Fruit and seed morphology of *Euphorbia aggr. flavicoma*. Taxonomic implications

JOAN SIMON, JULIÀ MOLERO & CÈSAR BLANCHÉ

Resum

SIMON, J., J. MOLERO & C. BLANCHÉ (1992). Morfologia del fruit i la grana d'*Euphorbia aggr. flavicoma*. Implicacions taxonòmiques. Collect. Bot. (Barcelona) 21:211-242.

S'estudia la morfologia de les càpsules i les granes de les espècies d'*Euphorbia aggr. flavicoma* a l'Europa Occidental. S'ha investigat un total de 1500 granes de 13 tàxons amb microscopi òptic, microscopi electrònic de rastreig i lupa bincular. Les dades han estat sotmeses a una anàlisi multivariant i es presenta el corresponent dendrograma. Al final del treball s'aporta una clau que permet distingir els tàxons a nivell d'espècie per mitjà de caràcters de la càpsula i de la grana.

Mots clau: *Euphorbia*, granes, càpsules, MER, anàlisi multivariant.

Abstract

SIMON, J., J. MOLERO & C. BLANCHÉ (1992). Fruit and seed morphology of *Euphorbia aggr. flavicoma*. Taxonomic implications. Collect. Bot. (Barcelona) 21:211-242.

Capsule and seed morphology of W. European species of *Euphorbia aggr. flavicoma* has been studied. A total of 1500 seeds coming from 13 taxa have been investigated under light microscope, scanning electron microscope and binocular stereoscope. Data were processed by multivariate analysis and the corresponding dendrogram is presented. At the end of the paper, a key is presented allowing to the separation of taxa down to the species level.

Keywords: *Euphorbia*, Seeds, Capsules, SEM, Multivariate analysis.

1. INTRODUCTION

Fruit and seed characteristics are among the most widely used as taxonomic markers (ROTH, 1977; BARTHLOTT, 1981) and, in the last few years, their use has increased due to the large number of microcharacters that can be observed under the scanning electron microscope (SEM, BARTHLOTT, 1984). In genera with general very close flower structure between species or infraspecific taxa, both fruit and seed characters are even more valuable; this is the case of *Euphorbia* L.

J. SIMON, J. MOLERO & C. BLANCHÉ: Laboratori de Botànica, Facultat de Farmàcia, Universitat de Barcelona. Avgda. Joan XXIII s/n., 08028-Barcelona, Spain.

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Capsule morphology has been used as an «important» character since BOISSIER's (1862) monograph, in wich some minor groups of taxa were recognized into § *Galarrhaei* on the basis of capsule ornamentation. Nearly all the taxonomic keys of floras pointed out fruit characteristics in discriminating among species. SMITH & TUTIN (1964) divided sect. *Heliosco-pia* into several groups from capsule morphology. VINDT (1960) made an accurate revision of capsules, with a complete iconographic documentation from Moroccan species.

The number of seed characters has increased since the use of SEM. EHLER (1976) revised a few species coming from all the sections of *Euphorbia* and introduced new microcharacters such as cellular index, shape of anticlinal walls, ornamentation of periclinal walls, etc. This author, however, did not verify the validity of such characters at low taxonomic ranks, whereas PROKHANOV (1949), SMITH & TUTIN (l.c.) and RADCLIFFE-SMITH (1982) used seed morphology to describe subspecific taxa. The morphology of Iberian species was reviewed by BAIGES (1989).

Within the scope of biosystematic studies on subsect. *Galarrhaei* in Western Europe, we studied fruit and seed characters, testing their taxonomic validity at low ranks. Our research was focused primarily on the population level (SIMON, unpubl. data.) but the data presented here refer to taxonomic units.

2. MATERIAL AND METHODS

Capsules

Capsules from 13 taxa both from wild populations and from herbarium samples were studied. Wild material was fixed with Smith's reagent (formaldehyde (40 %)/glacial acetic acid/absolute ethanol, 40:7:100). The voucher specimens of the material studied are listed in Table 1.

Capsules were inspected under a Zeiss DRC stereomicroscope where the following parameters were recorded: total length, total width (excluding verrucae length), verrucae length and α (furrow angle). 5 capsules were measured for each population.

SEM observations were especially difficult because of the pressure differences with the surrouding environment during the gold metallization process. The explosive dehiscence of the tricoccae was stimulated when 0,01 Torr pressures were reached inside the metallizer (Diode-Sputtering Polaron E-5000) with damage risks for the SEM. Alternative treatments with osmium tetroxide did not lead to better results, even producing electrostatic worse observation conditions. Neither glycerol nor embedding capsules in synthetic resin improved work conditions. Finally, the best procedure was the use of cryoobservation techniques, using liquid N_2, able to reach -210° C in a very short time and, then, allowing capsules to achieve high rigidity. Working standard conditions were finally 30-40 nm of gold coating (1,3 kV, 16-18 mA, 0, 1 Torr) and observation under 15 kV acceleration and working distances of 20-40 mm.

Seeds

Seed material was coming from the same populations as those listed in Table 1. Seeds were washed with 96 % ethanol before binocular observations. The seed parameters recorded were: seed length and width, caruncle length and width and length of caruncle's stipe. For comparison with the findings of other authors, seed length was measured including the caruncle. Other qualitative characteristics, such as episperm color, plane seed shape in longitudinal section, surface roughness and chalaza evidence were also recorded. Caruncle

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Table 1.—Material studied

E. angulata Jacq.

France:

BASSES-PYRÉNÉES: (an5) «Bayonne», 4-V-1882, Blanchet (G s/n).

Spain:

CANTABRIA: (an4) «San Vicente de la Barquera, cabo Oyambre», 21-VII-1984, ¿? (MA 412916); LEÓN: (*an2) «Chana de Somoza, prop del riu», 800 m, 27-VI-1990, *C. Benedí & J. Simon* (BCF 37048); (an3) «La Guiana, prop del repetidor de televisió», 1600 m, 27-VI-1990, *C. Benedí & J. Simon* (BCF 37050); ZAMORA: (an1) «Sierra Calva de Porto, Puebla de Sanabria», 19-VII-1973, *B. Casaseca* (MA 196337).

E. brittingeri Opiz ex Samp.

France:

AIN: (br10) «Soura du Vallon d'Archan», 4-VIII-1878, *P. Chenevard* (G s/n); ALPES-MARITIMES: (br7) «Gorgues de Caussols», 900 m, 12-VI-1989, *J. Vallés & J. Simon* (BCF 37022); (br8) «Lopin du Pin, carretera cap a Saint-Lambert», 1000 m, 13-VI-1989, *J. Vallés & J. Simon* (BCF 37024); BASSES-PYRÉNÉES: (br1) «Cirque de moundelhs, Massif d'Ossau, Gabás», 1850 m, 8-VII-1980, *L. Villar & P. Montserrat* (JACA 375280); CHARENTE: (br11) «Angoulême», *A. Guillon* (G s/n); ISÈRE (br9) «Uriage», 30-VII-1897, *E. Peyron* (G s/n).

Ge:

NORDRHEIM: (br19) «Damm Huningo Kanal, NE. Rixheim», 240 m, 4-VI-1971, *P. Geissler* (G 215850)

Greece:

FLORINA: (br20) «montes Varnous (Kalo Nero), in austro-orientali verticum "Bela Voda" vocatorum», 2000 m, 1-VIII-1976, *W. Greuter* (G 134851).

Switzerland:

GENÈVE: (br17) «Genève, Vernier-Peney», 5-VI-1943, *V. Handwerk* (G 48270); VAUD: (br16) «La Dôle», 31-VII-1880, *E. Ayasse* (G s/n).

Spain:

BARCELONA: (br5) «Massif del Montseny, Santa Fe», 1150 m, 12-VII-1913, *F. Sennen* (MA 74944); GIRONA: (bró) «Sils», V-1949, *Caselles* (MA 128364); HUESCA: (br3) «Puente de la Reina», 550 m, 26-VI-1988, *A. Beltran, C. Montoya & J. Simon* (BCF 34917); (*br4) «Castejón de Sos, a 2 Km del poble en direcció Benasque», 900 m, 14-V-1988, *M. Belmonte & J. Simon* (BCF 34931); (br2) «El Portalet, Sallent de Gallego, gran peñasco de fluorita, al lado de la carretera», 1710 m, 23-VII-1982, *P. Montserrat* (JACA 109782).

Italy:

FRIULI-VENEZIA GIULIA: (br15) «Tarceto, ad muros secus viam prope Zomeais», 270 m, 29-VI-1966, *A. Contardo* (G 273656); LIGURIA: (br12) «in collibus vallis dictae "del Lagaccio" prope Genuam», VI-1888, *O. Penzig* (G s/n); LOMBARDIA: (br14) «colline sur Illusone», 1100 m, 27-VII-1913 *P. Chenevard* (G s/n); (br13) «Alpes Bergomiae, in latere orientale jugi inter pagos Orezza et Aviatico», 1000 m, 21-VI-1969, *A. Charpin & W. Greuter* (G 8545).

Slovenia:

ISTRIA: (br18) «nördliches Istrien "bei Kozina"», 500 m, 7-VI-1961, *G. Wagenitz & T. Wraber* (G s/n).

E. dulcis L.

Czechoslovakia:

JIHOCESKY: (dl10) «dist. Blatná, prope stationem viae ferreae pagi Závisín, 500 m, 22-VII-1971, B. Deylova (MA 250390).»

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

France:

MEURTHE-ET-MOSELLE: (dl8) «bois Collombey», 1-VI-1909, *J. Briquet* (G s/n); SAONE-ET-LOIRE: (dl7) «Molte St. Jean, 300 m, 22-V-1961 *A. Charpin* (G 126561).»

Germany:

RHEINLAND: (dl9) «Aggerhal», V-1929, *A. Schumacher* (MA 75025).

Spain:

ASTURIAS: (dl4) «Luarca, a 1 Km. del mirador», 40 m, 27-V-1971, *P. Montserrat* (JACA 210771); CANTABRIA: (dl2) «Espinama», 1927, *M. Losa* (MA 75046); LEÓN: (dl3) «Puerto del Pontón, baixant del Port direcció a Oseja de Sajambre», 1100 m, 26-VI-1990, *C. Benedí & J. Simon* (BCF 37046); LLEIDA: (*dl5) «Noves de Segre, sota Espahent, prop la Guàrdia», 780 m, 28-IV-1990, *C. Benedí, J. Molero & J. Simon* (BCF 35017); NAVARRA: (dl6) «Irati, cap a Ibarrondoa, zona de Lapatia anant a el Orhi en Lerbaclocha», 1500 m, 23-VI-1960 *P. Montserrat* (JACA 42660).

Portugal:

TRAS-OS-MONTES: (dl1) «Montalegre», 1150 m, 15-VII-1957, *A. Silva* (G s/n).

E. duvalii Lecoq & Lamotte

France:

AUDE: (*dv2) «Mont Alaric, serres superiors», 500 m, 13-VI-1990, *J. Vicens & J. Simon* (BCF 37017); AVEYRON: (dv5) «Cirque de Madasse, a 3 Km en direcció a les Gorges de la Jonte», 350 m, 12-VI-1990, *P. Vicens & J. Simon* (BCF 37040); (dv6) «Millau», VI-1903, *A. Faurés*, (G 196784); HÉRAULT: (dv1) «bois des Arenables, près Bèdarieux», V-1876, *A. Schmidely* (G s/n); (dv3) «La Boissiere», 1-VI-1925, *G. Blanchet* (MPU s/n); LOZÈRE: (dv4) «Saint-Enimie, baixant cap a les Gorges», 550 m, 12-VI-1990, *P. Vicens & J. Simon* (BCF 37038).

E. flavicoma subsp. ***costeana*** (Rouy) Greuter & Burdet

France:

AVEYRON: (*fc1) «Firmy, Puy de Wolf, en les pendents meridionals de la muntanya», 580 m, 12-VI-1990 *P. Vicens & J. Simon* (BCF 37036).

E. flavicoma DC. subsp. ***flavicoma***

France:

AUDE: (ff16) «La Clâpe, prop dels radars», 300 m, 7-X-1988, *A. Cauwet, C. Blanché, J. Vallés & J. Simon* (BCF 37002); (ff17) «Tauch, serres culminals», 900 m, 7-X-1988, *A. Cauwet, C. Blanché, J. Vallés & J. Simon* (BCF 37004); HÉRAULT: (ff18) «Bionne», 3-V-1902, *E. Moudon*, (G s/n).

Spain:

ALBACETE: (ff1) «Ossa de Montiel», 14-VI-1982, *Belmonte, Cantó, Borga & Sanchez-Mata* (MAF 129179); ALICANTE: (ff3) «Sierra del Carrascal», 18-VI-1978, *M. Ladero & S. Rivas-Goday* (MAF 104201); BARCELONA: (*ff13) «Collbato, carretera a les Caves de Salnitre», 270 m, 5-V-1988, *E. Pascual, R. Raventos & J. Simon* (BCF 34912); (ff14) «Baga, a 4 Km pujant cap a Gisclareny», 1000 m, 28-V-1989, *C. Montoya & J. Simon* (BCF 37014); CASTELLÓN: (ff7) «Eslida», 500 m, 26-VI-1983, *G. Mateo* (VAB 83/162); GIRONA: (ff15) «entre l'Escala i L'Estartit, prop de la desviació del cuartel militar antic», 100 m, 13-III-1988, *C. Blanché & R. Ferrer* (BCF 34849); LLEIDA: (ff12) «Hostalets, prop de Noves de Segre», 400 m, 6-VI-1988, *J. Molero & A. Romo* (BCF 34878); MÁLAGA: (ff2) «Sierra Bermeja, prop del cim», 1350 m, 18-III-1988, *J. Molero & J. Simon* (BCF 34772); MURCIA: (ff4) «Sierra de Espuña, prop del cim», 1150 m, 19-III-1988, *J. Molero & J. Simon* (BCF 34794); TARRAGONA: (ff11) «Ports de Tortosa, principi del cami del Rajatxol», 1000 m, 22-IV-1989, *C. Montoya & J. Simon* (BCF 34801); TERUEL: (ff8) «Valdelinares, entre Barranco de Peñarroya y barranco la Gitana», 1900

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

m, 12-VII-1973, *L. Villar & P. Montserrat* (JACA 351273); (ff9) «Alcala de la Selva, Peñarroya del Monegro», 1600 m, 5-VII-1957, *P. Montserrat* (JACA 145457); VALENCIA: (ff5) «Collado Umán, Buñol», 13-V-1988, *A. Cerver* (VAB 881773); (ff6) «Serra», 12-V-1984, *G. Stübing & J.B. Peris* (VF 11330); ZARAGOZA: (ff10) «Montes de Castejon, Castejón de Valdejasa», 500 m, 22-V-1988, *P. Montserrat* (JACA 90188).

E. flavicoma subsp. ***occidentalis*** Laínz.

Spain:

ALAVA: (fo14) «Arceniaga», 300 m, 26-VI-1973, P. Montserrat (JACA 229573); (fo13) «Arrieta, al lado de la carretera de Vitoria», 600 m, 24-VI-1973, *P. Montserrat* (JACA 223773); (fo15) «Pico de Serantes, prope Bilbao», VI-1936, *M. Losa* (BCF s/n); ASTURIAS: (*fo4) «Puerto de la Tarna, pujant al port pel congost del riu Nalón», 650 m, 1-VI-1988, *P. Laínz, C. Blanché & J. Simon* (BCF 34971); (fo10) «Alto de las Estazadas, baixant del port», 430 m, 30-VI-1990, *C. Benedí & J. Simon* (BCF 37066); (fo2) «Santillán», 150 m, 19-VI-1969, *P. Montserrat* (JACA 276369); (fo3) «Covadonga, carretera al lago de Enol», 1000 m, 18-VII-1969, *P. Montserrat* (JACA 266069); BURGOS: (fo9) «Valle de Mena. Mediana-Montiano», 550 m, 20-VI-1983, *P. Montserrat* (JACA 176283); CANTABRIA: (fo12) «Fuente De», 1300 m, 17-VII-1877, *P. Montserrat & F. Fillat* (JACA 97277); (fo11) «Espinama. Collada Valdeon-Canal de Pedabejo», 1900 m, 2-IX-1988, *P. Montserrat & M. Laínz* (JACA 279088); LA CORUÑA: (fo1) «Brandomil, Km 27 de la carretera a Baiñas», 200 m, 29-VI-1990, *C. Benedí & J. Simon* (BCF 37056); LEÓN: (fo5) «La Uña», 1200 m, 26-VI-1990, *C. Benedí & J. Simon* (BCF 37044); (fo7) «Puerto de San Isidro, poc després de Puebla de Lillo», 1200 m, 26-VI-1990, *C. Benedí & J. Simon* (BCF 37042); (fo6) «Puerto de Vegarada», 14-VI-1981, *M.T. Ponga* (LEB 25946): PALENCIA: (fo8) «Piedrasluengas», 28–VI-1982, *G. Mateo* (VAB 82/950).

