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A new species of the genus *Sarcocapnos* (*Fumariaceae*) from eastern Andalusia (Spain)

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Abstract: A biometric study of the *Sarcocapnos crassifolia* complex from eastern Andalusia (Spain), Algeria, and Morocco was carried out. Twentytwo populations were used in a principal components analysis based on 14 variables. The results support the recognition of two species, *S. crassifolia* and *S. pulcherrima*, spec. nova. The taxon described by Boissier as *S. speciosa* (*S. crassifolia* subsp. *speciosa*) is maintained in *S. crassifolia.*

Desfontaines (1798: 126) described *Fumaria crassifolia* from the mountains of Algeria (Tlemcen), and subsequently, De Candolle (1821: 129) created the genus *Sarcocapnos*, distributed in western Mediterranean areas. De Candolle (1821) included *Fumaria crassifolia* Desf. and *F. enneaphylla* L. in the genus *Sarcocapnos.* Boissier (1841: 18) alluded to specimens collected in the Sierra Nevada Mountains (Spain), which he designated as *S. crassifolia.* Later, Boissier (1853: 14) described a new species with the name *S. speciosa*, which he used to describe material from various locations in the southeastern part of the Iberian Peninsula. Lange (1880: 87) and Rouy (1884: 53) subordinated this species to *S. crassifolia*, the former as a variety and the latter as a subspecies. Lidén (1986 a, b) considered all material from the Iberian Peninsula to belong to *S. crassifolia* subsp. *speciosa* (Boiss) Rouy.

Upon comparing material from eastern Andalusia (Spain), we detected appreciable differences between populations from the siliceous central area of the Sierra Nevada and populations collected in adjacent limestone mountains in the same range as well as in other limestone mountain ranges in eastern Andalusia. The morphological features in populations from the central area of the Sierra Nevada Mountains approach the description of Boissier (1853: 14), whereas the characteristics of the remaining populations do not. This fact was noted by Boissier (1853) in referring to one of these populations: "Cerro de Jabalcon prope Baza (Bourgeau forma major et floribus intensibus roseis)". It should also be noted that the populations, this author was alluding to in his description of *S. speciosa*, were from the provinces of Jaén and Valencia, and were in fact *S. enneaphylla* (Lidén 1986 b: 435).

Clearly, Boissier designated as *S. speciosa* material from different taxa, and this has led to confusion between *S. crassifolia* and *S. speciosa.*

These observations led us to the conclusion that two groups of different populations exist in eastern Andalusia, one pertaining to the taxon described by BOISSIER as *S. speciosa* and the other yet to be described, or else corresponding to the northern African taxon. To clarify this matter, we compared material from Spain and northern Africa.

Material and methods

The specimens studied and the corresponding abbreviation of the populations are given in Table 1. Specimens with well-preserved flowers and leaves were used in the statistical analysis (DIXON & al. 1985). We used the P4M principal components analysis of FRANE & HILL

Table 1. *Sarcocapnos* material studied. Herbarium abbreviations after HOLMGREN & al.1990)

Sarcocapnos crassifolia subsp. *crassifolia*

Northern Africa: Algeria: Oran, Garrouban, 28.5.1856, E. BOURGEAU, G 7205 (2); AFR 3, Tlemcem, G 7205 (1); Tlemcem, 1856, COSSON, G 7205 (6); AFR 1, Tlemcem, 4.1849, BOISSIER, G 7205 (7); Tlemcem, 10.5.1914, CLAVÉ, G 7205 (8). Tlemcem, 5.1914, ALLEIZETTE, G 7205 (9); AFR 2, Tlemcem, 5.1855, MUMBY, G 7205 (11); Tlemcem, 4.1889, BATTANDIER & TRABUT, G 7205 (12); Tlemcem, Warion, 15.6.1874, G 7205 (16), G 7205 (17).

