

## Rotifer occurrence in relation to temperature

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### Abstract

Information on the distribution of 225 species of planktic, periphytic and benthic rotifers from diverse waters in south and central Sweden was analyzed for temperature preference and tolerance. Most rotifers have a very wide tolerance range. Certainly differences in temperature dependence exist between separate species. However, these differences are, in a regional material like this, generally less distinct than what has been found for the distribution within individual lakes.

### Introduction

The relation to temperature of planktic rotifers within an individual lake has been discussed in several connections (see, e.g., May, 1983, Berner-Fankhauser 1986 and the references there). In the present paper, a large regional material is utilized for this analysis, enabling a new aspect of the problem to be studied. The material also includes the non-planktic species, in which the dependence on temperature is far less known.

### Materials and methods

The material derives from about 350 lakes, 50 ponds, 20 pools, 15 mires and 150 running water localities in southern and central Sweden. The localities, as well as the microzoan species, are listed and codified in Bērziņš (1978). The material was obtained during a long succession of years (1945–1982), in connection with diverse projects and occasional investigations. It is not collected in a systematic way and originally not with the aim

of being computerized (starting long before the computer age): From some waters only single samples were studied, from others a large number from different seasons and depths. The bias which possibly results from this is counteracted by the large amount of samples. In order to get an apprehension of the number of samples where a certain species was found, the reader is referred to Fig. 1 in Bērziņš and Pejler 1987 (about the same number applies to temperature).

In most of the localities only samples from the warmer (ice-free) season were taken, but winter samples were often collected as well. Because winter samples are underrepresented, the inclination for low temperatures by cold-stenothermal species is probably in reality somewhat greater than what appears from our diagrams. The difference in temperature preference between cold-water and warm-water species thus might be a little more pronounced in nature.

The temperature was measured using a Ruttner sampler at the same spot (in vertical and horizontal respect) as the corresponding biological sample was taken. For the technique connected

with the biological samples, as well as for taxonomic considerations, the reader is referred to Bērziņš and Pejler (1987).

By means of a computer, correlations were obtained between temperature and occurrence of individual species, resulting in several hundred diagrams (one per species) which are archived at the Institute of Limnology in Lund. In each such diagram the abundance (1 to 10) is set off at the y-axis, the temperature at the x-axis. For each marking the number of finds (with the respective abundance and temperature) is given. The computer also denotes the median value for each abundance.

However, the archived diagrams mentioned are too numerous and too spacious for international publication. Thus, in the present connection a drastic reduction was made (Figs. 1–4). First, the only species included were those observed in at least 50 of the studied samples. Second, only two degrees of abundance were discriminated, the thin line indicating simply occurrence, the thicker line a common occurrence. The median point was also denoted by subjective estimation on the basis of the computer sheets. Because of the mentioned compression of the material the account ought to be regarded as mainly of a qualitative character, though it is based upon quantitative or semi-quantitative sampling. Its nature of a *regional* investigation ought to be considered, leaving problems of population dynamics to detailed studies of single lakes.

## Discussion

It is apparent from the diagrams that rotifers generally have a very wide tolerance to temperature, most of them occurring from close to zero up to about 20 °C or more. Also the range of high abundance is often very wide. For planktic rotifers the seasonal, vertical and horizontal distribution in separate lakes is, on the contrary, often strongly restricted and connected with temperature differences. In the cross-profile investigated in Lake Skärshultsjön (Bērziņš, 1958), for instance, almost all common rotifer species were limited to

either the warm-temperated epilimnion or to the cold hypolimnion. This was true even for such species as *Keratella cochlearis* and *Kellicottia longispina* which are pronouncedly eurythermal according to all previous experience.

