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The taxonomy of the genus *Enteromorpha* Link in the Gulf of Gdańsk, a numerical approach

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Abstract

The genus *Enteromorpha* Link is one of the most common algae in the Gulf of Gdańsk. The literature mentions that several *Enteromorpha* species occur in the western part of the Gulf of Gdańsk. The material for analysis was collected in the littoral zone down to a depth of 1 m in the Gulf of Gdańsk and on the open Baltic coast once a month from April to November 1986. The taxonomical characters, the nature of the bottom sediments and the sampling season were used for describing OTUs. 6 dissimilarity coefficients and 7 clustering methods were employed. The two principal clusters and some intermediate OTUs are shown on the dendrograms. The difference between these two clusters lies in the morphological characters. In one of them, the filaments are unbranched, without prolification, and the cells are multilateral and rounded, setting in random fashion; in the second one the filaments are branched, and the cells are rectangular, setting in an orderly manner along the main axis and the branches. The remaining characters, especially the quantitative ones do not seem to be important from the cluster analysis point of view.

Introduction

Enteromorpha species are currently the dominant group of algae in the littoral zone of the Gulf of Gdańsk (PLIŃSKI et al. 1988). The importance of this genus in the biocoenosis of the Gulf od Gdańsk has risen as a result of the declining numbers of other taxons, such as *Fucus vesiculosus* and *Furcellaria fastigiata* possibly as a result of changing environmental conditions and ongoing eutrophication of the Gulf. Studies of the macroflora in the Gulf of Gdańsk (LAKOWITZ 1907, KORNAS et al. 1960, PLIŃSKI 1982, PLIŃSKI and FLORCZYK 1984) have shown that a change in the species composition of the genus *Enteromorpha* has taken place over the past 60 years. The once clear picture of this composition has become blurred, owing to the poor environmental conditions in the Gulf (PLIŃSKI and WIKTOR 1987). Together with the considerable morphological plasticity of the genus *Enteromorpha* (VINOGRADOVA 1972, KOEMAN 1985), this blurring has created serious problems of taxonomic classifications. Therefore, while the usual taxonomic characters were employed as a basis for determining the species composition of the genus *Enteromorpha* from the Gulf of Gdańsk, the analysis was completed by the use of numerical methods. As yet, these methods have been applied in only a few algological papers, but they do give good results: for example, the Ectocarpaceae family was described in this way by RUSSELL (1975, 1978).]

Material and methods

The material was collected from the littoral zone down to a depth of 1m every month from April to November 1986. Samples were taken from all around the Gulf of Gdańsk and from

the open-sea side of the Hel Peninsula. Each individual thallus in a sample was counted as one OTU. The OTUs were described by a set of morphological characters which included the main taxonomic characters given by various authors in keys. In addition, a number of ecological characters connected with the mode of the OTU occurrence were introduced (Table 1).

Table 1

List of characteristics

1. Width of main axis cells
2. Length of main axis cells
3. Thallus width
4. Distance between branchings
5. Number of pirenoids
6. Order of branchings
7. Months
8. Epiphytes
9. Occurrence of branching
10. Opposite branchings dominant
11. Alternate branchings dominant
12. Occurrence of irregular branching
13. Singular row of cells at the end of branches
14. Prolifications
15. Circular cross-section
16. Plants attached
17. Thallus waved
18. Cells rectangular
19. Cells square
20. Cells multilateral
21. Cells rounded
22. Cells setting in random fashion in the main axis
23. Cells setting in random fashion in branches
24. Cells setting in an orderly manner (main axis and branches)
25. Stony bottom
26. Wooden pales
27. Concrete plates
28. Submerged thallus

6 dissimilarity coefficients and 7 clustering methods were applied.

Coefficients:
Squared Euclidean Distance:

$$ED = \sum_{n=1}^{k} (x_i - x_j)^2$$

Manhattan Distance:

$$MD = \sum_{n=1}^{k} | (x_i - x_j) |$$

Canberra Distance:

$$CD = \sum_{n=1}^{k} \frac{|(x_i - x_j)|}{|(x_i + x_j)|}$$

Sajzy Distance:
(ABBOTT et al. 1985)

$$SD = \sum_{n=1}^{k} \frac{|(x_i - x_j)|}{\max(x_i, x_j, |x_i - x_j|)}$$

Queue Coefficient:

$$T_{ij}^{1} = \sum_{n=1}^{k} L_p f_p$$

Queue Distance:
(BATKO 1986)

$$T_{ij}^{2} = 2T_{ij}^{1} - T_{ij}^{1} + T_{ij}^{2}$$

k:– number of characters
x_i: value of character in i item
x_j: value of character in j item
L_p: values of character p in items i and j
f_p: number of items which have values of character p between items i and j

Clustering methods: UPGMA, WPGMA, Flexible sorting, Centroid sorting, Ward method, Single link, Complete link (ABBOTT et al. 1985).

