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Pollen morphology and taxonomy of *Genista* sect. *Cephalospartum* Spach emend. P. Gibbs (*Genisteae*, *Fabaceae*)

Abstract

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A pollen analysis of *Genista* sect. *Cephalospartum* has been carried out on 52 samples from eight taxa. The taxa were compared in terms of quantitative and qualitative characters, examined by LM, SEM and TEM. Some taxa are better distinguishable for the quantitative, others for the qualitative characters by LM and SEM; the ultrastructural characters examined by TEM are less significant, but useful in separating some taxa. The joint use of the four groups of characters provides the most complete information. Numerical analysis subdivides taxa into three clusters. *Genista umbellata* and *G. clavata* result rather similar and are well distinguishable from the other taxa. *G. microcephala, G. microcephala* var. *tripolitana*, *G. capitellata* and *G. quadriflora* form a sort of "central grouping" of the section. *G. cephalantha* and *G. demnatensis* result more isolated from the other taxa; however, *G. cephalantha* distinguishes from *G. demnatensis* for some characters. Section *Cephalospartum* results rather heterogeneous on the basis of the complex of pollen characters, confirming the heterogeneity already highlighted on the basis of macromorphological and karyological characters, and molecular analysis. The results of the present pollen analysis don't justfy, however, the separation of the taxa of sect. *Cephalospartum* into the two sections (*Cephalospartum* and *Lasiospartum*) as proposed by some Authors.

Introduction

The tribe *Genisteae* (*Fabaceae*) includes about twenty genera mainly distributed in the Mediterranean region. The delimitation and systematics of *Genisteae* have been matter of debate for a long time. Studies on the morphology (Gibbs 1966; Polhill 1976; Bisby 1981), anatomy (Pellegrin 1908), morphometry (Bisby & Nicholls 1977), cytotaxonomy (Sañudo 1979; Cusma Velari & al. 1998, 2003), serology (Cristofolini & Feoli Chiapella 1977, 1984; Cristofolini 1989), cladistic analysis (Cristofolini 1997), molecular systematics (Käss & Wink 1997; De Castro & al. 2002; Caputo & al. 2003; Pardo & al. 2004), chemotaxonomy (Harborne 1969; Faugeras & Paris 1971), pollination biology (Polhill 1976; Bisby 1981) and pollen morphology (Ferguson & Skvarla 1981) of the tribe have been carried out.

The pollen of *Genisteae* shows a relatively uniform morphology as regards the main pollen characters (Polhill 1976); in the pollen identification keys, Fægri & Iversen (1989) include the main genera of this tribe (*Genista* L., *Ulex* L., *Cytisus* L.) in the *Genista* type, Moore & al. (1991) place them in the *Ulex* type.

Since *Genisteae* is considered a rather stenopollinic tribe, it is difficult to distinguish and identify the taxa only on the basis of the main pollen characters. Detailed morphological and biometric analyses were thus undertaken by the authors in order to try to distinguish the taxa on the basis of the complex of pollen characters, both qualitative and quantitative (Rizzi Longo & Feoli Chiapella 1981). A certain variability in pollen characters was noted, also within the same taxon (Feoli Chiapella 1983; Rizzi Longo 1986; Rizzi Longo & Feoli Chiapella 1994); for this reason, several populations per taxon, scattered within the distributional range, are examined in order to assess the intra- and interspecific variability. A detailed study of pollen characters, not only by light (LM), but also by scanning (SEM) and trasmission electron microscope (TEM), was started by the authors on *Genista*, the most heterogeneous and complex genus (about 90 species) of the tribe. Pollen grains of several taxa of *Genista* and *Cytisus* have been so far analysed (Feoli Chiapella 1983; Rizzi Longo & Feoli Chiapella 1993; 1994; Ghirardelli & al. 1994, 1997). Other studies on the pollen of *Genisteae* (*Ulex*, *Stauracanthus* Link, *Cytisus* and *Genista* of West Mediterranean region) have been carried out by Misset & al. (1982), Cubas & Pardo (1992) and Pardo & al. (1994, 2000).

In the present study a detailed pollen analysis of *Genista* sect. *Cephalospartum* Spach emend. P. Gibbs is carried out by LM, SEM and TEM. The pollen analysis has been undertaken in order to contribute to the knowledge of the pollen morphology of the taxa of the section and to clarify the systematic correlations among them.

Systematics of the section

According to Gibbs (1966), section *Cephalospartum* (incl. *Lasiospartum* Spach) belongs to subgenus *Spartocarpus* Spach and includes seven species distributed mostly in the Western Mediterranean region: *Genista cephalantha* Spach, *G. demnatensis* Cosson ex Murb., *G. microcephala* Cosson & Durieu, *G. capitellata* Cosson, *G. quadriflora* Munby, *G. umbellata* (L'Hér.) Poiret, *G. clavata* Poiret.

The taxa of the section are non-spiny shrubs with alternate or opposite branching, simple or trifoliolate leaves carrying three vascular traces, capitate inflorescence, flowers with broadly ovate or triangular standard petal, or ovate with an acute apex, of equal size or shorter than the keel, ovoid-acuminate 1-2 seeded, or narrowly oblong, several-seeded legume (Pellegrin 1908; Gibbs 1966).

Spach (1844, 1845) placed the species known at his time partly in sect. *Cephalospartum* (*Genista cephalantha*) and partly in sect. *Lasiospartum* (*G. umbellata* and *G. clavata*). The distinction between sect. *Cephalospartum* and sect. *Lasiospartum* is based mainly on the shape of the legume (ovate-acuminate and 1-2 seeded in the former section, narrowly oblong and 3-5 seeded in the latter); other characters concern the shape of the bracts and bracteoles, the stipules and the pulvini. Maire (1987) accepts this distinction, including in sect. *Cephalospartum* also *G. demnatensis* (as *G. cephalantha* ssp. *demnatensis*), *G. micro-*

cephala and *G. capitellata* (as *G. microcephala* var. *capitellata*), and adding *G. quadriflora* to sect. *Lasiospartum*. Recently, also Talavera & Salgueiro (1999) consider the two sections as distinct, placing *G. microcephala*, *G. capitellata* and *G. cephalantha* in sect. *Cephalospartum*, *G. umbellata* and *G. clavata* in sect. *Lasiospartum*, while they place *G. quadriflora* in the new section *Phyllodioides* Talavera & P. E. Gibbs. This arrangement is confirmed in Flora Iberica (Talavera 1999) for the only European species, *G. umbellata*.

Gibbs (1966) highlights the heterogeneity of the section; in fact, its only distinctive characters are the capitate inflorescence and the partly opposite branching. Various species, however, display characters which are distinctive of other subgenera of *Genista* (subgen. *Genista* and subgen. *Phyllobotrys* Spach). The corolla of *G. clavata* and *G. umbellata* displays a broadly ovate standard petal equal to the keel (feature common to subgen. *Genista*), while the other taxa of subgen. *Spartocarpus* have a standard usually shorter than the keel. The standard petal of *G. capitellata* (triangular) and *G. cephalantha* (ovate with an acute apex) is more similar to that of the species of subgen. *Phyllobotrys*. The legume of *G. quadriflora*, *G. clavata* and *G. umbellata* is narrowly oblong and several-seeded like in subgen. *Genista*, as opposed to the ovoid-acuminate and 1-2 seeded pod of subgen. *Spartocarpus*.

The species of the section

The species of section *Cephalospartum* are prevalently distributed in North Africa, from Morocco to Libya, with only one species (*Genista umbellata*) occurring also in Southern Spain.

Genista cephalantha, the type species of the section, grows on coastal ranges of Morocco (Rif, Beni-Snassen, Monts des Kebdana) and North Western Algeria, Oran Region (Jahandiez & Maire 1932; Quezel & Santa 1962; Raynaud 1979; Maire 1987).

Genista demnatensis (= *G. cephalantha* subsp. *demnatensis* (Coss. ex Murb.) C. Raynaud) is a species endemic to few mountain areas of Morocco: Grand Atlas, Montagnes de Debdou, Rif (Jahandiez & Maire 1932; Raynaud 1979; Maire 1987).

These two taxa both differ from all the other species of the section for having pulvinules with two persistent spinose stipules and recurved and angled branches (Gibbs 1966).

Genista microcephala aggr. includes *G. microcephala* and *G. capitellata* (Greuter & al. 1989). Jahandiez & Maire (1932), Quezel & Santa (1962) and Maire (1987) consider *G. capitellata* a variety of *G. microcephala*, while Gibbs (1966), Raynaud (1979) and Greuter & al. (1989) consider the two taxa as independent species.

Genista microcephala is distributed in Eastern Algeria (Aurès, Hauts-Plateaux) and Tunisia (Quezel & Santa 1962; Maire 1987). *G. microcephala* var. *tripolitana* (Bornm.) Maire occurs only in Libya (Tripolitania) and South-Eastern Tunisia (Jafri 1980; Maire 1987).

Genista capitellata is distributed in Algeria (Monts du Hodna, Hauts-Plateaux), Eastern Morocco (Atlas saharien) and central Tunisia (Jahandiez & Maire 1932; Quezel & Santa 1962; Raynaud 1979; Maire 1987).

