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Taxonomic revision of the genus *Calendula* (Asteraceae) in Morocco, including taxa from Algeria and Tunisia

A taxonomic revision of *Calendula* (Asteraceae) in Morocco, including some taxa from Algeria and Tunisia

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Abstract

This study examines morphological patterns within *Calendula* (Asteraceae) from Morocco, including some taxa from Algeria and Tunisia. This genus was inadequately studied in this territory, particularly the perennial plants with $2n = 32$ (classically included under *C. suffruticosa* and *C. incana*), whose specimens held in the herbaria generally lacked achenes, essential for proper classification/identification. Principal components analyses allowed us to reassess the classification, relationships, distribution and evolution of *Calendula* taxa, which was further supported by chromosome numbers and genome size estimations. Morphometric analyses among and between *C. maroccana* and *C. suffruticosa* groups found that the major delimiting characters were the achene's morphology. A taxonomic treatment for SW Mediterranean region (Morocco, Algeria and Tunisia) taxa is presented, based on field and herbarium specimens. Three new species and seven new subspecies of *C. suffruticosa* were described. Identification keys full generic descriptions, complete nomenclature including typification and notes on distribution and habitat, are also provided for this complex genus.

Introduction

The genus *Calendula* Linnaeus (1753: 921) is widely distributed in the Mediterranean region, occurring from Macaronesia throughout most of the north African countries, south of Europe and Middle East regions (Heyn et al. 1974; Nordenstam 2007; Nordenstam & Källersjö 2009; Norlindh 1946, 1977). However, most species are restricted to the SW Mediterranean region, the main centre of the evolution of the genus (Norlindh 1977). One widespread (*C. arvensis* Linnaeus (1763: 1303)) and another cultivated (*C. officinalis* Linnaeus (1753: 921)) species are found in other parts of the world. A brief history of the generic delimitation of the genus can be found in Norlindh (1946: 1977).

Calendula is one of the most challenging and least-known genus within the family Asteraceae, whose complexity derives from frequent hybridisation, and polyploidisation (Heyn and Joel 1983; Nora et al. 2013; Plume 2015), unusual diversity of fruits – heterocarpy (Heyn and Joel 1983; Ruíz De Clavijo 2005) and its intricate heredity (Heyn and Joel 1983). The achenes produced differ not only in types of morphology (morphs) but also in respect to dispersal mechanisms (Ruíz De Clavijo 2005). These variations lead

to uncertainty in species classification and determination. Consequently, many species have been described within what should be one single taxon, including a wide spectrum of forms and their intermediates (Heyn and Joel 1983). For example, up to 46 names related to *C. arvensis* have been published, many of which misapplied in other taxa, like *C. tripterocarpa* Ruprecht (1856: 231) or *C. stellata* Cavanilles (1791: 3).

As presently redefined, *Calendula* is a genus of 16 species, usually annual or perennial herbs, characterised by having sessile leaves, arranged alternately, capitula solitary with internal tubular yellow, orange, brown or violet-purple flowers, functionally male and external yellow or orange ligulate female flowers and by its heteromorphic achenes, pappus absent (Nordenstam 2007; Gonçalves et al. 2014). According to Heyn et al. (1974), the annuals comprised five species: *C. stellata*, *C. tripterocarpa*, *C. arvensis*, *C. palaestina* Boissier (1849: 10), and *C. pachysperma* Zohary (1941: 172). The annual *C. lanzae* Maire (Maire 1928a: 138), which is from Morocco, was not included. While the perennials are grouped into: (1) *C. maroccana* (Ball) B.D. Jackson (1893: 383) group; (2) *C. suffruticosa* Vahl (1791: 94) and *C. incana* Willdenow (1803: 2341) group; and (3) the cultivated *C. officinalis* (Ohle 1974: 1975 a; b). Ohle (1974, 1975 a; b) recognised 24 perennial taxa, among these groups, most of them based on leaves' shape and thickness. Meikle's (1976) treatment included both, annual and perennial taxa, but only for the European flora. This author recognised few infraspecific taxa under *C. suffruticosa*, neglecting Ohle's work. However, the variability of the genus is greater than what was described by these authors. Gonçalves et al. (in press) took a deeper view into the genus and recognised the importance of some morphological characters, especially the variation of achene morphology and its combinations. Furthermore, new data obtained by means of fieldwork in the study area lead to a reassessment of the classification of the genus. A brief taxonomic history and the criteria used for the taxonomic treatment and characters were discussed in Gonçalves et al. (in press).

Prior taxonomic works on Calendula from North Africa

Since the description of the genus by Linnaeus (1753), *Calendula* was known only in Europe. Considering that the species of *Calendula* occur in the Mediterranean region and its immediate vicinities, soon it became the object of study by many botanists. Among which, works made by Candolle (1838), Boissier (1839, 1849, 1859, 1875), Boissier &

Reuter (1852), Cosson (1856, 1882), Cosson & Kralik (1857) or Battandier (1890, 1902, 1910, 1919, 1921) contributed greatly to the knowledge of the genus. Our intention in this section is not to describe in detail all works on *Calendula*, especially since excellent reviews exist (Lanza 1919; Ohle 1974; 1975 a; b; Gonçalves et al. 2017), but just to highlight here some significant/critical points for the discussion, concerning the study area.

The first species described for the north Africa was *C. suffruticosa* Vahl (1791)[1] from Tunisia. Since its description, the typical appearance of the real *C. suffruticosa* has been discussed quite intensively. Several authors mentioned its presence in other Mediterranean regions, e.g. Candolle (1837) reported the taxon for Portugal or Boissier (1839) for southern Spain. It was also misapplied in Moroccan taxa ('*C. suffruticosa* subsp. *C. maroccana*' Ball (1873: 367)). Only much later, Ohle (1975b) has considered that the range of the typical *C. suffruticosa* was limited to the coast of the Gulf of Tunis, in Tunisia.

For a long time, the morphology of the achenes went disregarded by many authors. Ball (1878) was the first to recognise *C. maroccana* as a distinct taxon based on the achenes, but originally it was described as '*C. suffruticosa* subsp. *C. maroccana*' Ball (1873: 367). This author used the first diagnosis to confirm it. Nevertheless, the name '*C. maroccana* (Ball) B.D. Jackson (1893: 383)' has been preserved as a new combination, which has generated some confusion. However, Jackson (1893: 383) only included the taxon in the Index Kewensis referring to Ball's works. Apart from the authorship of *C. maroccana*, for a long time, many of the SW Mediterranean taxa remain recognised under *C. suffruticosa* (Ohle 1975a). The segregation of these taxa was made by Ohle (1975a), a German botanist who worked with perennial taxa. Ohle (1974: 1975 a; b) compared morphology (e.g. growth habit, leaves, capitula, achenes, pollen), cytology and distribution in his revision. As mentioned, Ohle divided the genus into groups, the first group *C. maroccana* included four species, with $2n = 18$, diploid, all of them from Morocco; the second group included *C. incana* and *C. suffruticosa*, both with $2n = 32$, tetraploid, mainly distributed in the SW Mediterranean coast, and the cultivated *C. officinalis*, also with $2n = 32$. However, this classification has been questioned, since some species have the same/identical chromosome number and a gradual transition in

[1] Both, *C. stellata* and *C. suffruticosa* were described in 1791, but the origin of *C. stellata* is uncertain ('*Plant grow from seeds*' maybe from north Africa).

genome size (Nora et al. 2013). Silveira et al. (2013), proposed to include all *C. incana* under *C. suffruticosa* taxa because these groups are artificial and difficult to distinguish one from the other. These studies shed some light on this problem as well as helped to clarify the relationships among species, but many taxonomical problems remain unclear. More detailed and discussions on these issues and taxa are found in Gonçalves et al. in press.

Another controversy subject has been the recognition of *C. tomentosa* Desfontaines (1799: 305), subsequently treated as *C. suffruticosa* subsp. *tomentosa* (Ball) Murbeck (1905: 9), or *C. incana*, both erroneously described from North Africa, but based on a type collected in the south of Spain. A brief history about this nomenclatural problem is found in Silveira et al. (2013), who also proposed a new lectotype for *C. suffruticosa* subsp. *tomentosa*.

Compared with Algeria and Tunisia, the Moroccan *C. suffruticosa* taxa have received comparatively little attention from the taxonomists. In a major review, Lanza (1919) focused especially on the impact of hybridisation, transmission, and dominance or recession, in a Mendelian sense, of some morphological characters. This author recognised 10 species in two groups: '*Annuae*' (three species) and '*Perennes vel perennantes'* (seven species), many of which from North African countries. Later, this author described the annual *C. murbeckii* Lanza ex Murbeck (1923: 59), pointing out that it has two morphologies (morphs) of achenes (trialate and vermiculate-exalate achenes). Maire (Maire 1928b), however, distinguished the specimens of *C. murbeckii* from Marrakesh by having distinct morphs of the achenes (rostrate, trialate, cymbiform and vermiculate-exalate). He also described a new variety '*C. murbeckii* var. *pinnatiloba*' (Cosson) Maire (Maire 1928c: 57) [*C. suffruticosa* var. *pinnatiloba* Cosson (Lanza 1919: 134), *nom. nudum*.]. In the same year, Maire described *C. lanzae* Maire (1928a: 138), differing from *C. murbeckii* by having deeply sinuate-dentate to pinnatisect leaves with hydatodium dark-purple in the margin.

As previously discussed, Ohle (1975 a) recognised the *C. maroccana* group, which included four species, *C. maroccana*, *C. meuselii* Ohle (1975 a: 4), *C. eckerleinii* Ohle (1975 a: 8) and *C. lanzae*. However, in Ohle's (1975 a) revision, the *C. suffruticosa* taxa from Morocco were not monographed. Instead, the knowledge of this group in Morocco remained largely based on older and outdated works, like of Jahandiez & Maire

(1934). These authors made the first major treatment, as part of a revision of plants from Morocco. They recognised five *C. suffruticosa* taxa (subsp. *eusuffruticosa* Maire (Jahandiez and Maire 1934: 789), var. *maroccana* (Ball) Maire (Jahandiez and Maire 1934: 789), subsp. *tomentosa* (Desfontaines) Maire (Jahandiez and Maire 1934: 789), subsp. *marginata* (Willdenow) Maire (1934: 789), and var. *balansae* (Boissier & Reuter) Maire (Jahandiez and Maire 1934: 789)). However, it is difficult to interpret the taxonomic categories described. Besides the *C. suffruticosa* group, these authors also study other taxa from Morocco. The major inconsistency was that *C. murbeckii* and *C. lanzae* where treated as varieties of *C. echinata* Candolle (1838: 453). Later, Jahandiez & Maire (1938)warned that *C. echinata* is a synonym of *C. arvensis*. Maire (1938) further placed *C. murbeckii* as a distinct species based on the broader cauline leaves with less developed teeth, and by the indumentum.

Apart from partial (e.g. Heyn et al. 1974, Meikle 1976, Ohle 1974, 1975 a; 1975b) or regional revision's (Fennane and Ibn Tattou 1998, 2005; Valdés 2002; Dobignard and Chatelain 2011; Oualidi et al. 2012; Gonçalves et al. 2014), no significant revisions on the genus have been undertaken. Most of the earlier taxonomic studies were focused on the limited material available at that time, and shown recurrent discrepancies between the different classification attempts, since, most of the studies were based on the dried material, many times incomplete. Some characters that can be easily observed on living material become unclear in dried herbarium specimens. In particular, the habit, leaf thickness, diameter or colour of the capitula, and shape of the achenes. Moreover, many herbarium specimens, especially in North Africa, lack some important features, such as capitula and/or, most of all, achenes.

Finally, as part of an ongoing project to revise *Calendula*, two floristic treatments, one for the Iberian Peninsula (Silveira & Gonçalves, in press, Gonçalves et al. in press) and Morocco (Gonçalves et al. 2014) have been published. A revision of selected *Calendula* taxa from the SW Mediterranean region (Morocco, Algeria and Tunisia), aiming at (1) analyse the variation between and within taxa, and (2) re-evaluate taxa delimitations, is presented. Several taxonomical changes, including the description of new species/taxa, designation of new combinations, the establishment of new synonyms, and the exclusion of some taxa, are also presented.

Material and methods

Plant material

An intensive survey was conducted by A.C. Gonçalves and P. Silveira in the years 2012–2014, during the spring season, throughout most of the study area (Morocco, Algeria and Tunisia), to collect *Calendula* species and see their characteristics in the field. A total of 32 field collections resulted from this fieldwork, which are given in APPENDIX 1 and are held at the University of Aveiro (AVE). Specimens deposited at ABH, AL (ENSA), ARAN, B, BC (IBB), BCN, BM, BONN, BR, C, COI, E, ELVE, FI, G, GAT, GDA (GDAC), HAL, JACA, JAEN, JE, K, LD, LEB, LISI, M, MA, MACB, MAF, MARK, MGC, MPU, O, P, PO, RAB, RNG, SALA, SANT, SEV, TFMC, US, VAL and W herbaria were also examined. Over 5 000 specimens, including types of most taxa, have been examined. Specimens' information of all collections examined was entered in a BRAHMS (Version 7.9.6 – University of Oxford) database, available on request from the authors.

Morphological studies

Morphological characters of *Calendula* were examined *in situ* and in herbaria material. In each population, 10 randomly selected specimens were sampled. However, at some locations, this number was reduced due to the lower number of samples available. The morphological characters screened are summarised in Table 13 and 14, following Gonçalves et al. (in press), adapted for North African taxa. Each specimen represents an Operational Taxonomic Unit (OTU) in the multivariate analysis (see below).

Data analysis

Morphological data were subjected to one-way analysis of variance to determine the significant difference between taxa for each character measured. For normally distributed and homoscedastic variables, *t*-test (between two groups) or One-way ANOVA (between more than two groups) were performed. When normality and homoscedasticity were not achieved, Mann-Whitney test (between two groups) and Kruskal-Wallis One-way ANOVA on ranks (between more than two groups) were used instead. Some taxa were excluded from the analysis of variance because of the scarcity of available samples (e.g. leave thickness or head diameter). Boxplots containing medians and percentiles of each character within species and subspecies were prepared. The most discriminant characters

were used to perform the multivariate analysis and to build the identification keys. Principal component analysis (PCA) was used to evaluate the morphological variation among taxa. All statistical analyses were performed using the R programme (R Development Core Team 2010), except for PCA, which was performed with StatistiXL (Broadway – Nedlands, AUS).

Mapping and conservation status assessment

Map distributions of each taxon were plotted using QGIS 2.18.4 (QGIS 2017), available in http://qgis.org, based on field and herbarium collection. Species richness distribution was assessed in a grid cell of 0.3º × 0.3º.

The conservation status assessments followed the IUCN Red List Categories and Criteria procedure (IUCN 2012), available in http://www.iucnredlist.org/, where any taxa can be classified in one of seven categories: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC) or Data Deficient (DD). The extent of occurrence (EOO) and area of occupancy (AOO) were calculated for each taxon to evaluate their status based on geographic coordinates, using the software GeoCAT (Geospatial Conservation Assessment Tool), available in http://geocat.kew.org/.

Taxonomic concept

The species concept used in the present work is Genotypic Cluster or Genomic Cluster Species Concept (GCSC), in line with that previously employed in the Iberian Peninsula (Gonçalves et al. 2017). Species of *Calendula* are defined as groups of individuals that form genetic (chromosome numbers, ploidy level, and genome size) or morphological clusters with few or no intermediates (Mallet 1995). Hybridisation and/or introgression may occur when closely related species meet occasionally. Species will differ from each other in a few, distinct characters, but intergrade in areas where their distribution and habitats overlap. The "75% rule" that defines the criteria for subspecies classification was also applied (Amadon 1949).

Table 13 – Quantitative characters of both vegetative and reproductive structures used in this study.

Characters	Abbreviation	Unit/Scale
Length of the longest branch	LB	cm
Basal leaf length	LL	cm
Basal leaf width	LW	cm
Basal leaf distance from base to point of greatest width	LD	cm
Ratio leaf length/point of greatest width	R1	ratio
Ratio leaf length/width	R2	ratio
Basal leaf thickness	LT	mm
Head diameter	HD	cm
Involucre length	IL	mm
Ligule length	LG	mm
Ratio ligule/involucre	R3	ratio
Sub-exalate achene length	SEL	mm
Sub-exalate achene width	SEW	mm
Rostrate achene length	RL	mm
Rostrate achene width	RW	mm
Bialate achene length	BL	mm
Bialate achene width	BW	mm
Bialate achene rostrum length	BR	mm
Trialate achene length	TL	mm
Trialate achene width	TW	mm
Cymbiform achene length	CL	mm
Cymbiform achene width	CW	mm
Sub-cymbiform achene length	SCL	mm
Sub-cymbiform achene width	SCW	mm
Vermiculate-alate achene length	VAL	mm
Vermiculate-alate achene width	VAW	mm
Vermiculate-exalate achene length	VEL	mm
Vermiculate-exalate achene width	VEW	mm

Table 14 – Qualitative characters of both vegetative and reproductive structures used in this study.

Characters	Characters states	Abbreviation
Life cycle	(1) annual; (2) annual to short-lived perennial (3) perennial	LF
Stem pubescence	(1) mostly glandular; (2) glandular pubescent; (3) mostly white-arachnoid; (4) densely white-arachnoid	SP
Leaf shape	(1) linear to oblanceolate; (2) oblanceolate to spatulate (3) oblanceolate to obovate	LS
Leaf apex	(1) acuminate; (2) acute; (3) obtuse	LA
Leaf margins	(1) entire to sub-entire; (2) sinuate-dentate; (3) sinuate-dentate with acute teeth (4) sinuate-dentate with acute teeth to ± irregularly pinnatifid; (5) deeply sinuate-dentate to ± irregularly pinnatipartite	LM
Leaf lamina pubescence	(1) mostly glandular; (2) glandular pubescent; (3) mostly white-arachnoid; (4) densely white-arachnoid	LP
Sub-exalate achene		
ventral wings	(0) absent; (1) < than lateral; (2) sub-equal; (3) > than lateral	SEvw
lateral wings	(0) absent; (1) sub-entire; (2) sinuate-dentate; (3) incised; (4) deeply pinnately cut	SElw
Rostrate achene		
ventral tooth	(0) absent; (1) apical; (2) basal; (3) both	Rvt
Bialate achene		
lateral wings	(0) absent; (1) sub-entire; (2) sinuate-dentate; (3) incised; (4) deeply pinnately cut	Blw
dorsal wings	(0) absent; (1) < 2 mm straight; (2) > 2 mm bent towards the ventral face	Bdw
Trialate achene		
ventral wings	(0) absent; (1) < than lateral; (2) sub-equal; (3) > than lateral	Tvw
lateral wings	(0) absent; (1) sub-entire; (2) sinuate-dentate; (3) incised; (4) deeply pinnately cut	Tlw
dorsal wings	(0) absent; (1) < 2 mm straight; (2) > 2 mm bent towards the ventral face	Tdw
Cymbiform achene		
ventral wings	(0) absent; (1) < than lateral; (2) sub-equal; (3) > than lateral	Cvw
dorsal wings	(0) absent; (1) < 2 mm straight; (2) > 2 mm bent towards the ventral face	Cdw
ventral tooth	(0) absent; (1) apical; (2) basal; (3) both	Cvt
Sub-cymbiform achene		
ventral wings	(0) absent; (1) < than lateral; (2) sub-equal; (3) > than lateral	SCvw
lateral wings	(0) absent; (1) sub-entire; (2) sinuate-dentate; (3) incise; (4) deeply pinnately cut	SClw
dorsal wings	(0) absent; (1) < 2 mm straight; (2) > 2 mm bent towards the ventral face	SCdw
Vermiculate-alate achene		
Shape	(0) absent; (1) circular to hemicyclic; (2) hook-shaped; (3) falcate	Vas
ventral tooth	(0) absent; (1) apical; (2) basal; (3) both	VAvt
Vermiculate-exalate achene		
Shape	(0) absent; (1) circular to hemicyclic; (2) hook-shaped; (3) falcate	VEs
ventral tooth	(0) absent; (1) apical; (2) basal; (3) both	VEvt

Results

Analysis of variance

The analysis of variance performed on various quantitative data, for both species and subspecies, showed significant differences ($P < 0.001$) (Table 15 and 16). The highest variation estimated from the ratio basal leaves length/width for species, and rostrate achenes length for *C. suffruticosa* subspecies, result from the existence of a high degree of variability on these traits and the same can be used for differentiating some of the taxa. The dimensions of the sub-exalate and sub-cymbiform achenes were only determined for those taxa that produce such achenes, i.e. the subspecies of *C. suffruticosa*. Boxplots showing the variability of the quantitative characters used are presented in Figure 50 to 57. Characters that appear in a single taxon were not represented in a boxplot, but are provided in APPENDIX 2.

Table 15 – Univariate statistical analysis of *Calendula* species from Morocco

Morphological trait	**d.f.**	**statistical test**	***P***
Length of the longest branch	8	H = 31.807	0.001
Basal leaf length	8	H = 18.089	0.021
Basal leaf width	8	H = 115.664	0.001
Basal leaf distance from base to point of maximum width	8	H = 48.283	0.001
Ratio leaf length/point of maximum width	8	H = 106.276	0.001
Ratio leaf length/width	8	H = 164.821	0.001
Basal leaf thickness	7	H = 33.314	0.001
Head diameter	7	H = 19.924	0.001
Rostrate achene length	8	H = 117.545	0.001
Rostrate achene width	8	H = 94.078	0.001
Bialate achene length	4	H = 54.990	0.001
Bialate achene width	4	H = 23.224	0.001
Bialate achene rostrum	2	H = 42.066	0.001
Trialate achene length	5	H = 114.271	0.001
Trialate achene width	5	H = 97.790	0.001
Cymbiform achene length	3	H = 52.520	0.001
Cymbiform achene width	3	H = 55.599	0.001
Vermiculate-alate achene length	2	H = 8.085	0.018
Vermiculate-alate achene width	2	H = 10.378	0.006
Vermiculate-exalate achene length	8	H = 88.167	0.001
Vermiculate-exalate achene width	8	H = 101.541	0.001

Kruskal-Wallis One-way ANOVA *H* for characters with non-normal distributions. d.f. – degrees of freedom.

Table 16 – Univariate statistical analysis of *C. suffruticosa* subspecies from Morocco

Morphological trait	**d.f.**	**statistical test**	***P***
Length of the longest branch	14	H = 97.302	0.001
Basal leaf length	14	H = 103.940	0.001
Basal leaf width	14	H = 110.291	0.001
Basal leaf distance from base to point of maximum width	14	H = 102.958	0.001
Ratio leaf length/point of maximum width	14	F = 7.889	0.001
Ratio leaf length/width	14	H = 94.675	0.001
Basal leaf thickness	14	H = 115.970	0.001
Head diameter	14	H = 81.710	0.001
Rostrate achene length	14	H = 144.709	0.001
Rostrate achene width	14	H = 135.726	0.001
Bialate achene length	12	F = 27.738	0.001
Bialate achene width	14	H = 75.194	0.001
Bialate achene rostrum	14	H = 70.779	0.001
Trialate achene length	14	H = 69.559	0.001
Trialate achene width	14	H = 58.950	0.001
Cymbiform achene length	6	F = 49.791	0.001
Cymbiform achene width	13	H = 70.350	0.001
Sub-cymbiform achene length	14	H = 45.250	0.001
Sub-cymbiform achene width	2	F = 529.509	0.001
Vermiform alate achene length	14	H = 34.945	0.004
Vermiform alate achene width	14	H = 42.059	0.001
Vermiform exalate achene length	14	H = 87.807	0.001
Vermiform exalate achene width	14	H = 62.936	0.001

One-way ANOVA: *F* for characters with normal distributions. Kruskal-Wallis One-way ANOVA on ranks: *H* for characters with non-normal distributions. d.f. – degrees of freedom.

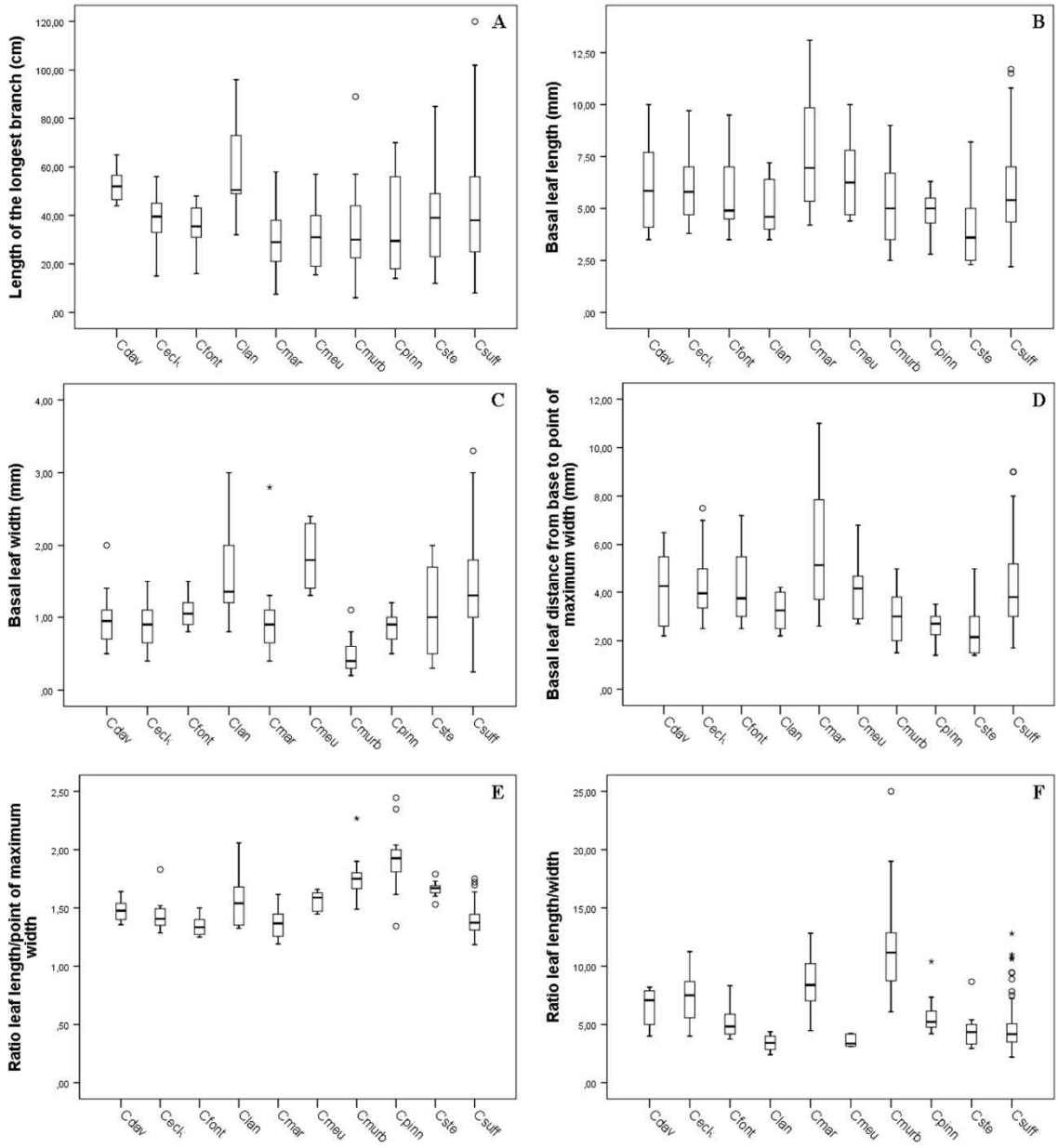


Figure 50 – Boxplots representing the variability of quantitative characters in *Calendula* species. Median (lines), 25%-75% (boxes), minimum and maximum values (whiskers), outliers (small circles). Different letters reveal statistical differences at $P < 0.05$.

