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Floristic analysis of the Almeriensian Sierra Nevada (Almería, SE Spain)

Abstract

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This paper presents a floristic analysis of the Almeriensian Sierra Nevada, examining several aspects, such as: the distribution of taxa in the main botanical groups, families and genera; the biotype spectrum; the presence of taxa by thermotypes and ombrotypes; their affinity for syntaxonomic units and physiognomic vegetation types; the classification of floristic elements; and their relative abundance.

Key words: Iberian Peninsula, Biological forms, Bioclimatology, Chorology, Phytosociology.

Introduction

The Sierra Nevada (S Spain) has been cited by numerous authors as one of the most important centres of plant diversity in the Mediterranean, both for the total number taxa that it harbours, estimated at some 2100 taxa (Molero Mesa & Pérez Raya 1987), as well as for its endemic and/or endangered flora (Molero & al. 1992; Domínguez & al. 1996; Blanca & al. 1998). This important diversity is the result of the history of the Sierra Nevada and its current characteristics (Blanca & Lorite 2003).

Although the flora of the Sierra Nevada within the province of Granada has been analysed in different works (Molero & Pérez Raya 1987; Molero & al. 1992), such analyses have not been made in the Sierra Nevada within the province of Almería, which has been the object of only partial studies restricted to certain areas (Mota & Valle 1987), broader studies that encompass the territory treated in the present work (Sagredo 1987; Valdés & Talavera 1991), or studies restricted to particular botanical groups (e.g. Pallarés 1997; 1999). With the publication of the floristic catalogue of this area (Lorite & al. 2002, 2003, 2005), information that has been compiled can be analysed in order to separate data and draw relationships between other massifs and geographic zones.

These analyses of the flora, which have appeared with relative frequency in recent years, are highly informative because they take different aspects into account, enabling common patterns as well as singularities to be discerned for a given area. Some of these data can provide a better understanding of the behaviour of the flora as a group, and of certain groups in particular.

The Almeriensian Sierra Nevada (the eastern zone of the Sierra Nevada massif) presents a broad range of different environmental factors. The altitude ranges from 2609 m at Chullo peak to 250 m at the confluence of the Nacimiento and Andarax Rivers. From a geological standpoint, the Nevado-Filabride and Alpujarride complexes are well represented; the former extends to the central core and is composed mainly of micaschists and quartzites, while the second occupies the middle area of the mountain and the southern slope, where limestones and phillites are the dominant materials. Also present are Tertiary materials composed of conglomerates, sandstones, marls, and Quaternary deposits associated with rivers, gullies, and seasonal water courses (*ramblas*). In phytogeographical terms (Lorite, 2001), the Murcian-Almeriensian province (Almeriensian sector) in the southeastern zone, and the Betic province are represented by the Alpujarrean-Gadorensean sector (southern slope) and Nevadensian sector (central summit zone and northern slope). Finally, thermo-, meso-, supra-, and oromediterranean thermotypes, as well as semiarid, dry, and subhumid ombrotypes are represented.

Materials and methods

Based on the floristic catalogue of the area (Lorite & al., 2002; 2003; 2005), we analysed a number of aspects such as the main groups, families, and genera, for which we used the classifications of Pichi-Sermoli (1977) for *Pteridophyta*, Melchior & Werdermann (1954) for *Pinophyta*, and Cronquist (1981) for *Magnoliophyta*. For the analysis of the spectrum of biological forms, the classical system of Raunkjaer (1934) was followed, with the modifications of Bolòs & Vigo (1984) and Rivas Martínez (1996). With respect to the biogeography and bioclimatology, Rivas Martínez & al. (1999, 2002) were followed. To analyse the affinity of the flora for different syntaxonomic and physiognomic units of the vegetation, the types established by Rivas Martínez & al. (2001) were considered. The classification of floristic elements was adapted from the work of Mateo & Figuerola (1987). Finally, the relative abundance was established according to the values established by Willmans and Rasbach (1973); these values were compared with the distribution range of the species and with the spectrum of biological forms.

Results and Discussion

Analysis of the main groups, families and genera

Table 1 displays the relative representation of each of the main taxonomic groups of the Almeriensian Sierra Nevada in comparison to that of the massif as a whole (Blanca 1996). It is noteworthy that most of the families of the different groups appear in our study zone in proportions very similar to those of the Sierra Nevada as a whole, while some differences appear at the species level.