Genista quadriflora is distributed in Morocco (Rif, Moyen and Grand Atlas) and North-Western Algeria, Oran Region (Quezel & Santa 1962; Maire 1987).

Genista umbellata (incl. subsp. *equisetiformis* (Spach) Rivas Goday & Rivas Mart.) is the only species of the section to reach Europe, in Southern and South-Eastern Spain (Gibbs 1966; Talavera 1999); it occurs also in North-Western Algeria (Oranese littoral) and Northern Morocco, Rif (Jahandiez & Maire 1932; Raynaud 1979; Maire 1987).

Genista clavata (= *G. capitata* (Cav.) Spach) is a species endemic to the coastal ranges of North-Western Morocco: Tanger Region and South-Western Rif (Jahandiez & Maire 1932; Raynaud 1979; Maire 1987).

Materials and methods

Four to fourteen samples of different populations of each taxon of section *Cephalospartum* have been examined using herbarium material from Trieste (TSB), Firenze (FI) and Genève (G). The geographical origin of the 52 populations studied is reported in Appendix.

The following groups of characters were taken into account:

- *quantitative characters by LM*: length of the polar axis (P), equatorial diameter (E), length of the colpus, equatorial breadth of the colpus, equatorial breadth of the mesocolpium, in equatorial view; distance between the apices of two ectocolpi in polar view;
- *qualitative characters by LM:* outline in equatorial and polar view; shape of the colpi in equatorial view;
- *qualitative and quantitative characters by SEM:* exine ornamentation at mesocolpium, at apocolpium and at the rim of the apertures; aperture membrane; density of the exine perforations in the interapertural zone at equatorial level;
- *quantitative characters by TEM*: thickness of the exine layers in the interapertural area at equatorial level.

For light microscopy (LM), the material was acetolysed according to Erdtman (1960). The measurements were made by filar ocular micrometer mounted on a Nikon Optiphot within a standard period after preparation of the slide (4 hours), in order to avoid any alteration in dimensions (Van Campo 1966; Hanks & Fairbrothers 1976; Rizzi Longo 1986). Thirty pollen grains have been considered for each sample since the average values of the quantitative characters stabilize after 20-25 measures (Rizzi Longo 1986). Thirty grains have been observed for each sample also for qualitative characters.

For SEM, acetolysed anthers were dehydrated in acetone, dried according to the critical point technique (Anderson 1951). The pollen was coated with gold-palladium and examined with a Philips 500 SEM. Thirty pollen grains have been observed for each sample to study exine pattern; ten counts of the number of the perforations in a standard area (10 μm^2) were carried out at x 5000 for each sample.

For TEM, acetolysed anthers from buds were embedded in 5% hydrated Agar; Agar containing pollen was cut in little blocks, fixed with 4% glutaraldehyde buffered by phosphate and postfixed with 1% osmium buffered as above, dehydrated in increasing acetone and embedded with Spurr resin (Spurr 1969), sectioned by LKB Ultrotome, stained with uranyl acetate and lead citrate (Reynolds 1963) and examined with a Philips EM201 TEM. On the photographs obtained by TEM, the thickness of every layer of exine was measured

by means of a Peak Glass scale 100. Twenty to thirty measurements for each layer for each sample were made, according to the mean stabilization.

The taxa were compared in terms of average value of the quantitative characters and in terms of average frequency of the qualitative characters states. The comparison has been done both keeping separately the four groups of characters, using the Euclidean distance, and by analyzing all the characters together with the Gower's index of similarity. Sum of squares agglomeration clustering was applied to obtain a hierarchical classification (Sneath & Sokal 1973) and an eigenanalysis was applied to the similarity matrix to order the taxa (Lagonegro & Feoli 1981). To link the taxa according to maximum affinity a minimum spanning tree (Gower & Ross 1969) was constructed. The computer programs used for classification and ordination are described in Podani (1994).

The nomenclature of the taxa follows Gibbs (1966) and Maire (1987). For pollen terminology see Punt & al. (1994).

Results

Description of pollen grains

The pollen grains of *Genista* sect. *Cephalospartum* are single, isopolar, radially symmetric, medium-sized, with a perforate suprareticulate tectum (Plates 1-4). The apertures are three furrows located in the equatorial region (3-zonocolpate grains). Sometimes the colpi break in their central part forming a long and rather undefined endoaperture, often resulting in a longitudinal interruption (3-zonocolporate with long ectoaperture and diffuse lolongate endoaperture, corresponding to tricolporoidate grains after Erdtman, 1952). Such apertures have already been observed in *Genisteae* by various authors (among others: Misset & al. (1982) in *Ulex* and *Stauracanthus*; Rizzi Longo & Feoli Chiapella (1994) in *Genista* sect. *Spartocarpus*; Pardo & al. (2000) in *Cytisus* s.l.).

Quantitative pollen characters (LM)

Table 1A presents the means and standard deviations of all the quantitative characters considered by LM and of the ratios in the taxa of the section.

The pollen grains are oblate spheroidal to prolate and small to medium-sized (sensu Erdtman 1952). The grains of *Genista cephalantha* differ from those of the other taxa because of their size, their average values being the highest for the length of the polar axis (36.6 μm), the equatorial diameter (27.5 μm) and the length of the colpus (27.2 μm). By contrast, *G. umbellata* distinguishes itself for its smaller size, presenting the lowest average values for the length of the polar axis (25.7 μm) and of the colpus (19.6 μm); also the equatorial diameter is rather small (22.1 μm). *G. clavata* presents the lowest average values for the equatorial diameter (21.8 μm) and the breadth of the mesocolpium (12.1 μm). *G. demnatensis,* G. *microcephala, G. microcephala* var. *tripolitana, G. capitellata* and *G. quadriflora* have relatively similar average dimensions. Among these taxa, *G. microcephala* shows the lowest average value for the breadth of the colpus (1.1 μm) and the highest for the breadth of the mesocolpium (14.4 μm); its equatorial diameter is rather large as well (25.2 μm). *G. microcephala* var. *tripolitana* presents the highest distance

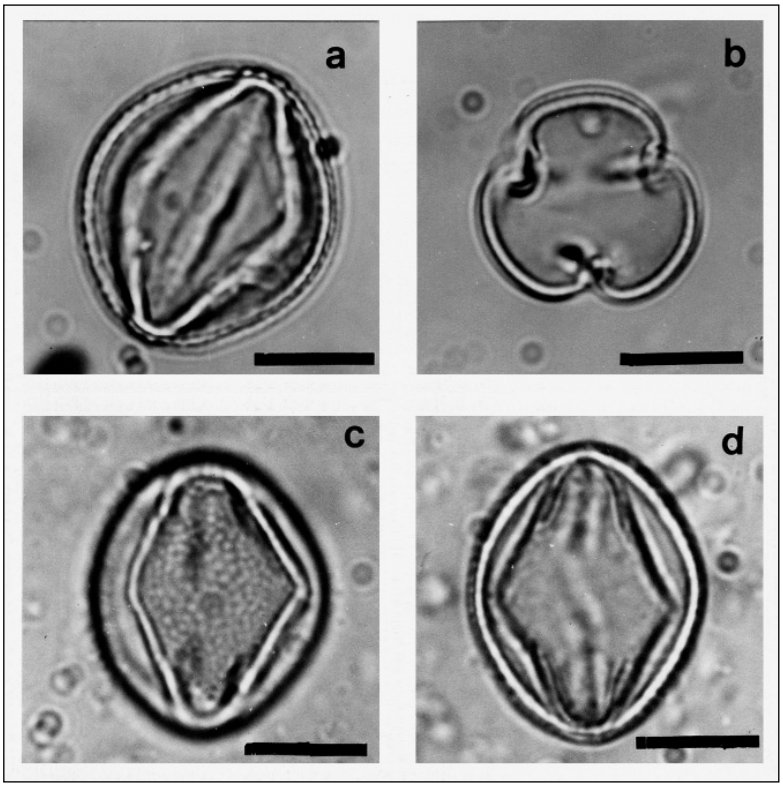

Plate 1. LM micrographs of pollen grains of *Genista* sect. *Cephalospartum*. (a) Optical cross-section in equatorial view, *Genista umbellata*. (b) Optical cross-section in polar view, *G. clavata.* (c) Low focus, equatorial view, *G. demnatensis*. (d) Optical cross-section in equatorial view, *G. demnatensis.* – Scale bar – 10 μm.

between the apices of two ectocolpi (5.4 μm) and G. *quadriflora* the lowest (3.5 μm). The pollen grains of *G. cephalantha* and *G. clavata* are prolate, with a mean P/E ratio respectively of 1.36 and 1.39. The grains of the other taxa are subprolate, with the lowest P/E ratio (1.17) in *G. demnatensis* and *G. umbellata.* The mean apocolpium index varies between 0.16 in *G. microcephala* and 0.25 in *G. clavata*.

Qualitative pollen characters (LM)

Table 1B shows the average frequencies of qualitative characters states by LM in the taxa of the section. For qualitative characters (Plate 1) see also Plate 2.

