Biological assessment of inorganic and organic enrichment of watercourses by Hatfield, Rye Meads, Deephams and Bishop Stortford sewage effluents.

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SUMMARY

1. The four sewage discharges investigated have previously been considered too difficult to assess biologically because of the depth and width of the watercourse being considered for sensitive area status under the Urban Waste Water Treatment Directive. This study assessed each discharge for both inorganic nutrient and organic enrichment using collections of midge pupal skins to indirectly assess benthic algal growth.

2. There was a doubling in the proportion of algal grazing midges downstream of Rye Meads sewage discharge compared with upstream. There was also a proportional increase in grazers downstream of Deephams sewage effluent despite there being a very high proportion of grazers upstream. This effluent also demonstrated the most marked increase in organic enrichment of the four considered.

3. There was no evidence that either Hatfield or Bishops Stortford sewage discharges were supplying inorganic nutrients limiting to algal growth upstream of these impacts.

Introduction

Relative abundances of different species of organisms (biota) in rivers will be influenced by the physical and chemical environment that was present prior to and during their existence. Abundance variations in the biota can reflect recent environmental conditions integrated over a time span related to their life cycle and recolonisation abilities. The European Community Urban Waste Water Treatment Directive (UWWT) requires us to designate rivers sensitive to inorganic nutrient enrichment (eutrophication by nitrogen and phosphorus). Chemical monitoring is largely achieved manually and a comprehensive record of concentrations in rivers is not available. Furthermore, a full knowledge of the chemical causative agents is not evidence of any effects which have to be assessed by surveillance or monitoring of the biota.

E.A. biologists have been evaluating nutrient enrichment by sewage treatment works (STW) by monitoring their effects on macrophytes and benthic (bottom-dwelling) algal populations. Biologists have experienced difficulty in sampling macrophytes and benthic algae in deep rivers, especially if they are also turbid and macrophyte growth is restricted. This was a study of four STWs that could not be assessed for nutrient enrichment by a direct study of the flora. Growth of benthic algae above and below STWs has been assessed indirectly by monitoring abundances of algal grazers in relation to other feeding preferences among species of non-biting midges (family Chironomidae). About 600 species of chironomid are present in Britain and they reflect a broad range of tolerances or preferences for different habitats and water qualities. For any particular habitat, e.g. silt or gravel, there are a range of chironomid species which could exist there, depending on the quality of the water. A comprehensive study of lakes has indicated that food availability was more important than oxygen concentrations in determining the distribution of chironomid populations (Saether, 1979, Holartic Ecology, **2**, 65-74).

After spending several weeks to several months as larvae, all aquatic chironomid species (with one novel exception) will pupate and rise to the water surface so that the adult can emerge from the pupal skin. Pupal skins float for about two days before sinking. The skins soon become trapped behind obstacles, mostly at the margins of the lake, river or canal. Collections of floating debris from the margins of deep rivers or canals will therefore reflect the relative abundances of chironomid species that have emerged over the couple of days prior to sampling and from any of the available habitats a short distance upstream (in a 10m wide river most pupal skins will drift less than 100m). The ecology of British chironomid species is sufficiently well-known that they can be classified according to their general feeding preferences as well as to their sensitivity to organic pollution (tolerance of low oxygen conditions). These classifications have been used for assessing both nutrient enrichment and organic loading above and below the four STWs. For the particular STWs in this investigation, it is believed that this is the first study which has been able to assess the influence of the discharge on biota independently of any changes in habitat occurring between the upstream and downstream sites.

Methods

Sampling sites were located on the watercourses under review for UWWT sensitive area status and not necessarily the receiving watercourse of the four STW discharges (Table 1). The distances of the downstream sites from their respective discharges were all considered adequate to ensure that pupal skin collections would be representative of larvae that had also lived downstream of the discharge. Two upstream sites were considered necessary for monitoring the impact of Rye Meads STW because the R. Stort and the Toll House Stream (carrying the effluent) enter the Lee at the same point.

