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A first ecological evaluation of the diatom flora in Central Europe. Species diversity, selective human interactions and the need of habitat protection

[Die Diatomeenflora der Binnengewässer Mitteleuropas. Habitatbindung, selektive anthropogene Veränderungen und notwendiger Schutz gefährdeter Habitate]

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With 3 figures

Schlagwörter: Bacillariophyceae, Algen, Mitteleuropa, Autökologie, Ökologie, Habitatbindung, Gefährdung, Rote Liste, Schutz, Trophie

The recently revised check-list of diatoms in Germany contains 1437 taxa (1632 taxa for all of Central Europe). Clear correlations with ecological conditions were established for 1000 taxa (= 70 %). 267 predominantly marine taxa also occur in inland waters; they penetrate progessively into rivers under the influence of industrial waste waters. 61 are aerophilic, 164 eutraphentic, 91 tolerant to all trophic conditions. Extremely few species in these ecological groupings are endangered. However, by far most of the 417 oligo- or slightly mesotraphentic taxa are members of the "Red list". This strongly indicates that species diversity can best be protected by conserving oligo- and dystrophic, and the lower mesotrophic habitats.

Die neue Florenliste der Kieselalgen in Deutschland umfaßt 1437 Taxa gegenüber 1632 für ganz Mitteleuropa. Für 1000 Taxa (= 37 %) kennt man die Habitatbindung. 267 überwiegend marine Taxa kommen auch in Binnengewässern vor; sie dringen als Folge der Abwasserbelastung in die Flüsse ein. 61 Taxa sind aerophil , 164 sind als eutraphent bekannt und 91 als indifferent in trophischer Hinsicht; aus diesen Gruppen sind nur wenige Arten gefährdet. Hingegen wurde die überwiegende Zahl der 417 oligo- bis schwach mesotraphenten Taxa in die "Roten Liste" aufgenommen. Dies zeigt deutlich, daß die Artenvielfalt der Kieselalgen vor allem durch den Schutz oligo-, schwach meso- und dystropher Standorte erhalten werden kann. Erstmalig wird hier eine umfassende ökologische Evaluierung der Diatomeen einer größeren Region vorgestellt. Vergleichbare Untersuchungen gibt es bisher in anderen Ländern noch nicht.

1 Introduction

The recently revised and emended check-list ("Florenliste") of plants in Germany contains approximately 13 500 taxa representing all taxonomic classes. It is published as a book and includes the Red list ("Rote Liste") of endangered taxa (BUNDESAMT FÜR NATURSCHUTZ 1996). The Spermatophyta and Pteridophyta together contain 3001 specific and intraspecific taxa. For the first time the Bacillariophyceae are also presented together with other classes of photoautotro-

phic organisms which are known traditionally under the term algae, treated by the author (LANGE-BERTALOT 1996).

Diatoms represent the group of algae with by far the most taxa: 1437 taxa in inland waters. Marine diatoms have not been included, but the number of species is about the same as the limnetic diatoms. Thus, (surprisingly?) diatom diversity equals that of the so called higher plants in this area. Moreover, another 195 taxa which occur in adjoining regions of Central Europe have not yet been found or have disappeared in Germany recently. They are not included in the calculations used here. All data on diatoms in the check-list and Red list are based on literature published up to 1994, excluding the more recent publications with numerous taxa described as new, or established taxa newly detected in the area under discussion here. Without exception all taxa included in the check-list are documented by photographs in the reference literature.

Information about the criteria used for classing the species for instance as extremely rare or more or less endangered, or actually not endangered but regressive - is given in the publication of BUNDESAMT FÜR NATURSCHUTZ (1996, p. 8-13). The actually revised criteria are specified in detail and considerably complicated and apply in general to all classes of the plant kingdom.

From an international point of view this seems to be a pilot study. No comparable study from other countries is known that concerns a qualitative and quantitative evaluation of the diatom flora of a larger region.

2 Results

Grouping between endangered and more to less unaffected taxa (Fig. 1)

The number of 1437 diatom taxa for Germany, 1632 for Central Europe, reflects the progress of studies since HUSTEDT (1930), who cited only c. 600 taxa in his comprehensive "Süsswasserflora von Mitteleuropa"

1. This first Red list contains 304 (variously) endangered and 231 extremely rare taxa determined as endangered by definition. Extremely rare is defined as only a single or less than six records, and then always in low individual numbers. The total of endangered taxa - so qualified by the specialists of our country is therefore 535 (= 37.2 %). This percentage is quite similar to the other classes of plants. The percentage would be significantly higher if the 195 (altogether more or less rare) taxa of Central Europe which have not yet been found in Germany were taken into consideration.