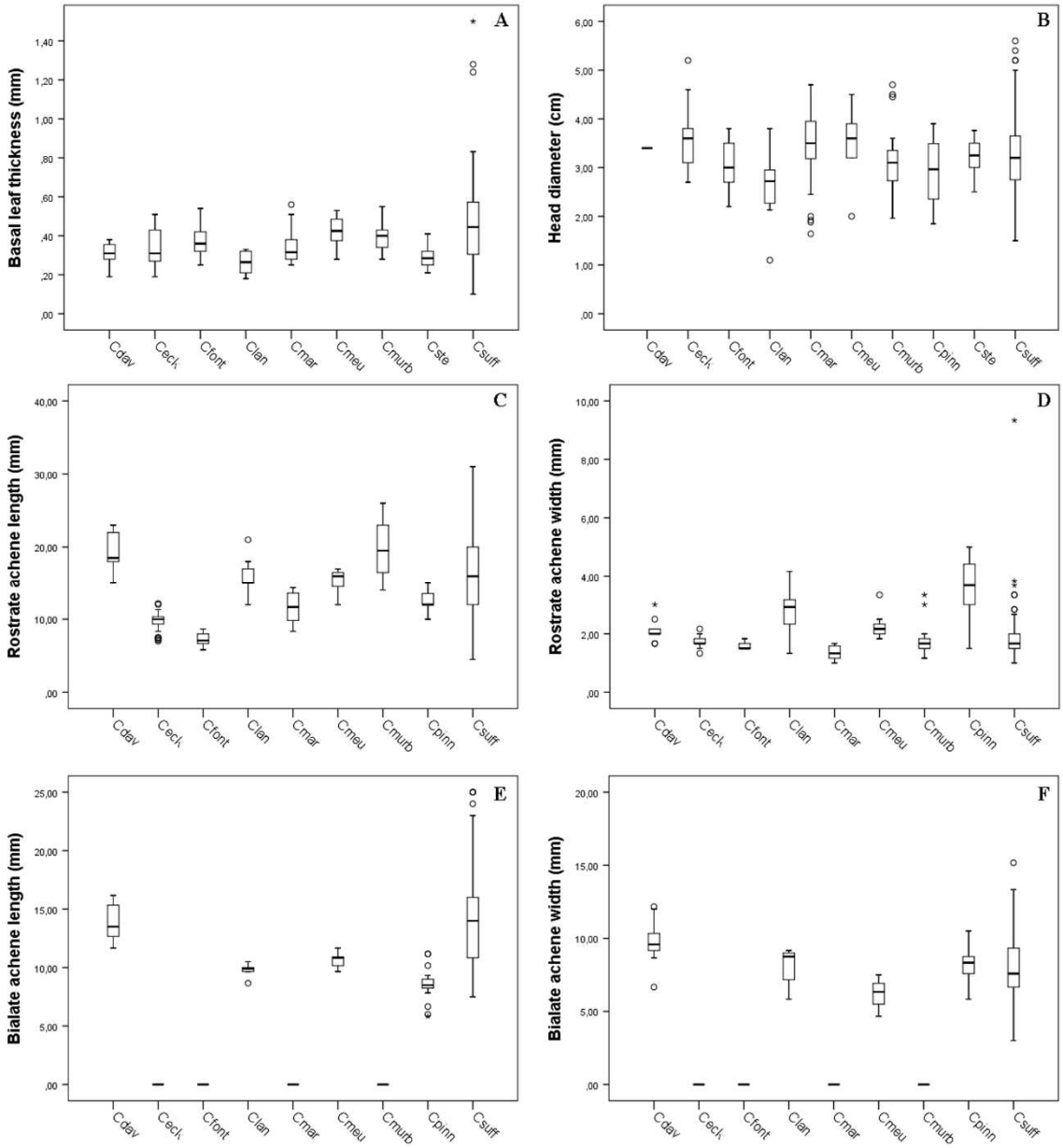


Figure 51 – Boxplots representing the variability of quantitative characters in *Calendula* species. Median (lines), 25%-75% (boxes), minimum and maximum values (whiskers), outliers (small circles). Different letters reveal statistical differences at $P < 0.05$.

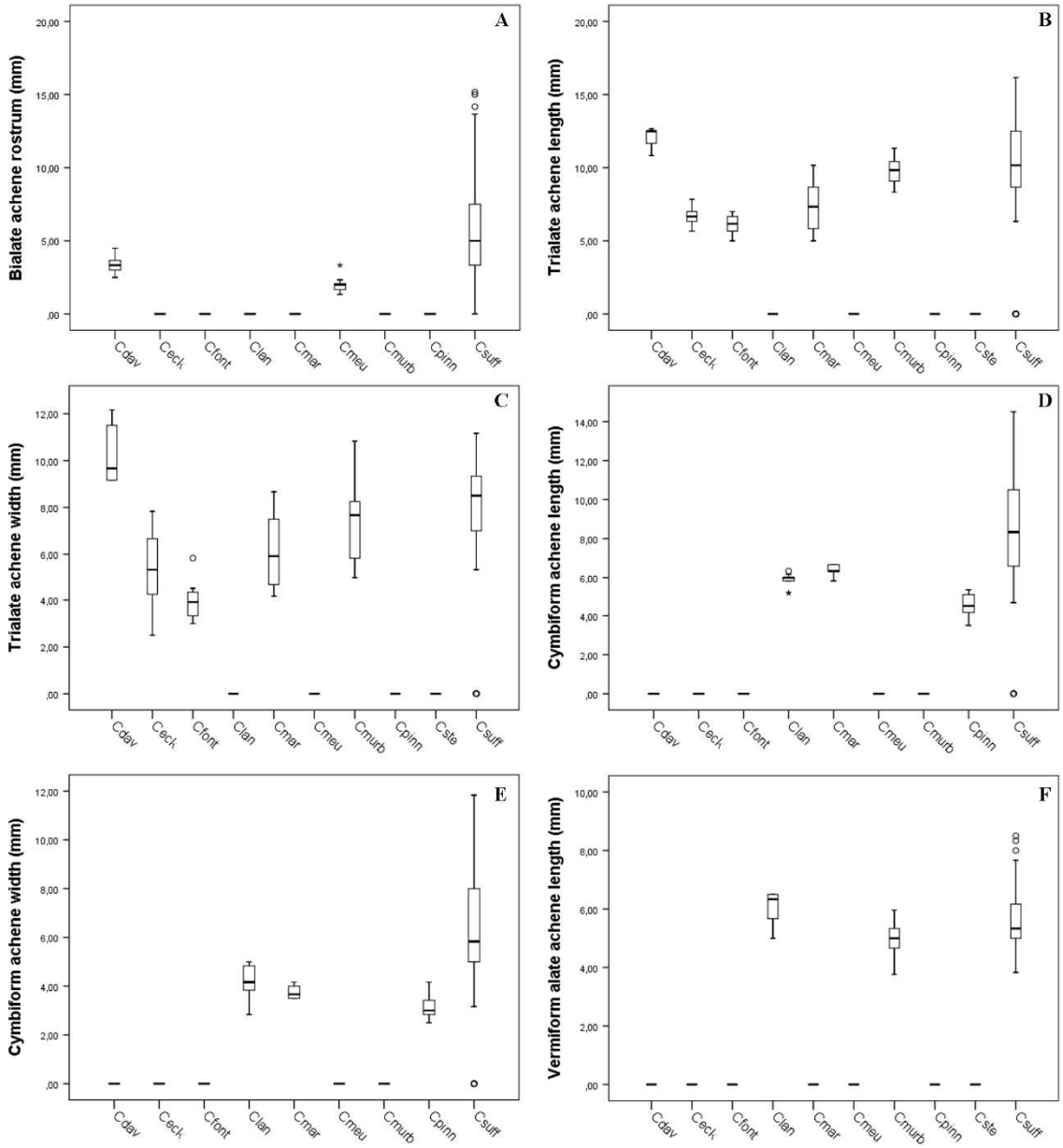


Figure 53 – Boxplots representing the variability of quantitative characters in *Calendula* species. Median (lines), 25%-75% (boxes), minimum and maximum values (whiskers), outliers (small circles). Different letters reveal statistical differences at $P < 0.05$.

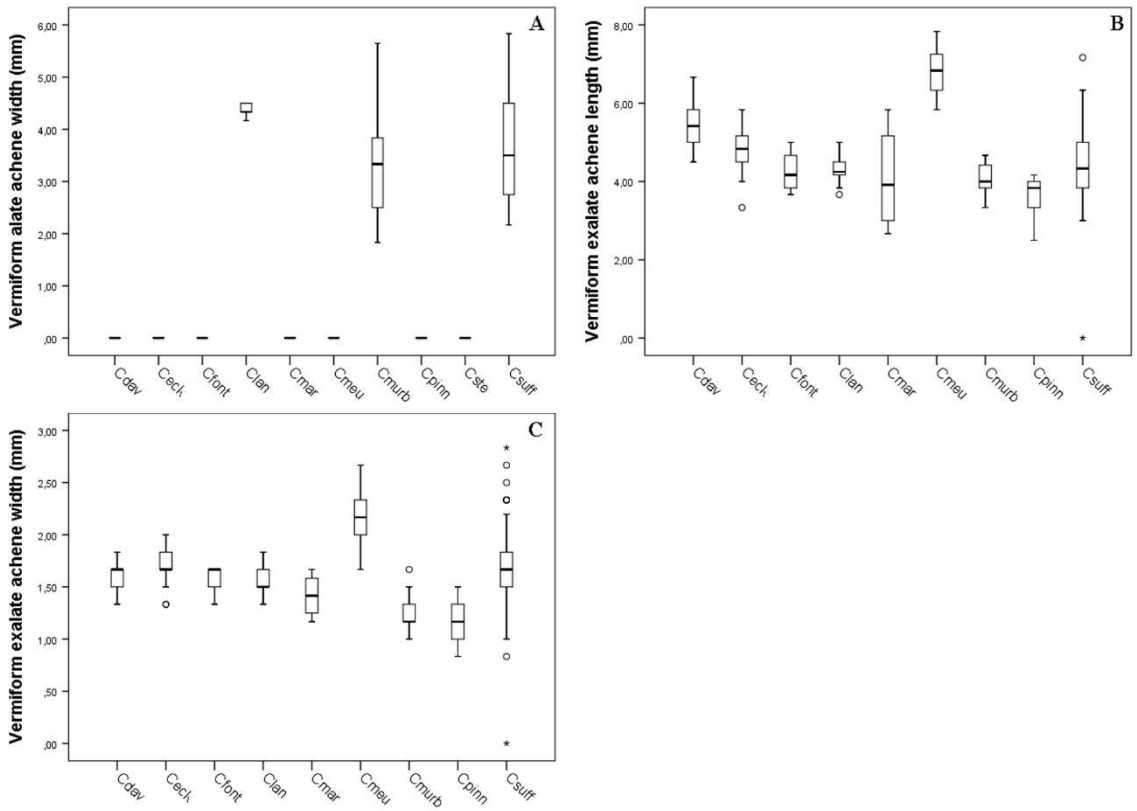


Figure 54 – Boxplots representing the variability of quantitative characters in *Calendula* species. Median (lines), 25%-75% (boxes), minimum and maximum values (whiskers), outliers (small circles). Different letters reveal statistical differences at $P < 0.05$.

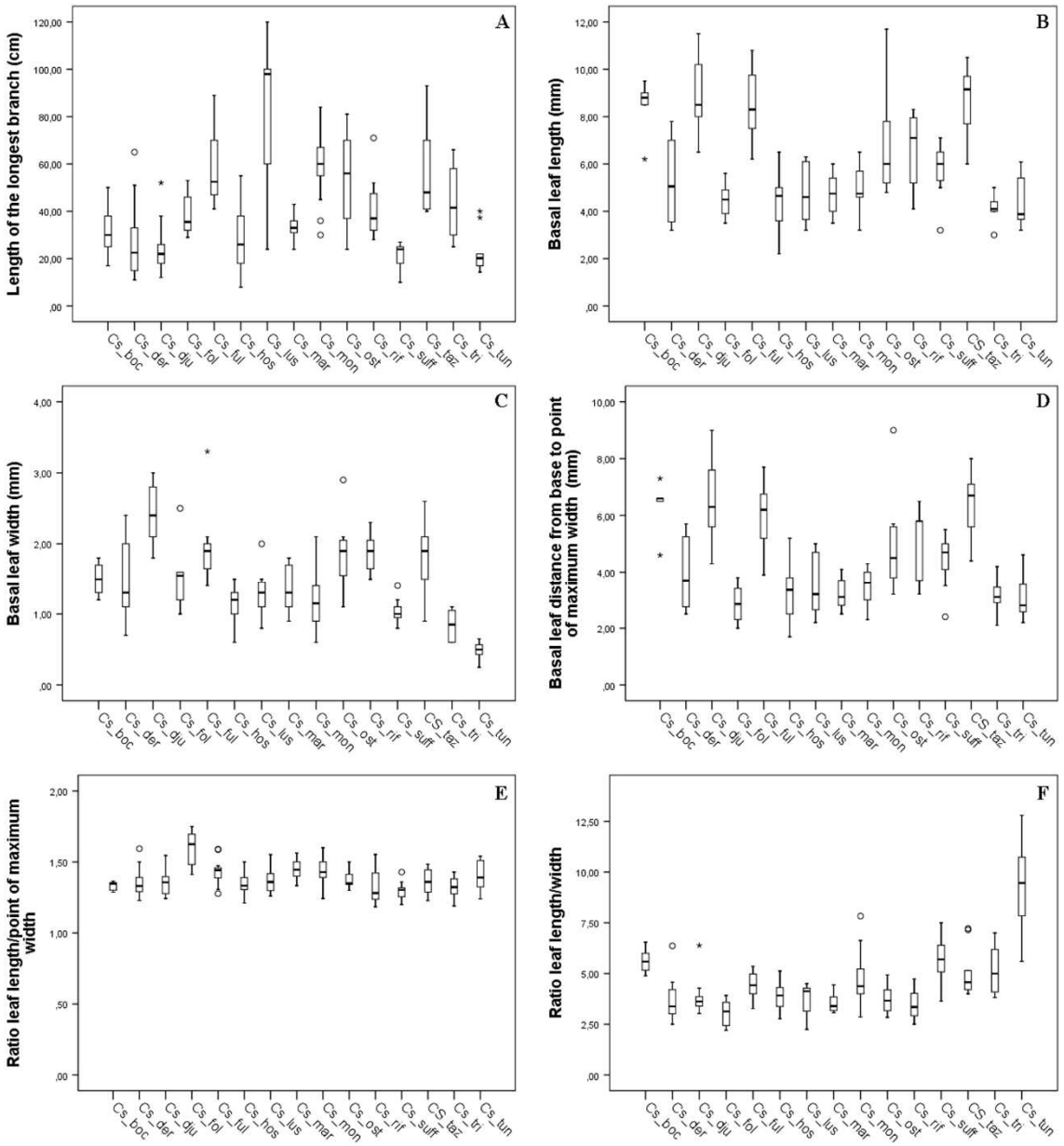


Figure 55 – Boxplots representing the variability of quantitative characters in *C. suffruticosa* taxa. Median (lines), 25%-75% (boxes), minimum and maximum values (whiskers), outliers (small circles). Different letters reveal statistical differences at $P < 0.05$.

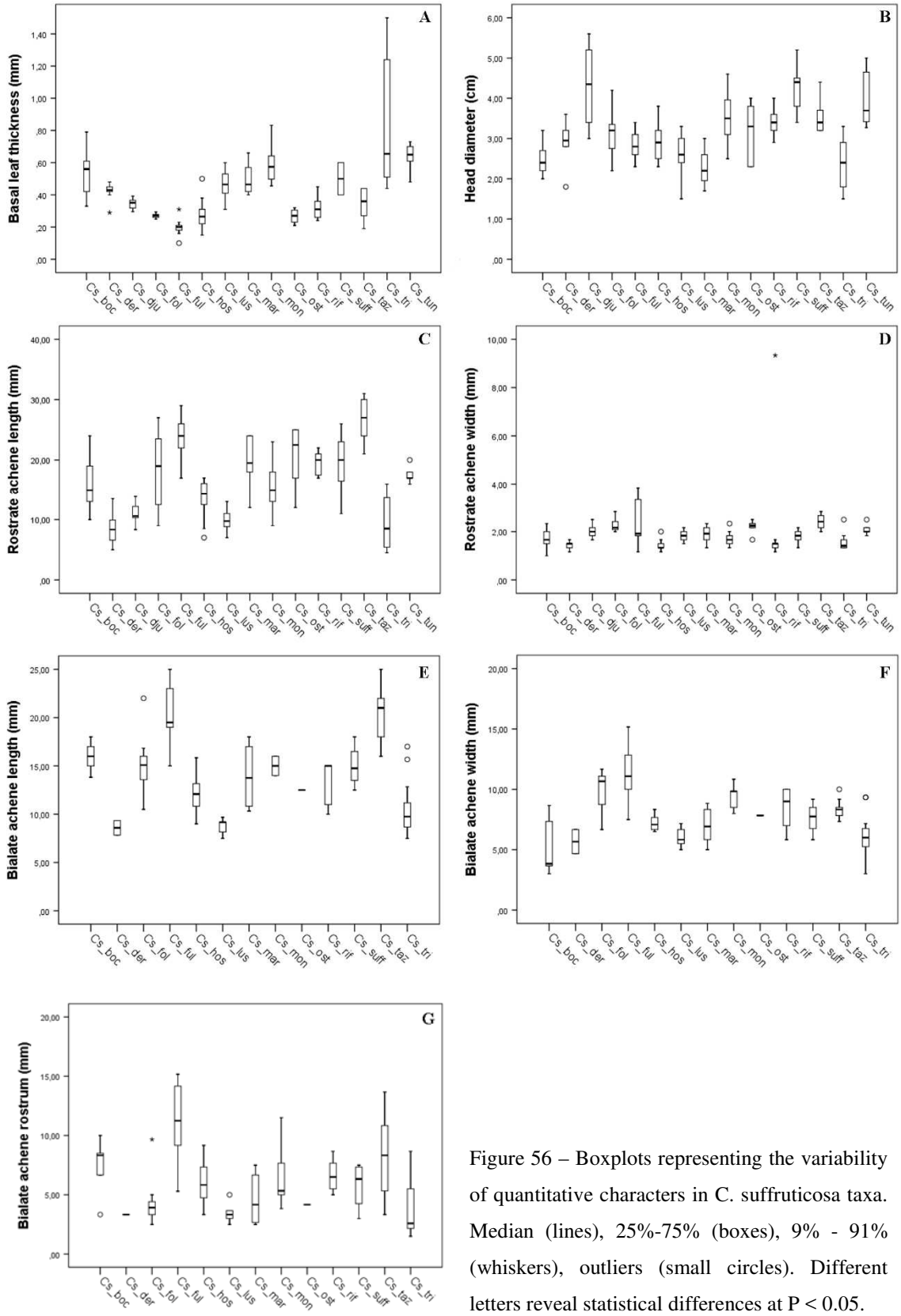


Figure 56 – Boxplots representing the variability of quantitative characters in C. suffruticosa taxa. Median (lines), 25%-75% (boxes), 9% - 91% (whiskers), outliers (small circles). Different letters reveal statistical differences at $P < 0.05$.

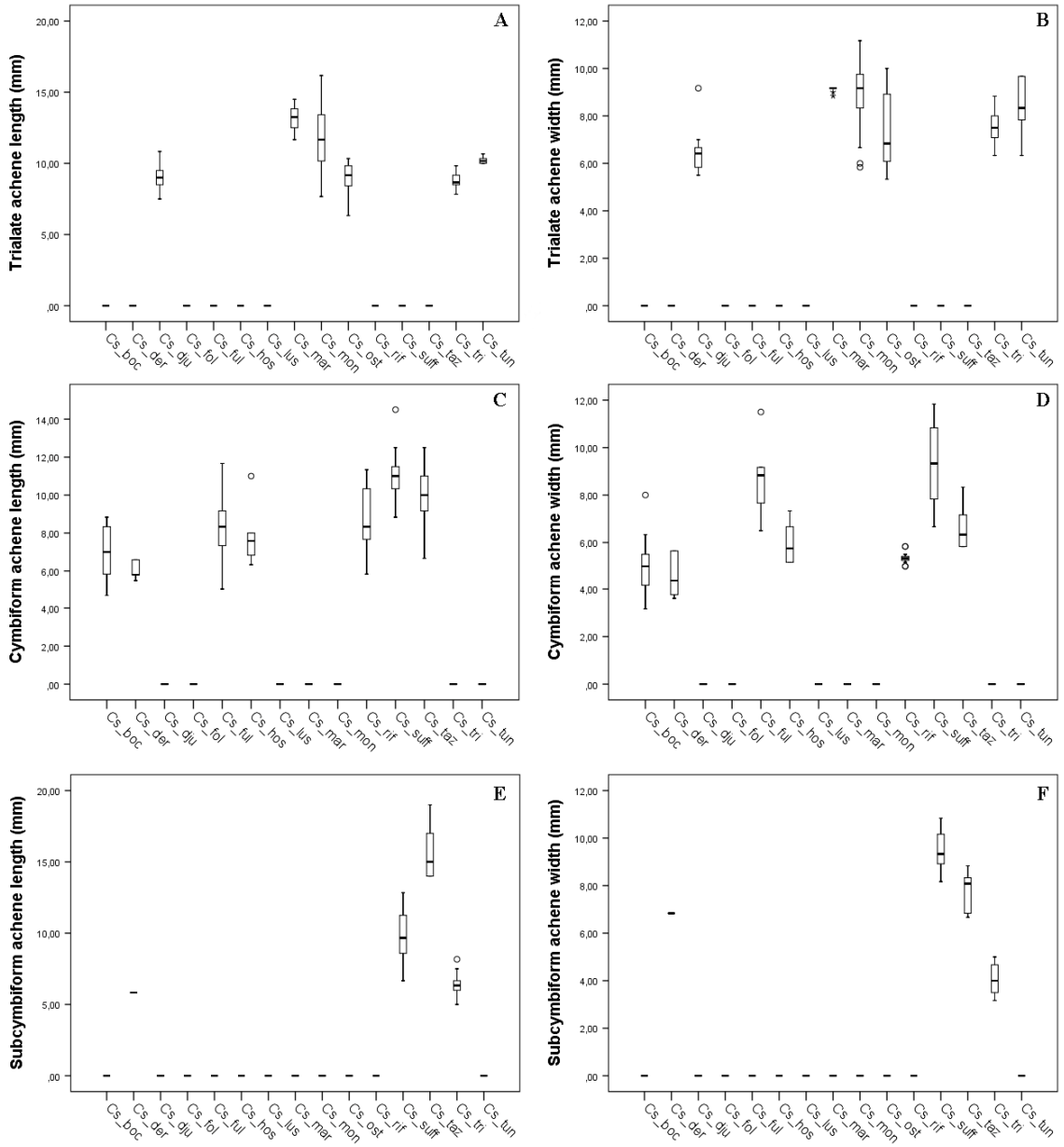


Figure 57 – Boxplots representing the variability of quantitative characters in *C. suffruticosa* taxa. Median (lines), 25%-75% (boxes), minimum and maximum values (whiskers), outliers (small circles). Different letters reveal statistical differences at $P < 0.05$.

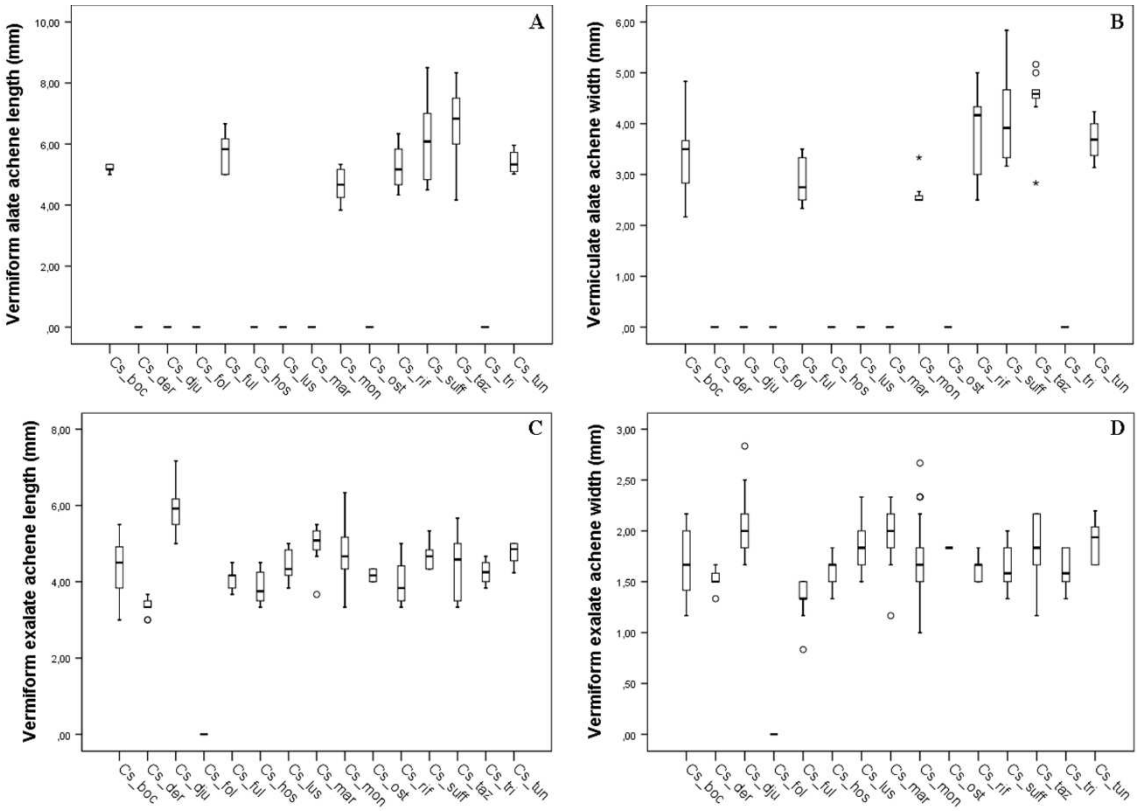


Figure 58 – Boxplots representing the variability of quantitative characters in *C. suffruticosa* taxa. Median (lines), 25%-75% (boxes), minimum and maximum values (whiskers), outliers (small circles). Different letters reveal statistical differences at $P < 0.05$.

Principal component analysis

The most complex and difficult to classify groups of *Calendula* taxa were analysed separately: (1) *Calendula maroccana* group, taxa with 2n = 18 and (2) *Calendula suffruticosa* group, taxa with 2n = 32.