Morocco: AFR 4, Asni, Haute Atlas, 18.4.1921, WILCZEK, G 7205 (4); AFR 5, Itzer, Moyen Atlas, Vallé del'Oued Bon Halfs 2 000 m, 5.5.1925, JAHANDIER, G 7205 (5); AFR 7, Timhadit, Moyen Atlas 1 900 m, 18.4.1926, WILCZEK, G 7205 (14); AFR 6, Timhadit, Moyen Atlas 1 850 m, 17.7.1924, JAHANDIER, G 7205 (15).

Sarcocapnos crassifolia subsp. *speciosa*

Spain: Sierra Nevada: Granada, SNE 3, La Calahorra, subida al Puerto de la Ragua, 5.1976, GIL, GDAC 3792; SNE 4, Laroles, subida al Puerto de la Ragua, 1 750 m, 29.5.1976, MOLERO MESA, GDA 7050; (idem) 18.6.1984, GUIRADO, GDAC 22872; SNE 1, Paterna, 26.1.1984, GUIRADO & MOTA, GDAC 18680; SNE 2, (idem), 26.1.1984, MENDOZA, GDAC 22873; SNE 5, Trevelez 1 450 m, 10.6.1980, MOLERO MESA, GDA 10734; SNE 6, Hoya del Fuerte, 2 000 m, 17.6.1957, PRIETO, GDA.

Sarcocapnos pulcherrima

Spain: Limestone mountains of **eastern Andalusia:** Granada, AND 6, Alhama de Granada, Los Tajos 800 m, 14.4.1985, ROMERO-GARCÍA, GDAC 22852; AND 7, Alhama de Granada, camino del Balneario 800 m, 8.4.1980, MARTÍNEZ PARRA, GDA 20813; Alhama de Granada, pantano de los Bermejales, 14.4.1985, ROMERO-GARCÍA, GDAC 22854; Baza, cerro Jabalcon, 28.5.1851, BOISSIER, G 7205 (24); Cogollos Vega, Sierra de Harana, Peñón de la Mata, 1 500 m, 22.5.1988, SOCORRO & al., GDA 21624; Güejar Sierra, Sierra Nevada, 7.1837, BOISSIER, G 7205 (26), (27); Loja, Sierra de Loja, Cruz de Periquete, 14.2.1985, MENDOZA & al., GDAC 22874; 1 000 m, 15.5.1978, MARÍN & al., GDAC 5034, 5035; AND 4, Moclin, Castillo de Moclín, 8.1.1984, MORALES TORRES, GDAC 22851; AND 5, (idem), 16.4.1985, MENDOZA & al., GDAC 22850; AND 8, Monachil, Los Cahorros, 3.6.1989, DE LA ROSA & VIZOSO, GDAC; Nigüelas, Sierra del Manar 1 650 m, Rupérez, GDAC; Pinos Genil, Canales, 19.4.1851, BOISSIER, G 7205 (23); (idem), 20.5.1852, BOISSIER, G 7205 (25); (idem), 11.3.1944, MUÑOZ MEDINA, GDA; AND 9, (idem), 4.1950, MUÑOZ MEDINA, GDA; (Idem), 15.5.1970, MORALES TORRES, GDAC 521; AND 3; Quentar, 18.5.1980, ROMERO GARCÍA & SÁNCHEZ CASTILLO, GDAC 9472. Jaén, AND 2, Huelma, Sierra de Mágina, 31.5.1977, VARO & al., GDAC 4508, 4809; AND 1, Fuensanta de Martos, 800 m, 8.5.1988, BLANCA, GDAC 28030.

(1976). As the populations consisted of few specimens, the data were based on three to six specimens per population. We examined the 14 morphological characters presented in Table 2 and Fig. 1.

The characters used were those which showed variation between the different taxa. We disregarded characters relating to stamens, gynoecium, pollen and others which were similar among all taxa. We were unable to use fruit characters, as they were present only sporadically among the samples analyzed, and were rarely present in material from northern Africa. Upper leaves were those from the upper third of the stem, and lower leaves were those from the lower third.

The principal components analysis was carried out in a correlation matrix with the parameters measured and the populations. The data were mean values of each parameter per population (Table 3), with the exception of FS, SH, and CN, for which the shape or texture of the leaves predominating in 50% of the population was considered the mean value.

