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Abstract

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A numerical analysis is presented of the species composition of 20 assumed natural areas of N Morocco, using a similarity matrix of the distribution of 3113 taxa and a k-means partitive cluster analysis. The results largely support the phytogeographical divisions of N Morocco proposed by Sauvage & Vindt and by Dobignard.

Key words: plant distribution, phytogeographical districts, statistical analysis, Mediterranean.

Introduction

N Morocco is understood here in the sense of Valdés & al. (2002) including all territories north of the Sebou and Inaouene valleys and extending eastwards to the Algerian frontier. It covers the Tanger Peninsula, the Rif Mts, the Loukkos, Sebou and low Moulouya valleys, the Forêt de la Mamora, the plateaux of Gareb, Saka and Guercif and the Beni-Snassen Mts. It also includes Jebel Tazzeka, which belongs to the Middle Atlas geographically but is clearly isolated from the rest of the Atlas system and is floristically linked to the Rif Mts (Jahandiez & Maire 1931, Emberger 1939).

Valdés & al. introduced a division of this territory into 20 presumably natural areas (Fig. 1) for the purpose to standardize the distributional classification of the taxa recognized in their Catalogue des Plantes Vasculaires du Nord du Maroc (Valdés & al. 2002). These natural areas are based on geographical and geological features rather than on biogeographical data.

The numbers of taxa known from these areas are rather unequal and vary from 283 for High Ouerrha to 1758 for W Rif (Table 1). The differences depend on variation in topography and geological complexity, but also on an uneven exploration of the areas, some being much more attractive to botanists (especially the mountainous and the arid areas) than others. Therefore we undertook several botanical expeditions to the less investigated areas in the last three years (Project BIOGEO, Valdés 2005). This has resulted in an increase of the number of taxa known, e.g., for Ouezzane from 321 to 608 and for High Ouerrha from 283 to 607 (Romo & Soriano 2004, 2005, Valdés & al. 2005, Ennabili & Gharnit 2003). However, these new data are not included in the present analysis, which is based on the figures given in Valdés & al. (2002).

The aim of this paper is to test whether the 20 supposed natural areas cluster in a biogeographically meaningful way, when the similarity of taxa distribution between the areas is numerically analysed.

Material and methods

The two variables analysed in this study are the presumably natural areas (Fig. 1) and the taxa recorded for each area. Most of the areas are rather uniform, but some, particularly Tanger, W Rif, Ouezzane, Zerhoun, Central Pre-Rif and High Ouerrha, include two clear geomorphological subunits. It might have been desirable to separate these, but the available information in Valdés & al. (2002) only allows area by area comparisons.

Valdés & al. (2002) list 3168 taxa (2907 species, 231 subspecies (excluding type subspecies), 24 varieties and 30 hybrids). For the present analysis only species and subspecies were considered, in total 3138 taxa. Of these, 25 were excluded because of their insufficiently known distribution, e.g., the widespread escapes *Ailanthus altissima* and *Iris germanica,* so that 3113 taxa were included in the calculations.

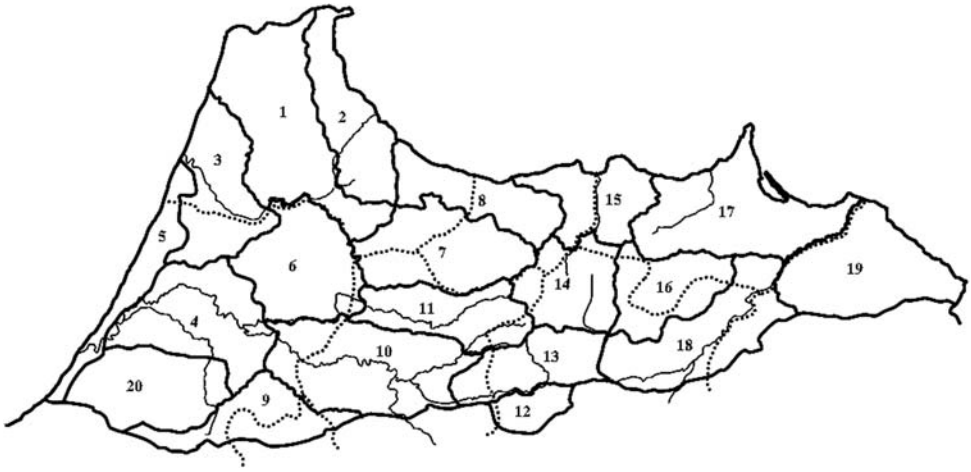

Fig. 1. The 20 natural areas recognized for N Morocco (after Valdés & al. 2002). The numbers of the areas correspond to those for the areas listed in Table 1.