Dicotyledons are the best represented group, with 78.3% of the total of the taxa recorded, followed by monocotyledons, with 18.7%. Also, the representation of gymnosperms was low (1.1 %), given that this percentage also includes species used in plant-recovery

Table 1. Representation of the main taxonomical groups of the Almeriensian Sierra Nevada (shaded) compared to the whole of the Sierra Nevada (data from Blanca 1996).*Species and subspecies.

	Families				Taxa*			
	nº	%	nº	%	nº	%	nº	%
Pteridophytes	10	9.5	14	12.2	27	1.9	48	2.3
Gymnosperms	4	3.9	4	3.5	14	1.1	14	0.7
Dicotyledons	81	77.1	83	72.1	1,069	78.3	1,718	81.8
Monocotyledons	10	9.5	14	12.2	255	18.7	320	15.2
Total	**105**		115		**1,366**		2,100	

programmes, some of these plants being allochthonous. The Pteridophyte species (indicators of the degree of moisture) was 1.9 %, this being appreciably lower than for the Sierra Nevada as a whole, where this group represents 2.3%, although it is higher than in other mountainous zones of the southern Iberian Peninsula, such as 1.1% in the Sierra de María (Cueto & al. 1991) and 0.9 % in the Sierra de Baza (Blanca & Morales 1991).

Among families with the greatest representation (Table 2), *Asteraceae* was notable, with 81 genera and 184 species, followed by *Poaceae*, with 66 genera and 143 species, *Fabaceae* with 32 genera and 116 species, and *Brassicaceae*, with 42 genera and 79 species. Among *Pteridophytes*, the only striking family was *Aspleniaceae*, with 3 genera and 10 species.

The index of *Cistaceae*, indicator of the degree of the Mediterraneity of the flora, was 1.68 less than 2.3% in the Sierra de María-Orce (Cueto & al. 1991) and the Sierra de Baza (Blanca & Morales 1991) or 2.1 % in Cabo de Gata (Cueto & al. 1998). All these zones have marked summer dryness and a lower altitudinal gradient, although higher than in other south-western zones of the Iberian Peninsula, such as the Sierras de Cardeña and Montoro, where this family represents only 1.5% of the flora (Melendo 1998), which could be due to a greater Atlantic influence of this latter territory.

With regard to the genera, we emphasize: *Trifolium* (23 taxa), *Carex* (21), *Silene* (16), *Centaurea* (15), *Galium* (14), *Plantago* (13), *Ranunculus* (13), *Euphorbia* (12), *Sedum* (12), *Senecio* (12), *Festuca* (11), *Helianthemum* (11) and *Juncus* (11).

Analysis of the spectrum of biological forms

The spectrum of biological forms of the flora in a territory provides information on the structure of the vegetation and represents the morphological response of the plants to the surrounding environmental conditions.

Table 3 presents the spectrum of biological forms, in comparison to other areas. The predominant biological form in the flora of the Almeriensian Sierra Nevada are thero-

Table 2. Flora of the Almeriensian Sierra Nevada by families (with representation greater than or equal to 10 species): *Species and subspecies.