The pollen grains present generally an ellipsoid form in equatorial view. In *Genista clavata*, *G. microcephala* var. *tripolitana*, *G. umbellata* and *G. capitellata* the outline is broadly elliptic (Plate 1a) in most cases (67-100%); *G. microcephala* and *G. quadriflora* present a greater variety of forms, although the most frequent one is also here broadly ellip-

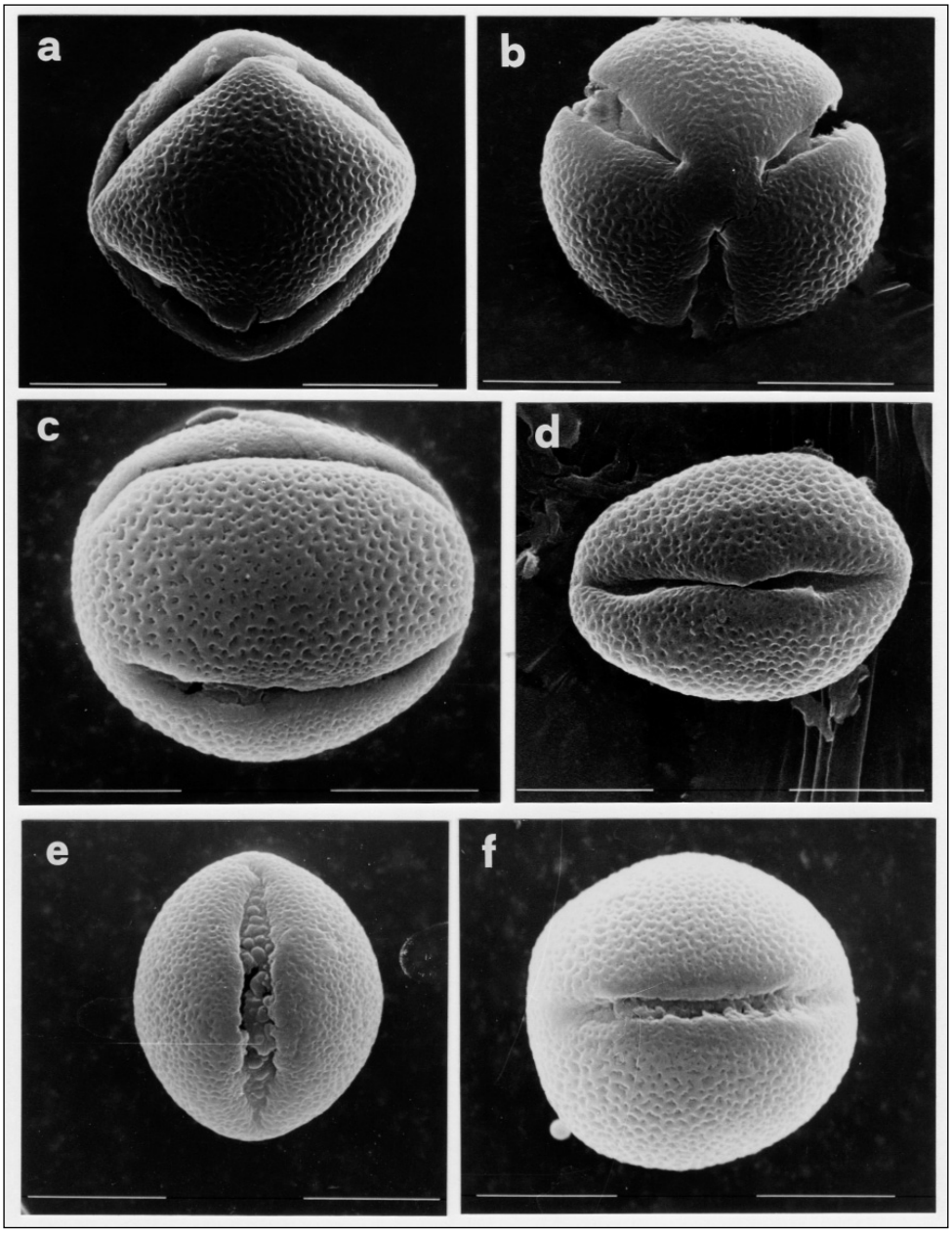

Plate 2. SEM micrographs of *Genista* sect. *Cephalospartum*: a, c-f, equatorial view; b, polar view. (a) Rhombic-obtuse outline, angular furrows in profile view, *Genista demnatensis*. (b) Subcircular outline, *G. cephalantha*. (c) Broadly elliptic outline, curved furrows in profile view, *G. quadriflora.* (d) Narrowly elliptic outline, equatorially constricted furrow in direct view, *G. quadriflora*. (e) Boat-shaped furrow in direct view, *G. umbellata*. (f) Rectangular furrow in direct view, *G. quadriflora*.– Scale bar – 10 μm.

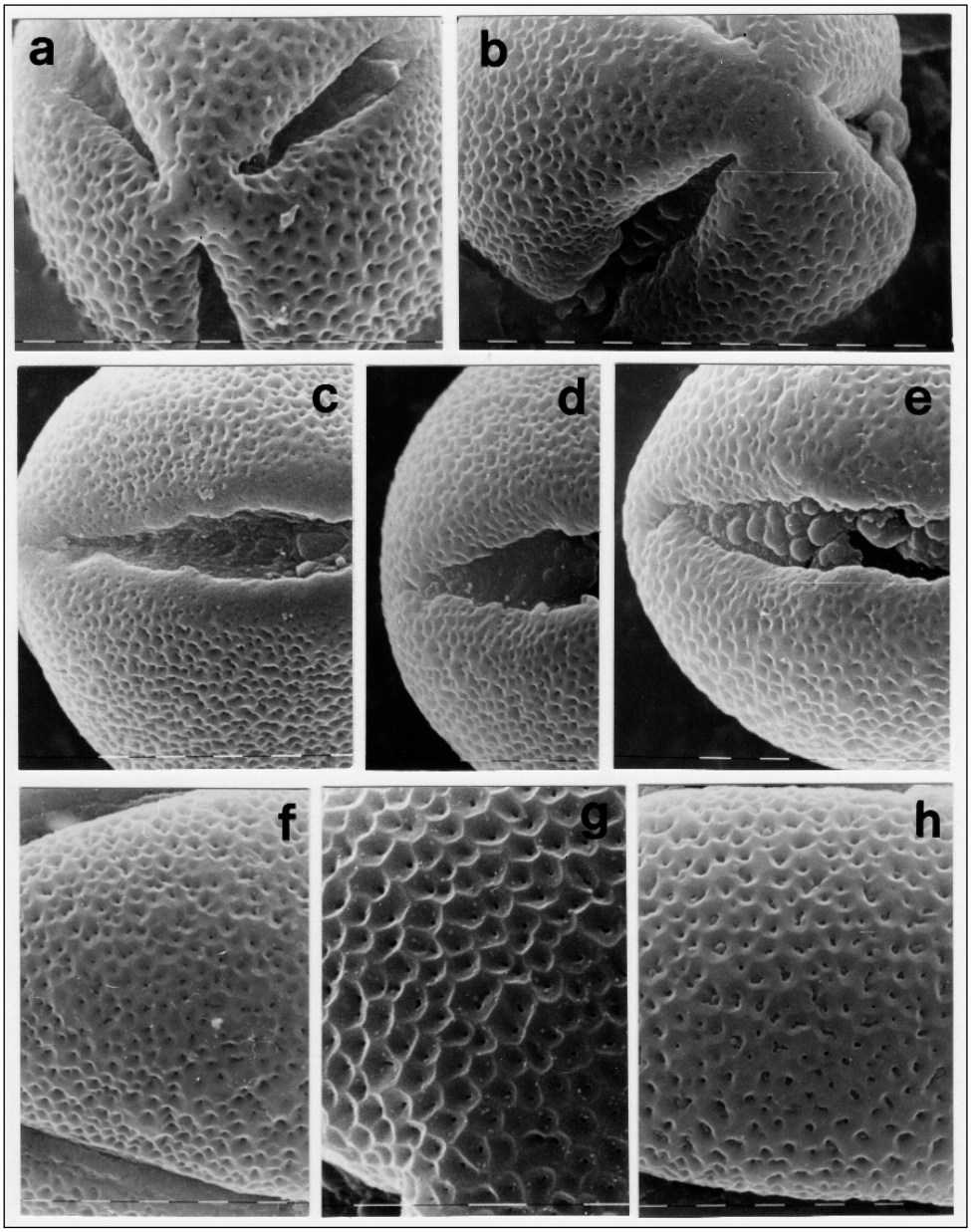

Plate 3. SEM micrographs of *Genista* sect. *Cephalospartum*: a-b, polar view; c-h, equatorial view. (a-b) Tectum ornamentation at apocolpium: (a) Pattern similar to mesocolpium, *Genista quadriflora*. (b) Lower reticulum, *G. capitellata*. (c-e) Colpus membrane: (c) Granulate, *G. demnatensis*. (d) Microverrucate, *G. clavata.* (e) Verrucate, *G. umbellata.* (f-h) Tectum ornamentation at mesocolpium: (g) Homogeneously supramicroreticulate perforate, lumina with one circular perforation, *G. umbellata*. (f) Some small unperforate areas, *G. microcephala*. (h) Some fossulate areas, lumina with irregular shaped and joined perforations, *Genista quadriflora*. – Scale bar – 10 μm.