The analysis was done on standarised (Squared Euclidean Distance, Manhattan Distance), normalised (Sajzy Distance) and basic data (Canberra Distance, Sajzy Distance, Queue Coefficient, Queue distance). 49 dendrograms were obtained which were then scanned for repeating clusters.

The computations were done on an Amstrad PC 1512 computer using the "CLUSTER" programme (FLORCZYK 1987).

Results

The analysis of the dendrograms showed that two principal clusters **A** and **B** were repeated on most of them (Fig. 1). The fundamental difference between these two clusters is the presence or absence of branching. The OTUs in cluster **A** were unbranched, those in cluster **B** were branched. The OTUs in cluster **A** were additionally characterised by randomly arranged polygonal cells and unprolificated thalli. Cluster **B** was further distinguished by the presence of rectangular or square cells arranged linearly along both the main axis and the branches; some thalli were prolificated.

The remaining OTUs (cluster **C**) which were linked in various ways depending on the coefficient and clustering method did not give any clear group.

No separate cluster of OTUs from the open-sea side of the Hel Peninsula was found.

Discussion and conclusion

The two clusters of thalli from the genus *Enteromorpha* distinguished in the material collected from the Gulf of Gdańsk can be assigned to the species described in keys (STARMACH 1972, PANKOW 1971, PLIŃSKI 1980) Cluster **A** can be classified as

Enteromorpha intestinalis (L.) Link, whereas cluster **B** shows characteristics typical of two species – *Enteromorpha flexuosa* (Dillwyn) Bliding and *E. ahlneriana* Bliding. The presence