	Gen.	Sp.*
Pteridophytes		
Aspleniaceae	3	10
Asplenium 8; Others 2		
Dicotyledons		
Asteraceae	81	184
Centaurea 15; *Senecio* 12; *Cirsium* 8; *Crepis* 6; *Lactuca* 6; *Leontodon* 6; *Launaea* 5; *Carduus* 4; *Onopordum* 4; *Sonchus* 4; *Achillea* 3; *Andryala* 3; *Artemisia* 3; *Bellis* 3; *Filago* 3; *Logfia* 3; *Phagnalon* 3; *Santolina* 3; *Scorzonera* 3; *Tanacetum* 3; *Tolpis* 3; *Tragopogon* 3; *Anthemis* 2; *Arctium* 2; *Bombycilaena* 2; *Calendula* 2; *Carthamus* 2; *Cichorium* 2; *Coleostephus* 2; *Conyza* 2; *Crupina* 2; *Evax* 2; *Helichrysum* 2; *Hieracium* 2; *Jasonia* 2; *Matricaria* 2; *Picris* 2; *Pulicaria* 2; *Scolymus* 2; *Taraxacum* 2; *Xanthium* 2; Others 40		
Fabaceae	32	116
Trifolium 23; *Astragalus* 10; *Vicia* 10; *Medicago* 9; *Anthyllis* 6; *Genista* 6; *Lathyrus* 6; *Lotus* 6; *Ononis* 6; *Coronilla* 3; *Cytisus* 3; *Dorycnium* 3; *Hippocrepis* 2; *Melilotus* 2; *Ornithopus* 2; *Scorpiurus* 2; *Trigonella* 2; Others 15		
Brassicaceae	42	79
Alyssum 6; *Arabis* 5; *Sisymbrium* 5; *Erysimum* 4; *Lepidium* 4; *Matthiola* 4; *Biscutella* 3; *Brassica* 3; *Cardamine* 3; *Moricandia* 3; *Thlaspi* 3; *Coincya* 2; *Diplotaxis* 2; *Draba* 2; *Rorippa* 2; *Teesdalia* 2; Others 26		
Caryophyllaceae	24	74
Silene 16; *Cerastium* 8; *Arenaria* 5; *Herniaria* 5; *Minuartia* 5; *Dianthus* 4; *Paronychia* 4; *Scleranthus* 3; *Spergularia* 3; *Corrigiola* 2; *Petrorhagia* 2; *Sagina* 2; *Spergula* 2; *Stellaria* 3; Others 10		
Lamiaceae	22	64
Teucrium 9; *Thymus* 8; *Mentha* 7; *Sideritis* 5; *Lamium* 3; *Lavandula* 3; *Nepeta* 3; *Origanum* 3; *Phlomis* 3; *Salvia* 3; *Ballota* 2; *Calamintha* 2; *Marrubium* 2; *Prunella* 2; Others 8		
Scrophulariaceae	13	52
Veronica 11; *Linaria* 10; *Verbascum* 7; *Chaenorrhinum* 6; *Scrophularia* 4; *Euphrasia* 3; *Antirrhinum* 2; *Digitalis* 2; *Odontites* 2; *Parentucellia* 2; Others 3		
Apiaceae	22	38
Bupleurum 5; *Conopodium* 4; *Eryngium* 4; *Torilis* 4; *Anthriscus* 2; *Chaerophyllum* 2; *Scandix* 2; Others 15		
Rosaceae	12	29
Rosa 7; *Potentilla* 5; *Prunus* 5; *Alchemilla* 3; *Sorbus* 2; Others 7		
Ranunculaceae	9	25
Ranunuculus 13; *Aconitum* 2; *Clematis* 2; *Nigella* 2; *Thalictrum* 2; Others 3		
Cistaceae	4	23
Helianthemum 11; *Cistus* 6; *Fumana* 4; Others 2		
Rubiaceae	7	22
Galium 14; *Crucianella* 3; Others 5		
Boraginaceae	11	20
Myosotis 5; *Echium* 3; *Anchusa* 2; *Buglossoides* 2; *Cynoglossum* 2; Others 5		
Chenopodiaceae	5	18
Chenopodium 8; *Atriplex* 4; *Salsola* 3; *Suaeda* 2; *Hammada* 1		
Crassulaceae	5	17
Sedum 12; *Umbilicus* 2; Others 3		
Geraniaceae	2	17
Erodium 9; *Geranium* 8		
Euphorbiaceae	4	16
Euphorbia 12; *Mercurialis* 2; Others 2		

Table 2. (continued).

