



## Taxonomy and evolution of the *Convolvulus sabatius* complex (Convolvulaceae)

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### Abstract

A revision of the *Convolvulus sabatius* complex is presented and five taxa are now recognised. *Convolvulus valentinus* is re-circumscribed to comprise only blue-flowered individuals. Yellow-flowered plants previously referred to this species are transferred to *C. supinus* where they are recognised as a distinct variety: *C. supinus* var. *melliflorus*, comb. nov. Variation in intensity of flower colour, pubescence and leaf shape among blue-flowered *C. valentinus* is highly variable within populations and in contrast to earlier treatments, no infraspecific taxa based on these traits are recognised. Despite suggestions to the contrary, the delimitation of the cultivated ornamental *C. sabatius* and its two subspecies is unproblematic. Molecular data from the chloroplast *trnH-psbA* region support the recircumscription of *C. supinus* and *C. valentinus* and highlight the genetic distinctiveness of a disjunct Iberian population of the latter that merits further investigation.

**Key words:** Western Mediterranean, Maghreb, nomenclature, revision, species delimitation, *trnH-psbA*

### Introduction

The genus *Convolvulus* Linnaeus (1753; Convolvulaceae) has a cosmopolitan, though largely temperate distribution and comprises approximately 200 species worldwide. More than half of the species occur in the Mediterranean region, Macaronesia and Western Asia with 118 species enumerated in the most recent revision covering this region (Sa'ad 1967). Taxon delimitation in *Convolvulus*, as with other genera of Convolvulaceae, has proven to be problematic and whilst Sa'ad's (1967) treatment addressed a number of taxon delimitation problems, many uncertainties remain (e.g. Stace 1971, Mendoza-Heuer 1983, Greuter *et al.* 1986).

One particularly problematic group in the western Mediterranean comprises the cultivated ornamental species *C. sabatius* Viviani (1823) together with *C. valentinus* Cavanilles (1793; including *C. suffruticosus* Cavanilles (1793)) and *C. supinus* Cosson & Kralik (1857). This complex has a largely North African distribution with disjunct populations in Italy and Spain. Morphologically it comprises perennial plants that are woody at the base, with trailing or scrambling unarmed stems, petiolate leaves that are truncate or rounded at the base, flowers borne in axillary cymes, conspicuous peduncles that are generally shorter than the subtending bracts, and corollas that are blue, yellow or rarely white. The monophyly of the group is supported by molecular data and it appears to be closely related to a clade comprising the blue-flowered annual species *C. gharbensis* and *C. siculus* (Carine *et al.* 2004).

Taxon delimitation within the *C. sabatius* complex has focussed on three main characters, namely flower colour, leaf shape and pubescence, and an excess of thirty names, although not all validly published, have been proposed to account for the variation encountered in these traits. As currently circumscribed, *C. sabatius* is distinguished by a combination of blue flowers and leaves that are broadly ovate, rounded at the apex and never more than twice as long as broad. It is distributed in Italy and north Africa and has a peculiarly

disjunct distribution. In Italy it occurs in Liguria in the northwest (Pignatti 1982) and in Sicily and Puglia in the south although the Sicilian population is now considered to have been introduced (Giardina *et al.* 2007). In north Africa its distribution encompasses the Western Rif and Middle and High Atlas of Morocco and the Algérois and Kabyle regions of north central Algeria. Two subspecies have been recognised within *C. sabatius*, and Sa'ad (1967) distinguished subsp. *mauritanicus* from the type on the basis of pubescence, specifically on the indumentum of the leaf. For the most part, *C. sabatius* is easily distinguished from other taxa within the complex, although Stace (1971) suggested that where *C. sabatius* and *C. valentinus* are sympatric in north Africa the two are difficult to distinguish.

The delimitation of *C. valentinus* and *C. supinus* has been more problematic. *Convolvulus supinus* is endemic to north Africa with a distribution extending from Morocco to Libya. It is readily distinguished from *C. sabatius* by its yellow flowers, although in herbarium material this trait is not always apparent. The leaves are variable but generally ovate and the plant is densely pubescent throughout. *Convolvulus valentinus*, in its present circumscription, is distributed mainly in north Africa, although isolated disjunct populations also occur in mainland Spain (Aguadulce and the Alpujaras in Almeria and Cabo Nao in Valencia) and Mallorca (Marina de Lluçmajor and Illa de s'Espartar). This species is particularly common in northeastern Morocco and northwest Algeria where it is extremely variable morphologically. Blue, yellow and white flowered forms of *C. valentinus* may all be observed in this region. The leaves of plants in this area also show considerable variation in size and shape, and both leaves and inflorescences vary markedly in the degree of pubescence. Much of the variation within *C. valentinus* has received formal taxonomic recognition and two subspecies, eight varieties and three formae were recognised in north Africa by Sauvage & Vindt (1954). In flower colour, indumentum and leaf shape, some varieties within *C. valentinus* approach *C. supinus*, and distinguishing these two species is problematic.

The main aim of this paper is to clarify taxon delimitation in the *C. sabatius* complex. Based on field and herbarium work, we review the morphological variation in the complex and provide a taxonomic revision. In addition, we use data from the *trnH-psbA* spacer region of chloroplast DNA to further test hypotheses of taxon delimitation and investigate the evolution of the complex.

## Material and methods

Herbarium material from the following herbaria was examined: BC, BM, E, K, MA, MAF, MPU, P, RNG, SEV. In total over 500 specimens were investigated representing more than 400 collections. For the most part, the examination of herbarium specimens focussed on traits currently used for taxon delimitation in the group, notably the size, shape, apex and indumentum of the leaf, pubescence of the inflorescence and flower colour. However, flowers of some spirit-preserved and herbarium material were dissected to investigate androecium and gynoecium variation. In the case of herbarium specimens, dissections were performed following immersion in boiling water for approximately one minute.

Fieldwork was undertaken in Morocco. *Convolvulus valentinus* is particularly variable in north-eastern Morocco and a north-south collecting 'transect' was established in north-eastern Morocco, along which populations belonging to this complex were sampled. The 'transect' spanned the coastal plains in the north, the Beni Snassen mountains and the Geurcif plain at its southern extent. This facilitated sampling of a wide range of morphologies and the assessment of levels of intra-population variation within traits.

A total of twenty populations were sampled and examined in the field. This comprised: twelve populations of blue and white flowered *C. valentinus*, seven populations of yellow flowered plants that are referable to *C. valentinus* in its current circumscription, and two populations of *C. sabatius* in the Western Rif.

