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HYDROLOGICAL TYPOLOGY OF BASINS IN THE LIGHT OF CLUSTER ANALYSIS

Within each larger continent area there is usually a characteristic diversification of physico-geographical features of a basin affecting the mutability of hydrologic cycle and its character. One of the objectives facing the present-day hydrology is therefore the tendency to try to describe diversification of the hydrological system and possibly also its features. The realization of this problem can be achieved through classification (typology) or hydrological regionalization. Each typological division, therefore, or regionalization of a basin ought to result from certain well-defined criteria.

Most recent hydrological regionalizations of the Polish rivers have been carried out against generally multiple criteria, i.e. hydrological features, including primarily seasonal runoff variation, character of feeding and of the regime of rivers (Stachý 1965, Dynowska 1971, Gutry--Korycka 1977, 1978; and Dobija 1981). A similar approach to the problem of regional division criteria of rivers is shown by Scandinavians: Tollan (1975), Gottschalk and others (1979). Properties of rivers as seen from the viewpoint of runoff variability have in all cases been dominating, while the criteria of division tend to be genetic in their character.

In hydrological divisions so far much of the discretion has been allowed for the approach to the boundaries of units, reference having been made chiefly to the deductively isolated physico-geographical regions, and this must be seen as a major research drawback. Looking for some more objective methods of delimitation seems therefore quite reasonable.

The use of numerical technique in hydrology carries along with it much greater potential as regards both methods and methodology in hydrological regionalization—as brought out by Simmers (1984). The decision-making procedure under each phase of the hydrological data regionalization analysis, in which room is reserved for both spatial and time-related mutability, comes in Simmer's opinion as a highly complex problem.

In this paper an attempt is made to confine this problem to the numerical method (cluster analysis) only, as the one based on the objective principles of hydrological classification.

The hierarchical grouping technique (cluster analysis) was rather popular in use in geography among Doornkamp and King (1971), Duran and Odell (1974) as well as Kaczmarek, Parysek (1977) and Kostrubiec (1980). A sequential criterion of adding separate elements of the basin is featuring it. According to several authors, the measure of distances *(d)* found from the Euclidean geometrical space appears to be the most objective criterion of a common taxonomic similarity
$D = \{d_{ik}\}$:

$$dik = \sqrt{\sum_{j=1}^{p} [y_{ij} - y_{kj}]^2}$$

wherein: y_{ij} — is the value of the j-th feature for the i-th basin item $[i \neq k = 1,2...m]$
Spatial information matrix consisting of 23 physico-geographical features, 6 digital characteristics of a normal hydrological cycle (i.e. corrected precipitation, total runoff, surface runoff, groundwater runoff, evaporation and area moisture),[1] found for 383 basins, constituted a data base for the numerical operation (Gutry-Korycka 1984).

Späth (1980) identifies several methods of hierarchical grouping (going uphill). This is why, the best criterion i.e. searching for the centre of gravity for clusters over the whole set has been chosen from among five trials. At the first procedural stage, groups (one cluster) consist of basins with the most similar features but as the value of threshold tends to abate more and more basins combine together to form groups until all of them are merged into only one class. A solution in this case is hence a hierarchy of classes with the number of clusters equal to n — 1; in other words, there are 382 dual-element clusters in the set under test. The resultant computer-produced dendrogram (Fig. 1) is the graphical image of the hierarchy of classes. The taxonomic space matrix (d) is included in the list of dual-element combinations (merge list) with a vast digital spread of taxonomic distances ranging from 0.2342 (the lowest grouping level) up to 68.4 for the highest dual-element combination.

The computer proceeds next with the automatic selection of merging basins and with the reordering of the succession of elements violating the order of the set (permutation), by following numerical rules as proposed by Anderberg (1973) and Boyd (1980).

