STUDIA GEOBOTANICA
4: 137-145, 1984

COMPARISON OF ORDINATIONS OF SOME APENNINE FOREST COMMUNITIES BASED ON DIFFERENT CHARACTERS AND METHODS

E. FEOLI, L. ORLÓCI and M. SCIMONE

Keywords: character sets, comparisons, cluster analysis, methodology, ordinations.

Abstract. In the course of numerical ordinations of Apennines woodlands, the problem arose of different performance of ordination methods, using different character sets and methods. To reveal underlying trends and relationships, 47 ordinations are jointly examinated, corresponding to combinations of 6 methods and 8 character types. The Spearman formula has been used to measure the similarity between different ordinations. The ordinations based on families are, on the average, the most similar to the other ones irrespective to the method used. The ordination based on detailed life forms (growth forms) are the least similar to the other ordinations. Ordinations based on the same character set and different methods could be different as well as ordinations based on different character sets and the same method. The suggested procedure can be the basis to select among different ordinations those explaining complementary informations.

Introduction

The ordination methods are all based on algorithms which reduce the dimensionality of the space under study. The aim is to describe synthetically the relationships of similarity between the objects and the correlation between the characters describing the objects. Different methods applied to the same data set may give different results, i.e. informations which remain unexplained by one method can be revealed by another one. Furthermore the same set of objects may be described by different characters with the aim to investigate different biological phenomena. The characters may be redundant, because of correlation (see Orlóci, 1975) or hierarchical relationships (see Feoli, 1984). The comparison of ordinations of the same sets of objects based on different methods and descriptions should be useful to select among several ordinations those which are supposed to reveal complementary informations. The problem is addressed with regard to 4 character sets with a hierarchical structure:
(I) Taxonomic (species, genera, families)
(II) Structural (growth-form, life-form)
(III) Syntethic (species groups)
(IV) Chorological (chorology, subchorology)
and different ordination methods:

(I) MDSCAL (Brambilla & Salzano, 1981; Fewster & Orlóci, 1983)
(II) AOC (Feoli & Orlóci, 1979)
(III) SIPLO (Feoli & Feoli Chiapella, 1980).

The use of these is contemplated in the analysis of the data from a broader survey (Feoli, Ganis & Scimone, in prep.).

The modus operandi of the study is relatively simple: repeat an ordination by character sets at different hierarchical levels, proceeding from low (higher information level) to high (lower information level). When the ordinations are completed, classify and ordinate the ordinations and study the resulting dendrogram and scattergram for patterns and trends. The data, method and results are discussed in the following sections.

Data

The set of data consists of 17 types of woods of Apennines obtained by clustering procedures applied to synthetic tables structured in a data bank (Lagonegro et al., 1982) which will be described in detail by Feoli, Ganis & Scimone (in prep.). In Tab. 1 some informations about the types are given.

Table 1 — Characterization of the 17 types of the woods of Apennines used for the analysis according to the number of synthetic tables from which they were obtained, the regional distribution and the main tree composition.

Group	n. of synthetic tables	Localities from	Constant trees
1	8	Toscana/Liguria/Puglia	Quercus ilex, Arbutus unedo, Quercus suber
2	2	Lazio	Myrtus communis, Pistacia lentiscus
3	8	Liguria/Toscana/Marche/ Umbria	Quercus cerris, Quercus frainetto
4	11	Umbria/Marche/Liguria	Quercus petraea, Quercus cerris
5	2	Marche	Sorbus domestica, Juniperus communis, Quercus cerris
6	10	Toscana/Marche/Umbria	Ostrya carpinifolia, Quercus ilex
7	7	Umbria/Lazio/Abruzzo	Quercus cerris, Acer campestre, Ostrya carpinifolia
8	8	Umbria/Marche/Abruzzo	Acer campestre, Quercus cerris, Carpinus betulus
9	9	Campania/Lazio/Basilicata	Ostrya carpinifolia, Acer obtusatum
10	6	Liguria/Toscana	Quercus pubescens, Acer campestre
11	5	Abruzzo/Lazio	Quercus pubescens, Carpinus orientalis, Acer campestre, Ostrya carpinifolia
12	7	Liguria/Toscana/Marche	Ostrya carpinifolia, Acer pseudoplatanus
13	2	Lazio/Abruzzo	Quercus pubescens, Juniperus communis
14	13	Liguria/Toscana/Lazio/ Umbria	Ostrya carpinifolia, Acer obtusatum, Quercus pubescens, Juniperus communis, Quercus cerris
15	9	Puglia/Abruzzo/Campania/ Calabria	Fagus sylvatica
16	5	Liguria/Emilia/Toscana/ Abruzzo	Fagus sylvatica
17	3	Liguria/Abruzzo/Toscana	Fagus sylvatica

