STUDIA GEOBOTANICA
4: 49-62, 1984

CONTRIBUTIONS TO QUANTITATIVE PHYTOGEOGRAPHY OF SICILY II: CORRELATION BETWEEN PHYTOGEOGRAPHICAL CATEGORIES AND ELEVATION

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Keywords: Phytogeography, Flora, Sicily.

Abstract. Data source: Central Databank of the Italian flora and vegetation. Database: phanerogamic flora of Sicily; percents of species with similar distribution patterns, subdivided into 49 phytogeographical categories, in 23 elevation intervals of 100 m each. Methods: Complete Linkage Clustering with Correlation Coefficient for the classification of categories and of elevation intervals; Concentration Analysis for the ordination. Results: species with similar distribution tend to be most frequent along given sections of the elevation gradient. The degree of correlation between phytogeographical categories and elevation has been quantified.

Introduction

Phytogeography has been one of the branches of Botany in which the use of non-operationally defined concepts, the adoption of intuitive thinking and the formulation of non-falsifiable hypotheses has always been more the rule than the exception. The adoption of numerical methods in the analysis of phytogeographical data is likely to produce a shift towards a more formalized type of phytosociological analysis. This process, however, is still at the beginnings; new methods are to be developed, and a consistent numerical database has to be assembled before quantitative phytogeography will produce biologically new and original results. Phytogeographical data in numerical from could be the basis to disengage phytogeography from a merely descriptive stage, and move it toward the use of formalized quantitative models, in which more abstract and general parameters will play a major role (Crovello, 1981; Lausi & Nimis, 1984, 1985).

The present paper is the second of a series in which phytogeographical data concerning the phanerogamic flora of Sicily at species level are analyzed by multivariate methods. Data source is the Data Bank of the Italian Flora and Vegetation (Pignatti, 1981; Nimis, 1981; Nimis et al., 1983). In the first paper of the series (Nimis, 1984) the analysis was addressed to the study of the relations between phytogeographical categories (as in Pignatti, 1982) and environment-types. The present study is dedicated to the analysis of the relations between phytogeographical categories and elevation.

There are three points concerning the data that could cause misunderstandings in the interpretation of the results; they are discussed in the following:

1 the grouping of species into phytogeographical categories is not based on objective criteria (see Pignatti, 1982). In general, the accuracy in the delimitation of categories decreases with increasing distance of the areas covered by species ranges from the italian territory (e.g. there are several categories for mediterranean species s.l., just one for circumboreal species s.l.). A numerical elaboration of distribution maps to obtain clearly defined types of ranges is not yet possible, since detailed distribution maps are not available for the greatest part of the species in the flora of Europe.

2 the elevation range of each species is calculated on the basis of the behaviour of the species on the whole of the italian territory. This is a major handicap, particularly for the study of the flora of Sicily, since the region is located at the southern end of Italy. This is likely to be reflected in lower elevation ranges than the actual ones, above all as far as northern species are concerned.

3 some of the phytogeographical categories are defined on the basis of the response of species to elevation (e.g. mediterranean-montane, orophytes etc.). This could lead to circular reasoning, this study being centered just on the relations of phytogeographical categories with an elevation gradient.

The first and last points are related: although the analysis of detailed distribution maps is the best way to obtain a satisfactory classification of species into phytogeographical categories, it is a fact that the species listed as "orophytes" or "montane" have specific distribution patterns (e.g. SW- mediterranean orophytes should have a fragmented range in the Southwestern part of the Mediterranean Region, and their distribution patterns should differ from those of typical SW-mediterranean species). This means that reference to elevation in the names of these categories is actually related with their distribution patterns. For the rest, the degree of approximation in the delimitation of the various categories seems to be fairly satisfactory, also considering the very high correlation that has been found between them and ecological factors (Nimis, 1984).

The second point is the most troublesome: it should be always kept in mind when interpreting the results. The elevation range in Italy is here considered as a character of each species, and the frequency distribution of species included in the same phytogeographical category along the elevation gradient is considered as a character of the category. Phytogeographical categories, and not Sicily, are the main object of the analysis. The curves rapresenting the frequency distributions of the categories along the elevation gradient, if referred to the actual situation in Sicily, depict just trends of species responses to elevation.

The results will be tested with field-data in another paper of this series and this will be the basis for the introduction of a correction factor in the data bank, that should contribute to solve the problem. This is in line with the main aim of this series of papers: to test the data of the Data Bank towards their utilization for the construction of phytogeographical quantitative models.

Data and methods

The data matrix is in Tab. 1. It contains the relative frequencies of 49 phytogeographical categories in 23 elevation intervals of 100 m each, from sea level to 2300 m. The highest mountain in Sicily is M. Etna, that is more than 3000 m high. However, the number of species occurring above 2300 m is so small that they have been omitted. This in order to avoid extremely high frequencies in the upper elevation intervals due to categories formed by only a few species.

The frequencies in Tab. 1 are calculated over the total number of species present in each elevation interval. This means that the Operational Geographic Units (OGUs, sensu Crovello, 1981) that are compared are 23 portions of the sicilian territory, obtained by its subdivision into belts of 100 m each. The Operational Geographic Set (Crovello, 1981) corresponds to the isle of Sicily and the surrounding small islands. The reason why the data have been normalized by columns is the following: surfaces with different areas are included in the different elevation intervals, the areas in each interval becoming narrower along with the increase in elevation. If the data would have been normalized by rows, the different areas of the elevation belts could have strongly affected the results; for instance, the frequency of SW-mediterranean species in the elevation belts, calculated over the total of SW-mediterranean species present in Sicily, depends on the floristic diversity of each belt; the latter is probably related to their respective areas. However, the relation between the areas of OGUs and their floristic diversity is not known, so that the interpretation of the results would have been extremely difficult.