For molecular work a total of thirty seven accessions, comprising 35 ingroup and two outgroup accessions, were sampled. Of these, thirteen were collected in the field and 24 were herbarium specimens from the collections at BM. Full collection details are provided in Table 1. Specimens were selected to represent the full range of morphological variation and to sample as widely as possible from the geographical

range of the complex. Blue-flowered individuals of *C. valentinus* were sampled from Alicante (two accessions) and Almeria (one accession) and from northeast Morocco/northwest Algeria (10 accessions). Yellow-flowered specimens were similarly sampled from northeast Morocco/northwest Algeria and more widely in those two countries (12 accessions). Material was also sampled from Tunisia (two specimens) and Libya (one specimen). Material referable to *C. sabatius* was sampled from the Western Rif (three specimens) and High Atlas (one specimen) and from Algeria (three specimens). Unfortunately, we were unsuccessful in amplifying the target region from any of the Italian material of *C. sabatius* available to us, all of which was over 100 years old.

**TABLE 1.** Vouchers of material used in the *trnH-psbA* sequencing study.

Accession number	Voucher	Genbank accession code
<i>C. supinus</i> var. <i>melliflorus</i>		
C. sup. mel. 1	<i>Carine et al</i> , 365. Morocco, Beni Snassen: 23km from Uojda on road to Taza. 16.vi.2004. (BM).	HQ616174
C. sup. mel. 2	<i>Carine et al</i> , 368. Morocco, 49km from Oujda on road to Taza. 1km before road crosses Oued Bourdim. 16.vi.2004 ( BM )	HQ616175
C. sup. mel. 3	<i>Carine et al</i> , 366. Morocco, Beni Snassen: 23km W. from Oujda on road to Taza. 16.vi.2004 (BM)	HQ616181
C. sup. mel. 4	<i>Carine et al</i> , 370. Morocco, 6km E of Taourirt on Taourirt-El Ayoun Road. 16.vi.2004. (BM)	HQ616176
C. sup. mel. 5	<i>Jury</i> , 16928. Morocco, 121 km from Midelt along the road to Guercif. 26.iv.1995. (BM000630754)	HQ616191
C. sup. mel. 5	<i>Davis and Davis</i> , 49179. Morocco, ED. Ziz Gorge (Ksar-es-Souk to Rich). 7.iv.1969 (BM000630749)	HQ616198
C. sup. mel. 5	<i>Lambert</i> , 357. Morocco, Meski Spring, 11km S.E. of Ksar-es-Souk, O. Ziz. 20.iv.1969. (BM000630746)	HQ616199
C. sup. mel. 6	<i>Davis and Davis</i> , 49093. Morocco, ED: Ksar-es-Souk to Erfoud. 5.iv.1969. (BM000630741)	HQ616196
<i>C. supinus</i> subsp. <i>supinus</i>		
C. sup. sup. 1	<i>Turner, D.</i> , DT22/82. Libya, Fezzan, Brack, Wadi Zigzah. xii.1981-iv.1982. (BM000809240)	HQ616207
C. sup. sup. 2	<i>Kralik</i> , 398bis. Tunisia, Insual Djerba, in arensosi. 19.vi.1894. (BM000039781)	HQ616194
C. sup. sup. 3	<i>Berghen</i> , s.n. Tunisia, Matmata, 15.iv.1992. (BM000809234)	HQ616182
C. sup. sup. 4	<i>Murbeck</i> , s.n. Algeria, Tunetia meridian: Dj. Dissa –Dj. Regouba. 1.v.1896. (BM000809233)	HQ616195
C. sup. sup. 5	<i>Davis</i> , 58667. Algeria, AS2: E. foot of Dj. Amour, 50km from Laghouat to Aflou. 3.vi.1975. (BM000809228)	HQ616197
C. sup. sup. 6	<i>Bocquet</i> , 10779. Morocco, Sur la route d'Erfoud. 18.vi.1971. ( BM000809235 )	HQ616193
C. sup. sup. 7	<i>Jury</i> , 14592. Morocco, c. 16 km SSW of Goulmima, along main road from Tinerhir, on way to Er Rachidia. 25.iii.1994 (BM000630752 )	HQ616192
<i>C. sabatius</i> subsp. <i>sabatius</i>		
C. sab. sab. 1	<i>Ait Lafkih, Carine, Jury and Rumsey</i> , 191. Morocco, Western Rif Mountains, Oued Laou, Oued Tassikeste. 7.vi.2005. (BM)	HQ616210

..... continued

TABLE 1 (continued)