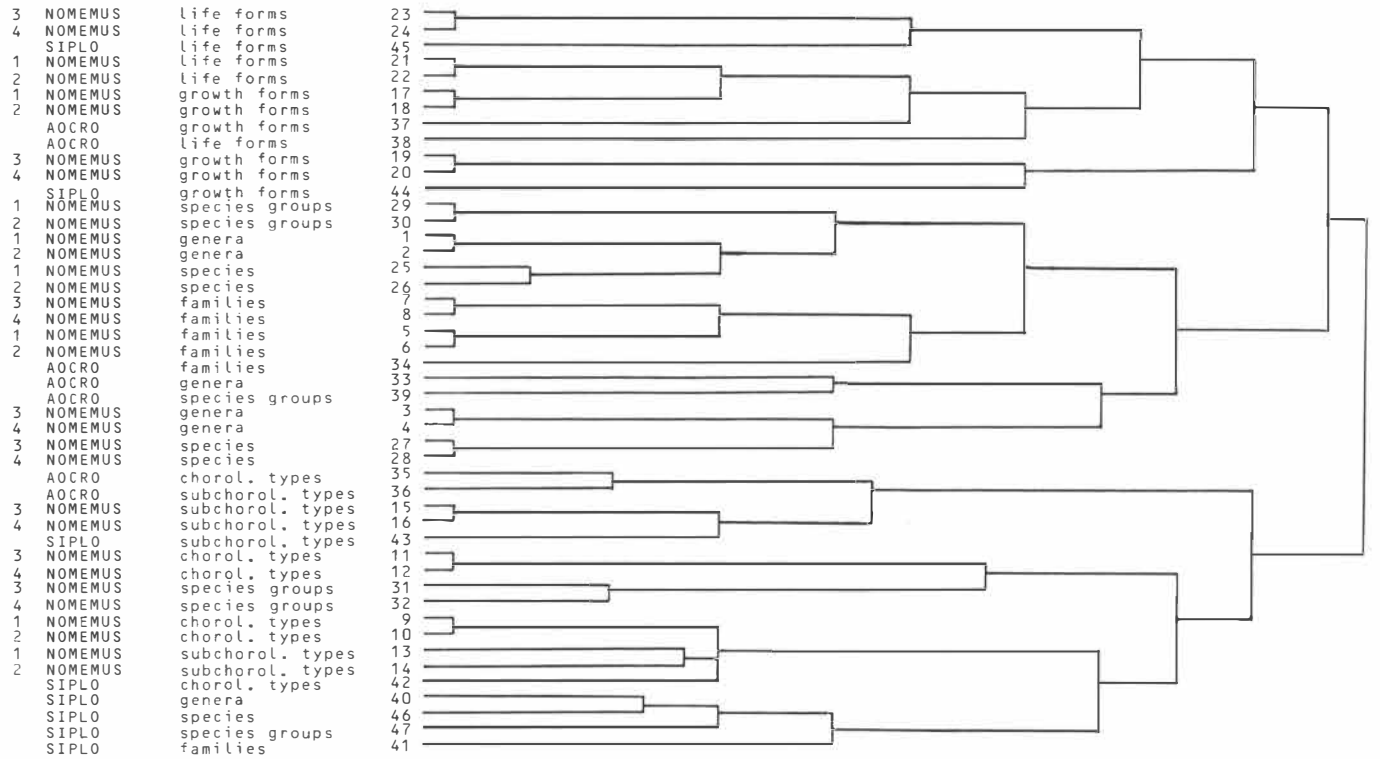

Fig. 1 — Average linkage clustering of 47 ordinations. The symbols identify ordination method and occupancy variable: N - MDSCAL, a modification of the Kruskal & Carmone (1971) algorythm. N1 - random initial configuration, Orlóci's internal distance. N2 - random initial configuration, Euclidean distance. N3 - minimum variance option, Orlóci's internal distance. N4 - minimum variance option, Euclidean distance. S - SIPLO ordination. A - AOC ordination. SPE - species. GEN - genera. FAM - family. SG - species groups. LF - life-form. GF - growth-form. CHORT - chorological type. SUBCHORT - sub-chorological type.

Method of analysis

The occupancy matrices were subjected to ordinations by 6 methods (see legend to Figure 1) and correlations were calculated between the ordinations among axes by the Spearman formula. The correlations were averaged for the first three axes and arranged in a 47x47 symmetric matrix (S) which, in turn, was subjected to cluster analysis and ordination. The order 47 comes from 6x8 minus one combination (AOC on species has not been computed). The clustering method was average linkage and the ordination was based on eigenvectors of S. The program used for MDSCAL is NOMEMUS which have been adapted by M. Lagonegro to the method suggested by Orlóci (1978) and Fewster & Orlóci (1983). AOCRO is the program for AOC and SIPLO the program for SIPLO.