E. flavicoma subsp. ***giselae*** (ined.)

France:

ARDÈCHE: (fg1) «Païolive», 1-VI-1914, *M. Roux* (G 260469); VAR: (*fg2) «Mont Coudon, près Toulon», 21-V-1869, *S. Alioth* (G s/n).

E. polygalifolia subsp. ***hirta*** (Lange) Laínz

Spain:

ASTURIAS: (*ph5) «Vegadeo cap a la Garganta; cruilla de carreteres cap a Taramundi», 620 m, 17-VII-1989, *C. Montoya & J. Simon* (BCF 34976); LA CORUÑA: (ph1) «Brandoñas de Arriba, prop del poble», 350 m, 28-VI-1990, *C. Benedí & J. Simon* (BCF 37054); (ph2) «Brandomil, Km 27 de la carretera a Baiñas», 200 m, 29-VI-1990, *C. Benedí & J. Simon* (BCF 37058); (ph3) «Lamas, carretera a Zas, prop d'una fabrica de fusta», 100 m, 29-VI-1990, *C. Benedí & J Simon* (BCF 37062); LUGO: (ph4) «Cabreira-Fonsagrada», VII-1957, *E. Carreira* (G s/n).

E. polygalifolia Boiss. & Reuter ex Boiss. subsp. ***polygalifolia***

France:

BASSES-PYRÉNÉES: (pp7) «Saint-Jean-de-Luz», 26-VI-1973, *Vivant* (G 65830).

Spain:

BURGOS: (*pp1) «Corconte, a uns 5 Km del Puerto del Escudo al costat de l'embassament de l'Ebro», 850 m, 14-VII-1989, *C. Montoya & J. Simon* (BCF 34954); (pp4) «Puerto de los Tornos», 920 m, 14-VII-1989, *C. Montoya & J. Simon* (BCF 37026); (pp3) «Lunada, en les pistes d'esqui», 1400 m, 31-VI-1990, *C. Benedí & J. Simon* (BCF 37068); CANTABRIA: (pp6) «Pico Cordel, Reinosa», 14-VII-1969, *S. Rivas Goday, J. Borja, M. Ladero & Valdés Bermejo* (MAF 74608); (pp5) «Reinosa», 7-VII-1948, *J. Borja* (MAF 23883); (pp2) «L'Henar pujant a l'estació d'esqui d'Alto Campoo», 1400 m, 14-VII-1989, *C. Montoya & J. Simon* (BCF 34964).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

E. pyrenaica Jordan

France:

BASSES-PYRÉNÉES: (*py4) «Pic d'Anie, prop del cim», 2100 m, 13-VII-1989, *J. Simon* (BCF 35013); (py7) «Pic du Midi», 1849, *Delessert* (G s/n); (py8) «Pic de Ger», VIII-1876), *H. Bordère* (G s/n); (py9) «Pic Cézy, dans la Hte-Vallée d'Oseau», 2100 m, 16-VIII-1881, *E. Doassans* (G s/n); (py6) «Eaux Bonnes», VII-1870, *E. Boissier & G.F. Reuter* (G s/n).

Hs:

BURGOS: (py3) «Rebollero Transpeña, en les serres sobre el poble», 1100 m, 15-VII-1989, *J. Simon* (BCF 37028); NAVARRA: (py5) «Isaba, Larra, Portillo de Larra, Insolo, picos entre Amielarra y la Mesa de los Tres Reyes», 2000 m, 2-IX-1971, *L. Villar* (JACA 217271); PALENCIA: (py1) «Pico Fraile», 10-VIII-1985, ¿? (LEB 38926); (py2) «Camporedondo de Alba, solana del Pico Espiguete, descenso por la canal», 2350 m, 12-VIII-1972, *P. Montserrat* (JACA 63772).

E. spinosa L.

France:

ALPES-MARITIMES: (*sp2) «Levens», 570 m, 12-VI-1989, *J. Vallés & J. Simon* (BCF 37020); (sp1) «Guillaumes», 850 m, 11-VII-1972, *P. Geissler* (G 216953).

Italy:

CALABRIA: (sp6) «de Morano à Campo Cenese», 29-VI-1891, *Saint-Lager* (G s/n); PIEMONTE: (sp3) «Val de Gorzenta» rupi fra Lerma e Laragminor, 24-VI-1905, *E. Ferrari* (Fl s/n); TOSCANA: (sp4) «Bains de St. Julien, près Pise», III-1836, *P. Savi* (G s/n); (sp5) «Alpi Apuane: Stazzema», VII-1882, *A. Biondi* (Fl s/n);

E. uliginosa Welw. ex Boiss. in DC.

Spain:

LA CORUÑA: (*ul1) «Lamas, carretera a Zas», 100 m, 29—VI-1990, *C. Benedí & J. Simon* (BCF 37060).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Table 2.—Capsule biometry

Localities	CAPSULE		VERRUCAE				FURROWS
	length	width	height	density	(1)dist.	(2)shape	ANGLE
E. flavicoma subsp. flavicoma							
Hs: Ossa de Montiel	3,91	4,11	0,14	104	1	3	180º-160º
Hs: Sierra Bermeja	4,08	4,30	0,43	144	1	4	180º-160º
Hs: Sierra Carrascal	4,11	4,33	0,26	132	1	2	180º-160º
Hs: Sierra de Espuña	3,55	3,88	0,28	180	1	3	180º-160º
Hs: Buñol	4,15	4,43	0,21	132	1	2	180º-160º
Hs: Serra	3,82	4,28	0,31	96	1	3	180º-160º
Hs: Eslida	3,32	3,58	0,11	132	1	2	180º-160º
Hs: Valdelinares	3,11	3,26	0,17	162	1	2	180º-160º
Hs: Alcala de Selva	3,48	3,54	0,23	144	1	2	180º-160º
Hs: Castejón	3,81	4,39	0,61	150	1	3	180º-160º
Hs: Ports de Tortosa	3,81	4,08	0,21	144	1	2	180º-160º
Hs: Hostalets	3,47	3,71	0,19	108	1	2	180º-160º
Hs: Collbato	3,69	3,95	0,25	132	1	2	180º-160º
Hs: Baga	3,66	3,78	0,13	210	1	2	180º-160º
Hs: L'Estartit	3,54	4,12	0,22	102	1	2	180º-160º
Hs: La Clâpe	4,22	4,44	0,22	300	1	2	180º-160º
Hs: Tauch	3,97	4,13	0,31	132	1	3	180º-160º
Hs: Bionne	3,56	3,71	0,18	216	1	3	180º-160º
	3,74	4,00	0,25	151	1	2	180º-160º
E. flavicoma subsp. occidentalis							
Hs: Brandomil	3,79	3,91	0,64	186	1	5	160º-140º
Hs: Santillán	2,95	3,07	0,66	186	1	5	160º-140º
Hs: Covadonga	3,45	3,52	0,44	132	1	5	160º-140º
Hs: Puerto de Tarna	3,53	3,81	0,44	228	1	5	180º-160º
Hs: La Uña	3,65	3,88	0,61	210	1	5	160º-140º
Hs: Puerto Vegarada	3,77	4,07	0,62	162	1	5	160º-140º
Hs: Puebla de Lillo	3,65	3,83	0,41	228	1	5	160º-140º
Hs: Piedrasluengas	3,91	4,08	0,61	160	1	5	160º-140º
Hs: Valle de Mena	3,63	3,73	0,67	174	1	5	160º-140º
Hs: Alto Estazadas	3,62	3,87	0,39	150	1	5	180º-160º
Hs: Espinama	3,89	4,05	0,95	132	1	5	160º-140º
Hs: Fuente De	3,61	3,71	0,46	150	1	5	160º-140º
Hs: Arrieta	3,41	3,47	0,51	198	1	5	160º-140º
Hs: Arceniaga	3,81	4,02	0,58	216	1	5	160º-140º
Hs: Pico Serantes	3,61	3,77	0,42	120	1	3	160º-140º
	3,62	3,79	0,56	175	1	5	160º-140º
E. flavicoma subsp. costeana							
Ga: Firmy	2,86	3,13	0,26	120	1	3	180º-160º
E. flavicoma subsp. giselae							
Ga: Païolive	3,25	3,54	0,31	208	1	3	180º-160º
Ga: Toulon	3,62	4,06	0,41	180	1	3	180º-160º
	3,44	3,80	0,36	194	1	3	180º-160º
E. spinosa							
Ga: Guillaumes	3,68	3,45	1,23	96	1	6	160º-140º
Ga: Levens	3,41	3,22	1,14	90	1	6	160º-140º
It: Val de Gorzenta	3,67	3,74	1,33	90	1	6	160º-140º
It: Pise	3,86	3,81	1,16	112	1	6	140º-120º
It: Stazzema	3,98	3,93	1,28	90	1	6	160º-140º
It: Morano	3,54	3,57	1,09	112	1	6	140º-120º
	3,69	3,62	1,21	98	1	6	160º-140º

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Localities	CAPSULE		VERRUCAE				FURROWS
	length	width	height	density	(1)dist.	(2)shape	ANGLE
E. pyrenaica							
Hs: Pico Fraile	5,03	5,34	0,41	18	2	1	160º-140º
Hs: Pico Espiguete	4,83	5,28	0,78	30	2	1	160º-140º
Hs: Rebollero	5,26	5,42	0,57	60	2	1	160º-140º
Hs: Pic d'Anie	4,37	4,87	0,51	56	2	1	160º-140º
Hs: Larra	4,33	4,68	0,56	36	2	1	160º-140º
Hs: Eaux Bonnes	4,45	5,15	0,35	24	2	1	160º-140º
Hs: Pic du Midi	4,91	5,55	0,23	30	2	1	160º-140º
Hs: Pic de Ger	4,21	4,98	0,43	48	2	1	160º-140º
Hs: Pic de Cezy	4,87	5,45	0,34	42	2	1	160º-140º
	4,70	5,19	0,46	38	2	1	160º-140º
E. duvalii							
Ga: Bèdarieux	3,61	3,97	0,79	84	1	4	160º-140º
Ga: Mont Alaric	3,58	3,72	0,84	96	1	4	160º-140º
Ga: La Boissiere	4,03	4,17	0,93	86	1	4	160º-140º
Ga: Saint-Enimie	4,62	4,64	1,02	60	1	4	160º-140º
Ga: Cirque Madasse	4,05	4,09	0,92	90	1	4	160º-140º
Ga: Millau	4,23	4,67	1,08	72	1	4	160º-140º
	4,02	4,21	0,93	81	1	4	160º-140º
E. brittingeri							
Ga: Gabás	3,43	3,64	0,43	132	1	3	160º-140º
Hs: Sallent Gallego	3,65	4,05	0,65	210	1	5	160º-140º
Hs: Puente de Reina	3,52	3,77	0,47	186	1	5	160º-140º
Hs: Castejón de Sos	2,87	3,07	0,42	132	1	5	160º-140º
Hs: Montseny	3,24	3,46	0,42	114	1	5	160º-140º
Hs: Sils	3,23	3,46	0,63	132	1	5	160º-140º
Ga: Caussols	3,29	3,66	0,41	156	1	5	160º-140º
Ga: Lopin du Pin	3,04	3,42	0,45	210	1	3	160º-140º
Ga: Uriage	3,16	3,26	0,59	155	1	5	160º-140º
Ga: Vallon d'Archan	2,97	2,87	0,46	180	1	3	160º-140º
Ga: Angoulême	3,43	3,48	0,36	108	1	5	140º-120º
It: Lagaccio	2,88	3,21	0,29	204	1	5	160º-140º
It: Orezza	3,36	3,61	0,47	180	1	5	160º-140º
It: Illusone	3,45	3,48	0,46	132	1	5	160º-140º
It: Zomeais	2,42	2,54	0,26	144	1	5	160º-140º
He: La Dôle	3,43	3,53	0,35	144	1	5	160º-140º
He: Vernier-Peney	3,48	3,62	0,51	132	1	5	160º-140º
Slo: Kozina	3,41	3,61	0,46	138	1	5	160º-140º
Ge: Rixheim	2,87	3,07	0,35	180	1	5	160º-140º
Gr: Montes Varnous	3,25	3,88	0,41	180	1	4	160º-140º
	3,22	3,43	0,44	157	1	5	160º-140º
E. dulcis							
Lu: Montalegre	2,81	2,96	0,37	24	2	3	140º-120º
Hs: Espinama	2,79	2,97	0,33	48	2	3	140º-120º
Hs: Puerto de Pontón	3,02	3,12	0,21	24	2	3	140º-120º
Hs: Luarca	2,87	3,05	0,47	42	2	3	140º-120º
Hs: Noves de Segre	2,95	3,13	0,47	18	2	3	140º-120º
Hs: Irati	3,05	3,21	0,58	42	2	3	140º-120º
Ga: Saint-Jean	2,87	2,98	0,51	42	2	3	140º-120º
Ga: Collombey	2,97	3,17	0,78	42	2	3	140º-120º
Ge: Aggerhal	3,08	3,29	0,72	42	2	3	140º-120º
Cz: Závisin	2,89	3,22	0,69	48	2	3	140º-120º
	2,93	3,11	0,51	37	2	3	140º-120º

(c) Consejo Superior de Investigaciones Científicas
Licencia Creative Commons 3.0 España (by-nc)
http://collectaneabotanica.revistas.csic.es

Localities	CAPSULE		VERRUCAE				FURROWS
	length	width	height	density	(1)dist.	(2)shape	ANGLE
E. angulata							
Hs: Puebla Sanabria	2,73	2,93	0,53	42	2	3	140º-120º
Hs: Chana de Somoza	2,75	3,01	0,21	42	2	3	140º-120º
Hs: La Guiana	2,75	3,00	0,48	60	2	3	140º-120º
Hs: Cabo Oyambre	2,95	3,15	0,55	48	2	3	140º-120º
Ga: Bayonne	2,65	2,91	0,43	24	2	3	140º-120º
	2,77	3,00	0,48	43	2	3	140º-120º
E. polygalifolia subsp. polygalifolia							
Hs: Corconte	2,76	3,07	0,49	162	1	5	120º-90º
Hs: Alto Campoo	3,03	3,29	0,54	204	1	5	120º-90º
Hs: Lunada	2,85	3,58	0,45	210	1	5	120º-90º
Hs: Puerto Tornos	3,19	3,46	0,47	150	1	5	120º-90º
Hs: Reinosa	2,83	3,11	0,51	156	1	5	120º-90º
Hs: Pico Cordel	2,67	2,83	0,54	150	1	5	120º-90º
Ga: Saint-Jean	3,05	3,25	0,38	168	1	3	120º-90º
	2,91	3,23	0,48	171	1	5	120º-90º
E. polygalifolia subsp. hirta							
Hs: Brandoñas	2,32	2,59	0,35	144	1	6	120º-90º
Hs: Brandomil	2,31	2,83	0,55	162	1	5	120º-90º
Hs: Lamas-Zas	2,54	2,74	0,41	108	1	5	120º-90º
Hs: Cabreira	2,47	2,63	0,38	210	1	3	120º-90º
Hs: Vegadeo	2,28	2,52	0,41	180	1	5	120º-90º
	2,38	2,66	0,42	160	1	5	120º-90º
E. uliginosa							
Hs: Lamas-zas	2,70	2,89	0,27	162	1	5	120º-90º

Length and width are expressed as mean of the population (in mm). Shaded lines the mean of the populations of the same taxon and the predominant character if qualitative.

Density is expressed as mean verrucae number per capsule.

(1) **dist.**= verrucae distribution on the capsule. **1.**– regular; **2.**– irregular.

(2) **shape**= shape of verrucae. **1.**– crested; **2.**– subhemisphaeric; **3.**– subconic **4.**– subpiramidal; **5.**– digitates; **6.**– subcilyndric.

morphology was not considered because of alterations that may have taken place in the herbaria. 10 seeds were measured from each population.