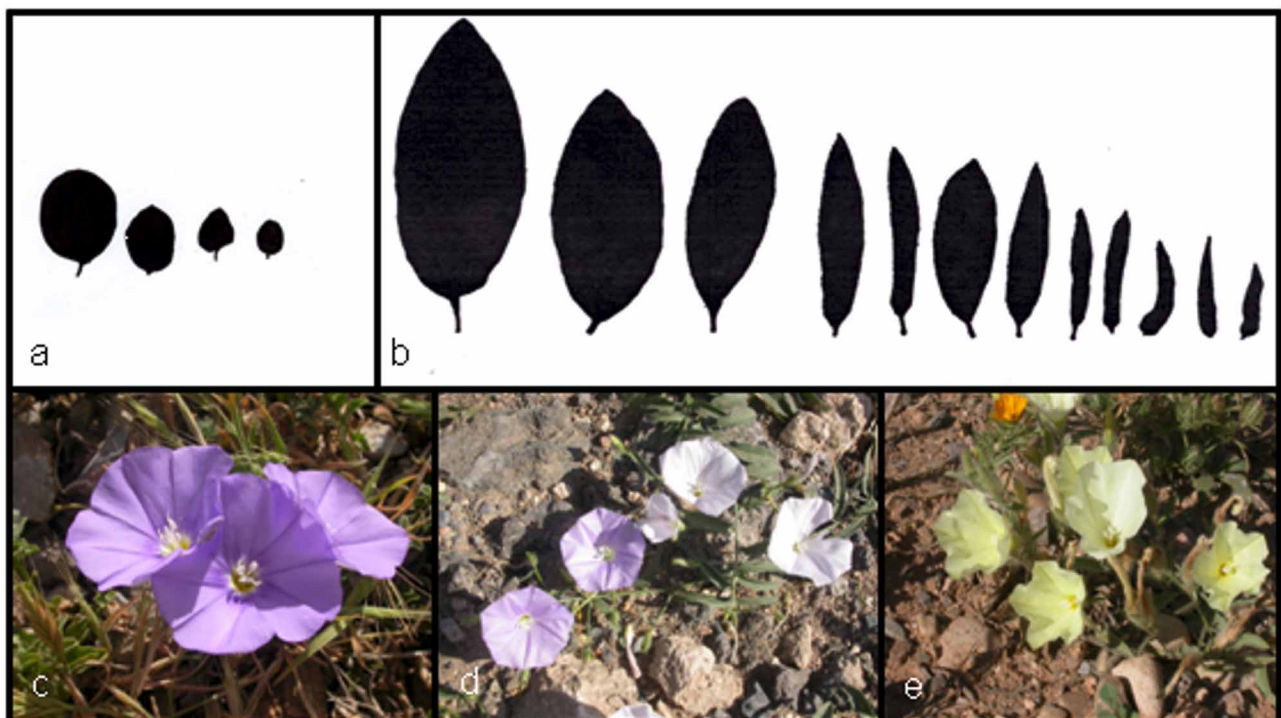
Accession number	Voucher	Genbank accession code
C. sab. sab. 2	<i>Davis, 54809.</i> Morocco, J. Tisouka, above Xauen. 5.vii.1973. (BM000039771)	HQ616203
C. sab. sab. 3	<i>Carine et al, 282.</i> Morocco, Western Rif: Chefchaouen. In the centre of Mechnella, opposite Mosque. 11.vi.2004. (BM)	HQ616180
C. sab. sab. 4	<i>Harley and Lankester, 105.</i> Morocco, Province of Beni Mellal, at entrance to Asif Arous. 8.viii.1964 (BM000630762)	HQ616204
C. sab. sab. 5	<i>Davis, 59461.</i> Algeria, K1: Djurdjura: E.side of Lalla Khedidja, S. of Tizi-N'Kouillal pass. 23.vi.1975. (BM000809241)	HQ616201
C. sab. sab. 6	<i>Davis, 52982.</i> Algeria, K2: Pic de Singes, above Bejaia. 29.v.1971. (BM000809244)	HQ616200
C. sab. sab. 7	<i>Davis, 52087.</i> Algeria, H2: 30km from Constantine to Setif. 8.v.1971 (BM000809243)	HQ616202
<i>C. valentinus</i>		
C. val. 1	<i>Faure, 34167.</i> Morocco, Env. De Martimprey du Kiss. 11.v.1930. (BM000630751)	HQ616189
C. val. 2	<i>Carine et al, 339.</i> Morocco, Beni Snassen: Gorges de Zegsel, 3km N. of turning to Grottes du Chameau. 15.vi.2004 (BM)	HQ616178
C. val. 3	<i>Davis, 51530.</i> Algeria, Maghina to Nedroma. 24.iv.1971 (BM)	HQ616190
C. val. 4	<i>Carine et al, 349.</i> Morocco, Beni Snassen: Road from Sidi-Bouhouria to Oujda, 3km SE of Labsabsa. 15.vi.2004 (BM)	HQ616187
C. val. 5	<i>Carine et al, 369.</i> Morocco, 49km W from Oujda on road to Taza, 1km before road crosses Oued Bourdim. 16.vi.2004. (BM)	HQ616183
C. val. 6	<i>Carine et al, 330.</i> Morocco, Gareb: 21km S of lighthouse at Cap de Trois Fourches on road to Farknana. 13.vi.2004. (BM)	HQ616184
C. val. 7	<i>Carine et al, 361.</i> Morocco, Beni Snassen: 8km W from Oujda on road to Taza. 15.vi.2004 (BM)	HQ616185
C. val. 8	<i>Borja, et al, s.n..</i> Spain, Entre Agra y Aguadulce (Almeria).iv.1965 (BM000809258)	HQ616206
C. val. 9	<i>Carine et al, 359.</i> Morocco, Beni Snassen: Ain-es-Sta. 15.vi.2004 (BM)	HQ616188
C. val. 10	<i>Carine et al, 337.</i> Morocco, Gareb: 37km W from Berkane on main road to Zaïo. 15.vi.2004. (BM)	HQ616186
C. val. 11	<i>Carine et al, 335.</i> Morocco, Gareb: 13km East from Kariat-Arrkmane on road to Ras-el-Mar. 14.vi.2004 (BM)	HQ616177
C. val. 12	<i>Peris et al, s.n.</i> Spain, Alicante: Moraira. En las orillas de la carretera sobre suelos algo removidos y nitrificados. 1970 (BM000809259)	HQ616205
C. val. 13	<i>Carine, s.n.</i> Spain, Rubble tip beside building site, Cabo de Nao, Alicante, 20.v.2004 (BM)	HQ616179
Outgroups		
<i>C. gharbensis</i>	<i>Jury, 13738</i> Morocco, c. 17 km E of Fèz on main road, to Taza. 3.iii.1994. (RNG)	HQ616208
<i>C. siculus</i>	<i>Jury et al, 19425.</i> Morocco, Rabat, Institut Agronomique et Vétérinaire Hassan II, Botanic Garden. 1.vi.2002. (BM)	HQ616209

Protocols for DNA extraction, PCR and sequencing of the *trnH-psbA* region followed Carine *et al.* (2005). GapCoder (Young & Healy 2003) was used to code indels. Phylogenetic analyses of the sequence data and combined sequence and gap data were performed using PAUP\* Beta version 4.0b5 (Swofford 2001) using the search strategy of Catalán *et al.* (1997), as implemented in Carine *et al.* (2004) to search efficiently for most parsimonious trees and ensure that multiple islands of trees were found. Trees were rooted on the branch between the *C. sabatius*-complex and *C. siculus/C. gharbensis* based on knowledge from previous phylogenetic analyses (Carine *et al.* 2004). The ensemble consistency index (CI; Kluge & Farris 1969) and retention index (RI; Farris 1989) were calculated in PAUP\*. Bootstrap values were determined from 100 bootstrap replicates each comprising 1000 random stepwise addition heuristic searches with TBR branch swapping, saving two trees per replicate. Bootstrap analyses were restricted to parsimony informative characters.