Similarly, during a seasonal succession some species are restricted to the winter period (and hypolimnion during summer). Thus, Carlin (1943) distinguishes 12 'winter species' in L. Glan. Some of these are rare and not included in the material now presented, but the following are to be found in Fig. 1: *Notholca squamula*, *N. acuminata*, *N. caudata*, *Keratella hiemalis*, *Synchaeta lakowitziana*, *Filinia terminalis* (called '*F. maior*' by Carlin) and *Polyarthra dolichoptera*. The more or less cold-stenothermal character of the six first-named of these species is evidenced by all available experience (see, e.g., Pejler, 1957; Nauwerck, 1963; Ruttner-Kolisko, 1972; Zimmermann, 1974, May, 1980 and 1983, Berner-Fankhauser, 1983 and 1986; Laxhuber, 1987; Laxhuber and Hartmann in press). As regards *P. dolichoptera*, however, there is varying experience: In large lakes like L. Glan (Carlin, 1943), Erken (Nauwerck, 1963), Sempachersee (Zimmermann, 1974), Längelmävesi (Hakkari, 1969) and L. Königssee (Laxhuber, 1987) it is strictly confined to cold water, and May (1983) mentions it as one of the two cold-stenothermal species in Loch Leven (the other being *N. squamula*). In small lakes and ponds, however, it can occur at higher temperatures as well (Carlin, 1943, Pejler, 1957 and 1961). Such populations are deviating morphologically and are suspected by Pejler (1956) as having arisen through hybridization with *P. vulgaris*. For *F. terminalis* the conditions may be similar (see Pejler, 1957 and 1961). The situation gets complicated because a new cold-water species, *F. hofmanni* Koste, has been described after the material now presented was collected and identified (Koste, 1980; Hofmann, 1982). This could possibly be the reason why the hypolimnion species in L. Skärshultsjön was determined as '*F. longiseta*' (Bērziņš, 1958). The most pronounced cold-stenothermal rotifer according to our Fig. 1, *Polyarthra longiremis*, has not been studied to any great extent before: By Carlin