1) In the PCA of *Calendula maroccana* group, 32.38% of the variance was accounted for by the first principal component, followed by 20.64% for the second and 8.85% for the third principal component (APPENDIX 3, Figure 59). The characters LF, VEs, TL, VAs, VAvt and Cvt, that significantly loaded on the first component. For the second component, the highest loadings included Tlw, R2, TL, LW, BL and Blw. The PCA of *Calendula maroccana* group (Figure 59) displays a good separation between eight species, mainly distinguished by different achene morphologies; *C. lanzae* and *C. pinnatiloba*, both annual to

short-lived perennial, form two distinct clusters separated from the remaining species. Although they are in very close geographic regions, they can be differentiated from each other by the basal leaf margin, bialate and cymbiform achenes. Furthermore, the nuclear DNA content among these taxa are different, 1.85 ± 0.08 pg and 2.09 ± 0.15 pg, respectively (Table 17); *C. murbeckii* has trialate achenes with wings deeply pinnately cut into segments with truncate apices, which is easy to distinguish from other species; the species *C. maroccana*, *C. eckerleinii*, *C. davisii, C. fontquerii* and *C. meuselii* partially grouped on the positive part of axis 2, which tends to be correlated with the life cycle, but also with vermiculate achenes; *C. meuselii* was well separated along the negative side of PC2, due to basal leaf, stem pubescence and bialate achenes. *C. maroccana* and C. murbeckii appear in the positive section of PC2 mostly due to the presence of trialate achenes.

2) In the PCA of *C. suffruticosa* taxa 48.3% of the variance was accounted for the three first axis, 23.6% for the first component, followed by 13.2% for de second component and 11.5% for the third principal component (APPENDIX 3, Figure 60). The characters TL, TW, Tvw, CL, CW and R3 were found influential for the first component. These characters allow us to separate the *C. suffruticosa* group in two subgroups: taxa with and without trialate achenes. Therefore, PCA2 distinguished taxa mainly by pubescence and vermiculate achenes, only a few taxa separate from the others. For the PCA of *C. suffruticosa* taxa with trialate achenes, the first component accounted for 29.08% of the variations observed, while the second component accounted for 21.4% of the variations (Figure 61). Thus, the three components show a cumulative of 66.42% of the variance. The characters that significantly loaded on the first component were LT, TW, VAW, LD, LA and Blw. For the second component, the characters which showed a high loading included LS, Tvw, Tlw, R1, R2 and SP. For the PCA of *C. suffruticosa* taxa without trialate achenes, the first principal component accounts for 25.65% of the variation, the second component for 17.56%, and the third component for 13.09% for a total of 56.3% (Figure 62). The following

variables load heavily on the first component variables: VAL, VAW, Vas, SEL, SElw and VEs.

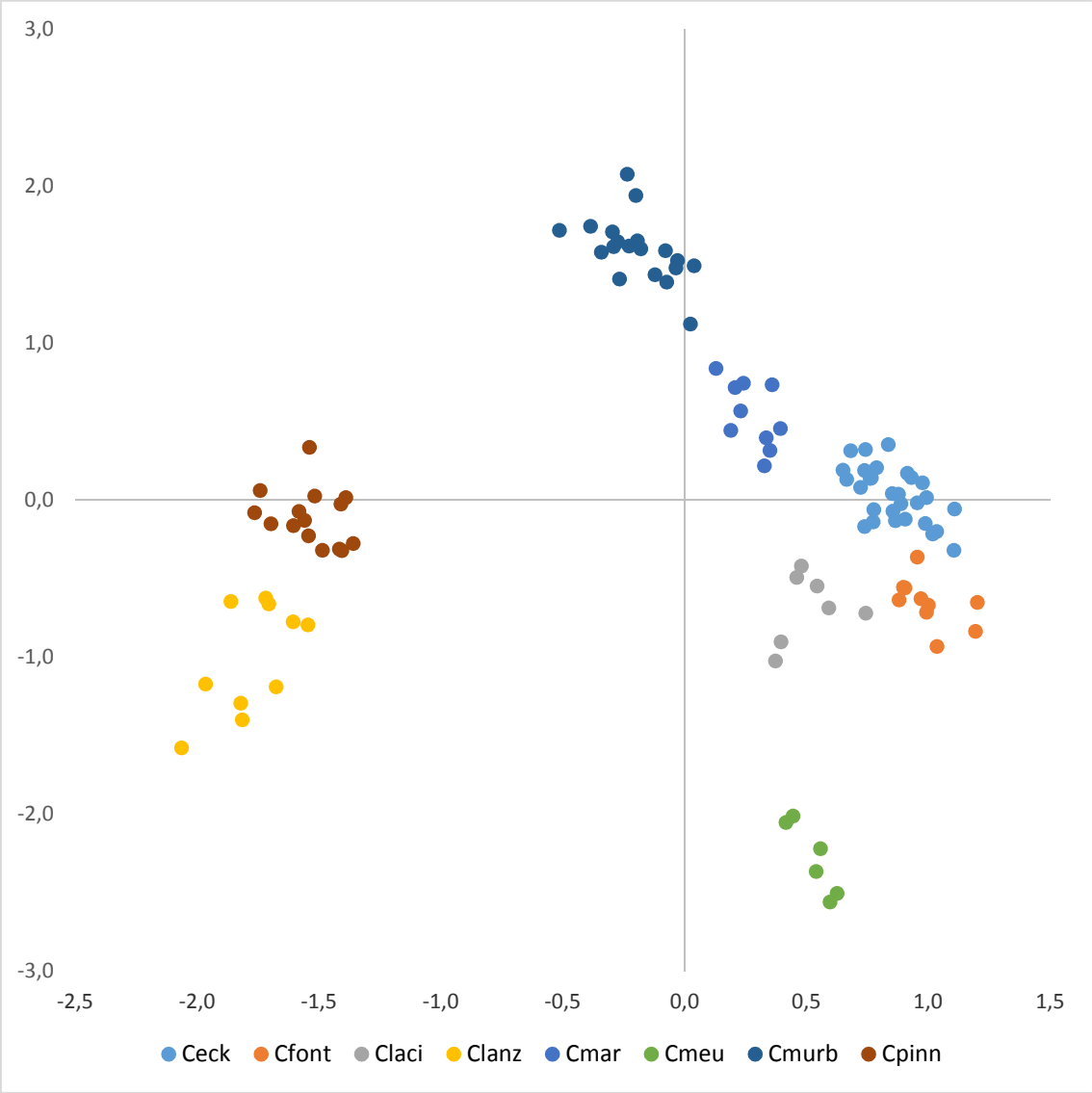


Figure 59 – Two-dimensional ordination diagram of PC 1x2 based on 34 morphological characters of 107 specimens from *Calendula maroccana* group.

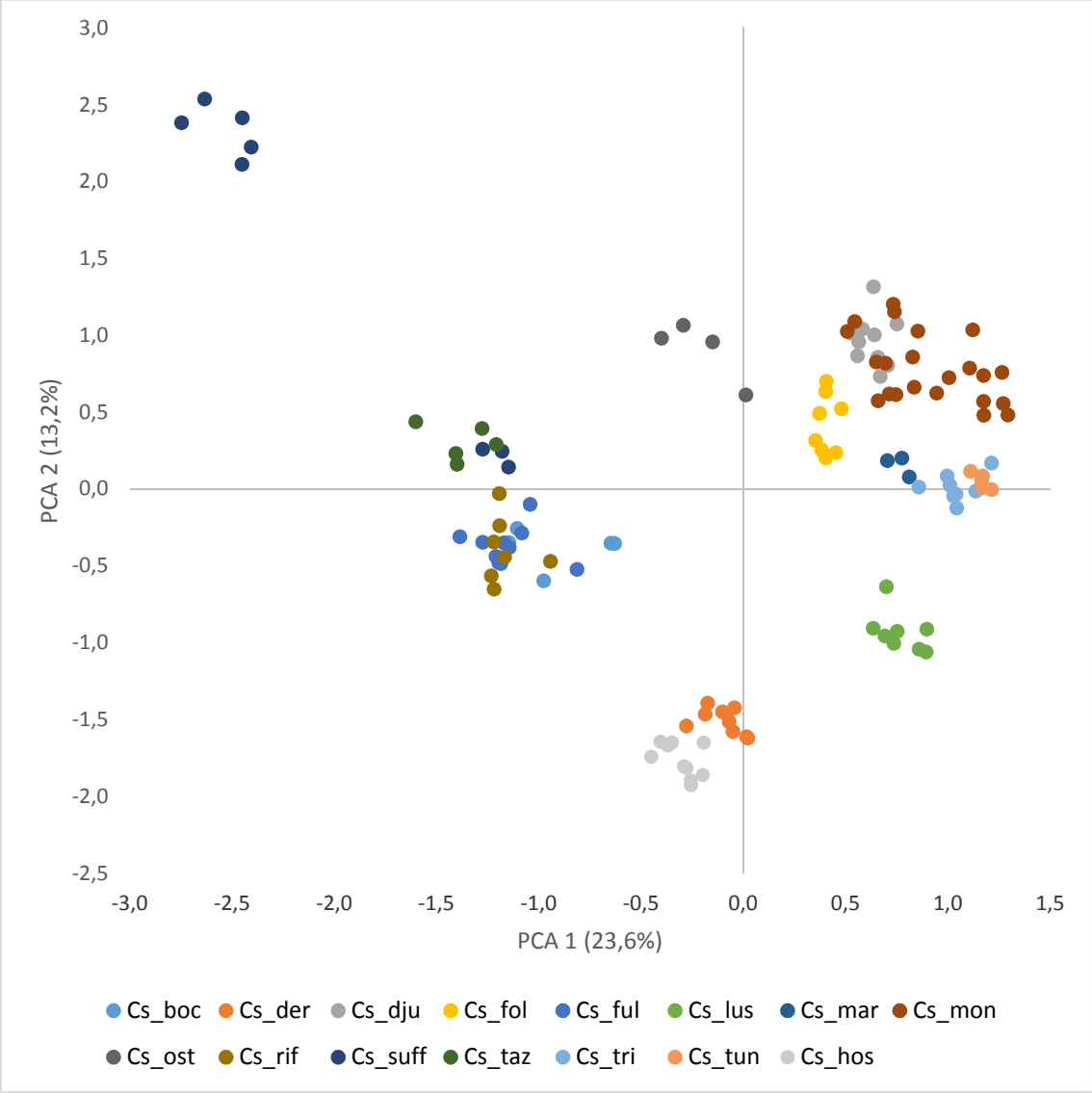


Figure 60 – Two-dimensional ordination diagram of PC 1x2 based on 49 morphological characters of 125 specimens from *C. suffruticosa* group.

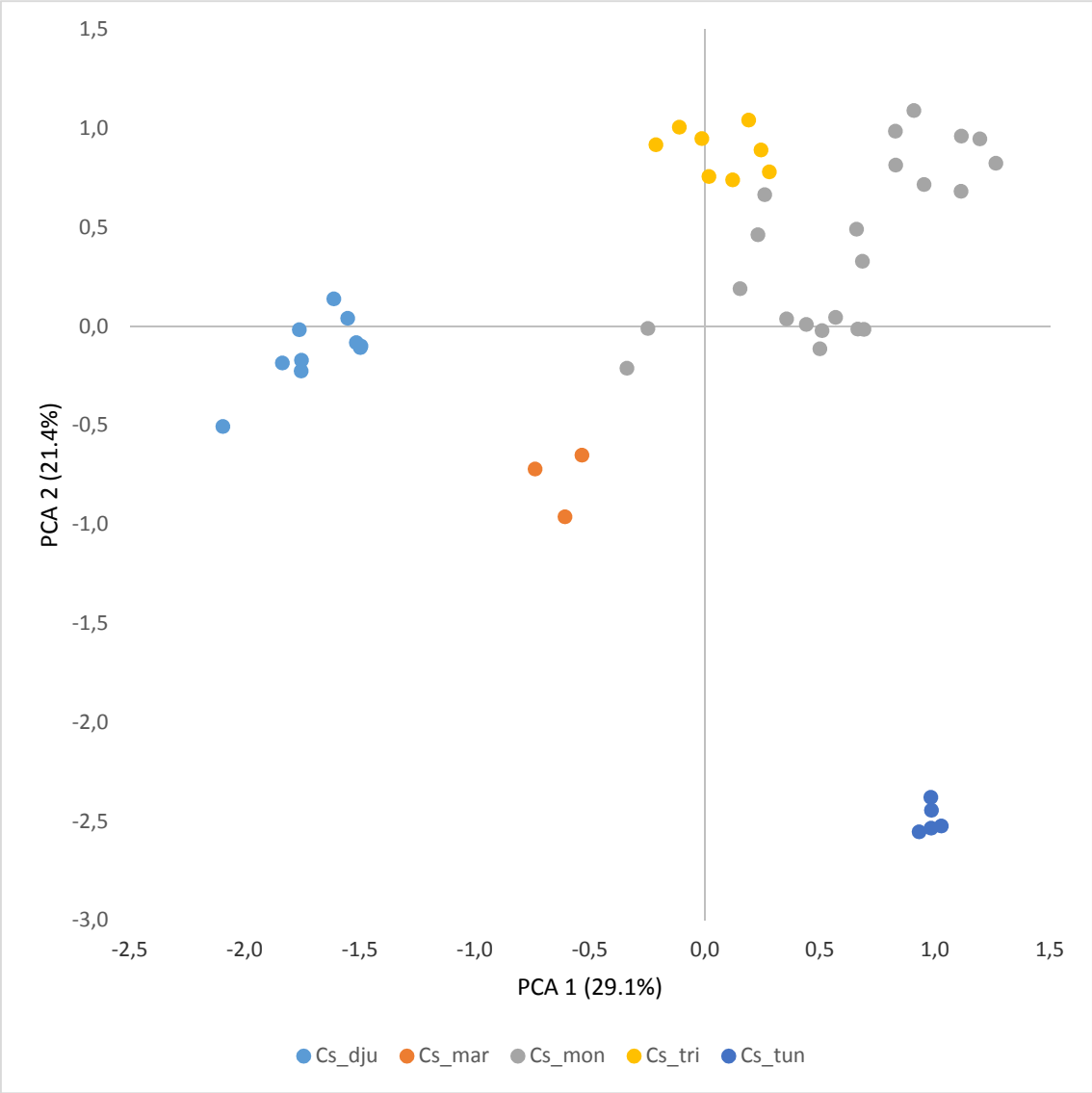


Figure 61 – Two-dimensional ordination diagram of PC 1x2 based on 31 morphological characters of 49 specimens from *C. suffruticosa* taxa with trialate achenes.

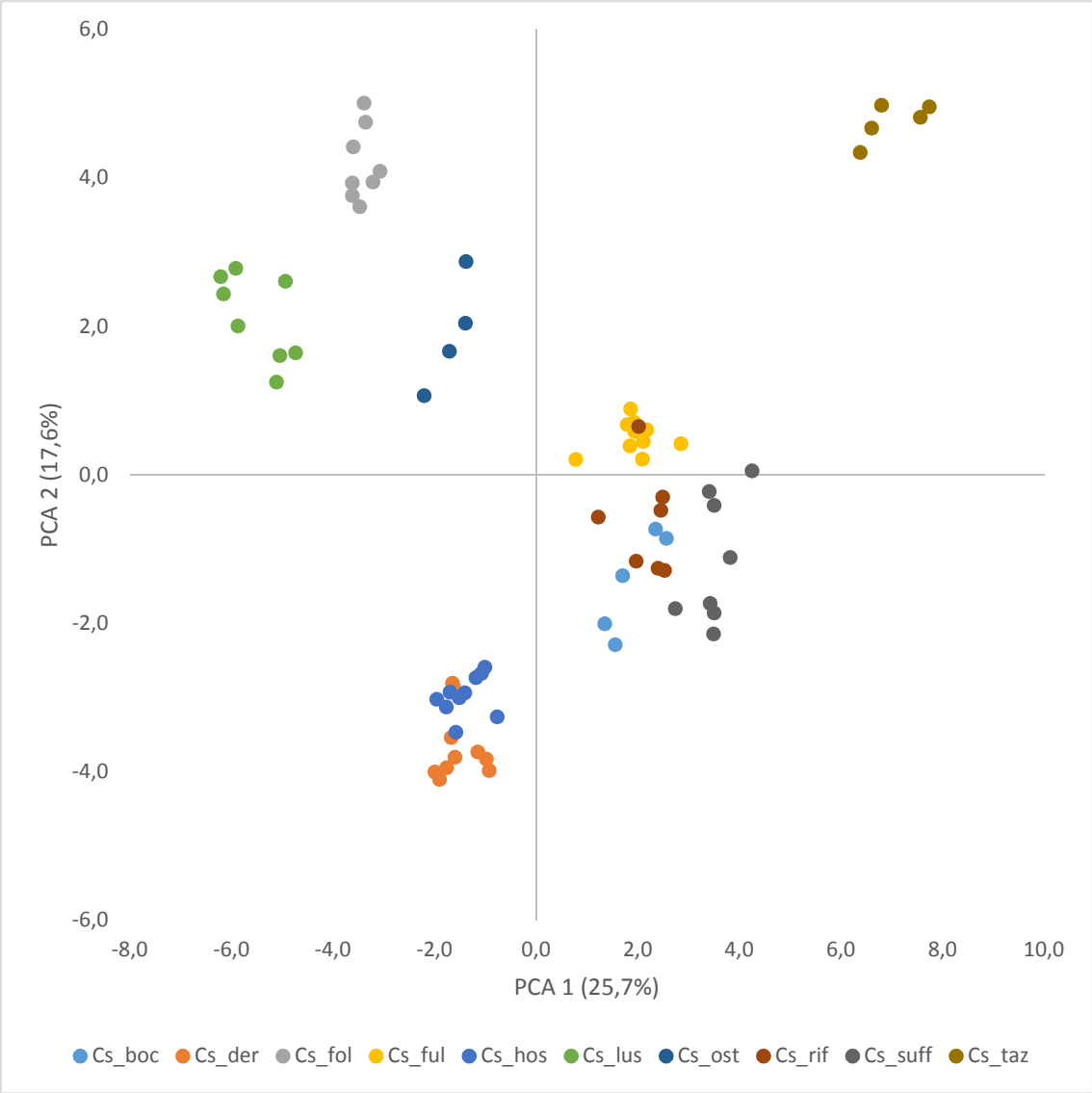


Figure 62 – Two-dimensional ordination diagram of PC 1x2 based on 44 morphological characters of 76 specimens from *C. suffruticosa* taxa with non-trialate achenes.

Taxonomical implications for Calendula species

The statistical analysis of quantitative characters showed significant differences among the *Calendula* studied, which allows identification of those quantitative characters that distinguish taxa. Thus, these characters can be taxonomically useful.

Our results showed that the morphological characters provide enough support to identify different taxa within the genus *Calendula*. Based on achene's morphology, especially the bialate and trialate achenes, the *Calendula maroccana* group can be divided into eight independent species. In addition, the life form and the basal leaf characters contributed significantly to the grouping. These characters were used in the identification key for the species of *Calendula* provided in the taxonomic treatment section. In the step 5, *C. murbeckii* is distinguished from the other *C. maroccana* annuals group, by having trialate achenes with lateral wings deeply pinnately cut into segments with truncate apices. The basal leaves of *C. lanzae* and *C. pinnatiloba* are distinct and unique, pinnatifid and not pinnatifid with the margin repand-dentate with the teeth more or less prominent, respectively. This character were used in step 6. The margin of the basal leaves (step 9 and 10) and the presence or absence of cymbiform achenes were also used to distinguish the perennial *C. maroccana* group.

For the *Calendula suffruticosa* group, the major delimiting characters for taxa were trialate and cymbiform achenes. The taxa with these characters were separated into two groups: trialate achenes and non-trialate achenes, to perform separate PCAs, which allowed a more detailed analysis. The *C. suffruticosa* taxa with trialate achenes separate very well the five taxa analysed. The subsp. *tunetana* is the only taxa from this group with linear to narrowly oblanceolate basal leaves (step 2 of key for *C. suffruticosa*). Normally, the rostrate achenes in *C. suffruticosa* taxa are straight, without dorsal spines, however in this group the rostrate achenes of subsp. *rirensis* are slightly curved, forming an angle of approx. 90º and with spines 0.5-1.5 mm on the dorsal face. The bialate and trialate achenes were also used in steps 5, 6 and 7. The *C. suffruticosa* subsp. *monardii* reveal to be the most variable taxon within this group. On the contrary, one of the subspecies of the *C. suffruticosa* taxa with non-trialate achenes; subsp. *riffiniensis* appeared with some overlapping with subsp. *fulgida* and subsp. *boccoyana*. Nonetheless, some qualitative morphological characters important to distinguish these subspecies did not have a significant impact on the analysis. Actually, in these cases, the plants are from

geographically separated regions and characters allowing a clear distinction were identified based on a careful study of the specimens, as can be seen in the key prepared for the *C. suffruticosa* group. Results of the statistical analysis indicate that these taxa did not show more than 75% of overlap and we accepted the subspecies classification under the "75% rule".

The achene's morphology was found significant in the grouping of different taxa. Gonçalves et al. (2017) also made similar observations where they emphasised the importance of achene's morphology. The present study also reflected the importance of the nuclear DNA content, which can be used as a supporting aid to morphological characters.

Geographic distribution, endemism and ecology

The SW Mediterranean is the most important centre of diversity and speciation of the genus C*alendula* (Norlindh 1977). Morocco host the highest diversity of species, with 8 of 15 recognised species, which grow in a variety of habitats, from sea level to above 3000 m of elevation in the High Atlas Mountains (Figure 63 to 65). The distribution of endemic species in the study area reveals that most of them are unique, particularly in Morocco. It is furthermore interesting that a high concentration of endemic species is found along the Atlas Mountains. *C. eckerleinii*, *C. davisii* and *C. meuselii* inhabiting the Medium Atlas, *C. maroccana* and *C. murbeckii* in the High Atlas, and the *C. lanzae* and *C. pinnatiloba* in the Anti-Atlas Mountains, while *C. fontquerii* occupying the Mediterranean littoral (Figure 63).

C. suffruticosa comprises 16 infraspecific taxa, eight from Morocco (subsp.: *boccoyana, dercana, fulgida, hosmarensis, lusitanica, marsea, osteni, riffiniensis, suffruticosa,* and *tazzea*), six from Algeria (subsp.: *balansae, boissieri, djurdjurensis, foliosa, monardii* and *tlemcensis*), and two from Tunisia (subsp.: *suffruticosa* and *tunetana*). Most of them occur near the sea from 0 to 200 m of elevation, only a few taxa occurs inland (e.g. subsp. *riffiniensis*, *tazzea* or *djurdjurensis*).