The analysis of the data matrix (Tab. 1) has been performed in the following steps:

- Classification of OGUs, in order to obtain elevation belts with similar phytogeographical features.
- Classification of phytogeographical categories, to obtain groups of categories with similar response to the elevation gradient.
- Concentration Analysis (AOC) of the matrix in Tab. 1, to quantify the correlation between each category and each of the OGUs.
- Ranking categories on the basis of the percentages of chi square accounted for by each of them on the two first canonical variates of AOC in the previous analysis. Only those categories have been retained for further graphical displays that retain more than 2% of the interaction chi square on either canonical variate.
- Construction of graphs reporting the frequency distributions along the elevation gradient of the species included in those categories that have been retained after ranking.

The methods adopted for data analysis are:

- Complete Linkage Clustering (Anderberg, 1973) on Correlation Coefficient (Orloci, 1978) for classifications, with the package of programs by Wildi & Orloci (1980).
- Concentration Analysis (Feoli & Orloci, 1979) for the ordination.

PHYT.CATEGORY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Saharo-Sindic	0.4	0.4	0.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pantropical	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NW-Medit.Montane	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.6	0.6	0.7	0.6	0.3	0.4	0.5	0.7	0.0	0.0	0.0
N-Stenomedit.	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.3	0.2	0.3	0.3	0.4	0.5	0.7	0.0	0.0	0.0
W-Stenomedit.	5.3	5.1	5.0	5.2	5.0	4.7	3.0	2.2	2.5	1.7	1.6	0.8	0.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S-Stenomedit.	2.9	3.0	2.9	2.5	2.4	2.1	1.2	1.1	1.1	0.7	0.6	0.6	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paleotropical	0.7	0.7	0.7	0.5	0.6	0.6	0.2	0.2	0.3	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SW-Stenomedit.	2.5	2.4	2.4	2.0	1.9	1.8	1.1	1.1	1.1	0.9	0.9	0.8	0.7	0.7	0.8	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Subtropical	1.6	1.5	1.4	1.3	1.2	1.1	0.8	0.8	0.6	0.4	0.4	0.5	0.3	0.3	0.2	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Introduced	4.9	5.2	5.1	4.7	4.5	4.2	2.7	2.7	2.2	1.9	1.3	1.4	1.5	1.2	1.4	0.8	1.0	1.2	0.5	0.7	1.2	0.0	0.0
NW-Stenomedit.	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E-Eurimedit.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphiatlantic	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurimedit.-Atl.	1.0	1.1	1.1	1.1	1.1	1.1	1.3	1.2	0.8	0.9	0.6	0.6	0.6	0.5	0.4	0.3	0.3	0.4	0.5	0.7	1.2	0.0	0.0
Subatlantic	1.2	1.1	1.1	1.2	1.2	1.0	1.1	1.1	1.1	1.1	0.9	0.9	0.9	0.9	0.8	0.8	1.0	0.8	0.5	0.0	0.0	0.0	0.0
E-Stenomedit.	2.0	2.2	2.2	1.9	1.9	1.9	1.5	1.8	1.3	1.3	1.1	1.2	1.2	1.4	1.2	1.4	1.4	1.2	0.5	0.0	0.0	0.0	0.0
Medit.-Turanic	2.4	2.2	2.2	2.0	2.1	2.1	2.3	2.2	2.1	2.2	1.8	1.7	1.6	1.9	1.8	1.7	1.7	1.6	2.0	1.3	1.2	1.6	1.9
E-Medit. Montane	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.4	0.5	0.4	0.5	04.	05.	0.6	0.6	0.3	0.4	0.5	0.0	0.0	0.0	0.0