1 Use has been made of the 1931—1960 hydrological data.

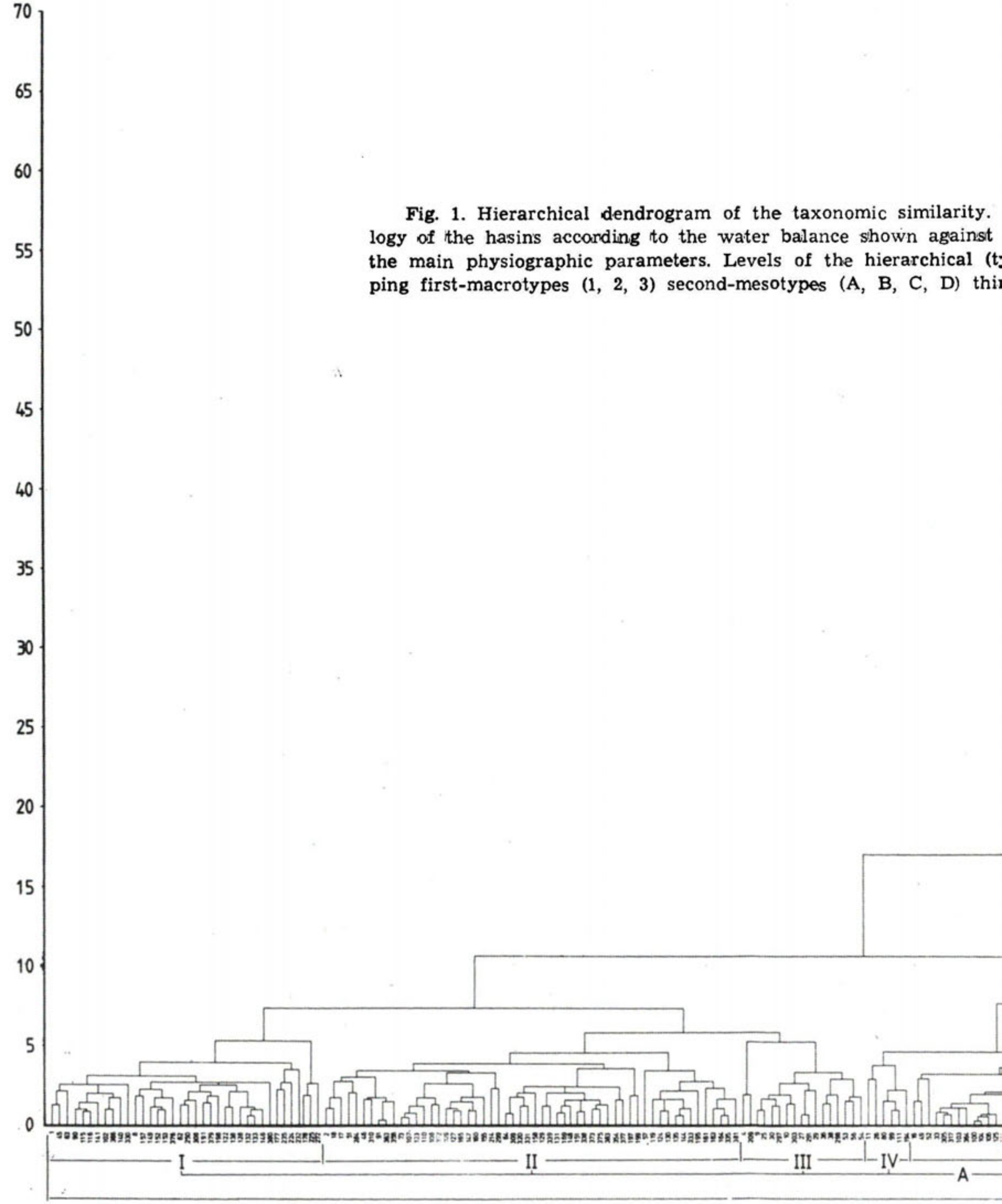