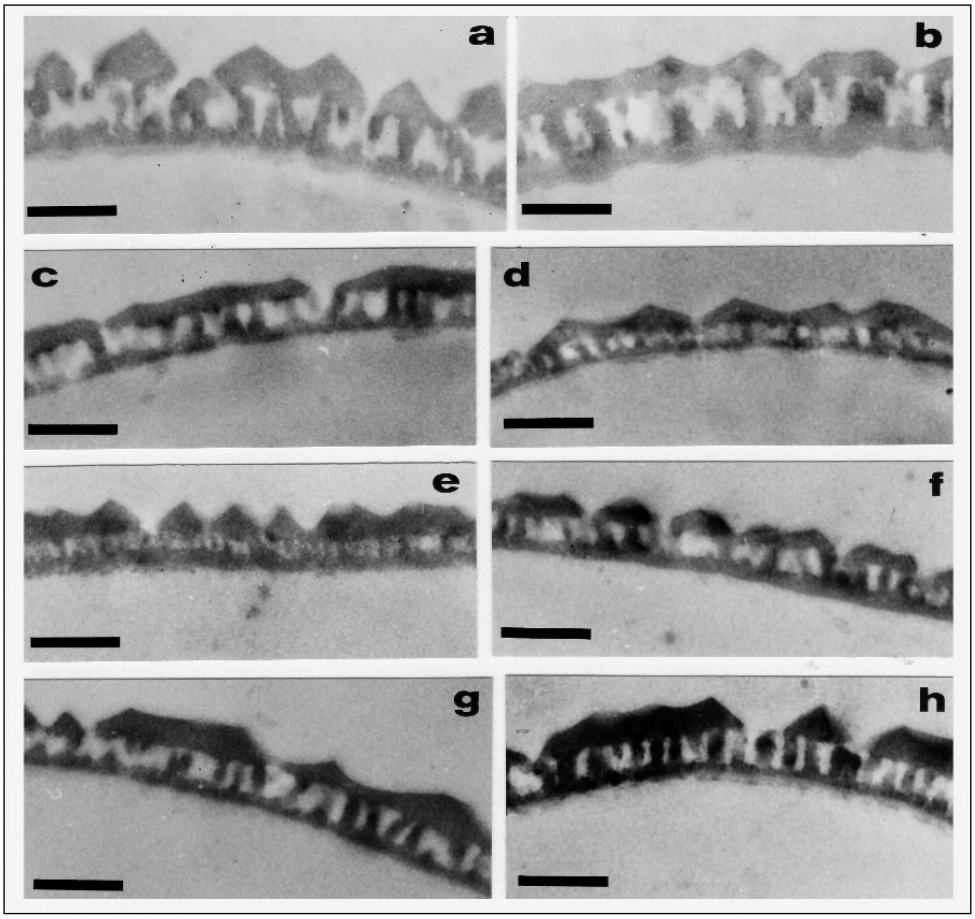

Plate 4. TEM micrographs of *Genista* sect. *Cephalospartum*.
(a) Thick exine, high thickness of tectum and columellar layer, *Genista quadriflora*. (b) Thick exine, high thickness of columellar and foot layer, *G. cephalantha*. (c) Thin exine, thin tectum, *G. capitellata.* (d) Thin exine, low thickness of columellar and foot layer, *G. umbellata*. (e) Thin columellar layer, *G. clavata*. (f) Thin tectum, *G. demnatensis.* (g) *G. microcephala* var. *tripolitana*. (h) Thin foot layer, *G. microcephala.* – Scale bar – 10 μm.

tic (44-55%). Narrowly elliptic grains were rarely observed only in *G. quadriflora* (9%). *G. cephalantha* and *G. demnatensis* never present elliptic grains, having only subrhomboidal to rhombic-obtuse ones. The outline in polar view is usually subcircular (41-74%), less frequently circular or subtriangular; only *G. capitellata* presents more frequently subtriangular grains (50%). Triangular and 3-lobate (Plate 1b) grains were more rarely found.

The taxa show a certain variability in the apertural types; colpate pollen grains prevail in all the taxa (51-69%), but a consistent frequency of colpi with diffuse endoaperture was observed especially in *Genista quadriflora* (49%) and *G. cephalantha* (46%). The most fre-

Table 1. Pollen characters in *Genista* sect. *Cephalospartum*.
Means and standard deviations (µm) of quantitative characters (LM, TEM) and average frequencies of qualitative characters states (LM, SEM) are given.

	G. cephalantha	G. demnatensis	G. clavata	G. umbellata	G. quadriflora	G. microcephala	G. microcephala var. tripolitana	G. capitellata
A) QUANTITATIVE POLLEN CHARACTERS (LM)								
in equatorial view								
polar axis length (P)	36,6 ± 3,22	28,7 ± 1,45	29,7 ± 1,37	25,7 ± 1,73	28,9 ± 2,37	30,1 ± 1,64	29,4 ± 2,24	28,9 ± 2,79
equatorial diameter (E)	27,5 ± 3,81	24,9 ± 2,68	21,8 ± 3,38	22,1 ± 1,97	23,8 ± 2,16	25,2 ± 3,16	23,2 ± 1,88	24,0 ± 2,81
colpus length	27,2 ± 2,80	20,6 ± 1,22	23,6 ± 1,02	19,6 ± 1,80	21,3 ± 3,14	22,7 ± 1,00	23,2 ± 1,49	21,7 ± 2,45
equatorial colpus breadth	1,4 ± 0,75	1,5 ± 0,43	1,5 ± 0,41	1,3 ± 0,15	1,4 ± 0,14	1,1 ± 0,13	1,3 ± 0,09	1,5 ± 0,36
equatorial mesocolpium breadth	14,1 ± 3,32	13,5 ± 3,15	12,1 ± 3,32	13,5 ± 2,03	13,6 ± 2,74	14,4 ± 2,58	13,7 ± 2,01	13,6 ± 2,91
in polar view								
distance between the apices of two ectocolpi	5,1 ± 0,54	4,5 ± 1,32	5,3 ± 0,96	4,5 ± 0,40	3,5 ± 1,94	4,1 ± 0,61	5,4 ± 0,94	4,4 ± 1,01
P/E ratio	1,36 ± 0,23	1,17 ± 0,19	1,39 ± 0,22	1,17 ± 0,13	1,25 ± 0,20	1,21 ± 0,15	1,27 ± 0,10	1,22 ± 0,26
apocolpium index	0,18 ± 0,01	0,18 ± 0,05	0,25 ± 0,05	0,20 ± 0,02	0,18 ± 0,06	0,16 ± 0,04	0,23 ± 0,03	0,19 ± 0,04
B) QUALITATIVE POLLEN CHARACTERS (LM)								
outline in equatorial view								
narrowly elliptic	-	-	-	-	9	-	-	-
broadly elliptic	-	-	100	82	55	44	83	67
subrhomboidal	50	75	-	18	-	28	17	33
rhomboidal	17	-	-	-	18	28	-	-
rhombic-obtuse	33	25	-	-	18	-	-	-
outline in polar view								
circular	19	21	16	30	31	20	11	13
subcircular	43	50	60	44	41	43	74	36
3-lobate	1	2	6	2	3	13	5	1
subtriangular	37	26	10	21	24	16	9	50
triangular	-	1	8	3	1	8	1	-
apertures in equatorial view								
colpi	54	63	69	60	51	61	66	62
colpi with diffuse endoaperture	46	37	31	40	49	39	34	38
in direct view								
rectangular	51	44	37	36	34	49	41	52
boat-shaped	24	26	33	29	15	28	30	20
equatorially constricted	25	30	30	35	51	23	29	28
straigth rim	69	56	32	28	56	45	46	48
wavy rim	31	44	68	72	44	55	54	52
in profile view								
curved	74	59	66	72	68	54	68	61
angular	26	41	34	28	32	46	32	39
long thickening towards the poles	39	41	44	43	34	35	25	44
medium length thickening towards the poles	40	40	39	46	50	41	48	39
short thickening towards the poles	21	19	17	11	16	24	27	17

Table 1. (continued.)