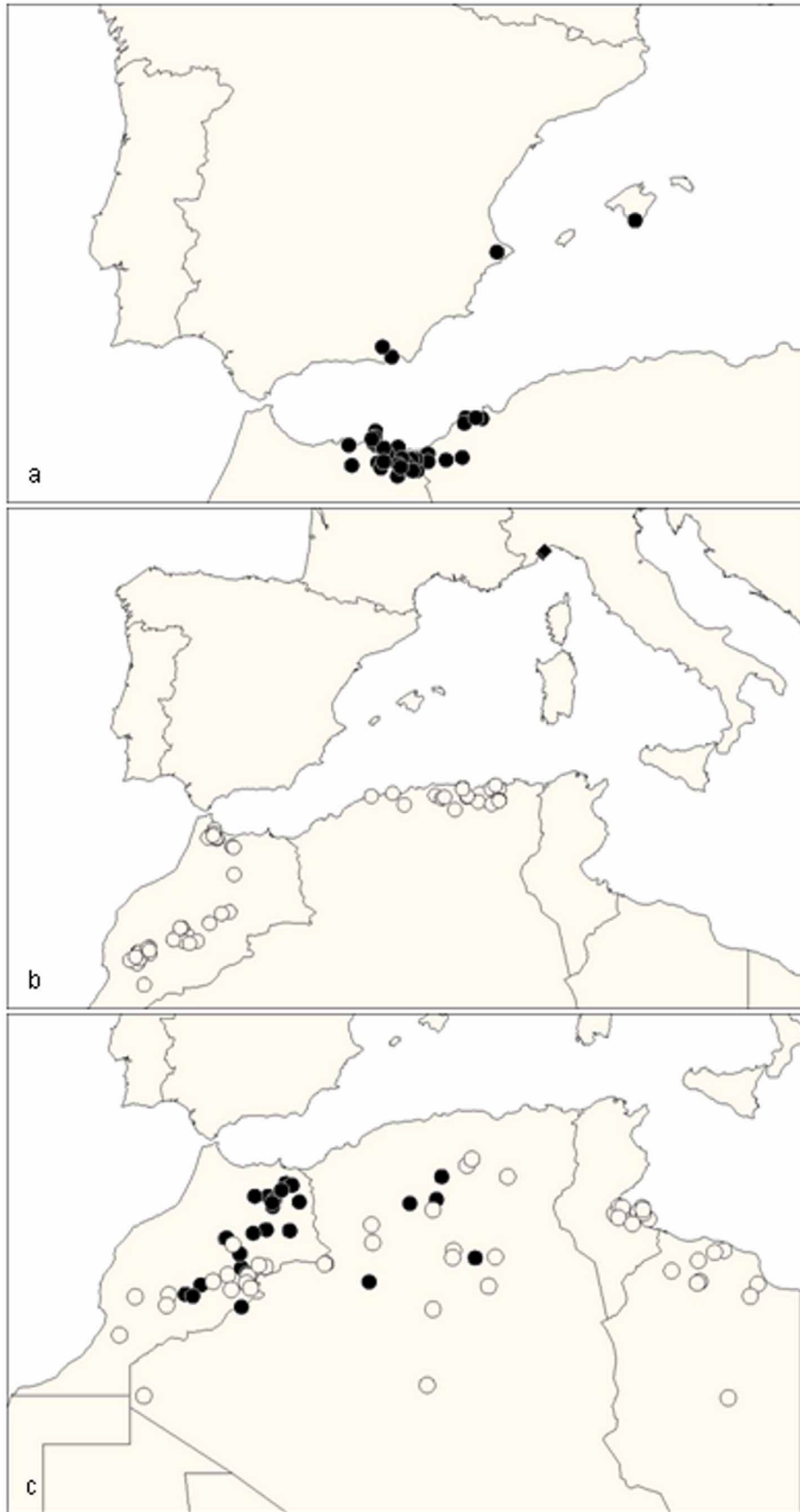
## Results

### *Morphological variation and taxon delimitation*

*The distinction between C. sabatius and C. valentinus* — Some forms of *C. valentinus* and all *C. sabatius* possess blue flowers, and Stace (1971) suggested that these two species intergrade in North Africa. However, from examination of herbarium specimens and populations in the field, it is apparent that leaf shape may be used to consistently distinguish these two taxa. In *C. sabatius*, the leaves are never more than twice as long as wide and generally possess rounded or obtuse apices (fig. 1a). In contrast, whilst the leaves of *C. valentinus* are extremely variable (fig. 1b), they are always more than twice as long as wide and acute at the apex. This distinction is consistently observed in all herbarium material and wild populations observed. Contrary to the suggestion of Stace (1971), these two species are therefore readily distinguished. The two are also geographically isolated in North Africa. Both species occur in Morocco and Algeria, but *C. sabatius* is confined to mountainous areas of the Western Rif, Jebel Tissouka and the High and Middle Atlas of Morocco and the Kabyle and Algérois regions of north central Algeria (fig. 2a) whereas blue flowered *C. valentinus* is confined to the north-east of Morocco (the Gareb and Beni Snassen Mountain areas as defined by Valdes *et al.* 2002) and the Oran region of northwest Algeria (fig. 2b).



**FIGURE 1.** Morphological variation in the *C. sabatius* complex. (a) Leaf shape and size variation in *C. sabatius*. (b) Leaf shape and size variation in *C. valentinus*. (c) Habit of *C. sabatius*. (d) Habit of *C. valentinus*. (e) Habit of *C. supinus* var. *melliflorus*.



**FIGURE 2.** Distributions of taxa in the *C. sabatius* complex. (a) *C. valentinus*, (b) *C. sabatius* subsp. *mauritanicus* (open circles) and *C. sabatius* subsp. *sabatius* (closed diamonds), (c) *C. supinus* var. *supinus* (open circles) and *C. supinus* var. *melliflorus* (closed circles).

*The subspecies of C. sabatius* — *Convolvulus sabatius* was described by Viviani (1824) from material collected at Capo di Noli in Liguria. Boissier (1839) later described and illustrated *C. mauritanicus* from Algeria without reference to Viviani's earlier description. Murbeck (1923) relegated *C. mauritanicus* to subspecific rank within *C. sabatius* distinguishing the two subspecies by pubescence of the calyx (long and spreading hairs in subsp. *mauritanicus* and appressed hairs in subsp. *sabatius*). He also suggested that North African plants had smaller leaves with more truncate bases than the Italian plants and that their sepals were herbaceous rather than coriaceous at the apex. The distinction between the two subspecies was retained by Sa'ad (1967) who distinguished the subspecies by leaf pubescence with subsp. *sabatius* being glabrous on the upper leaf surface and subsp. *mauritanicus* being pubescent.