Results and discussion

Fig. 1 contains the dendrogram by average linkage clustering and Figs. 2 and 3

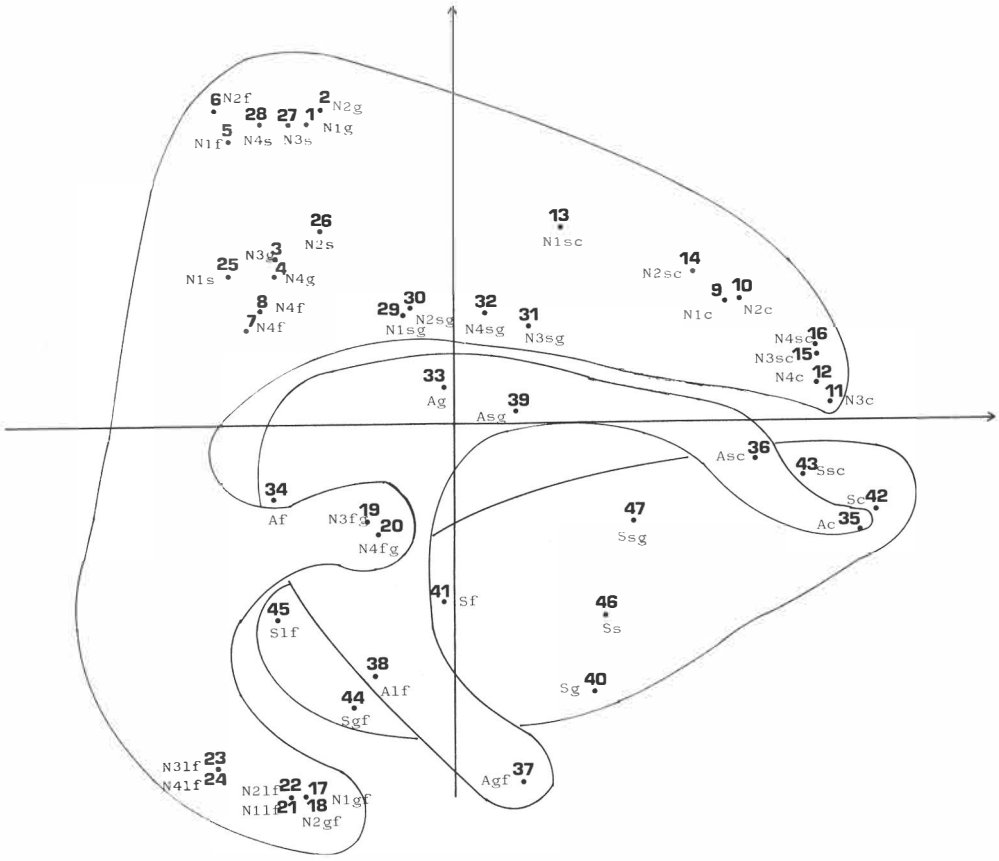

Fig. 2 — Ordination of the 47 ordinations by the 2nd and the 3rd eigenvectors of the matrix of Spearman coefficients. Top horseshoe - MDSCALE. Middle horseshoe - AOC. Straight cluster - SIPLO. Symbols are explained in the title of Fig. 1.