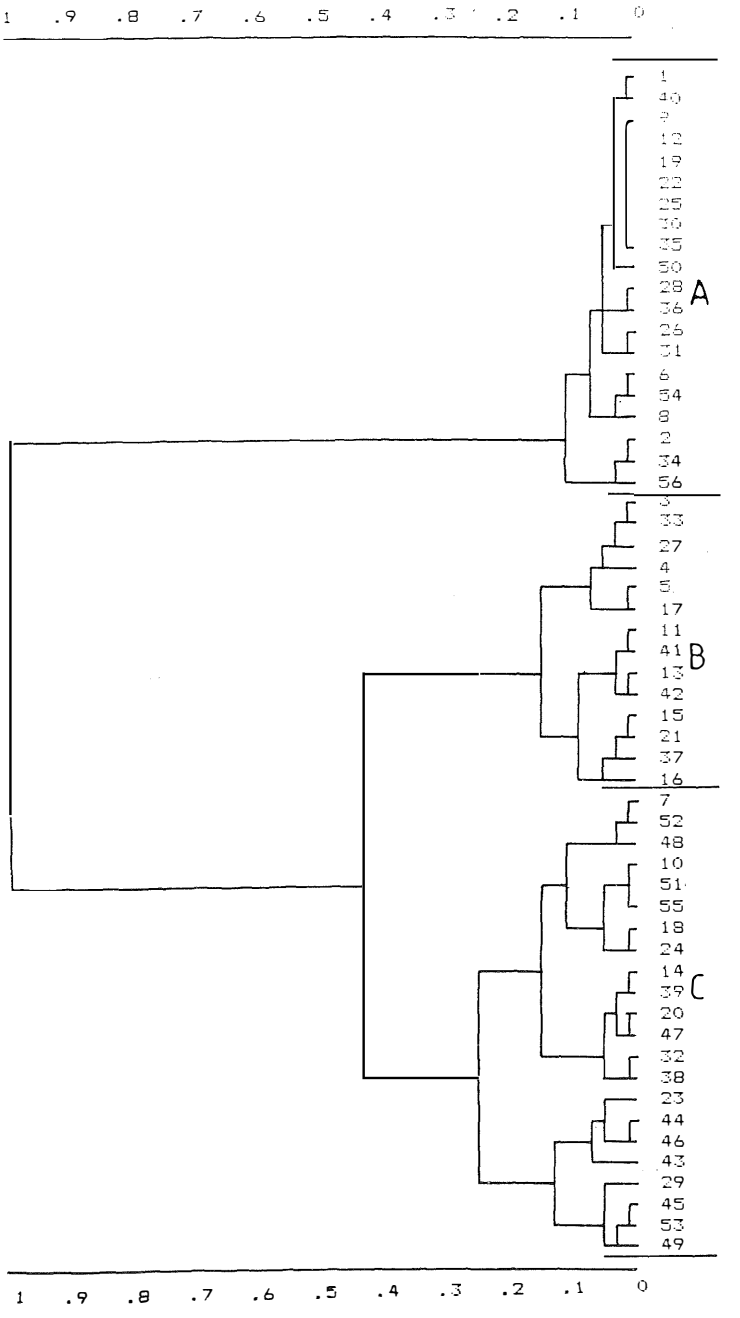

Figure 1

Dendrogram showing *Enteromorpha* clusters. Squared Euclidean Distance; Ward method (all characteristics)

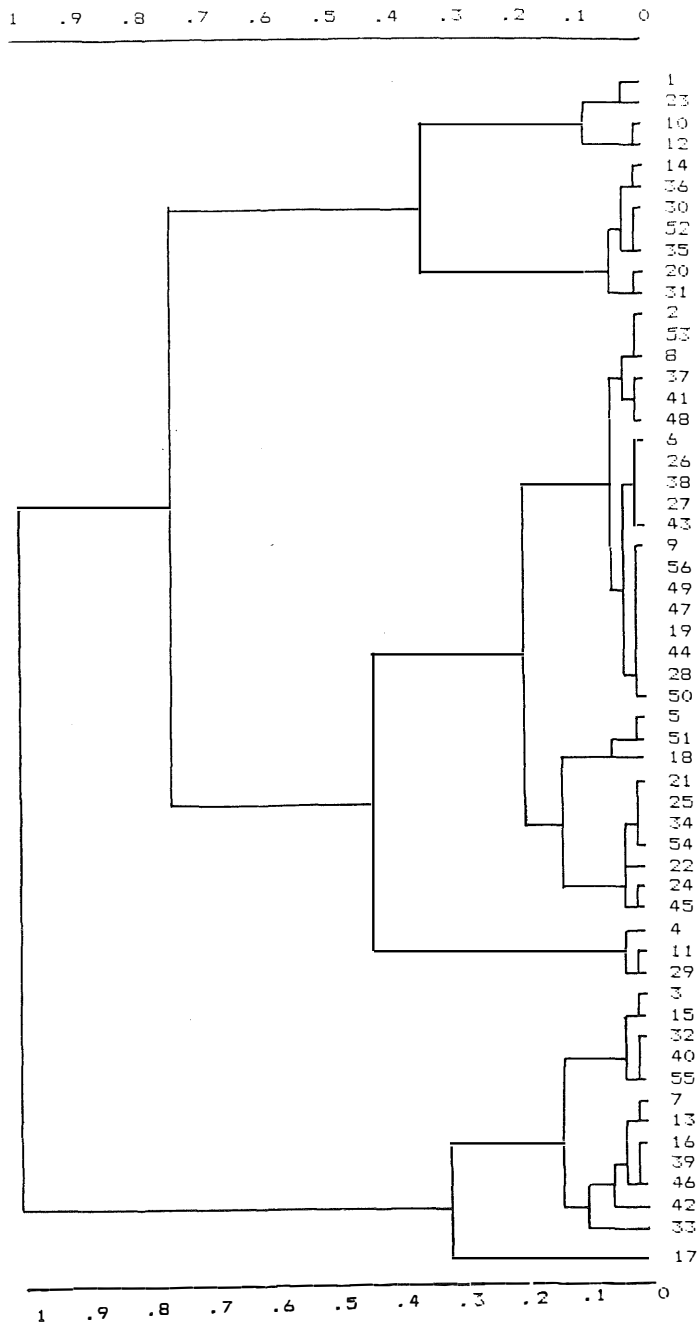

Figure 2

Dendrogram showing *Enteromorpha* clusters. Squared Euclidean Distance; Ward method (quantitative characteristics)