Leaf shape and sepal apex texture are variable in north African *C. sabatius* and extremes in the size and shape of leaves may be observed on a single herbarium sheet. The distinction between subspecies based on glabrous versus pubescent leaf upper surfaces is also problematic; whilst many North African specimens are indeed pubescent on both surfaces, others are consistently glabrous on the upper surface and still others variable for this trait. Furthermore, a spectrum of forms may be observed within a particular area. For example, in the Constantine region of Algeria we have examined specimens consistently pubescent on both surfaces (e.g. *Durieu s.n.*, Bougie, vi.1839 (P)) and others only sparsely pubescent or glabrous above (e.g. *Durieu s.n.*, Bougie, 23.iii.1840 (P)).

A consistent difference that can be observed between plants from Capo di Noli and those from North Africa is the calyx indumentum, the character used by Murbeck (1923) to delimit the two subspecies. In plants from Capo di Noli the calyx indumentum comprises short, appressed hairs, whereas in North Africa the hairs are longer and spreading. On this basis the two subspecies may be consistently distinguished.

Whilst several collections have been examined from Capo di Noli as part of this study, no material from the localities in Sicily or Puglia has been examined. Giardina *et al.* (2007) considered *C. sabatius* to be introduced in its Sicily locality of Taormina, and this is plausible given that *C. sabatius* subsp. *mauritanicus* is commonly cultivated. We have also observed a plant collected from 'The Forum, Rome' (*Heard s.n.*, BM) that is referable to *C. sabatius* subsp. *mauritanicus*, further indicating that the North African plant is known to be in cultivation in Italy.

*Morphological variation within C. valentinus* — *Convolvulus valentinus* as presently circumscribed is a variable species that is usually distinguished from other taxa within the complex by its leaves that are always more than twice as long as wide, usually with acute apices and either glabrous or glabrescent upper surfaces. Within the species, flower colour, leaf shape and pubescence have all been used to delimit infraspecific taxa, with flower colour generally playing a subsidiary role to traits such as pubescence in the delimitation of taxa. For example, Sauvage & Vindt (1954) recognised both the blue-flowered var. *eusuffruticosus* and yellow-flowered var. *melliflorus* within subsp. *suffruticosus* that was itself characterised by the spreading indumentum of the calyx. Intensity of flower colour was also used, together with leaf shape and leaf and calyx size, to distinguish two varieties within subsp. *euvalentinus*: var. *transfetanus*, characterised by its pale flowers and var. *typicus* Maire that has blue flowers. Irrespective of nomenclatural problems associated with the application of these names, it is apparent from field observations that the use of intensity of flower colour to delimit taxa is inherently problematic within *C. valentinus*. Blue and white flowers co-occur within a population and may even be found on a single individual. The intensity of colour is most probably related to exposure to sunlight as plants in more exposed areas tended to have lighter coloured flowers. On a single individual larger, older flowers will often be paler in colour than smaller, younger flowers. The intensity of flower colour (between blue and white) would therefore appear to be of no taxonomic value.

In contrast, the distinction between blue/white (fig. 1d) and yellow (fig. 1e) flower colour appears to be of greater taxonomic value than its previous usage would suggest. There is a clear pattern of geographical structure in the distribution of blue- and yellow-flowered plants with blue/white-flowered forms occurring in Spain, northeast Morocco and northwest Algeria and yellow forms distributed further south. In Morocco, the

area between the Beni Snassen mountains and the Geurcif plain forms the southern extent of the distribution of the blue/white-flowered forms and the northern extent of the distribution of yellow-flowered individuals. This region was surveyed during fieldwork and our observations indicate that blue-flowered *C. valentinus* becomes less frequent to the south of the Beni Snassen Mountains as the vegetation becomes more arid whilst yellow-flowered plants become progressively more abundant. In several places, the two forms may be observed in sympatry but no intermediates in flower colour are apparent. The blue and yellow forms also differ markedly in habit, with the yellow forms more robust than the blue and, again, no intermediates appear to occur. A further difference may be observed in the stigma/style ratio with the style at least 1.5× the length of the stigma in yellow-flowered individuals and the stigma and style subequal in length in blue-flowered individuals.

In contrast to the clear geographical pattern correlated to flower colour, there is no geographical pattern in the variation in leaf shape and size, nor with leaf and inflorescence pubescence. Indeed, there is considerable variation in these traits within populations. For example, at sites where *C. valentinus* was observed both scrambling through vegetation and in exposed areas, those plants in the shelter of other vegetation tend to be more robust and possess larger leaves than plants in more exposed areas. This suggests a strong ecological component to the variation.

Silvestre (in press) suggests that there are no grounds to distinguish infraspecific taxa on the basis of leaf size and shape and indumentum in Spain and our results suggest that this conclusion applies more generally. Whilst a large number of names have been published within *C. valentinus* as presently circumscribed, only two taxa can be reliably distinguished on the basis of flower colour, stigma/style ratio and habit: a blue-flowered form with stigma and style more or less equal in length and a yellow-flowered, more robust form with the style at least 1.5 times as long as the stigma. Both taxa are variable in other traits such as leaf shape, size and indumentum and no taxonomic value should be attached to these traits although yellow-flowered forms do show a tendency to be more densely pubescent. Existing names are available for both blue- and yellow-flowered forms. The type of *C. valentinus* is blue-flowered, whilst *C. valentinus* var. *melliflorus* Pau is the earliest published name based on a yellow-flowered specimen.

*A reassessment of the circumscription of C. supinus* — *Convolvulus supinus* is the second yellow-flowered taxon within the *C. sabatius*-complex. Typically, the leaves of *C. supinus* are densely pubescent on both upper and lower surfaces and less than twice as long as broad. In this respect, typical *C. supinus* may be distinguished from yellow-flowered plants previously referred to *C. valentinus*. A further trait commonly observed in *C. supinus* is the ‘double indumentum’ of the stem, in which both long appressed hairs and short erect hairs are present (e.g. Sauvage & Vindt 1954).

*Convolvulus supinus* in its present circumscription is a plant of arid North Africa. Its distribution extends from southern Morocco eastwards through Algeria and Tunisia to Libya in the west. In Morocco it is, in general, distributed further south than yellow flowered forms referred to *C. valentinus* although the two overlap in the western Sahara region. The delimitation of yellow-flowered taxa is further complicated by the fact that whilst typical forms of both are readily distinguished by a combination of leaf shape and pubescence characteristics, none of the traits is entirely consistent. Of the three traits considered, leaf upper surface pubescence shows the strongest geographical signal. All specimens seen from Libya and Tunisia, most plants from Algeria, and a large proportion of plants from southern Morocco are consistently pubescent on the leaf upper surface, whereas plants distributed further north in Morocco and some specimens from Algeria are either glabrous or glabrescent on the leaf upper surface. In general, plants that are pubescent on the leaf upper surface also possess leaves that are less than twice as long as wide and more rounded in outline although these two traits are not entirely congruent. Similarly, pubescent-leaved plants also tend to have a double indumentum on the stem although this trait also occurs within plants with glabrous upper leaf surfaces within which at least some evidence of a double indumentum may often be observed.