2. An additional 132 taxa (9.2 %) seem to have been regressing over the last decades although they are not virtually endangered - at the moment.

3. Insufficient data is available for 230 taxa (16 %). The reasons are mostly uncertain taxonomic identities, e.g. questionable diagnoses or difficulties in discriminating between similar forms in a species complex. Difficulties originate not

only from splitting groups of traditional entities, but also from new synonymies at the species level as in the case of many centric plankton diatoms.

4. 340 taxa (23,7 %) seem not actually to be endangered. This category contains taxa that are fairly rare to frequent or abundant and that are included because their habitats remain unaffected. They do not however, show a tendency to mass development, and seem not to be as favoured by effects of civilisation as the next group.

5. High vitality is characteristic of the group of "opportunists" which are apparently favoured by the well known anthropogenic impacts on the natural conditions of waters. This group has exactly 200 taxa (13.9 %), mostly cosmopolitan.

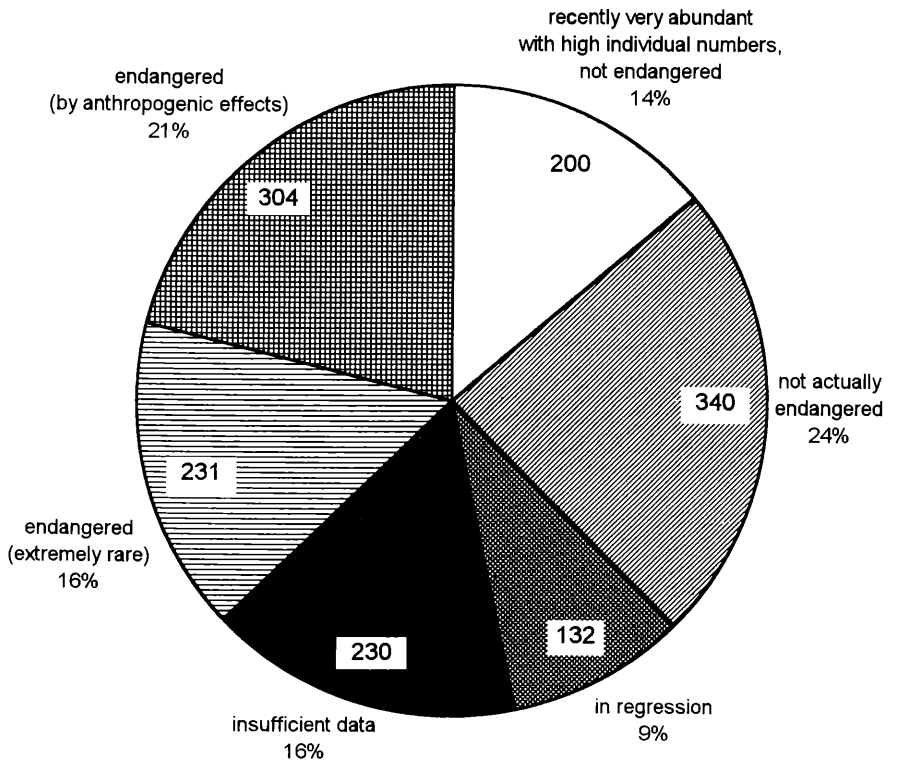

Fig. 1: Evaluation of 1437 diatom taxa known and documented from inland waters in Germany (until 1994). The sectors represent the number and percentage of taxa belonging to distinct categories, dependant on different tolerance/sensitivity to civilisation influences

Habitat correlations (autecology) of the taxa (Fig. 2)