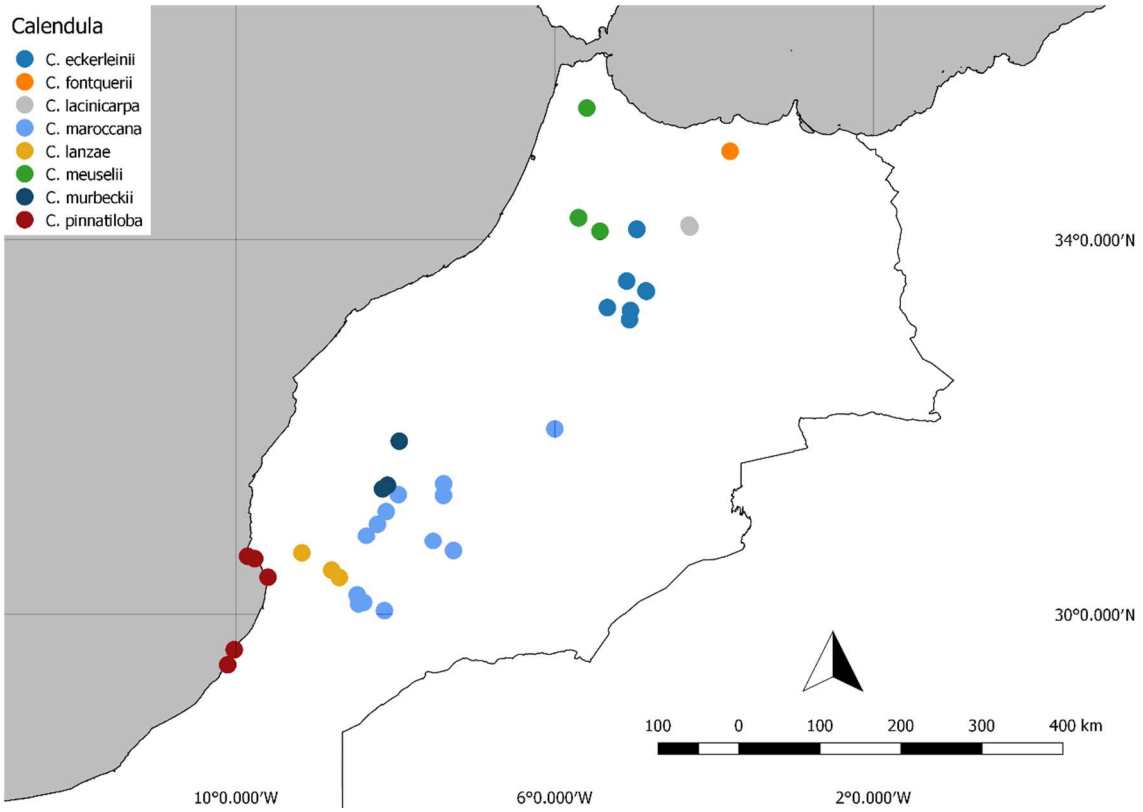
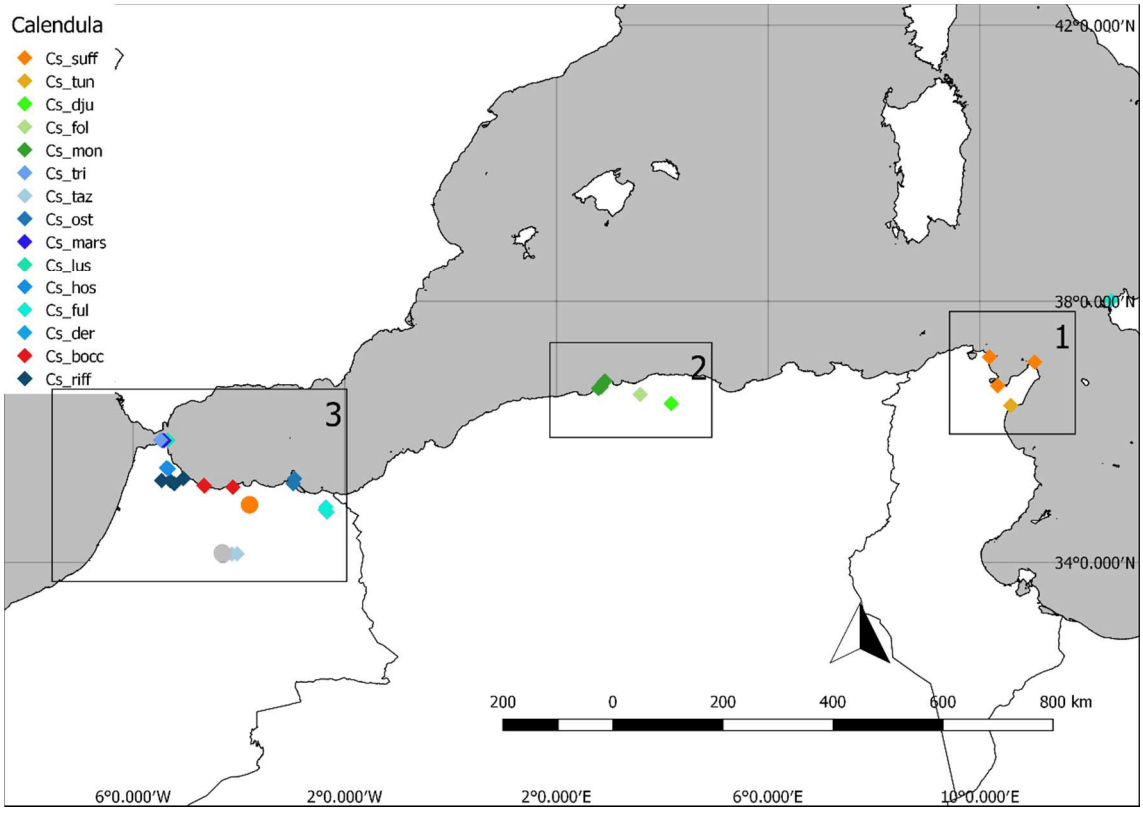
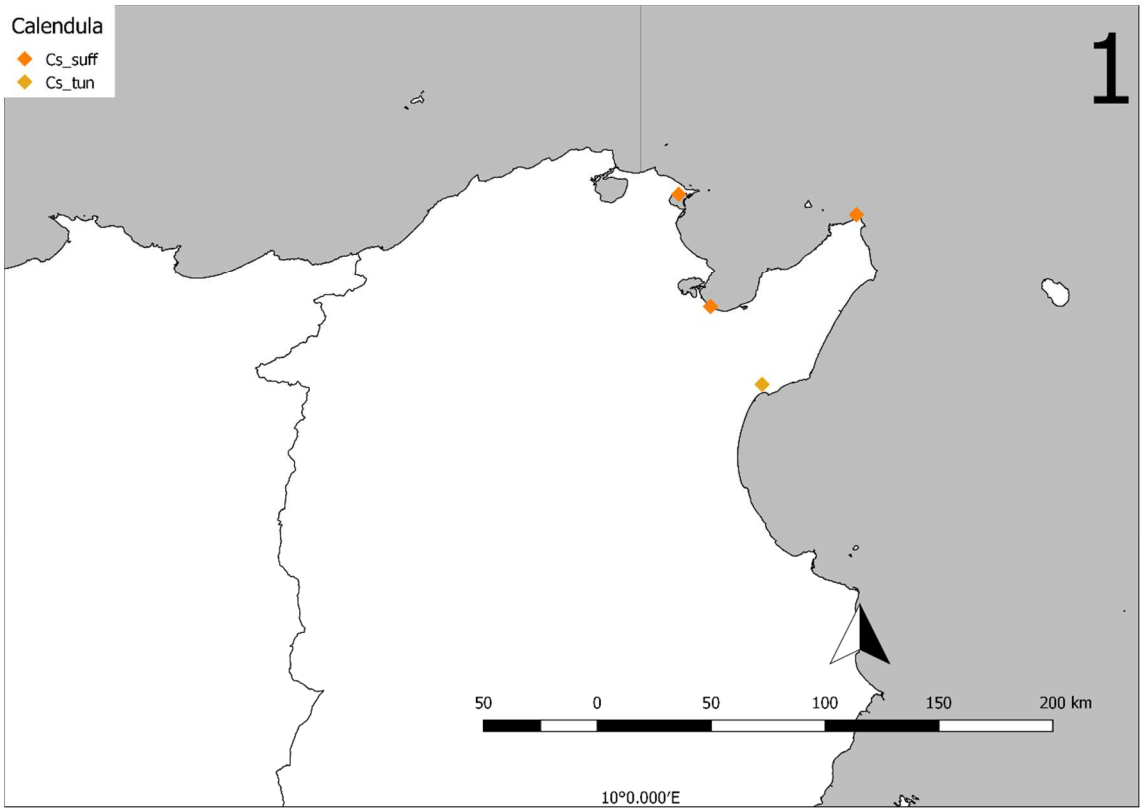
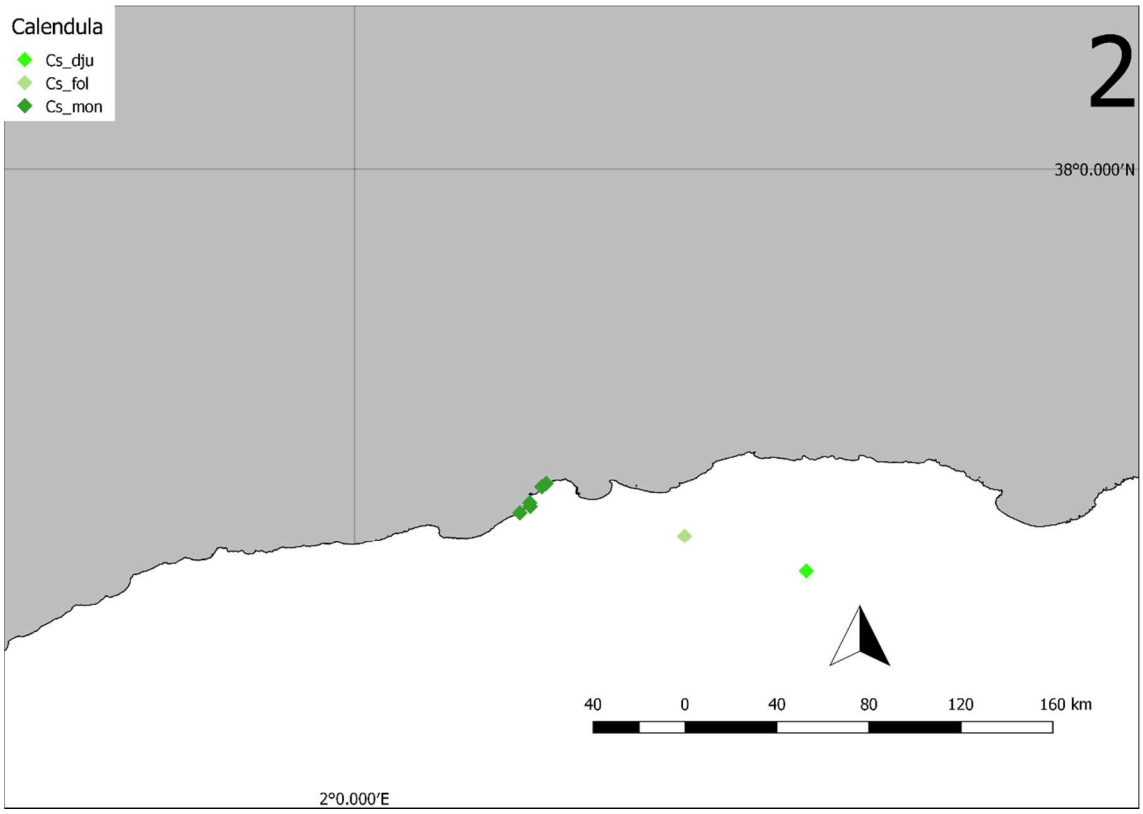


Figure 63 – Geographic distribution of the species included in the *C. maroccana* group.




Calendula
Cs_suff
Cs_tun
1
50 0 50 100 150 200 km
10°0.000'E


Calendula
Cs_dju
Cs_fol
Cs_mon
2
38°0.000'N
40 0 40 80 120 160 km
2°0.000'E

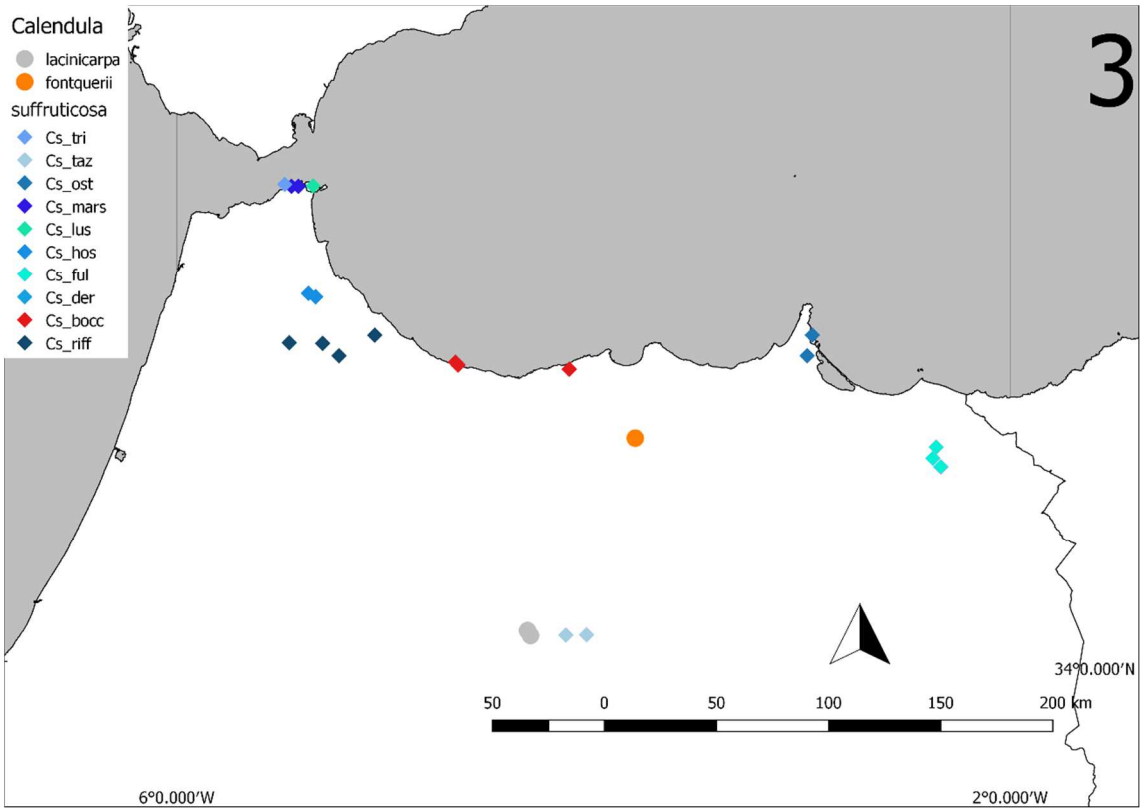


Figure 64 – Geographic distribution of *C. suffruticosa* in Morocco, including taxa from Algeria and Tunisia. 1. *C. suffruticosa* taxa in Tunisia. 2. *C. suffruticosa* taxa in Algeria. 3. *C. suffruticosa* taxa in Morocco.

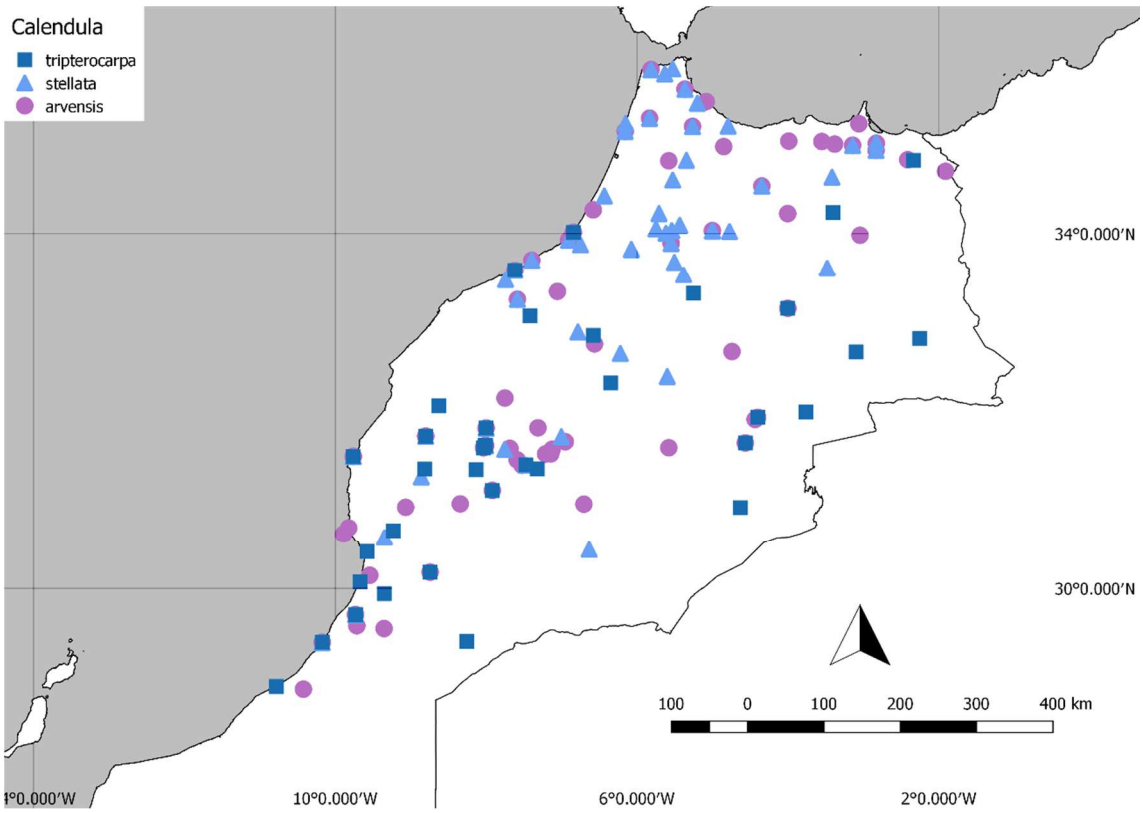


Figure 65 – Geographic distribution of *C. arvensis*, *C. stellata*, and *C. tripterocarpa* in Morocco.

Conservation assessments

Some of the *Calendula* species are widespread and co-occur, more or less, in the same areas, like *C. arvensis*, *C. stellata* and *C. tripterocarpa* (Figure 65), which are found in most of the North African countries. These species were assessed least concern (LC). The cultivated (*C. officinalis*) was not analysed in this study. Unfortunately, detailed information of endemism/conservation assessments of Algerian and Tunisian *Calendula* is not available, but we know that some taxa are restricted to some of these regions. For the three species with only one population (*C. fontquerii*, *C. davisii* and *C. meuselii*), the assessed category of threat was critically endangered (CR). For the three species with two or three known populations (*C. lanzae*, *C. pinnatiloba* and *C. murbeckii*), the assessed category of threat was endangered (EN). Only *C. eckerleinii* assessed as Vulnerable (VU), and *C. maroccana* widely distributed in High Atlas Mountains assessed as least concern (LC). For the majority of *C. suffruticosa* subspecies, Data Deficient or critical endangered (CR) were assessed, most of them from Algeria and Tunisia. The ones assessed as Data Deficient need a future careful analysis based on further field surveys.

Table 17 – Chromosome numbers and genome size in *Calendula* taxa from SW Mediterranean (Morocco, Algeria and Tunisia).

Heyn et al. (1974)	Ohle (1975 a)	Ohle (1975b)	This study	Acronym	*2n*	Genome size (2C/pg)
						Mean ± SD
C. arvensis			*C. arvensis*[1]	Carv	44	5.23 ± 0.29
C. stellata			*C. stellata*[1]	Cste	14	2.11 ± 0.10
C. tripterocarpa			*C. tripterocarpa*[1]	Ctrip1	30	3.52 ± 0.12
	C. maroccana group		*C. maroccana* group			
	C. eckerleinii		*C. eckerleinii*	Ceck	18	1.74 ± 0.08
			*C. fontquerii***	Cfont	18	1.69 ± 0.10
			*C. davisii***	Claci	18	1.76 ± 0.05
	C. lanzae		*C. lanzae*	Clan	18	1.85 ± 0.08
	C. maroccana subsp. *maroccana*		*C. maroccana*	Cmar	18	1.59 ± 0.14
	C. meuselii		*C. meuselii*	Cmeu	18	1.71 ± 0.03
	C. maroccana subsp. *murbeckii*		*C. murbeckii**	Cmurb	18	2.07 ± 0.14
			*C. pinnatiloba***	Cpinn	18	2.09 ± 0.15

*nomenclatural changes; **new taxa described.

Table 17 – Continued.

Heyn *et al.* (1974)	Ohle (1975 a)	Ohle (1975b)	This study	Acronym	2n	Genome size (2C/pg)
						Mean ± SD
		C. suffruticosa group	*C. suffruticosa* group	C suff		
		C. suffruticosa subsp. *balansae*	*C. suffruticosa* subsp. *balansae*[1]	Cs_bal	32	––
			C. suffruticosa subsp. *boccoyana***	Cs_boc	32	3.17 ± 0.06
		C. suffruticosa subsp. *boissieri*	*C. suffruticosa* subsp. *boissieri*[1]	Cs_boi	32	—–
			C. suffruticosa subsp. *dercana*	Cs_der	32	3.00 ± 0.07
			C. suffruticosa subsp. *djurdjurensis*	Cs_dju	32	3.10 ± 0.14
			C. suffruticosa subsp. *foliosa**	Cs_fol	32	3.08 ± 0.04
			C. suffruticosa subsp. *hosmarensis***	Cs_hos	32	3.10 ± 0.10
		C. suffruticosa subsp. *fulgida*	*C. suffruticosa* subsp. *fulgida*	Cs_ful	32	3.06 ± 0.21
			C. suffruticosa subsp. *lusitanica*	Cs_lus	32	3.36 ± 0.15
		C. suffruticosa subsp. *monardii*	*C. suffruticosa* subsp. *monardii*	Cs_mon	32	2.86 ± 0.07
			C. suffruticosa subsp. *marsea***	Cs_mar	32	3.44 ± 0.12
			C. suffruticosa subsp. *osteni***	Cs_ost	32	2.96 ± 0.05
			C. suffruticosa subsp. *riffiniensis***	Cs_riff	32	3.06 ± 0.10
		C. suffruticosa subsp. *suffruticosa*	*C. suffruticosa* subsp. *suffruticosa*	Cs_suff	32	3.28 ± 0.07
			C. suffruticosa subsp. *tazzea***	Cs_taz	32	3.42 ± 0.07
		C. suffruticosa subsp. *tlemcensis*	*C. suffruticosa* subsp. *tlemcensis*[1]	Cs_tlem	32	—–
			C. suffruticosa subsp. *trialata*	Cs_tri	32	3.21 ± 0.05
		C. suffruticosa subsp. *tunetana*	*C. suffruticosa* subsp. *tunetana*	Cs_tun	32	3.39 ± 0.08

*nomenclatural changes; **new taxa described; [1]taxa not included in this taxonomic treatment.

Taxonomic treatment

A taxonomic revision of the genus *Calendula* in Morocco including some taxa from Algeria and Tunisia is presented. Treatments for other areas are under preparation and planned to be published.

Calendula Linnaeus (1753: 921). **Lectotype** (designated by Green in Hitchcock & Green 1929: 183): — *C. officinalis* Linnaeus (*vide* M. L. Green in A. S. Hitchcock & M. L. Green, Prop. Brit. Bot. 183. Aug 1929).

Annual (to short-lived perennial) or perennial herbs, sometimes woody at the base, habit various but most commonly erect, or prostrate to ascending, often with glandular and aromatic, and non-glandular hairs. Leaves alternate, undivided, rarely pinnatisect; spatulate, obovate, oblanceolate, lanceolate, or linear-oblong, one nerved, apex acute to obtuse; base attenuate, truncate or auriculate; margins sub-entire, sinuate-dentate, or ± irregularly sinuate-dentate to pinnatisect; glandular or non-glandular pubescent; the middle and upper cauline leaves progressively smaller and small stalked towards the apex, oblanceolate to lanceolate, usually auriculate. Capitula terminal, solitary, radiate, heterogamous. Involucre bracts campanulate, 1–2 rows, sub-equal, herbaceous, linear-lanceolate, acute, with a narrow scarious-hyaline margin, glandular and non-glandular hairs. Receptacle flat-convex, glabrous. Florets dimorphic; ray florets ligulate, female, fertile, yellow or orange, 1–2 rows rarely more; disc florets tubular, male with a rudimentary ovary, yellow, orange, brown or violet-purple, 5–lobed; anthers sagittate-caudate. Achenes heteromorphic, the outer rostrate, less common bialate or trialate achenes; middle usually cymbiform, sometimes bialate, trialate or sub-cymbiform achenes; the internal vermiculate-alate or vermiculate-exalate.

Key to the species of *Calendula* in Morocco

1. Annual to short-lived perennial plants 2

   Perennial plants 7

2. Ligules, less than twice the length of the involucre 3

   Ligules, more than twice the length of the involucre 4

3. Outer achenes trialate, with the margin of the wings entire ..... ***C. tripterocarpa***

   Outer achenes rostrate or bialate with the margin of the wings deeply incised ..... ***C. arvensis***

4. Leaves with the margin entire; disc florets violet-purple; trialate achenes absent and bialate achenes, when present, with the margins of the wings deeply incise with triangular teeth..... ***C. stellata***

   Leaves with the margin repand-dentate with the teeth more or less prominent or pinnatifid; disc florets yellow-orange, more rarely, violet-purple; trialate achenes present, or not and bialate achenes, when present, with the margins entire or with teeth not deeper than half of the width of the wing.....5

5. Trialate achenes with lateral wings deeply pinnately cut into segments with truncate apices, usually present; bialate achenes never present ..... ***C. murbeckii***

   Trialate achenes, when present, with the margins entire or inconspicuously toothed; bialate achenes predominant.....6

6. Leaves pinnatifid; capitula concolorous..... ***C. lanzae***

   Leaves not pinnatifid, with the margin repand-dentate with the teeth more or less prominent; capitula concolorous or, less frequently, discolorous ..... ***C. pinnatiloba***

7. Capitula appearing on the apex of stems usually branched and bearing cauline leaves; cymbiform and sub-cymbiform achenes, when present, usually with ventral wings; plants with *2n* =32 chromosomes ..... ***C. suffruticosa***

   Capitula appearing on the apex of unbranched stems and not bearing cauline leaves for near half of its length, or with them very small; cymbiform achenes, when present, without ventral wings; plants with *2n* =18 chromosomes 8

8. Leaves mostly densely white-arachnoid pubescent.....9

   Leaves mostly glabrous or glandular pubescent.....10

9. Margin of the leaves repand-dentate; rostrate achenes (5.8) 6.5–8.1 (8.7); bialate achenes absent, trialate achenes with lateral wings entire..... ***C. fontquerii***

   Margin of the leaves entire; rostrate achenes (12) 14.5–17; bialate achenes present, trialate achenes with lateral wings repand-dentate ..... ***C. meuselii***

10. Margin of the leaves entire; trialate achenes with lateral wings deeply incise dentate ..... ***C. davisii***

    Margin of the leaves repand-dentate, trialate achenes with lateral wings entire to sinuate-dentate 11

11. Cymbiform achenes absent; vermicular achenes falcate or hook-shaped .....***C. eckerleinii***

    Cymbiform achenes present; vermicular achenes circular to hemicyclic ..... ***C. maroccana***

C. arvensis Linnaeus (1763: 1303); Desfontaines 1799; Battandier and Trabut 1902; Pitard 1913; Jahandiez and Maire (1934); Quezel and Santa (1963: 967); Heyn et al. 1974; Potteier-Alapetite 1981; Valdés 2002; Fennane and Ibn Tattou 2005; Dobignard and Chatelain 2011; Gonçalves et al. 2014. Lectotype (designated by Heyn et al. 1974)**:—** EUROPE: '*in Europae arvis*', *Löfling s.n* (LINN! [1035.1]).

Heterotypic synonyms*:*

C. arvensis var. *micrantha* Ball (1878: 516). **Type:** ITALY: Sicily, Palermo, *s. coll. s.d.*, (holotype: S-G-1106)

C. aegyptiaca Persoon (1807: 492). Quezel and Santa (1963: 966)

C. aegyptiaca var. *ceratosperma* (Viv.) Pamp. (1931: 450)

C. ceratosperma Viviani (1824: 59)

C. aegyptiaca subsp. *ceratosperma* (Viv.) Murbeck (1897: 102)

C. crista-galli Viviani (1824: 59)

C. aegyptiaca var. *crista-galli* (Viv.) Bég. & A.Vacc. (1912: 66)

C. sancta subsp. *crista-galli* (Viv.) Gallego & Talavera (1983: 103)

C. aegyptiaca var. *exalata-longirostris* Lanza (1919)

C. aegyptiaca var. microcephala Boissier (1875)

C. aegyptiaca var. suberostris Boissier (1875)

C. bicolor Raffiniesque (1810: 82)

C. arvensis var. bicolor (Rafinesque) Font Quer (1838)

C. officinalis var. hydruntina Fiori (1904)

C. hydruntina (Fiori) Lanza (1919)

C. arvensis subsp. hydruntina (Fiori) Lanza (1919)

C. arvensis subsp. macroptera Rouy (1903)

C. parviflora Raffiniesque

C. arvensis var. parviflora (Rafinesque) Battandier (1889)

C. malacitana Boissier & Reuter (1852)

C. malvaecarpa Pomel (1874)

C. platycarpa var. *malvaecarpa* (Pomel) Battandier (1889)

C. sancta L. (1763 : 1304). Lectotype (designated by Heyn *et al.* 1974: 170)**:—** PALAESTINA, s.d., *Hasselquist & Linnaeus* (LINN! [Herb. Linn. Nº 1035.2]).

C. arvensis Battandier

C. subinermis Pomel (1874)

C. sicula var. *hymenocarpa* Candolle

C. stellata var. *hymenocarpa* (Candolle) Cosson & Kralik (1857)

C. aegyptiaca var. *hymenocarpa* (Candolle) Pamp. (1914)

C. aegyptiaca var. *intermedia* (Cosson & Kralik) Pamp.

C. stellata var. *intermedia* Cosson & Kralik (1857)

C. arvensis var. *echinata* Ball (1878)

C. gracilis Candolle (1838). **Type:—**IRAN. Karabagh: circa castellum Schachlagh, 1832, *F. E. L. Fischer s.n.* (syntype G00472406!)

C. persica C.A. Mey. (1831)

Annual herbs. Stems (2) 17.3–45.5 (80) cm long, ascending to erect, sometimes decumbent, branched at the base, with glandular and non-glandular hairs, in varying proportions, ± viscous. Basal leaves (1.2) 2.4–4.8 (6.5) × (0.2) 0.4–0.8 (1.1) cm, (0.3) 0.3–0.5 (0.5) mm thick, oblanceolate, acute or obtuse, margin sub-entire to sinuate-dentate, base attenuated in a ± longer petiole, with glandular and non-glandular hairs; the middle and upper cauline leaves progressively smaller towards the apex, oblanceolate to lanceolate, sessile and usually auriculate. Capitula solitary, (1) 1.2–1.4 (2) cm of in diameter. Outer achenes rostrate (5) 7.1–11.7 (15.2) × (0.8) 1.3–1.9 (2.7) mm, usually strongly curved and with long spines at the back, usually with two small teeth, one at the base and another at the apex, sometimes bialate (8.3) 10.8–12.4 (13.3) × (7.2) 7.7–9.3 (10.2) mm, with two wings, with irregularly incise margins, extended along both sides up to the apex; middle achenes cymbiform (4.8) 6.7–8 (8.5) × (3.8) 5.3–7 (8) mm, sometimes lacking; inner achenes vermicular-alate (3.5) 3.8–5.2 (5.8) × (2) 2.7–3.3 (3.7) mm, hook-shaped to circular, with two narrow lateral wings, and/or vermicular-exalate (3.2) 3.7–4.5 (5.3) × (1.2) 1.2–1.7 (1.8) mm, circular.

Habitat and distribution: Dispersed throughout the North Africa in waste grounds, cultivated fields and grasslands or in the margin of roads and ditches, up to 1300 m. The remainder of its native range embraces also Central and South Europe, SW Asia and Macaronesia. Introduced in other parts of the globe such as Australia and California.

Conservation status: This species is a widely spread plant in the study area, and in the circum-Mediterranean region, including central Europe and the Middle East. It inhabits ruderal and wastes grounds and, currently, it does not face any major threat. Therefore, we propose to assess it as Least Concern (LC) for Morocco.

