Hydrobiologia **506–509:** 203–207, 2003.
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Factors controlling the occurrence of Dinophyta species in Hungary

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Key words: Dinophyta, water temperature, chemical organic demand, total phosphorus, phytoplankton functional groups

Abstract

A total of 512 samples collected from 86 Hungarian water bodies were analyzed for Dinophyta species and compared to common limnological characteristics. Temperature and organic matter content were the most important factors controlling the occurrence of Dinophyta species. Total phosphorus and conductivity were of lesser importance. On average, seven to eight taxa of Dinophyta were recorded in individual samples at a temperature of 12–18 °C and a COD_{Mn} < than 5 mg l^{-1}. Usually five to seven Dinophyta taxa were recorded at a temperature of 22–26 °C and COD_{Mn} > than 10 mg l^{-1}. The most important genera were *Peridiniopsis, Cleistoperidinium* and *Ceratium*. A two-factor principal component model explained 72% of the total variance within the data set. The first principal component explained 75 and 85% of the total variance within the temperature and organic matter variables. A cluster analysis, using within-group linkages, resulted in five groups of organisms that differed primarily with respect to their distribution along a temperature gradient.

Introduction

In spite of the importance of the Dinophyta in many freshwaters, very little is known about factors that influence their occurrence. They can be found in lakes from near the equator (Lake Victoria: *Ceratium brachyceros, Peridinium cunningtonii, P. westii, P africanum*; Woloszynska, 1914); Lake Tanganyika: *Peridinium africanum*; Hecky et al., 1978), to high latitude Arctic lakes (*Peridinium willei, P. cinctum*; Darkin & Latarche, 1913). The range of altitudinal distribution is also considerable. *P. cinctum* f. *westii* blooms in Lake Kinneret (Sea of Galilee, Israel) 209 m below sea level (Komarovsky, 1959; Pollingher, 1986) and in Sasuma reservoir (Kenya) 2474 m above sea level (Lind, 1968). Accumulating information on Dinophyta ecology did not solve some crucial questions since much of it remained scattered without substantial ecological analyses (Nõges et al., 2003; Rodrigo et al., 2003). In this paper our purpose is to investigate the relative importance of water temperature, chemical organic demand (COD_{Mn}) and total phosphorus levels that may control the distribution of 23 taxa of Dinophyta species found in 512 samples from 86 water bodies.

Material and methods

A total of 512 samples from 86 bodies of water were collected between 1991 and 2001 and analyzed for the presence of Dinophyta taxa. All the studied lakes were rather shallow ecosystems (0.5–4.2 m) of various origin (artificial ponds, oxbows, dead-arms, natural small lakes formed largely by wind erosion). Identification of Dinophyta was based on Popovský & Pfiester (1990) and Grigorszky et al. (1999). Phytoplankton counting was done according to Utermöhl (1958) with an inverted microscope (Axiovert-100). Of the measured chemical variables, only water temperature, total

phosphorus and chemical organic demand (COD) are used in this paper to characterize the samples. These were measured according to technical guidelines of the Hungarian water quality monitoring service. We checked the species richness along trophic gradient with Box-Whisker calculations (Jeppesen et al., 2000). Cluster analysis (Euclidean distance; average within-group linkages) was used to group the 23 taxa (Tóthmérész, 1993). PCA was done by the PC version of the SPSS package (Nörusis, 1985).

Results

Twenty-three species were found during this study: *Ceratium cornutum, C. furcoides, C. hirundinella, Diplopsalis acuta, Gonyaulax apiculata, Katodinium vorticella, Peridiniopsis berolinense, P. cunningtonii, P. elpatiewskyi, P. kevei, P. penardiforme, P. polonicum, Peridinium achromatium, P. aciculiferum, P. bipes, P. cinctum, P. incospicuum, P. lomnickii, P. palatinum, P. umbonatum, P. willei, Sphaerodinium cinctum* and *Woloszynskia pascheri.* Total phosphorus content had little effect on number of Dinophyta species per collection (Fig. 1A). For the five ranges of total phosphorus (TP) considered, no significant differences in the number of Dinophyta species were found. The water temperature and COD had strong influences on the number of Dinophyta taxa per collection (Fig. 1B, C). On average, 12 species per collection were recorded in the water temperature range of 13–14 °C (Fig. 1B). Fewer taxa were found at water temperature ranges either below or above. At temperatures > 20 °C the number of taxa increased and reached another maximum at 23–24 °C (twelve species). Above this temperature the number of Dinophyta species per collection decreased. On average, 12 species of Dinophyta per collection were recorded between a COD range of 3.75 and 6.25 mg l^{-1} (Fig. 1C). Fewer taxa were found as the COD increased above 6.25 mg l^{-1}. Likewise, the number of taxa per collection was reduced significantly in waters when COD is = 3.75 mg l^{-1}. Fewer species were found below 13.75 and above 16.25 mg l^{-1}. (Fig. 1c). Species diversity was independent of physisco-chemical parameters using Box-Whisker calculation. A two-factor principal component model explained 72% of the total variance within the data set. The first principal component explained 75 and 85% of the total variance within the temperature and organic matter variables. The first principal component analysis