Each site was visited on 3 occasions during 1996; May 14, July 2 and September 5. Floating debris trapped behind lock gates, vegetation or other obstacles was sampled with a 250µm mesh net attached to an extendable carbon-fibre landing pole. Bagged debris was brought back to the laboratory and passed through a 4mm sieve to remove coarse material. The finer material was stored in 70% ethanol before subsequent random sub-sampling. About 200 skins were sorted and identified to genus or species from each sample except for in May from the Stort Navigation upstream of Bishop Stortford STW when only 53 skins were found.

Taxa (species or genus) abundances from the 3 collections at each site were amalgamated before data analysis so that seasonal variations in adult emergence periods were smoothed. The proportions of pupal skins belonging to taxa considered to have one of four feeding preferences (predator, algal grazer, detritivore and filter-feeder) were calculated for the 600 or so skins collected from each site. The same taxa could also be classified according to their tolerance of low oxygen conditions as an indicator of the organic impact of the effluents. In addition to these 'indicator organism' approaches, the chironomid community of each site was also compared with the other eight sites for similarities of taxa and their abundance. The matrix of similarities was used to group sites into clusters with similar chironomid communities.

Results

These will be presented in three sections; feeding (trophic) group analysis, organic pollution intolerance and community similarity.

Trophic groups

Hatfield STW The proportion of algal grazers decreased downstream of the effluent as detritivores increased (Fig. 1). Filterers feed on fine (<125μm) suspended organic material composed of algae and detritus but their abundance above and below the discharge was negligible.

Rye Meads STW Detritivores dominated both upstream sites. The proportion of algal grazers upstream of the discharge was close to 20% in both the Lee and the Stort (Fig. 2). Downstream of the discharge, at Dobb's Weir on the R. Lee, the proportion of grazers had almost doubled as detritivores declined. The proportion of predators at the downstream site was intermediate between the proportions at the two upstream sites. Filterers were absent in the Stort and increased from 0.3% upstream to 1.1% downstream in the Lee.

Deephams STW Grazers dominated both upstream and downstream sites, in contrast to communities around the other three discharges (Fig. 3). Despite a very high grazer population above the effluent there was a further increase downstream so that predators disappeared and detritivores were reduced. Filterers were absent from both sites.

Bishop Stortford STW Grazers declined in relative abundance downstream of the effluent as detritivores and predators increased (Fig. 4). The proportion of filterers was unaffected by the discharge.

Pollution intolerance Below Hatfield and Rye Meads STWs the proportion of individual pupal skins representing taxa intolerant of organic pollution was higher than the upstream site (Fig. 5). Note that the Lee and Stort, above Rye Meads STW, were indicated as having similar organic loadings. Deephams STW produced a sharp decline in the relative abundance of pollution intolerant individuals in the Salmon Brook. Bishop Stortford STW produced a moderate decline of intolerant individuals.

Community similarity Sites on the Lee and Stort were most similar to their nearest site, upstream or downstream (Fig. 6). The chironomid community above Deephams STW was most similar to that occurring above Hatfield STW (39%) while the site downstream of Deephams had its closest association with the Lee below Rye Meads STW (31%). The two sites on Salmon Brook had a 28% similarity with each other.

Discussion

Assuming that an increase in the proportion of chironomid algal grazers is directly related to algal growth, Hatfield and Bishop Stortford STWs did not promote production of benthic algae. Bishop Stortford is implicated as causing moderate organic enrichment. Dissolved oxygen concentrations experienced by chironomid larvae during 1996 until September were higher below Hatfield STW than above the discharge. Most of the pupal skins collected upstream would have been derived from larvae living in an on-line lake situated about 10m upstream of the collection points. This lake would act as a sink for any polluting organic sediments which would in turn deplete oxygen levels and this appears to have occurred here.