Table 1. The 20 natural areas recognized for N Morocco by Valdés & al. (2002), with the numbers of taxa recorded. Compare Fig. 1.

Natural areas	No. of taxa	Natural areas	No. of taxa
1. Tanger area	1046	11. High Querrha	283
2. W Rif	1758	12. Tazzeka	897
3. Loukkos	692	13. Tsoul	449
4. Gharb	341	14. Aknoul	722
5. Atlantic Coast	797	15. Imzorène	852
6. Ouezanne	321	16. Kert Ganc	745
7. Central Rif	1056	17. Gareb	1335
8. Targuist area	1044	18. Guercif	448
9. Zerhoun	762	19. Beni-Snassen Mts	878
10. Central Pre-Rif	584	20. Forêt de la Mamora	640

In the analysis the natural areas are the Operational Geographic Units (OGU). Although they vary in size, it was not considered appropriate to introduce surface standardisation as was done for Denmark by Lawesson & Skov (2002), since the variation in floristic richness does not seem to be correlated with area size, but rather with sampling intensity. A symmetric distance matrix between the OGUs was generated from the initial presence/absence matrix by calculating the complement of the Sørensen similarity index (Sørensen 1948). This index is very similar to Jaccard's and its values have a monotonic relationship, that is, they are fully equivalent in relation to the order of similarities. Sørensen gives, however, double weight to coincidences and does not consider the co-absences.

A cluster analysis has been applied to test the presence of clusters of areas with similar floristic composition. Among the methods available, k-means (McQueen 1967) has been chosen, a partitive clustering method, whose objective function minimizes the internal dispersion of k groups or clusters (Birks 1987). K-means has been successfully used for, e.g., the recognition and cartography of plant communities (Nilsen & al. 1999) and topoclimatic classification (Burrough & al. 2001). Its algorithm can be described in short as an iteration of the following steps: starting from an initial partition cluster centroids are calculated, then, each individual is reclassified to the group with the closest centroid, the centroids are calculated again, and so on. As the number of groups is a parameter to be chosen by the user, k-means was executed several times, for k values ranging from k= 2 to k = 11. For each k value the analysis was repeated 2000 times starting from initial random partitions to ensure that a global minimum of the functional was found.

The sigmatist phytosociological school defines fidelity as the degree of preference of a taxon for a particular syntaxon (Barkman 1958). In the same way, the fidelity of a taxon for a particular phytogeographical group can be evaluated. Among the different statistical methods for fidelity evaluation (see Chytrý & al. 2002 for a good review), the phi-fidelity (Sokal & Rohlf 1995)was chosen, because its value is not affected by variation in sampling size. phi-values vary between +1 and -1, where +1 indicates the presence of a taxon in all areas of a group and the absence in all others; 0 indicates indifference, and -1 indicates presence in all areas except in the analysed area. The fidelity statistic was used to interpret the groups of areas resulting from the cluster analysis.

The application of the phi-cluster analysis implicates that the weight of the different taxa changes with the number of the clusters analysed. As the analysis progresses and smaller clusters are formed, species with a more restricted distribution area get a higher weight. To evaluate the significance of the partitions we have used the statistics silhouette (Rousseeuw 1987)

All analyses have been done by using the modul Ginkgo of VegAna software (Bouxin 2005, VegAna 2005).

Results

The data of the 20 natural areas allow to form different significant clusters, from two to eleven. Several classifications were generated, but only those resulting in five and seven clusters are compared below, as they have the highest phytogeographical meaning. For convenience the classification in five clusters (Fig. 2) will be addressed as "partition five" and that in seven clusters (Fig. 3) as "partition seven".

When five clusters are generated (Fig. 2), the 20 areas aggregate in the following way (overall mean silhouette 0.36792):

Cluster A: Tanger, W Rif, Central Rif, Targuist and Tazzeka (no. 1, 2, 7, 8 and 12 in Fig. 1). This cluster includes all mountainous areas of N Morocco except Aknoul and the Beni-Snassen Mts (no. 14 and 19 in Fig. 1).

Cluster B: most of the typical Mediterranean areas: Aknoul, Imzorène, Kert Ganc, Gareb and Beni-Snassen Mts (no. 14, 15, 16, 17 and 19 in Fig. 1).

Cluster C: the more oceanic Atlantic areas Loukkos, Gharb, Atlantic Coast and Forêt de la Mamora (no. 3, 4, 5 and 20 in Fig. 1).