	G. cephalantha	G. demnatensis	G. clavata	G. umbellata	G. quadriflora	G. microcephala	G. microcephala var. tripolitana	G. capitellata
C) ULTRASCULPTURAL EXINE CHARACTERS (SEM)								
tectum ornamentation at mesocolpium								
homogeneously supramicroreticulate perforate	95	94	91	93	92	93	94	93
percentage of unperforate areas	4	6	8	5	7	7	6	4
percentage of fossulate areas	1	-	1	2	1	-	-	3
muri								
angular	43	79	79	66	70	72	72	66
blunt	57	21	21	34	30	28	28	34
lumina								
with one circular perforation	30	62	84	66	71	76	68	52
with one irregular-shaped perforation	42	24	8	22	17	14	17	31
with several separated perforations	11	6	4	5	6	6	10	6
with several joined perforations	17	8	4	7	6	4	5	11
density of perforations (n°/10 µm^2)	29	28	32	32	27	32	33	25
tectum ornamentation at apocolpium								
pattern similar to mesocolpium	-	-	53	36	6	11	20	29
with lower reticulum	100	100	47	64	94	89	80	71
perforate as at mesocolpium	42	67	67	37	28	29	10	50
less densely perforate	16	-	17	27	11	14	45	36
more densely perforate	42	33	16	36	61	57	45	14
tectum ornamentation at furrow rim								
pattern similar to mesocolpium	-	-	33	-	-	-	-	-
with lower reticulum	43	40	50	57	50	67	20	20
with trend to disappearing reticulum	43	20	17	43	50	22	40	80
with disappeared reticulum	14	40	-	-	-	11	40	-
less densely perforate	100	83	57	86	85	80	100	100
more densely perforate	-	17	43	14	15	20	-	-
colpus membrane								
smooth	13	42	-	-	-	-	-	-
granulate	87	38	16	-	81	89	50	89
microverrucate	-	17	11	-	19	11	50	11
verrucate	-	3	73	100	-	-	-	-
D) ULTRASTRUCTURAL EXINE CHARACTERS (TEM)								
exine thickness	1,00 ± 0,12	0,74 ± 0,09	0,73 ± 0,04	0,65 ± 0,08	1,06 ± 0,17	0,78 ± 0,06	0,82 ± 0,06	0,64 ± 0,07
tectum thickness	0,34 ± 0,07	0,24 ± 0,04	0,33 ± 0,03	0,30 ± 0,04	0,41 ± 0,10	0,35 ± 0,03	0,32 ± 0,04	0,22 ± 0,04
columellar layer thickness	0,39 ± 0,09	0,28 ± 0,05	0,20 ± 0,03	0,18 ± 0,04	0,41 ± 0,05	0,26 ± 0,04	0,30 ± 0,03	0,25 ± 0,03
foot layer thickness	0,20 ± 0,02	0,18 ± 0,02	0,14 ± 0,02	0,09 ± 0,02	0,15 ± 0,03	0,10 ± 0,02	0,14 ± 0,02	0,12 ± 0,01
endexine thickness	0,06 ± 0,01	0,05 ± 0,01	0,06 ± 0,02	0,07 ± 0,02	0,09 ± 0,03	0,07 ± 0,02	0,06 ± 0,01	0,05 ± 0,02

quent shape of the furrows in direct view is rectangular (34-52%), except in *G. quadriflora*, where the colpi are mostly equatorially constricted (51%); boat-shaped colpi are less frequently found (15-33%). Most frequently, the rims of the colpi are straigth in *G. cephalantha* (69%), wavy in *G. clavata* and *G. umbellata* (68-72%). In the other taxa no character state is predominant. The colpi viewed in profile are mostly curved (54-74%); angular colpi (Plate 1c) occur with a certain frequency only in *G. microcephala* (46%) and *G. demnatensis* (41%). When viewed in profile, a thickening of the apertural region towards the poles can be observed (Plate 1d); it generally corresponds to half of the colpus, especially in *G. microcephala* var. *tripolitana* and *G. quadriflora* (48-50%), but it can be longer, as in *G. clavata* and *G. capitellata* (44%), or shorter.

Ultrasculptural exine characters (SEM)

Table 1C shows the average frequencies of the qualitative characters states by SEM of the exine ornamentation and the average number of the perforations in a standard area (10 μm^2) of the mesocolpium at equatorial level.

In the taxa of section *Cephalospartum* the tectum at the interapertural zone is supramicroreticulate perforate, with some small unperforate and more rised areas (Plates 2-3). Fossulate areas have been very rarely observed. The muri are often of irregular width and separate the polygonal depressions (lumina) which are usually not very deep. Only in *Genista clavata* the lumina may be deeper and the reticulum rather prominent; in *G. cephalantha* the lumina may be very shallow, and the reticulum consequently rather low. The muri are more frequently angular in all the taxa, except in *G. cephalantha*, where they are mostly blunt. Small perforations of the tectum, with or without inclusions, are present on the bottom of the lumina. The number of the perforations per $10\mu m^2$ varies from 25 in *G. capitellata* to 33 in *G. microcephala* var. *tripolitana*. Generally, only one circular (or, more rarely, irregular) perforation can be observed; sometimes, many small perforations are present on the bottom of the lumina, either separated or confluent.

At the apocolpium (Plate 3a, b) the reticulum usually lowers, but in some cases, particularly in *Genista clavata*, it extends unchanged across the poles. Besides, the reticulum may become finer, as in *G. quadriflora* and *G. microcephala*. Also the density of the perforations of the tectum varies: it can be as at mesocolpium (like in *G. clavata* and *G. demnatensis*), higher (as in *G. quadriflora* and *G. microcephala*) or, less frequently, lower.

The supratectal reticulum lowers and becomes finer also towards the rim of the colpi (Plate 3c-e), forming a margo of various width, particularly wide in *Genista cephalantha* and *G. demnatensis*; the reticulum may disappear more or less completely near the aperture, especially in the equatorial region. In this part of the margo, also the perforations of the tectum usually disappear.

The aperture membrane (Plate 3c-e) is usually finely granulate or slightly micro-verrucate, less frequently smooth (as, sometimes, in *Genista demnatensis*) or coarsely verrucate (as in *G. umbellata* and *G. clavata*).

Ultrastructural exine characters (TEM)

Table 1D presents the means and standard deviations of the thickness of the exine and of its layers measured by TEM in the interapertural zone of the acetolysed pollen grains.

In the taxa of the section the exine shows four layers: tectum, columellar layer, foot layer and endexine (Plate 4). The tectum, interrupted by perforations, has a supratectal reticulum. Towards the apertures the supratectal reticulum lowers and then disappears; tectum, columellar layer and foot layer, all well developed in the interapertural zone, also become thinner: on the whole, thus, the ectexine becomes thinner and rapidly disappears at the rim of the furrows (see Ghirardelli & al. 1994). The endexine, which is by contrast rather thin at the mesocolpium, becomes thicker along the apertural zone, as already found in *Ulex* by Misset & al. (1982), in many species of *Genista* by Ghirardelli & al. (1994) and in several species of *Cytisus* by Ghirardelli & al. (1997) and Pardo & al. (2000). If the pollen grains are sected towards the extremity of the colpi, the endexine appears as a dense and compact area, to which corresponds the thickening of the apertural region formerly observed by LM; on the other hand, in the equatorial region of the colpus, the endexine usually has a loose and discontinuous pattern resulting, in some cases, in a long and diffuse endoaperture, which corresponds to the oroid sensu Erdtman (1952); at this level, in the acetolysed pollen grains, the endexine sometimes appears lacerated (see Ghirardelli & al. 1994).

The exine thickness ranges from 0.64 μm in *Genista capitellata* to 1.06 μm in *G. quadriflora*. The tectum thickness ranges from 0.22 μm in *G. capitellata* to 0.41 μm in *G. quadriflora*. The columellar layer is well developed and varies from 0.18 μm in *G. umbellata* to 0.41 μm in *G. quadriflora*. On the other hand, the foot layer results thinner, ranging from 0.09 μm in *G. umbellata* to 0.20 μm in G. *cephalantha*. The endexine is very thin and ranges from 0.05 μm in *G. demnatensis* and *G. capitellata* to 0.09 μm in *G. quadriflora.*

Numerical analysis

Fig. 1 represents the ordinations with the minimum spanning tree overimposed of the taxa of section *Cephalospartum*, based on pollen characters.

On the basis of the quantitative characters measured by LM (Fig. 1a), *Genista cephalantha* is the most separated species, linked with *G. microcephala*. Also *G. umbellata* results distant, although to a lesser extent, linking with *G. quadriflora*. *G. clavata* is still less distant. *G. capitellata, G. quadriflora*, *G. demnatensis* and *G. microcephala* form a rather compact grouping at the bottom of the graphic. The greatest reciprocal affinity was found between *G. capitellata* and *G. quadriflora*. *G. microcephala* var. *tripolitana* acts as link between this grouping and *G. clavata.*

On the basis of the qualitative characters observed by LM (Fig. 1b), *Genista cephalantha* and *G. demnatensis* result rather similar, and more distinct from the other taxa. Also *G. quadriflora* is rather distinguished from the other species. *G. clavata, G. umbellata, G. microcephala* var. *tripolitana* and, to a lesser extent, *G. capitellata* and *G. microcephala* form a more homogeneous grouping; *G. clavata* and *G. umbellata* present the greatest reciprocal affinity. *G. microcephala* acts as trait d'union both with *G. quadriflora* and with *G. demnatensis*.