Trophic changes above and below Rye Meads suggest that this STW is providing inorganic nutrient enrichment leading to a doubling in algal-grazing chironomids downstream. Sampling of both the Lee and the Stort upstream has removed the possibility that the Stort itself was responsible for the enrichment. This nutrient enrichment has occurred when there is no evidence for organic enrichment. It is believed that chironomid larvae at the downstream site experienced higher oxygen levels than above Rye Meads STW because of Fieldes Weir and, more significantly, Dobb's Weir immediately upstream of the collection points.

The chironomid community of Salmon Brook was quite distinct from the other watercourses, as revealed by analysis of similarities. The effluent of Deephams STW is so large that the Brook has the appearance of being a tributary of the effluent channel. The chironomid community changed from a relatively pollution intolerant collection of algal grazers upstream of Deephams STW to a pollution tolerant population of algal grazers downstream. This STW has the biggest organic loading of the four considered in this study. Salmon Brook is considered to be eutrophic before the impact of Deephams STW and yet further nutrient enrichment occurs downstream of this discharge.

Conclusion

The growth of benthic algae was considered to have been significantly increased below Rye Meads and Deephams STWs in comparison with the respective upstream sites. This could be due to the supply of a limiting inorganic nutrient by the effluents.

Table 1 Sampling Sites

STW	population	Watercourse	Upstream (distance)	Downstream (distance)
Hatfield	16,350	R. Lee	TL 250 098 (10m)	TL 255 098 (500m)
Rye Meads	355,075	R. Lee	TL 391 091 (150m) Fieldes Weir Lock	TL 385 083 (1.5k) Dobb's Weir
		R. Stort	TL 392 093 (30m) PLER.0330	
Deephams	835,803	Salmon Brook	TL 352 933 (300m)	TL 356 927 (500m)
Bishops Stortford	31,825	Salmon Brook	TL 495 193 (400m) Twyford Lock	TL 490 176 (1.5k) Spellbrook Lock