Yellow flowers are unusual within *Convolvulus* and appear to have evolved infrequently; they are present in some western Asian species (e.g. *C. scammonia*) but outside of the *C. sabatius*-complex are unknown within any other western Mediterranean taxa. Given the infrequency with which yellow flowers have evolved in *Convolvulus*, it seems unlikely that the trait has evolved twice within two closely related taxa. A single origin for yellow flowers within the *C. sabatius*-complex therefore seems plausible. The stigma/style ratio also supports the grouping of all yellow-flowered members of the complex as the style is always at least 1.5 times as long as the stigma in yellow-flowered plants whereas in blue-flowered members of the complex it is more or less equal to the style in length.

In light of the difficulties associated with consistently separating taxa with yellow flowers, it is appropriate to refer all to a single, widespread and variable species, *C. supinus*. Within this species, two varieties may be distinguished on the basis of pubescence of the leaf upper surface although the distinction is not entirely clear cut. *Convolvulus supinus* var. *supinus* refers to plants distributed in Libya, Tunisia, most of Algeria and southern Morocco that possess leaves that are pubescent on the upper surface and are typically less than twice as long as broad. The stems of this variety always possess a conspicuous double indumentum. The name *C. supinus* var. *melliflorus*, based on Pau's name for yellow-flowered plants previously referred to *C. valentinus* is applied to plants that have leaves that are glabrous or glabrescent on the upper surface and often more than twice as long as broad. A double indumentum may or may not be present in this variety. The distribution of *C. supinus* var. *melliflorus* in Morocco extends northward from the Western Sahara to the Beni Snassen mountains. Outliers also occur in Algeria where *C. supinus* var. *supinus* dominates and there is no absolute geographical distinction in the distributions of these two taxa (fig. 2c).

*Molecular variation and evolution of the C. sabatius complex*—Sequences of the *trnH-psbA* region ranged in length from 297–373 bases and between five and eight gaps of 1–19 base pairs long were necessary to align all taxa. The aligned matrix was 392 base pairs long of which seventeen were parsimony informative characters. The use of GapCoder (Young & Healy 2003) to code indels resulted in an additional 23 gap characters of which 12 were parsimony informative.

Analysis of the combined sequence and gap character matrix resulted in 4086 trees of length 92 steps (CI (excluding autapomorphic characters) = 0.600; RI = 0.874). As can be seen from the strict consensus tree (fig. 3), the *C. sabatius* complex is resolved as monophyletic relative to the two outgroup taxa, albeit with weak support (61%). *Convolvulus valentinus* as re-circumscribed in this paper to contain only blue flowered plants is also resolved as a monophyletic group, although with bootstrap support of less than 50%. *Convolvulus supinus* as circumscribed here is resolved as a strongly supported monophyletic group (92% bootstrap) although with no differentiation between the two subspecies evident. *Convolvulus sabatius* is resolved as paraphyletic with respect to *C. supinus* although there is no bootstrap support for this relationship. Other clades resolved with bootstrap support of greater than 50% are the two accessions of *C. valentinus* included from Cabo Nao in Alicante (83%) that share a unique 20 base pair deletion, two accessions of *C. valentinus* from Morocco that are resolved as a monophyletic group with bootstrap support of 71% and two specimens of *C. supinus* var. *melliflorus* from the Ksar-es-Souk area of southern Morocco that are resolved as a clade with bootstrap support of 94%. Restricting the analysis to sequence data only resulted in 736 trees of length 52 steps (CI = 0.865 excluding uninformative characters; RI = 0.931). A monophyletic *C. sabatius*-complex and monophyletic *C. valentinus* and *C. supinus* were also recovered in this analysis, and whilst bootstrap support for the monophyly of the complex and of *C. supinus* was slightly lower than when gaps were included, support for the monophyly of *C. valentinus* was increased to 58%. *Convolvulus sabatius* forms an unresolved polytomy with the *C. valentinus* and *C. supinus* clades in the sequence-only analysis and only two of the four clades that were resolved within *C. supinus* and *C. valentinus* in the combined analysis were recovered. The sequence-only analysis also resolved one unique clade within *C. valentinus* and one within *C. supinus*, neither of which received bootstrap support.

The resolution of all yellow-flowered specimens as a clade in both analyses supports the recognition of a yellow-flowered taxon proposed on the basis of morphology. *Convolvulus sabatius*, *C. valentinus* s.s. and both outgroup taxa are blue-flowered and the yellow flowers of *C. supinus* therefore appear to be derived within the *C. sabatius*-complex.

Within the well-supported yellow-flowered clade, the lack of resolution between the two varieties is consistent with the lack of clear morphological differentiation between these taxa.

The unique deletion shared by the two accessions of *C. valentinus* from Alicante distinguishes them from both the Almeria accession and all North African accessions. The genetic structure of plant taxa distributed in northern Morocco and southern Spain has been little studied and, to-date, there are insufficient data to determine general patterns within taxa exhibiting such a distribution (Arroyo *et al.* 2008). The *trnH-psbA* data nevertheless suggest that even though the Iberian populations are limited in size and morphologically indistinguishable from those in North Africa, they do harbour distinctive genetic diversity. Further molecular work on intraspecific patterns of diversity within *C. valentinus* would be necessary to establish patterns of genetic diversity and the relationship of Spanish and North African populations.