On the basis of the ultrasculptural characters examined by SEM (Fig. 1c), *Genista clavata* and *G. umbellata* result rather similar, and are remarkably separated from the other taxa of the section. *G. demnatensis* is rather isolated as well, presenting the greater affinity with *G. cepha-*

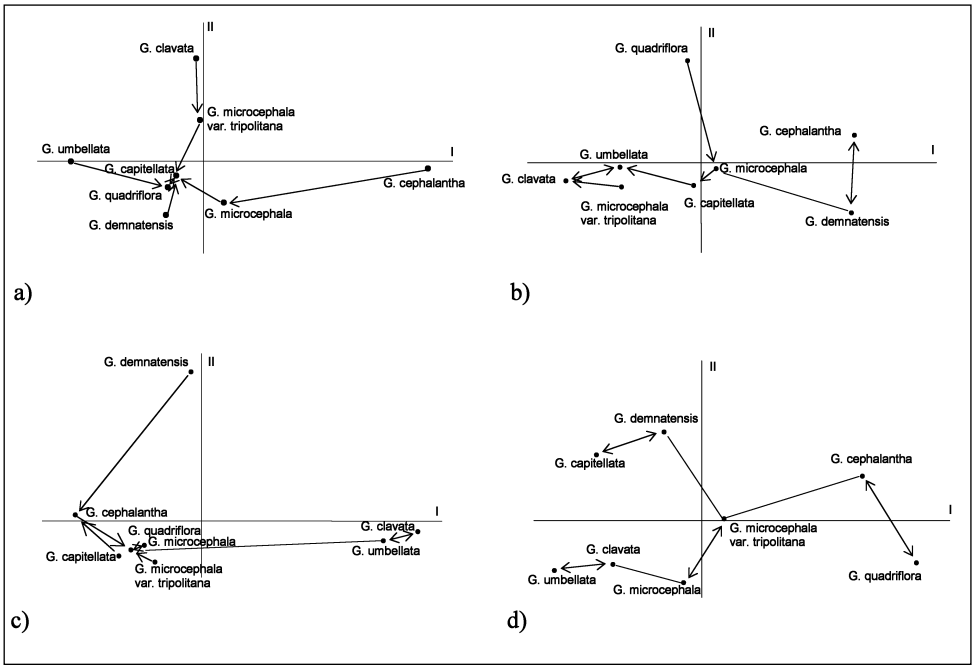

Fig. 1. Ordination and minimum spanning tree of the taxa of *Genista* sect. *Cephalospartum* on the basis of: a) quantitative pollen characters examined by LM; b) qualitative pollen characters examined by LM; c) pollen characters examined by SEM; d) pollen characters examined by TEM. The minimum spanning tree, that links the taxa according to maximum affinity, is overimposed.

lantha. A more homogeneous grouping is formed by *G. quadriflora*, *G. microcephala* (with the greatest reciprocal affinity), *G. microcephala* var. *tripolitana*, *G. capitellata* and *G. cephalantha*.

On the basis of the ultrastructural characters analyzed by TEM (Fig. 1d), *Genista quadriflora* and *G. cephalantha* result rather similar and are separated from the other taxa. Among these, *G. umbellata* and *G. clavata* have the greatest reciprocal affinity; also *G. capitellata* and *G. demnatensis* are remarkably similar, as, by the way, *G. microcephala* and *G. microcephala* var. *tripolitana.*

Fig. 2 represents the dendrogram of the taxa of section *Cephalospartum*, based on all the pollen characters considered, both qualitative and quantitative, examined by LM, SEM and TEM. Two main clusters can be highligthed, the former (I) comprehending *Genista cephalantha* and *G. demnatensis,* the latter (II) including two subclusters. Subcluster IIa is constituted by *G. clavata* and *G. umbellata*, which are linked at a low level of distance. Subcluster IIb includes *G. microcephala*, *G. microcephala* var. *tripolitana*, *G. capitellata* and *G. quadriflora*; the last species is linked at a higher level of distance.

Fig. 3 represents the ordination of the taxa studied, based on all the pollen characters, both qualitative and quantitative, examined by LM, SEM and TEM, and the overimposed minimum spanning tree. *Genista umbellata* and *G. clavata* (subcluster IIa) result very similar, placing on the left side of the graphic; the four taxa of the subcluster IIb place in the

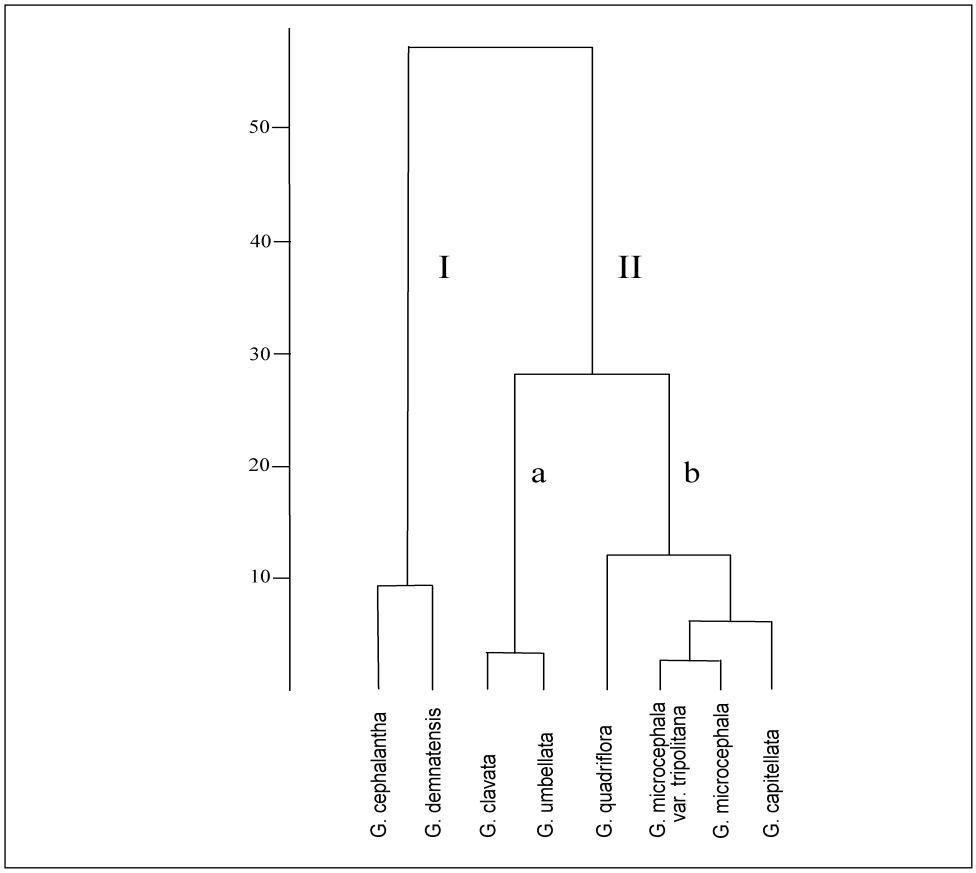

Fig. 2. Dendrogram of the taxa of *Genista* sect. *Cephalospartum* based on all pollen characters, both quantitative and qualitative, examined by LM, SEM and TEM.

central and inferior part of the graphic: *G. microcephala*, *G. microcephala* var. *tripolitana* (with the highest reciprocal affinity), *G. capitellata* and *G. quadriflora*, which both are linked to *G. microcephala*. The link between the two subclusters occurs through *G. umbellata* and *G. microcephala* var. *tripolitana*. *G. cephalantha* and *G. demnatensis* are rather isolated on the right side of the graphic; both are linked to *G. capitellata*.

Discussion

The morphological and biometrical analysis of the pollen grains of the section *Cephalospartum* confirms the main characters already described in various taxa of *Genista* and of other genera of *Genisteae*. The comprehensive analysis of the detailed characters allows to notice some differences among the taxa of the section, as underlined by the numerical analysis.