SEM seed study restricted to the populations marked with an asterisk (*) in Table 1. Mature seeds washed with ethanol were mounted on biadhesive belts over the stub. Electrostatic difficulties were again experienced and mounting on colloidal argent was necessary although photographs were not always clear enough. Technical working conditions were as reported for the capsules. Further research to improve mounting techniques is in progress at the Servei de Microscòpia Electrònica de la Universitat de Barcelona, where the observations were carried out. The characters considered were selected from among those chosen by BAIGES (1989): shape and topography of episperm cells and SCI (seed cell index per surface area, referred to a 100 x 100 µm square).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Table 3.–Seed biometry

Localities	SEED						CARUNCLE		
	length	width	(1)col.	(2)sha.	(3)sur.	(4)cha.	length	width	(5)sti.
E. flavicoma subsp. flavicoma									
Hs: Ossa de Montiel	2,91	2,23	3	2	1	2	0,47	0,81	< 0,2
Hs: Sierra Bermeja	2,90	2,08	1	1	1	2	0,65	0,75	< 0,2
Hs: Sierra Carrascal	2,56	2,11	2	1	1	2	0,56	0,82	< 0,2
Hs: Sierra de Espuña	2,43	1,90	2	2	1	2	0,52	0,80	< 0,2
Hs: Buñol	2,77	2,03	1	1	1	2	0,73	1,07	0,2-0,4
Hs: Serra	2,77	2,13	1	1	1	2	0,65	0,85	< 0,2
Hs: Eslida	2,18	1,98	3	2	1	2	0,49	0,81	< 0,2
Hs: Valdelinares	2,53	1,95	1	1	1	2	0,49	0,78	0,2-0,4
Hs: Alcala de Selva	2,48	1,85	2	1	1	2	0,41	0,71	0,2-0,4
Hs: Castejón	2,55	2,12	2	1	1	2	0,47	0,79	0,2-0,4
Hs: Ports de Tortosa	2,66	2,03	3	1	1	2	0,76	0,54	0,2-0,4
Hs: Hostalets	2,27	1,87	2	1	1	2	0,43	0,62	0,2-0,4
Hs: Collbato	2,76	1,96	2	1	1	2	0,60	0,75	0,2-0,4
Hs: Baga	2,54	2,07	2	2	1	2	0,51	0,80	0,2-0,4
Hs: L'Estartit	2,31	1,77	2	1	1	1	0,65	0,79	0,2-0,4
Hs: La Clâpe	2,91	2,00	2	1	1	2	0,71	0,99	< 0,2
Hs: Tauch	2,77	1,98	2	1	1	2	0,50	0,73	< 0,2
Hs: Bionne	2,37	1,79	1	1	1	2	0,52	0,64	0,2-0,4
	2,59	1,99	2	1	1	2	0,56	0,78	0,2-0,4
E. flavicoma subsp. occidentalis									
Hs: Brandomil	2,07	1,69	2	1	1	2	0,64	0,78	0,2-0,4
Hs: Santillán	2,01	1,53	2	1	1	2	0,52	0,77	0,2-0,4
Hs: Covadonga	2,23	1,65	2	1	1	2	0,43	0,67	< 0,2
Hs: Puerto de Tarna	2,53	2,00	2	1	2	2	0,55	0,82	> 0,4
Hs: La Uña	2,56	1,81	1	1	1	2	0,61	0,86	0,2-0,4
Hs: Puerto Vegarada	2,11	1,77	1	1	1	2	0,55	0,75	0,2-0,4
Hs: Puebla de Lillo	2,41	1,83	2	1	1	2	0,60	0,95	0,2-0,4
Hs: Piedrasluengas	2,29	1,88	3	1	1	2	0,68	0,94	< 0,2
Hs: Valle de Mena	2,41	1,87	2	1	1	2	0,56	0,87	< 0,2
Hs: Alto Estazadas	2,25	1,79	2	1	2	2	0,45	0,79	0,2-0,4
Hs: Espinama	2,29	1,77	2	1	1	2	0,65	0,94	0,2-0,4
Hs: Fuente De	2,44	1,79	2	1	2	2	0,49	0,63	0,2-0,4
Hs: Arrieta	2,18	1,73	2	1	1	2	0,62	0,82	< 0,2
Hs: Arceniaga	2,31	1,73	2	1	1	2	0,74	0,99	0,2-0,4
Hs: Pico Serantes	2,63	2,01	2	1	1	2	0,61	1,01	0,2-0,4
	2,31	1,79	2	1	1	2	0,58	0,84	0,2-0,4
E. flavicoma subsp. costeana									
Ga: Firmy	2,13	1,72	2	2	1	1	0,33	0,51	0,2-0,4
E. flavicoma subsp. giselae									
Ga: Païolive	2,27	1,65	2	1	1	2	0,68	0,84	0,2-0,4
Ga: Toulon	2,43	1,96	2	2	1	2	0,51	0,65	> 0,4
	2,35	1,81	2	1	1	2	0,60	0,75	0,2-0,4
E. spinosa									
Ga: Guillaumes	2,65	1,41	2	3	1	2	0,77	1,05	0,2-0,4
Ga: Levens	2,52	1,50	2	3	1	1	0,64	0,81	0,2-0,4
It: Val de Gorzenta	2,57	1,95	2	2	1	1	0,78	1,21	0,2-0,4
It: Pise	2,65	1,53	3	3	1	1	0,74	1,11	0,2-0,4
It: Stazzema	2,57	1,56	2	3	1	1	0,75	0,88	0,2-0,4
It: Morano	2,43	1,87	3	2	1	1	0,84	0,93	> 0,4
	2,57	1,64	2	3	1	1	0,75	1,00	0,2-0,4

(c) Consejo Superior de Investigaciones Científicas
Licencia Creative Commons 3.0 España (by-nc)
http://collectaneabotanica.revistas.csic.es

Localities	SEED						CARUNCLE		
	length	width	(1)col.	(2)sha.	(3)sur.	(4)cha.	length	width	(5)sti.
E. pyrenaica									
Hs: Pico Fraile	3,07	2,36	4	1	1	3	1,26	1,56	< 0,2
Hs: Pico Espiguete	3,78	2,52	3	1	1	3	0,93	1,48	< 0,2
Hs: Rebollero	3,37	2,36	3	2	1	3	1,12	1,57	< 0,2
Hs: Pic d'Anie	2,42	1,90	3	2	1	2	0,74	1,38	< 0,2
Hs: Larra	2,54	2,16	2	1	1	3	1,02	1,52	< 0,2
Hs: Eaux Bonnes	2,48	1,83	3	2	1	2	0,71	1,29	< 0,2
Hs: Pic du Midi	2,82	2,32	3	2	1	2	0 ,73	1,22	< 0 ,2
Hs: Pic de Ger	2,42	1,84	3	2	1	3	0,75	1,29	< 0,2
Hs: Pic de Cezy	2,62	2,03	4	2	1	2	0,64	1,24	< 0,2
	2,84	2,15	3	2	1	3	0,88	1,39	< 0,2
E. duvalii									
Ga: Bèdarieux	2,02	1,61	2	2	1	2	0,54	0,87	0,2-0,4
Ga: Mont Alaric	2,62	2,07	2	1	1	2	0,69	1,19	0,2-0,4
Ga: La Boissiere	2,58	2,05	2	2	1	2	0,63	1,01	0,2-0,4
Ga: Saint-Enimie	2,70	2,15	2	2	1	2	0,56	1,11	0,2-0,4
Ga: Cirque Madasse	2,60	2,16	2	2	1	2	0,61	0,96	0,2-0,4
Ga: Millau	2,28	1,82	2	2	1	2	0,58	0,81	0,2-0,4
	2,46	1,97	2	2	1	3	0,60	0,99	< 0,2
E. brittingeri									
Ga: Gabás	2,26	1,58	2	1	2	2	0,55	0,82	0,2-0,4
Hs: Sallent Gallego	2,21	1,77	2	1	2	2	0,58	0,89	0,2-0,4
Hs: Puente de Reina	2,35	1,93	3	1	2	1	0,59	0,89	> 0,4
Hs: Castejón de Sos	2,28	1,71	2	1	2	1	0,57	0,87	> 0,4
Hs: Montseny	2,23	1,78	3	2	2	2	0,68	0,87	> 0,4
Hs: Sils	2,07	1,65	1	2	2	2	0,65	0,77	> 0,4
Ga: Caussols	2,28	1,78	2	1	2	2	0,63	0,68	> 0,4
Ga: Lopin du Pin	2,19	1,74	2	1	2	1	0,53	0,61	> 0,4
Ga: Uriage	2,31	1,72	2	2	2	2	0,37	0,61	> 0,4
Ga: Vallon d'Archan	2,08	1,73	2	2	2	2	0,34	0,56	> 0,4
Ga: Angoulême	2,29	1,68	2	1	2	2	0,41	0,59	> 0,4
It: Lagaccio	2,08	1,55	2	1	2	2	0,31	0,54	> 0,4
It: Orezza	1,84	1,48	3	2	1	2	0,39	0,73	> 0,4
It: Illusone	1,88	1,66	3	2	2	2	0,38	0,78	0,2-0,4
It: Zomeais	1,77	1,57	1	2	1	1	0,32	0,57	> 0,4
He: La Dôle	2,14	1,58	2	1	2	2	0,38	0,62	> 0,4
He: Vernier-Peney	2,14	1,75	3	2	2	2	0,36	0,59	> 0,4
Slo: Kozina	1,92	1,58	3	2	2	2	0,51	0,76	0,2-0,4
Ge: Rixheim	1,86	1,41	1	1	1	2	0,39	0,63	> 0,4
Gr: Montes Varnous	2,32	1,66	2	2	1	2	0,55	0,71	> 0,4
	2,12	1,66	2	2	2	2	0,47	0,70	> 0,4
E. dulcis									
Lu: Montalegre	2,12	1,72	2	2	1	2	0,44	0,62	0,2-0,4
Hs: Espinama	1,97	1,64	1	2	1	2	0,28	0,42	> 0,4
Hs: Puerto de Pontón	2,26	1,54	2	2	1	2	0,41	0,47	< 0,2
Hs: Luarca	2,21	1,65	1	1	1	2	0,32	0,41	0,2-0,4
Hs: Noves de Segre	2,41	1,79	1	2	1	2	0,63	0,79	0,2-0,4
Hs: Irati	2,33	1,71	1	2	1	2	0,33	0,42	0,2-0,4
Ga: Saint-Jean	1,85	1,62	2	2	1	2	0,54	0,63	0,2-0,4
Ga: Collombey	2,27	1,74	2	2	1	2	0,57	0,68	> 0,4
Ge: Aggerhal	2,34	1,82	2	2	1	2	0,52	0,67	> 0,4
Cz: Závisin	2,38	1,73	2	2	1	2	0,49	0,65	0,2-0,4
	2,21	1,70	2	2	1	2	0,45	0,58	0,2-0,4

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Localities	SEED						CARUNCLE		
	length	width	(1)col.	(2)sha.	(3)sur.	(4)cha.	length	width	(5)sti.
E. angulata									
Hs: Puebla Sanabria	1,96	1,42	1	1	1	1	0,35	0,66	0,2-0,4
Hs: Chana de Somoza	1,87	1,46	1	1	1	1	0,32	0,61	0,2-0,4
Hs: La Guiana	2,03	1,58	1	1	1	2	0,36	0,58	0,2-0,4
Hs: Cabo Oyambre	2,22	1,75	1	2	1	1	0,39	0,54	> 0,4
Ga: Bayonne	1,87	1,61	1	2	1	2	0,54	0,63	> 0,4
	1,99	1,56	1	1	1	1	0,39	0,60	0,2-0,4
E. polygalifolia subsp. polygalifolia									
Hs: Corconte	1,83	1,50	3	2	1	1	0,67	0,83	< 0,2
Hs: Alto Campoo	1,89	1,47	4	2	1	1	0,41	0,67	< 0,2
Hs: Lunada	1,80	1,51	4	2	1	1	0,45	0,52	< 0,2
Hs: Puerto Tornos	2,02	1,55	3	2	1	2	0,43	0,61	< 0,2
Hs: Reinosa	1,83	1,44	2	2	1	2	0,33	0,67	< 0,2
Hs: Pico Cordel	1,83	1,45	4	2	1	2	0,47	0,67	< 0,2
Ga: Saint-Jean	1,82	1,55	2	2	1	1	0,33	0,75	< 0,2
	1,86	1,50	4	2	1	1	0,44	0,67	< 0,2
E. polygalifolia subsp. hirta									
Hs: Brandoñas	1,61	1,22	4	2	1	1	0,38	0,75	< 0,2
Hs: Brandomil	1,85	1,32	4	2	1	1	0,72	0,76	< 0,2
Hs: Lamas-Zas	1,71	1,24	4	2	1	1	0,59	0,74	< 0,2
Hs: Cabreira	1,73	1,19	3	2	1	1	0,37	0,49	< 0,2
Hs: Vegadeo	1,78	1,36	3	2	1	1	0,53	0,67	< 0,2
	1,74	1,27	4	2	1	1	0,52	0,68	< 0,2
E. uliginosa									
Hs: Lamas-zas	2,05	1,48	4	1	1	1	0,60	0,72	0,2-0,4

Length and width are expressed as mean of the population (in mm). Shaded lines the mean of the populations of the same taxon and the predominant character if qualitative.

(1) **col.**= seed color. **1.**– light brown; **2.**– brown; **3.**– dark brown; **4.**– greyish brown

(2) **sha.**= seed shape. **1.**– oval; **2.**– elliptic; **3.**– oblong.

(3) **sur.**= seed surface. **1.**– smooth; **2.**– rough.

(4) **càl.**= chalaza evidence. **1.**– little; **2.**– enough; **3.**– a lot of.

(5) **sti.**= stipe length (in mm).

Multivariate analysis

Global morphometric analysis of seeds and capsules was carried out through a data matrix built from data shown in Tables 2 and 3. 105 representative specimens (OTU) spanning the geographic area of 13 taxa (see Table 1) were scored for 16 characters. Among these characters, 8 are qualitative while the rest are quantitative (Table 4). This choice was made after the elimination of variables showing high correlations. The values in the data matrix are averages of several measurements for the quantitative characters and the predominant character for the qualitative character in each specimen. The coded data matrix is presented inTable 5.

After a preliminary PCA approach, hierarchical cluster analysis (HCA) was developed through the standardization proposed by ROHLF (1989) which measures dissimilarity by average taxonomic distance and which builds clusters using their unweighted pairing group based on arithmetic averages (UPGMA).

All the procedures were carried out using the NTSYS computer package v. 1.50 (ROHLF, 1989) with an IBM-compatible PC.

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Table 4.—Characters studied and state codification method.

crt 1. Seed length (in mm)
crt 2. Seed width (in mm)
crt 3. Seed color
(1) Ligth brown
(2) Brown
(3) Dark brown
(4) Greyish brown

crt 4. Seed shape
(1) Oval
(2) Elliptic
(3) Oblong

crt 5. Seed surface
(1) Smooth
(2) Rough

crt 6. Chalaza evidency
(1) small
(2) much
(3) high

crt 7. Caruncle length (in mm)
crt 8. Caruncle width (in mm)
crt 9. Caruncle's stipe length
(1) less than 0.2 mm
(2) 0.2-0.4 mm
(3) more than 0.4 mm

crt 10. Capsule length (in mm)
crt 11. Capsule width (in mm)
crt 12. Verrucae length (in mm)
crt 13. Verrucae density per capsule
crt 14. Verrucae distribution
(1) regular
(2) irregular

crt 15. Verrucae shape
(1) Crested
(2) subhemispheric
(3) subconic
(4) subpyramidal
(5) digitate
(6) subcylindric

crt 16. Capsule furrow angle
(1) 160-180º
(2) 140-160º
(3) 120-140º
(4) 90-120º

3. RESULTS

Capsules

Biometric data are shown in Figures 1 to 4. Capsule shape is globose to ovoid in all the taxa studied. In polar view, however, trends from subcircular (in *Euphorbia flavicoma* subsp. *flavicoma*) to trilobate (in *E. polygalifolia*) shapes can be observed, and these shapes are highly correlated with the angle of capsule furrows (160-180º to 90-120º respectively) (see Table 2).

Capsule size varies notably, both at population and at species level. Extreme average measures range between 4.70 x 5.19 mm (in *E. pyrenaica*) to 2.38 x 2.66 mm (in *E. polygalifolia* subsp. *hirta*). *E. pyrenaica* is clearly separate from the remaining taxa (Figures 1 and 2).