Fig. 1 Hatfield Trophic Groups

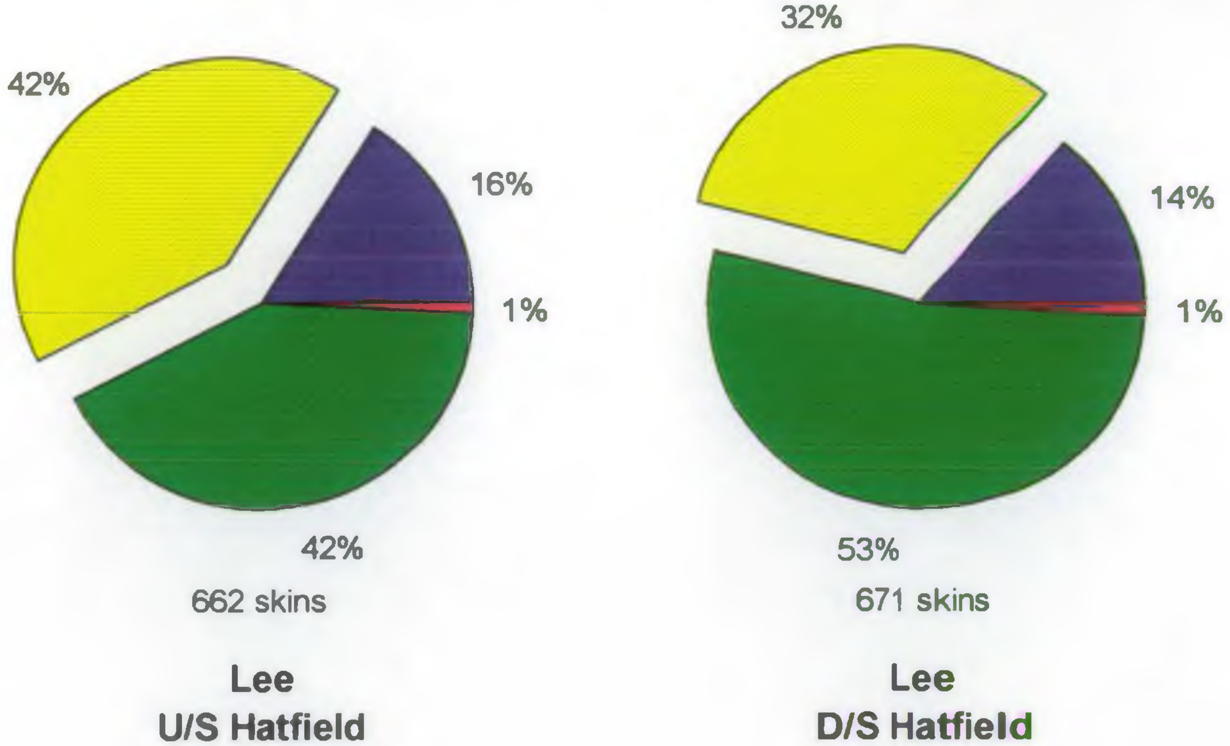

Fig. 2 Rye Meads Trophic Groups