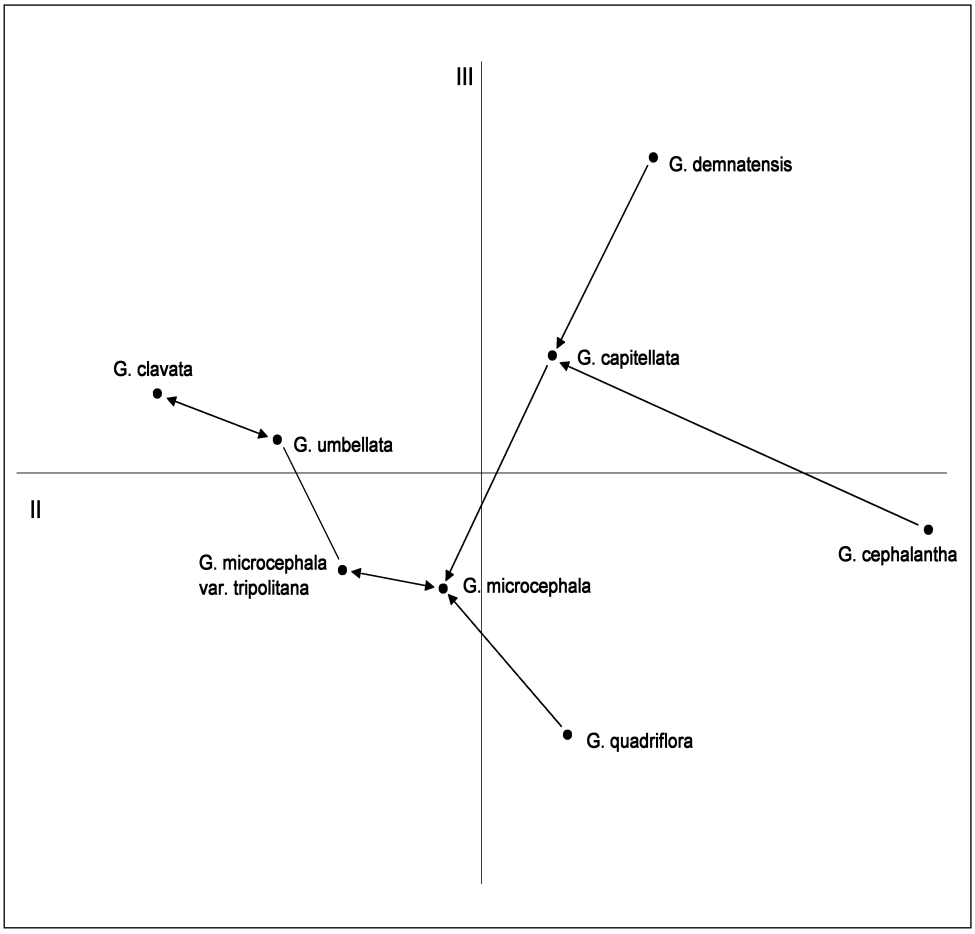

Fig. 3. Ordination and minimum spanning tree of the taxa of *Genista* sect. *Cephalospartum* on the basis of all pollen characters, both quantitative and qualitative, examined by LM, SEM and TEM; the minimum spanning tree, that links the taxa according to maximum affinity, is overimposed.

Genista umbellata and *G. clavata* result similar and are well distinguishable from the other taxa of the section. They share the following pollen characters: quantitative by LM (for example, lowest values of equatorial diameter); qualitative by LM (particularly high frequency of broadly elliptic grains and of furrows with wavy rim); sculptural by SEM (verrucate colpus membrane), and ultrastructural by TEM (thinnest columellar layer). Both the taxa share also some macromorphological characters - a broadly ovate standard petal, as long as the keel, and a narrowly oblong legume - not typical of subgen. *Spartocarpus*, but of subgen. *Genista*. However, the two species differentiate mostly for the pollen characters by LM (particularly the average P/E ratio), by SEM (tectum ornamentation at apocolpium and at furrow rim) and by TEM (foot layer thickness).

Genista microcephala, *G. microcephala* var. *tripolitana*, *G. capitellata* and *G. quadriflora* result rather similar as well on the basis of the complex of pollen characters, and form a sort of "central grouping" of the section. They present intermediate values for the main quantitative characters by LM (P, E, colpus length, P/E ratio) and some distinctive characters by SEM (their colpus membrane is only granulate and microverrucate). These taxa share also macromorphological characters: the standard petal is from angular ovate to broadly ovate and shorter than the keel (the most common feature in subgen. *Spartocarpus*), only *G. capitellata* has a triangular standard petal; they have ovoid-acuminate legumes (the most common feature in subgen. *Spartocarpus*), except for *G. quadriflora*, in which the legume is narrowly oblong; they have an ephedroid habitus, except for *G. quadriflora*, which sometimes may form hummocks with entangled branches. Among the taxa of this grouping, the pollen grains of *G. quadriflora* differentiate for characters by LM (as equatorially constricted furrows) and by TEM (highest thickness of exine, particularly of tectum and columellar layer). *G. capitellata* distinguishes by SEM (particularly for the lowest density of perforations) and by TEM (thinnest exine). *G. microcephala* var. *tripolitana* differentiates mostly for characters by LM, both quantitative (rather high apocolpium index) and qualitative (very high frequency of outline broadly elliptic in equatorial view); on the basis of these characters, *G. microcephala* var. *tripolitana* acts as trait d'union between the "central grouping" and *G. umbellata*.

Genista cephalantha and *G. demnatensis* result more isolated from the other taxa of the section. They differentiate from the others on the basis of some characters by LM (only subrhomboidal to rhombic-obtuse outline in equatorial view), by SEM (the only species with reticulum at apocolpium always lower than at mesocolpium and with a certain frequency of smooth colpus membrane) and by TEM (thickest foot-layer). These species are the only two of the section which present recurved, entangled and subspinescent branches, and pulvinules with two stipules conspicuous, persistent and spinose. *G. cephalantha* distinguishes nevertheless from *G. demnatensis* for most of the quantitative pollen characters by LM (highest values of P, E and colpus length), for some characters by SEM (higher frequency of blunt muri with shallow lumina in *G. cephalantha*, of angular muri with deeper lumina in *G. demnatensis*) and by TEM (higher thickness of exine, particularly of tectum and columellar layer). The pollen differences might confirm the two taxa as distinct species, as suggested by Gibbs (1966), and not the systematic arrangement proposed by Maire (1987), Raynaud (1979) and Greuter & al. (1989), who placed them as subspecies of *G. cephalantha*. These two taxa differentiate also on the basis of macromorphological characters: *G. demnatensis* presents a broadly ovate standard petal with a retuse apex, while *G. cephalantha* has an ovate-triangular standard petal with an acute apex.

Genista cephalantha, which is the most isolated taxon, is linked with the "central grouping" through *G. capitellata*, which also presents a triangular standard petal (typical character of subgen. *Phyllobotrys*). *G. cephalantha* shares with *G. capitellata* some pollen characters by LM, as the shape of the apertures (mostly rectangular furrows) and by SEM (highest frequency of irregular shaped and several joined perforations at the bottom of the lumina). On the other hand, *G. cephalantha* and *G. capitellata* share with the other species of section *Cephalospartum* the capitate inflorescence, the partly opposite branching and the leaves taking three vascular traces (character typical of the whole subgen.

Spartocarpus, Pellegrin 1908). Also *G. demnatensis,* although slightly less isolated, is linked with *G. capitellata*, sharing particularly the pollen dimensions by LM and some characters by TEM (particularly tectum and endexine thickness).

The section *Cephalospartum* results thus rather heterogeneous both from the palynological and macromorphological point of view.

Although the karyological data concerning the taxa of the section are not many, the section appears heterogeneous also from a karyological point of view: *Genista umbellata* presents the chromosome numbers $2n = 46$, more rarely 42, 48 (Santos 1944/45; Sañudo 1973; Talavera & Arista 1995; Cusma Velari & al. 1998); for *G. quadriflora* and *G. clavata*, Talavera & Arista (1995) and Tahiri & al. (2005), respectively, have counted 2n = 48; *G. cephalantha* has $2n = 26$ (Cusma Velari & al. 2000). In the section, therefore, both cases of euploidy ($2n = 48$) and of aneuploidy were found: ascending (hyperaneuploidy) for $2n = 26$, descending (hypoaneuploidy) for $2n = 46$. These numbers are traced back to basic chromosome number $x = 12$ by most of the authors (among others, Sañudo 1979; Goldblatt 1981; Cusma Velari & al. 2003). The chromosome heterogeneity of *Genista* is already well-known (Sañudo 1979; Verlaque 1988), particularly in the sections *Spartocarpus* (Rizzi Longo & Feoli Chiapella 1994) and *Voglera* (Cusma Velari & al. 1999).

Also the preliminary results of a phylogenetic analysis on some taxa belonging to *Genista*, which are based on the sequences of internal transcribed spacers of the nuclear ribosomal DNA (Caputo & al. 2003), show that section *Cephalospartum* is polyphyletic: *Genista microcephala*, *G. capitellata* and *G. cephalantha* are included in a clade, *G. umbellata*, *G. clavata* and *G. quadriflora* in another. On the other hand, Pardo & al. (2004), on the basis of nucleotide sequences of nrDNA (ITS region) and cpDNA (*trn*L-*trn*F intergenic spacer), find that *G. quadriflora* is separated from the only other taxa they examined of section *Cephalospartum* (*G. umbellata* and *G. clavata*).

A certain level of correlation among the pollen characters, the macromorphological, the karyological and those concerning genomic DNA (even if partial) is seemingly noticeable.

Conclusions

The comprehensive analysis of the detailed pollen characters allows to distinguish all the taxa of *Genista* sect. *Cephalospartum.* Some taxa are better distinguishable on the basis of the quantitative characters by LM (as *Genista cephalantha* and *G. umbellata*), others on the basis of the qualitative characters by LM (as *G. demnatensis* and *G. cephalantha* from the others) and by SEM (as *G. umbellata* and *G. clavata* from the others). The ultrastructural characters analyzed by TEM are less significant, but nevertheless important in separating some taxa (as *G. quadriflora* from *G. microcephala* aggr.), which are not completely distinguishable on the basis of the characters by LM and by SEM. Thus, the joint use of the four groups of characters provides the most complete information.

The section results rather heterogeneous from a palynological point of view, confirming the heterogeneity already highlighted by Gibbs (1966) on the basis of macromorpho-

logical characters and suggested by molecular data from DNA studies, although incomplete (Caputo & al. 2003; Pardo & al. 2004).