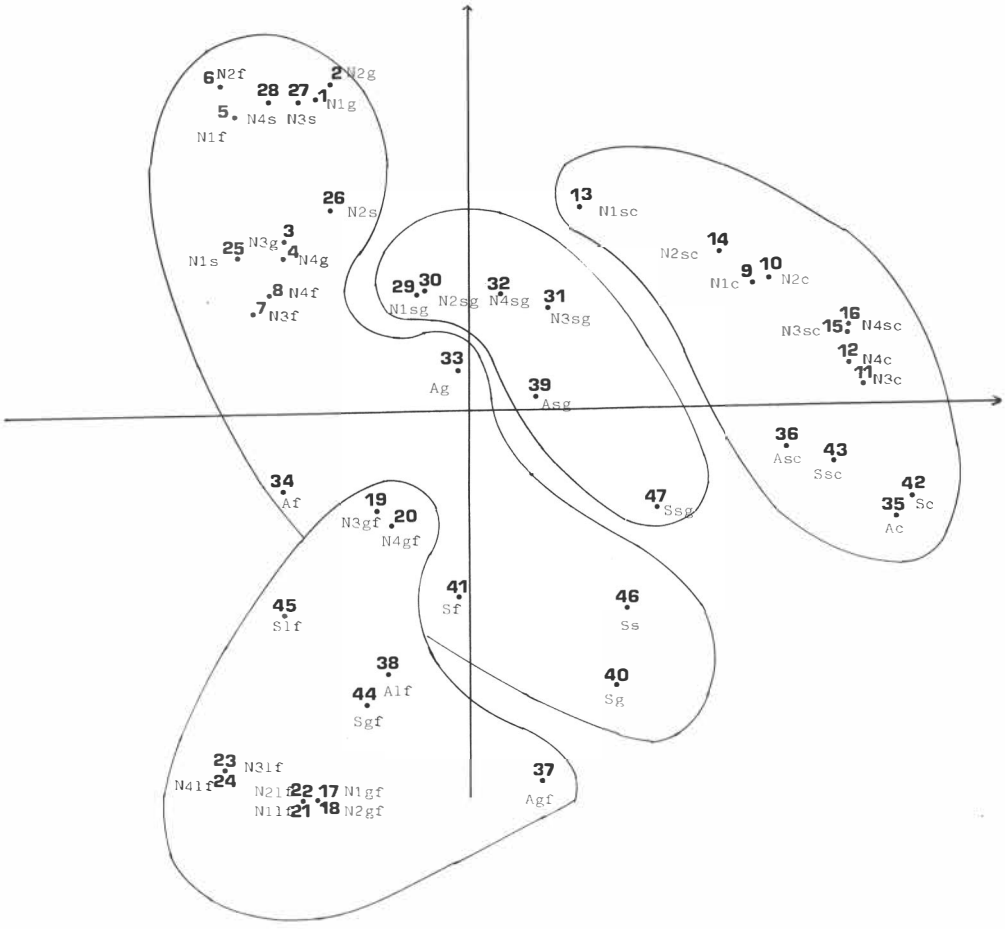

Fig. 3 — Ordination of 47 ordinations as in Fig. 2. Groups of characters are included in lines. Symbols are explained in the title of Fig. 1.

the ordination based on matrix S. Some statistics describing the 47 ordinations are given in Table 2.