Results

The principal components analysis detected four factors with significant loading (Table 4). The first three factors were used to plot Fig. 2, in which the positive side of the abscissa (first factor) represented distal width of the upper petal (WP = 0.92), leaf texture (CN = 0.91), width of the leaflets of the lower leaves

Table 2. Characters used in the principal components analysis of the *Sarcocapnos crassifolia* species complex

Length of leaflets of lower leaves (mm)	LL
Width of leaflets of lower leaves (mm)	WL
Length of leaflets of upper leaves (mm)	LU
Width of leaflets of upper leaves (mm)	WU
Leaflet shape (1 = ovate, 2 = orbicular, 3 = reniform, 4 = oval)	FS
Leaf texture (1 = not thick, 2 = thick, 3 = very thick)	CN
Number of leaflets in lowers leaves	FL
Number of leaflets in upper leaves	FU
Corolla size (mm)	CS
Distal width of upper petal (mm)	WP
Spur size (mm)	SS
Sepal length (mm)	SL
Sepal width (mm)	SW
Sepal shape (1 = deltoid, 2 = ovate)	SH

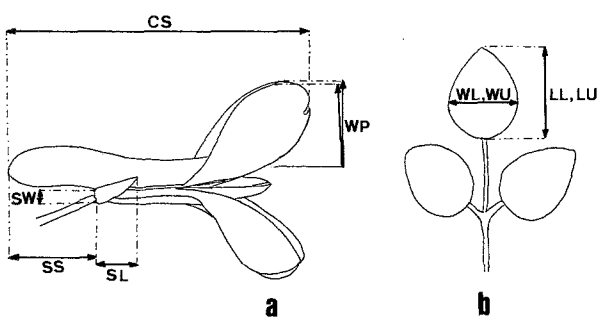

Fig. 1. Biometric data for *Sarcocapnos* flowers (a) and leaves (b)

Table 3. Mean values and variation of the characters analyzed in 22 *Sarcocapnos* populations. *AND* Populations from eastern Andalusia excluding siliceous area of the Sierra Nevada Mountains. *SNE* Populations from the siliceous area of the Sierra Nevada Mountains. *AFR* Populations from northern Africa. For character abbreviations see Table 2