The results of the present pollen analysis don't justify the separation of the taxa of section *Cephalospartum* Spach emend. P. Gibbs into the two sections (*Cephalospartum* and *Lasiospartum*) proposed by Spach (1844, 1845) and accepted by Maire (1987) and Talavera (1999), but not by Gibbs (1966) and Raynaud (1979). Of the three species (*Genista umbellata*, *G. clavata* and *G. quadriflora*) separated in sect. *Lasiospartum* on macromorphological basis (particularly for the narrowly oblong legume), the first two distinguish from all the other taxa also on the basis of pollen characters; on the other hand *G. quadriflora* appears palynologically more similar to the taxa of *G. microcephala* aggr., which typically belong to sect. *Cephalospartum* sensu Spach for the ovoid-acuminate legume. At this stage of the research, the systematic collocation of *G. quadriflora* requires further studies. Its inclusion in sect. *Phyllodioides* (Talavera & Salgueiro 1999), already not supported by molecular data (Pardo & al. 2004), should be reconsidered also for its pollen similarity to the taxa of sect. *Cephalospartum*. Within *Genista microcephala* aggr., on the basis of the pollen characters are distinguishable not only *G. microcephala* and *G. capitellata*, already recognized as independent species by Gibbs (1966), Raynaud (1979) and Greuter & al. (1989), but also *G. microcephala* var. *tripolitana* (= *G. tripolitana* Bornm.). *G. tripolitana* is synonymized with *G. microcephala* by Gibbs (1966) and Greuter & al. (1989), while is distinguished as a variety by Maire (1987). The systematic rank of this taxon, therefore, deserves further studies, also because of its geographical disjunction.

Since, however, some groups of species within section *Cephalospartum* are recognizable, further studies on all the taxa of the section, particularly regarding the molecular and karyological data (at present incomplete), will be useful to clarify the opportunity to divide the section into taxa of lower rank. At this stage of the research, with the data available from macromorphological, palynological, karyological and molecular analysis, the following informal arrangement might be suggested:

Genista umbellata and *G. clavata*, which display the above mentioned macromorphological characters typical of subgen. *Genista*, and molecular and pollen similarity, might be included in a first subsection (possibly named *Lasiospartum*);

- *Genista cephalantha*, *G. demnatensis* and *G. microcephala* aggr. (*G. microcephala, G. microcephala* var. *tripolitana* and *G. capitellata),* which present the typical macromorphological characters of sect. *Cephalospartum* and molecular similarity, might be included in another subsection (possibly named *Cephalospartum*); some macromorphological differences and the pollen heterogeneity might justify the subdivision of this subsection into two series, one with *G. cephalantha* and *G. demnatensis*, the other with *G. microcephala* aggr.;

- *Genista quadriflora* **-** with its peculiar habitus (shrub strongly entangled, often forming hummocks, branches sometimes spinescent, subtended by a swollen pulvinule, leaves reduced and fugacious, inflorescence capitate with only 2-4 flowers), the legume similar to *G. umbellata* and *G. clavata*, the corolla and pollen more similar to *G. microcephala* aggr., some molecular data that differentiate the species both from taxa of the first group (*G. umbellata* and *G. clavata*) and of the second one (*G. cephalantha*, *G. microcephala* and *G. capitellata*) **-** might be included in a monospecific subsection.

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Appendix

List of voucher specimens from which pollen samples were obtained for this study:

Genista cephalantha Spach – ALGERIA: Oran, grand ravin, 20.02.1852, *Balansa* (FI); Oran, 03.1857 (FI); Oran, Djebel Santo, 21.04.1881, *Debeaux* (FI); Oran, Santa Cruz, 09.04.1905, *Faure* (FI); MOROCCO: Bocoia, Tesacut, 300m, 05.04.1929, *Font Quer* (G); tra Nador e Melilla, 25.07.1989, *Feoli Chiapella* (TSB).

Genista demnatensis Cosson ex Murb. – MOROCCO: Demnat, Djebel Tahallati, 18.06.1882, *Ibrahim* (FI); Haut Atlas, Demnat, mountains near Imi-n-Ifri, 29.06.1987, *Feoli Chiapella* (TSB); Oujda, Mt. Beni Snassen près de la MF d' Aïn Almou, 1200m, 15.06.1980, *Charpin*, *Jacquemoud & Jeanmonod* (G); Massif des Kebdana, 12.06.1934, *Sennen et Mauricio* (G).

Genista microcephala Cosson & Durieu – ALGERIA: El Kantara, 28.05.1896, *Chevallier* (FI); Wilaya Batna: Massif de l'Aurès, 3km E Arris an der Strasse nach Batna, 1200m, 06.06.1984, *Podlech* (G); Sommet des montagnes entourant l'oasis de Mnechounès, près Biskra, 18.05.1853, *Balansa* (G); Constantine, entre El Kantara et Maafa, 02.05.1906, *Romieux* (G); Aïn-Azel ex Ampère (wilaya Sétif), piste longeant la base du Djebel Bouthaleb, 20km au SW d' Aïn-Azel, 1000m, 18.06.1982, *Dubuis* (G); TUNISIA: Medjez, 05.1882, *Letourneux* (FI, sub *G. capitellata*).

Genista microcephala Cosson & Durieu var. ***tripolitana*** (Bornm.) Maire – LIBYA, Tripolitania: Uadi Garian, 26.04.1913, *Pampanini* (FI, sub *G. capitellata* var. *tunetana* Cosson); Mesellata, Uadi Gherrim, 15.04.1913, *Pampanini* (FI, sub *G. capitellata* var. *tunetana*); Tarhuna, colline ad Est di Kasr Tarhuna, 28.03.1913, *Pampanini* (FI, sub *G. capitellata* var. *tunetana*); Tarhuna, Ras Bu Tauil, 21.03.1913, *Pampanini* (FI, sub *G. capitellata* var. *tunetana*); Garian, 24.03.1931, *Zodda* (FI, sub *G. capitellata* var. *tunetana*); Tarhuna, Uadi Sart, 27.03.1913, *Pampanini* (FI, sub *G. capitellata* var. *tunetana*).

Genista capitellata Cosson – ALGERIA: Oran, Guelta Abdesson entre Khadra et Aïn Madhy, sud de la prov. d'Oran, 07.06.1856, *Kralik* (G); Djebel Djellal au Seba Mokhan près de Djelfa, 06.1857, *Reboud* (G); Djebel Haona prés Djelfa, *Reboud* (G); Mouilah (wilaya Djelfa), au col de Teniet-Neguigaa, entre les Djebels Chebeibita et Sahary, à env. 35km au NE de Djelfa, 1200m, 15.06.1984, *Dubuis* (G).

Genista quadriflora Munby – MOROCCO: Atlante Riphaeo, Tizzi Iffri, 1500m, 24.06.1927, *Font Quer* (FI); Moyen Atlas, Taza, M. Tazzeka, Bab-Bou-Idir, 1450m, 25.07.1989, *Feoli Chiapella* (TSB); Moyen Atlas, Azrou, 01.07.1987, *Feoli Chiapella* (TSB); ALGERIA: Oran, Ténira, 11.05.1876, *Warion* (FI); Oran, Bousset, 16.06.1930, *Faure* (FI); Oran, Dhaya, 1876, *Munby* (FI); Dhaya, entre Aïn-Tindamine et Dhaya, à env. 60km au sud de Sidi-Bel-Abbès, 1300m, 21.05.1983, *Dubuis* (TSB).

Genista umbellata (L'Hér.) Poiret – SPAIN: Granada, entre Motril et Almuñécar, 21.05.1971, *Galiano & Valdés* (TSB); Almería, 300m, 12.04.1994, *Gallizia Vuerich* (TSB); Almería, Caballar, 16.05.1928, *Lacaita* (FI); Sierra Nevada, Cerro del Almirez, 1500m, 27.05.1902, *Gandoger* (FI); Barranco de Caballar, prope Almería, 22.04.1879, *Huter*, *Porta & Rigo* (FI); Málaga, Ventas de Zafarraya, 1000m, 06.1983, *Wikus* (TSB); Almería, Rambla de Tabernas, 26.03.1998, *Bacchetta* (TSB); MOROCCO: Tiganimin (Bocoya-Littore riphaeo), 100m, 02.05.1927, *Font Quer* (G); Sidi Abd-el-Kader-el-Xitali (Melilla), 100m, 07.04.1929, *Font Quer* (G); ALGERIA: Oran, Batterie espagnole, 27.04.1856, *Bourgeau* (FI); Oran, Cagneret, Broussailes, 11.06.1911, *Faure* (FI); Oran, Kristel, entre Kristel et Aïn-Franin, à 15km au NE d'Oran, 3m, 24.05.1980, *Dubuis* (TSB); Oran, Port-aux-Paules, 09.05.1879, *Warion* (FI); Oran, 1892, *Debeaux* (FI).

Genista clavata Poiret – MOROCCO: Tanger, Audjera, 03.1912, *Pitard* (FI); Tétouan-Larache, 25.04.1953, *Jovet*, *Sauvage & Vindt* (G); Tanger ad Tétuan, Audjera, 18.04.1911, *Pitard* (G); Tetouan, 02.05.1979, *Pasquier* (G, sub *G. umbellata*); prope oppidulum El Manzla (Marruecos, prov. Tétouan), 31.03.1985, *Fernández Casas*, *Martínez*, *Muñoz Garmendia & Regueiro* (G).