Campanulaceae	5	14
Campanula 7; *Legousia* 3; *Jasione* 2; Others 2		
Plantaginaceae	1	13
Plantago 13		
Salicaceae	2	12
Salix 7; *Populus* 5		
Fumariaceae	4	11
Fumaria 7; *Sarcocapnos* 2; Others 2		
Polygonaceae	3	11
Rumex 7; *Polygonum* 3; *Fallopia* 1		
Resedaceae	2	10
Reseda 9; *Sesamoides* 1		
Primulaceae	7	10
Anagallis 2; *Androsace* 2; *Coris* 2; Others 4		
Onagraceae	1	10
Epilobium 10		
Monocotyledons		
Poaceae	66	143
Festuca 11; *Bromus* 8; *Poa* 8; *Agrostis* 7; *Stipa* 6; *Vulpia* 6; *Aegilops* 4; *Avenula* 4; *Brachypodium* 4; *Eragrostis* 4; *Setaria* 4; *Aira* 3; *Briza* 3; *Holcus* 3; *Koeleria* 3; *Lolium* 3; *Melica* 3; *Alopecurus* 2; *Arrhenatherum* 2; *Avena* 2; *Corynephorus* 2; *Cynosurus* 2; *Dactylis* 2; *Echinochloa* 2; *Glyceria* 2; *Polypogon* 2; Others 40		
Cyperaceae	3	30
Carex 21; *Cyperus* 5; *Scirpus* 4		
Liliaceae	13	28
Allium 6; *Gagea* 6; *Asparagus* 3; *Asphodelus* 3; *Muscari* 2; Others 8		
Orchidaceae	10	26
Ophrys 7; *Dactylorhiza* 6; *Orchis* 6; *Cephalanthera* 2; Others 6		
Juncaceae	2	15
Juncus 11; *Luzula* 4		

phytes, with 37% of the total, a value very close to that of other Betic sierras (e.g. María-Orce, Rio Segura, and Tejeda y Almijara). In a close second position, hemicryptophytes, at 31.2%, are followed at some distance by chamaephytes, 14.2%, this latter group having major repercussions in the plant landscape. With regard to the phanerophytes, 9.1%, and geophytes, 6.5%, we find that the percentages are appreciably lower than in other sierras, such as Segura. Also, there was a lower percentage of hydrophytes, 1.1%, although in the areas most similar to the study zone this percentage was even lower. A comparison with the rest of the areas (Table 3) reveals that the proportion of therophytes increased with greater warmth and lower rainfall, while the number of hemicryptophytes rose as the temperatures cooled and rainfall augmented.

The area that showed the greatest similarity in terms of the percentage representation of the different biological forms was the Sierra de María, which to a certain degree was understandable, given the comparable precipitation and altitude.

Table 4 shows the spectrum of biological forms combined with other biotype qualities. As shown in the table, the most frequent combination was scapiform therophyte (35%), followed by scapiform hemicryptophyte (17.7 %) and subfruticose chamaephyte (8.8 %), followed by nanophanerophytes (4.6%). At the far extreme, were the pulviniform and bulbous hemicryptophytes, parasitic geophytes, and natant hydrophytes, with only one taxon per type.

ANALYSIS BY THERMOTYPES AND OMBROTYPES

Table 5 lists the representation (number of taxa and their percentage) in the different thermotypes and ombrotypes.

First, with respect to the thermotypes, only 41 taxa appear in all the thermotypes (eurythermal taxa). At the other extreme, there was also a low percentage of species linked to only one thermotype, just as there was a low number of species present in three of more thermotypes. The highest number of taxa occupied the meso-supramediterranean (381) and the thermo-mesomediterranean thermotypes (335). The highest number of taxa exclusive to a single thermotype was found in the oromediterranean (93), where many exclusively high-mountain species appeared, followed by the mesomediterranean (84), the thermotype that inhabited most of the Almeriensian Sierra Nevada. On the contrary, the thermomediterranean presented only 46 taxa.

With regard to ombrotypes; the greatest number of taxa exclusive to a thermotype were those of the subhumid one. These species have demanding water requirements and thus do not appear in other ombrotypes; also striking was the great abundance of hygrophilous species (294), which are independent of the general ombrotype. There were few species present in three or more ombrotypes. With respect to the combination of two ombrotypes, the highest number of taxa appeared in dry-subhumid (235), followed closely by semiarid-dry (229) zones. These latter data are to be expected, as most of the zone belongs to a combination of these ombrotypes. As with the thermotypes, only 43 species had a broad range of ombrotypes (i.e. were euryhydric).

Table 3. Spectrum of biological forms (%) of the flora of the Almeriensian Sierra Nevada, compared with other zones. Ph= Phanerophyte. Ch= Chamaephyte. H= Hemicryptophyte. G.= Geophytes. Hy= Hydrophyte. Th= Therophyte. **1)** Nieto Caldera (1987); **2)** Cueto & al. (1991); **3)** Cueto & al. (1998); **4)** Pajarón (1988); **5)** Rios & Alcaraz (1995); **6)** Melendo (1998); **7)** Nieto Feliner (1985); **8)** Braun-Blanquet (1979); **9)** Braun-Blanquet (1979); **10)** Raunkjaer in Braun-Blanquet (1979).