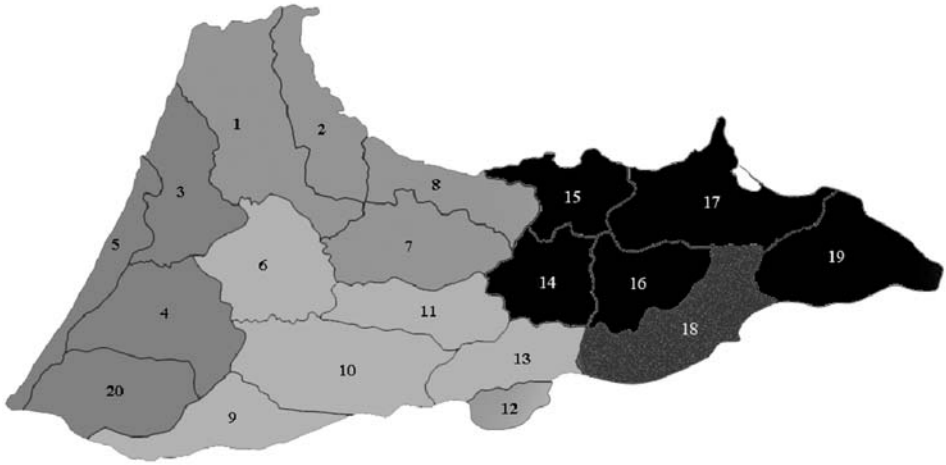

Fig. 2. Clusters of areas generated in partition five. For explanation, see the text.

Cluster D: the more continental Atlantic areas Ouezzane, Zerhoun, Central Pre-Rif, High Ouerrha and Tsoul (no. 6, 9, 10, 11 and 13 in Fig. 1).

Cluster E: Guercif (no. 18 in Fig. 1), which is separated from the other Mediterranean areas.

When seven clusters are generated (Fig. 3), the grouping has an even higher significance (overall mean silhouette 0.43759):

Tanger and W Rif (no. 1 and 2 in Fig. 1; cluster 1 in Table 3) separate from the rest of the Rif Mts, now covering the areas Targuist and Central Rif, plus the mountainous area of Aknoul (no. 7, 8 and 14 in Fig. 1; cluster 2 in Table 3). Tazzeka (no. 12 in Fig. 1) is still linked to this group.

The more oceanic Atlantic areas Loukkos, Gharb, Atlantic Coast and Forêt de la Mamora (no. 3, 4, 5 and 20 in Fig. 1; cluster 4 in Table 3) maintain their cohesion, while the more continental Atlantic areas separate into two clusters, which more or less agree with the division of the "Moyen Sebou" in N and S by Sauvage & Vindt (1952) (Fig. 4), and with the division of Sebou in S Rif-Beni Zeroual and Moyen Sebou by Dobignard (2002) (Fig. 4). One is formed by the ar-

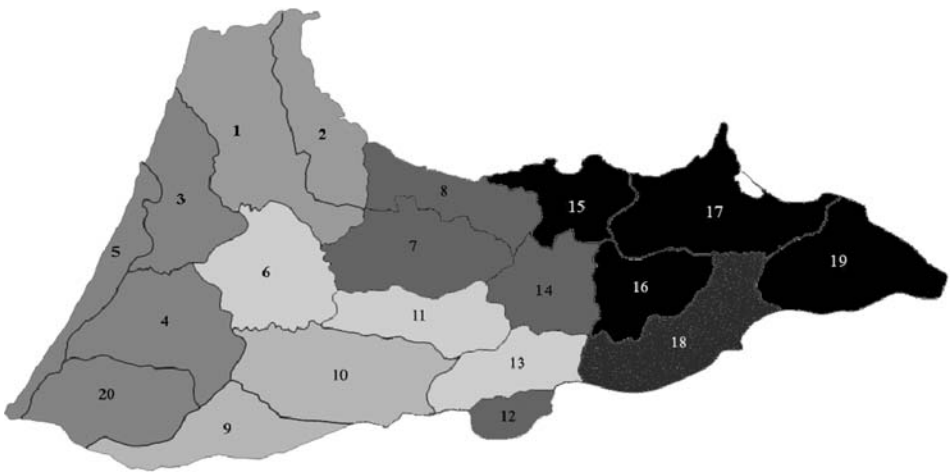

Fig. 3. Clusters of areas generated in partition seven. For explanation, see the text.

eas Zerhoun and Central Pre-Rif (no. 9 and 10 in Fig. 1; cluster 5 in Table 3); the other by the areas Ouezzane, High Ouerrha and Tsoul (no. 6, 11 and 13 in Fig. 1; cluster 6 in Table 3). This cluster may, however, be an artefact, as the flora of these three areas are the least known (Table 1) and thus negatively segregated from the others.