Chromosome number: *2n* = 44.

Genome size: 5.23 ± 0.29 pg.

C. davisii A.C. Gonç. & P. Silveira ***sp. nov.*** **Type:** —MOROCCO. NW foot of Jbel Tazzeka (W of Taza), 350–400 m, [34°09' N, 4°19' W], 14 April 1971, *Davis 51 257* (holotype BM! [813 587], isotypes RNG!, E! [245 753]).

"C. maroccana" auct. Vogt & Oberprielier (2012: 198) *non* (Ball) Ball (1878: 517).

C. davisii seems close to *C. eckerleinii* and some forms of *C. maroccana*. It differs from the first by presenting leaves with margins entire and by having trialate or bialate achenes

with lateral wings deeply incised, and from the second by the margin of the leaves and by not presenting cymbiform achenes.

Perennial herbs, ± woody at the base. Stems (44) 45–57 (65) cm, erect to ascending, with glandular hairs. Basal leaves (3.5) 4.1–8 (10) × (0.5) 0.7–1.2 (2) cm, with (0.2) 0.3–0.4 mm thick, oblanceolate to spatulate, apex acute, margin entire to sub-entire, attenuated in a ± large petiole, with glandular hairs predominating in the lamina and white-aracnoid non-glandular hairs in the margin. Capitula solitary, ± 3.4 cm diameter, concolorous, yellow. Outer achenes rostrate (15) 18–22 (23) × (1.7) 1.9–2.3 (3) mm, ± straight or slightly curved, without dorsal spines, or with them very small; middle achenes bialate (11.7) 12.5–15.4 (16.2) × (6.7) 9–10.8 (12.2) mm, with a rostrum (2.5) 3–3.8 (4.5) mm, lateral wings incised, without dorsal wings but, sometimes, with small dorsal spines; or, less frequently, trialate 8.1–12.5 (12.7) × 6.9–11.7 (12.2) mm, with lateral and ventral wings incised, without dorsal wings but, sometimes, with small dorsal spines; inner achenes vermiculate-exalate (4.5) 4.9–6.0 (6.7) × (1.3) 1.5–1.7 (1.8) mm, hemicyclic to hook-shaped, with a small basal ventral tooth.

Habitat and distribution: Limestone cliffs with some intrusion of granites, at 350–530 m elevation and is found growing under a semi-arid to sub-humid Mediterranean bioclimate. Endemic to Morocco restricted to the eastern slope of Jbel Tazzeka in Taza (Morocco) – Figure 66

Conservation status: This species is under numerous threats, especially climate change (extreme weather and drought). It is rare and with a small-restricted range, since only one subpopulation is currently known (the two points on the map belong to the same subpopulation) and few herbarium specimens are known (from the same locality). The species lives in a Natural Park, which might result in some protection. However, the number of mature individuals is estimated to be <50 based on field observations. The estimated area of occupancy is 8 km^2, which qualifies for CR. We propose to assess it as CR B1ab(iii, v)+2ab(iii, v), due to the reduced size of the population and of its habitat, which confers a high risk of extinction due to climate changes, or other unexpected threats.

Chromosome number: *2n* = 18.

Genome size: 1.76 ± 0.05 pg.

Notes: Neighbour of *C. suffruticosa* subsp. *tazzea* in the same region, *C. davisii* inhabits the east face of Jbel Tazzeka Mountains. Only one head flower was found in the field. The specific epithet *davisii* is in honour of the collector of the type specimen P.H. Davis.

C. eckerleinii Ohle (1975 a: 8). Valdés (2002: 671); Fennane and & Ibn Tattou (2005: 27); Gonçalves et al. (2014: 273). **Type:** —MOROCCO. Middle Atlas, Ifrane, 15 May 1955, *Meusel s.n.* (holotype HAL! [29 895]).

Heterotypic synonym:

C. suffruticosa var. *maroccana* (Ball) Maire in Jahandiez & Maire (1934: 789) *p.p. quoad distr*. "Moyen Atlas".

Perennial herbs, ± woody at the base. Stems (15) 33–45.5 (56) cm long, ascending to decumbent, with glandular hairs. Basal leaves (3.8) 4.6–7.0 (9.7) × (0.4) 0.6–1.1 (1.5) cm, with (0.2) 0.3–0.4 (0.5) mm thick, linear to oblanceolate, apex obtuse, margins sinuate-dentate, with glandular hairs predominating in the lamina and white-aracnoid non-glandular hairs in the margin. Capitula solitary, (2.7) 3.1–3.8 (5.2) cm diameter, concolorous, yellow. Achenes heteromorphic: outer achenes rostrate (7) 9.3–10.3 (12.2) × (1.3) 1.7–1.8 (2.2) mm, ± straight or slightly curved, without dorsal spines and ventral tooth; middle achenes trialate (5.7) 6.3–7 (7.8) × (2.5) 4.2–6.7 (7.8) mm, slightly curved, lateral wings sinuate-dentate, with a narrow ventral wing, without dorsal wings or spines; inner achenes vermiculate-exalate (3.3) 4.5–5.2 (5.8) × (1.3) 1.7–1.8 (2) mm, falcate or hook-shaped, sometimes with a small ventral wing.

Habitat and distribution: Limestone rocks, slopes or gravel of low and medium mountains, at 895–1950 m elevation, and is found in humid to sub-humid cold Mediterranean bioclimates. Endemic to Medium Atlas (Ifrane, Ain Leuh near Oued Oum-er-Rbia; Timahdite; Massif du Kandar; and Jbel Zalagh); with one population in Kef-el-Ghar WSW de Tainaste (?) – Figure 66

Conservation status: Some populations of this species are threatened by climate change, due to reduced range of habitat and lack of connection between some of the populations. The species is currently known from six subpopulations (6 locations) in the Medium Atlas Mountains. The species is rare and local with a small-restricted range. Both the estimated

extent of occurrence 17 871.722 km^2 and the estimated area of occupancy is 52 km^2, qualify for EN. Therefore, we propose its assessment as EN Bab(iii, v) +2ab(iii, v).

Chromosome number: 2*n* = 18.

Genome size: 1.74 ± 0.08 pg.

Notes: Widely distributed in the moist region of Ifrane, *C. eckerleinii* inhabits near *C. meuselii* in the Middle Atlas Mountains. According to Ohle (1975 a), the limits of this taxon may extend further towards Tlemcen (Algeria), however, no specimen of *C. eckerleinii* was found beyond the above-mentioned area. Moreover, later Ohle (1975b) described *C. suffruticosa* subsp. *tlemcensis* from Tlemcen, but no mention about *C. eckerleinii* in this region was made. Some authors (Fennane & Ibn Tattou (2005: 27); Valdés (2002: 671) also cited the *C. eckerleinii* for Jbel Tazzeka, but a different plant morphology was found in this region (see *C. davisii* described for Jbel Tazzeka). As *C. maroccana*, it was identified as *C. suffruticosa*, as well as *C. maroccana*, due to some similar morphologies (e.g. habit, basal leaves). Nevertheless, it was supposed to be at the origin of the *C. suffruticosa* group (*2n* = 32), from the cross of *C. eckerleinii* (*2n* = 18) and *C. stellata* (*2n* = 14) (Heyn & Joel 1983; Ohle 1975 a). The basal leaves of the populations nearby Ifrane have the narrowest leaves, with margins sinuate-dentate, while those from Jbel Zalagh and Oued Oum-er-Rbia have oblanceolate leaves, with margins sub-entire. This variation of basal leaves may be linked to environmental conditions (temperature, humidity, shade). In contrast with the description made by Ohle (1975 a), sometimes they present achenes trialate with a narrow ventral wing or with it reduced, resembling a bialate achene.

C. fontquerii A.C. Gonç. & P. Silveira ***sp. nov.*** **Type:** —MOROCCO. Bokkoya, 33 km from Imzouren, 740 m [34°54'46" N, 3°47'59" W], 13 May 2014, *Silveira & Gonçalves 3339* (holotype G!, isotype AVE!)

C. fontquerii seems close to *C. eckerleinii* but differs from it by its white-arachnoid indumentum and trialate achenes with margins sub-entire.

Perennial herbs, ± woody at the base. Stems (16) 30.3–44 (48) cm long, erect to ascending, with a mixture of glandular and white-aracnoid non-glandular hairs. Basal leaves (3.5) 4.5–7.1 (9.5) × (0.8) 0.9–1.3 (1.5) cm, with 0.3–0.4 (0.5) mm thick, oblanceolate to spatulate, apex acute, margins sinuate-dentate, with some glandular hairs, but predominantly white-arachnoid pubescent. Capitula solitary, (2.2) 2.6–3.6 (3.8) cm diameter, concolorous, yellow. Achenes heteromorphic: outer achenes rostrate (5.8) 6.5–8.1 (8.7) × 1.5–1.7 (1.8) mm (brevirostrate), ± straight or slightly curved, without dorsal spines; middle achenes trialate (5) 5.6–6.7 (7) × (3) 3.3–4.4 (5.8) mm, lateral and ventral wings sub-equal and sub-entire; inner achenes vermiculate-exalate (3.7) 3.8–4.8 (5) × (1.3) 1.5–1.7 mm, falcate, without ventral wing.

Habitat and distribution: Limestone rocks, at ± 740 m elevation, and grows under semi-arid Mediterranean bioclimates. Endemic to Bokkoya Mountains in Al Hoceïma (Morocco) – Figure 66

Conservation status: This species is under numerous threats, especially grazing, climate change and drought. The species is rare and local with a small-restricted range; only one subpopulation is currently known, intersected by a road. The number of mature individuals is estimated to be <50 based on field observations. The estimated area of occupancy is 8 km^2, which qualifies for CR. Although it is not known for sure if there are more populations or not, this is not very probable, so we propose to assess this species as CR B1ab(iii, v)+2ab(iii, v).

Chromosome number: *2n* = 18.

Genome size: 1.69 ± 0.10 pg.

Notes: The specific epithet is in honour of the well-known botanist Font Quer, who did important collections in the North of Morocco.

C. lanzae Maire (1928a: 138). Fennane and Ibn Tattou (1998: 23, 2005: 28); Gonçalves et al. (2014). **Neotype** (designated here): —MOROCCO. Aït-Massi, rochers gréseux près de Tirkou, 500–600 m, 21 April 1922, MAIRE *s.n.* (neotype MPU! [001956], isoneotype P! [00084055]).

Homotypic synonyms:

C. echinata subsp. *lanzae* (Maire) Maire in Jahandiez and Maire (1934: 788)

C. murbeckii subsp. *lanzae* (Maire) Maire (1938: 424) *p.p.*Anti Atlas

Heterotypic synonyms:

C. echinata subsp. *murbeckii* (Lanza) Maire in Jahandiez and Maire (1934: 788) *p.p. quoad distr.* "*Maroc Atlantique Moyen*" (S), High Atlas, Anti Atlas

C. echinata subsp. *murbeckii* var. *pinnatiloba* Maire in Jahandiez and Maire (1934: 788) *p.p. quoad distr.* "*Maroc Atlantique Moyen*" (S), High Atlas, Anti Atlas

Annual herbs. Stems (32) 45.8–78.5 (96) cm, ascending, with glandular hairs. Basal leaves (3.5) 4–6.5 (7.2) × (0.8) 1.2–2.1 (3) cm, with 0.2–0.3 mm thick, outline oblanceolate to obovate, apex acute to obtuse, margin deeply sinuate-dentate to ± irregularly pinnatipartite, not wavy, glandular pubescent. Capitula solitary, (1.1) 2.2–3 (3.8) cm diameter, concolorous, yellow to orange. Achenes heteromorphic: outer achenes rostrate (12) 14.8–17.3 (21) × (1.3) 2.3–3.2 (4.2) mm, ± straight or slightly curved, with dorsal spines or muricate, sometimes with a apical ventral tooth; middle achenes bialate (8.7) 9.7–10 (10.5) × (5.8) 7.1–9 (9.2) mm, with lateral wings sinuate-dentate; and cymbiform (5.2) 5.7–6 (6.3) × (2.8) 3.8–4.9 (5) mm, with two ventral teeth, one basal and one apical; inner achenes vermiculate-alate (5) 5.3–6.5 × (4.2) 4.3–4.5 mm, circular to hemicyclic; with a small ventral wing; vermiculate-exalate (3.7) 4.1–4.6 (5) × (1.3) 1.5–1.7 (1.8) mm, circular to hemicyclic; both with small apical and/or basal teeth.

Habitat and distribution: Gravel riverbeds, mostly composed of limestone, at 200–600 m elevation and is found in semi-arid to arid Mediterranean bioclimates. Endemic to Morocco with a restricted distribution to the Anti-Atlas in Tirkou near Bigoudine; Aït-Yazza and Tiout – Figure 66.

Conservation status: This species is under numerous threats, especially climate change (extreme weather and drought) urbanization and water pollution. It is rare, with two currently known populations, while only Maire has collected in the classical population, at Tiout. The number of mature individuals is estimated to be <250 (100-150 individuals) based on field observations. The estimated extent of occurrence is 62.781 km^2, which qualifies for CR and the estimated area of occupancy is 12 km^2, which qualifies for EN. Therefore, we propose to assess this *taxon* as CR C2a(I)EN B1+2ab(iii).

Chromosome number: $2n = 18$.

Genome size: 1.85 ± 0.08 pg.

Notes: In the protologue, Maire mentioned that the holotype of *C. lanzae* is "*in rupestribus arenaceis et in arganietis clivi meridionalis Atlantis Majoris: in valle amnis Aït-Moussa prope Tirkou, 500–600 m, ubi martio et aprili floret*" housed at AL and RAB herbaria. Despite the several attempts, no type of *C. lanzae* was found in these herbaria. Most of Maire's collection was transferred to MPU herbarium, where a specimen collected in 1922 (duplicated at P herbarium) was found, which corresponds to the description of *C. lanzae*. The specimen with a label in Maire's hand that reads "*Aït-Massi, rochers gréseux près de Tirkou, 500–600 m, 21 April 1922*." Therefore, a neotype is designated here (Art. 9.7 of the ICBN, McNeill et al. 2012). Besides the characteristic of the achenes, *C. lanzae* differs from other taxa of the *C. maroccana* group by having pinnatisect leaves. Ohle (1974a) seemed to have included specimens of what we now call *C. pinnatiloba*, with discolorous capitula, under *C. lanzae*.

C. maroccana (Ball) Ball (1878: 517). Valdés (2002: 672); Fennane and Ibn Tattou (2005: 28). Basionym: *C. suffruticosa* subsp. *maroccana* Ball (1873: 367). **Lectotype** (corrected here): —MOROCCO. Greater Atlas, Seksaoua, May 1871, *Hooker s.n.* (K! [000307201]).

Homotypic synonyms:

C. maroccana subsp. *maroccana* (Ball) B.D. Jackson (1893: 383) *comb. illeg.*

C. suffruticosa var. *maroccana* (Ball) Maire *in* Jahandiez & Maire (1934: 788) *p.p. quoad distr.* "High Atlas" and "Anti Atlas".

Heterotypic synonym:

C. echinata subsp. *murbeckii* (Lanza ex Murb. 1923: 59) Maire in Jahandiez and Maire (1934: 788) *p.p. quoad distr.* High Atlas, Anti Atlas.

C. maroccana subsp. *murbeckii* (Lanza ex Murb. 1923: 59) Ohle (1975 a: 13) *p.p. quoad spec.* Tachokcht, 8 June 1936, *Balls 2691* (BM!, K!, RAB!, E!).

Perennial herbs. Stems (7.5) 21–38 (58) cm, erect to ascending, with glandular or, sometimes, white-aracnoid, hairs. Basal leaves (4.2) 5.3–10 (13.1) × (0.4) 0.6–1.1 (2.8)

cm, with 0.3–0.4 (0.6) mm thick, oblanceolate to spatulate, apex acute, margin slightly sinuate-dentate, glandular pubescent in the lamina, and glandular or white-aracnoid pubescent in the margin. Capitula solitary, (1.6) 3.2–4 (4.7) cm diameter, concolorous, yellow. Achenes heteromorphic: outer achenes rostrate (8.3) 9.5–13.7 (14.3) × (1) 1.2–1.7 mm, ± straight or slightly curved, without dorsal spines or muricate; middle achenes usually trialate, (5) 5.8–8.7 (10.2) × (4.2) 4.6–7.5 (8.7) mm, with lateral wings entire to, more rarely, sinuate-dentate; cymbiform (5.8) 6.1–6.7 × 3.5–4.1 (4.2) mm, with basal and apical teeth; inner achenes vermiculate-exalate (2.7) 2.8–5.5 (5.8) × 1.2–1.6 (1.7) mm, circular to hemicyclic; with a small ventral wing and/or with apical and/or basal teeth.

Habitat and distribution: Various substrates from rocky to sandy especially in limestone cliffs, between 980?–3000 m elevation, and is found in sub-humid Mediterranean bioclimates; Endemic to High Atlas Mountains (Amizmiz, Asni, Igherm, Tachokcht, Taroudant, Tizi-n-Test, Tizi-n-Tichka, etc) – Figure 66.

Conservation status: This species is under numerous threats, especially agricultural intensification, grazing, climate change, development (tourism in the Atlas area, leisure activities), and human interference. The species is currently known from 13 subpopulations in the High Atlas Mountains. The number of mature individuals is estimated to be >10 000, based on field observations. The estimated extent of occurrence is 17 871.722 km^2, which qualifies for VU and the estimated area of occupancy is 52 km^2, which qualifies for EN. Considering the number of populations and that it occurs at different elevations, despite all the threats we propose to assess it as LC.

Chromosome number: *2n* = 18.

Genome size: 1.59 ± 0.14 pg.

Notes: Ohle (1975 a, 10) mentioned the lectotype as to be: *"Marokko, Marrakech, leg. Hooker 1871* (K)*"*, but it is an error to be corrected. In K herbarium, one folder with three sheets was found, one sheet with three specimens and two separate specimen's sheets with different labels, collector, date and location. Ohle (1975 a) "*clearly indicated the type element*" (Art. 7.10, before 2001 of the ICBN, McNeill et al. 2012) as to be the collection at K as the "*lectotype*," but the number and locality are not in agreement with the prologue (Ball 1873, 1878). Nevertheless, there is no *C. maroccana* in "*N of the city*" (Marrakech), but instead *C. murbeckii*. Our data suggest that *C. maroccana* and *C.*

murbeckii are distinct taxa. In this study, the correct lectotype of *C. maroccana* is presented, because in the last revision of the genus some confusion was made by Ohle (1975 a).

C. meuselii Ohle (1975 a: 6). Fennane & Ibn Tattou (1998: 23, 2005: 28); Valdés (2002: 672); Gonçalves et al. (2014: 271). **Neotype** (designated here): —MOROCCO. Meknès, Zerhoun, 11 April 1955, *Pailler 841* (RAB!).

Heterotypic synonym:

C. suffruticosa subsp. *marginata* var. *balansae* (Boiss. & Reut. in Boissier 1859: 107) Maire in Jahandiez & Maire (1934: 789) *p.p. quoad distr.* "*Maroc Central, partie septentrionale*" (Mont Zerhoun). Lectotype (designated here): — ALGERIA, *Oran, dans les sables avoisinant la Batterie espagnole, 20 April 1852*, *Balansa 515* (G! [G00386549]).

Perennial herbs. Stems (15.5) 18.1–44.3 (57) cm long, erect to ascending, densely white-arachnoid pubescent, not viscous. Basal leaves (4.4) 4.6–8.4 (10) × (1.3) 1.4–2.3 (2.4) cm, with (0.2) 0.3–0.5 (0.6) mm thick, oblanceolate to spatulate, apex acute to slightly acuminate, margins entire to sub-entire, densely white-arachnoid pubescent. Capitula solitary, (2) 3.3–3.8 (4.5) cm diameter, concolorous, yellow to orange. Achenes heteromorphic: outer achenes rostrate (12) 14–17 × (1.8) 2–2.3 (3.3) mm, ± straight or slightly curved, without dorsal spines or muricate; middle achenes bialate (9.7) 10.2–11 (11.7) × (4.7) 5.3–7 (7.5) mm, with a rostrum (1.3) 1.7–2.2 (3.3) mm, lateral wings sinuate-dentate, sometimes with a rudimentary ventral wing; inner achenes vermiculate-exalate (5.8) 6.3–7.3 (7.8) × (1.7) 2–2.3 (2.7) mm, falcate with a small ventral wing, or with an apical and/or a basal tooth

Habitat and distribution: Limestone cliffs at 650–800 m elevation and is found in sub-humid to humid Mediterranean bioclimates. Endemic to Massif du Zerhoun, Jbel El–Rherraf near Sidi Kdat, and Jbel Takerma (distribution that is, based on herbarium specimens and literature).

Conservation status: This species is threatened by climate change, due to its small-restricted range; the team currently knows only one population, but there may be others in the Massif of Zerhoun (based on herbarium specimens), although we have known, that,

other researchers have recently searched for it, unsuccessfully. The number of mature individuals is estimated to be <50 based on field observations. The estimated area of occupancy, based in the only subpopulation known by the team, is 4 km^2, which qualifies for CR. This result in a categorisation of CR B1ab(i, ii, iv, v)+2ab(i, ii, iv,v) – Figure 66.

Chromosome number: *2n* = 18.

Genome size: 1.71 ± 0.03 pg.

Notes: Several unsuccessful attempts have been made to find the type. We know that the type was loaned to Ohle, but was never returned. Therefore, a neotype was selected to serve as a nomenclatural type of *C. meuselii* (Art. 9.6 of the ICNB, McNeill et al. 2012). Although the neotype has no capitula and achenes, it is the only duplicate at MPU herbarium. It is distinguishable from the remaining C. *maroccana* group species by having leaves with very dense white-arachnoid indumentum, and by the absence of cymbiform and vermiculate-alate achenes. The vermiculate-exalate achenes are usually large and falcate. There is a specimen collected in Zoumi (MGC), but the team failed to found this population on the field. Two gatherings were originally indicated as types of *C. balansae* Boiss. & Reut., one collected by Balansa (nº515) and other by Boiss. & Reut. themselves (v. Boissier 1859: 107). We prefer to select Balansa's collection as type, as it seem to have been the first collected and is more complete.

C. murbeckii Lanza ex Murb. (1923: 59). Maire (1928b: 56) *p.p. excl. spec.* Mogador; Jahandiez & Maire (1941: 1152); Nègre (1958:1-7, 1962: 300). **Type**: —MOROCCO. Environs de Marrakech: Aviation, champs arides, 1921, *Murbeck s.n.* (holotype LD! [1217767]; syntype MPU! [00819]).

Homotypic synonyms:

C. echinata subsp. *murbeckii* (Lanza ex Murb. 1923 : 59) Maire in Jahandiez & Maire (1934: 788) *p.p. quoad distr. "Maroc meridional steppique"*.

C. maroccana subsp. *murbeckii* (Lanza ex Murb. 1923: 59) Ohle (1975 a: 13) *p.p. excl. distr.* Mogador, Agadir and Tachocht

Annual to short-lived perennial herbs. Stems (6) 22–46 (89) cm long, ascending to diffuse, with glandular hairs. Basal leaves (2.5) 3.5–6.7 (9) × (0.2) 0.3–0.6 (1.1) cm, with (0.2) 0.3–

0.4 (0.6) mm thick, linear to oblanceolate, apex acute to slightly acuminate, margins sinuate-dentate, with acute teeth, to ± irregularly pinnatifid, glandular pubescent. Capitula solitary, (2) 2.7–3.4 (4.7) cm diameter, concolorous, yellow to orange. Achenes heteromorphic: outer achenes rostrate (14) 16.3–23 (26) × (1.2) 1.5–1.8 (3.3) mm, ± straight or slightly curved, with dorsal spines or muricate; middle achenes trialate (8.3) 9–10.5 (11.3) × (5) 5.8–8.3 (10.8) mm, lateral wings deeply pinnately cut into segments with truncate apices; inner achenes vermiculate-alate (3.8) 4.3–5.6 (6) × (2.2) 3.1–5.6 mm, with basal and apical teeth; and vermiculate-exalate (3.3) 3.8–4.5 (4.7) × (1) 1.2–1.3 (1.7) mm, both circular to hemicyclic.

Habitat and distribution: Clay-limestone rocks, between 20–150 m a.s.l., and is found in arid Mediterranean bioclimates. Endemic to Morocco with a distribution restricted to Marrakech (Jbilet and Lalla Takerkoust) – Figure 66.

Conservation status: This species is under numerous threats, especially climate change, drought, development (infrastructures, urbanisation), human interference and grazing. The species is rare and local with a small-restricted range; at present, we only know two populations, one in a reserve of gazelles and another near the Lalla Takerkoust barrage. The classic population disappeared due to the development of the airport. The number of mature individuals is estimated to be <250 based on field observations. The estimated extent of occurrence is 124.946 km^2 and the estimated area of occupancy is 12 km^2, both qualifying for EN. There was an observed and is projected a future continuing decline in the extent of occurrence, the area of occupancy, area, extent and quality of the habitat, number of locations/subpopulations and number of mature individuals. Therefore, we propose to assess it as EN B1ab(i, ii, iii, iv, v) +2ab(i, ii, iii, iv, v), C2a(i), D.

Chromosome number: $2n = 18$.

Genome size: 2.07 ± 0.14 pg.

Notes: Lanza described this species has displaying only trialate and vermiculate achenes, without specifying which type of vermiculate achenes (alate or exalate). Later Maire confirmed, that they have found rostrate, trialate, cymbiform and vermiculate-exalate achenes. We have not seen any specimen (field or herbaria) with cymbiform achenes. So, two hypotheses are raised, either Maire considered as cymbiform the vermicular-alate achenes, or the specimen he observed was a hybrid. We observed in the field that two, or

more, different combinations of achenes may appear in the fruiting capitula. For example, we observed plants with rostrate, trialate, vermiculate-alate and vermiculate-exalate achenes and others lacking the trialate achenes. Nègre (1958) made some observations about *C. murbeckii* under cultivation: the first generation came out with the same characteristics, the *second* generation displayed intermediate characteristics between *C. stellata* and *C. murbeckii*. However, we cannot exclude that this variability result from cross-pollination with some *C. stellata* that he had growing in the garden at the same time. Maire (Jahandiez and Maire 1934: 788) synonymised all *C. murbeckii* specimens collected in the coastal of the Anti-Atlas region (*environs of Mogador, collines des Haha, Agadir, Sous*) under *C. echinata*, without seeing the type (G00457529 = *C. arvensis*) from Mogador. Later the same author (Maire 1938: 424) revised his description and elevated this taxon to species. We agree with this last option, particularly when comparing with *C. maroccana*, the species where *C. murbeckii* has been included by recent authors (e.g. Ohle, 1975?), due to the different life form, achene morphology and 2C values.

C. pinnatiloba Maire (1928c: 57) A.C. Gonç. & P. Silveira ***comb. nov.*** Basionym: *C. murbeckii* var. *pinnatiloba* Maire (1928b: 57); Maire (1938: 424). **Lectotype** (designated here):— MOROCCO. Agadir, Sud-Ouest du Maroc '*Par les soins de M. Beaumier,*' *Mardochee s.n.* (P! [02413663]).

Homotypic synonym:

C. echinata subsp. *murbeckii* var. *pinnatiloba* (Maire) Maire (Jahandiez and Maire 1934: 788) *p.p. quoad distr.* "*Secteur macaronésien marocain*".