SE-Stenomedit.	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NE-Stenomedit.	0.8	0.9	0.9	0.8	0.8	0.7	0.8	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.2	0.3	0.3	0.4	0.0	0.0	0.0	0.0	0.0
N-Eurimedit.	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.5	0.3	0.3	0.2	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eurimedit.	15.4	15.6	15.5	16.1	15.9	16.1	17.9	17.6	16.8	17.1	15.6	15.6	14.3	11.9	9.2	8.2	7.4	7.3	6.3	7.3	7.1	3.1	3.8
W-Eurimedit.	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Steno Med. Atl.	1.5	2.2	2.2	2.2	2.2	0.9	0.8	0.8	1.0	1.0	0.9	0.7	0.6	0.5	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stenomedit.	16.6	16.4	16.2	16.6	16.1	16.4	14.6	14.3	11.7	10.9	9.9	9.1	7.2	6.6	5.9	5.6	4.7	5.3	4.4	4.0	2.4	0.0	0.0
SE-European	1.1	1.1	1.1	1.2	1.2	1.3	1.4	1.4	1.6	1.7	1.7	1.5	1.0	1.0	1.2	0.6	0.7	0.8	1.0	0.7	0.0	0.0	0.0
NW-Eurimedit.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SW-Med.Montane	1.2	1.1	1.1	1.2	1.3	1.1	1.0	1.1	1.2	1.4	1.5	1.4	1.5	1.4	1.4	1.7	1.4	1.2	1.5	1.3	1.2	1.6	0.0
Subcosmopolitan	3.8	3.8	3.7	3.7	3.7	3.7	4.2	4.2	4.3	4.3	4.5	4.5	4.7	4.4	4.5	4.2	3.7	4.1	3.4	4.7	3.6	4.7	1.9
S-Eurimedit.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paleotemperate	5.8	4.0	5.9	6.4	6.4	6.4	7.7	7.7	8.3	8.5	8.4	8.4	8.5	9.0	8.8	8.8	9.8	8.1	7.3	8.0	6.0	7.8	7.7
Europ.-Caucas.	3.4	3.6	3.6	3.8	3.9	4.2	5.1	5.1	6.0	6.1	7.0	7.3	7.2	7.1	7.3	6.5	6.8	6.5	7.3	6.7	4.8	4.7	5.8
NE-Med.Montane	0.8	0.8	1.0	1.0	1.1	1.3	1.7	2.0	2.3	2.2	2.6	2.7	2.8	2.7	2.9	3.4	4.1	3.3	3.4	2.7	2.4	3.1	1.9
Eurasiatic	4.8	4.9	4.9	5.2	5.2	5.3	6.1	6.1	6.9	7.3	8.3	8.6	9.9	10.2	11.0	11.3	11.1	11.4	9.8	11.3	8.3	9.4	9.6
Eurosibirian	1.4	1.5	1.5	1.5	1.5	1.7	2.1	2.1	2.4	2.4	2.5	2.5	2.8	3.2	3.5	4.2	3.7	2.8	3.4	3.3	3.6	4.7	3.8
Circumboreal	2.3	2.3	2.3	2.6	2.7	2.9	3.4	3.5	4.1	4.3	4.8	4.7	5.4	6.1	7.1	6.8	4.7	4.9	5.9	6.7	4.8	4.7	3.8
W-European	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.9	0.9	1.0	1.4	1.7	1.2	1.0	0.7	0.0	0.0	0.0
Central European	0.5	0.7	0.7	0.7	0.7	0.8	1.0	1.0	1.1	1.2	1.5	1.5	1.8	1.9	2.0	2.0	2.0	2.4	2.0	2.7	0.0	0.0	0.0
Cosmopolitan	1.5	1.5	1.4	1.5	1.4	1.4	1.5	1.6	1.7	1.7	1.8	1.9	1.9	2.2	2.8	3.4	3.4	3.7	3.9	3.3	3.6	0.0	0.0
NE-Eurimedit.	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.0	0.0	0.0	0.0
S-Europ.Orophytes	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.4	0.6	0.7	0.8	1.0	.13	2.4	3.1	3.8
SE-Europ.Orophytes	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.4	0.4	0.5	0.4	0.5	0.8	1.4	1.7	2.0	2.4	2.0	2.4	3.1	3.8
N-Medit.Montane	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.6	0.6	0.6	0.7	1.0	1.1	1.0	1.2	1.0	1.3	2.4	3.1	3.8
Endemic	4.6	4.6	4.9	4.8	5.3	5.4	5.3	6.0	5.7	6.1	7.0	7.6	9.3	10.4	11.8	11.9	13.5	14.6	16.6	15.3	22.6	25.0	26.9
W-Medit.Montane	1.1	1.2	1.2	1.1	1.1	1.1	1.1	1.2	1.3	1.4	1.6	1.6	1.6	1.7	2.0	2.3	2.4	2.8	2.4	2.0	2.4	3.1	3.8
European	0.6	0.5	0.6	0.6	0.6	0.6	0,7	0.7	0.8	0.8	0.9	0.9	1.2	1.4	1.4	1.1	1.4	1.2	1.5	2.0	2.4	1.6	1.9
S Eur-S Sibirian	2.5	2.6	2.6	2.5	2.7	2.9	3.5	3.5	3.6	3.6	3.8	3.8	3.5	3.6	3.3	3.1	3.4	3.3	3.9	2.7	4.8	6.2	7.7
S-Medit.Montane	1.5	1.5	1.4	1.1	1.2	1.0	0.8	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.8	0.8	1.4	1.2	1.5	1.3	1.2	1.6	1.9
SW-Europ.Orophytes	0.2	0.2	0.2	0.2	0.2	0.2	01.	0.2	0.3	0.3	0.6	0.6	0.7	0.9	1.0	1.4	1.7	2.4	3.4	4.7	8.3	7.8	7.7