The most Mediterranean areas plus the Beni-Snassen Mts cluster again (no. 14, 15, 16, 17 and 19 in Fig. 1; cluster 3 in Table 3), while Guercif maintains its individuality (no. 18 in Fig. 1 and cluster 7 in Table 3).

When five clusters are formed, four are clearly defined, while the fifth has a very weak characterisation (no. 6, 9, 10, 11 and 13 in Fig. 1). When seven clusters are formed, six are clearly defined, while one remains again very weakly characterised and is negatively defined (cluster 6 in Table 3; no. 6, 11 and 13 in Fig. 1).

Discussion

Cluster A in partition five coincides approximately with the Tanger-Rif-Tazzeka division of Sauvage & Vindt (1952) (Fig. 4), except that they include also the Aknoul area.

Cluster B in partition five segregates the most Mediterranean areas. It covers the geographic divisions of Nekor-Triffa and Beni-Snassen, the eastern part of the Tanger-Rif-Tazzeka area of Sauvage & Vindt (1952) and most of the Rif Oriental, Nekor-Triffa and the Tell Marocain of Dobignard (2002) (Fig. 4).

Cluster C coincides with the "Rhab" and the "Region de Rabat" divisions of Sauvage & Vindt (1952) and with the "Gharb" of Dobignard (2002).

Cluster D largely agrees with the area separated by Sauvage & Vindt (1952) and by Dobignard (2002) as Moyen Sebou.

Cluster E separates Guercif. This is not shown by Sauvage & Vindt (1952), although it partly agrees with their "Moulouya" subsector, nor by Fennane & Ibn Tattou (1998) or Fennane & al. (1999), who recognize a wide area "Moulouya" or "Basse Moulouya", including most of the Mediterranean areas of our cluster 3. Dobignard (2002), however, treats it as part of the Basse-Moulouya, excluding the Mediterranean areas (Table 2 and Fig. 5).

Only two clusters are the same in both partitions, one comprising Guercif only (no. 18 in Fig. 1; cluster E in partition five; cluster 7 in partition seven) and the other comprising the Atlantic areas Loukkos, Gharb, Mamora and Atlantic Coast (no. 3, 4, 5 and 20 in Fig. 1; cluster C in partition five; cluster 4 in partition seven).

Comparison of partition five with partition seven shows further that in the identical clusters the species with the highest phi-values in the ordination are the same in both partitions. However, in the clusters of partition five which appear divided in partition seven, the responsible species are totally different in both partitions.

Phytogeographical characterisation. – For a phytogeographical characterisation of the clusters attention has been paid to the strongly supportive species, those which contribute positively to the separation of the different clusters in the two analyses (partitions five and seven) and have a phi-value higher than 0.5. Although there exists a large study on biogeographical affinities of the flora of N Africa and Sahara with a wide chorological classification (Quézel 1978), a more restrictive classification has been used here for the chorological classification of N Morocco. The adopted floristic categories are the following:

1. Endemic: Moroccan endemic taxa.
2. Euro-Mediterranean: European taxa whose distribution extends to N Africa.
3. Euro-Siberian: including Boreal and widely distributed Holarctic as well as truly Euro-Siberian taxa.
4. Ibero-Maghrebian: taxa occurring in both the Iberian Peninsula and NW Africa.
5. Maghrebian: taxa that only occur in two or three of the NW African countries Morocco, Algeria and Tunisia.

6. W Mediterranean: Mediterranean taxa occurring from the Italian Peninsula and Tunisia westwards (some species with an Atlantic distribution sensu Quézel (1978) are included).
7. Mediterranean: circum-Mediterranean taxa.
8. Irano-Turanian: taxa of the Irano-Turanian region as defined by Zohary (1973).
9. Saharo-Arabian: taxa of the Saharo-Arabian region as defined by Zohary (1973).
10. Anthropogenous: naturalized taxa, mostly introduced as crops, gardening plants or weeds.