Epicarp surface is verrucose in all cases, but the shape of emergences provides good grouping criteria. Thus, 6 groups can be recognized: crestate, subhemispheric, subconical, subtetrahedric, digitate and subcylindrical according to capsule emergences, as shown in Figure 5 a,b,c, and Table 2. Density, distribution and particularly size of such emergencies are good markers too and *E. spinosa,* with emergences of 1.21 mm on average, can be easily identified (Figure 5 a). Capsule surfaces are uniformly glabrous, but small epidermal papillae can be found in all the taxa studied, except for *E. dulcis* subsp. *purpurata.*

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Table 5.—Coded data matrix

POBLAC.	crt 1	crt 2	crt 3	crt 4	crt 5	crt 6	crt 7	crt 8	crt 9	crt 10	crt 11	crt 12	crt 13	crt 14	crt 15	crt 16
ff1	2,91	2,23	3	4	1	3	0,47	0,81	1	3,91	4,11	0,14	104	1	3	1
ff2	2,90	2,08	1	1	1	3	0,65	0,75	1	4,08	4,30	0,43	144	1	4	1
ff3	2,56	2,11	2	1	1	3	0,56	0,82	1	4,11	4,33	0,26	132	1	2	1
ff4	2,43	1,90	2	3	1	3	0,52	0,80	1	3,55	3,88	0,28	180	1	3	1
ff5	2,77	2,03	1	1	1	3	0,73	1,07	2	4,15	4,43	0,21	132	1	2	1
ff6	2,77	2,13	1	1	1	3	0,65	0,85	1	3,82	4,28	0,31	96	1	3	1
ff7	2,18	1,98	3	4	1	2	0,49	0,81	1	3,32	3,58	0,11	132	1	2	1
ff8	2,53	1,95	1	2	1	3	0,49	0,78	2	3,11	3,26	0,17	162	1	2	1
ff9	2,48	1,85	2	1	1	3	0,41	0,71	2	3,48	3,54	0,23	144	1	2	1
ff10	2,55	2,12	2	1	1	3	0,47	0,79	2	3,81	4,39	0,61	150	1	3	1
ff11	2,66	2,03	3	1	1	2	0,76	0,54	2	3,81	4,08	0,21	144	1	2	1
ff12	2,27	1,87	2	1	1	3	0,43	0,62	2	3,47	3,71	0,19	108	1	2	1
ff13	2,76	1,96	2	2	1	3	0,60	0,75	2	3,69	3,95	0,25	132	1	2	1
ff14	2,54	2,07	2	3	1	3	0,51	0,80	2	3,66	3,78	0,13	210	1	2	1
ff15	2,31	1,77	2	1	1	1	0,65	0,79	2	3,54	4,12	0,22	102	1	2	1
ff16	2,91	2,00	2	1	1	3	0,71	0,99	1	4,22	4,44	0,22	300	1	2	1
ff17	2,77	1,98	2	1	1	3	0,50	0,73	2	3,97	4,13	0,31	132	1	3	1
ff18	2,37	1,79	1	2	1	3	0,52	0,64	2	3,56	3,71	0,18	216	1	3	1
fo1	2,07	1,69	2	2	1	2	0,64	0,78	2	3,79	3,91	0,64	186	1	5	2
fo2	2,01	1,53	2	1	1	3	0,52	0,77	2	2,95	3,07	0,66	186	1	5	2
fo3	2,23	1,65	2	1	1	3	0,43	0,67	1	3,45	3,52	0,44	132	1	5	2
fo4	2,53	2,00	2	1	2	3	0,55	0,82	3	3,53	3,81	0,44	228	1	5	1
fo5	2,56	1,81	1	1	1	2	0,61	0,86	2	3,65	3,88	0,61	210	1	5	2
fo6	2,11	1,77	1	1	1	3	0,55	0,75	2	3,77	4,07	0,62	162	1	5	2
fo7	2,41	1,83	2	1	1	3	0,60	0,95	2	3,65	3,83	0,41	228	1	5	2
fo8	2,29	1,88	3	2	1	3	0,68	0,94	1	3,91	4,08	0,61	160	1	5	2
fo9	2,41	1,87	2	1	1	3	0,56	0,87	1	3,63	3,73	0,67	174	1	5	2
fo10	2,25	1,79	2	1	2	3	0,45	0,79	2	3,89	4,05	0,95	132	1	5	2
fo11	2,29	1,77	2	1	1	3	0,65	0,94	2	3,89	4,05	0,95	132	1	5	2
fo12	2,44	1,79	2	1	2	3	0,49	0,63	2	3,61	3,71	0,46	150	1	5	2
fo13	2,18	1,73	2	1	1	3	0,62	0,82	1	3,41	3,47	0,51	198	1	5	2
fo14	2,31	1,73	2	1	1	3	0,74	0,99	2	3,81	4,02	0,58	216	1	5	2
fo15	2,63	2,01	2	1	1	3	0,61	1,01	2	3,61	3,77	0,42	120	1	3	2
fc1	2,13	1,72	2	3	1	1	0,33	0,51	2	2,86	3,13	0,26	120	1	3	1
fg1	2,27	1,65	2	1	1	3	0,68	0,84	2	3,25	3,54	0,31	208	1	3	1
fg2	2,43	1,96	2	3	1	3	0,51	0,65	3	3,62	4,06	0,41	180	1	3	1
sp1	2,65	1,41	2	5	1	2	0,77	1,05	2	3,68	3,45	1,23	96	1	6	2
sp2	2,52	1,50	2	5	1	1	0,64	0,81	2	3,41	3,22	1,14	90	1	6	2
sp3	2,57	1,95	2	4	1	1	0,78	1,21	2	3,67	3,74	1,33	90	1	6	2
sp4	2,65	1,53	3	5	1	1	0,74	1,11	2	3,86	3,81	1,16	112	1	6	3
sp5	2,57	1,56	2	5	1	1	0,75	0,88	2	3,98	3,93	1,28	90	1	6	2
sp6	2,43	1,87	3	4	1	1	0,84	0,93	3	3,54	3,57	1,09	112	1	6	3
py1	3,07	2,36	4	2	1	4	1,26	1,56	1	5,03	5,34	0,41	18	2	1	2
py2	3,78	2,52	3	2	1	4	0,93	1,48	1	4,83	5,28	0,78	30	2	1	2
py3	3,37	2,36	3	4	1	4	1,12	1,57	1	5,26	5,42	0,57	60	2	1	2
py4	2,42	1,90	3	4	1	3	0,74	1,38	1	4,37	4,87	0,51	56	2	1	2
py5	2,54	2,16	2	2	1	4	1,02	1,52	1	4,33	4,68	0,56	36	2	1	2
py6	2,48	1,83	3	4	1	2	0,71	1,29	1	4,45	5,15	0,35	24	2	1	2
py7	2,82	2,32	3	4	1	3	0,73	1,22	1	4,91	5,55	0,23	30	2	1	2
py8	2,42	1,84	3	4	1	4	0,75	1,29	1	4,21	4,98	0,43	48	2	1	2
py9	2,62	2,03	4	4	1	3	0,64	1,24	1	4,87	5,45	0,34	42	2	1	2
dv1	2,02	1,61	2	4	1	3	0,54	0,87	2	3,61	3,97	0,79	84	1	4	2
dv2	2,62	2,07	2	1	1	3	0,69	1,19	2	3,58	3,72	0,84	96	1	4	2
dv3	2,58	2,05	2	3	1	3	0,63	1,01	2	4,03	4,17	0,93	86	1	4	2
dv4	2,70	2,15	2	3	1	3	0,56	1,12	2	4,62	4,64	1,02	60	1	4	2
dv5	2,60	2,16	2	3	1	3	0,61	0,96	2	4,05	4,09	0,92	90	1	4	2
dv6	2,28	1,82	2	4	1	3	0,58	0,81	2	4,23	4,67	1,08	72	1	4	2
br1	2,26	1,58	2	1	2	3	0,55	0,82	2	3,43	3,64	0,43	132	1	3	2
br2	2,21	1,77	2	2	3	3	0,58	0,89	2	3,65	4,05	0,65	210	1	5	2

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

POBLAC.	crt 1	crt 2	crt 3	crt 4	crt 5	crt 6	crt 7	crt 8	crt 9	crt 10	crt 11	crt 12	crt 13	crt 14	crt 15	crt 16
br3	2,35	1,93	3	2	3	1	0,59	0,89	3	3,52	3,77	0,47	186	1	5	2
br4	2,28	1,71	2	1	2	1	0,57	0,87	3	2,87	3,07	0,42	132	1	5	2
br5	2,23	1,78	3	3	2	2	0,68	0,87	3	3,24	3,46	0,42	114	1	5	2
br6	2,07	1,65	1	3	2	3	0,65	0,77	3	3,23	3,46	0,63	132	1	5	2
br7	2,28	1,78	2	1	2	3	0,63	0,68	3	3,29	3,66	0,41	156	1	5	2
br8	2,19	1,74	2	1	2	1	0,53	0,61	3	3,04	3,42	0,45	210	1	3	2
br9	2,31	1,72	2	4	2	3	0,37	0,61	3	3,16	3,26	0,59	155	1	5	2
br10	2,08	1,73	2	4	2	3	0,34	0,56	3	2,97	2,87	0,46	180	1	3	2
br11	2,29	1,68	2	2	2	3	0,41	0,59	3	3,43	3,48	0,36	108	1	5	3
br12	2,08	1,55	2	2	2	3	0,31	0,54	3	2,88	3,21	0,29	204	1	5	2
br13	1,84	1,48	3	4	1	3	0,39	0,73	3	3,36	3,61	0,47	180	1	5	2
br14	1,88	1,66	3	4	2	3	0,38	0,78	2	3,45	3,48	0,46	132	1	5	2
br15	1,77	1,57	1	4	1	1	0,32	0,57	3	2,42	2,54	0,26	144	1	5	2
br16	2,14	1,58	2	2	2	3	0,38	0,62	3	3,43	3,53	0,35	144	1	5	2
br17	2,14	1,75	3	4	2	3	0,36	0,59	3	3,48	3,62	0,51	132	1	5	2
br18	1,92	1,58	3	4	2	3	0,51	0,76	2	3,41	3,61	0,46	138	1	5	2
br19	1,86	1,41	1	2	1	3	0,39	0,63	3	2,87	3,07	0,35	180	1	5	2
br20	2,32	1,66	2	4	1	3	0,55	0,71	3	3,25	3,88	0,41	180	1	4	2
dl1	2,12	1,72	2	4	1	2	0,44	0,62	2	2,81	2,96	0,37	24	2	3	3
dl2	1,97	1,64	1	4	1	2	0,28	0,42	3	2,79	2,97	0,33	48	2	3	3
dl3	2,26	1,54	2	4	1	3	0,41	0,47	1	3,02	3,12	0,21	24	2	3	3
dl4	2,21	1,65	1	2	1	2	0,32	0,41	2	2,87	3,05	0,47	42	2	3	3
dl5	2,41	1,79	1	4	1	3	0,63	0,79	2	2,95	3,13	0,47	18	2	3	3
dl6	2,33	1,71	1	4	1	3	0,33	0,42	2	3,05	3,21	0,58	42	2	3	3
dl7	1,85	1,62	2	4	1	3	0,54	0,63	2	2,87	2,98	0,51	42	2	3	3
dl8	2,27	1,74	2	4	1	2	0,57	0,68	3	2,97	3,17	0,78	42	2	3	3
dl9	2,34	1,82	2	4	1	2	0,52	0,67	3	3,08	3,29	0,72	42	2	3	3
dl10	2,38	1,73	2	4	1	2	0,49	0,65	2	2,89	3,22	0,69	48	2	3	3
an1	1,96	1,42	1	2	1	1	0,35	0,66	2	2,73	2,93	0,53	42	2	3	3
an2	1,87	1,46	1	2	1	1	0,32	0,61	2	2,75	3,01	0,21	42	2	3	3
an3	2,03	1,58	1	2	1	2	0,36	0,58	2	2,75	3,00	0,68	60	2	3	3
an4	2,22	1,75	1	3	1	1	0,39	0,54	3	2,95	3,15	0,55	48	2	3	3
an5	1,87	1,61	1	4	1	2	0,54	0,63	3	2,65	2,91	0,43	24	2	3	3
pp1	1,83	1,50	3	4	1	1	0,67	0,83	1	2,76	3,07	0,49	162	1	5	4
pp2	1,89	1,47	4	4	1	1	0,41	0,67	1	3,03	3,29	0,54	204	1	5	4
pp3	1,80	1,51	4	4	1	1	0,45	0,52	1	2,85	3,58	0,45	210	1	5	4
pp4	2,02	1,55	3	4	1	2	0,43	0,61	2	3,19	3,46	0,47	150	1	5	4
pp5	1,83	1,44	2	3	1	3	0,33	0,67	1	2,83	3,11	0,51	156	1	5	4
pp6	1,83	1,45	2	3	1	3	0,47	0,67	2	2,67	2,83	0,54	150	1	5	4
pp7	1,82	1,55	2	4	1	1	0,33	0,75	1	3,05	3,25	0,38	168	1	3	4
ph1	1,61	1,22	4	4	1	1	0,38	0,75	1	2,32	2,59	0,35	144	1	6	4
ph2	1,85	1,32	4	4	1	1	0,72	0,76	1	2,31	2,83	0,55	162	1	5	4
ph3	1,71	1,24	4	4	1	1	0,59	0,74	1	2,54	2,74	0,41	108	1	5	4
ph4	1,73	1,19	3	3	1	1	0,37	0,49	1	2,47	2,63	0,38	210	1	3	4
ph5	1,78	1,36	3	4	1	1	0,53	0,67	1	2,28	2,52	0,41	180	1	5	4
ul1	2,05	1,48	4	2	1	1	0,60	0,72	2	2,70	2,89	0,27	162	1	3	4

Seeds

After the examination of nearly 1,500 seeds, the results obtained from seed biometry are shown in Table 3. Seed size ranges from $2.84 \pm 0.13 \times 2.15 \pm 0.11$ mm (on average, in *E. pyrenaica*) to $1.74 \pm 0.1 \times 1.27 \pm 0.07$ mm (on average, in *E. polygalifolia* subsp. *hirta*). Thus, there is a close relationship between seed and capsule size.

Seed shape varies from oval in the *E. flavicoma* group, to subglobose (in *E. polygalifolia, E. dulcis* and *E. duvalii*) to subcylindric (in *E. spinosa*). Chalaza evidence is very variable,

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Table 6.—Variable contributions to axis formation

CHARACTERS	AXIS (%)		
	1	2	3
seed length	10,47	2,12	,49
seed width	10,47	3,96	2,30
seed color	0,84	6,92	11,43
seed shape	2,25	12,75	2,93
seed surface	2,26	7,57	4,43
chalaza evidency	6,94	6,46	3,96
caruncle length	8,72	4,10	8,54
caruncle width	9,73	4,51	7,64
caruncle's stipe length	4,23	6,20	2,40
capsule length	11,19	1,06	4,04
capsule width	11,12	0,38	2,83
verrucae length	0,59	6,33	11,05
verrucae density per capsule	4,08	11,94	9,26
verrucae distribution	3,15	11,20	12,94
verrucae shape	7,04	2,61	13,58
capsule furrow angle	6,83	11,89	2,13

although trends from evident chalazae (in *E. pyrenaica*) to low marked chalazae (in *E. polygalifolia*) are observed (see Table 3 and Figure 6).

Under light stereoscope, seeds are finely punctate to smooth in all taxa, except *E. brittingeri* and some populations of *E. flavicoma* subsp. *occidentalis* and subsp. *costeana*, where more irregular topographies are observed, such as ondulations, roughness and protuberances.

SCI is very variable between species (Figure 7).

Caruncle size does not distinguish between taxa (except for *E. pyrenaica*). More specific is the caruncle shape which can be arranged in 5 major groups named Type 1 to Type 5 (see Figure 8).

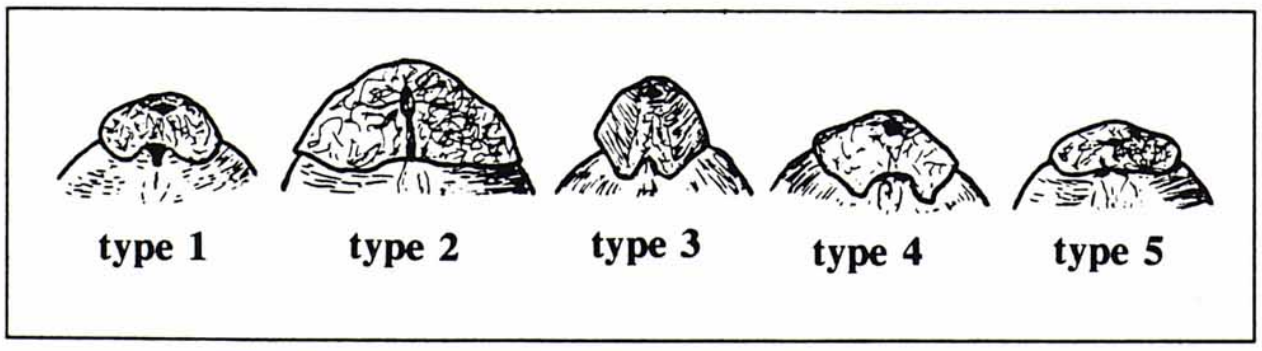


Fig. 8.—Caruncles classification (Types 1-5. For explanations, see text).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

4. NUMERICAL TAXONOMY

From the data listed in Tables 2 to 3, the codification of characters is shown in Table 4. 105 populations (UTO) from 13 taxa are considered for 16 multistate characters and Table 5 shows the coded data matrix.