	Ph	Ch	H	G	Hy	Th
Almeriensian Sierra Nevada	9.1	14.2	31.2	6.5	1.1	37.6
Sierras de Tejeda y Almijara[1]	9	19	27	7	0	38
Sierras de María-Orce[2]	9	16.8	35.5	5.7	0.25	32.6
Cabo de Gata-Níjar Natural Park[3]	12.2	12	20.5	10.7	0	44.6
Sierra de Segura[4]	10.7	12.3	37.2	12.9	0.3	27.1
Segura River[5]	10.8	3.1	36.2	9.5	3.9	36.5
Sierras de Cardeña-Montoro Natural Park[6]	9.2	5.9	20.2	8.5	4.1	52.1
Mountains south-west of León[7]	6.5	16	57	7	0.5	13
Alps (2000-3000 m)[8]	0	24.5	68	4	0	3.5
El Golea (Sahara)[9]	9	13	15	5	2	56
World mean[10]	46	9	26	6	-	13

Table 4. Different biological types according to life forms.

Biological type	Subtypes	Nº taxa	%
Phanerophyte	Nanophanerophyte	62	4.6
	Macrophanerophyte	44	3.2
	Nanophanerophyte climbers	17	1.3
	Total	**123**	**9.1**
Chamaephyte	subfruticose	118	8.8
	fruticose	44	3.3
	pulviniform	13	1
	succulent	7	0.5
	graminoid	5	0.4
	creeping	3	0.2
	Total	**190**	**14.2**
Hemicryptophyte	scapiform	237	17.7
	cespitose	89	6.6
	rosulate	38	2.8
	rhizomatose	30	2.2
	creeping	11	0.8
	climbing	10	0.7
	succulent	3	0.2
	pulviniform	1	0.1
	bulbous	1	0.1
	Total	**420**	**31.2**
Therophyte	scapiform	449	33.5
	climbing	21	1.6
	rosulate	12	0.9
	creeping	8	0.6
	parasitic	7	0.5
	succulent	6	0.4
	cespitose	2	0.1
	Total	**505**	**37.6**
Geophyte	bulbous	53	4
	rhizomatose	33	2.4
	parasitic	1	0.1
	Total	**87**	**6.5**
Hydrophyte	radicant	13	1
	natant	1	0.1
	Total	**14**	**1.1**

Table 6 lists the accumulated value (e.g.: T= T + [T+M] + [T+M+S] + broad) for each of the thermotypes or ombrotypes, and furthermore indicates that the greatest number of species appeared in the mesomediterranean (998), followed by the supramediterranean (752). Both the thermomediterranean (517), which is usually semiarid, as well as the oromediterranean (341), restricted to the zone of the peaks, presented a lower number of species. In terms of the ombrotypes, the one that presented the most taxa were the dry one (694), which was the most extensive, and the subhumid one (625), which harboured the most demanding species.

Table 5. Distribution of flora of the Almeriensian Sierra Nevada into the different thermotypes and ombrotypes: T=thermomediterranean; M=mesomediterranean; S=supramediterranean; O=oromediterranean; Sa=semiarid; D=Dry; Sh=Subhumid; H=Humid; Broad= present in all the thermotypes or ombrotypes.

Thermotype	Nº taxa	%	Ombrotype	Nº taxa	%
Undetermined	56	4.0	Undetermined	40	2.9
T	46	3.4	Sa	56	4.1
M	84	6.1	D	82	6.0
S	28	2.0	Sh	96	7.0
O	93	6.8	H	21	1.5
T + M	335	24.5	Sa + D	229	16.8
M + S	381	27.9	D + Sh	235	17.2
S + O	145	10.6	Sh + H	146	10.7
T + M+ S	95	7.0	Sa + D + Sh	85	6.2
M+ S + O	62	4.5	D + Sh + H	20	1.5
Broad	41	3.0	Hygrophilous	294	21.5
			Broad	43	3.1

Analysis by syntaxa and physiognomic units of vegetation

With regard to the representation by syntaxa (Table 7), using the affinity criterion of Rivas Martínez & al. (2002), it is notable that 405 taxa were included in *Stellarietea mediae* (nitrophilous and subnitrophilous vegetation), followed at a distance by *Molinio-Arrhenatheretea* (hygrophilous meadows and rush beds), with 128. The first syntaxon found to have importance in the plant landscape was *Rosmarinetea officinalis* (basophilous thickets), with 95 associated taxa. The class *Asplenietea trichomanis* (chasmophyte communities) was of interest because, despite their reduced spatial coverage, it occupied a noteworthy place in terms of characteristic taxa (42).