Table 2. Approximate equivalences of the geographic divisions of N Morocco by Sauvage & Vindt (1952), Fennane & Ibn Tattou (1998), Fennane & al. (1999), Dobignard (2002) and Valdés & al. (2002). Roman numbers and subindexes in the first and fourth columns refer to divisions and subdivisions by those authors, as in maps 1 and 2. * In the column four the Rif is entered three times and Rif Oriental and Nekor-Triffa twice because Dobignard extends the Rif to Moulouya river and includes the Kert Gank area.

S. & V. (1952)	F. & Ibn T. (1998)	F. & al. (1999)	Dobignard (2002)	V. & al. (2002)
I. Tanger-Rif-Tazzeka	**Rif**	**Rif**	**I. Rif***	
I_1 Tanger-Rif S.-O.	Tangerois		Ia. Tangerois	1. Tanger
			Ib. Rif Central	2. W. Rif
	Rif Occidental			7. C. Rif
I_2 Rif N.-E.	Rif Oriental			8. Targuist
			Ic. Rif Oriental*	14. Aknoul
	Moyen Atlas	**Moyen Atlas**	**XI. Moyen Atlas**	
I_3 Tazzeka	Tazzeka		XId. Tazzeka	12. Tazzeka
II. Rharb	**Maroc Atlantique Nord**	**Maroc Atlantique Nord**	**II. Gharb**	
II_1 Littoral	Rharb		IIa. Gharb littoral	5. Atlantic Coast
II_2 Nord			IIb. Gharb interior-Low	3. Loukkos
II_3 Sud				4. Gharb
III. Region de Rabat	Mamora-Zemmour - Zaër		IIc. Zaër-Chaouïa	20. Mamora
VII. Moyen Sebou			**VI. Sebou**	
VII_1 Nord	Pre-Rif et Moyen Sebou		VIa. S Rif-Beni-Zerou	6. Ouezanne
				11. High Ouerrha
			VIb. Moyen Sebou-Saïs	13. Tsoul
				10. Pre-Rif
VII_2 Sud				9. Zerhoun
XVIII. Nekor-Triffa	**Littoral de la Méditerranée**	**Littoral de la Mediterranée**	**I. Rif***	
	Boccoya-Nekkor		Ic. Rif Oriental*	15. Imzorène
	Triffa-Moulouya		Id. Nekor-Triffa*	17. Gareb
XIX. Maroc Oriental	**Plaines et Plateaux du Maroc Oriental**	**Plateaux du Maroc Oriental**	**XIV. Steppes Orientales**	
XIX_1 Moulouya	Basse Moulouya		XIVa. Basse Moulouya	18. Guercif
			I. Rif*	
XIX_2 Haut Msoun			Id. Nekor-Triffa*	16. Kert Ganc
XX. Atlas Tell.	**Monts du Maroc Oriental**	**Monts du Maroc Oriental**	**XVI. Tell marocain**	
XX_1 Beni Snassen	Beni Snassen		XVIa. Bass Moulouya-Kiss	19. Beni Snassen
			XVIb. Beni Snassen	

Fig. 4. Divisions and subdivisions of N Morocco in Sauvage & Vindt (1952). – I: Tanger-Rif-Tazzeka; 1: Tanger-Rif S-O; 2: Rif N-E; 3: Tazzeka. II: Rhab; 1: Littoral; 2: Nord; 3: Sud. III: Region de Rabat. VII: Moyen Sebou; 1: Nord; 2: Sud. XVIII: Nekor-Triffa. XIX: Maroc Oriental; 1: Moulouya; 2: Haut Msoun. XX: Atlas Tell.; 1: Beni-Snassen (Table 2).

11. Palaeotropical: taxa distributed predominantly in the tropics of the Old World.
12. Pluriregional: cosmopolitan and subcosmopolitan taxa.

Table 3 presents the percentages of strongly supportive taxa for each of these 12 floristic elements, which characterise the clusters of partition seven.

A closer look at the species with higher phi-fidelity for both partitions shows that in partition five the mountainous areas (Cluster A) are characterised by the presence of forest species (*Quercus canariensis, Q. faginea, Cedrus atlantica, Prunus lusitanica, Luzula forsteri, Viola reichenbachiana,* etc.), montane Mediterranean and Ibero-Maghrebian (*Sagina sabuletorum, Neoti-*