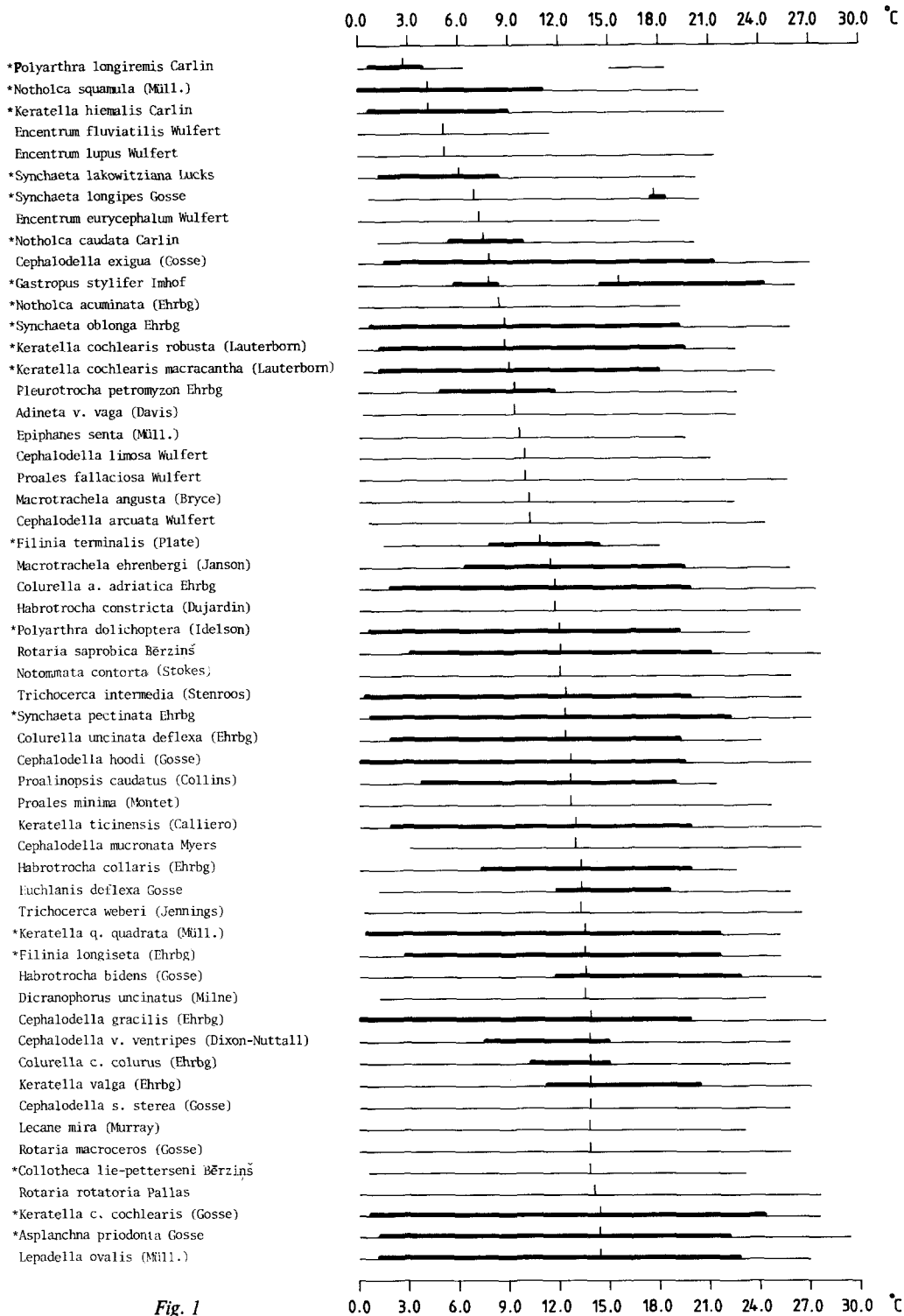


Fig. 1

Figs. 1-4. Occurrence of rotifers in relation to temperature in Swedish waters. The range (horizontal thin lines), high abundance (horizontal thick lines) and maximum abundance (vertical lines) of 225 rotifers are given. Species are ranked according to temperature preference, beginning with those having their peak abundance at  $\leq 14$  °C (Fig. 1) through those having their peak abundance at  $> 18$  °C (Fig. 4). Planktic species are indicated by an asterisk.

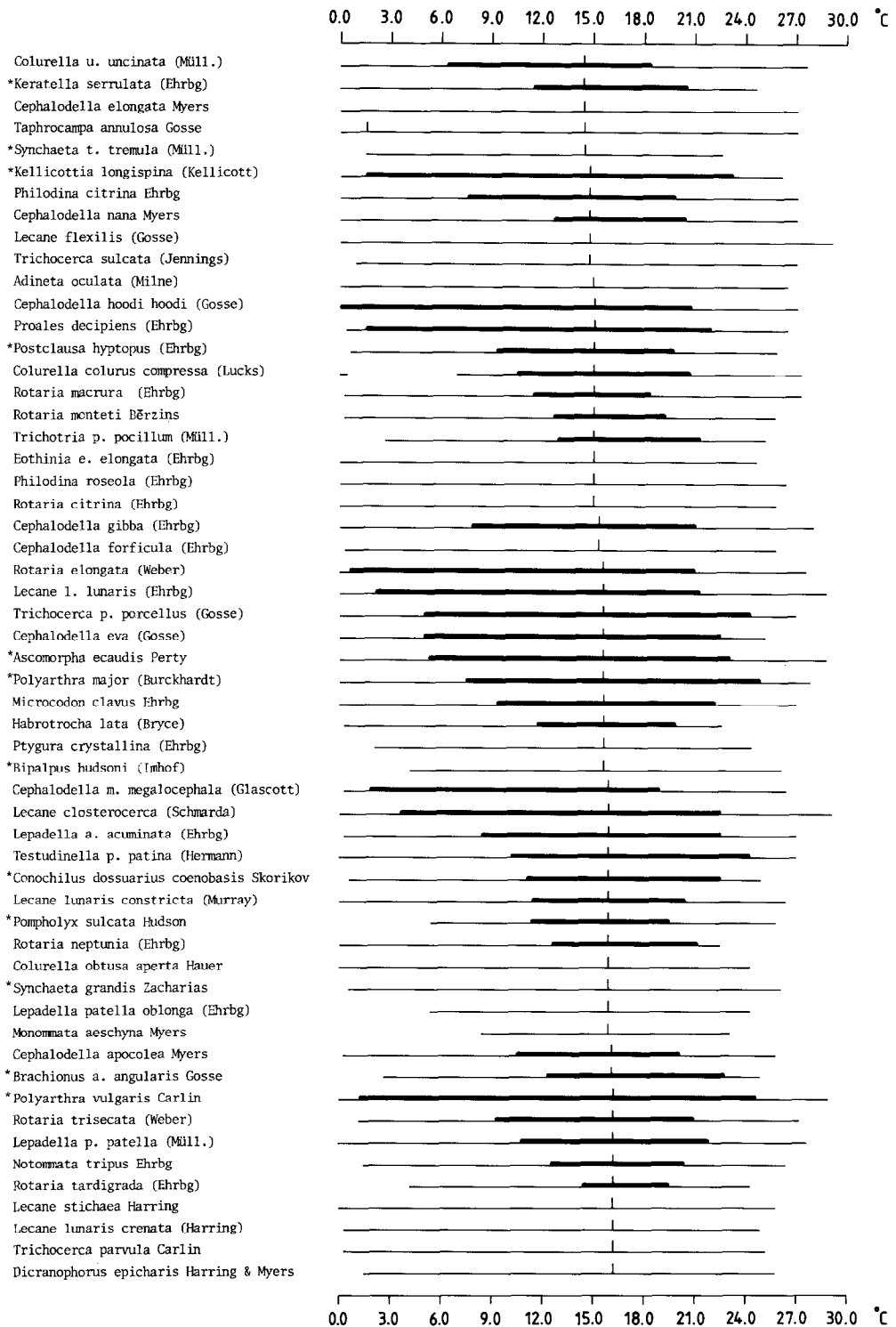


Fig. 2. For caption see p. 225.