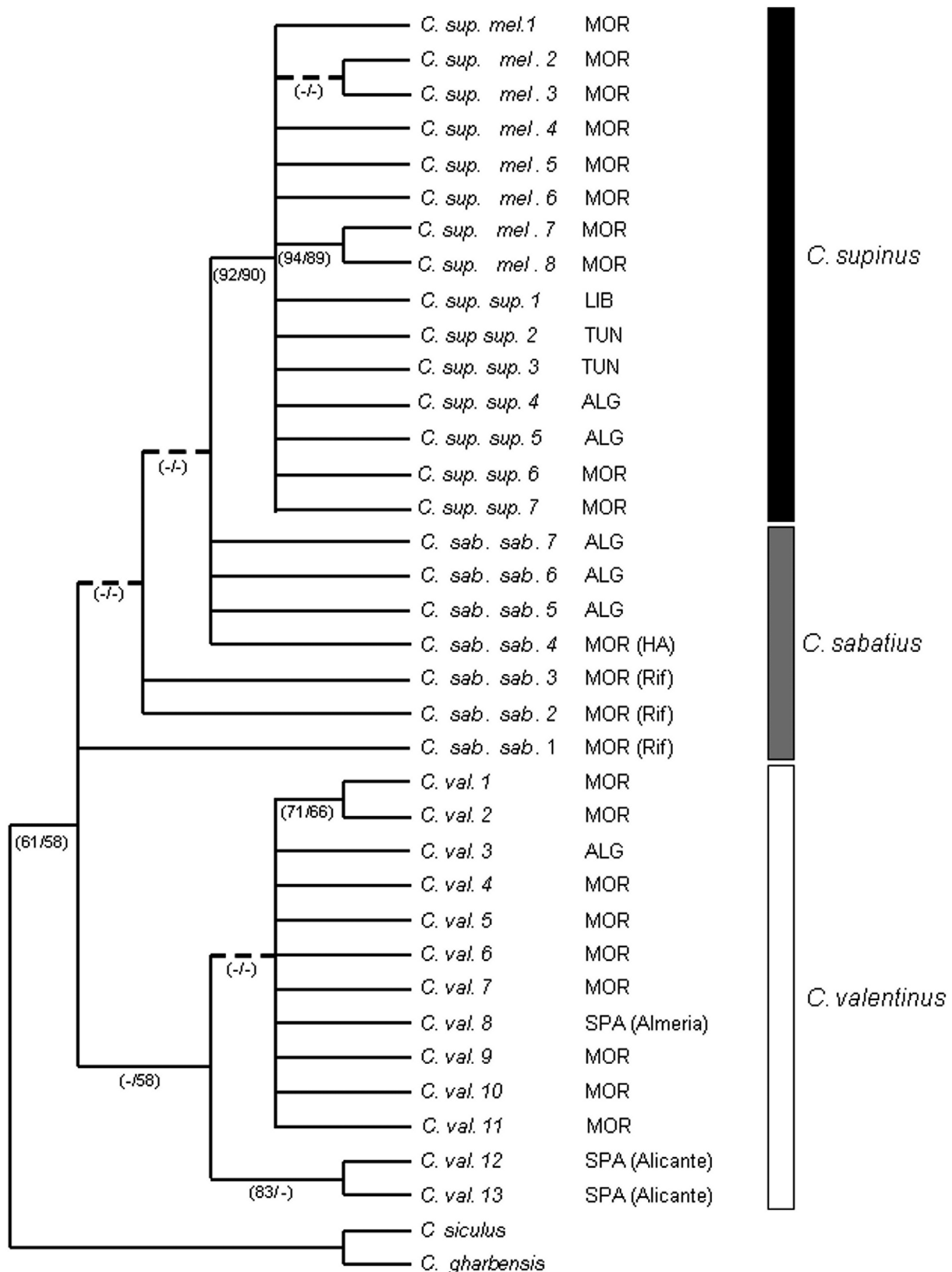
The resolution of *C. sabatius* as paraphyletic with respect to *C. supinus* is surprising given the morphological distinctiveness of these taxa. The analysis further suggests that accessions of *C. sabatius* from the High Atlas of Morocco and Algeria are resolved in a more distal position than those from the Western Rif, albeit with no bootstrap support.

It is interesting to note that the distributions of *C. sabatius* and *C. valentinus*, though disjunct, are restricted to refugial areas identified by Médail & Diadema (2009) pointing to an interesting evolutionary history for the group. However, sampling within taxa and the support for the topology are both limited and this precludes robust biogeographic hypotheses at the present time. Additional taxon sampling including, if possible, material of *C. sabatius* subsp. *sabatius* from Capo Noli in Italy, together with data from additional markers are necessary to shed further light on the evolution of the group.

*Taxonomy and nomenclature*—In light of the changes proposed within the *C. sabatius*-complex, a taxonomic account of the group is provided below.

### **Taxonomic treatment of the *C. sabatius* complex**

Prostrate or scrambling perennial herbs, woody at the base, with stems to 30 cm or more long. *Leaves* shortly petiolate, lamina oblong, elliptic, ovate, deltoid or orbicular, margins entire, apices acute, obtuse or emarginate. *Flowers* axillary, pedunculate, solitary, or in pairs, or rarely in 3-flowered cymes. *Peduncles* equal to or longer than the pedicels. *Bracteoles* lanceolate to elliptic. *Calyx* lobes five, unequal, lanceolate, elliptic or obovate, apices acute, attenuate or rarely rounded with a short attenuate point. *Corolla* funnel-shaped, blue, white or yellow, underside with five paler, pubescent bands. *Stamens* 5, unequal (2 long + 3 short); filaments glabrous or glandular pubescent; anthers sagittate. *Ovary* narrowly conical to spheroidal, glabrous or rarely pubescent. *Style* glabrous. *Stigma* bifid, the lobes narrowly cylindrical. *Fruit* a dehiscent capsule. *Seeds* brown.



**FIGURE 3.** Strict consensus tree from analysis of *trnH-psbA* data of the *C. sabatius* complex. The tree is rooted between the complex and (*C. siculus*, *C. gharbensis*) based on the results of Carine *et al.* (2004). Dashed lines indicate groups recovered in analysis of sequence and gap data that are not recovered when only sequence data are analysed. Bootstrap proportions are indicated in parentheses below nodes. The first figure is from analysis of both sequence and gap characters; the second figure is from analysis of sequence data only. Dashes indicate bootstrap proportions of less than 50%. Distributions are indicated as follows: ALG = Algeria; LIB = Libya; MOR = Morocco [(HA) = High Atlas; (Rif) = Rif Mts.]; TUN = Tunisia; SPA = Spain .

## Key to the species

- 1 Corolla yellow, style at least 1.5 times as long as stigma..... 2
- Corolla blue or white, stigma and style +/- equal in length..... 3
- 2 Upper leaf surface pubescent; stem indumentum comprising long appressed hairs and short +/- erect hairs .....  
..... 2a. *C. supinus* var. *supinus*
- Upper leaf surface glabrous or glabrescent; stem indumentum comprising only long appressed hairs .....  
..... 2b. *C. supinus* var. *melliflorus*
- 3 Leaves >2 x longer than broad; apices usually acute ..... 1. *C. valentinus*
- Leaves usually <2x as long as broad; apices rounded ..... 4
- 4 Calyx with an indumentum comprising short, appressed hairs ..... 3a *C. sabatius* subsp. *sabatius*
- Calyx lobes sparsely to densely villous 3b *C. sabatius* subsp. *mauritanicus*

### 1. *Convolvulus valentinus* Cavanilles (1793: 65).

Holotype: SPAIN. Benitachell, *Cavanilles s.n.* (MA!)