PCA (Figures 9 and 10) clearly shows the different groups wich can be well identified by capsule and seed characters. The two-axis ordenation contains more than the half of total variance (53.10 %), whereas three-axis projection increases this value to 65.59 %. Factor loadings, indicating contributions of each variable to the PCs can be seen in Table 6. Three groups of points can be easily distinguished in this analysis (Figure 9): the first group consists only on *E. pyrenaica* populations (lowermost right corner of the diagram); the second unites the populations of *E. polygalifolia, E. uliginosa, E. spinosa, E. dulcis* and *E. angulata* (lowermost left corner of the diagram); finaly, the third group includes the remaining species (*E. flavicoma, E. duvalii* and *E. brittingeri*, at the upper part of the diagram). The characters with the highest contribution to axis formation (Table 6) are length and width of capsule and seed (1st axis) and seed shape, emergences density in the capsule and furrow angle in the capsule (2nd axis). The projection over the 3rd axis allows, in relation to the lowermost left cluster, to a marked separation of two new minor groups: *E. dulcis* and *E. angulata*, on one side and *E. polygalifolia, E. uliginosa* and *E. spinosa*, on the other (above, Figure 10). In this case, the most contributing characters are distribution and shape of verrucose emergences of capsules.

In interpreting the dendrogram (HCA) and scatter plot (PCA) it must be remembered that HCA is more reliable for revealing similarity towards the tips of the dendrogram (Figure 11), whilst PCA is most useful for detecting major clusters and gradients in the data set (Figure 9). The two techniques are used here in a complementary manner on the same data sets.

HCA (Figure 11) demonstrates that differences up to specific rank can be recognized between all the taxa considered using the characters listed above. With the only exception of *E. uliginosa* (of which species only one population has been considered), all the remaining populations perfectly agree with the rank we assigned *a priori*. Thus, 5 major groups can be distinguished (with dissimilarity values higher than 1.1).

The first group consists of the *E. flavicoma* and *E. duvalii* populations. It should be pointed out that *E. duvalii* is perfectly individualized within this group and that two minor groups also emerge from Figure 11. They correspond to the two subspecies of widest distribution area (*E. flavicoma* subsp. *flavicoma* and subsp. *occidentalis*). *E. flavicoma* subsp. *costeana* seems to be clearly removed from the *E. flavicoma* center (in basis on the high taxonomic distance, higher than 1.1) but the few materials investigated (only 1 population) advise caution. *E. flavicoma* subsp. *giselae* is not recognizable through the characters considered.

The second group consists only of *E. brittingeri*. The third is composed of two units: the *E. dulcis-E. angulata* group (although well differentiated among them) and the *E. polygalifolia-E. uliginosa* group (this last species was not separable).

The fourth and fifth groups are monospecific and correspond to *E. spinosa* and *E. pyrenaica* respectively.

5. DISCUSSION

The results show the real taxonomic weitht of capsule and seed characters and, at least in our group of species, it might be possible to build a taxonomic key based on carpological characters down to species level (see Chapter 6). Nevertheless, the grouping of OTUs shown by the final dendrogram (Figure 11) can be regarded as a first draft of phylogenetic relationship among the species dealt with here, to be completed in further contributions focused on new characters (pollen grains, cytogenetics, anatomy, ecology, phytodermology, etc.).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

From numerical analysis of capsule and seed biometric data and from the study of Figures 1, 2 and 3, *E. pyrenaica* is the most isolated taxon within the *E. verrucosa*-group and perhaps its affinities lie nearer other orophyte species, such as *E. capitulata* from the Balkans, than the W. Mediterranean ones.

Seed size and shape characters are highly variable and only some trends can be pointed out if quantitative analysis of a number of individuals can be performed. Seed coat topography is very homogeneous in all the taxa studied except for *E. brittingeri*. This particular feature of this species has been noted previously only by EHLER (1976) and BAIGES (1989) who used SEM to observe the rugosities of the seed surface. However, as BAIGES (l.c.) pointed out, these rugosities could easily be confused with other minor ornamentation protrusions (pustules, squamations, mottles) that we can find in any other taxon of this group. Even EHLER (l.c.) published a photograph corresponding to *E. brittingeri* in which this kind of artefact is confused with the true rugosities. Moreover, EHLER (l.c.) included *E. brittingeri* side by side to the *Euphorbia* species with rough surface (*E. berythea* Boiss. & Blanché ex Boiss. in DC., *E. microsphaera* Boiss., *E. oxyodonta* Boiss. & Haussk. ex Boiss. in DC., *E. polychroma* Kerner and *E. helioscopia* L.) of Sect. *Helioscopia*. If it is true that the seeds of *E. brittingeri* do not have smooth surface, it is also true that their surface is as far from rough surface seeds (type *E. helioscopia*) as from the smooth surface ones. After having studied a large number of seeds coming from sect. *Helioscopia*, *E. brittingeri* shows more affinities to *E. hirsuta* L.

KHAN (1964) discussed the evolutive position of seeds with sculptural elements in relation to smooth seeds. This author concluded, after the study of 2 species from the 3 subsections of sect. *Esula*, that because of their more restricted distribution, smooth seeds should be regarded as a more evolved character. After a survey of seed characteristics of European, north-African and Russian taxa of subsect. *Galarrhaei*, we cannot agree with Khan's conclusions because the predominance of species with smooth seeds is much higher than rough ones. Thus, it seems more probable that species with rough seeds might be regarded as derivative from species with smooth seeds, the latter being much more widespread than the former.

Seeds with rough surface have been found in some populations of *E. flavicoma* subsp. *occidentalis* and *E. flavicoma* subsp. *costeana*, as shown in Table 3. This can be interpreted as a common origin of the three taxa having rough seed coats. This common origin may be *E. flavicoma* subsp. *flavicoma*, a thermo-mediterranean camephyte, manifesting this character progressively during the process of adaptive radiation to most northern and moist areas but without any possibility of genetic exchange due to the present geographic isolation of derivative taxa.

The taxonomic value of SCI is of great interest for discrimination of very closely related taxa. This idea was pointed out by EHLER (l.c.) and confirmed by BAIGES (l.c.). It permits a clear separation of the following pairs of taxa: *E. flavicoma / E. brittingeri, E. dulcis / E. angulata* and *E. polygalifolia / E. uliginosa*, all often confused in the herbarium label determinations we studied. There is a high correlation between SCI data and cell size on leaves studied for phytodermology (SIMON unpubl. data).

From a biogeographical point of view, some considerations should be made. *E. pyrenaica* shows a clear disjunction for seed size between Cantabric and Pyrenaean populations, as shown in Figure 12 and in HCA (Figure 11). This disjunction is not obviously correlated with any other difference, either in seed or in any other plant organ, and may be considered only as a minor differentiation caused by geographic isolation which usually is regarded as «race locale» (JEANMONOD, 1984).

A certain polarity in the shape of seeds of *E. spinosa* has also been detected but, in this case, not related to phenomena of geographic isolation. In Figure 14, we can observe that seeds of French populations of this species are elongate (length/width ratio higher than 1.6), whereas in Italian populations, subglobose seeds (length/width ratio lower than 1.45) are

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

found together with rather longer seeds without intermediate forms. After a revision of a large number of herbarium specimens from the whole area of distribution of *E. spinosa*, the elongate seeds are predominant over the globose ones. The two kinds of seed are not found together in the same population but there is no clear geographic boundary between the populations, thus we cannot treat them as separate stirps since no other correlated characters have been found.

Anticlinal wall characteristics of surface seed cells have been used as a discriminant character by BAIGES (1989). But working with herbarium materials, the SEM characteristics observed are very variable depending on conservation conditions, seed maturation states and preparation procedures.

The main seed characteristics agree well with infrageneric and supraspecific divisions of the genus *Euphorbia*, and caruncle or mucilages presence or absence, or intercellular spaces with small granulate elements, very constant in subgenera and sections should be considered as outstanding taxonomic markers (sense BARTHLOTT, 1981). In other words, caruncle is regarded as a primitive element within the genus, as stated by BERG (1975); the mucilaginous projections of some seeds, possibly related to dispersion syndromes (CARLQUIST, 1966) can be considered as evolved.

In sect. *Helioscopia*, seeds are characterized by the presence of caruncle, absence of mucilages and lack of intercellular spaces on the seed coat (except for *E. pterococca* Brot., *E. lagascae* Sprengel and *E. isatidifolia* Lam., cf. BAIGES, l.c.). If we accept the phylogenetic value of the characters stated above in relation to seeds, sect. *Helioscopia* might be regarded as one of the most archaic within the genus. At the other extreme, much more advanced, there is the (previously considered) subgenus *Chamaesyce*, now accepted as a separate genus (ORELL, 1990), with seeds ecarunculate, having mucilages and intercellular spaces with glandular elements (see BAIGES, l.c.). Among the species considered in the scope of our work, only minor variations at caruncle level have been observed. Following KHAN (1964), within subsect. *Galarrhaei*, seeds can be carunculate, with deciduous caruncle or, in further steps, totally ecarunculate. KHAN (l.c.) also regarded this progressive lacking of caruncles as an evolutive trend, and he pointed out a great relation between lack of caruncle and biogeographical features (eastern mediterranean endemics). *E. brittingeri* shows a clear trend to the caducity of its caruncle, and this can be interpreted as an advanced feature within the group, which is in agreement with the roughness of its seed surface as mentioned above.

As the surface topography seems generally correlated with inner structural characteristics, we are strongly convinced that further resarch should include anatomical studies of seeds to provide better data with which to interprete outer seed coat diversity.

6. Dichotomous key based on fruit and seed characters

1. Capsules longer than 4.5 mm ..... *E. pyrenaica*
– Capsules shorter than 4.3 mm 2
2. Capsules with digitate or subcylindric verrucae 3
– Capsules with other shapes of verrucae 5
3. Capsule with marked furrows; more than 150 verrucae per capsule; verrucae digitate shorther than 0.6 mm 4
– Capsule with scarcely marked furrows; less than 130 verrucae per capsule; cylindrical verrucae over 1 mm long ..... *E. spinosa*
4. Seeds of elliptic longitudinal shape ..... *E. polygalifolia*
– Seeds of oval longitudinal shape ..... *E. uliginosa*
5. Verruca density per capsule less than 50; capsule furrows strongly marked 6
– Verruca density per capsule more than 70; capsule furrows scarcely marked 7
6. Seeds clear brown, with oval longitudinal shape ..... *E. angulata*

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

– Seeds dark brown, with elliptic longitudinal shape ..... *E. dulcis*
7. Capsule verrucae subtriangular, more than 0.7 mm high ..... *E. duvalii*
– Capsule verrucae subhemisphaeric or subconical, less than 0.6 mm high 8
8. Episperm surface rough (stereoscope!) ..... *E. brittingeri*
– Episperm surface smooth ..... *E. flavicoma*

Acknowledgements

To the Servei de Microscòpia Electrònica of the Unversitat de Barcelona for working facilities.

This work was subsidized by Grant PB87-1008 from D.G.I.C.Y.T., Ministerio de Educación y Ciencia, Spain.

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

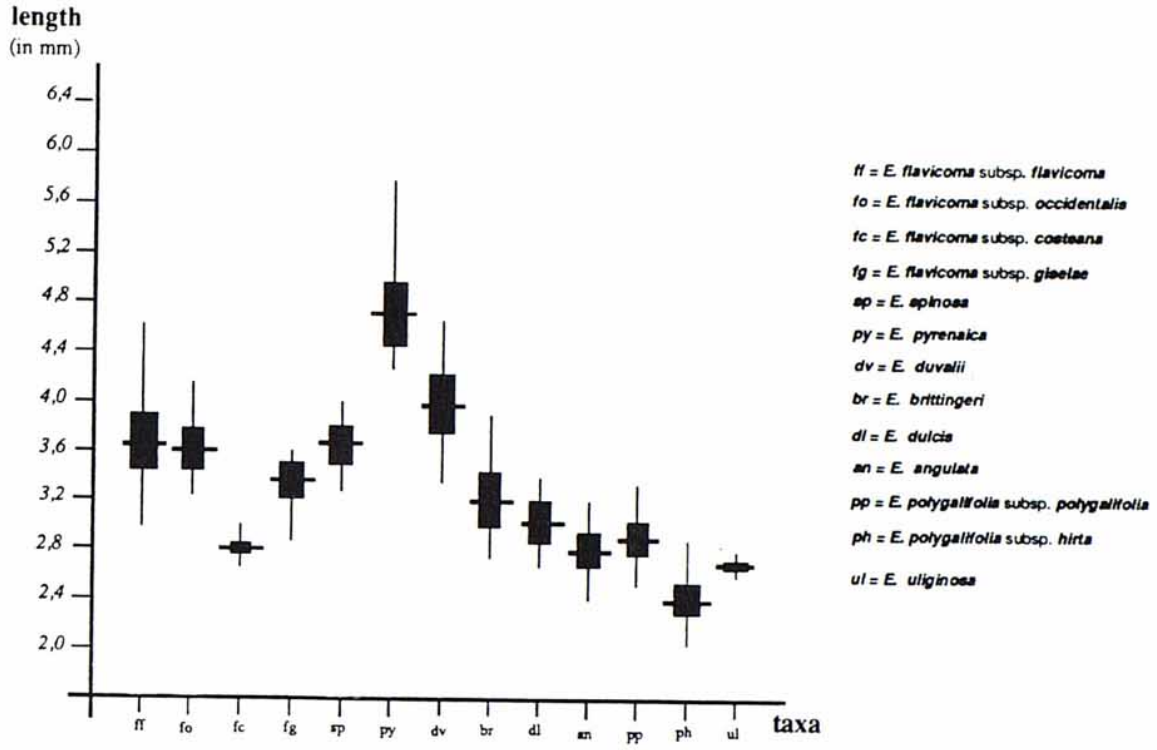


Fig. 1.–Simpson & Roe's Test for capsule length.

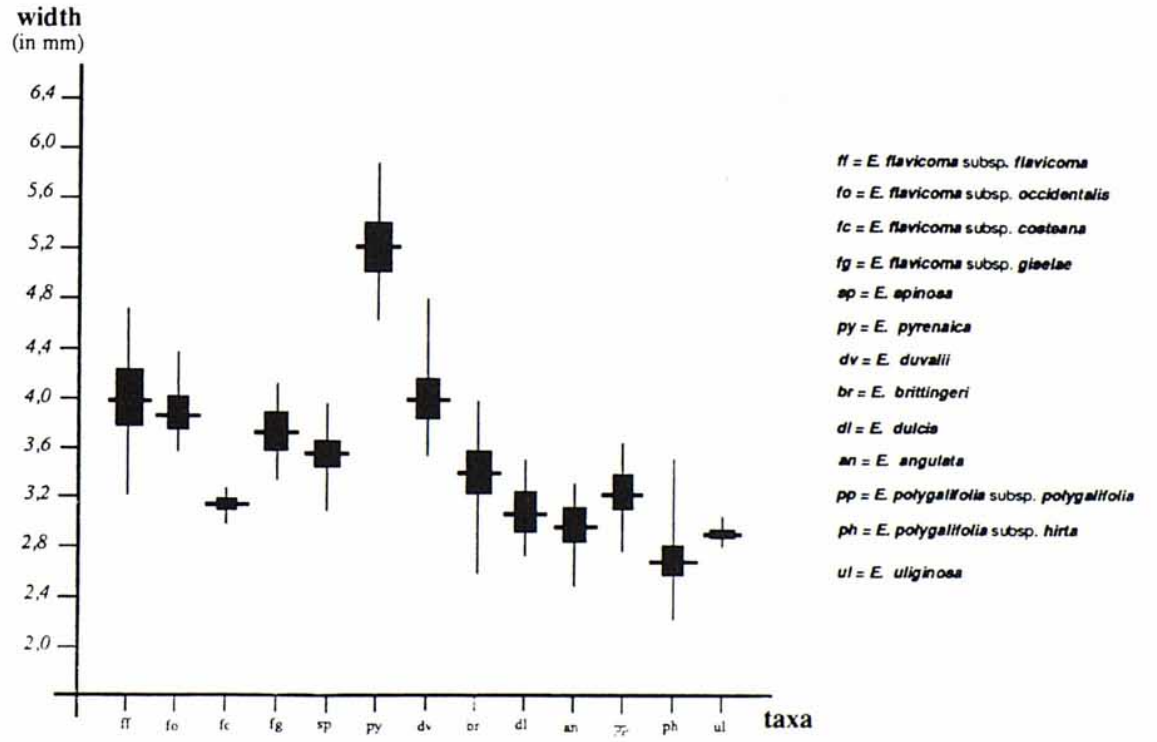


Fig. 2.–Simpson & Roe's Test for capsule width.