The above data underscore the enormous floristic richness of subnitrophilous pastures, which far exceeds that of the other formations, and thus is important to the appropriate management of pasturing in order to encourage and preserve this diversity.

Table 6. Cumulative representation of thermotypes and ombrotypes in the Almeriensian Sierra Nevada.

Thermotype	Nº taxa	Ombrotype	Nº taxa
T	517	**Sa**	413
M	998	**D**	694
S	752	**Sh**	625
O	341	**H**	230
		Hygrophilous	294

Table 7. Assignment of the taxa to different phytosociological classes present in the area.

Classes	nº taxa	%
Stellarietea mediae	405	33.4
Molinio-Arrhenatheretea	128	10.5
Rosmarinetea officinalis	95	7.8
Artemisietea vulgaris	73	6.0
Querco-Fagetea	56	4.6
Festucetea indigestae	50	4.1
Quercetea ilicis	43	3.6
Asplenietea trichomanis	42	3.4
Thero-Brachypodietea	38	3.1
Pegano-Salsoletea	30	2.5
Helianthemetea annuae	28	2.3
Thlaspietea rotundifolii	26	2.1
Phagnalo-Rumicetea	23	1.9
Nardetea strictae	22	1.8
Phragmiti-Magnocaricetea	19	1.6
Rhamno-Prunetea spinosae	18	1.4
Galio-Urticetea	18	1.4
Cisto-Lavanduletea	14	1.1
Isoeto-Nanojuncetea	12	1.0
Nerio-Tamaricetea	10	0.82
Bidentetea tripartitae	10	0.82
Others (13 classes)	54	4.4

In terms of the distribution by types and subtypes of vegetation (Table 8), notably in first place with 44.5% (540 taxa) was anthropogenic vegetation (515 taxa of synanthropic vegetation)—i.e., intimately associated with habitats highly altered by humans. At a certain distance was the meadow and pascicolous vegetation, with 220 taxa. The most important subtype within this category was that of the meadow and chionophilous grassland, with 150 taxa. Next in importance was the serial subfruticose, fruticose, and shrubby vegetation, with 133 taxa; this vegetation has major repercussions on the plant landscape. Notable vegetation types with a lower number of associated species were halophilous and continental plants, with only 2 species, which appear only at certain points in the zone and with few characteristic species. Also, few were associated with floating, submerged, or rooted freshwater taxa, added to their scant spatial representation for the paucity of characteristic species belonging to these types of communities.

Analysis of floristic elements

As reflected in Table 9, the Mediterranean element (57.1%) amply predominated over the rest, as might be expected, the most abundant elements having the broadest distribution range within the Mediterranean. Also, we highlight an important contingent of

Table 8. Distribution of the taxa by vegetation types.

Physiognomic types and subtypes of vegetation	Nº taxa	%
1. Freshwater floating, submerged or rooted vegetation	**6**	**0.5**
2. Amphibious vegetation of fresh-waters, springs and fens	**49**	**4.0**
2. a. Pioneer ephemeral vegetation	22	1.8
2. b. Vegetation of springs, fens, and bogs	27	2.2
3. Continental halophilous vegetation	**2**	**0.2**
4. Chasmophytic, epiphytic, and scree vegetation	**94**	**7.7**
4. a. Chasmophytic vegetation	45	3.7
4. b. Chasmocomophytic, epiphytic, and scree vegetation	49	4.0
5. Synanthropic, fringe, and megaforbic vegetation	**540**	**44.5**
5. a. Synanthropic vegetation	515	42.4
5. b. Fringe and megaforbic vegetation	25	2.1
6. West Mediterranean orophilous silicicolous vegetation	**50**	**4.1**
7. Grassland and meadow vegetation	**220**	**18.1**
7. a. Therophitic grasslands	28	2.3
7. b. Perennial xeophytic and mesophytic grasslands	42	3.5
7. c. Meandow and chionophilous grassland vegetation	150	12.3
8. Seral subfruticose, fruticose, and shrubby vegetation	**133**	**11.0**
8. a. Seral subfruticose vegetation	109	9.0
8. b. Seral and mantle shrublands	24	2.0
9. Forest and woodland potential natural vegetation	**120**	**9.9**
9. a. Pioneer riparian shrublands and woodlands	13	1.1
9. b. Climatophilous Mediterranean and Eurosiberian vegetation	107	8.8