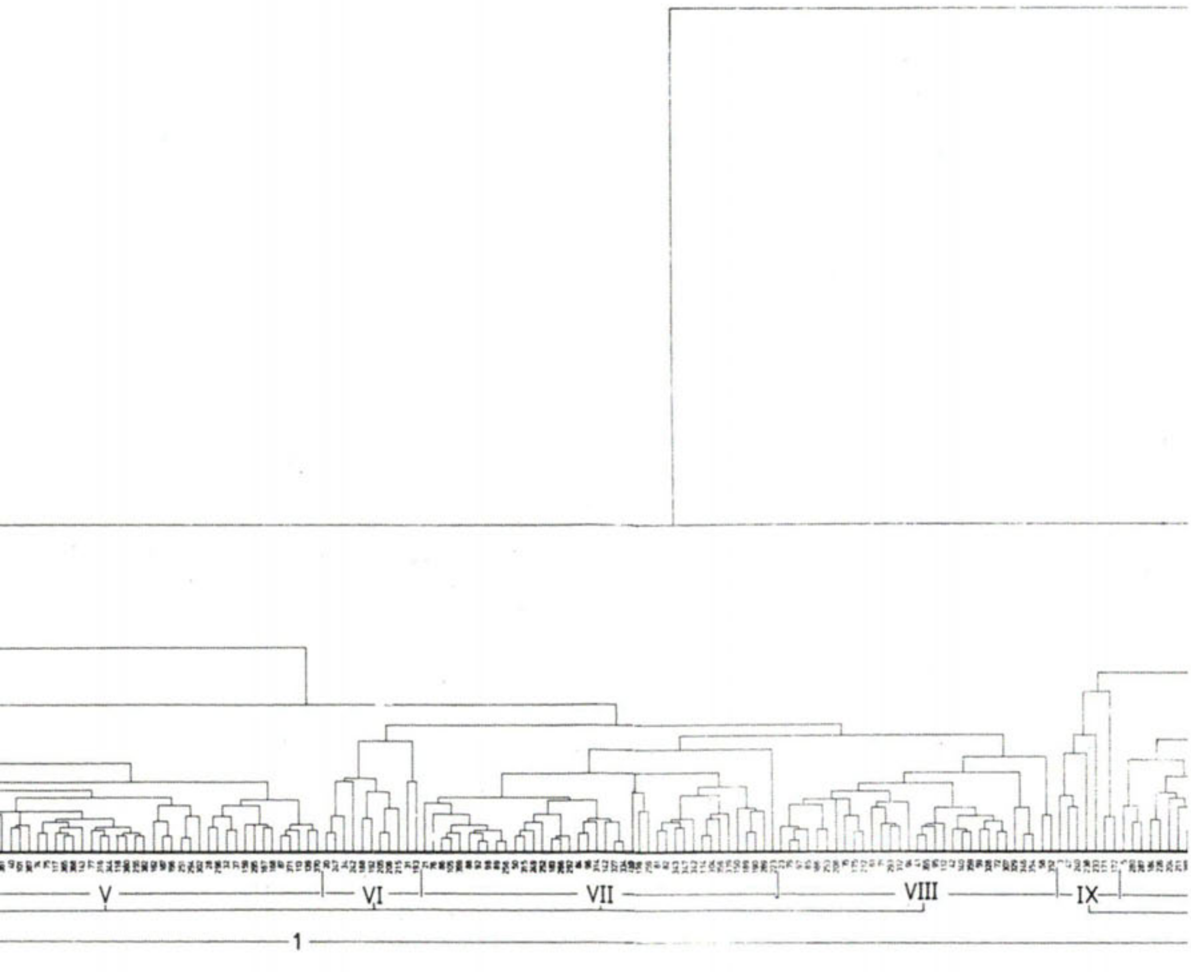
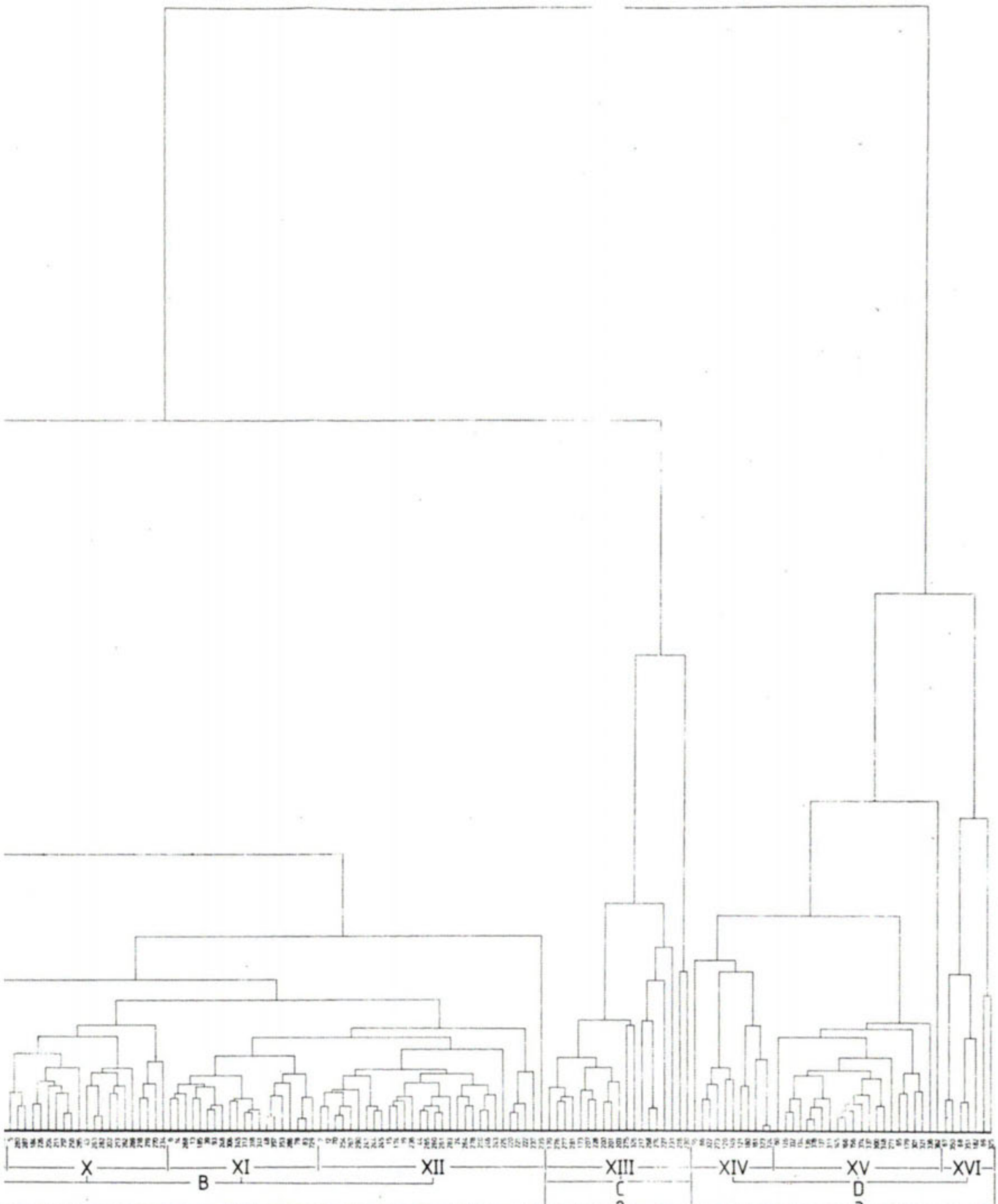