Table 1 — Data matrix. Percents of species belonging to 49 phytogeographical categories in 23 elevation intervals of 100 m each.

Results

The variation of species diversity in the OGUs along with the elevation gradient is shown in Fig. 1. Species diversity tends to decrease with increasing elevation. The decrease is slight from 0 to 600 metres, more pronounced and almost linear from 600 to 1600 m, with an average loss of 100 species every 100 m, and slight again from 1600 to 2300 m. How far this is due to elevation or to the progressive reduction of the surface of the OGUs along with elevation is not known. Probably both facts are involved, but the problem could be solved only after a quantitative analysis of the relation between surface of OGUs and species diversity.

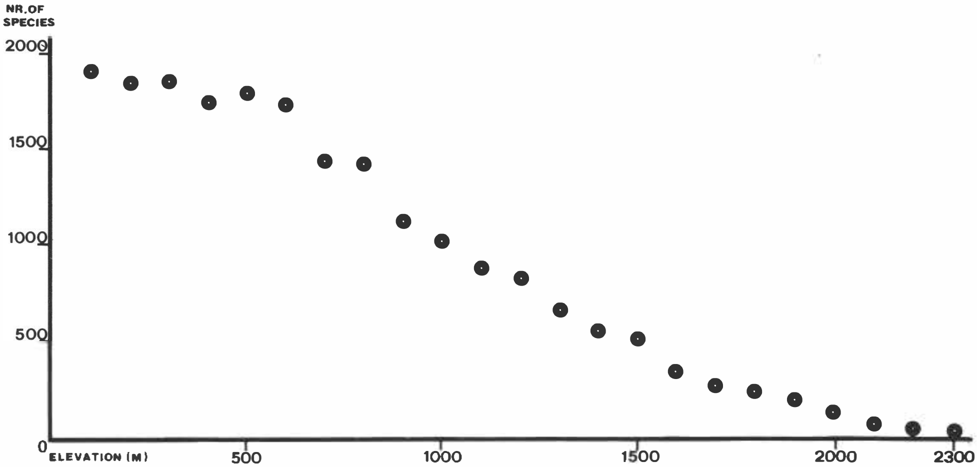

Fig. 1 — Floristic diversity along the elevation gradient in Sicily. Number of species in the 23 elevation intervals of 100 m each.

Classifications

The dendrograms of the OGUs and of the phytogeographical categories are respectively in Fig. 2 and in Fig. 3.

Two main clusters are formed in the dendrogram of OGUs, and each of them is subdivided into three subclusters, as follows (Fig. 2):

Cluster 1: it includes the elevation intervals from sea level to 1000 m. The first interval (0-100 m), forms a subcluster by itself. Two further subclusters respectively include the elevation intervals from 100 to 600 m and those from 600 to 1000 m.

Cluster 2: it includes the elevation intervals from 1000 to 2300 m; the three subclusters are as follows: 1000-1400 m, 1400-2000 m, 2000-2300 m.

The subclusters contain OGUs that are contiguous along the elevation gradient, and correspond to the following vegetation belts:

Lowland belt: 0-100 m.
Hill belt: 100-600 m.
Lower montane belt: 600-1000 m.

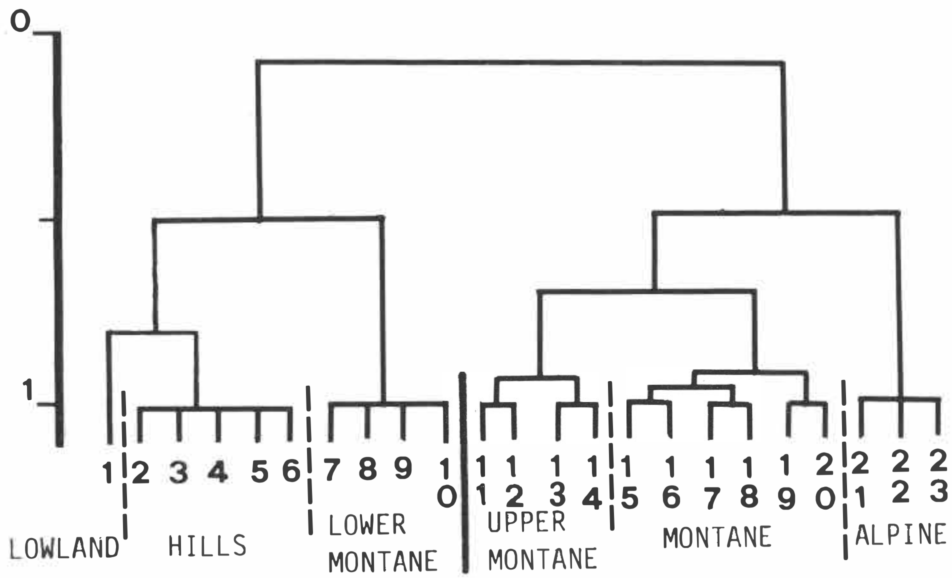

Fig. 2 — Dendrogram of the elevation intervals based on the matrix in Tab. 1.

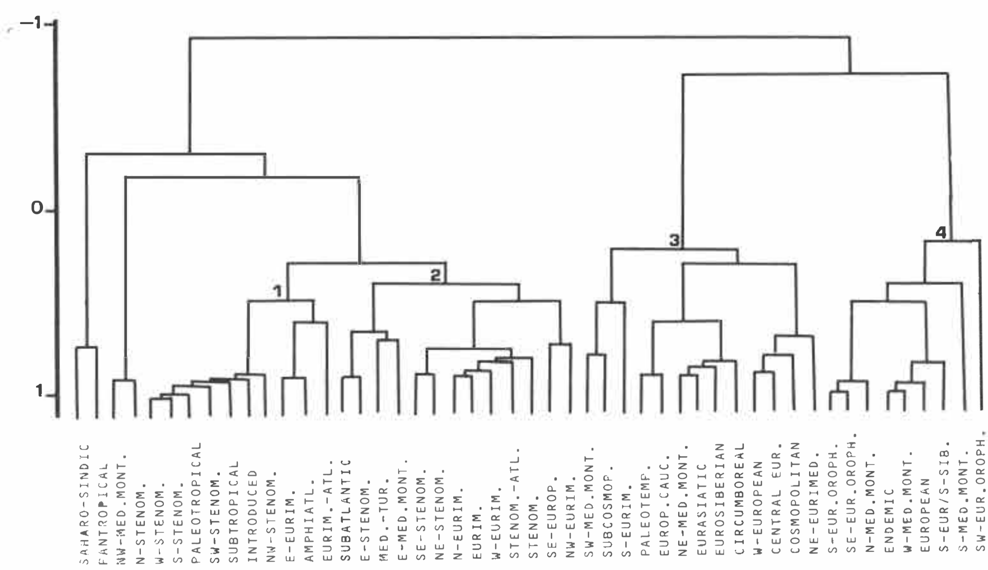

Fig. 3 — Dendrogram of the phytogeographical categories based on the data in Tab. 1. Numbers refer to cluster numbers as in Fig. 4.