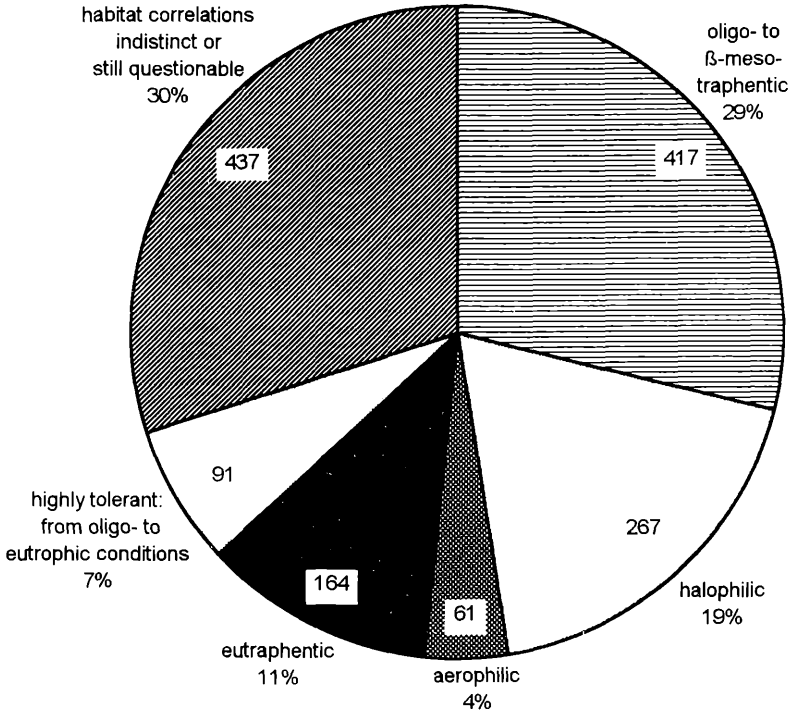

Fig. 2: Correlation of 1437 taxa (see Fig. 1) with habitat conditions

Clear correlations with specific ecological conditions could be established for 1000 taxa (70 % of 1437), but the correlation was broader, less clear, or questionable for 437 (30 %), in the present state of our knowledge. This group also includes taxa with known ecological amplitudes which, however, do not fit into the recognized categories, although the species may be used as indicators for the presence or absence of other special environmental conditions.

1. Halophilic or mesohalobic: 267 taxa (18.6 %). They live predominantly in the marine littoral, but also occur in inland waters of high electrolyte content, e.g. springs of different salt concentrations, the tidal zone of river estuaries.

2. Characterized as aerophilic: 61 taxa (4.2 %). Mainly occurring in subaerial conditions, e.g. the so called earth diatoms from wet to dry soils, and on intermittently wet bryophytes, or in the supralittoral of running and standing waters.

3. Almost exclusively under eutrophic conditions: 164 taxa (11.4 %). This category includes oligosaprobic to polysaprobic conditions in relation to the level of organic pollution. It should be noted that a detailed evaluation of indicator value was not the subject of this study (cf. LANGE-BERTALOT 1979).

4. Tolerant in relation to the trophic state: 91 taxa (6.4 %). They live with equally high vitality under oligo- through meso- to eutrophic conditions, but do not tolerate pollution levels greater than beta-mesosaprobic.

5. Distinctly intolerant of higher trophic (and inherently saprobic) conditions: 417 taxa (29 %). They indicate oligo- to moderately mesotrophic (= beta-mesotrophic) waters. The differentiation between dystrophic and calcium-rich and electrolyte poor water is not considered in this paper, though it is at least partly covered in the check-list and Red list.

3 Discussion

The Fig. 3 is an intentionally simplified graph summarizing the relations between numbers of taxa, autecology and Red list groupings. It must be admitted that there are more than a few exceptions.

In general the vitality of halophilic, aerophilic, eutraphentic, and trophically tolerant taxa is not affected by anthropogenic influences. Thus they are not members of the Red list. The halophilic species appear not only to be unendangered, but also to be penetrating progressively into rivers and streams under the influence of industrial waste waters.

Organic pollution (= saprobity) resulting from untreated or insufficiently treated sewage from purification plants has stopped, or at least has been reduced over the last 15 years. The effect on diatoms has been a considerable regression of pollution tolerant or extremely resistant species groups indicating water qualities from a-mesosaprobic to polysaprobic (LANGE-BERTALOT 1979).

The assemblages that were previously abundant almost everywhere in Central Europe have been replaced (extensively) by other assemblages dominated by 150-200 taxa indicating beta-mesosaprobic waters. Thus in a long term study of the river Rhine - the upper and middle reaches downstream from Basel there are c. 180 taxa (KRAUSE 1994). Comparable or lower numbers are found in many other eutrophic/beta-mesosaprobic rivers or lakes and ponds. In contrast we found a record of 502 taxa in a single sample from an oligodystrophic lake in Finland (LANGE-BERTALOT & METZELTIN 1996). This number is extremely high but we find regularly more than 200 and occasionally more than 300 taxa in other oligotrophic lakes.