Table 2a — Stress values in ordination by MDSCAL. Explanations in Fig. 1.

Axis	N1			N2			N3			N4		
	1	2	3	1	2	3	1	2	3	1	2	3
Species	.30	.13	.11	.37	.17	.15	.35	.15	.11	.33	.15	.11
Species groups	.37	.13	.09	.43	.15	.09	.30	.13	.09	.44	.13	.09
Genera	.41	.17	.17	.44	.13	.17	.37	.15	.09	.35	.15	.09
Families	.19	.11	.09	.48	.11	.09	.19	.11	.07	.19	.11	.07
Chorological types	.28	.17	.11	.28	.19	.11	.16	.15	.07	.28	.15	.07
Subchorological types	.48	.13	.11	.24	.13	.13	.26	.13	.09	.26	.15	.09
Growth-forms	.15	.09	.06	.15	.11	.06	.15	.09	.06	.15	.09	.06
Life-forms	.44	.11	.07	.16	.22	.07	.31	.17	.04	.31	.17	.04

Table 2b — Cumulative percent of variance explained by three axes in ordinations of character groups by SIPLO.

Axes	1	2	3
Species	53.4	82.7	88.6
Species groups	60.8	82.3	88.7
Families	61.9	79.5	88.7
Genera	51.4	82.1	88.3
Chorological types	51.1	69.4	87.0
Subchorological types	65.0	80.9	91.5
Growth-forms	88.5	95.8	97.4
Life-forms	95.1	97.7	99.1

Table 2c — Cumulative percent of total chi-square explained by canonical axes of AOC in different character groups.

Axes	1	2	3
Species groups	21.8	39.5	51.1
Genera	21.4	37.5	46.6
Families	33.6	53.6	61.7
Chorological types	38.3	61.3	76.9
Subchorological types	41.8	57.9	69.9
Growth-forms	36.2	54.0	69.2
Life-forms	58.7	84.8	95.5

Three main groups can be seen in the dendrogram (Fig. 1). The first includes the ordinations corresponding to structural characters of life-form and growth-form. The second group contains the ordination based on taxonomic characters, and the third group consists of the remaining ordinations based on the chorology and subchorology characters. A smaller group, attached to the third contains ordination of SIPLO based on taxonomic characters and species groups. By-and-large it is apparent that the group structure of the 47 ordinations is dominated by character differences rather than by differences in ordination method.

An examination of Figs. 2 and 3 reveals additional patterns. The figures are based on the same axes, but different groups of the 47 ordinations (each point is one ordination). In Fig. 2 the clusters of the three methods occupy distinct locations. They also have different shapes. Considering the AOC cluster, its shape is an horseshoe. What follows logically is that the ordinations based on AOC are non-linearly related among the character groups. The same apply to the MDSCAL cluster, but not to SIPLO. In the case of SIPLO, the cluster is straight, suggesting only proportional differences among the ordinations of the character groups. SIPLO is more efficient in handling non-linear relationships among the characters than each of the other methods. The sequence of the ordinations are more or less the same along the curves fitting the dispersion within the cloud of the same method, i.e.