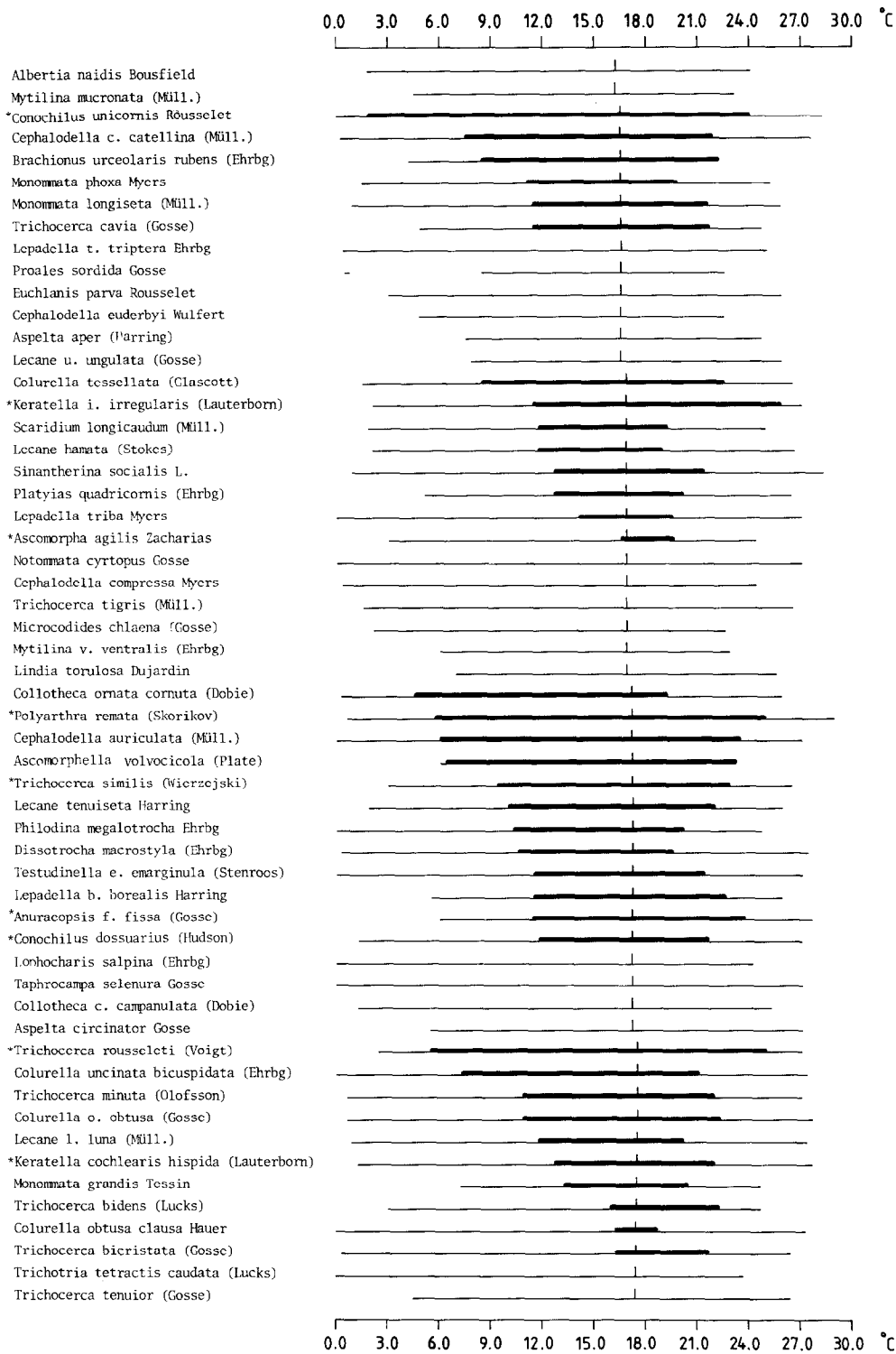


Fig. 3. For caption see p. 225.