Populations	LL	WL	LU	WU	FS	CN	FL	FU	WP	CS	SS	SL	SW	SH
AND 1	14.0±1.5	10.5±1.0	4.5±0.5	5.0±2.1	(1−)2(−3)	2	3±0	6.5±0.5	10.0±1.1	18.0±0.9	3.1±0.1	2.6±0.1	1.0±0.1	1
AND 2	15.0±2.1	14.0±1.0	7.5±0.5	3.5±0.5	(1−2−) 4	2	3±0	3.0±0.0	11.0±1.3	15.5±1.6	2.5±0.5	2.4±0.4	1.1±0.1	1
AND 3	9.5±1.6	10.0±1.1	5.0±1.0	6.0±1.0	2(−3)	2	3±0	4.0±1.0	11.5±1.1	19.0±1.0	3.5±0.5	2.3±0.2	1.0±0.1	1
AND 4	9.5±1.5	12.0±1.0	4.5±0.5	4.5±0.5	2	3	3±0	3.5±0.5	10.0±1.1	17.5±0.5	3.0±0.2	2.9±0.1	1.2±0.1	1
AND 5	8.0±1.0	10.0±1.0	6.0±1.0	7.0±1.0	2(−3)	2	3±0	4.0±1.0	10.0±1.4	17.0±1.0	3.3±0.3	3.3±0.3	1.3±0.3	1
AND 6	12.0±1.0	11.5±1.6	6.0±1.0	5.0±1.0	1(−2−3)	3	3±0	3.0±0.0	10.0±1.1	17.0±2.0	3.5±0.5	3.3±0.2	1.4±0.3	1
AND 7	11.0±1.0	10.0±1.0	5.0±0.5	4.0±1.0	1	2	3±0	3.0±0.0	10.0±1.0	17.5±0.5	3.0±0.5	2.6±0.1	1.5±0.1	1
AND 8	12.0±1.0	14.0±1.5	13.0±1.5	17.5±0.5	(1−2−) 3	2	3±0	5.0±0.0	7.0±1.0	16.5±0.5	4.0±0.5	2.4±0.1	1.5±0.1	1
AND 9	17.0±2.0	15.0±1.0	10.0±1.0	8.0±0.5	1	3	1±0	4.0±0.0	12.0±1.0	17.0±1.0	4.0±0.5	2.9±0.1	1.8±0.1	1
SNE 1	6.5±1.6	7.0±2.0	3.5±0.6	3.5±0.5	1(−3)	1	3±0	4.0±1.0	5.0±1.6	16.0±1.2	3.0±0.5	1.5±0.1	1.0±0.1	2
SNE 2	6.0±1.0	6.5±0.5	5.0±1.9	5.0±2.0	1(−3)	1	3±0	4.0±1.0	7.0±0.9	16.0±1.2	3.0±0.2	1.5±0.1	1.0±0.1	2
SNE 3	9.0±1.0	7.0±1.0	6.0±1.0	6.0±1.0	1(−2)	1	3±0	4.0±1.0	6.0±1.3	15.0±1.6	4.0±0.6	2.0±0.1	1.5±0.5	2
SNE 4	7.5±0.6	8.0±2.3	5.0±2.1	4.5±1.6	1(−2)	1	3±0	3.5±0.5	8.0±0.7	16.0±0.9	3.0±0.3	1.5±0.1	1.0±0.1	2
SNE 5	5.7±1.3	6.0±1.0	6.7±1.0	6.8±1.2	1(−4)	1	3±0	4.0±1.0	6.0±1.1	14.3±0.3	3.0±0.3	1.6±0.1	1.0±0.1	2
SNE 6	8.0±1.0	9.5±1.5	4.5±1.6	4.5±1.3	(1−)2(−3)	1	3±0	5.0±2.0	7.0±1.0	15.0±0.2	3.5±0.5	1.6±0.1	1.0±0.1	2
AFR 1	7.5±1.0	7.5±0.5	7.0±1.0	5.5±0.5	1(−2)	1	3±0	3.0±0.0	5.5±0.5	14.5±0.5	3.8±0.2	1.5±0.1	1.0±0.1	2
AFR 2	10.0±1.6	8.0±1.0	5.5±1.5	3.8±1.7	1(−2−3)	2	2±1	2.0±1.0	5.0±1.0	13.0±1.0	2.8±0.3	1.7±0.1	1.0±0.1	2
AFR 3	8.0±1.0	7.5±0.5	6.5±0.5	4.5±0.5	1	1	3±1	3.0±0.0	5.0±1.0	13.0±1.0	2.8±0.5	1.9±0.1	1.0±0.1	2
AFR 4	8.5±1.5	9.0±2.0	5.0±1.5	4.0±1.0	1(−2)	1	3±1	3.5±0.5	5.8±0.2	14.0±1.0	2.8±0.2	1.9±0.2	1.0±0.1	2
AFR 5	9.0±1.0	8.5±1.5	5.0±1.0	5.0±1.0	1(−3)	1	3±1	3.0±1.0	5.0±1.0	12.5±0.5	2.8±0.1	1.8±0.2	1.1±0.1	2
AFR 6	9.0±2.0	9.0±2.0	6.0±1.0	4.5±0.5	1	1	2±1	3.0±0.5	5.5±0.5	13.5±0.5	3.0±0.1	2.0±0.1	1.1±0.1	2
AFR 7	8.5±0.5	8.5±0.5	5.5±0.5	4.0±1.0	1	1	1±1	2.0±1.0	6.0±1.0	14.5±1.5	3.3±0.2	1.1±0.1	1.0±0.1	2

Table 4. Loading of the variables on the four factors obtained in the principal components analysis of the *Sarcocapnos crassifolia* species complex. For character abbreviations see Table 2