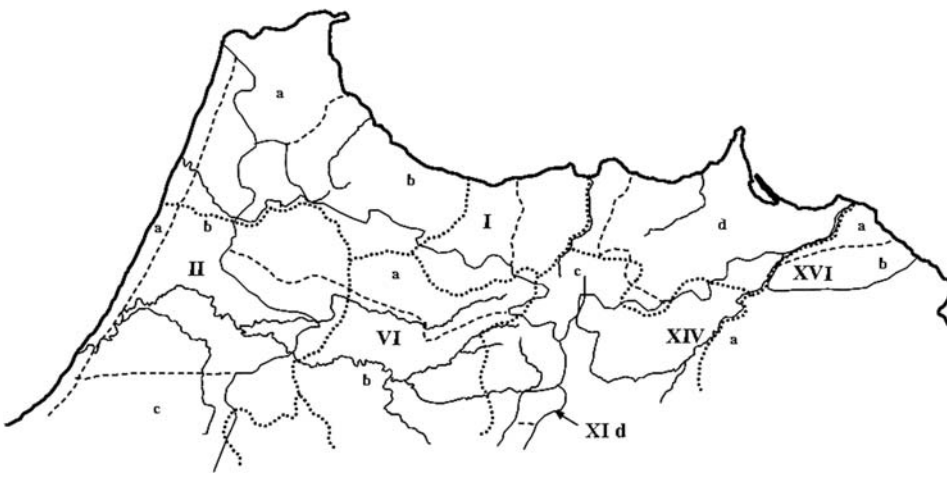

Fig. 5. Divisions and subdivisions of N Morocco in Dobignard (2002): I: Rif; a: Tangerois; b: Rif central; c: Rif oriental; d: Nekor-Triffa. II: Gharb; a: Gharb littoral; b: Gharb interieur-Loukkos; c: Zaër-Chaouïa. VI: Sebou; a: Sud-Rif-Beni Zeroual; b: Moyen-Sebou-Saïs. XI: Moyen-Atlas; d: Tazzeka. XIV: Steppes orientales; a: Basse-Moulouya-Kiss; b: Beni-Snassen (Table 2).

Table 3. Phytogeographical composition of the clusters of partition seven (C1-C7, Fig. 3), with shares (in %) of the most significant taxa (phi-value 0.49) belonging to the listed floristic elements.

Elements	C1	C2	C3	C4	C5	C6	C7
Endemic	14	15	5	17	22	29	10
Euro-Mediterranean	15	14	4	2	8	0	0
Euro-Siberian	7	11	2	4	3	0	0
Ibero-Maghrebian	21	18	21	25	14	0	11
Maghrebian	18	11	19	1	10	0	18
W Mediterranean	14	10	9	9	18	14	5
Mediterranean	2	12	27	23	18	0	19
Irano-Turanian	0	6	8	2	1	0	15
Saharo-Arabian	4	0	3	0	0	0	12
Anthropics	3	0	0	10	3	0	8
Paleotropical	0	0	0	3	0	0	1
Pluriregional	3	3	1	5	5	0	0
Total number of taxa	647	204	255	115	79	7	73

nea maculata, Tuberaria lignosa, Lamium flexuosum, etc.), some Euro-Siberian (*Anagallis tenella, Sambucus nigra, Taxus baccata,* etc.) and some endemic species with a wide distribution (*Ptilostemon rhiphaeus, Silene cuatrecasasii,* etc.). A comparison of Fig. 2 (partition 5 map) with the phytogeographic map of Morocco published by Emberger (1939) shows a high coincidence between this group and the spots which represent on that map the presence of cedar and deciduous oak forests. The absence of this type of forest might partly explain why in this partition Aknoul is joined with the Mediterranean areas.

However, when these areas form two clusters (in partition seven, Fig. 3), the Tanger peninsula (cluster 1) is characterised by endemic species with restricted range *(Anthemis abylaea, Leucojum tingitanum, Limonium auriculae-ursifolium, Ptilostemon abylensis, Scrophularia papillaris, Silene legrangei),* Euro-Mediterranean *(Agrostis curtisii, Danthonia decumbens, Erinus alpinus, Hydrocotyle vulgaris, Lotus angustissimus),* Euro-Siberian *(Geranium robertianum),* and Ibero-Maghrebian species (*Crepis tingitana, Drosophyllum lusitanicum, Eryngium dilatatum, Halimium atlanticum, Iberis gibraltarica, Klasea alcalae, Nothobartsia aspera, Polygala boissieri, Scilla monophyllos,* etc.).

Cluster 2 of partition 7, the second mountain cluster, consisting of Central Rif, Aknoul, Tazzeka and Targuist, is characterised, among others, by the presence of Ibero-Maghrebian *(Ononis speciosa),* N Moroccan endemic *(Rhodanthemum gayarum* subsp. *demnatense),* Euro-Siberian *(Veronica verna)* and Maghrebian species (*Astragalus incanus* subsp. *incurvus, Campanula filicaulis, Filago numidica,* etc.).