Montane belt: 1000-1400 m.
Upper montane belt: 1400-2000 m.
Alpine belt: 2000-2300 m.

Being this subdivision based on the frequency distributions of phytogeographical categories in the OGUs, it is to be expected that each belt will be characterized by a typical phytogeographical spectrum.

In the dendrogram of phytogeographical categories (Fig. 3), only those clusters have been considered, that are formed at levels of the Correlation Coefficient above 0.0. The two clusters obtained under this level (each with two categories) include categories with very low frequency in each of the OGUs. Between 0.2 and 0.3 four main clusters are formed, as follows:

Cluster 1: it mostly includes categories limited to restricted portions of the Mediterranean Region. Tropical and Introduced species are also included in this cluster.

Cluster 2: the greatest part of the species included in the categories of this cluster are characterized by ranges extending over the whole of the Mediterranean Region (Euri- and Stenomediterranean species).

Cluster 3: the categories in this cluster either include species with very broad ranges (Subcosmopolitan, Cosmopolitan, Paleotemperate) or species whose distribution is centered north of the Mediterranean Region (Eurosibirian, Circumboreal, Central European etc.).

Cluster 4: this cluster mostly includes Orophytes. Endemic and European species s.l. also belong to it.

The frequency distributions of the four clusters of categories in the 23 elevation intervals are in Fig. 4:

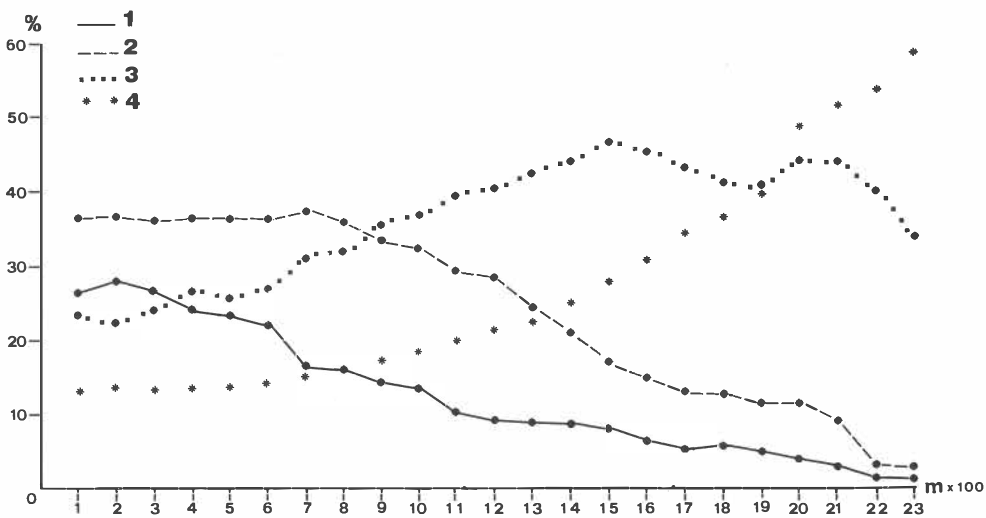

Fig. 4 — Frequency distributions of the species in clusters 1, 2, 3, 4 (Fig. 3) along the elevation gradient.

- the species included in the categories of Cluster 1 are most frequent in the lowland and colline belts (20-30% of the flora in each OGU); from 700 to 1000 m they tend to decrease and fall under 10% after 1100 m. They characterize the arid-mediterranean and the mediterranean vegetation belts (Pignatti, 1979). The fact that introduced species are included in this cluster is indicative of the fact that in these belts human impact on the natural ecosystems is maximal.
- The species included in the categories of Cluster 2 are most frequent (30-40% of the flora in each OGU) from sea level to 1200 m. They still constitute 20-30% of the floras up to 1400 m. Their frequency distribution curve differs from the previous one for a less marked decrease at lower elevations. Most of the species in this cluster are Steno- or Eurimediterranean. They characterize the Mediterranean Vegetation belt (*Quercus ilex* stands and their degradation stages).
- The species included in the categories of cluster 3 have a frequency maximum around 1500 m, and more or less regularly decrease both at lower and higher elevations. They characterize the deciduous summergreen belt dominated by *Quercus pubescens*, and the subatlantic belt (Pignatti, 1979), dominated by *Fagus sylvatica.*
- Finally, the species included in the categories of Cluster 4 have a maximum at higher elevations, and characterize the alpine vegetation belt.

Concentration analysis

The results of AOC performed on the contingency table of phytogeographical categories and OGUs are shown in Fig. 5. Tab. 2 gives the percentages of the total interaction chi square accounted for by the first and second Canonical Variates in AOC, and its relative shares accounted for by phytogeographical categories.

In Fig. 5 the sequence of the OGUs along the first Canonical Variate reflects a regular elevation increase from sea level to 2300 m. The OGU and the category points are further arranged along a horse-shoe shaped curve. The first Canonical Variate accounts for 53.2% of the total interaction chi square, the second for 27.1%. The fact that the sequence of OGUs along the first Canonical Variate corresponds with a regular elevation increase, and the high share of the interaction chi square accounted for by the two first Canonical Variates (altogether 80.3%) indicate a very high degree of correlation between phytogeographical categories and OGUs.

Over a total of 49 phytogeographical categories, 16 account for more than 2% of the chi square on either the first or the second Canonical Variates (boldface in Tab. 2). These categories have been retained to characterize the phytogeographical changes along the elevation gradient. Four graphs have been constructed (Figg. 6, 7, 8, 9), each of them respectively showing the frequency distributions of those of the 16 categories that are included in the four clusters obtained in the classification of categories (Clusters 1, 2, 3, 4, see Fig. 3).