Heterotypic synonyms:

C. suffruticosa var. *pinnatiloba* Cosson *in schedulis* ex Lanza (1919: 134) *nom. nudum.*

C. suffruticosa subsp. *ifniensis* Font Quer (1936: 16); Maire (1941: 1152). Lectotype (designated here): —MOROCCO. *In montibus Sidi Tual et Bu-Mesguida, in rupibus arenaceis*, 1 000 a 1 250 m alt., 14 April 1935, *Font Quer s.n.* (holotype: BC! [812047! and 812050!]).

C. maroccana subsp. *murbeckii* (Lanza) Ohle (1975 a: 13) *p.p. quoad distr.* Mogador, Agadir.

Annual herbs. Stems (14) 18–57.5 (70) cm long, diffuse to erect, with glandular hairs. Basal leaves (2.8) 4.2–5.6 (6.3) × (0.5) 0.7–1 (1.2) cm, linear to oblanceolate, apex acute to acuminate, margins sinuate-dentate with acute teeth, with glandular hairs. Capitula solitary, (1.8) 2.3-3.5 (3.9) cm, concolorous or discolorous. Achenes heteromorphic: outer achenes rostrate (10) 12–14 (15) × (1.5) 2.8–4.5 (5) mm, ± straight or slightly curved, without, or with small, dorsal spines, occasionally with a apical ventral tooth; middle achenes bialate, or sometimes trialate with similar dimensions, (5.8) 8.2–9.2 (11.2) × (5.8) 7–8.8 (10.5) mm, lateral wings sub-entire to sinuate-dentate; cymbiform (3.5) 4.2–5.2 (5.3) × (2.5) 2.8–3.5 (4.2) cm; inner achenes vermiculate-exalate (2.5) 3.3–4 (4.2) × (0.8) 1–1.3 (1.5) mm, circular to hemicyclic, with a small ventral wing or with apical and/or basal teeth.

Habitat and distribution: Clay -limestone rocks; coastal plains and hills, at 20–150 m elevation and is found in arid Mediterranean bioclimates. Endemic to Agadir, Aït-Baha, Tamanar, Adar-Ou-Aman, Cap Rhir and Sidi Ifni – Figure 66.

Conservation status: This species is under numerous threats, especially climate changes (in some places rise in sea level, extreme weather events) and urban development (coastal development, urbanisation, tourism). The species is currently known from about five subpopulations. The number of mature individuals is estimated to be <2 500 based on field observations and declining. The estimated extent of occurrence is 1 994.687 km^2, which qualifies for EN and the estimated area of occupancy is 20 km^2, which also qualifies for EN. Therefore, we propose its assessment as EN B1ab(ii, iii, iv, v) +21ab(ii, iii, iv, v).

Chromosome number: *2n* = 18.

Genome size: 2.09 ± 0.15 pg.

Notes: Maire (1928: 57) indicated several specimens (syntypes) in the description of this taxon. Therefore, there is the need to select one as type (lectotype). We prefer Mardochée's specimen, which is the oldest. Since Font Quer (1936: 16) cites two collections as types of is *C. suffruticosa* subsp. *ifniensis*, there is also the need to select one as type (lectotype).

C. stellata Cavanilles (1791, 3). Desfontaines (1799: 3048); Fennane and Ibn Tattou (1998: 24, 2009: 29); Valdés (2002: 671). **Type: —**AFRICA?: '*Plant grow from seeds*', *Lemmonier s.n* ([*fide* Heyn et al. 1974]).

Homotypic synonym:

C. arvensis var. *stellata* (Cav.) Lanza

Heterotypic synonyms:

C. algeriensis Boissier & Reuter (1859: 109). Lectotype (designated by ?) – ALGERIA: circa Alger, 1849, Boissier & Reuter s.n. (G photo! [00022976]).

C. sicula Willdenow (1809: 934)

C. arvensis var. sicula (Willd.) Quézel & Santa (1963)

C. bicolor Rafinesque (1810: 82)

C. bicolor var. *cossonii* Quézel & Santa (1963)

C. bicolor var. *faurelii* Quézel & Santa (1963)

C. bicolor var. *odettei* Quézel & Santa (1963)

C. vidalii Pau (Pau y Español 1924)

C. denticulata Schousb. In Willdenow (1809: 935)

Annual herbs. Stems (2) 17.3–45.5 (80) cm long, ascending to erect, sometimes decumbent, branched at the base, with glandular hairs predominating over non-glandular hairs, ± viscous. Basal leaves (1.2) 3–6,5 (10) × (0.4) 1.5–3 (4) cm, (0.3) 0.3–0.5 (0.5) mm thick, oblanceolate, acute or, more frequenty, obtuse, margin sub-entire to sinuate-dentate, base attenuated in a ± longer petiole, with glandular hairs predominating over non-glandular hairs, ± viscous; the middle and upper cauline leaves progressively smaller towards the apex, oblanceolate to lanceolate, sessile and usually auriculate. Capitula solitary, (2,5) 3–4 (5) cm of in diameter. Achenes heteromorphic: outer achenes rostrate (5) 7.1–11.7 (15.2) × (0.8) 1.3–1.9 (2.7) mm, usually strongly curved and with long spines at the back, usually with two small teeth, one at the base and another at the apex; sometimes bialate (8.3) 10.8–12.4 (13.3) × (7.2) 7.7–9.3 (10.2) mm, wings with irregularly incised margins, extended along both sides up to the apex; middle achenes

cymbiform (4.8) 6.7–8 (8.5) × (3.8) 5.3–7 (8) mm; inner achenes vermiculate-alate (3.5) 3.8–5.2 (5.8) × (2) 2.7–3.3 (3.7) mm, hook-shaped to circular, with two narrow lateral wings, and/or vermiculate-exalate (3.2) 3.7–4.5 (5.3) × (1.2) 1.2–1.7 (1.8) mm, circular.

Habitat and distribution: widespread taxon in Morocco, Algeria, Tunisia and Sicilia, occurring in ruderal and waste ground cultivated fields and grasslands or in the margin of roads and ditches, up to 1300 m.

Conservation status: Since this is a widespread taxon we assess it as least concern (LC), based on the IUCN criteria, for the study area.

Chromosome number: *2n* = 44.

Genome size: 2.11 ± 0.10 pg.

C. suffruticosa Vahl (1791: 94). Lectotype (designated by Ohle 1975b):—TUNISIA. '*Legi in montosis circa Portum Farinam Tuneti*', *Forskål s.n.* [not Vahl *fide* Ohle 1975b] (C! [100003279]).

Key to the subspecies of *C. suffruticosa*

1. Trialate achenes present 2

   Trialate achenes absent.....7
2. Basal leaves linear to narrowly oblanceolate ..... subsp. *tunetana*

   Basal leaves oblanceolate to spatulate.....3
3. Rostrate achenes curved forming and angle of aprox. 90º and with spines 0.5-1.5 mm on the dorsal face..... subsp. *djurdjurensis*

   Rostrate achenes strait, or not so curved, usually without spines 4
4. Plants with a predominantly white-arachnoid indumentum.....5

   Plants glabrous to glandulose 6
5. Trialate achenes (11.7) 12.4–13.8 (14.5) × (8.8) 9.1–9.2 mm, with length/width > 1.5.....subsp. *marsea*

Trialate achenes (6.3) 8.4–9.8 (10.3) × (5.3) 6–9.1 (10) mm, with length/width approx. 1 ..... subsp. *osteni*

6. Trialate achenes length (7.8) 8.5–9.2 (9.8) mm ..... subsp. *trialata*

   Trialate achenes length (7.7) 10.2–13.5 (16.2) mm ..... subsp. *monardii*

7. Middle achenes exclusively bialate (10.5) 13.5–16.1 (22) × (6.7) 8.5–11.1 (11.7) mm, with a rostrum (2.5) 3.3–4.5 (9.7) mm, lateral wings sinuate-dentate to incise dentate; inner vermiculate achenes falcate ..... subsp. *foliosa*

   Middle achenes not exclusively bialate, with another more predominant type of achene (sub-cymbiform or cymbiform), and/or smaller and margins entire or almost entire; inner vermiculate achenes ±circular, not falcate 8

8. Middle achenes sub-exalate or, at least, predominantly sub-exalate ..... subsp. *lusitanica*

   Middle achenes, not sub-exalate..... 9

9. Outer rostrate achenes length (17) 21.5–26.5 (29) mm, with conspicuous dorsal spines averaging 2 mm ..... subsp. *fulgida*

   Outer rostrate achenes smaller, without spines or with them much smaller or less abundant 10

10. Indumentum of leaves and stems predominantly white-arachnoid 11

    Indumentum of leaves and stems not predominantly white-arachnoid, ± glabrous to glandulose, or mostly glandulose with young parts ± white-arachnoid 12

11. Outer rostrate achenes length (5) 6–10.2 (13.5) mm, with 4-6 dorsal spines averaging 1 mm; middle achenes exclusively cymbiform ..... subsp. *dercana*

    Outer rostrate achenes length (7) 12.3–16.1 (17) mm, without dorsal spines; middle achenes cymbiform, sub-cymbiform and/or bialate ... subsp. *hosmarensis*

12. Indumentum of leaves and stems predominantly ± glabrous to glandulose..... 13

    Indumentum of leaves and stems mostly ± glabrous to glandulose but with young parts ± white-arachnoid 14

13. Rostrate achenes length (21) 24–30 (31) mm; cymbiform achenes width 5.8–7.3 (8.3) mm ..... subsp. *tazzea*

Rostrate achenes length (11) 16–23 (26) mm; cymbiform achenes width (6.7) 7.7–10.8 (11.8) mm .....subsp. *suffruticosa*

14. Ratio length/width of basal leaves (2.5) 2.7–4.2 (4.7); basal leaves thickness (0.2) 0.3–0.4 (0.5) mm ..... subsp. *riffiniensis*

    Ratio length/width of basal leaves (4.9) 5.0–6.3 (6.5); basal leaves thickness (0.3) 0.4–0.6 (0.8) mm ..... subsp. *boccoyana*

subsp. ***boccoyana*** A.C. Gonç. & P. Silveira ***subsp. nov.*** **Type:** —MOROCCO. Al Hoceïma, Bokkoya, Taoussarte, 133 m [35°13'08" N, 4°05'14" W], 14 May 2014, *Silveira & Gonçalves 3340* (holotype AVE!)

C. suffruticosa subsp. *boccoyana* seems close to *C. suffruticosa* subsp. *riffiniensis* but it has larger [(6.2) 8.5–9 (9.5) × (1.8) 2.1–2.8 (3) cm] and thicker [1.7–2.2] basal leaves.

Perennial herbs. Stems (17) 24–39 (50) cm long, prostrate to decumbent, with both glandulose and white-arachnoid pubescence, the latter predominant in younger parts. Basal leaves (6.2) 7.4–9.3 (9.5) × (1.2) 1.3–1.8 cm, (0.3) 0.4–0.6 (0.8) mm thick, oblanceolate to spatulate, apex obtuse, or sometimes ± acute, margins sub-entire to sinuate-dentate, with both glandulose and white-arachnoid pubescence, the latter predominant in younger parts. Capitula solitary, (2) 2.2–2.8 (3.2) cm diameter. Outer achenes rostrate (10) 13–19.5 (24) × (1) 1.5–2 (2.3) mm, straight or slightly curved, without dorsal spines, sometimes with one teeth at the base and/or at the apex; middle achenes bialate (13.8) 14.4–17.5 (18) × (3) 3.3–8 (8.7) mm, with a rostrum (3.3) 5–9.3 (10) mm; most frequently cymbiform (4.7) 5.8–8.3 (8.8) × (3.2) 4–5.5 (8) mm, with ventral wings surpassing the lateral ones; inner achenes vermiculate-alate (5) 5.2–5.3 × (2.2) 2.7–3.7 (4.8) mm, and vermiculate-exalate (3) 3.8–5 (5.5) × (1.2) 1.4–2 (2.2) mm, both circular.

Habitat and distribution: Limestone rocks/cliffs, at ± 133 m elevation, and is found growing under a semi-arid Mediterranean bioclimates. Endemic to Morocco with a restricted distribution in the National Park of Al Hoceïma (Bokkoya) coastal mountains to El-Yebha.

Conservation status: This taxon is under numerous threats, especially climate change (in some places rise in sea level, extreme weather events) and drought. The species is rare and local with a small-restricted range; the species is currently known from about two populations located in hillside slopes with difficult access. The number of mature individuals is estimated to be <50 in one of the populations, based on field observations, but we do not have accurate data for other localities whose access is difficult, in the coastal cliffs. The estimated extent of occupancy is 121 km^2, and the estimated area of occupancy is 16 km^2, both qualify for EN. This result in a categorisation of NT.

Chromosome number: *2n* = 32.

Genome size: 3.17 ± 0.06 pg.

subsp. ***dercana*** A.C. Gonç. & P. Silveira **subsp. *nov.* Type:** —MOROCCO: Tetouan, Jbel Dersa, 468 m [35°35'26" N, 5°22'45" W], 7 June 2012, *Silveira & Gonçalves 3262* (holotype: AVE!)

C. tomentosa Desf. (1799: 305) *p.p.* in regno Maroccano

C. suffruticosa subsp. *dercana* seems close to *C. suffruticosa* subsp. *hosmarensis* but it has smaller rostrate achenes (with 8-10 mm instead of 11-17 mm) and with dorsal spines, and its middle achenes are exclusively cymbiform, while *C. suffruticosa* subsp. *hosmarensis* presents other types of achenes

Perennial herbs. Stems (11) 17–32.5 (65) cm long, prostrate to decumbent, with white–arachnoid pubescence. Basal leaves (3.2) 3.5–7 (7.8) × (0.7) 1.1–2 (2.4) cm, (0.3) 0.4–0.4 (0.6) mm thick, oblanceolate to spatulate, apex obtuse, or sometimes ± acute, margins sub-entire to sinuate-dentate, with white–arachnoid pubescence. Capitula solitary, (1.8) 2.8–3.2 (3.6) cm diameter. Outer achenes rostrate (5) 6–10.2 (13.5) × (1.2) 1.3–1.5 (1.7) mm, straight or slightly curved, without dorsal spines, sometimes with 1–2 teeth, at the base or at the apex; middle achenes cymbiform (5,5) 5.8–6.6 × (3.6) 3.8–5.6 mm; inner achenes vermiculate-exalate (3) 3.3–3.5 (3.7) × (1.3) 1.5–1.7 mm.

Habitat and distribution: The species occurs in limestone rocks/cliffs, at ± 500 m elevation, and is found in per humid Mediterranean bioclimates. Endemic to Jbel Dersa in Tetouan (Morocco).

Conservation status: This taxon is under numerous threats, especially agricultural intensification (grazing), climate change (extreme weather), and human intervention. The species is rare and local with a small-restricted range; only one population is currently known close to abandoned pastures/fields. The number of mature individuals is estimated to be <50 based on field observations. The estimated area of occupancy is 8 km^2 and qualify for CR. The population is. This result in a categorisation of CR B2ab(ii, iii).

Chromosome number: 2*n* = 32.

Genome size: 3.00 ± 0.07 pg.

subsp. ***djurdjurensis*** Ohle ex A.C. Gonç. & P. Silveira **subsp. *nov.* Type:** —ALGERIA. Algier: versant septentrional des montagnes du Djurdjura, territoire des Beni Bou Addou, cercle de Dra el Mizan, July 1854, *Boissier, P. E. s.n.* (holotype G!).

Heterotypic synonyms:

C. suffruticosa subsp. *boissieri* Lanza (1919: 142, 143); Ohle (1975b: 539); *p.p. quoad distr.* Djurdjura.

C. suffruticosa subsp. *boissieri* Lanza (1919, 142); Ohle (1975b, 539);

"C. tomentosa" auct. Battandier & Trabut (1888, 479) *p.p. quoad distr.* Djurdjura *non* Desfontaines (1799: 305), *nom. illeg*., *non* Linnaeus filius (1782: 384)

C. suffruticosa subsp. *djurdjurensis* seems close to *C. suffruticosa* subsp. *boissieri* but it differs by its leaves predominantly glandular pubescent and middle achenes sub-cymbiform to trialate with lateral wings with serrate margins.

Perennial herbs, ± woody at the base. Stems (12) 17.8–29 (52) cm long, erect to ascending, ± branched, predominantly glandular pubescent to slightly white-arachnoid pubescent. Basal leaves (6.5) 7.8–10.4 (11.5) × (1.8) 2–2.8 (3) cm, 0.3–0.4 mm thick, narrowly oblanceolate to obovate, apex acute, or sometimes ± obtuse, margins sinuate-dentate, with glandular and non-glandular white-arachnoid pubescence. Capitula solitary, (3) 3.4–5.3 (5.6) cm diameter. Outer achenes rostrate (8.3) 10.3–12.3 (13.8) × (1.7) 1.8–2.3 (2.5) mm, curved at aprox. 90º, with dorsal spines 0.5 – 1.5 mm long, normally with

one basal tooth; middle achenes sub-cymbiform to trialate (7.5) 8.4–9.7 (10.8) × (5.5) 5.8–6.8 (9.2) mm, with ventral wings smaler than the lateral ones, and lateral wings with serrate margins; inner achenes vermiculate-exalate (5) 5.5–6.2 (7.2) × (1.7) 1.8–2.3 (2.8) mm, generally circular to hemicyclic.

Habitat and distribution: Limestone mountains at 1150–1800 m elevation and is found in humid Mediterranean bioclimates. Endemic to Algeria with a restricted distribution to the Djurdjura Mountains (National Park of Tikdja, Tizi n'Kouilal).

Conservation status: This taxon is under numerous threats, especially climate change, and development (uncontrolled tourism, leisure activities). The species is rare and local with a small-restricted range. However, although we found only one population, there seems to be more in other parts of the Djurdjura Mountains. The estimated area of occupancy is 4 km^2, which qualifies for CR. However, since there is no appropriate information to assess their extinction risk based on distribution and/or population we assess this taxon as Data Deficient (DD) on the IUCN Red List.

Chromosome number: *2n* = 32.

Genome size: 3.10 ± 0.14 pg.

Note: Although Ohle has not published this taxon, the achene's morphology corresponds its "*C. suffruticosa* var. *djurdjurensis*" *in sched.* – CAL44 (D4766) from Djurdjura.

subsp. ***foliosa*** (Batt.) A.C. Gonç & P. Silveira, ***comb. nov.*** Basyonym: *C. foliosa* Batt. in Battandier & Trabut (1888: 479). Lectotype (designated here): — ALGERIA. Djebel Bou Zecza, *May 1882*, *Battandier s.n.* (MPU! [007674]).

Homotypic synonyms:

C. fulgida var. *foliosa* (Batt.) Quezel & Santa (1963: 968) *des. inval.*

C. tomentosa var. *foliosa* (Batt.) Battandier & Trabut (1902: 189).

Heterotypic synonyms:

C. suffruticosa subsp. *boissieri* Lanza (1919: 143) *p.p.* versante .settentrionale dei nionti del Djurdjura a Dra el Mizan

C. fulgida var. polymorphocarpa Lanza (1919, 137)

Perennial herbs. Stems (29) 32–46.3 (53) cm long, erect to ascending, with glandular and non-glandular pubescence, in some areas, sligtlhy white-aracnoid. Basal leaves (3.5) 3.8–5.1 (5.6) × (1) 1.2–1.6 (2.5) cm, (0.2) 0.3–0.3 (0.3) mm thick, obovate to oblong, apex acute to obtuse, margins sub-entire to slightly sinuate-dentate, with glandular and non-glandular pubescence, sligtlhy white-aracnoid in the margins. Capitula solitary, (2.2) 2.6–3.4 (4.2) cm diameter. Outer achenes rostrate (9) 12.3–23.8 (27) × 2–2.5 (2.8) mm, ± straight or slightly curved, without dorsal spines, with or without a ventral basal tooth; middle achenes bialate (10.5) 13.5–16.1 (22) × (6.7) 8.5–11.1 (11.7) mm, with a rostrum (2.5) 3.3–4.5 (9.7) mm, lateral wings sinuate-dentate to incise dentate; inner achenes vermiculate-exalate (3.3) 4.3–5.5 (7.2) × (1.3) 1.7–2 (2.8) mm, falcate.

Habitat and distribution: Limestone rocks/cliffs, at ± 200 m elevation, and is found in sub-humid Mediterranean bioclimates; Endemic to Gorges of Lakhdaria (ex Palestro), Zaccar, Jbel Bou Zecza.

Conservation status: The species is under numerous threats, especially climate change and drought. The species is rare and local with a small restricted range; only one population is currently known (classical population), but there may be others in this region. The number of mature individuals is estimated to be <250 based on field observations. The estimated area of occupancy is 4 km^2 and qualify for CR. This result in a categorisation of Data Deficient (DD) on the IUCN Red List, because there is inadequate information to assess their extinction risk based on distribution and/or population status.

Chromosome number: *2n* = 32.

Genome size: 3.08 ± 0.04 pg.

Notes: Since few herbarium materials are available; this taxon went unnoticed by many botanists. Even Lanza (1919), showed his concern about '*C. foliosa*,' placing it under *C. fulgida* var. *polymorphocarpa*. However, there is an evident consistence of characters on the available specimens, which as been also proved by us to be persistent under culture. Since Battandier (in Battandier & Trabut 1888: 479) listed two localities for is taxon (Djebel bou Zecza and Gorges de Palestro), there is the need to select one of is specimens as lectotype. We selected MPU007674, since it is clearly from one of the

mentioned localities (Djebel bou Zecza), which is not possible to say from some of its other known collections (MPU007673 has been databased as “Gorges de "illisible"”, and P00084054 is from “Gorges de Kedara”).

subsp. ***fulgida*** (Raf.) Guadagno (1922: 64). Fennane & Ibn Tattou 1998, 2005; Gonçalves et al. 2014. Basionym: *C. fulgida* Raffiniesque (1810: 82). Neotype (designated here): — ITALY. Escarpments of Monte Pellegrino, Palermo, Sicily (loco Rafinesque), 04 June 1847, *Kralik s.n.* (P! [04277642]).

Perennial herbs. Stems (41) 46.8–71 (89) cm long, prostrate to decumbent, with glandular and non-glandular pubescence, mostly white-aracnoid towards the base. Basal leaves (6.2) 7.5–9.9 (10.8) × (1.4) 1.5–2 (3.3) cm, (0.1) 0.2–0.2 (0.3) mm thick, oblanceolate to spatulate, apex obtuse, or sometimes ± acute, margins sub-entire to sinuate-dentate, with glandular and non-glandular pubescence, white-aracnoid especially in the margins and midrib. Capitula solitary, (2.3) 2.6–3.2 (3.4) cm diameter. Outer achenes rostrate (17) 21.5–26.5 (29) × (1.2) 1.8–3.4 (3.8) mm, straight or slightly curved, with conspicuous dorsal spines averaging 2 mm long, sometimes with one teeth, at the base and/or at the apex; or bialate rostrate (15) 18.3–23.5 (29) × (7.5) 9.7–13 (15.2) mm, with a rostrum (5.3) 8.6–14.4 (15.2) mm, middle achenes cymbiform (5) 6.8–9.3 (11.7) × (6.5) 7.5–9.2 (11.5) mm, with ventral wings smaller than the lateral ones; inner achenes vermiculate-alate 5–6.2 (6.7) × (2.3) 2.5–3.4 (3.5) mm; or vermiculate-exalate (3.7) 3.8–4.2 (4.5) × (0.8) 1.3–1.5 mm, both circular.

Habitat and distribution: Limestone rocks/cliffs, c. 50-1200 m, in sub-humid Mediterranean bioclimate. This taxon in Morocco is distributed in the Béni Snassen Mountains, but there are other well-known native populations in Italy, Sicily and Malta (Greuter (2006+[2017]).

Conservation status: This taxon is under numerous threats, especially climate change (extreme weather), and development (tourism, leisure activities). The species is currently known from three populations in the Béni Snassen Mountains, but there may be others in this region. The number of mature individuals is estimated to be <250 based on field observations. The estimated extent of occupancy is 11.26 km^2 and qualify for CR, and the estimated area of occupancy is 12 km^2 and qualify for EN. This result in a categorisation for Morocco of Data Deficient (DD) on the IUCN Red List, because there

is inadequate information to assess their extinction risk based on distribution and/or population status.

Chromosome number: *2n* = 32.

Genome size: 3.06 ± 0.21 pg.

Notes: Most of Rafinesque's herbarium was lost wen E.M.Durand (1794-1873) bought it, and when finding that it was in very bad shape he discarded a great part of the specimens (Pennell 1944-1945). Later, Durand sent his personal herbarium to Paris, but it is difficult to known which specimens came from Rafinesque's herbarium because they usually lack labels (Reveal 2013). The result of this is that no previous author could find the type of rafinesque's *C. fulgida.* Therefore, we have chosen one that seemed a god option for a neotype.

subsp. ***hosmarensis*** A.C. Gonç. & P. Silveira ***subsp. nov.*** Type: **—**MOROCCO. Tetouan: Jbel Gorghiz (Beni Hosmar) [35°28'50" N, 5°22'06" W], 6 June 2012, *Silveira & Gonçalves 3261* (holotype AVE!).

Heterotypic synonims:

C. tomentosa Desf. (1799: 305), nom. illeg., non Linnaeus filius (1782: 384) *p.p.* in regno Maroccano

C. incana subsp. *incana* Willd. (Willdenow 1803: 2342) *p.p. in regno Maroccano*

C. suffruticosa subsp. *tomentosa auct. non* (Desf. ex Ball) Murb. (1905: 9) *sensu* Ball (1878)

C. suffruticosa subsp. *hosmarensis* seems close to *C. suffruticosa* subsp. *dercana* but it has bigger rostrate achenes, with (7) 12.3 – 16.1 (17) mm instead of (5) 6 - 10.2 (13.5) mm, and without dorsal spines, and its middle achenes are of diverse types and not exclusively cymbiform like in subsp. *dercana.*

Perennial herbs. Stems (8) 15–42 (55) cm long, prostrate to decumbent, ± densely white–arachnoid pubescent. Basal leaves (2.2) 3.6–5 (6.5) × (0.6) 1–1.3 (1.5) cm, 0.2–0.3 (0.5) mm thick, oblanceolate to spatulate, apex obtuse, or sometimes ± acute, margins sub-entire to sinuate-dentate, white-arachnoid pubescent. Capitula solitary, (2.3) 2.5–3.4 (3.8)

cm diameter. Outer achenes rostrate (7) 12.3–16.1 (17) × (1.2) 1.3–1.5 (2) mm; middle achenes bialate (9) 10.7–13.2 (15.8) × (4.7) 6.7–7.7 (8.3) mm, with a rostrum (3.3) 4.4–7.3 (9.2); trialate (6) 8–15 (17) × (1.3) 1.5–1.9 (2.3) mm; or cymbiform (6.3) 6.7–8.8 (11) × 5.2–6.8 (7.3) mm; inner achenes vermiculate-exalate (3.3) 3.5–4.3 (4.5) × (1.3) 1.5–1.7 (1.8) mm, circular.

Habitat and distribution: Limestone mountains, at ± 430-1070 m elevation, in pre-humid Mediterranean bioclimate. This taxon is endemic to Morocco with a restricted distribution to the southern Tetouan Mountains (Beni Hosmar).

Conservation status: This taxon is under numerous threats, especially climate change (extreme weather), and droughts. The species is rare and local with a small restricted range; only two populations are currently known and few herbarium specimens are known (from the same locality). The number of mature individuals is estimated to be <50 based on field observations. The estimated area of occupancy is 8 km2 and qualify for CR. This result in a categorisation of DD Data Deficient on the IUCN Red List, because there is inadequate information to make an assessment of their extinction risk based on distribution and/or population status.