Characters	No.	Factor 1	Factor 2	Factor 3	Factor 4
LL	1	0.82	0.27	0.09	−0.20
WL	2	0.87	0.41	0.09	−0.05
LU	3	0.26	0.82	0.42	−0.10
WU	4	0.14	0.73	0.55	0.26
FS	5	0.53	0.53	−0.39	0.37
CN	6	0.91	−0.01	0.15	−0.12
FL	7	−0.13	−0.06	−0.26	0.81
FU	8	0.16	0.05	0.34	0.78
WP	9	0.92	−0.21	0.11	0.12
CS	10	0.55	−0.77	0.08	0.17
SS	11	0.12	0.17	0.90	0.06
SL	12	0.86	−0.04	0.19	0.15
SW	13	0.55	0.15	0.65	−0.21
SH	14	−0.94	−0.06	−0.13	−0.19

(WL = 0.87), sepal length (SL = 0.86) and length of the leaflets of the lower leaves (LL = 0.82). In contrast, the negative side of the abscissa comprised sepal shape (SH = −0.94). The positive side of the ordinate (second factor) was defined by length of the leaflets of the upper leaves (LU = 0.82), and the negative side represented corolla size (CS = −0.77). The third factor (z-axis) was defined by spur size (SS = 0.90), and a fourth factor, not shown in the PCA plot (Fig. 2), comprised the number of leaflets per lower (FL = 0.81) and upper leaf (FU = 0.78).

The results (Fig. 2) make it possible to distinguish two groups of populations, (AND 1 − AND 9) and (SNE 1 − AFR 7), on the basis of the dominant factors, i.e. sepal shape (Fig. 3), distal width of the upper petal, and other characters mentioned above. The second group contained two less well-defined subgroups, (SNE 1 − SNE 4, SNE 6), located on the negative side, and (SNE 5, AFR 1 − AFR 7), located on the positive side of the ordinate. Both subgroups are distinguishable mainly by mean size of the corolla, which is greater than 15 mm in the former and less than 15 mm in the latter (Table 3).

Discussion

Groups of populations became evident upon plotting the results of the principal components analysis (Fig. 2). The first group (populations AND 1 − AND 9), located in the positive side of the abscissa, represents populations from limestone mountains in eastern Andalusia. These specimens have clearly distinct characterstics in comparison to other populations, e.g., larger overall size, larger and thicker leaflets, larger, pink-coloured flowers with a longer corolla, wider distal petal, and deltoid sepals measuring more than 2 mm in mean length (Table 3). This group is nevertheless highly variable in certain characters, including morphology, size, number of leaflets and leaf texture.