Fig. 6 shows the frequency distributions of four categories included in Cluster 1: W-Stenomediterranean, Introduced, S-Stenomediterranean and SW-Stenomediterranean. They have a similar response to elevation, with high frequencies in the lowland and colline belts, and a sharp decrease after 600 m.

Fig. 7 shows the frequency distributions of two categories included into cluster

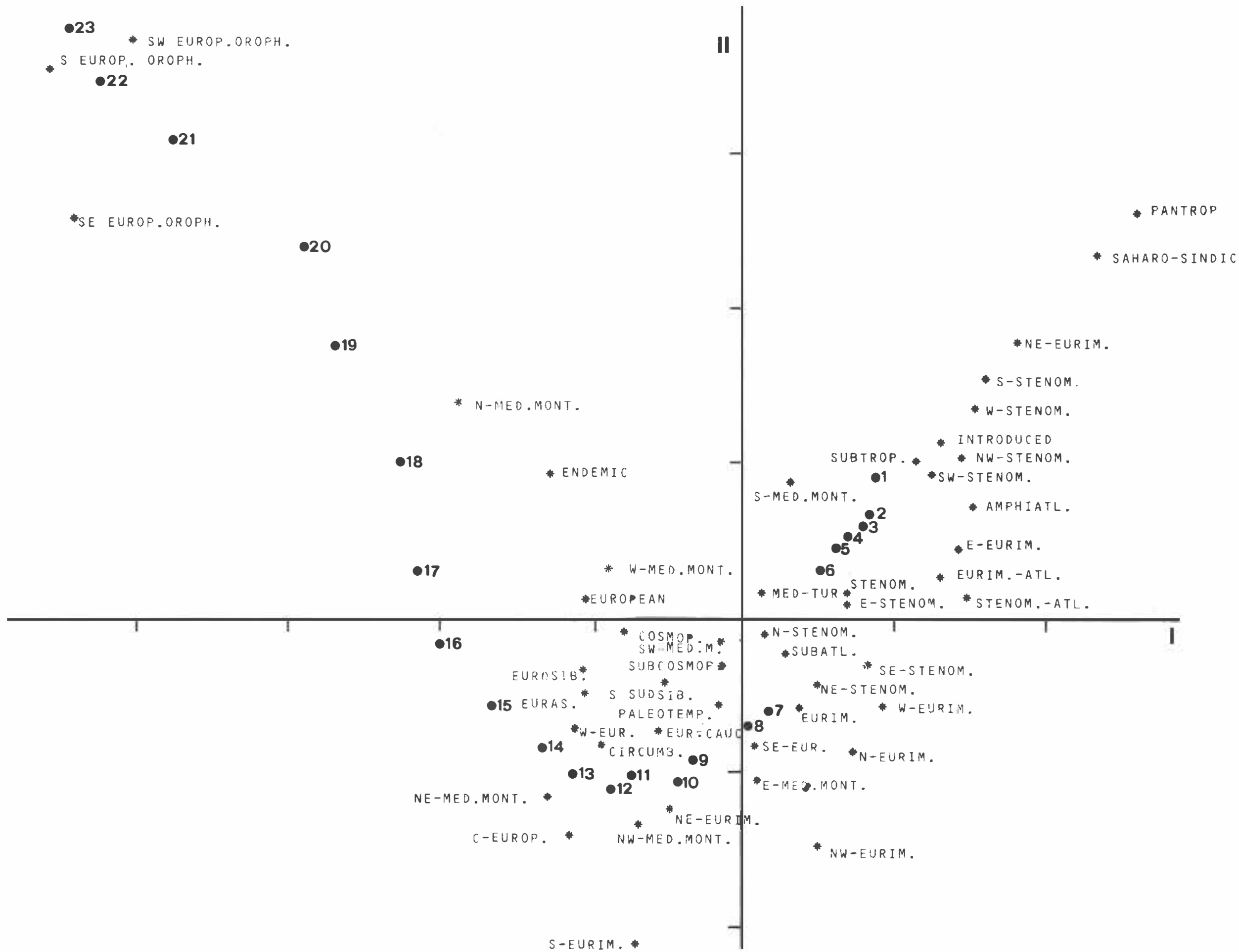

Fig. 5 — Arrangement of elevation intervals (numbers) and phytogeographical categories according to the Ist and IInd Canonical Variates in AOC.

Table 2 — Absolute and percentual values of the chi square accounted for by phytogeographical categories (Ist and IInd canonical variates).