Another big cluster in partition five, cluster B, is formed by Imzorène, Gareb, Kert Ganc, Beni-Snassen and Aknoul, of which Aknoul is separated in partition seven. This is clearly justified by the presence in the Aknoul area of Jebel Akrou, one of the highest mountains in N Morocco, which shares a number of characteristic species with Central Rif. In partition five, this cluster is characterised by Mediterranean and Maghrebian taxa, and negatively by the absence of deciduous forest trees, while in partition seven some mountain species also have an important weight. The highest phi-values in partition five correspond to Maghrebian or endemic taxa such as *Dianthus sylvestris* subsp. *longibracteatus, Ornithogalum sessiliflorum, Gagea algeriensis,* etc., while in partition seven these species, shared with the Aknoul area, still have a positive phi-value although lower than 0.8, and the cluster without Aknoul (cluster 3) is characterised by Ibero-Maghrebian *(Ceratocapnos heterocarpa, Helianthemum marifolium* subsp. *origanifolium, Silene aellenii)* and Mediterranean taxa (*Erodium neuradifolium, Euphorbia serrata, Onobrychis crista-galli, Rosmarinus eriocalyx,* etc.).

The cluster formed by the Atlantic areas of Loukkos, Gharb, Atlantic Coast and Mamora is very well characterized, because there are no changes at successive partitions. As is shown in table 2 the chorological areas of cluster 4 have a strong Ibero-Maghrebian component, formed by a high number of species which are shared with the W Andalusian lowland and an important number of anthropogenic species, plus a high percentage of taxa endemic of the Moroccan Atlantic littoral. The potential vegetation of these sectors is constituted by olive tree and cork oak forests. The soils, as in SW Spain, are deep black vertisols, mainly formed by littoral sands. Formerly many permanent or temporary marshes existed in these areas. Already Emberger (1939) indicated that many of these had been drained for agricultural use. Nowadays the swamps and the associated, rich flora have disappeared. Some characteristic species of these habitats are positive discriminators for the natural areas with oceanic influence. Endemics such as *Rorippa africana,* and palaeotropical or subcosmopolitan taxa such as *Pycreus polystachyos, Wolffia arrhiza, Spirodela polyrhiza* and *Utricularia gibba,* were quite common in the past, but nowadays are found mainly in herbaria. Many species occur only on sandy soils, which are frequent in all these areas, and especially near the coast. Among those with high phi-values we can mention some endemics *(Ammochloa involucrata, Asphodelus gracilis, Elizaldia heterostemon),* many Ibero-Maghrebians *(Malcolmia triloba, Tuberaria echioides, Heteranthemis viscide-hirta, Astragalus algarbiensis, Brassica tournefortii, Retama monosperma)* and a significant group of naturalized and palaeotropical species (*Oenothera striata, Eragrostis atrovirens,* etc.).

The cluster formed by Zerhoun and central Pre-Rif (no. 9 and 10 in Fig. 1; cluster 5 in Table 3) is characterized by a series of Moroccan endemic, Mediterranean, and Ibero-Maghrebian taxa. The species with highest values of phi-fidelity are ordered as follows: *Teucrium barbarum, Rytidocarpus moricandioides, Marsilea strigosa, Medicago scutellata, Orchis papilionacea, Ballota hirsuta* subsp. *maroccana, Marrubium echinatum, Stachys saxicola* subsp. *villosissima, Anthemis maroccana* subsp. *maroccana, Onobrychis alba* subsp. *mairei, Arum hygrophilum, Teucrium brevifolium.*

Cluster 6, formed by the chorological areas of Ouezzane, High Ouerrha and Tsoul, is negatively defined, because only 7 species have a phi-value higher than 0.5 (Table 3). Its status will probably change when more data are available.

While the former group is weakly defined, the Guercif area (no. 18 in Fig. 1) separates both in partition five and in partition seven as a distinct cluster. It is strongly characterised by a series of Irano-Turanian *(Plantago notata, Fagonia glutinosa, Medicago anguina)* and Saharo-Arabian taxa *(Acanthorrhinum ramosissimum, Anvillea radiata, Atractylis serratuloides* and *Deverra denudata),* reflecting the arid conditions of this area (Le Houerou 2001), and by the strong penetration of taxa of more southern origin along the Moulouya valley. A considerable number of restricted endemic species such as *Astragalus reesei, Teucrium drucelleri, Salsola gemmascens* subsp. *maroccana,* and a group of Maghrebian species, shared with NW Algeria and N Sahara, such as *Atractylis echinata, Catananche arenaria, Euphorbia cossoniana, Genista capitellata, Muricaria prostrata,* also contribute to segregate this cluster, as does the complete absence of Euro-Siberian and Euro-Mediterranean species (Table 3).