of these two species in the same cluster suggests that they are very similar to each other. It is possible that a more precise analysis of characters will show that this cluster is in fact one species. A thorough analysis of these clusters indicates that some of the characteristic hitherto deemed essential in the systematics of the genus *Enteromorpha*, are of no importance. They include the length and breadth of the cell, neither of which is characteristic of a cluster. The common practice of identifying a species according to its quantitative characters as for example cell dimensions (VINOGRADOVA 1972, KOEMAN 1985), would therefore appear questionable. For the most part, these characters are not significant, that is, they do not differentiate the OTUs sufficiently well. The clustering based on the quantitative characters (1–5 from the table 1) gave results, which are very difficult for clear interpretation (Fig. 2), especially comparing this with the classification done on the all characters (Fig. 1), in which this quantitative once make up only 18 %. Therefore we believe that the qualitative characters, particulary the presence of branching and the arrangement of cells in the thallus and their shape, are of greater significance. The methods of numerical taxonomy are extremely useful in obtaining results of this type.

References

ABBOTT, L.A., F.A. BISBY and D.J. ROGERS, 1985. Taxonomic analysis in biology. Computers, models, and databases. Columbia University Press, New York, 1–332.

BATKO, A., 1986. The numerical taxonomy package TAXAL (Algorithms for Taxonomy). Institute of Botany, Warsaw University.

FLORCZYK, I., 1987. The numerical taxonomy package CLUSTER (Algorithms for Taxonomy). Institute of Oceanography, Gdańsk University.

KOEMAN, R.P.T., 1985. The taxonomy of *Ulva* Linnaeus 1753, and *Enteromorpha* Link 1820, (Chlorophyceae) in the Netherlands. Drukkerij van Denderen B.V. Groningen. 1–201.

KORNAS, J., E. PANCER and B. BRZYSKI, 1960. Studies on Sea – Bottom Vegetation in the Bay of Gdańsk off Rewa. Fragm. Flor. Geobot. **6**, 3–92.

LAKOWITZ, K., 1907. Die Algenflora der Danziger Bucht. Gdańsk, 1–149.

PANKOW, H., 1971. Algenflora der Ostsee. Benthos. V. E. B. Gustav Fischer Verlag, Jena, 1–388.

PLIŃSKI, M., 1980. Glony Zatoki Gdańskiej. Klucz do oznaczania gatunków. Cz. VI, Zielenice. (The algae from the Gulf of Gdańsk. Key for species identification. Part VI, Green algae.) University of Gdańsk, 23–32. (In Polish).

PLIŃSKI, M., 1982. The distribution and biomass of phytobenthos in Puck Bay. SiMO. **6**, 33–40.

PLIŃSKI, M. and I. FLORCZYK, 1984. Analysis of the composition and vertical distribution of the macroalgae in western part of the Gulf of Gdańsk in 1979 and 1980. Oceanologia, **19**, 101–115.

PLIŃSKI, M., I. FLORCZYK and M. MANASTERSKA, 1988. Long-term changes in the composition of phytobenthos from the Gulf of Gdańsk. Proceedings of 21st European Marine Biologists Symposium, Gdańsk 1986.

PLIŃSKI, M. and K. WIKTOR, 1987. Contemporary changes in coastal biocenoses of the Gdańsk Bay (south Baltic). A review. Pol. Arch. Hydrobiol. **34**, 81–90.

RUSSELL, G. and R.L. FLETCHER, 1975. A numerical taxonomic study of the British Phaeophyta. J. Mar. Biol. Ass. U.K. **55**, 763–783.

RUSSELL, G. and D. GARBARY, 1978. Generic circumscription in the family Ectocarpaceae (Phaeophyta). J. Mar. Biol. Ass. U.K. **58**, 517– 525.

STARMACH, K., 1972. Flora słodkowodna Polski. t. 10. Zielenice. (Freshwater flora of Poland. v. 10. Green algae.) PWN. Warszawa, Kraków, 1–694. (In Polish).

VINOGRADOVA K. L., 1979. Opredielitiel vodoroslej dalnievostocnych morej SSSR. Zelonye vodorosli. (Key for identification of the algae from eastern seas of the Soviet Union. Green algae). Nauka, Leningrad, 94–116. (In Russian).