	Ist CANONICAL VARIATE		IInd CANONICAL VARIATE	
	x^2	%	x^2	%
SAHARO-SINDIC	12.60	0.550	0.855	0.165
PANTROPICAL	5.92	0.259	3.890	0.752
NW-MEDIT. MONT.	1.76	0.072	3.440	0.665
N-STENOMEDIT.	0.50	0.022	0.002	0.001
W-STENOMEDIT.	200.00	**8.734**	29.100	**5.692**
S-STENOMEDIT.	112.00	**4.891**	22.100	**4.275**
PALEOTROPICAL	5.92	0.259	6.160	1.191
SW-STENOMEDIT.	60.80	**2.655**	7.720	1.493
SUBTROPICAL	41.40	1.808	5.390	1.043
INTRODUCED	126.00	**5.502**	23.200	**4.487**
NW-STENOMEDIT.	7.280	0.318	0.965	0.187
E-EURIMEDIT.	3.850	0.168	0.004	0.001
AMPHIATLANTIC	2.630	0.115	0.168	0.032
EURIMEDIT.-ATL.	11.400	0.498	0.264	0.051
SUBATLANTIC	4.690	0.205	0.705	0.136
E-STENOMEDIT.	20.100	0.878	0.500	0.097
MEDIT.-TURANIAN	3.040	0.133	0.007	0.001
E-MED. MONTANE	0.216	0.009	1.220	0.236
SE-STENOMEDIT.	4.980	0.217	0.197	0.038
NE-STENOMEDIT.	7.100	0.310	0.672	0.130
N-EURIMEDIT.	3.700	0.162	1.190	0.230
EURIMEDIT.	56.700	**2.476**	19.900	**3.149**
W-EURIMEDIT.	4.460	0.195	0.362	0.070
STENOMEDIT.-ATL.	19.700	0.860	0.006	0.001
STENOMEDIT.	242.000	**10.568**	3.810	0.737
SE-EUROPEAN	0.901	0.039	6.630	1.282
NW-EURIMEDIT.	0.455	0.020	0.602	0.116
SW-MEDIT. MONT.	1.060	0.046	0.472	0.091
SUBCOSMOPOLITAN	1.700	0.074	2.710	0.524
S-EURIMEDIT.	0.914	0.040	1.830	0.354
PALEOTEMPERATE	28.400	1.240	13.000	**2.515**
EUROPEAN-CAUCAS.	58.200	**2.541**	22.500	**4.353**
NE-MED. MONTANE	72.300	**3.570**	11.900	**2.302**
EURASIATIC	116.000	**5.066**	7.820	1.513
EUROSIBERIAN	43.700	**2.000**	1.270	0.246
CIRCUMBOREAL	79.800	**3.485**	13.000	**2.515**
W-EUROPEAN	12.900	0.563	1.920	0.371
CENTRAL EUROPEAN	29.900	1.306	8.590	1.662
COSMOPOLITAN	20.000	0.873	0.007	0.001
NE-EURIMEDIT.	1.790	0.078	1.170	0.226
S-EUROP. OROPHYTES	244.000	**10.655**	0.602	0.116
SE-EUROP. OROPHYTES	142.000	**6.201**	18.300	**3.540**
N-MED. MONTANE	35.800	1.563	4.700	1.909
ENDEMIC	273.000	**11.921**	31.000	**5.996**
W-MED. MONTANE	19.800	0.865	0.994	0.192
EUROPEAN	21.600	0.943	0.113	0.022
S-EUR./S-SIBER.	17.900	0.782	9.850	1.805
S-MED. MONTANE	2.100	0.022	6.930	1.340
SW-EUR. OROPHYTES	90.000	**3.930**	76.600	**14.816**

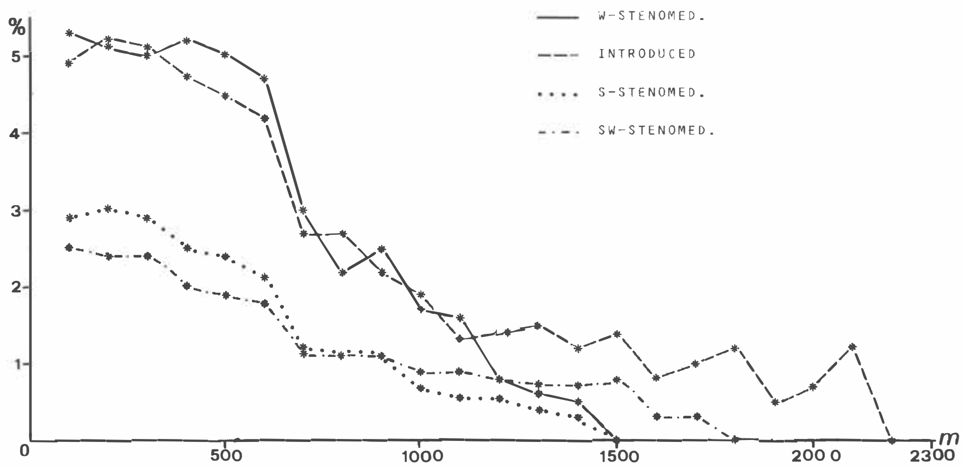

Fig. 6 — Frequency distributions of 4 phytogeographical categories in Cluster 1 (Fig. 3) along the elevation gradient.

Fig. 7 — Frequency distributions of 2 phytogeographical categories in Cluster 2 (Fig. 3) along the elevation gradient.

2: Steno- and Eurimediterranean. They differ from the categories in Cluster A for a more regular decrease along the elevation gradient. Eurimediterranean species are most frequent in the OGUs between 700 and 1000 m (lower montane belt).

Fig. 8 shows the frequency distributions of three categories included in cluster 3: European-Caucasian, Circumboreal and Eurosibirian. Also in this case they have similar responses to elevation, with higher frequencies in the montane belt.

Fig. 9 shows the frequency distributions of three categories included in cluster 4: Endemic: SW-European Orophytes and S-European Orophytes. They have the maximum frequency in the alpine belt.