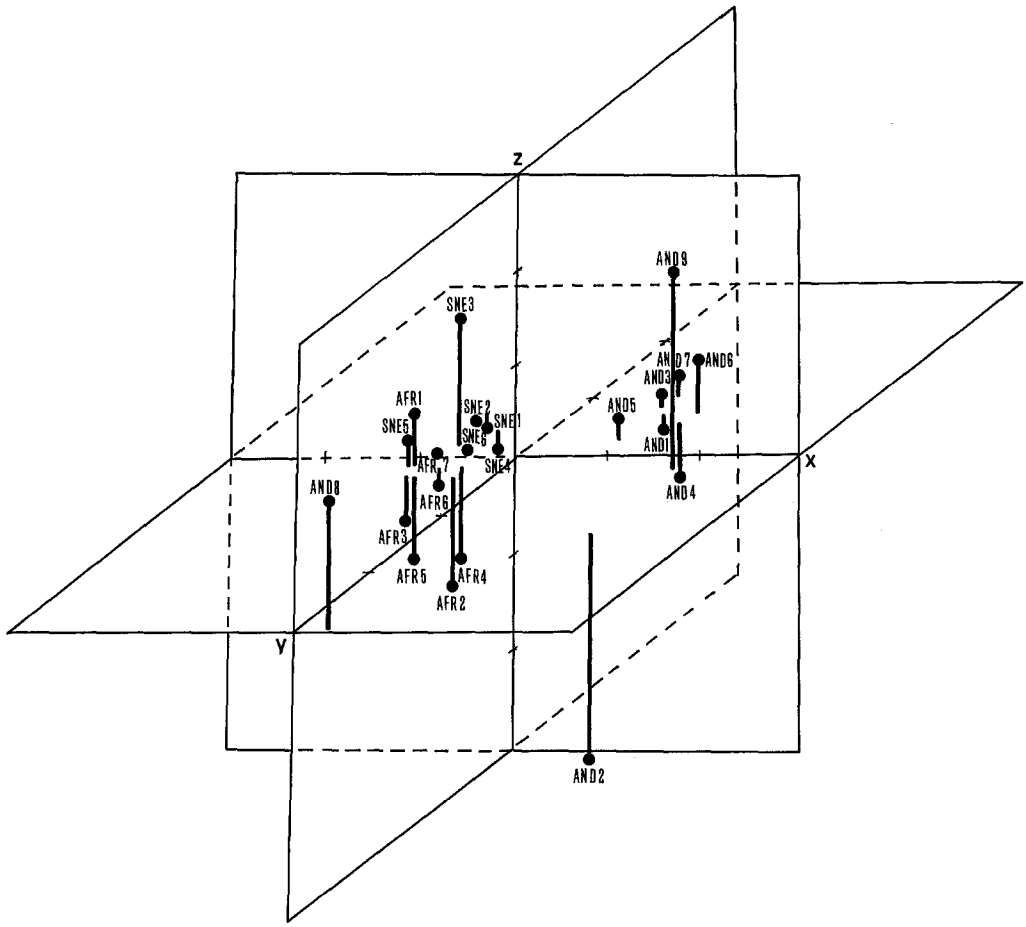

Fig. 2. Principal components analysis of the 22 populations studied with on the three axes (x, y, and z) representing the first three factors obtained from PCA. *AND* Populations from eastern Andalusia excluding siliceous area of the Sierra Nevada Mountains. *SNE* Populations from the siliceous area of the Sierra Nevada Mountains. *AFR* Populations from northern Africa

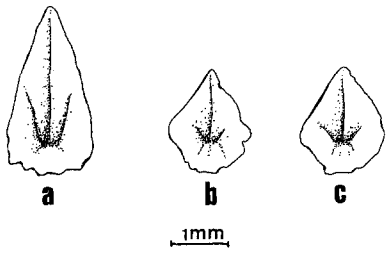

Fig. 3. *Sarcocapnos* sepal morphology. *a* Deltoid; AND populations. *b* Ovate; SNE populations. *c* Ovate; AFR populations

We should note that within the AND 1 – AND 9 group, AND 8 differs somewhat from the other populations due to the greater mean length of the leaflets of the upper leaves (Table 3), and thus lies in the positive side of the ordinate defined by

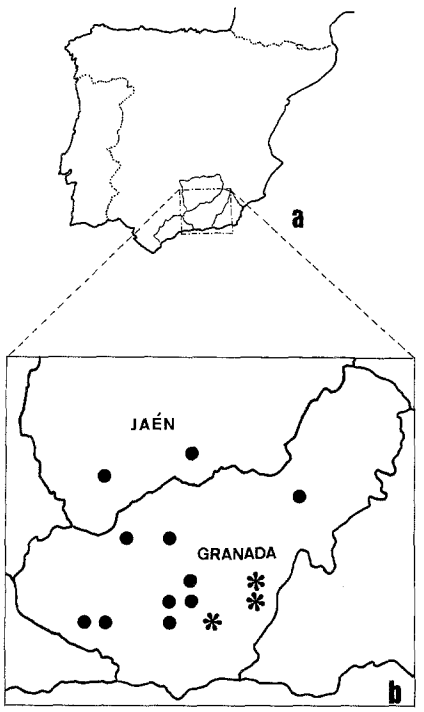

Fig. 4. *a* Map of the Iberian Peninsula. *b* Detail of the distribution area of Iberian populations of the *Sarcopapnos crassifolia* complex. ● *S. pulcherrima.* * *S. crassifolia* subsp. *speciosa*

this parameter (LU). This difference may reflect microclimatic conditions in the area inhabited by this population, characterized by greater humidity.