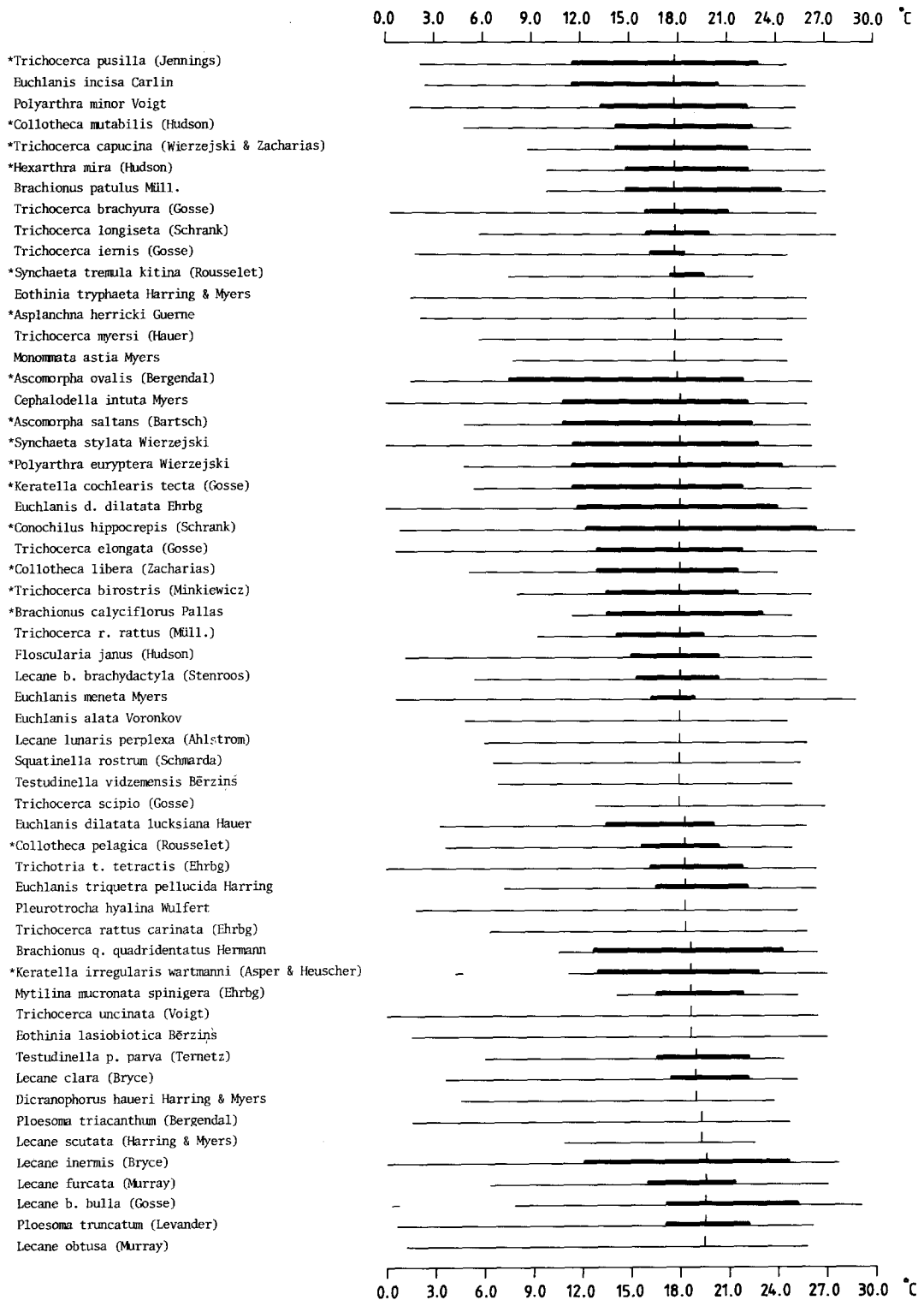


Fig. 4. For caption see p. 225.

(1943, p. 88) it was found in ponds in South Sweden and Czechoslovakia, on May 18 and June 25, respectively, and consequently at relatively high temperatures. In L. Skärshultsjön, however, it was restricted to the cold-temperated hypolimnion (Bērzinš, 1958).