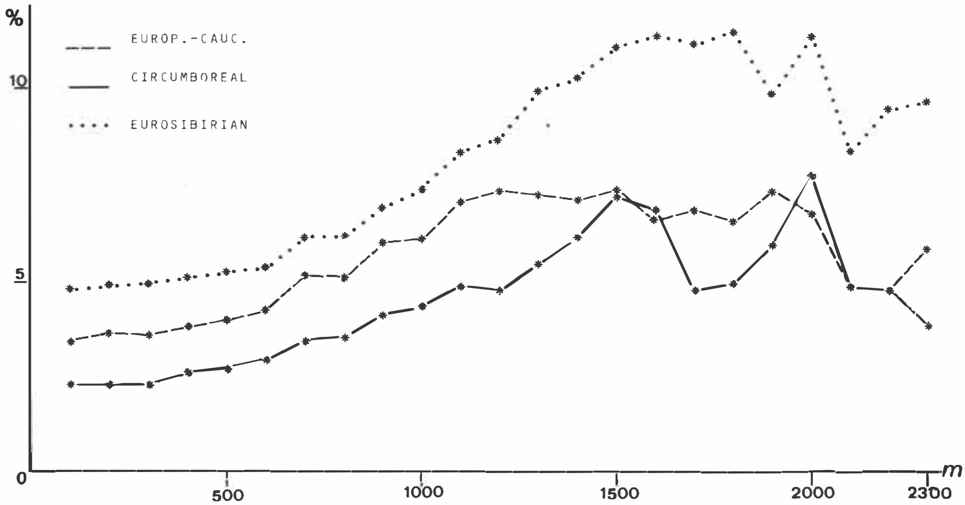

Fig. 8 — Frequency distributions of 3 phytogeographical categories in Cluster 3 (Fig. 3) along the elevation gradient.

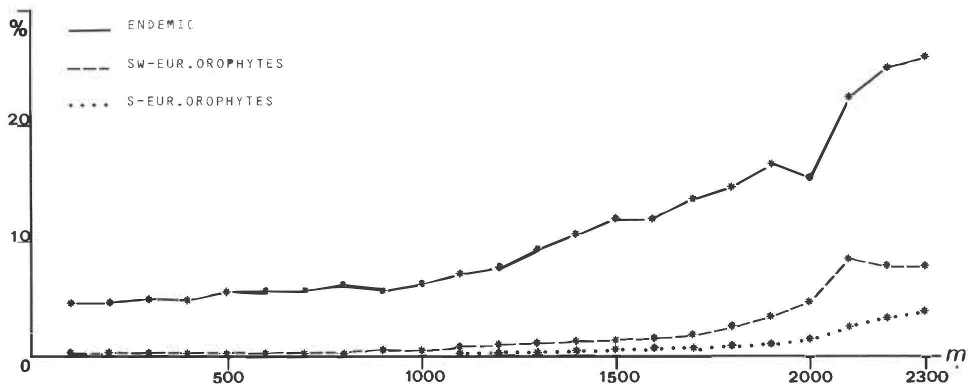

Fig. 9 — Frequency distributions of 3 phytogeographical categories in Cluster 4 (Fig. 3) along the elevation gradient.

In Mediterranean orobiomes temperatures and precipitation increase with elevation. Potential evapotranspiration is highest at lower elevation, and increases upwards. From the previous results, it seems that there is a relation between latitudinal range of species and their relative frequencies along the elevation gradient: the more the range of a species extends towards the north, the higher this species occurs in the mountains. The entire range of a species can be considered as one of the expressions of its genotype. From the study of the entire range, it is possible to make assumptions on some ecological requirements of a species in a given area. In Mediterranean orobiomes an exception is given by the alpine vegetation belt, that has a great number of species with narrow ranges, mostly restricted to the mediterranean high mountains. This exception is due to historical factors, chiefly the very old age of the oromediterranean flora. A chorological-ecological interpretation of this flora cannot be based on pure actualistic hypotheses, but mostly on historical factors, whose age may date back to the late Tertiary period; for this reason, an analysis at taxonomic levels higher than the one of species is probably more suited to the phytogeographical study of the mediterranean flora at high elevations (Nimis, 1981b).

Concluding remarks

A general remark on the results presented above is that the very high degree of correlation between phytogeographical categories and OGUs represents a positive test of the Data Bank from which the data have been obtained.

The regular responses of the phytogeographical categories to elevation may be a suitable basis to produce quantitative predictive models in phytogeography. The next step will be the joint analysis of the response of phytogeographical categories to environment-types and to elevation and the test of these results against field-data. This will be presented in further papers of this series.

Riassunto. I dati sottoposti ad elaborazione provengono dalla Banca Dati sulla Flora e Vegetazione d'Italia. Essi si riferiscono alla flora fanerogamica della Sicilia. La matrice dei dati riporta le percentuali di specie, raggruppate in 49 categorie fitogeografiche sulla base della somiglianza dei loro areali, in 23 intervalli altitudinali di 100 m ciascuno. Essa è stata sottoposta a programmi di classificazione e di ordinamento. I cluster di intervalli ottenuti dalla classificazione corrispondono bene alla suddivisione della Sicilia in fascie altitudinali di vegetazione. La classificazione delle categorie fitogeografiche ha permesso di individuare 4 gruppi di categorie fitogeografiche con diverse distribuzioni di frequenza lungo il gradiente altitudinale. In base ai risultati dell'ordinamento sono state individuate le categorie fitogeografiche maggiormente correlate con il gradiente altitudinale. I risultati si inseriscono in una serie di elaborazioni sulla flora vascolare della Sicilia il cui scopo è di fornire una base metodologica per l'applicazione di modelli quantitativi in fitogeografia.

Acknowledgements. The author expresses this thanks to Prof. D. Lausi and E. Feoli (Trieste), Prof. S. Pignatti (Rome) and Prof. D. Goodall (Perth, Australia) for comments to the manuscript.

The work has been supported by a CNR grant to "Gruppo Biologia Naturalistica".

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