Iberian-North African elements (86), which, added to the Betic-North African ones (18), showed a strong relationship with the flora of North Africa. Among the elements with the most restricted distribution appeared a high percentage of Nevadensian elements (3.1%) and Betic ones (3.4%).

In second place in terms of importance were elements with wide distributions (23.3%), notably palaeotemperate ones (12.8%). Next came the elements of European influence (13.4%). Finally, the percentage of allochthonous elements was quite low (2.8%), these being concentrated particularly in environments severely altered by humans (roadsides, crops, etc.).

Analysis of relative abundance

This analysis was based on the comparison of the relative abundance with respect to the type of floristic element on the one hand, and to the biotype, on the other. In this way, it was also possible to gain an idea of the relative abundance of each of the floristic elements and the biotypes in addition to their percentage composition, given that this in most cases

Table 9. Spectrum of floristic elements in the Almeriensian Sierra Nevada.

	Floristic element	Nº taxa	%	Total
Mediterranean element	Eurimediterranean	158	12.4	**57.1**
	Stenomediterranean	157	12.3	
	Western Mediterranean	146	11.5	
	Iberian-North African	86	6.8	
	Betic-North African	18	1.4	
	Iberian	61	4.8	
	Betic	43	3.4	
	Nevadensian	40	3.1	
	Alpujarrean-Gadorensean	3	0.2	
	Murcian-Almeriensian	15	1.2	
European influence element	Eurimedioeuropean	66	5.2	**13.4**
	Eurasian	81	6.4	
	Arctic-Alpine	23	1.8	
Warm influence element	Iranoturanian	10	0.8	**2.5**
	Saharo-sindian	19	1.5	
	Macaronesian	3	0.2	
Wide distribution	Cosmopolitan	11	0.9	**23.3**
	Subcosmopolitan	61	4.8	
	Holarctic	41	2.4	
	Palaeo-temperate	163	12.8	
	Palaeo-subtropical	30	2.4	
Allochthonous		36	2.8	**2.8**
Unknown/imprecise		2	0.2	**0.2**

does not provide information on the elements that have the best representation in the plant landscape.

First, the majority of the taxa (608) appeared occasionally, while a lower proportion were common elements (306) or very common (106); also, 163 were rare and 90 very rare. This distribution was expected, given that the highest percentage of species of any plant formation corresponds to species that appear with relative frequency but that reach low coverage values.

An analysis of these values by types of floristic elements (Table 10) reveals that the most abundant one is the Mediterranean-occasional group (342 taxa) and among the subdivisions of this group the stenomediterranean-occasional (84 taxa). Within this Mediterranean group appears a good percentage of rare and very rare species. Of these values, we can highlight the presence of 9 rare-Nevadensian and 10 very rare-Nevadensian elements, while the very common elements within this group were, primarily, widely distributed Mediterranean elements (eurimediterranean, stenomediterranean, and western Mediterranean).

With respect to the element of European influence, although it presented a distribution similar to the previous one, there was a notably high number of rare and very rare species belonging to this group, an aspect that is easily related to the conditions of the zone, which

Table 10. Relationship between the spectrum of floristic elements and the relative abundance of the different taxa. VR= very rare, R= rare, O= occasional, C= common, VC= very common.