Conclusion

The results shown here have been reached from the analysis of a matrix including the whole flora of the studied territory and not only the endemic taxa. In the classification of the chorological areas all species and subspecies recognized by Valdés & al. (2002) contribute positively or negatively, except the very common species that are present in all chorological areas (phi = 0).

The first geographic division of N Morocco, proposed by Jahandiez & Maire (1931), is not sufficient since the five regions distinguished little agree with both more recent treatments and our results.

The division adopted by Sauvage & Vindt (1952), which has been followed with some modifications by Fennane & Ibn Tattou (1998) and by Dobignard (2002), seems to be more appropriate.

N Morocco is divided into seven main areas, some of them subdivided into smaller subareas, with a total of 13 geographical units at two different levels. The geographic divisions adopted by Fennane & al. (1999) are basically the same but with six divisions only.

The geographic divisions adopted by Sauvage & Vindt (1952), Fennane & Ibn Tattou (1998), Fennane (1999) and Dobignard (2002) are indicated in Table 2, and compared with the areas recognized by Valdés & al. (2002).

The main difference between Sauvage & Vindt and Dobignard, and the others is that Fennane & al. (1999) recognize for NW Morocco only one main area "Maroc Atlantique Nord", in which they include the three main areas of Sauvage & Vindt: Rhab, Region de Rabat and Moyen Sebou. These areas are still recognized as subdivisions of Maroc-Atlantique Nord by Fennane & Ibn Tattou (1998). Another difference is that the "Maroc Oriental" of Sauvage & Vindt (1952) is not subdivided into two subareas by the other authors. Further Sauvage & Vindt (1952) include the Tazzeka area in the same unit as Tanger-Rif Mts, while the other authors separate it as a part of the Middle Atlas. Our analyses thus largely corroborate the geographical subdivisions by Sauvage & Vindt (1952) and Dobignard (2002).

The comparison of the clusters of partitions five and seven suggests the following:

1. N Morocco includes three main floristic regions: a mountainous central region formed by the Rif and Tazzeka Mts extending to Tanger, with Aknoul; second a western region and third an eastern region.
2. The Tazzeka Mts are not segregated from the other mountainous regions, but belong to the same biogeographical unit.
3. The "Maroc Atlantique Nord" of Fennane & al. (1999) it is not a uniform region, but includes three distinct regions, as defined by Sauvage & Vindt (1952), Fennane & Ibn Tattou (1998) and Dobignard (2002).
4. The Forêt de la Mamora does not constitute a separate sector as considered by Sauvage & Vindt (1952) but has to be grouped with the other N Moroccan Atlantic areas.
5. The Beni-Snassen area clusters with the other Mediterranean areas (Imzorène, Kert Ganc and Gareb) perhaps because as defined by Valdés & al. (2002) this area includes not only the Beni-Snassen Mts themselves, but a wide Mediterranean territory surrounding them, which extends from the Moulouya river to the Algerian frontier, an area separated by Dobignard (2002) as Basse Moulouya-Kiss. In this sense, the treatment by Dobignard (2002) of this area is quite appropriate, as he subdivides his Tell marocain (Beni-Snassen area sensu Valdés & al.) into two sectors "Basse Moulouya-Kiss" for the Mediterranean territory and "Beni-Snassen" for the mountains. This area has a flora very rich in endemic taxa shared between NE Morocco and NW Algeria (Oran Region), included here in the Maghrebian element.
6. The Guercif area is clearly separated from the other Mediterranean areas, because the Mediterranean influence does not seem to penetrate south of the borderline which separates Guercif from the Gareb area.

A general conclusion is that Mediterranean species (including circum-Mediterranean, W Mediterranean, Ibero-Maghrebian, Maghrebian and Moroccan endemics) are absolutely dominant in the flora of N Morocco. Varying percentages of these groups contribute to the characterization of the clusters, while some other elements have an important weight in their separation.

The results presented here should be considered as preliminary because only the floristic data from N Morocco by Valdés & al. (2002) have been evaluated. This is especially true for the biogeographical attribution of the Jebel Tazzeka to the Rif Mts. A comparison based on more observations of the Tazzeka area with the Rif Mts and the Middle Atlas is needed to reach a better decision on its true floristic affinities.

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