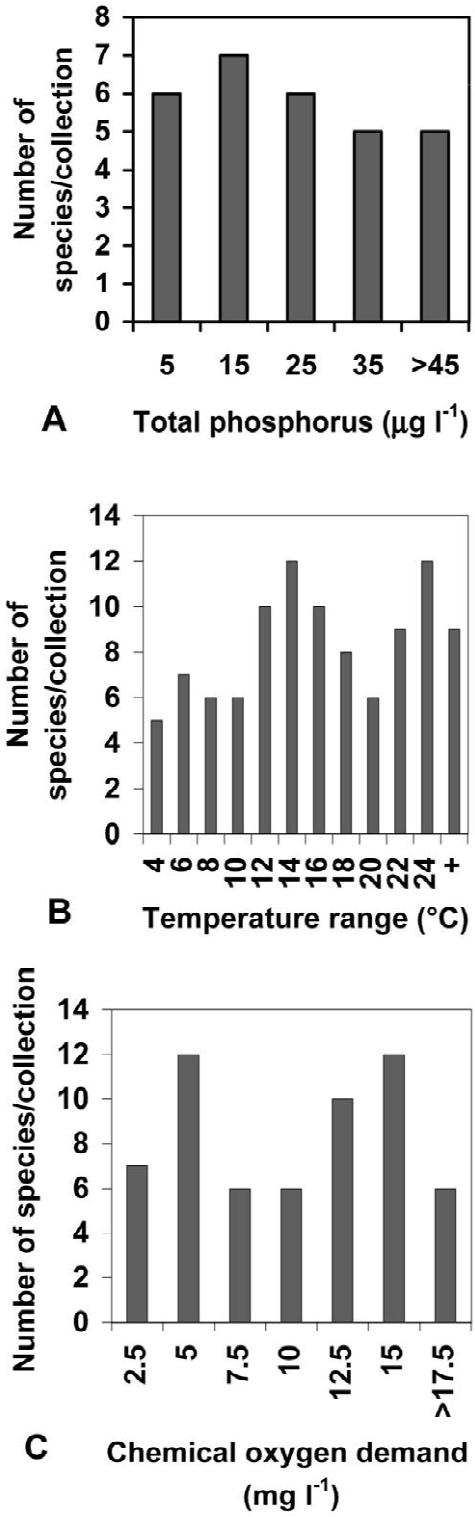

Figure 1. The mean number of Dinophyta species found per collection for different ranges of physico-chemical parameters. (A) total phosphorus; (B) water temperature; (C) chemical oxygen demand.

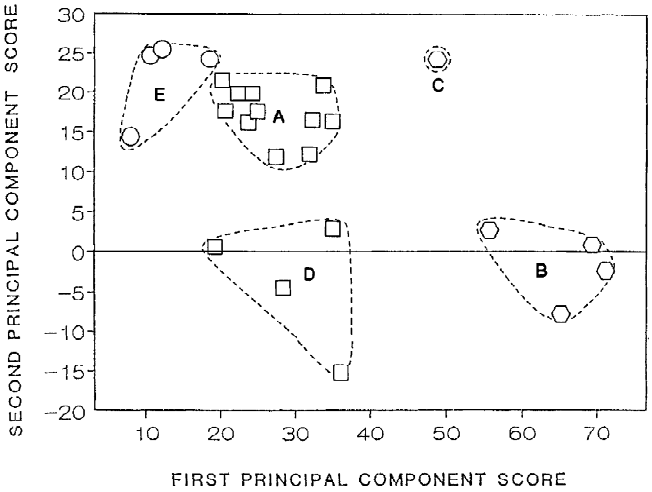

Figure 2. Ordination plot of 23 Dinophyta species on the first and second principal component axis. Five groups (clusters) defined by dashed lines, as determined by the cluster analysis presented in Fig 5. Symbols reflecting the temperature for each taxon (8, 9, 21, 22 °C).