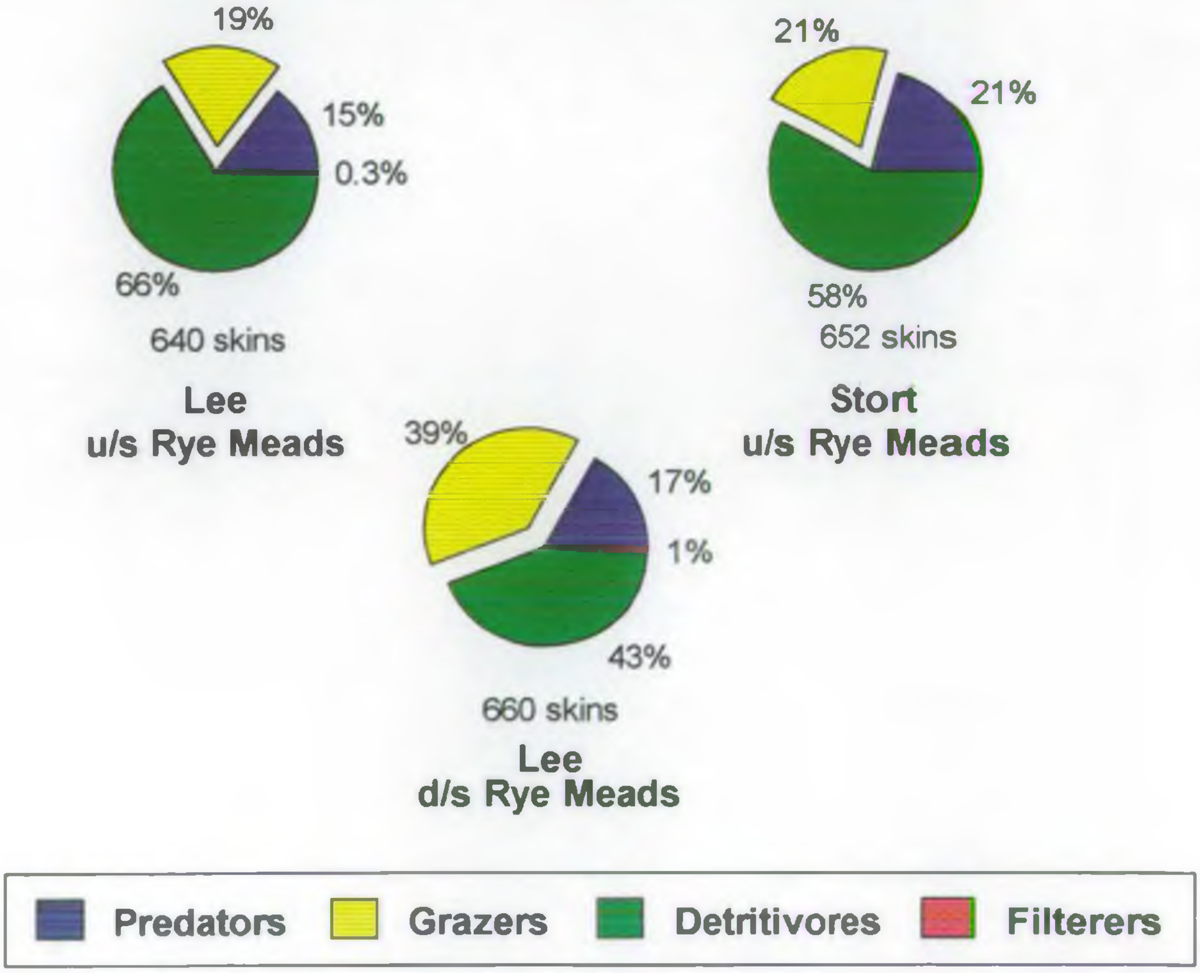

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Fig. 3 Deephams Trophic Groups