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

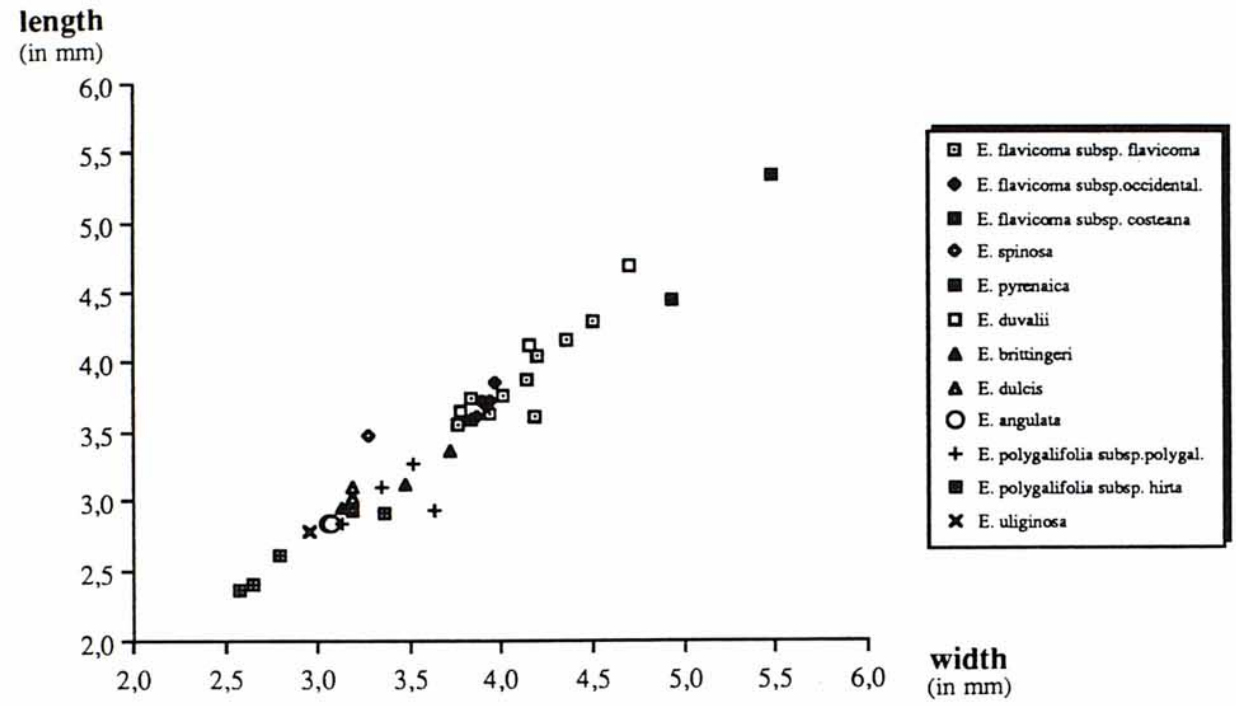


Fig. 3.—Capsules length/width ratio.

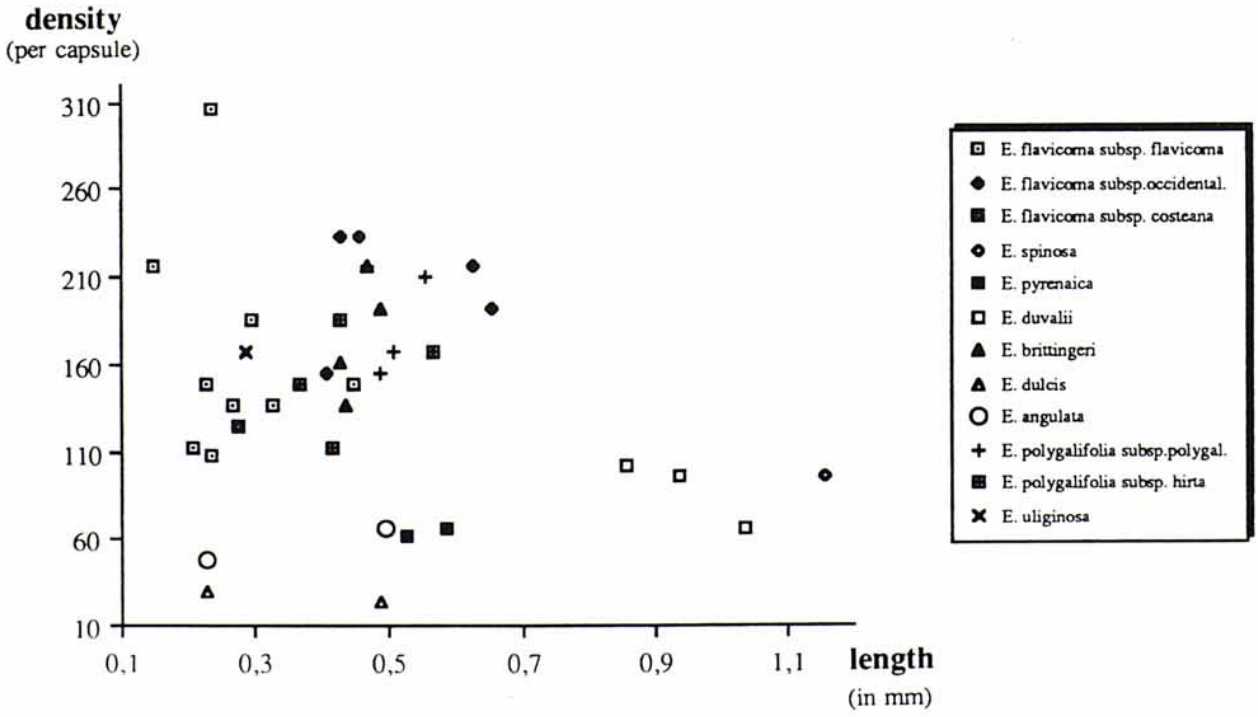
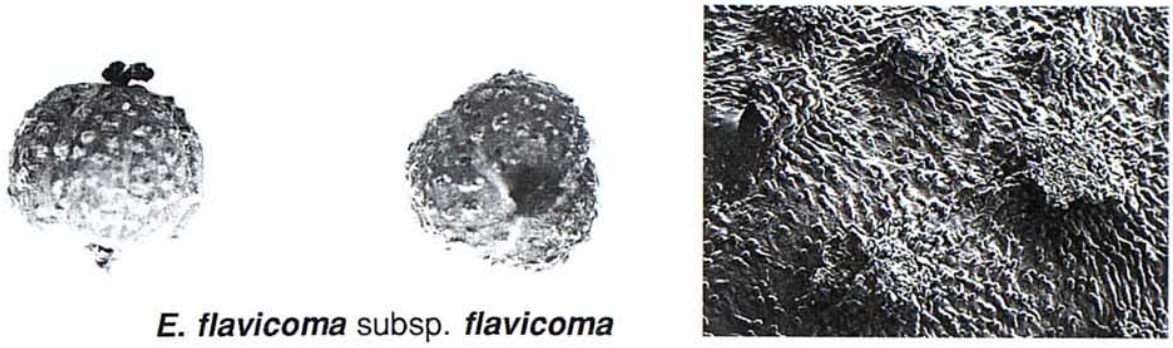
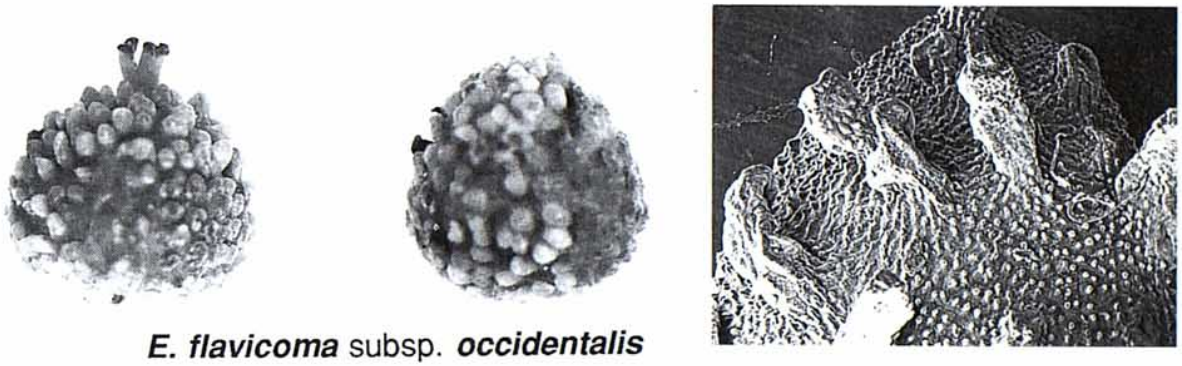


Fig. 4.—Verrucae density/length ratio.

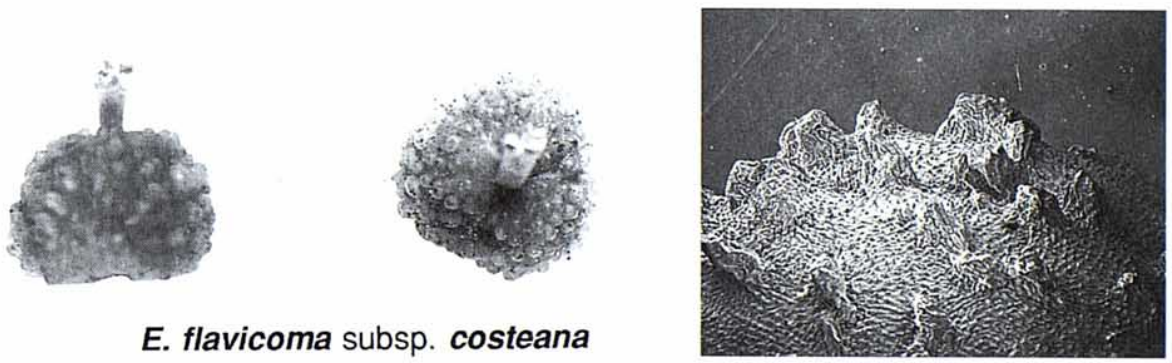
(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)



E. flavicoma subsp. *flavicoma*



E. flavicoma subsp. *occidentalis*



E. flavicoma subsp. *costeana*

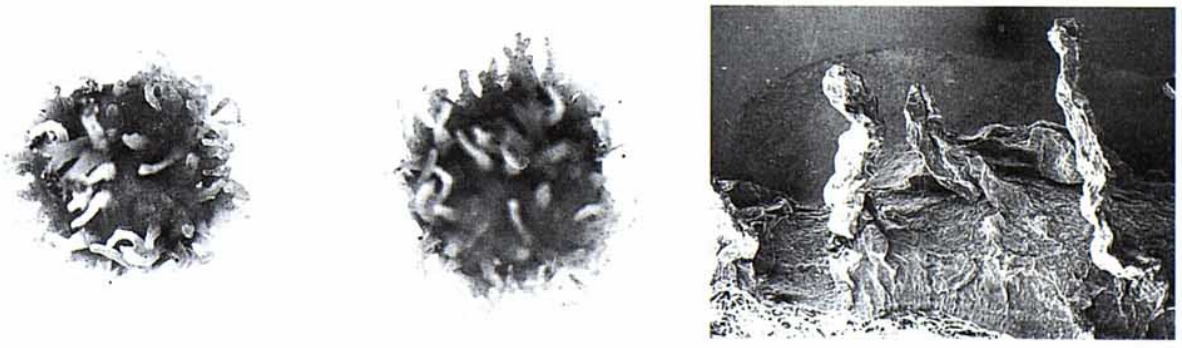


Fig. 5.—Capsule morphology (polar and lateral view, verrucae amplification).

(c) Consejo Superior de Investigaciones Científicas
Licencia Creative Commons 3.0 España (by-nc)
http://collectaneabotanica.revistas.csic.es

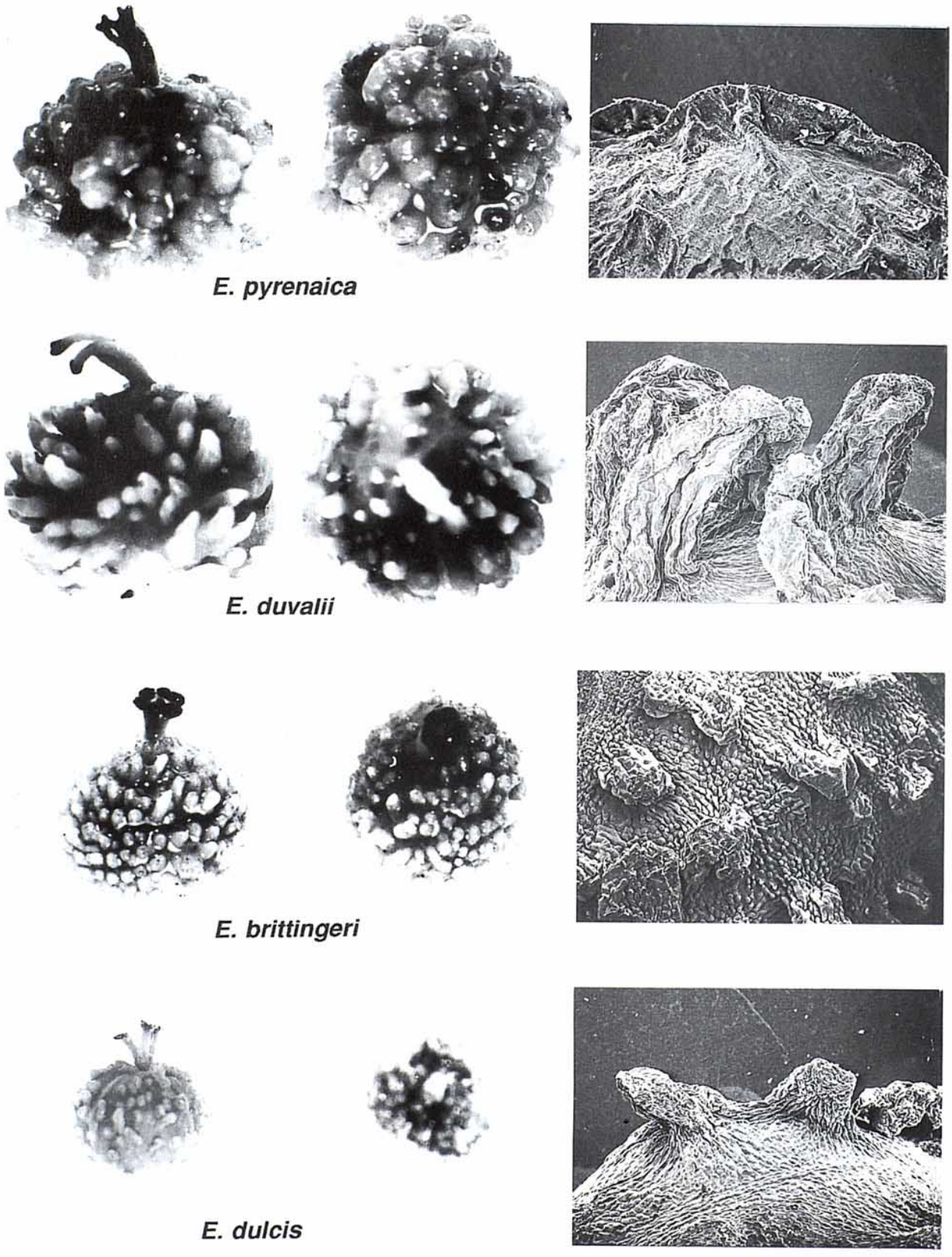
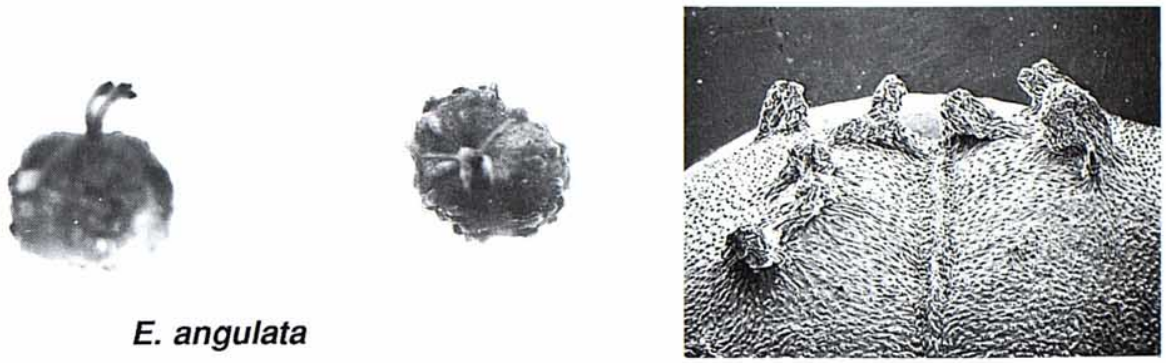
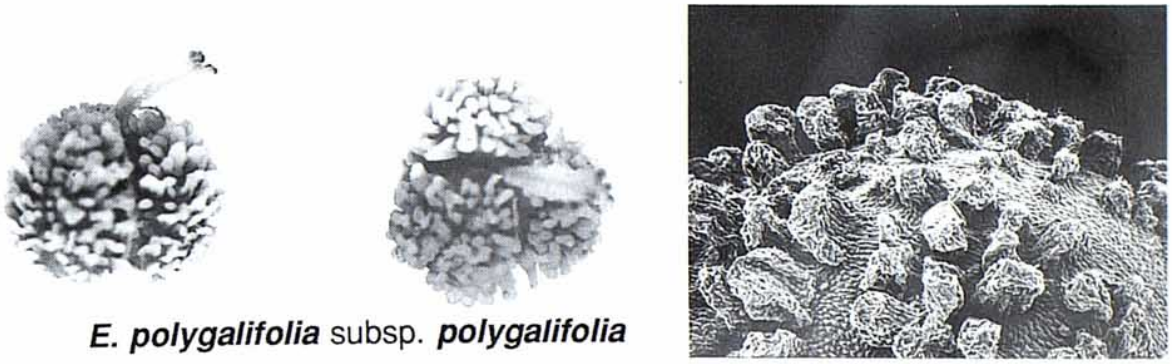


Fig. 5.—Capsule morphology (continuation).