Chromosome number: *2n* = 32.

Genome size: 3.10 ± 0.10 pg.

subsp. ***lusitanica*** (Boissier) Ohle (1974: 270); Fennane & Ibn Tattou (2005); Gonçalves et al. (2014 : 272). Basionym: *C. lusitanica* Boissier (1849: 83). Lectotype (designated by Burdet et al. 1983):—PORTUGAL. Estremadura: '*prope Cintra Lusitaniae in petrosis*', *Guthnik* s.n. (G!).

Perennial or annual herbs, ± woody at the base. Stems (24) 59–100.5 (120) cm long, diffuse to erect, ± branched, with glandular hairs predominating over non-glandular, sometimes white-aracnoid, hairs, ± viscous. Basal leaves (3.2) 3.5–6.2 (6.3) × (0.8) 1.1–1.5 (2) cm, (0.3) 0.4–0.5 (0.6) mm thick, narrowly oblanceolate to spatulate, apex acute to obtuse, margins sub-entire to sinuate-dentate, attenuate into a ± large petiole, with glandular hairs more abundant than non-glandular hairs, except in the margins, where white-aracnoid hairs predominate. Capitula solitary, (1.5) 2.4–3 (3.3) cm diameter. Outer

achenes rostrate (7) 8.7–11 (13) × (1.5) 1.6–2 (2.2) mm, generally slightly curved to straight, without dorsal spines or with them small, sometimes with one tooth at the base and/or another at the apex; middle achenes typically sub-exalate (7.5) 7.8–9.4 (9.7) × (5) 5.3–6.9 (7.2) mm, lateral wings missing or narrow and sinuate-dentate, and ventral wing also missing or narrow and sub-entire, less frequently sub-cymbiform to cymbiform (5.2) 6.1–7.5 (10.7) × (4.2) 5–6.1 (8) mm, with the ventral wing smaller to sub-equal to the laterals; inner achenes vermiculate-exalate (3.8) 4.2–4.9 (5) × (1.5) 1.7–2 (2.3) mm, always present, hemicyclic to circular.

Habitat and distribution: Clearings of forests and shrub vegetation, on granitic, loamy, limestone soils, hills, and mountains of the coast; 0–500 m elevation and is found in sub-humid Mediterranean bioclimates. West and South of Portugal, in Morocco, it has a distribution restricted to Benzu (Ceuta)

Conservation status: This taxon is under numerous threats, especially climate change (extreme weather), and human intervention (gardening or embankment fixation). It is rare and local with a small-restricted range; only one population is currently known. The number of mature individuals is estimated to be <250 based on field observations. The estimated area of occupancy is 4 km^2, which qualifies for CR. We propose to assess this taxon for Morocco as CR C2a(ii).

Chromosome number: *2n* = 32

Genome size: 3.36 ± 0.15 pg.

subsp. ***marsea*** A.C. Gonç. & P. Silveira ***subsp. nov.*** **Type:** — MOROCCO. Tanger, Oued Marsa, 3–5 m, [35°54' N, 5°27' W], 13 June 2012, *Silveira, P. & Gonçalves, ACRS 3268* (holotype AVE!);

C. suffruticosa subsp. *marsea* seems close to *C. suffruticosa* subsp. *osteni* but its midlle achenes are bi-trialate (10.5) 13.6–16 (22) mm, with length/width > 1.5, instead of trialate (6.3) 8.5–9.8 (10.3) mm, with length/width approx. 1.

Perennial herbs. Stems (24) 30.3–36.3 (43) cm long, erect to ascending, with glandular hairs distaly and predominace of non-glandular white-aracnoid pubescence proximaly, not viscid/viscous. Basal leaves (3.5) 4–5.5 (6) × (0.9) 1.1–1.7 (1.8) cm, 0.4–0.6 (0.7) mm thick, obovate to oblong, apex obtuse, margins sub-entire to slightly sinuate-dentate,

densely white-arachnoid pubescent, with progressively less white-aracnoid and more glandular pubescence towards the apice of the stems. Capitula solitary, 1.7–2.6 (3) cm diameter. Outer achenes rostrate (12) 17.8–24 × (1.3) 1.6–2.2 (2.3) mm, ± straight or slightly curved, without dorsal spines, without a ventral basal tooth; middle achenes bialate (10.3) 10.8–17 (18) × (5) 5.8–8.3 (8.8) mm, with a rostrum (2.5) 2.6–6.9 (7.5) mm, to trialate (11.7) 12.4–13.8 (14.5) × (8.8) 9.1–9.2 mm, lateral wings sinuate-dentate to incised; inner achenes vermiculate-exalate (3,7) 4,8–5,3 (5,5) × (1,2) 1,8–2,2 (2,3) mm, hemicyclic to circular.

Habitat and distribution: We could only found this taxon growing slightly above sea level, but there are older specimens, probably of the same taxon, collected at 400-500 m elevation. It is found in sub-humid Mediterranean bioclimate. Endemic to Morocco with distribution that seems restricted to the NW foot of Jbel Mousa, margins of Oued Marsa (Tétouan).

Conservation status: This taxon is under numerous threats, especially climate change (extreme weather, the rise in sea level), and human intervention. The species is rare and local with a small-restricted range; only one population is currently known and suffering from high habitat degradation due to human pressure. The number of mature individuals is estimated to be <50 based on field observations. The estimated area of occupancy is 4 km^2, which qualifies for CR. Although it is not known if there are more populations or not, this is not very probable, so we propose to assess this species as CR B2ab(iii, v), C2a(I, ii), D.

Chromosome number: *2n* = 32.

Genome size: 3.44 ± 0.12 pg.

subsp. ***monardii*** (Boissier & Reuter 1859: 108) Ohle (1975b). Le Floc'h & Boulos (2008). Basyonym: *C. monardii* Boissier & Reuter (1859: 108). **Type** (corrected here): —ALGERIA. Sidi Ferruch, July 1830, *Monard s.n.* (holotype G! [0386646]).

Perennial herbs. Stems (30) 55–67 (84) cm long, erect to ascending, with glandular pubescence predominating over non-glandular, sometimes white-aracnoid, pubescence. Basal leaves (3.2) 4.6–5.7 (6.5) × (0.6) 0.9–1.4 (2.1) cm, 0.5–0.6 (0.8) mm thick, obovate to oblong, apex acute to obtuse, margins sub-entire to slightly sinuate-dentate, lamina with few glandular and non-glandular hairs, and margins predominantly with white-aracnoid hairs. Capitula solitary, (2.5) 3.1–4 (4.6) cm diameter. Outer achenes rostrate (9) 13–18 (23) × (1.3) 1.5–1.8 (2.3) mm, ± straight or slightly curved, without dorsal spines, or with few and small, with or without a ventral basal tooth; middle achenes trialate (7.7) 10.2–13.5 (16.2) × (5.8) 8.3–9.8 (11.2) mm, margin of lateral wings slightly sinuate-dentate; inner achenes vermiculate-alate 3,8–5,3 x 2,5–2,7 (3,3); and vermiculate-exalate (3,3) 4,3–5,2 (6,3) x (1) 1,5–1,8 (2,7) mm, both circular.

Habitat and distribution: Coastal limestone rocks/cliffs and sandy dunes, near the sea, from see level to ± 300 m elevation, and is found in semi-arid Mediterranean bioclimates. Distributed between Alger (Algeria) and Cape Tabarka (Tunisia).

Conservation status: This taxon is under numerous threats, especially climate change (extreme weather), and development (infrastructures, urbanisation, tourism, leisure activities). The species is currently known from about five populations with a small-restricted range. The number of mature individuals is estimated to be <250 based on field observations. Based on our field collection, the estimated extent of occupancy is 16.264 km^2 and qualify for CR, the estimated area of occupancy is 20 km^2 and qualify for EN. Although not taking into account all populations, there is an inferred continuing decline in the area of occupancy, quality of habitat and number of mature individuals. This result in a categorisation of CR B2b(ii, iv, v).

Note: The type of *C. monardii* is not at MPU like is stated by Ohle (1975b: 532), but at G.

Chromosome number: *2n* = 32.

Genome size: 2.86 ± 0.07 pg.

subsp. ***osteni*** A.C. Gonç & P. Silveira ***subsp. nov.*** Type: MOROCCO. Al Hoceïma, Gurugú, 950 m, [35°19' N, 2°57' W], 19 May 1932, *Sennen, F. & Mauricio, Hno.* 8 438 (holotype BM! [000813672]; isotypes BC! [139240], G!).

C. suffruticosa subsp. *osteni* seems close to *C. suffruticosa* subsp. *marsea* but its midlle achenes are trialate (6.3) 8.5–9.8 (10.3) mm, with length/width approx. 1, instead of bi-trialate (10.5) 13.6–16 (22) mm, with length/width > 1.5.

Perennial herbs. Stems (37) 44.5–75.5 (81) cm long, prostrate to decumbent, with glandular hairs distaly and predominace of non-glandular white-aracnoid pubescence proximaly, not viscid/viscous. Basal leaves (4.8) 5–7.9 (11.7) × (1.1) 1.5–2.1 (2.9) cm, 0.2–0.3 mm thick, oblanceolate to spatulate, apex obtuse, or sometimes ± acute, margins sub-entire to sinuate-dentate, with white-arachnoid pubescence. Capitula solitary, (2,3) 3.1–3.9 (4.0) cm diameter. Outer achenes rostrate (12) 16.5–25 × (1.7) 2.2–2.4 (2.5) mm, straight or slightly curved, without dorsal spines, sometimes with 1–2 teeth, at the base or at the apex; middle achenes trialate (6.3) 8.4–9.8 (10.3) × (5.3) 6–9.1 (10) mm, with a rostrum 2–3.6 (3.7) mm; inner vermiculate-exalate 4–4.3 × 1.8–1.8 mm, hemicyclic-falcate.

Habitat and distribution: As far as we know, this taxon might grows on greywacke rocks, under semi-arid Mediterranean climate, from sea level to 800 m ? (our collection is from c. 580 m) elevation, in mounts Gurugú and Kebdana, near Mellila, and with another know specimen from near sea level at Al Hoceima.

Conservation status: The taxon is under numerous threats, especially climate change (extreme weather events) and drought. The species is rare and local with a small restricted range; only one population is currently known by the team. The number of mature individuals is estimated to be <10 based on field observations. The estimated area of occupancy is 4 km^2, which qualifies for CR. Considering the number of individuals we propose to assess it as CR B2ab(ii, iv, v), due to the reduced size of the population and of its habitat, which confers a high risk of extinction due to climate changes, or other unexpected threats.

Chromosome number: 2n = 32.

Genome size: 2.96 ± 0.05 pg.

Notes: This name is inspired on a designation autored, but not validly published (McNeill *et al*. 2012, article 38.1), by Sennen & Mauricio (1933: 62), which was also used in the label of the specimen we selected as type.

subsp. ***riffiniensis*** A.C. Gonç. & P. Silveira ***subsp. nov.*** **Type:** — MOROCCO. Tétouan, Jbel Kelti, Arifane, 943 m, [35°17'04" N, 5°18'00" W], 15 May 2014, *Silveira, P.; Gonçalves, ACRS 3341* (holotype AVE!);

C. suffruticosa subsp. *riffiniensis* seems close to *C. suffruticosa* subsp. *boccoyana* but its basal leaves have a ratio length/width of (2.2) 2.4–4.0 (4.4) and a thickness of (0.2) 0.3–0.4 (0.6) mm.

Perennial herbs. Stems (28) 32–49 (71) cm long, erect to ascending with glandular hairs distaly and predominace of non-glandular white-aracnoid pubescence proximaly and in young branches. Basal leaves (4.1) 4.5–8.2 (8.3) × 1.5–2.1 (2.3) cm, (0.2) 0.3–0.4 (0.6) mm thick, obovate to oblong, apex obtuse, margins sub-entire to slightly sinuate-dentate, lamina with more glandular than non-glandular hairs, except in margins or leaves of young branches where non-glandular white-arachnoid pubescence predominates. Capitula solitary, (2.9) 3.2–3.6 (4) cm diameter. Outer achenes rostrate 17–21 (22) × (1.2) 1.3–1.5 (2.8) mm, ± straight or slightly curved, without dorsal spines, without a ventral basal tooth; middle achenes bialate (10) 10.8–15 × (5.8) 6.7–10 mm, with a rostrum (5) 5.4–7.9 (8.7) mm, margin of lateral wings sinuate-dentate to incised; cymbiform (5,8) 7,5–10,5 (11,3) × (5,0) 5,2–5,5 (5,8) mm; inner achenes vermiculate-alate (4,3) 4,5–5,8 (6,3) × (2,5) 2,8–4,5 (5) mm; and vermiculate-exalate 3,3–4,7 (5) × 1,5–1,7 (1,8) mm, both circular.

Habitat and distribution: Limestone rocks/cliffs, from 30 to 1800 m elevation, and is found in perhumid Mediterranean bioclimate. Endemic to Morocco with a restricted distribution to the southern Tetouan Mountains (Arrifane - Jbel Kelti).

Conservation status: This taxon is under numerous threats, especially climate change (extreme weather), and droughts. The taxon is rare and local with a small restricted range; only one population is currently known by the team, and few herbarium specimens are known (from the same locality). The number of mature individuals, in the population known by the team, is estimated to be <250 based on field observations. The estimated area of occupancy is 4 km^2, which qualifies for CR. However, we propose its assessment as Data Deficient (DD), because there is inadequate information to make an assessment of their extinction risk based on distribution, since we think that there might be other subpopulations in the area.

Chromosome number: 2n = 32.

Genome size: 3.06 ± 0.10 pg.

subsp. ***suffruticosa*** Vahl (1791: 94). Bonnet and Barratte (1896: 231); Jahandiez and Maire (1934: 789); Quezel and Santa (1963: 969); Potteier-Alapetite (1981: 1024); Le Floc'h and Boulos (2008: 80); Fennane and Ibn Tattou (2005: 29). Lectotype (designated by Ohle 1975b): —TUNISIA. 'Legi in montosis circa Portum Farinam Tuneti', *Forskål s.n.* [not Vahl fide Ohle 1975b] (C! [100003277]).

Perennial herbs. Stems (10) 16.5–25 (27) cm long, ascending to erect, sparsely glandular and non-glandular pubescent, very slightly white-aracnoid towards the base. Basal leaves (3.2) 5.1–6.5 (7.1) × (0.8) 0.9–1.2 (1.4) cm, 0.4–0.6 mm thick, broadly lanceolate, apex obtuse to slightly acute, margins sinuate-dentate, sparsely glandular and non-glandular pubescence, slightly white-aracnoid in the margins. Capitula solitary, (3.4) 3.6–4.6 (5.2) cm diameter, concolorous, yellow. Outer achenes rostrate (11) 16–23 (26) × (1.3) 1.7–2 (2.2) mm, straight or slightly curved, normally without dorsal spines or muricate, rarely with a ventral basal tooth; middle achenes bialate (12.5) 13–17.3 (18) × (5.8) 6.3–8.8 (9.2) mm, lateral wings sub-entire to sinuate-dentate, with a rostrum (3) 3.6–7.4 (7.5); more frequently cymbiform (8.8) 10.3–11.5 (14.5) × (6.7) 7.7–10.8 (11.8) mm, muricated dorsaly, ventral wing smaler to subequal to lateral wings; sub-cymbiform (6.7) 8.5–11.7 (12.8) × (8.2) 8.7–10.3 (10.8) mm, lateral wings sub-entire to sinuate-dentate; inner achenes vermiculate-alate (4.5) 4.8–7.3 (8.5) × (3.2) 3.3–4.7 (5.8) mm, and vermiculate-exalate 4.3–4.9 (5.3) × (1.3) 1.5–1.8 (2) mm, both circular to hemicyclic.

Habitat and distribution: Limestone rocks at 10–20 m elevation, near the sea, in semi-arid Mediterranean bioclimate. Endemic from Tunisia, Porto Farina (Ghar el Melh), Hammam-Lif, Korbous near Cap Bon.

Conservation status: Despite the small geographic distribution, the team was only able to visit one population (Ghar el Melh). The number of mature individuals is estimated to be <250 based on field observations. However, since there is inadequate information to assess their extinction risk based on distribution and/or population status, we propose to assess it as Data Deficient (DD).

Chromosome number: *2n* = 32.

Genome size: 3.28 ± 0.07 pg.

Notes: Since its description, this taxon was often confused with other taxa. Several authors cited *C. suffruticosa* for other Mediterranean areas: Portugal (Brotero 1804), Spain (Boissier 1849), Morocco (Ball 1873). Only Ball (1878) pointed out that his *C. maroccana* had nothing to do with *C. suffruticosa.* It has certain morphological similarities with those taxa, but the cymbiform achenes, do not resemble with the typical *C. suffruticosa*. Effectively, as far as we know, *C. suffruticosa* subsp. *suffruticosa* is restricted to the coast of the Gulf of Tunis, in Tunisia.

subsp. ***tazzea*** A.C. Gonç. & P. Silveira ***subsp. nov.*** **Type:** —MOROCCO. Taza, Ras-El-Ma, Sidi Msbar, 1460 m, [34°07'58" N, 4°07'58" W], 11 May 2014, *Silveira, P.; Gonçalves, ACRS 3334* (holotype AVE!).

C. suffruticosa subsp. *tazzea* seems close to *C. suffruticosa* subsp. *suffruticosa*, but its rostrate achenes are longer, (21) 24–30.0 (31) mm, and its cymbiform achenes are narrower, with 5.8–7.3 (8.3) mm width.

Perennial herbs. *Stems* (40) 40.5–81.5 (93) cm long, decumbent to erect, predominatly glandular pubescent distaly, slightly white-aracnoid proximaly. Basal leaves (6) 7.4–9.9 (10.5) × (0.9) 1.5–2.1 (2.6) cm, (0.2) 0.3–0.4 mm thick, oblanceolate, apex obtuse, or sometimes ± acute, margins sub-entire to sinuate-dentate, with glandular and non-glandular hairs to glabrescent, slightly white-arachnoid pubescent in the margins, becoming light green when dry. Capitula solitary, 3.2–4 (4.4) cm diameter. Outer achenes rostrate (21) 24–30 (31) × (2) 2.2–2.7 (2.8) mm, straight or slightly curved, without dorsal spines, sometimes with 1–2 teeth, at the base or at the apex; middle achenes bialate (16) 17,8–22,5 (25) × (7,3) 7,8–8,7 (10) mm, with a rostrum (3,3) 5,3–11 (13,7) mm; most frequently cymbiform (6.7) 8.5–11 (12.5) × 5.8–7.3 (8.3) mm, with ventral wings, frequently, surpassing the laterals; inner achenes vermiculate-alate (4.2) 6–7.5 (8.3) × (2.8) 4.5–4.8 (5.2) mm; vermiculate-exalate (3.3) 3.5–5.1 (5.7) × (1.2) 1.6–2.2 mm, circular.

Habitat and distribution: limestone rocks/cliffs, at ± 300 m elevation, and is found in subhumid Mediterranean bioclimate. Endemic to Morocco with a restricted distribution to the western Taza Mountains (Jbel Tazzeka).

Conservation status: The taxon is under numerous threats, especially climate change (extreme weather), and droughts. The species is rare and local with a small restricted range; only one population is currently known by the team, and few herbarium specimens are known (from the same region). The number of mature individuals is estimated to be <50 based on field observations. The estimated area of occupancy is 4 km2, which qualifies for CR. However, we propose its assessment as Data Deficient (DD), because there is inadequate information to make an assessment of their extinction risk based on distribution, since we think that there might be other subpopulations in the area.

Chromosome number: *2n* = 32.

Genome size: 3.42 ± 0.07 pg.

subsp. ***trialata*** P. Silveira & A.C. Gonç. (in press). **Type:** — SPAIN. Cádiz: Conil de la Frontera, [36°16'35" N, 6°05'15" W], 25 May 1981, *P. Cambó et al. 421/81* (holotype MA!).

Perennial herbs, ± woody at the base. Stems (25) 29.8–59.5 (66) cm, decumbent to diffuse, ± branched, mostly with glandular hairs and occasional non-glandular hairs, viscous. Basal leaves (3) 4–4.5 (5) × 0.6–1.1 cm, (0.4) 0.5–1.2 (1.5) mm thick, oblanceolate, apex acute to obtuse, margins sub-entire to sinuate-dentate or slightly undulate-dentate, attenuated in a ± large petiole, lamina with glandular and *non*-glandular hairs, mostly white-aracnoid in the margins, viscous. Capitula solitary, (1.5) 1.8–2.9 (3.3) cm diameter. Outer achenes rostrate (4.5) 5.4–14.1 (16) × 1.3–1.7 (2.5) mm, generally straight or slightly curved, without dorsal spines, at times with one tooth at the base; middle achenes, usually, trialate (7.8) 8.5–9.2 (9.8) × (6.3) 7–8 (8.8) mm, wings sub-entire and sinuate-dentate at the apex, sub-equal, or bialate (9.2) 10.3–13.5 (17) × (3) 5–6.9 (9.3) mm, with a rostrum (1.5) 2–5.7 (8.7) mm, with lateral wings sinuate-dentate; inner achenes vermiculate-exalate (3.8) 4–4.5 (4.7) × (1.3) 1.5–1.8 mm, generally hook-shaped to falcate.

Habitat and distribution: Dunes, sandy soils and hills not far from the sea, 0–130 m, near the lighthouse at Cape Cires in Tanger (Morocco).

Chromosome number: *2n* = 32.

Genome size: 3.21 ± 0.05 pg.

subsp. ***tunetana*** (Cuénod) A.C.Gonç. & P.Silveira ***Comb. nov.*** Basionym: *C. tunetana* Cuénod (1910, ci). **Type:** —TUNISIA. 'Berges sablounneuses de l'Oued, entre Bir bou Rekba et Hamamet', *Cuneod. A. s.n.* (holotype G! [00022975]).

Homotypic synonyms:

C. suffruticosa var. *tunetana* (Cuénod) Ohle (1975b: 532)

"C. suffruticosa subsp. *tunetana"* (Cuénod) Pottier-Alapetite (1981: 1024), *des. inv.* not validly published (McNeill *et al.* 2012, article 41.5)

Perennial herbs. Stems (14,3) 16.5–25.8 (40) cm long, ascending to erect, with glandular and non-glandular, slightly predominant white-arachnoid, pubescence. Basal leaves (3.2) 3.6–5.4 (6.1) × (0.3) 0.4–0.6 (0.7) cm, 0.4–0.6 mm thick, linear to narrowly oblanceolate, apex acute, margins slightly sinuate-dentate, with glandular and non-glandular, slightly predominantly white-arachnoid, pubescence, drying into a light grey-greenish colour. Capitula solitary, (3.3) 3.4–4.7 (5.0) cm diameter, concolorous, yellow. Outer achenes rostrate (16) 16.5–19 (20) × (1.8) 1.9–2.3 (2.5) mm, straight or curved up to ± 110º, with small dorsal spines or muricated, with basal, and sometimes apical, ventral teeth; middle achenes trialate (10) 10–10.5 (10.7) × (6.3) 7.1–9.7 (9.7) mm, lateral wings sub-entire; inner achenes vermiculate-alate (5.0) 5.1–5.8 (6.0) × (3.1) 3.3–4.1 (4.2); vermiculate-exalate 4.2–4.7 × 2.0–2.2 mm, both circular and with apical and basal teeth.

Habitat and distribution: Riverine sandy banks at 10–20 m elevation, in semi-arid Mediterranean bioclimate. Endemic to Tunisia is restricted to near Bir bou Rekba and Hamamet.

Conservation status: Despite the small geographic distribution, the team was only able to visit one population (Hamamet). The number of mature individuals is estimated to be <250 based on field observations. However, since there is inadequate information to assess their extinction risk based on distribution and/or population status, we propose to assess it as Data Deficient (DD).

Chromosome number: *2n* = 32.

Genome size: 3.39 ± 0.08 pg.

Notes: With its narrow basal leaves and trialate achenes this taxon is unique. Furthermore, due to the difference in habitats, and edaphic conditions we do not agree with Ohle, which included this taxon under *C. suffruticosa* subsp. *suffruticosa* as a variety.

C. tripterocarpa Ruprecht (1856: 231). Fennane & Ibn Tattou 2005; Le Floc'h & Boulos 2008; Gonçalves et al. 2014; Heyn et al. 1974; Valdés 2002. Type (designated by Heyn et al. 1974)**:—**IRAQ. Mesopotamia: *'Ad ripas Tigridis raram', Noë 515, 407* (lectotype LE!).

Homotypic synonym:

C. aegyptiaca subsp. *tripterocarpa* (Ruprertch) Lanza (1919)

Heterotypic synonyms:

C. aegyptiaca var. *platycarpa* Battandier

C. thapsiaecarpa Pomel (1875). Type – ALGERIA: Mzab, Metlili, s.d., Pomel s.n. (holotype P photo ! [00084057], isotype MPU photo ! [004740]).

C. platycarpa Cosson ex Battandier & Trabut (1888)

C. sicula var. *hymenocarpa* Candolle (1838)

C. stellata var. *hymenocarpa* (Candolle) Cosson & Kralik (1857)

C. palaestina var. *intermedia* (Cosson & Kralik) Bonnet & Barratte (1896)

C. palaestina var. *hymenocarpa* (Candolle) Bonnet & Barratte (1896)

Annual herbs. Stems (2) 5.6–15.8 (30) cm long, decumbent to diffuse, generally branched, with glandular hairs geneally predominating over non-glandular hairs. Basal leaves (1) 2–3.2 (9.5) × (0.2) 0.3–0.5 (0.8) cm, (0.3) 0.3–0.4 (0.5) mm thick, linear-oblong, acute, margin repand-dentate, rarely sub-entire, base attenuated in a ± longer petiole, the middle and upper cauline leaves, are smaller, oblanceolate to lanceolate, usually auriculate, both with glandular hairs geneally predominating over non-glandular hairs. Capitula solitary, (1.1) 1.2–1.4 (1.6) cm in diameter. Outer achenes trialate (5.7) 6.3–7.9 (9.5) × (4.5) 5.5–7.1 (8.5) mm, with wings entire to inconspicuously dentate, flat or muricated in the back, without dorsal spines; middle achenes cymbiform (4.2) 4.5–6.1

(6.7) × (3.5) 4.6–5.7 (6.7) mm, with ventral wings sub-equal or slightly surpassing the laterals; inner achenes vermiculate-exalate (2.2) 2.5–3.3 (4.2) × (0.7) 1–1.2 mm, circular or falcate; with small, apical and/or basal, ventral teeth.

Habitat and Distribution: In grasslands, semi-desert to desert regions, sand, sandstone and gravel, rarely in ruderal/wasteland sites, 0–450 m elev. In the south of Europe from Almeria to Murcia and Alicante (SPAIN) to the south of France (occasional) and in all the north of Africa (Morocco, Algeria and Tunisia) to the Middle East. More details in Gonçalves et al. 2017.

Conservation status: This is a widespread taxon in sub-arid areas of the south Mediterranean region. Therefore, we assess it as Least Concern (LC) following the IUCN criteria (IUCN, 2012).

Chromosome number: 2n = 30.

Genome size: 3.52 ± 0.12 pg.