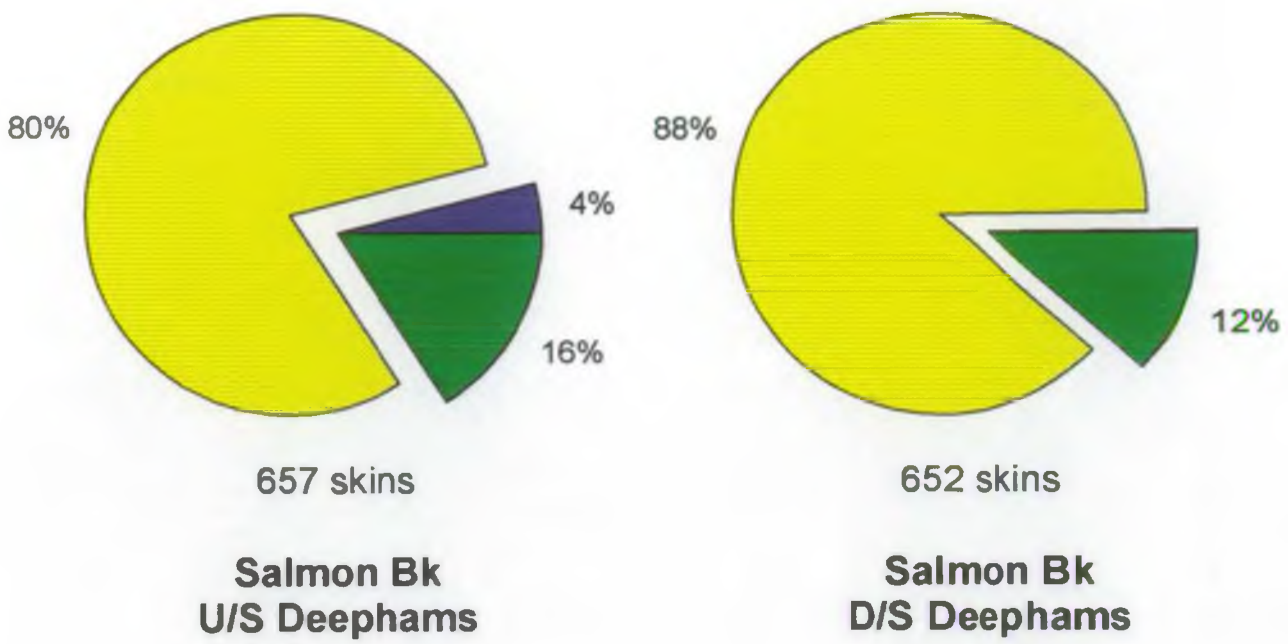

Fig. 4 Bishop Stortford Trophic Groups

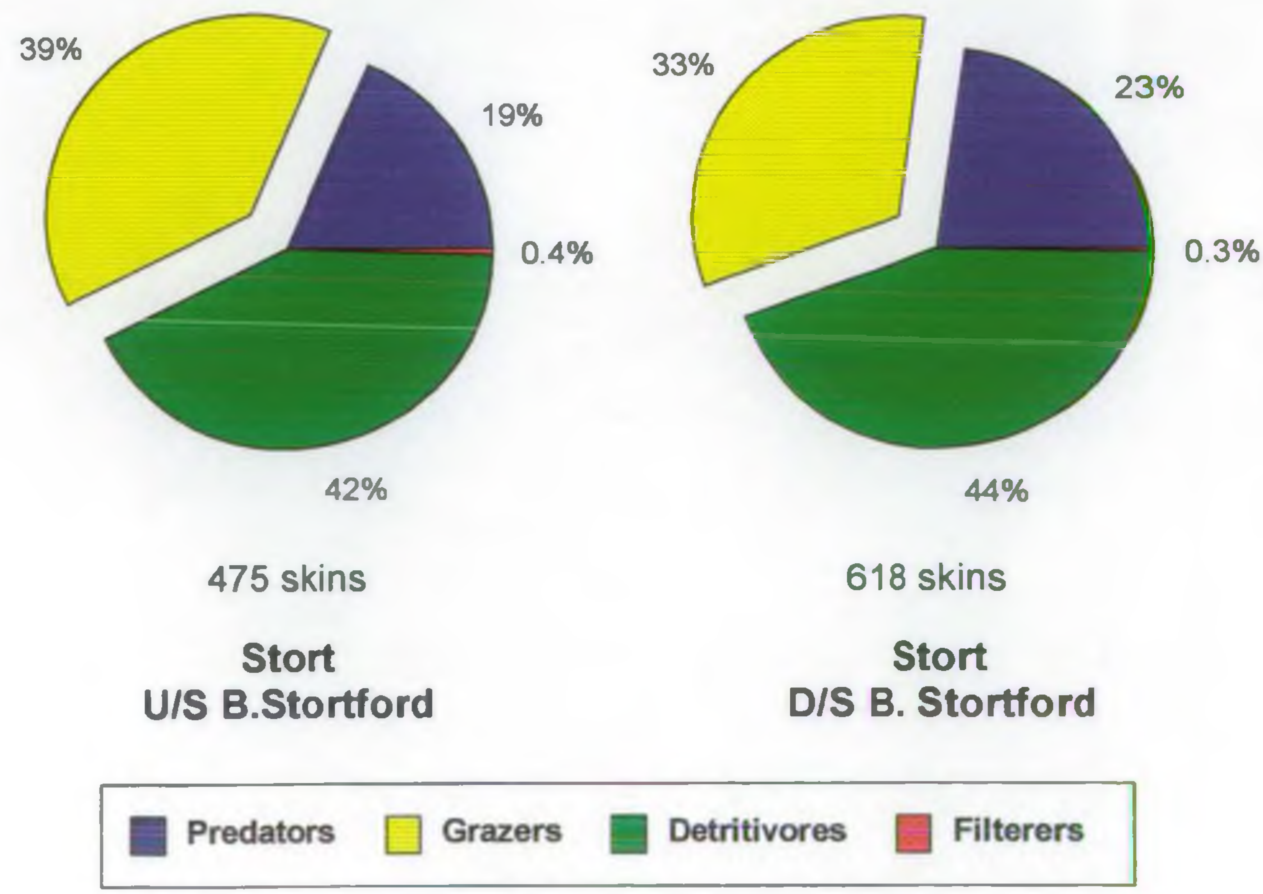

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Fig. 5 % Pollution Intolerant Individuals