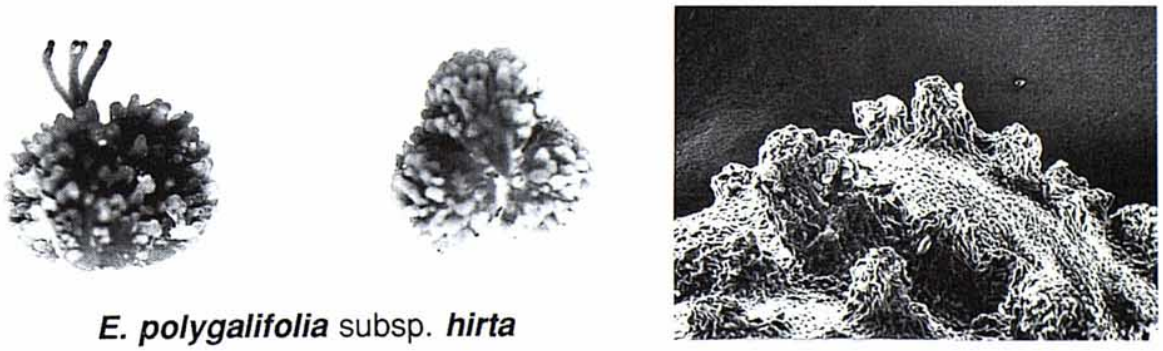
(c) Consejo Superior de Investigaciones Científicas
Licencia Creative Commons 3.0 España (by-nc)
http://collectaneabotanica.revistas.csic.es



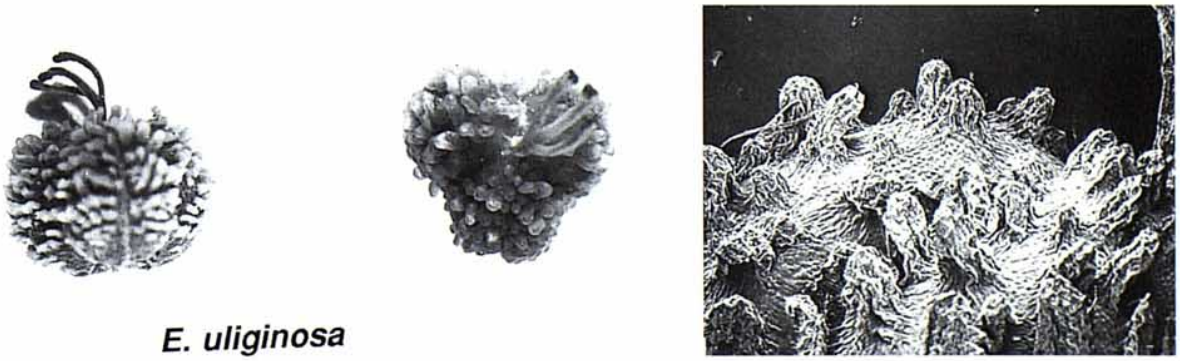
E. angulata



E. polygalifolia subsp. ***polygalifolia***



E. polygalifolia subsp. ***hirta***



E. uliginosa

Fig. 5.–Capsule morphology (continuation).

(c) Consejo Superior de Investigaciones Científicas
Licencia Creative Commons 3.0 España (by-nc)
http://collectaneabotanica.revistas.csic.es

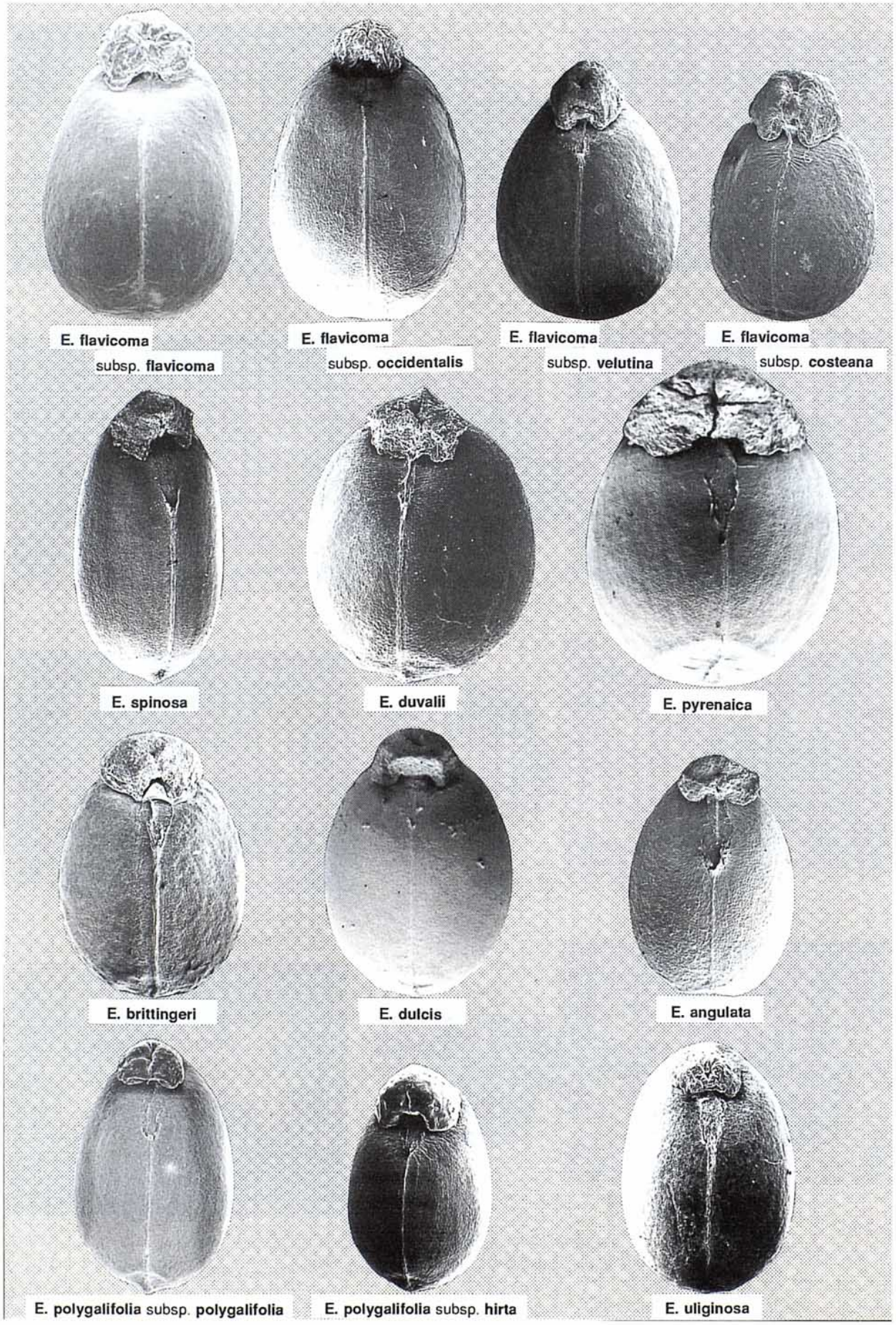


Fig. 6.—Seed morpholgy (ventral view).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

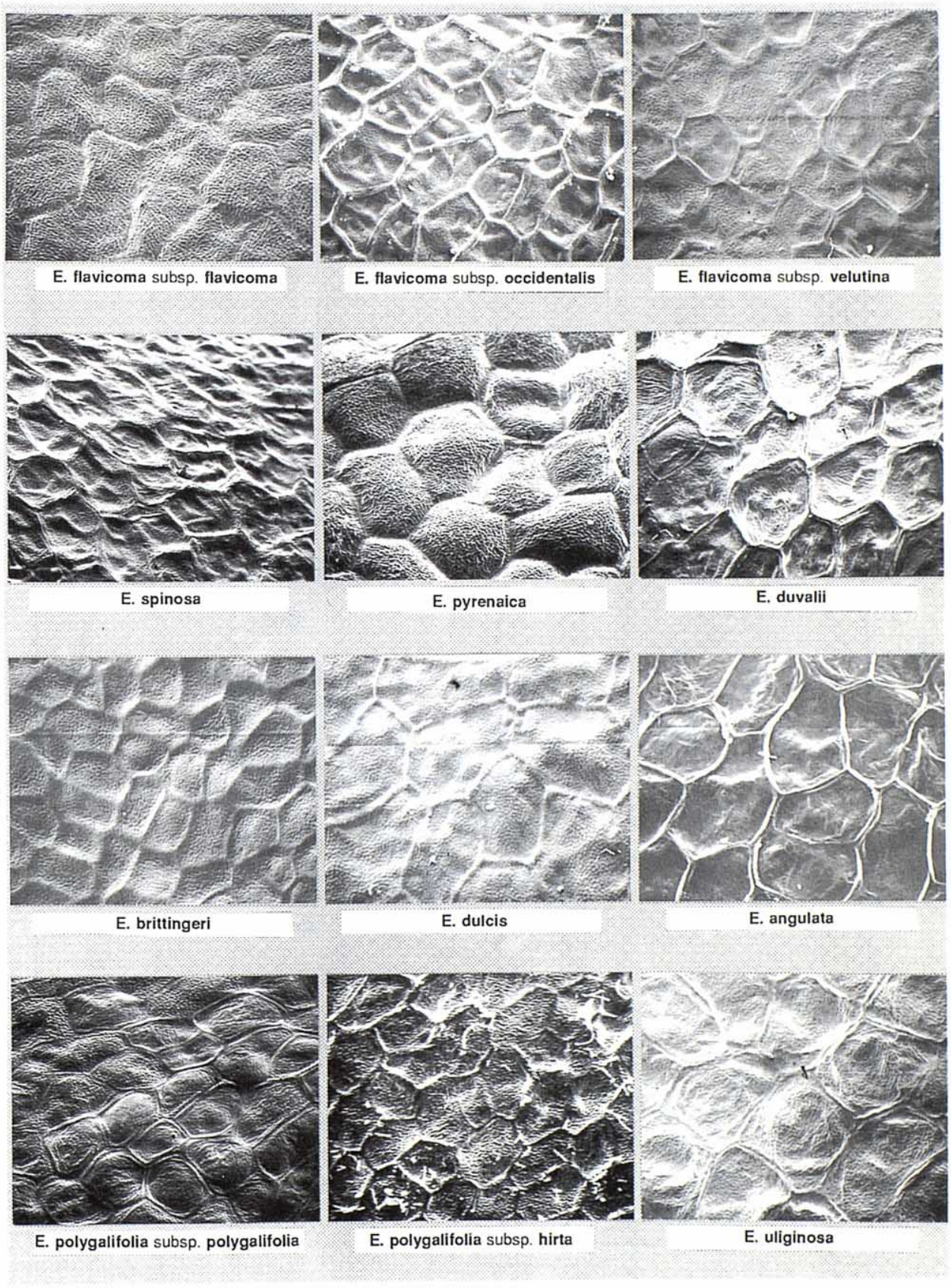


Fig. 7.–Seed coat ornamentation (SEM).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

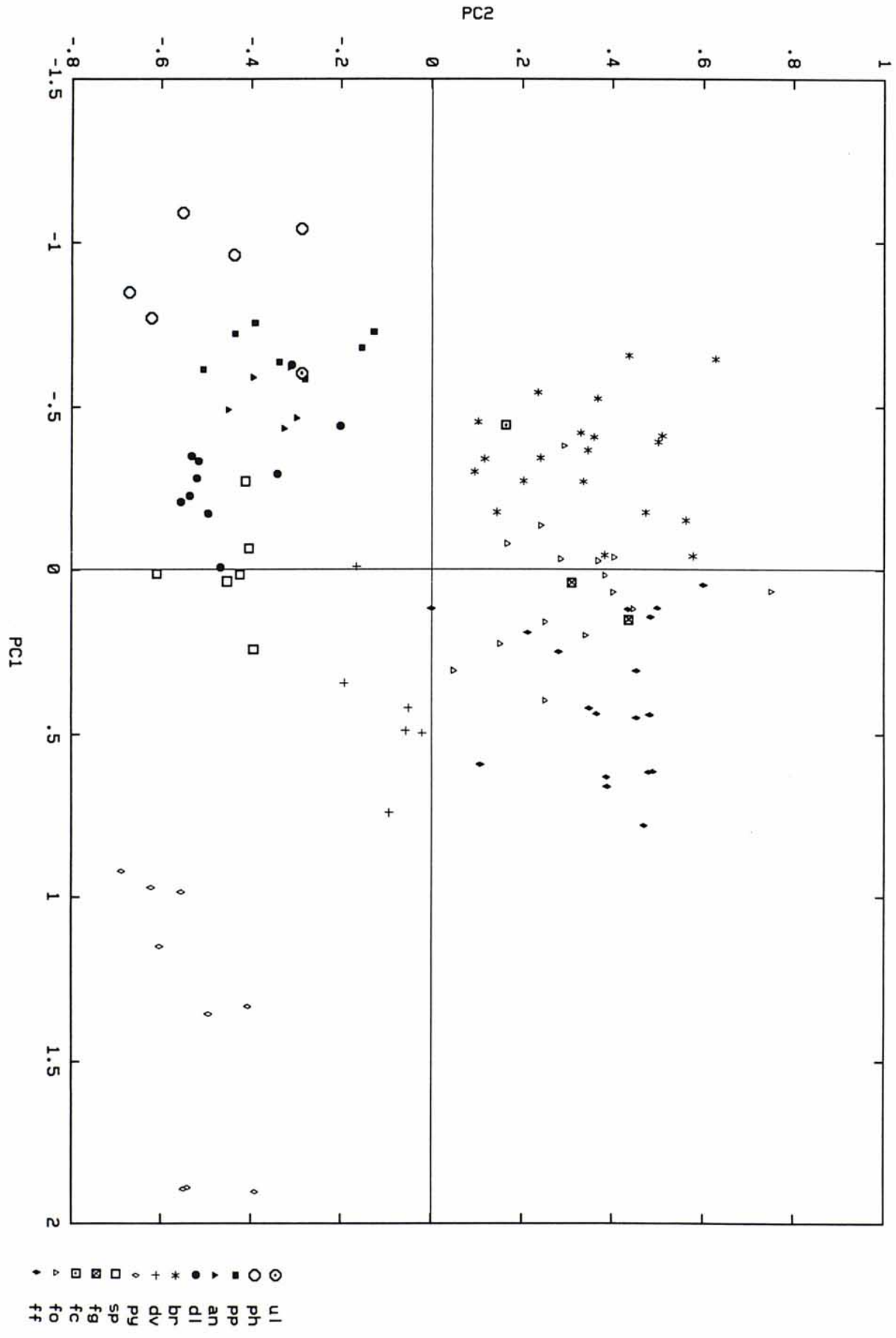


Fig. 9.—PCA analysis. Projections over axes 1 and 2 of 105 populations (OTU's).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