A large majority of the oligotraphentic or oligo- to beta-mesotraphentic species are members of the Red list. In addition, a considerable part of the group with still questionable habitat correlations belongs to the Red list taxa. Comparatively few Red list taxa are found in the other ecological groups. This strongly

indicates that species diversity can best be protected by conserving oligotrophic, dystrophic and the lower mesotrophic habitats. The question is whether or not it is possible to stop eutrophication - as was successfully achieved in the past with excessive saprobity. In reality oligotrophic habitats are still progessively contaminated by inorganic nutrients. Our forecast about the survival of many Red list taxa is consequently pessimistic at least for Central Europe. They were well adapted to oligotrophic or dystrophic waters. Such inland waters were widespread throughout prehistoric to historic times in Central Europe. During this period, the Red list taxa were abundant and even dominant. The eutraphentic taxa in contrast were representatives of a minority. The pre-industrial to the industrial period, together with intensive fertilizing of farmland has led to ubiquitous eutrophication. Almost no adequate habitats remain for the majority of sensitive taxa adapted to low nutrient concentrations.

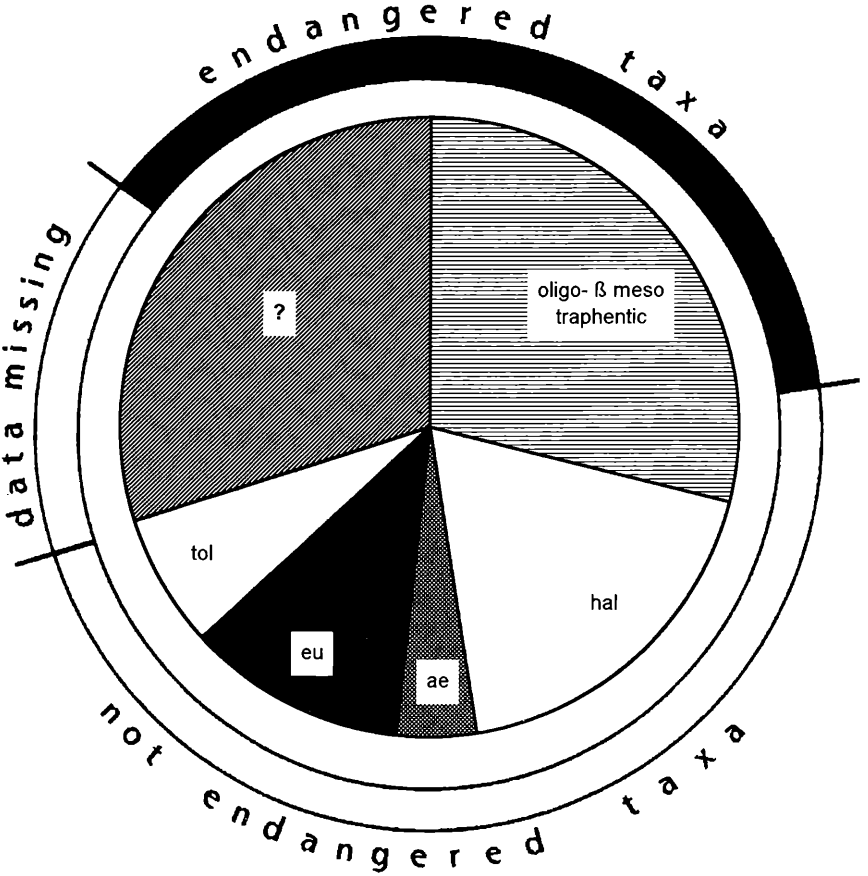

Fig. 3: Correlation of habitat conditions and "Red list" taxa (cf. Figs. 1 and 2)

Thus we find eutrophic conditions caused by airborne inorganic phosphorus contamination even in "organically unpolluted" sources of streams. An effect of this is highlighted by the rare oligotraphentic *Pinnularia* and *Eunotia* species with voluminous cells, which even in boreal Europe, America and Siberia exist only in low individual numbers. They have disappeared from the recent flora of Central Europe, but the valves still can be found as fossil or subfossil remains in cultivated grassland soils on former bogs or other wet habitats.

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