Fig. 1. Hierarchical dendrogram of the taxonomic similarity. logy of the hasins according to the water balance shown against the main physiographic parameters. Levels of the hierarchical (t ping first-macrotypes (1, 2, 3) second-mesotypes (A, B, C, D) thi

Numerical typo-
a background of
ypological) grou-
rd-types (I-XVI).




X
XI
XII
XIII
XIV
XV
XVI
B
C
D
2
3

In effect of calculations a numerical dendrogram has been led out to divide the whole set into 16 typological groups according to the lowest hierarchical grouping rung. The taxonomic similarity dendrogram exhibits a pretty clear-cut asymmetry with an equally distinct gravitation of clusters (in the right-hand direction) towards the highest-hydrological--distinction mountain basins. On a much higher grouping level 4 typological groups correspond to mesotypes, whereas 3 macrotypes let themselves separate at a still higher grouping level. As a result of calculations mutual Euclidean distances between 383 basins have been tabled down in a three-dimensional system plus plenty of their physico-geographical and hydrological features, which all taken together provided a basis for a group-oriented division. From among an infinite number of physical features those have been picked out which undoubtedly exert an impact on hydrological cycle of the basin, but this as a problem has been dealt with separately (see Gutry-Korycka 1984). The effect of grouping speaks for a characteristic differentiation of basins belonging among various typological groups. The evolved division of basins constitutes a basis for the deepened and unbiased set of conclusions concerning the type of mutual relations existing between basins and their peculiarities within the territory of Poland, whose identification by other means would simply be impossible.

Typological groups of basins as produced in effect of the cluster analysis could be presented spatially on a typological map being a spatial aggregation model (Gutry-Korycka 1984). In the adopted typological division boundaries of the units took reference to the natural hydrological divisions, i.e. to the basin.

An unbiased typological classification or regionalization of a basin on the basis of a multidimensional criterion covering several features may represent a starting poing for further studies facing the present--day regional hydrology. Quantitative criteria as hitherto in use (runoff regime) in the regionalization, as well as physico-geographical features of basins, ought to be utilized in the future for numerical hydrological delimitation purposes.

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