The AND 2 population differs because of the smaller mean flower size and reduced mean spur length (Table 3, SS, AND 2) in comparison with the other populations. Hence, this population lies closer to the negative side of the z-axis defined by the SS parameter.

The second group (SNE 1 – AFR 7) can be further divided into two subgroups based on geographical distribution. SN 1 – SN 6 represent the central area of the Sierra Nevada Mountain populations, whereas AFR 1 – AFR 7 correspond to populations from northern Africa.

However, it is more difficult on the basis of morphological features to distinguish these two subgroups, as some populations from both show intermediate characters. The most relevant feature is corolla size (CS), which is less than 15 mm in all African populations (AFR 1 – AFR 7). Corolla size in the SN 5 population, in contrast to the other Sierra Nevada populations shows a mean value of 14.3 mm (Table 3), similar to that of the African subgroup. Although variable, distal width of the upper petal (WS) tends to be higher in populations from the Sierra Nevada Mountains than from African populations. Spur size (SS) is smaller in African populations, with the exception of AFR 1, which consequently is located in the positive zone of the ordinate.

More noteworthy are the characters relating to the number of leaflets per leaf. In Sierra Nevada populations, 3 is the most common number of leaflets on lower leaves, whereas in African populations this number varied between 1 and 3. On upper leaves, more than 3 leaflets are usually found, in contrast to lower mean numbers in African populations.