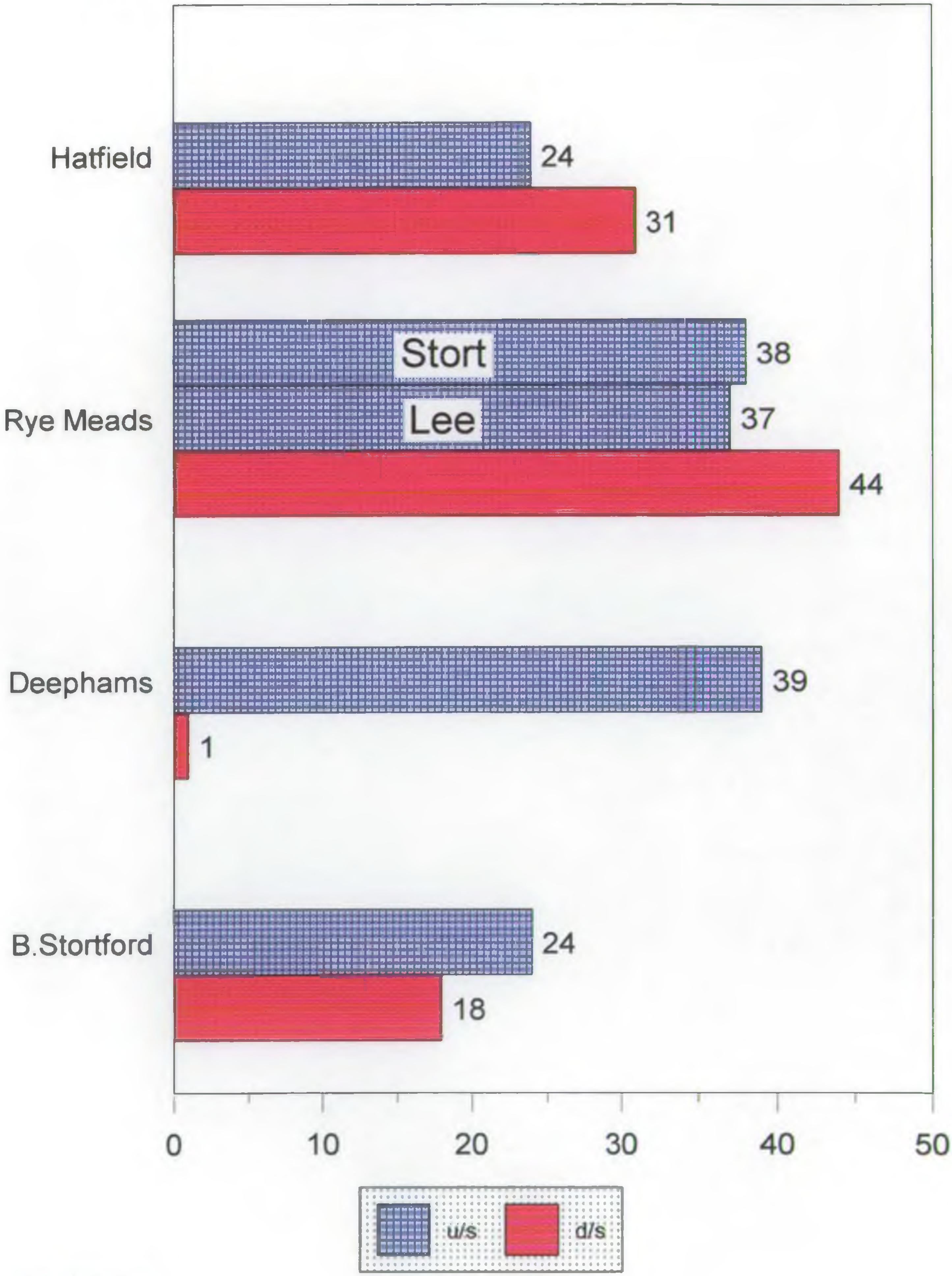

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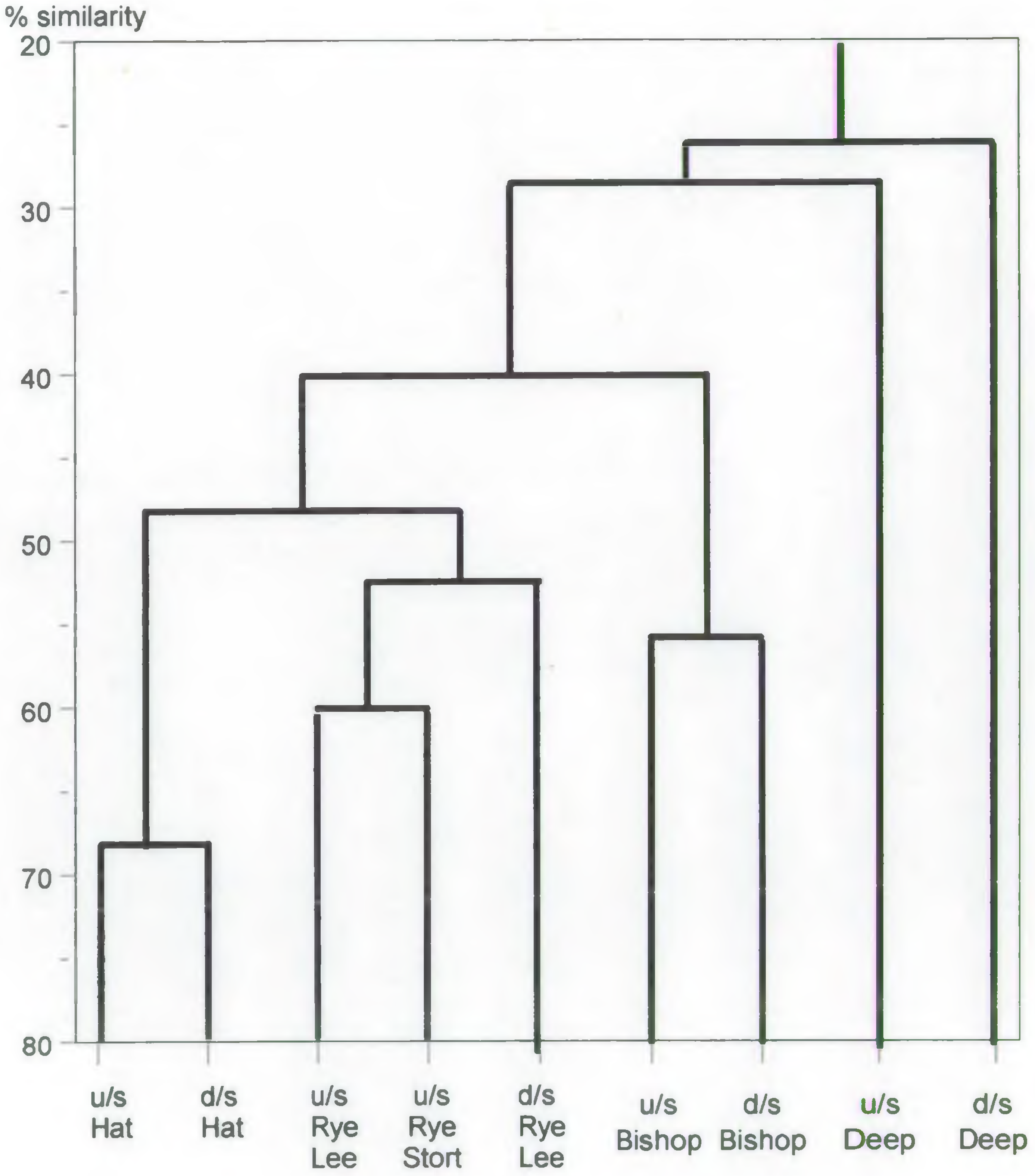
Fig. 6 Similarity of chironomid communities



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