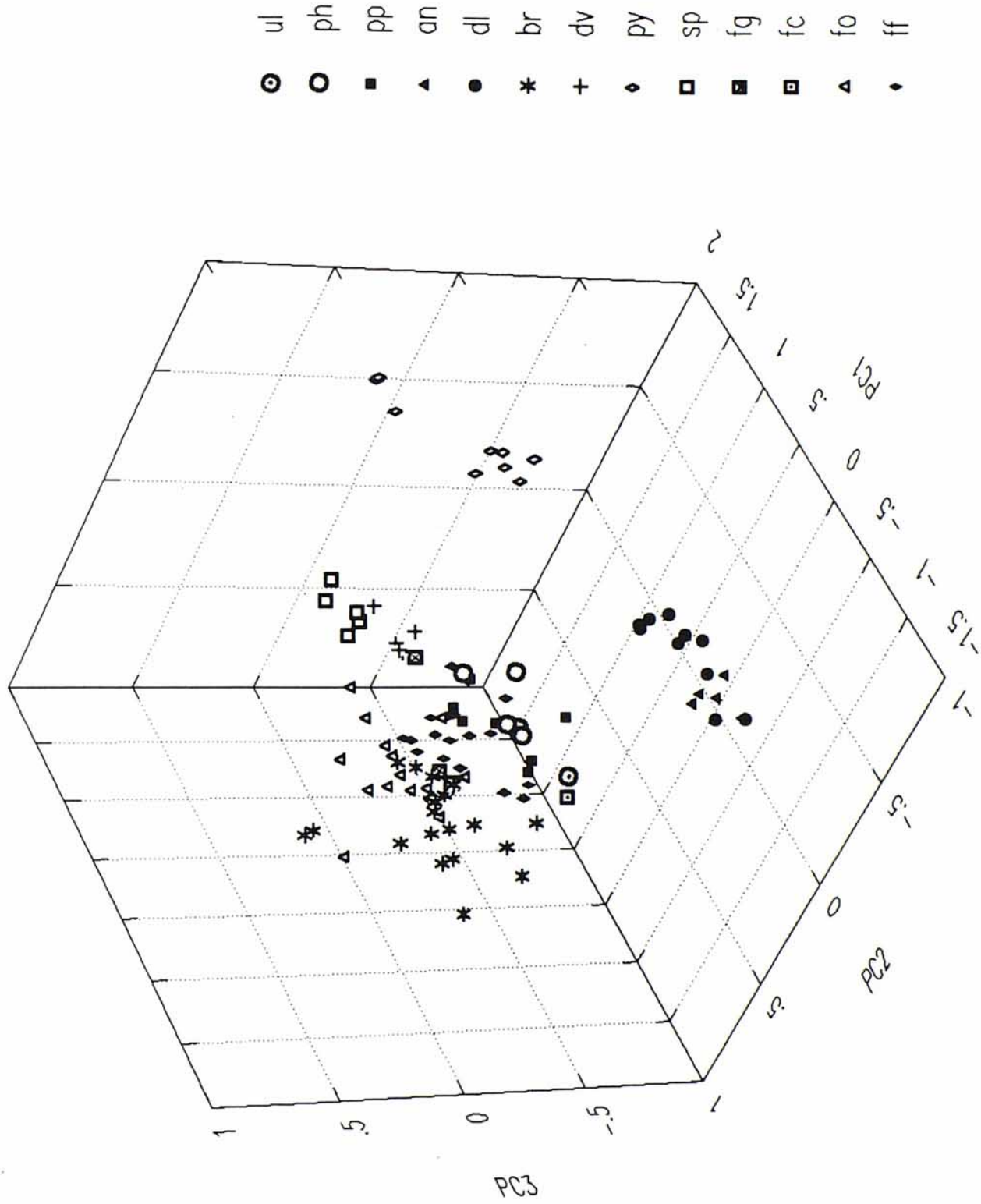


Fig. 10.—PCA analysis. Projections over axes 1, 2 and 3 of 105 populations (OTU's).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

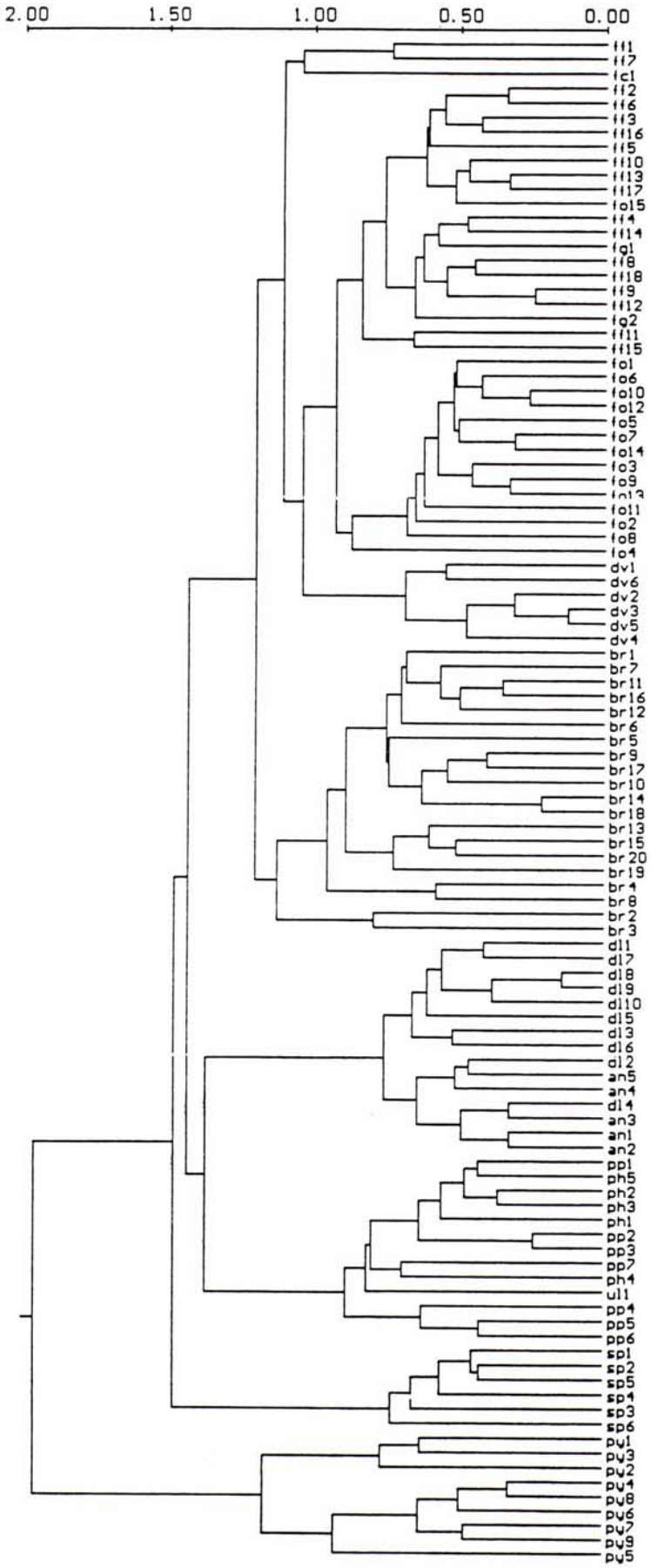


Fig. 11.–HCA dendrogram of 105 populations (OTU's) from capsule and seed characters (UPGMA method).

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

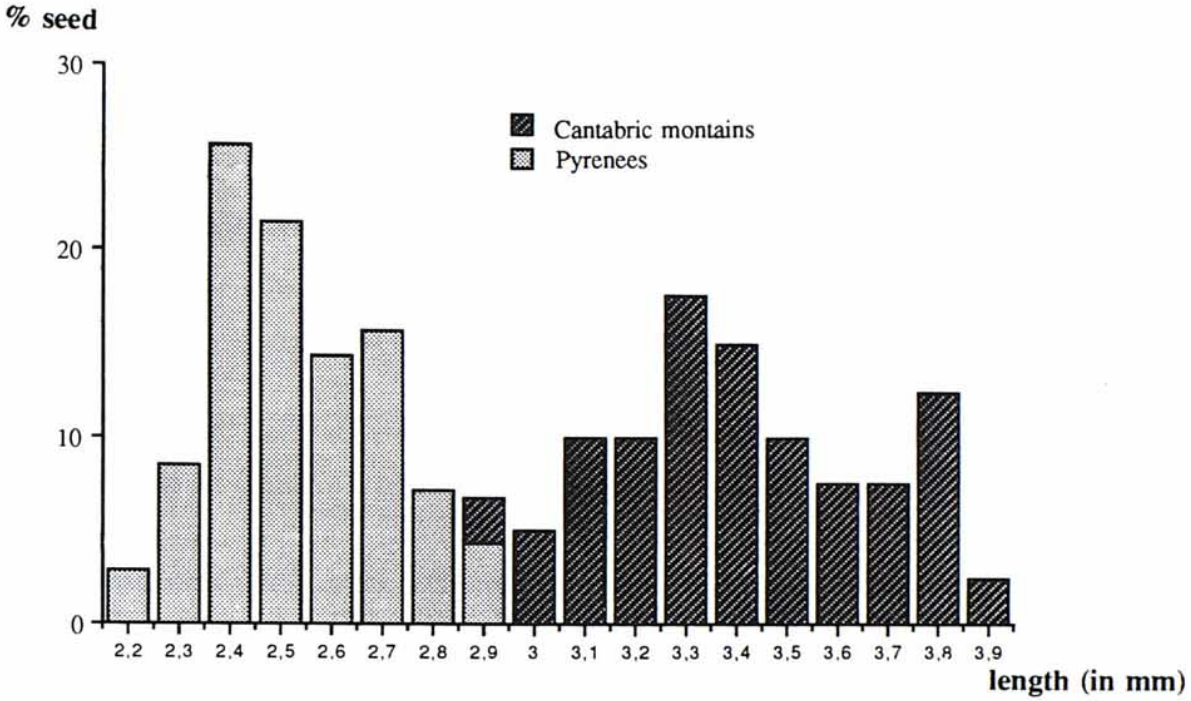


Fig. 12.–Frequency diagram of seed size of *Euphorbia pyrenaica* related to geographic distribution.

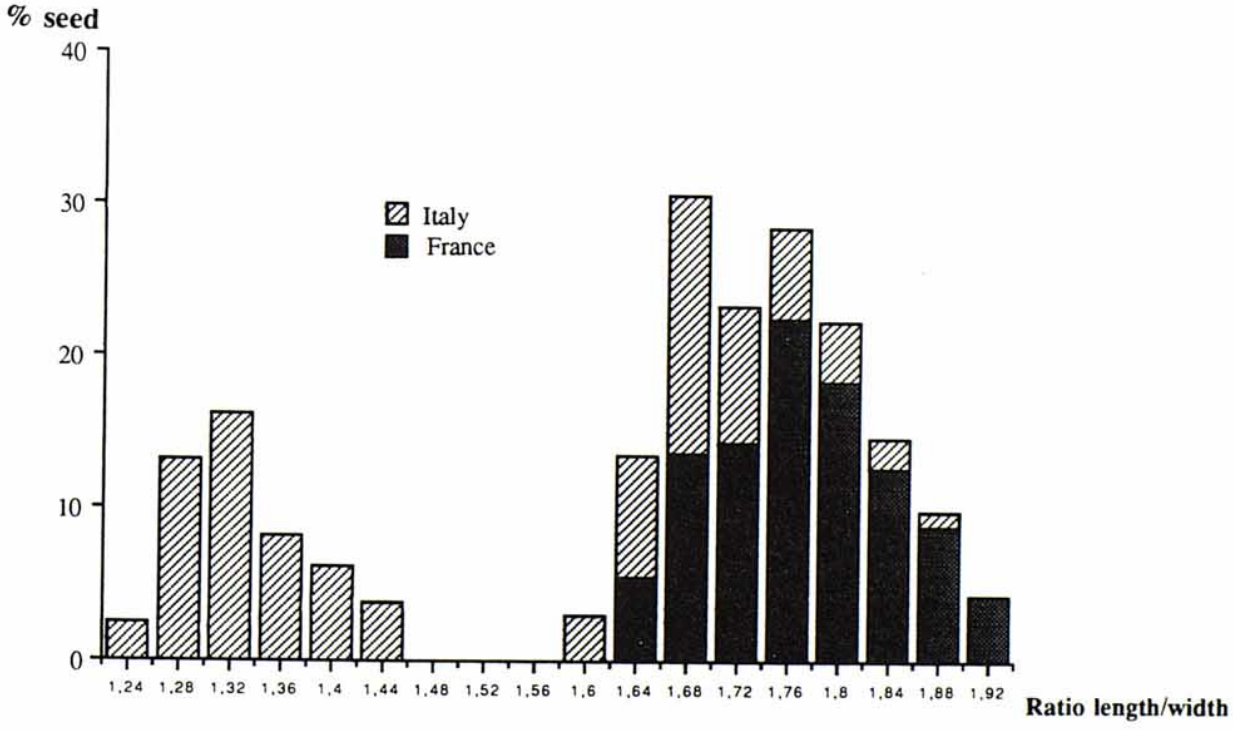


Fig. 13.–Frequency diagram of length/width ratio of seeds of *Euphorbia spinosa* related to geographic distribution.

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)

Literature cited

BAIGES, J.C. (1989). Estudi morfològic, anatòmic i de la dispersió de les granes de les espècies ibèrico-baleàriques del gènere *Euphorbia* L. Tesi de llicenciatura, Facultat de Farmàcia. Universitat de Barcelona, Barcelona.

BARTHLOTT, W. (1981). Epidermal and seed surface characters of plants: systematic applicability and some evolutionary aspects. Nord. J. Bot. 1 : 345-355.

BARTHLOTT, W. (1984). Microstructural features of seed surfaces In: V.H. Heywood & D.C. Moore (eds.), Current Concepts in Plant Taxonomy 25: 95-105. Systematic Association. Academic Press, Orlando.

BERG, R.Y. (1975). Fruit, seed and myrmecochorous dispersal in *Micrantheum* (Euphorbiaceae). Norw. J. Bot. 22: 173-194.

BOISSIER, E. (1862). *Euphorbieae. In*: A.P. de Candolle, Prodromus systematis naturalis regni vegetabilis 15(2): 3-188. Masson, Paris.

CARLQUIST, S. (1966). The biota of long-distance dispersal, III. Loss of dispersibility in the Hawaiian Flora. Brittonia 18: 310-335.

EHLER, N. (1976). Mikromorphologie der samenoberflächen der Gattung *Euphorbia*. Plant. Syst. Evol. 126: 189-207.

JEANMONOD, D. (1984). La spéciation: aspects divers et modèles recents. Candollea 39: 151-194.

KHAN, M.S. (1964). Taxonomic revision of *Euphorbia* in Turkey. Notes Roy. Bot. Gard. Edinburgh 25(2): 71-161.

ORELL, J.J. (1991). Taxonomía del género *Chamaesyce* S.F. Gray (Euphorbiaceae) en la Península Ibérica e islas Baleares. Tesis de licenciatura, Facultat de Farmàcia. Universitat de Barcelona, Barcelona.

PROKHANOV, Y.I. (1949). *Euphorbia* L. *In*: B.K. Shishkin & E.G. Bobrov (eds.), Flora ot the U.S.S.R. 14: 233-378. Izdatelstvo Akademii Nauk SSSR., Moskva & Leningrad. Translated from Russian, Israel Program for scientific translation, Jerusalem, 1974.

RADCLIFE-SMITH, A. (1982). *Euphorbia* L. *In*: P. Davis (ed.), Flora of Turkey and the East Aegean Islands. 7: 571-630. Edinburgh University Press, Edinburgh.

ROHLF, F.J. (1989). NTSYS-PC. Numerical taxonomy and multivariate analysis system. Exeter Publ. Ltd., New York.

ROTH, I. (1977). Fruits of Angiosperms. Berlin & Stuttgart.

SMITH, A.R. & T.G. TUTIN. (1968). *Euphorbia* L. *In*: T.G. Tutin & *al.* (eds.), Flora Europaea 2: 213-216. Cambridge University Press, Cambridge.

VINDT, J. (1960). Monographie des Euphorbiacées du Maroc. Trav. inst. sci. Chérifien, ser. bot. 19: 1-340.

(Received 6 july 1992, accepted 10 july 1992)

(c) Consejo Superior de Investigaciones Científicas http://collectaneabotanica.revistas.csic.es
Licencia Creative Commons 3.0 España (by-nc)