Floristic element		Nº taxa				
		VR	R	O	C	VC
Mediterranean element	Eurimediterranean	6	16	73	46	17
	Stenomediterranean	3	17	84	43	10
	Western Mediterranean	6	18	71	38	13
	Iberian-North African	0	16	40	21	9
	Betic-North African	0	5	7	3	3
	Iberian	7	10	28	11	5
	Betic	6	10	18	5	4
	Nevadensian	10	9	15	5	1
	Alpujarrean-Gadorensean	0	2	1	0	0
	Murcian-Almeriensian	5	2	5	3	0
		43	**105**	**342**	**175**	**62**
European influence element	Eurimedioeuropean	10	11	32	12	1
	Eurasian	4	9	44	21	3
	Arctic-Alpine	7	7	9	0	0
		21	**27**	**85**	**33**	**4**
Warm influence element	Iranoturanian	1	3	3	3	0
	Saharo-sindian	5	0	7	6	1
	Macaronesian	2	1	0	0	0
		8	**4**	**10**	**9**	**1**
Wide distribution	Cosmopolitan	0	0	4	5	2
	Subcosmopolitan	0	8	30	14	9
	Holarctic	6	2	19	10	4
	Palaeo-temperate	9	11	84	42	17
	Palaeo-subtropical	2	4	13	8	3
		17	**25**	**150**	**79**	**35**
Allochthonous		**0**	**2**	**20**	**10**	**4**
Unknown/imprecise		**1**	**0**	**1**	**0**	**0**
Total		**90**	**163**	**608**	**306**	**106**

Table 11. Relationship between the spectrum of biological forms and the relative abundance of the different taxa.

	Nº taxa				
	VR	R	O	C	VC
Phanerophyte	18	21	43	26	12
Chamaephyte	15	25	69	50	28
Hemicryptophyte	39	60	207	70	23
Geophyte	12	21	33	9	5
Hydrophyte	0	1	8	2	1
Therophyte	9	39	263	139	35
Total	93	167	623	296	104

are not favourable to the development of species that are normally more demanding in their water requirements than are Mediterranean taxa.

Also noteworthy, the allochthonous element was not exclusively rare or very rare, but was also often occasional, common or even very common, due to agricultural activity in the zone.

With regard to the combination of relative abundance with the spectrum of biological forms (Table 11), the most frequent combinations were: occasional-therophyte (263 taxa), occasional-hemicryptophyte (207), common-therophyte (139), common- hemicryptophyte (70). On the opposite end were the hydrophytes: very rare (0), rare (1), and very common (1). It bears mentioning that despite the abundance of therophytes, a small proportion of these were very rare (9); however, both phanerophytes as well as geophytes, which are much less abundant, presented a greater number of very rare species.

Conclusions

The flora of the Almeriensian Sierra Nevada is comprised of 1366 taxa, predominated by Dicotyledoneae (78.3 %), with the family *Asteraceae* the best represented (184 species and 81 genera). According to the Pteridophyte index, this zone is more arid than the Sierra Nevada massif overall and comparable with other massifs of similar characteristics. The index of *Cistaceae*, used as an indicator of Mediterraneity of the flora, was lower than in nearby zones for the higher altitudinal gradient and for microclimatic conditions of less dryness in the mountain zones.

Notable as the dominant biotype was that of the therophytes, a point in common with other Betic massifs, the phanerophytes presenting lower richness than in similar areas but with more abundant precipitation. The intermediate levels (meso- and supramediterranean) presented greater species richness than in lower levels (thermomediterranean) for the greater dryness, which limited the appearance of species with higher water demands, or in summit zones (oromediterranean), where the limitation is imposed by low winter temperatures and severe freezing.

From the standpoint of assignment to syntaxonomic or physiognomic units of the vegetation, there was a striking weight of nitrophilous and subnitrophilous plants (405 taxa) in a zone that *a priori* appeared to be in a state of acceptable conservation. The same was true of hygrophilous meadow vegetation and rush beds, which, despite their reduced distribution, appeared in second place in terms of richness.

With regard to chorotypes, as might be expected, the Mediterranean element greatly predominated over the rest. Both the Ibero-North African elements presented a relatively high importance as elements with a restricted distribution such as the endemic Nevadensian or Betic taxa. The low presence of allochthonous elements was also striking, these having a limited presence except for invasive cultivated species. Finally, it bears mentioning that the relative abundance had an expected distribution, with greater presence of elements in the intermediate categories (occasional) and lower numbers towards the extremes (very common or very rare).

From the standpoint of floristic conservation, it is worth highlighting the fact that 10 endemic Nevadensian elements are rare (9) and very rare (1).

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