a large extent they consist of minute forms ('μ-algae', with a size of 1–2 μ or less). Though *C. scutifer* is a potential predator it cannot feed extensively on other zooplankters, especially as it is often the dominating zooplankter (see Rodhe 1955; Table 1). For similar reasons cannibalism probably does not play an important role, and the copepod has to be considered as mainly herbivourous. In fact Taube & Nauwerck (1967) and Gerritsen (1978) have bred this species on exclusively algal food.

Food of eutrophic indicators

Some species enumerated by Pejler (1965, pp. 502–503, under point 5) are here discussed. In addition, a *pelagical* occurrence of *Chydorus sphaericus* Müll. ought to be considered indicative of eutrophy (op. cit., p. 470).

Table 1. Division of zooplanktic indicators into different feeding categories. See further the text. Only those species are included for which the feeding is known in a satisfying way. The three filtrator categories are taken from Geller & Müller (1981).

	(1)	(2)	(3)	(4)	(5)
Indicators of oligotrophy					
Asplanchna herricki					*
Synchaeta grandis					*
Ploesoma hudsoni					*
Holopedium gibberum				*	
Daphnia galeata			*		
Heterocope appendiculata					*
Cyclops scutifer					*
Indicators of eutrophy					
Brachionus angularis	*				
Brachionus calyciflorus	*				
Anuraeopsis fissa	*				
Polyarthra euryptera					*
Pompholyx sulcata	*				
Filinia longiseta	*				
Daphnia cucullata		*			
Chydorus sphaericus		*			

(1) Sedimentators.
(2) High-efficiency bacteria feeders.
(3) Low-efficiency bacteria feeders.
(4) Macrofiltrators.
(5) Raptorial forms.

The species of *Brachionus* are comparatively well known in this respect (see especially the reviews by Pourriot in 1977 and by Starkweather in 1980). The food is quite varying, consisting of diverse types of algae as well as of detritus and bacteria. The last-named item seems to be especially important for some species, e.g. *B. angularis* Gosse. Also *B. calyciflorus* Pallas, previously considered to feed mainly on algae, was cultured on the bacterium *Aerobacter aerogenes* for more than 40 generations, with no decrease in net reproductive rate (Starkweather *et al.* 1979). Furthermore, *Anuraeopsis fissa* (Gosse) as well as *Pompholyx sulcata* Hudson and *Filinia longiseta* (Ehrbg) feed predominantly on detritus and bacteria (Pourriot 1977). Finally, *Polyarthra euryptera* (Wierzejski) belongs to the raptors (see Pourriot 1977) and can feed on relatively large algae like *Cryptomonas ovata* Ehrbg (Dieffenbach & Sachse 1911) and *Peridinium* (Pejler 1961; Starkweather 1980).

Daphnia cucullata Sars feeds, on an average, on significantly smaller particles than *D. galeata* (Geller & Müller 1981). Its optimal filtering range is from below 0.5 to about 5 μm, and it is by the mentioned authors included in the category 'high efficiency bacteria feeders', in contrast to *D. galeata* which is considered a 'low efficiency bacteria feeder'. *Chydorus sphaericus,* with its optimal filtering range of 0.4–ca. 2 μm, belongs to the first-mentioned group as well (op. cit.). Also Gliwicz (1969) found its filtering range to be unusually small compared to other cladocerans, though he based his findings on another method than Geller and Müller.

Discussion

In connection with an increasing trophic degree, specialists on small-particle feeding are favoured and macrofiltrators disfavoured. Consequently, a successively larger fraction of the food will consist of bacteria. The survivors in hypertrophic lakes thus mostly consist of high-efficiency bacteria feeders and of raptors, which also seems to be in accordance with Patalas (1954), Pejler (1965) and Andersson *et al.* (1975). This can be achieved partly by a change in species composition, partly by changing proportions in the diet, implying that a greater fraction will consist of bacteria for the sedimentators and microfiltrators.

A change in the food uptake, connected with different trophic degrees, was observed also in a raptor, *Asplanchna priodonta* Gosse, by Ejsmont-Karabin (1974), the animal fraction of the food being much greater in the eutrophic than in the mesotrophic lake investigated. The present author studied, together with Hans Olofsson, the stomach contents of this species in still more oligotrophic lakes of central Sweden, whereby no animal remains were found at all. The visible contents consisted exclusively of larger algae such as peridineans.

In the extremely poor, i.e. ultraoligotrophic lakes, the number of steps of the ecological pyramid should be relatively small, and all zooplankters could be conceived to be herbivorous. It is interesting to note that in the rotifer community only suspension feeders (i.e. non-predatory forms) were found in all investigated arctic lakes of northern Sweden (Pejler 1957a, Table 29). Most subarctic lakes contained two or more such species, in one case (Lake Nedre Laksjön) as many as 5.

In other extreme arctic environments we meet a similar picture. Thus, in the poor large lakes of Spitsbergen Amrén (1964) found only suspension-feeding rotifers and *Cyclops,* though a species of *Daphnia* occurred in richer ponds. Similar conditions prevail on the island of Bjørnøya (Fleetwood *et al.* 1974).

The occurrence of an unusually high share of nannoplanktic algae in ultraoligotrophic lakes is stressed, e.g., by Pavoni (1963) and Gliwicz (1975) as well. Similarly in the lakes on Spitsbergen investigated by Amrén, small flagellates played a very important role (Willén 1980). It is astonishing to find very small particles (μ-algae) to constitute an important food source in ultraoligotrophic arctic lakes.

Along the trophic scale, beginning at the ultra-oligotrophic extreme, the number of planktic rotifer species successively increases up to a certain point (roughly in the 'mesotrophic' area), after which the species number declines again towards the hypertrophic end (Pejler 1957c). The same most likely also occurs if the whole zooplanktic community is considered. At the same time the number of functional groups both increases and decreases. The category most typical at both extremes is the small-particle feeders, whereby the food is predominated by μ-algae or bacteria. Obviously raptors appear as well. When approaching the center of the scale other functional groups increase in importance, such as macrofiltrators, 'low-efficiency bacteria feeders' and suckers.

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