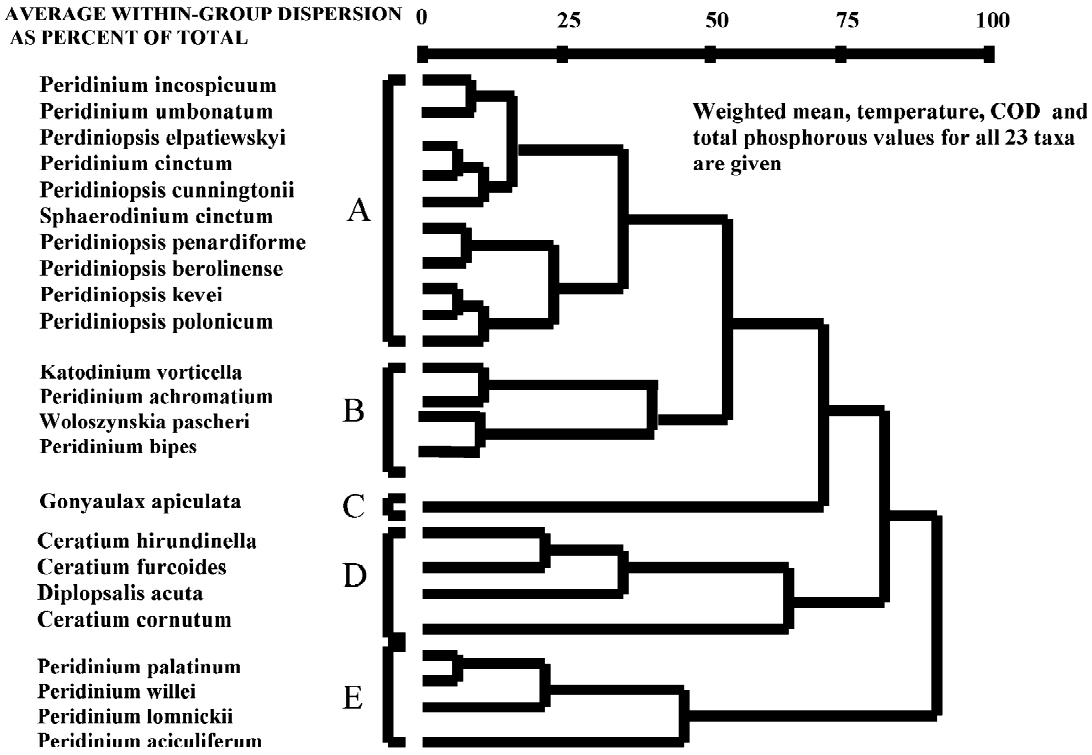

Figure 3. Cluster analysis for 23 Dinophyta species based on their distribution with respect to water temperature, chemical oxygen demand and total phosphorus in 86 water bodies.

(PC) was strongly dominated by temperature. The second PC was dominated by COD (Fig. 2). A cluster analysis, using within-group linkages, produced five groups of organism that differed primarily with respect to their distribution along temperature gradient (Fig. 3). Temperature and organic matter content were the most important factors controlling the distribution of Dinophyta species, total phosphorus was of minor importance.

Discussion

In recent years much emphasis has been placed on analyzing microalgal populations from different standing waters for monitoring water quality in Hungary (Padisák et al., 1991; Ács & Buczkó, 1996; Kiss et al., 2002; Borics et al., 2003). Diatoms have been used in most studies, but Dinophyta taxa have become an increasingly integral part of such limnological efforts (Gligora et al., 2003). Many of the most commonly reported species that were found in this study have wide environmental tolerances. Relationships between the importance of Dinophyta taxa and trophic state has been controversial. Some studies indicate a decline of species richness with increasing eutrophication (Lee et al., 1991), and other have not recorded any trend (Interlandi & Kilham, 1999).

Many of the most commonly reported species were clustered into group A (Fig. 3) and they have wide ranges of tolerance over 'normal ranges' of environmental conditions. Others had a variable occurrence pattern with respect to water temperature and they prefer higher organic matter content. Most 'high temperature + high COD' taxa were clustered into group B. The *Gonyaulax apiculata* occurred only in Lake Balaton, and formed alone group C. Group D taxa are found at higher water temperature with mesotrophic conditions. Most 'low temperature + low COD' taxa were clustered into group E. In the present study, the cluster analysis was used to demonstrate that lake water temperature combined with COD was instrumental in controlling the occurrence of taxa. Thus, these organisms could represent good biological indicators for COD in different water temperature ranges and results might be useful to sort Dinophyta species into the recently described functional groups of phytoplankton (Reynolds et al., 2002; Padisák et al., 2003).

Acknowledgements

The work was supported by the Hungarian National Science Foundation (OTKA No. F3182, T29636), the Békessy Science Foundation and the Higher Educational Research Fund (FKFP 0195).

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