Figure 66 – (next page) Variability of achene morphology of *Calendula*. A) *C. meuselii* (Silveira 3063, AVE); B) *C. eckerleinii* (Silveira 3064, AVE); C) *C. fontquerii* (Silveira & Gonçalves 3339, AVE); D) *C. davisii* (Silveira & Gonçalves 3263, AVE); E) *C. maroccana* (Silveira 3144, AVE); F) *C. maroccana* (Silveira, Gonçalves, & Ouhammou 3295, AVE); G) *C. murbeckii* (Silveira, Gonçalves, & Ouhammou 3280, AVE); H) *C. lanzae* (Silveira, Gonçalves, & Ouhammou 3293, AVE); I) *C. pinnatiloba* (Silveira 3137, AVE); J) *C. stellata* (Silveira 3137, AVE); K) *C. stellata* (Silveira 3062, AVE); L) *C. tripterocarpa* (Silveira 3068, AVE). Rostrate achenes: A1, 2; B1, 2; C1, 2; D1, 2; E1-3; F1, 2; G1-4; H1-2; I1, 2; J1, 2; K1. Bialate achenes: A3, 4; B3, 4; E4, H4-6; K2. Cymbiform achenes: E7, 8; G7; H7, 8; I6; J3, 4; K4, 5; L2, 3. Trialate achenes: B5, 6; C3, 4; D4, 5; E5, 6; F3, 4; G5, 6; I3, 4; L1. Vermiculate-alate achenes: H9; J5; K6; L4. Vermiculate-exalate achenes: A5; B7; B8; C5, 6; D6, 7; E9, 10; F5, 6; G8; H10, I7, J6, K7; L5. All achenes in side view, except: A3, B4, B5, C3, D3, D5, E4, E5, F3, G5, H4, H5, H7, I3, I5, I6, J3, K2, K4, L1 and L2 in ventral face view, and A4, B3, B6, C4, D4, E6, F4, G6, H6, H8, I4, J4, K3, K5 and L3 in ± dorsal face view. Scale bars = 1 cm.

A

B

C

D

E

F

G

H

I

J

K

L

Figure 67 – (next page) Variability of achene morphology of *Calendula*. A) *C. suffruticosa* subsp. *trialata* (Silveira & Gonçalves 3267, AVE); B) *C. suffruticosa* subsp. *marsea* (Silveira & Gonçalves 3268, AVE); C) *C. suffruticosa* subsp. *lusitanica* (Silveira & Gonçalves 3269, AVE); D) *C. suffruticosa* subsp. *dercana* (Silveira & Gonçalves 3262, AVE); E) *C. suffruticosa* subsp. *hosmarensis* (Silveira & Gonçalves 3261, AVE); F) *C. suffruticosa* subsp. *riffiniensis* (Silveira 3341, AVE); G) *C. suffruticosa* subsp. *tazzea* (Silveira & Gonçalves 3334, AVE); H) *C. suffruticosa* subsp. *boccoyana* (Silveira & Gonçalves 3266, AVE); I) *C. suffruticosa* subsp. *boccoyana* (Silveira & Gonçalves 3340, AVE); J) *C. suffruticosa* subsp. *osteni* (Silveira & Gonçalves 3265, AVE); K) *C. suffruticosa* subsp. *fulgida* (Silveira & Gonçalves 3335, AVE). Rostrate achenes: A1, 2; B1, 2; C1, 2; D1, 2; E1, 2; F1-3; G1, 2; H1, 2; I1, 2; J1, 2; K1-4; bialate achenes: A3; B3, 4; C3, 4; D3; E3; F4, 5; G3-5; cymbiform achenes: D4-6; E4, 5; F6, 7; G6, 7; H3, 4; I3, 4; K5, 6; subcymbiform achenes: B4, E4, E5, J3, J4; trialate achenes: A4, 5; B5; J3, 4; exalate achenes: C5, 6; vermicular-alate achenes: F8; G8; I5; K7; vermicular-exalate achenes: A6, B6, 7; C7; D7, 8; E6; F9; G9, 10; H5; I6; J5; K8. All achenes in side view, except: A3-5, B3-5, C3-6, D3, D5, E3, E4, F4-7, G3-6, H3, I3, J3, K2, and K5 in ventral face view, and D6, G7, H4, I4, J4, K1, and K6 in ± dorsal face view. Scale bars = 1 cm.

A

B

C

D

E

F

G

H

I

J

K

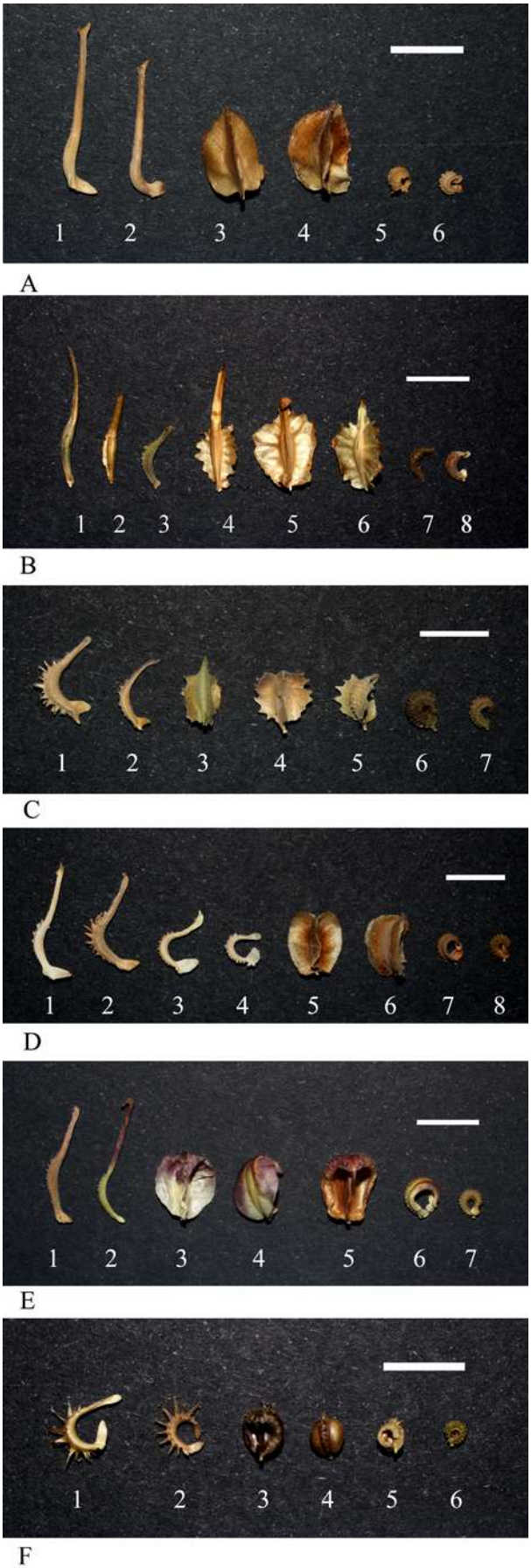


Figure 68 – Variability of achene morphology of Calendula. A) C. suffruticosa subsp. monardii (Silveira, Gonçalves & Amirouche 3316, AVE); B) C. suffruticosa subsp. foliosa (Silveira, Gonçalves & Amirouche 3320, AVE); C) C. suffruticosa subsp. djurdjurae (Silveira, Gonçalves & Amirouche 3321, AVE); D) C. suffruticosa subsp. tunetana (Silveira 3039d, AVE); E) C. suffruticosa subsp. suffruticosa (Silveira 3038, AVE); F) C. arvensis (S. Castro P35 in Silveira 3078, AVE). Rostrate achenes: A1, 2; B1-3; C1, 2; D1-4; E1, 2; F1, 2; bialate achenes: B4-6; trialate achenes: A3, 4; C3-5; D5, 6; ; cymbiform achenes: E3-5; F3, 4; vermicular-alate achenes: A5; D7; E6; F5; vermiculate-exalate achenes: A6, B7, 8; C6, 7; D8; E7 and F6. All achenes in side view, except: A3, B4, B5, C4, D5, E3, E5 and F3 in ventral face view, and B6, C3, C5, D6, E4 and F4 in ± dorsal face view. Scale bars = 1 cm.

Figure 69 – A – C) *C. fontquerii* (Silveira & Gonçalves 3339, AVE). A) habit; B) detail of leaves; C) fruiting capitulum; D-F) *C. maroccana* (D and E- Silveira 3142, AVE; F- Silveira, Gonçalves & Ouhammou 3299); D) habit; E) and F) fruiting capitula.

Figure 70 – A – D) *C. davisii* (C. Silveira & Gonçalves 3339, AVE). A) habit; B) detail of the base of stem; C) flowering capitulum; D) fruiting capitulum.

Figure 71 – A-B) *C. meuselii* (Silveira 3063, AVE). A) Habit and habitat; B) fruiting capitulum. C-F) *C. eckerleinii* (Silveira 3064, AVE). C) Habit; D) flowering capitulum; E) fruiting capitulum; F) detail of leaves.

Figure 72 – A – F) *C. murbeckii* (Silveira, Gonçalves & Ouhammou 3280, AVE). A) habit; B) habit and concolorous and discolorous forms; C) detail of leaves; D) detail of typical fruiting capitulum; E-F) detail of alternative fruiting capitula.

Figure 73 – A – C) *C. pinnatiloba* (A- Silveira 3137, AVE; B-C Silveira 3130, AVE). A) Habit of a discolorous form; B) flowering capitulum; C) fruiting capitulum. D-F) *C. lanzae* (Silveira, Gonçalves & Ouhammou 3293). D) Habit; E) flowering capitulum; F) fruiting capitulum.

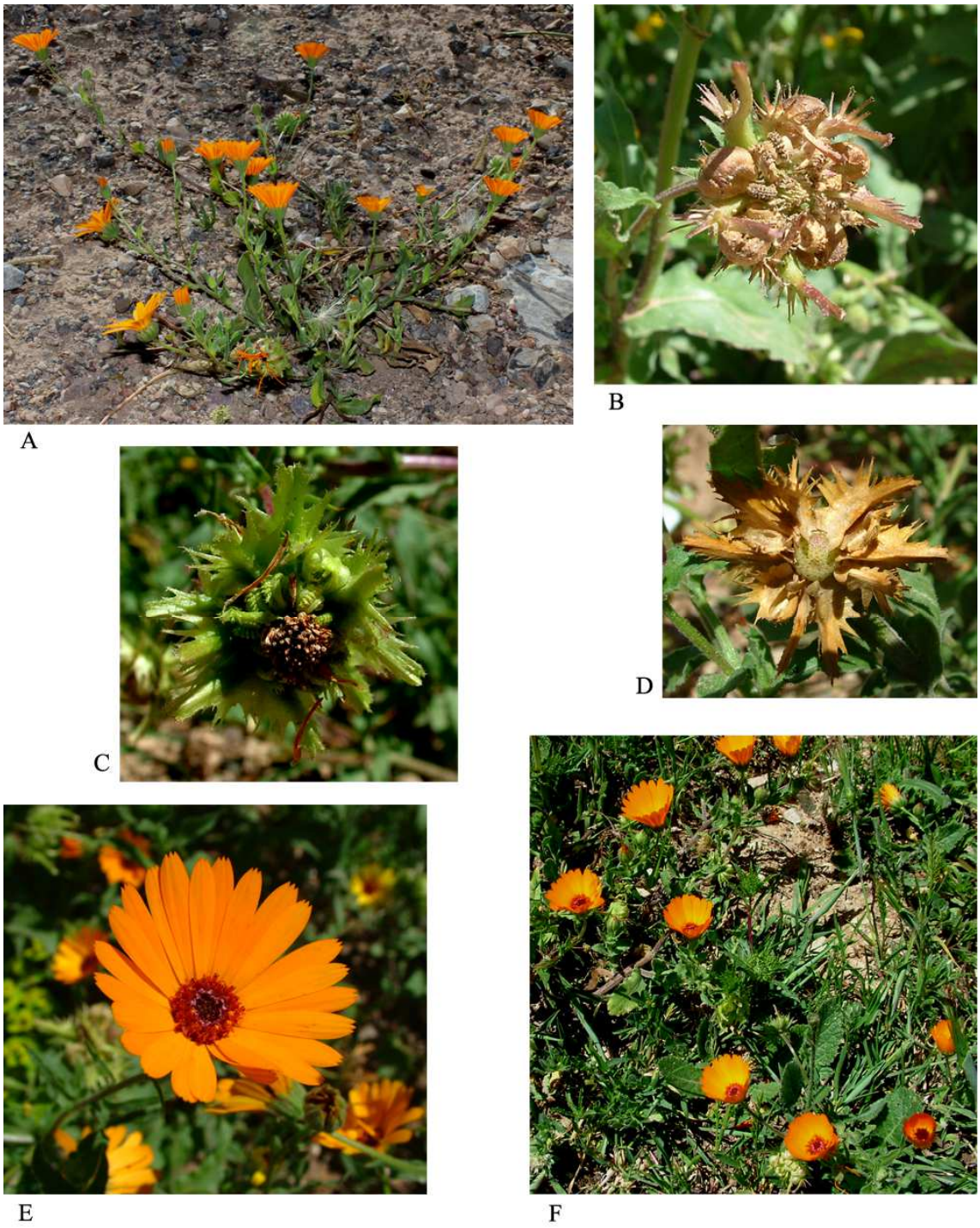


Figure 74 – A – F) *C. stellata* (A-Silveira & Gonçalves 3337, AVE; B) Silveira 3061, AVE; C-F) Silveira 3062). A) habit; B) fruiting capitulum; C) immature fruiting capitulum of the form with bialate achenes; D) mature fruiting capitulum of the form with bialate achenes; E) flowering capitulum; F) habit and habitat.

Figure 75 – A-C) *C. suffruticosa* subsp. *boccoyana* (A- Silveira & Gonçalves 3266, AVE; B-C. Silveira & Gonçalves 3340, AVE). A) Habit; B) flowering calitulum; C) fruiting capitulum. E-F) *C. suffruticosa* subsp. *fulgida* (Silveira & Gonçalves 3335, AVE); E) fruiting capitulum.

Figure 76 – A-C) *C. suffruticosa* subsp. *lusitanica* (Silveira & Gonçalves 3269, AVE). A) Habit; B) fruiting capitulum; C) flowering capitula. D-E) *C. suffruticosa* subsp. *marsea* (Silveira & Gonçalves 3268, AVE); D) habit; E) fruiting capitulum. F-G) *C. suffruticosa* subsp. *trialata* (Silveira & Gonçalves 3267, AVE); F) habit; G) fruiting capitulum.

Figure 77 – A-C) *C. suffruticosa* subsp. *ostenii* (Silveira & Gonçalves 3265, AVE). A) Habit; B) flowering capitulum; C) fruiting capitulum. D-E) *C. suffruticosa* subsp. *riffiniensis* (Silveira & Gonçalves 3341, AVE); D) habit; E) typical fruiting capitula; F) alternative fruiting capitula.

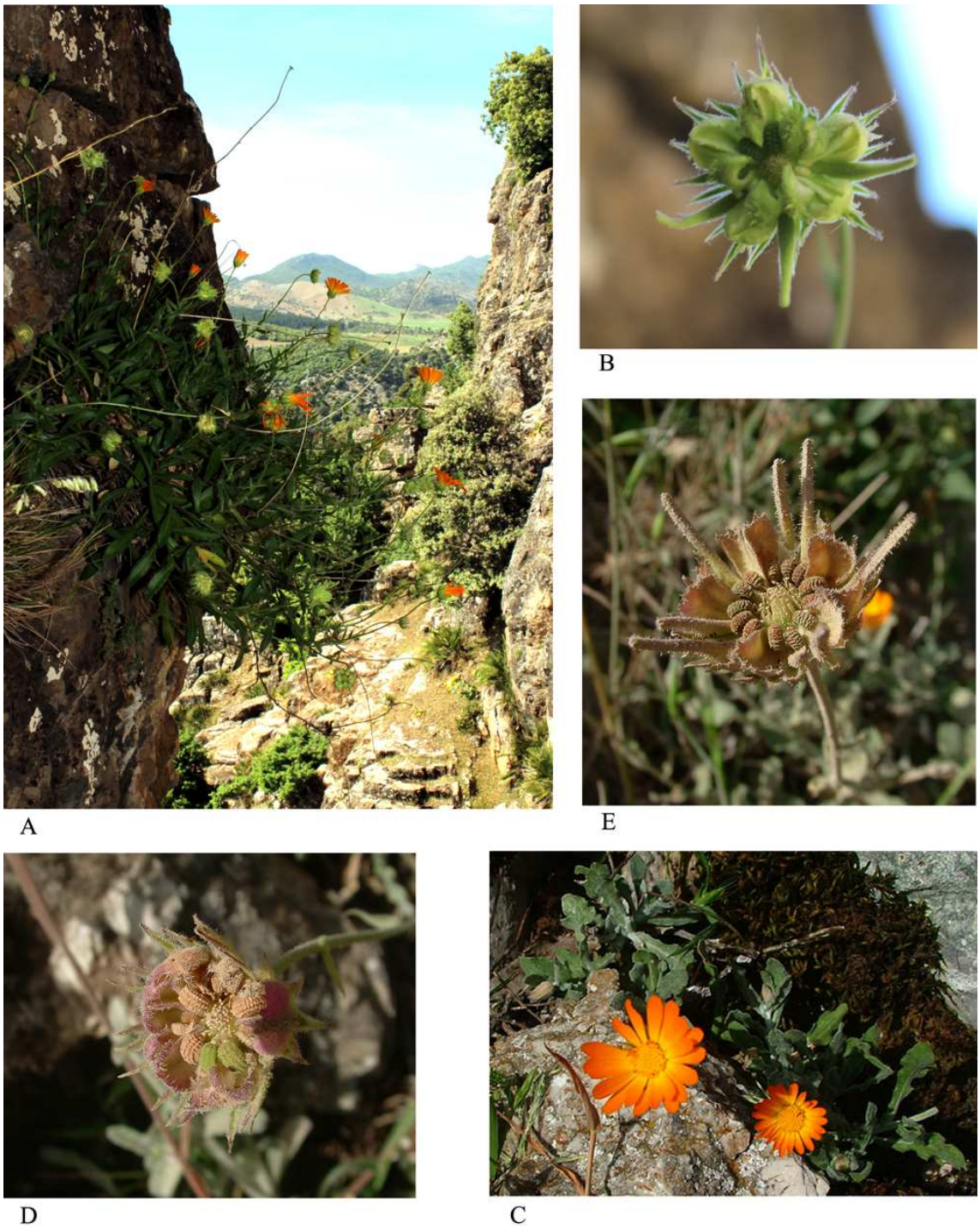


Figure 78 – A-B) *C. suffruticosa* subsp. *tazzea* (Silveira & Gonçalves 3334, AVE). A) Habit; B) fruiting capitulum. C-E) *C. suffruticosa* subsp. *hosmarensis* (Silveira & Gonçalves 3261, AVE); C) habit; D) fruiting capitula with cymbiform middle achenes; E) alternative fruiting capitula with sub-cymbiform middle achenes.

Figure 79– A-C) *C. suffruticosa* subsp. *dercana* (Silveira & Gonçalves 3262, AVE). A) Habit; B) fruiting capitulum; C) orange and yellow flowering capitula. D-F) *C. suffruticosa* subsp. *monardii* (Silveira, Gonçalves & Amirouche 3316, AVE); D) typical orange flowered form; E) alternative yellow flowered form; F) fruiting capitulum.

Figure 80 – A-C) *C. suffruticosa* subsp. *foliosa* (Silveira, Gonçalves & Amirouche 3320, AVE). A) Habit; B) fruiting capitulum; C) flowering capitula. D-F) *C. suffruticosa* subsp. *djurdjurensis* (Silveira, Gonçalves & Amirouche 3321, AVE); D) habit and habitat; E) fruiting capitulum; F) flowering capitulum.

Figure 81 – A-D) *C. suffruticosa* subsp. *suffruticosa* (Silveira 3038, AVE). A) Habit; B) fruiting capitulum; C) flowering capitulum; D) detail of leaves. E) *C. arvensis* (Silveira 3129, AVE); D) small sized form.

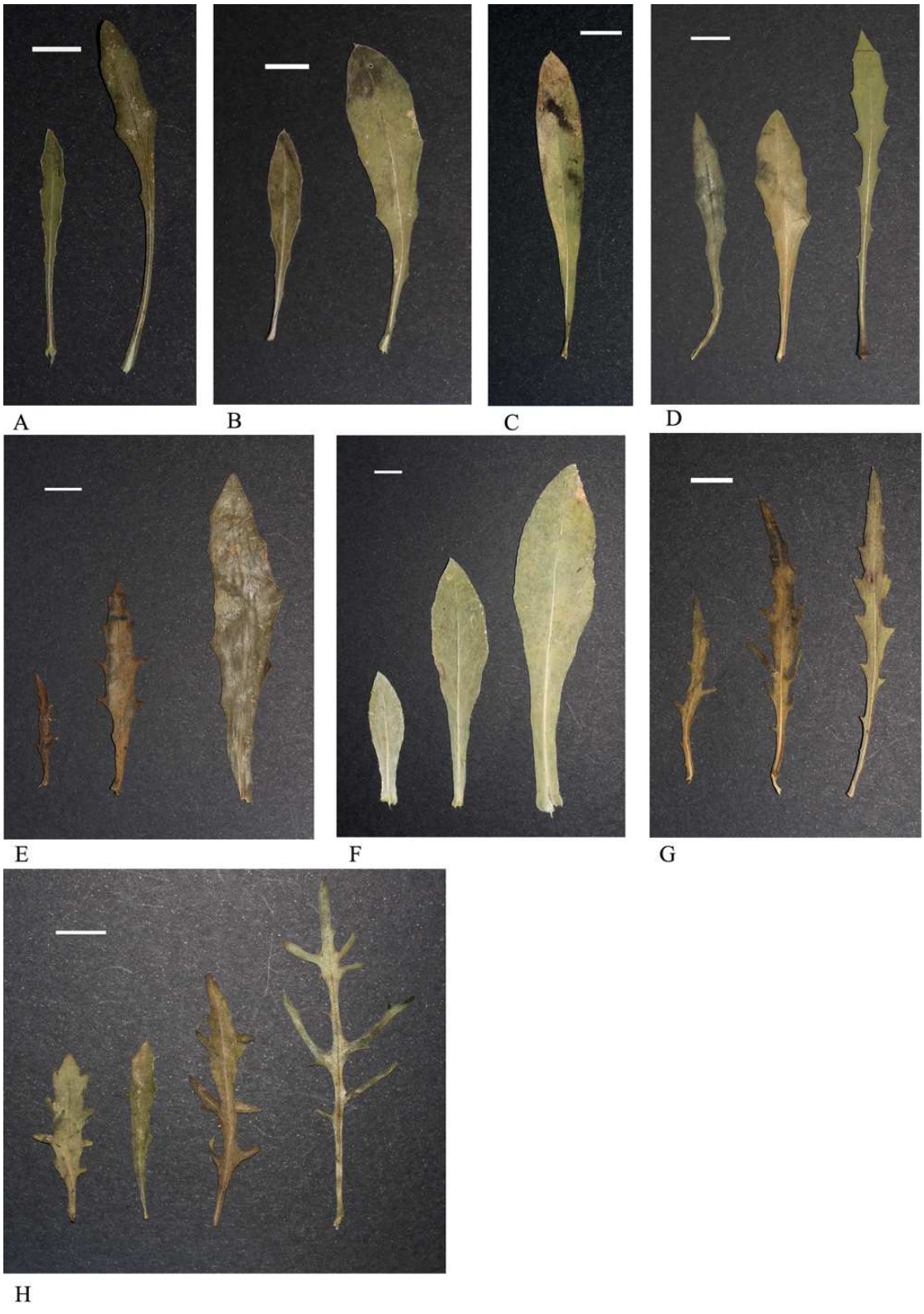


Figure 82 – Variability of basal leaf morphology in *Calendula*. A) *C eckerleinii* (Silveira & Gonçalves 3332, AVE); B) *C. fontquerii* (Silveira & Gonçalves 3339, AVE); C) *C. davisii* (Silveira & Gonçalves 3263, AVE); D) *C. maroccana* (Silveira & Gonçalves 3295, 3299, 3300, AVE); E) *C. pinnatiloba* (Silveira & Gonçalves 3138, AVE); F) *C. meuselii* (Silveira & Gonçalves 3063, AVE); G) *C. murbeckii* (Silveira & Gonçalves 3280, AVE); H) *C. lanzae* (Silveira & Gonçalves 3292, AVE).

Figure 83 – Variability of basal leaf morphology in *Calendula*. A) *C suffruticosa* subsp. *lusitanica* (Silveira & Gonçalves 3269, AVE); B) *C suffruticosa* subsp. *trialata* (Silveira & Gonçalves 3267); C) *C suffruticosa* subsp. *marsea* (Silveira & Gonçalves 3268, AVE); D) *C suffruticosa* subsp. *boccoyana* (Silveira & Gonçalves 3266, AVE); E) *C suffruticosa* subsp. *boccoyana* (Silveira & Gonçalves 3240, AVE); F) *C suffruticosa* subsp. *dercana* (Silveira & Gonçalves 3262, AVE)); G) *C suffruticosa* subsp. *riffiniensis* (Silveira & Gonçalves 3341, AVE); H) *C suffruticosa* subsp. *tazzea* (Silveira & Gonçalves 3334, AVE); I) *C suffruticosa* subsp. *hosmarensis* (Silveira & Gonçalves 3261, AVE); J) *C suffruticosa* subsp. *ostenii* (Silveira & Gonçalves 3265, AVE); K) *C suffruticosa* subsp. *fulgida* (Silveira & Gonçalves 3335, AVE).

Figure 84 – Variability of basal leaf morphology in *Calendula*. A) *C suffruticosa* subsp. *monardii* (1- Silveira & Gonçalves 3318, AVE, 2- Silveira & Gonçalves 3316, AVE); B) *C suffruticosa* subsp. *foliosa* (Silveira & Gonçalves 3320); C) *C suffruticosa* subsp. *djurdjurensis* (Silveira & Gonçalves 3321, AVE); D) *C suffruticosa* subsp. *tunetana* (Silveira 3029d, AVE); E) *C suffruticosa* subsp. *suffruticosa* (Silveira 3038, AVE).

Conclusions

The two subspecies of *C. maroccana* recognised by Ohle in 1975 a (*C. maroccana* and *C. maroccana* subsp. *murbeckii*) correspond, in our opinion, to clearly different taxa, which should have the rank of species. We consider that they have distinct morphologies, especially the achenes and duration of their life cycle. Furthermore, the type specimens

for these taxa were not properly established and were corrected here. Several other problems with typification were also found and corrected. Maire's (1928b: 57) variety *C. murbeckii* var. *pinnatiloba* was raised to species, and two new species were described *C. fontquerii* and *C. davisii*. In the treatment of perennial *Calendula* taxa by Ohle (1975 a), no *C. suffruticosa* is cited for Morocco, but thanks to surveys conducted by the team, eight subspecies of *C. suffruticosa* are now recognised for this country, five of them described as new. Additional taxa from Algeria and Tunisia were also analysed, in order to check relationships with Moroccan taxa. For Algeria, two new subspecies of *C. suffruticosa* are described. In future studies, we hope to expand the knowledge on the Algerian and Tunisian taxa and this might have implications on the treatment for Morocco now presented because some of the *C. suffruticosa* taxa here described could be reassessed and/or synonymised, on the light of new data. However, this study contributed towards a significant increase in the knowledge of the genus in Morocco and in the relationships with some Algerian and Tunisian taxa, although a global revision, including a phylogenetic study, is still needed.

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