Carlin (op.cit.) regards all the following rotifers as summer forms: *Gastropus stylifer*, *G. hyptopus*, *Bipalpus hudsoni* (called 'Ploesoma h.'), *Synchaeta grandis*, *S. pectinata*, *S. oblonga*, *S. kitina*, *S. stylata*, *Trichocerca rousseleti*, *T. birostris*, *T. capucina*, *T. pusilla*, *Pompholyx sulcata*, *Euchlanis dilatata*, *Ascomorpha ecaudis*, *A. saltans*, *A. ovalis*, 'A. cf. minima von Hofsten', *Polyarthra major*, *P. remata*, *P. euryptera*, *Asplanchna herricki*, *Collotheca* spp. and *Filinia longiseta* (called 'F. limnetica'). Most of these species are found in the latter parts of the temperature-preference series in our Figs. 1–4. However, the range of occurrence and even the range of abundant occurrence is often so wide that we are reluctant to designate these species as warm-stenothermal. Furthermore, two of Carlin's 'summer species' are even found quite early in our series, viz. *Gastropus stylifer* and *Synchaeta oblonga*. As regards *G. stylifer*, also Carlin is a little doubtful in this respect: He mentions that some authors consider it as a summer form, other authors as perennial, and he says that it could be judged as transitional between these two groups. As regards *S. oblonga*, Carlin's labeling is rather surprising since he sometimes found a high abundance of it even at quite low temperatures (op. cit., Fig. 26), and its relatively eurythermal occurrence is corroborated by later authors (see, e.g., Pejler, 1962; Ruttner-Kolisko, 1972 and Koste, 1978). Other previous authors are more restrictive in designating summer forms. May (1983), for instance, only regards two of the rotifers found in Loch Leven as warm-stenothermal, viz. *Pompholyx sulcata* and *Trichocerca pusilla*. However, it has to be noted that also these two species can be found in low abundance at low temperatures, like almost all other species, which is evident from Figs. 1–4 in the present paper.

There are at least two possible explanations of the discrepancy (apparent or real) between the

conditions in individual lakes and the regional material now presented: 1) Our data are based upon simultaneous measurements of temperature and species occurrence (and abundance), but the occurrence may be more dependent on the conditions prevailing some time before the sampling. Summer species, for example, often have a maximum (connected with a sexual period) in the autumn at comparatively low temperatures, just before they disappear for the season. – 2) Genetic differences could be suspected between different populations and geographical areas, where *Anuraeopsis fissa* and *Pompholyx sulcata*, for instance, otherwise known as pronounced summer forms, were only found at comparatively low temperatures in northern Swedish Lapland (Pejler, 1957).

In some cases two peaks may be traced in the diagrams, especially for *Synchaeta longipes* and *Gastropus stylifer*. Possibly this is a reflection of a splitting into populations with different genetic adaptations, or even into species. A still more pronounced bimodality was found for *Filinia longiseta* vis-à-vis pH (Bērzinš and Pejler, 1987). Perhaps one of these peaks in reality corresponds to the recently described species *F. hofmanni* (see above).

As regards temperature dependence of non-planktic species (without asterisk in Figs. 1–4), much less information is given in the literature. An interesting note is found in Wulfert (1961, p. 100): 'The setting in of coldness had hardly any influence on the littoral forms' (translated from German). These rotifers were contrasted with some planktic forms which disappeared during winter. In our diagrams, however, most non-planktic species have their peaks at comparatively high temperatures. This is not very surprising as most of them ought to be periphytic and dependent on macrophytes and their epiphytic flora which develops during summer (to be discussed in future papers). However, it is evident from Figs. 1–4 that most non-planktic species, like the planktic, can tolerate low temperatures as well.

The three first of the non-planktic species in our temperature-preference series (Figs. 1–4) all belong to the genus *Encentrum*. Of these species

*E. eurycephalum* was found by Wulfert (1936) only during the winter months, and Koste (1978) classifies it as cold-stenothermal (here called '*E. putorius* var. *eurycephalum*'). According to Wulfert (op.cit.) it is a typical mud form. *E. fluvialitis* was also found in mud (in a river), according to Wulfert (1939), but *E. lupus* was found in the algal cover along the shore of a heavily polluted brook. Apparently all three species prefer an environment of decaying material occurring during the winter.

Summarizing the evidence available, we conclude that temperature generally does not solely decide when and where a species may occur or not. Its influence ought mainly to be of an indirect nature, enhancing or retarding development (cf. Galkovskaja, 1987) and cooperating with other abiotic and biotic factors in the ways asserted by, e.g., Edmondson (1977) and Hofmann (1977).

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