1	XX																																															
2	99	XX																																													genera
3			XX																																													
4			98	XX																																												
5	63	62			XX																																											
6	61	61			98	XX																																											families
7	66	64			82	80	XX																																									
8	66	64			82	80	99	XX																																								
9							41	41	XX																																							
10							39	39	39	XX																																							chorological types
11											XX																																					
12											99	XX																																					**NOMEMUS**
13	66	66			48	49	63	63	56	55			XX																																			
14									93	95	37	37	56	XX																																			subchorological types
15			35	35					51	52	85	85		52	XX																																	
16									48	49	85	85		49	99	XX																																
17	39	38	44	41			40	40									XX																															
18	40	39	43	39			43	43									99	XX																															growth forms
19															35		49	51	XX																													
20															35		49	51	99	XX																												
21	40	39	56	54	38	39	52	52									69	68			XX																											
22	40	39	56	54	38	39	52	52									69	68			99	XX																											life forms
23			47	45			52	52									53	53			63	63	XX																									
24			47	45			52	52									53	53			63	63	99	XX																								
25	70	70			83	83	80	80			39	39	51								50	50			XX																							
26	72	72			74	74	83	83			54	54	54			35					51	51			96	XX																							species
27			69	74	56	60																			62	47	XX																					
28		37	68	71	55	60																	36	36	64	51	98	XX																				
29	57	57	35	37			52	52			42	42	66				58	56			57	57			61	66			XX																			
30	56	56		36			51	51			40	40	67				57	55			57	57			60	65			99	XX																			species groups
31					35	37	60	60	70	68			76	62											41	45			51	54	XX																	
32	58	57			67	67	85	85	41	39			79				35	37			43	43			73	78			71	69	66	XX																
33			51	55	47	41					47	47			38	36	42	40									76	73					XX																genera
34	66	66			78	63	85	85			54	54	41				36	39			42	42	58	58	62	73	45	41	37	35		58		XX															families **AOCRO**
35			35						60	61	80	80		66	88	88							40	40		35									XX														chorological
36									61	62	80	80		55	84	83									41	51		44							83	XX													subchorological
37			35	38											37	44			70	70	48	48	55	55											57	43	XX												growth forms
38	46	46	40	40	51	39	57	57	45	45			50	41			70	69			78	78			37	53			59	58	37	64		39				XX											life forms
39			43	42					49	47	49	49		39	44	42	37	38					36	36			56	56			48		89			51			XX										species gr.
40	60	59					63	63					41				49	50			42	42	60	60	53	56			40	40		48	48	55				40	42	XX									genera
41	60	59			57	41	79	79			39	39	42				49	51			47	47	62	62	50	66			46	45		63		80				49		83	XX								families **SIPLO**
42	35	35					38	38	43	46	78	78		49	85	85							41	41		48									56	77	73	42			44	46	XX							chorol.
43	43	43			53	45	50	50			85	85			82	83									47	65			35			38	53	52	65	70	35		49			88	XX						subchorol.
44																			37	37																									XX					growth f.
45	45	43					49	49									63	64			59	59	70	70	36	39			38	37			42						41	62	41			68	XX				life f.
46	55	54			37	38	63	63					36				53	53			39	39	63	63	55	57			40	38		48		61	40			39		96	83	54	35		60	XX			species
47	76	75			60	44	79	79			49	49	64		45	46	40	41					45	45	59	77			59	57	42	71		72				42		87	85	66	51			89	XX	sp.gr.
	24	24	16	16	21	21	29	29	14	14	17	17	21	13	18	15	25	25	6	6	25	25	20	20	27	30	10	14	26	24	16	25	16	29	16	15	15	27	21	25	27	23	23	3	20	27	28	

Table 3 — Matrix of the Spearman correlation coefficients (x 100) between the 47 ordinations (only the correlations significant at 5% level are displayed). The sums of the significant correlations for each ordination are at the bottom.

life-form + growth-form < families < genera < species < species groups < chorology + subchorology. This pattern suggests a good correlation between the ordination given by life forms and families and a high independence of the life forms in respect to the chorology. The detailed pattern of correlation between the first axes of ordinations based on the Spearman formula is given in Table 3, while in Table 4 a summary of the results is presented. The ordinations with the highest number of significant correlations are those obtained by NOMEMUS based on euclidean distance, the internal function suggested by Orlóci (1978) and Fewster & Orlóci (1983) and the starting by a random configuration (see Brambilla & Salzano, 1981). If the character type is considered, the ordination with the highest number of significant correlations are those based on families, followed by those based on life forms. The ordinations based on detailed life forms have the least number of significant correlations. This means that this character is the least correlated with the others. Within the same character the ordinations based on families have all significant correlations irrespective to the method used. Also the ordinations based on life forms are very similar irrespective to the method. The characters more sensitive to the method are the genus and the chorology.