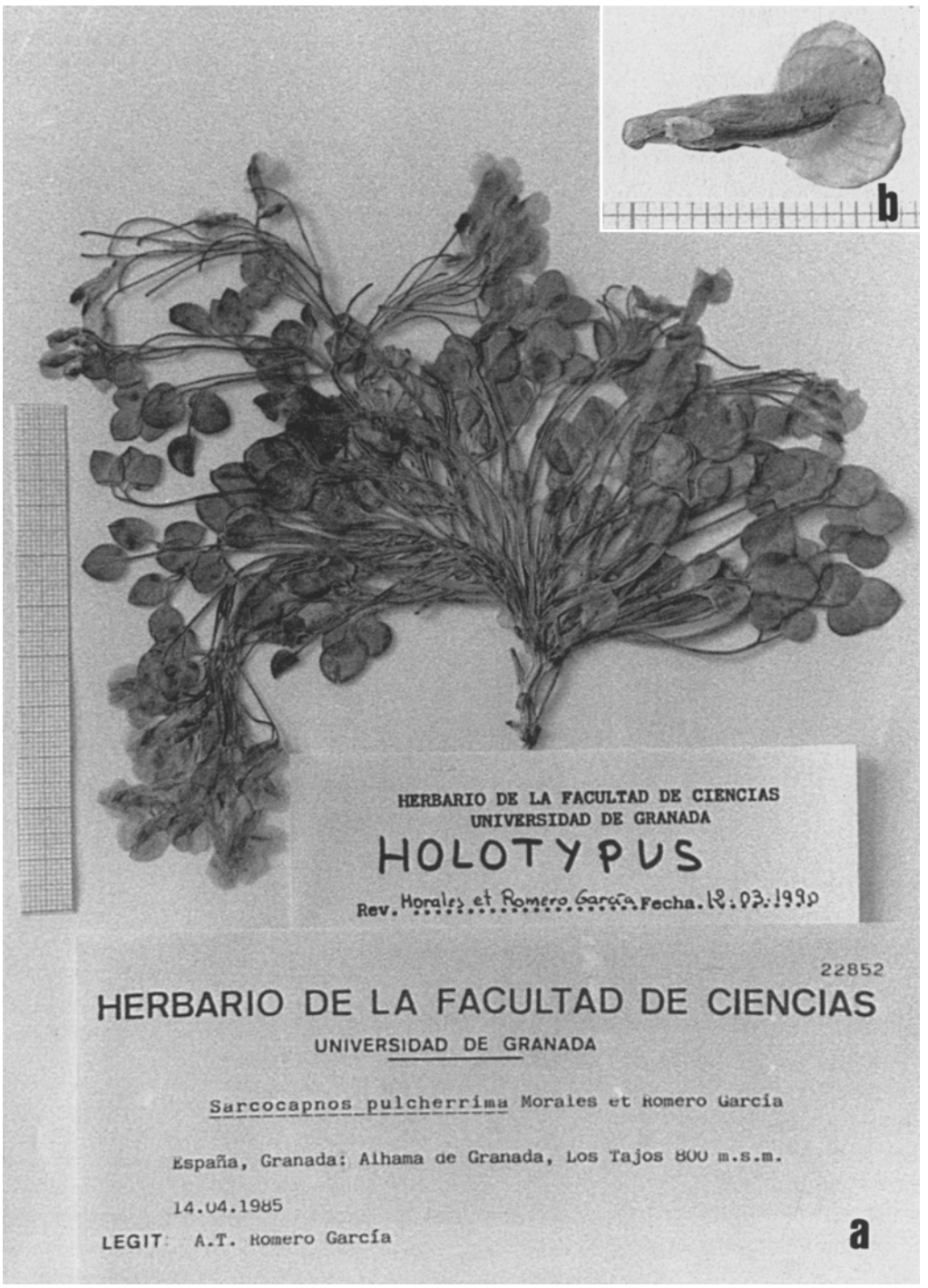

Fig. 5. Holotype of *Sarcocapnos pulcherrima. a* Habit. *b* Detail of flower

This analysis supports the hypothesis given in the introduction, and shows that populations from limestone mountains in eastern Andalusia. This latter group is designated as a new species (Figs. 3 and 4), while the former two are classified as subspecies.

Conclusions

Based on the results of the principal components analysis of the *Sarcocapnos crassifolia* complex, three taxa can be distinguished: *S. crassifolia* (DESF.) DC. subsp. *crassifolia*, restricted to northern Africa, *S. crassifolia* subsp. *speciosa* (BOISS.) ROUY, from the central area of the Sierra Nevada Mountains (Granada, Spain), and *S. pulcherrima*, spec. nova, for the limestone mountains of eastern Andalusia (Spain).

Sarcocapnos pulcherrima MORALES et ROMERO-GARCÍA, spec. nova (Fig. 5)

Planta perennis, robusta, caespitosa, basi caulis ligneis. Folia virido-glauca, crassa vel crassissima; basalia (1−)3 foliolis, (7−)9−15(−19) × (9−)10−14(−16) mm, superiora 3−5(−7) foliolis, 4−8(−15) × (3−)4−17(−18) mm; foliola variabili forma, abundanter orbicularia, interdum reniformia, obovata vel elliptica. Flores rosacei, magni, (14−)16−18(−21) mm longi, fasciculos grandes formantes corymbosos laxos, superiore petalum ala lata, et distale incisa, (7−)9−12 mm, calcar 3−4 mm. Sepala (2−)2.3−3.3(−3.5) × (1−)1.3−1.8 mm generatim deltoidea. Fructus 4−6 × 2−2.5 mm costis lateralibus latitudine marginem aequantibus. Habitat: ad rupes et scopulos calcareos, moderate nitrificatos, circa 800−1 200 m s.m.

Holotypus: in GDAC 22852. Hispania: Granada: Alhama de Granada, Los Tajos, 800 m s.m., 14. 4. 1985, leg. A. T. ROMERO-GARCÍA.

Robust, perennial, caespitose herb, with base of the stem woody. Thick or very thick glaucous green leaves; basal leaves with (1−)3 leaflets (7−)9−15(−19) × (9−)10−14(−16) mm, upper leaves with 3−5(−7) leaflets, 4−8(−15) × (3−)4−17(18) mm; leaflets of variable shape, predominantly orbicular, occasionally reniform-ovate. Large, loose, corymbose clusters of pink flowers, (14−)16−18(−21) mm long, upper petal with a wide, distally notched (7−)9−12 mm long wing, spur 3−4 mm long. Sepals (2−)2.3−3.3(−3.5) × (1−)1.5−1.8 mm, generally deltoid. Fruit 4−6 × 2−2.5 mm, with lateral ribs of the same width as the margin. Habitat: Clayey or rocky cliffs on moderately nitrified limestone substrates, from 800 to 1 200 m.

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