Table 4 — Number of significant correlations ($p < 0.05$) between the first ordination axes of the different methods. Columns indicate the significant correlations for the methods, rows for the characters. T = totals, P = number of significant correlations within the character types irrespective of the method, N1-N4 see Fig. 1

	N1	N2	N3	N4	A●C	SIPL●	T	P
Genera	24	24	16	16	16	25	121	7
Families	21	21	29	29	29	27	156	15
Chorology	14	14	17	17	16	23	101	11
Subchorology	21	13	18	15	15	23	105	10
Growth-form	25	25	6	6	15	3	80	11
Life-forms	25	25	20	20	27	20	137	12
Species	27	30	10	14	—	27	108	8
Species groups	26	24	16	25	21	28	140	11
Totals	183	176	132	142	139	176	949	85

Conclusions

The results suggest that the character choice is more critical than the choice of the method, different methods may give similar or dissimilar results in relation of the character set used. SIPLO resulted the least affected by the choice of characters, only the ordinations based on life forms are quite different from the others. The procedure that we suggest can be easily performed for different ordinations (computer programs are available on request to M. Scimone) and will certainly help in the choice of the ordinations which are dissimilar. The dendrogram of Fig. 1 and the Table 4 could be used to select the ordination which potentially should give complementary informations (i.e. the non-correlated ordinations).

Riassunto. Viene usato il coefficiente di correlazione di Spearman per confrontare ordinamenti ottenuti con metodi diversi e basati su caratteri diversi, applicati allo stesso insieme di dati vegetazionali. I risultati dimostrano come gli ordinamenti siano più dipendenti dal tipo di descrizione, piuttosto che dal metodo impiegato.

Acknowledgements. The work has been supported by Italian C.N.R. and Canadian N.S.E.R.C.. Thanks are due also to prof. M. Lagonegro for adaptations on program NOMEMUS.

References

Brambilla C. & Salzano G. (1981) - *A non-metric multidimensional scaling method for non-linear dimension reduction. Theory and computer program.* Istituto per le Applicazioni del Calcolo, Consiglio Nazionale delle Ricerche, Serie III - N. 121. Roma.

Feoli E. (1984) - *Some aspects of classification and ordination of vegetation data in perspective.* Studia Geobotanica: 4: 7-21.

Feoli E. & Orlóci L. (1979) - *Analysis of concentration and detection of underlying factors in structured tables.* Vegetatio 40: 49-54.

Fewster P.H. & Orlóci L. (1983) - *On choosing a resemblance measure for non-linear predictive ordinations.* Vegetatio 54: 27-35.

Kruskal J.B. & Carmone F. (1971) - *How to use M ▶ SCAL (version 5M) and other useful information.* (Mimeographed).

Orlóci L. (1978) - *Multivariate analysis for vegetation research.* 2nd ed. Junk, The Hague.

Orlóci L. (1979) - *Types of data structures and their description.* In Orlóci L., Rao C.R. and Stiteler W.M. (eds.), Multivariate Methods in Ecological Work, pp. 191-202. International Co-operative Publishing House, Burtonsville, Maryland.

Lagonegro M., Ganis P., Feoli E., Poldini L. & Canavese T. (1982) - *Un software per banche dati di flore territoriali, estendibile alla vegetazione.* CNR AQ/5/38, Roma, Udine.

Dr. E. Feoli
Dr. M. Scimone
Dipartimento di Biologia
Università di Trieste
Italy i-34100

Dr. L. Orlóci
Department of Plant Sciences
University of Western Ontario, London
Ontario, Canada N6A 5B7