*Convolvulus suffruticosus* Desfontaine (1798: 175) ≡ *C. valentinus* subsp. *suffruticosus* (Desf.) Maire in Jahandiez & Maire (1934: 3) ≡ *C. valentinus* var. *suffruticosus* (Desf.) Pau & Font Quer in Font Quer (1927: 489). Holotype: ALGERIA. Tlemcen, *Desfontaines, s.n.* (P!)

*Convolvulus valentinus* var. *oranensis* Pomel (1874: 86). Lectotype (designated by Sa'ad, 1967): ALGERIA. Prov. Oran: Bou-Tléis, *Pomel s.n.* (AL (n.v.); duplicate MPU!)

*Convolvulus valentinus* var. *melillensis* Pau (1911: 6). Holotype: MOROCCO. Molilk ribanadas del rio, *Pau, s.n.* (MA!)

*Convolvulus suffruticosus* f. *angustifolius* Maire (1938: 29). Holotype: MOROCCO. Ain Tellout, *Henry, 6-462*, 5 May 1936 (MPU!).

*Convolvulus valentinus* subsp. *euvalentinus* Maire in Jahandiez & Maire (1934: 3), *nom. non rite public.*

*Convolvulus valentinus* var. *typicus* Maire in Jahandiez & Maire (1934: 3), *nom. non rite public.*

*Convolvulus valentinus* f. *albiflorus* Sauvage & Vindt (1954: 2), *nom. nud.*

*Convolvulus suffruticosus* f. *valdepilosus* Sennen & Mauricio (1933: 79), *nom. nud.*

*Convolvulus suffruticosus* var. *debilis* Sennen & Mauricio (1933: 79), *nom. nud.*

*Convolvulus valentinus* f. *villosissimus* Sennen (1934: 9470), *nom. nud.*

*Convolvulus valentinus* var. *transfretanus* Pau & Font Quer in Font Quer (1930: 356), *nom. nud.*

*Stems* somewhat villous. *Leaves* with petioles 2–6 mm long; lamina oblong to elliptic, 10–40 mm long × 2–15 mm wide; base cuneate, truncate or rarely attenuate; apices acute or rarely obtuse; sparsely villous on lower leaf surface, glabrous or glabrescent above. *Flowers* solitary or in pairs. *Peduncles* 5–35 mm long at anthesis, sparsely villous. *Pedicels* 5–8(–15) mm long, sparsely villous. *Bracteoles* lanceolate, 6–12 mm long × 0.5 mm wide, villous. *Calyx* lobes lanceolate, elliptic or obovate, unequal, 6.5–9.5 mm long × 2–4 mm wide; apices acute, attenuate or rarely rounded with a short attenuate point; villous, often only along the margins and midrib. *Corolla* 15–30 mm long, intense blue-lavender to almost white, with a yellow centre. *Stamens* with filaments 5–7(–9) mm long on the shorter three, 6.5–8(–11) mm long on the longer two, the shorter filaments with stalked glandular hairs for the lower 1/3, the longer pair entirely glabrous; anthers 2–3 mm long on the longer filaments, 1.5–2.5 mm long on the shorter filaments. *Ovary* narrowly conical, 1–2 mm long, white, glabrous. *Style* white, 4–6 mm long. *Stigma* lobes 4–5.5 mm long, equal or nearly equal in length to the style (fig. 2d).

**Distribution:**—In Spain (Almeria, Alicante [Cabo Nao] and Mallorca [Marina de Lluçmajor and Illa de s'Espartar; Sáez and Rosselló 2001]), northeastern Morocco (Gareb and Beni Snassen Mountain areas as defined by Valdes *et al.* (2002)) and northwestern Algeria (Oran Province; fig. 2a).

**Habitat:**—Growing in dry pastures and disturbed areas, often alongside roads.

**Phenology:**—Flowering and fruiting April–June.

**Conservation:**—At a global level, this species meets the criteria for Least Concern (IUCN 2001). However, in Spain, it exists in a number of small, highly disjunct populations and molecular data suggest that plants from Alicante may be distinct from the rest (fig. 1). In the Balearics, *C. valentinus* is recognised as critically endangered (Category C2a(ii); Sáez and Roselló 2001)

**Other specimens seen:**—ALGERIA. Route de Bou Tilelu a Elancon, enc. D'Ozan, *d'Alleizette s.n.* (94109), April 1918 (MA); Coteaux arides á Lalla-Maghrnia, ouest fe la Prov. d'Oran *Bourgeau 80*, 14 May 1856 (E); Maghina to Nedroma, *Davis 51530*, 24 April 1971 (RNG, BM); nr. Maghina, *Davis 58995*, 9 June 1975 (BM); Tlemcen, *Desfontaine 396* (P); Les Lauriers-Roses (Departement d'Oran), *Faure s.n.*, 23 May 1915 (BM); Les Lauriers-Roses (Oran), *Faure s.n. (41681)*, 23 May 1915 (BC); Aïn Tellout, *Henry 6-462* 5 May 1936 (MPU); O. Bou Tlelis, *Pomel s.n.* (MPU); Oran, *Sennen & Maurico 269*, 14 April 1934 (MA).

MOROCCO. 49 km W from Oujda on road to Taza, 1 km before road crosses Oued Bourdim. *Carine, Ait Lafkih, Rumsey & Rutherford 369*, 16 June 2004 (BM, RNG, IAV); Nador: Cap des Trois Fourches, croisement à Farkhana, *Acchal, Benabid, Diaz, Diosdado, Santa-Bárbara & Valdés loc. 21/88*, 13 April 1988 (RNG); Pico de la Pieneta (Melilla), *Arnal s.n. (94105)*, 13 April 1943 (MA); Gareb: 13 km East from Kariat-Arrkmane on road to Ras-el-Mar., *Carine, Ait Lafkih, Rumsey & Rutherford 335*, 14 June 2004 (BM, RNG, IAV); Beni Snassen: Gorges de Zegsel, 3 km N. of turning to Grottes du Chateau, *Carine, Ait Lafkih, Rumsey & Rutherford 339*, 15 June 2004 (BM, RNG, IAV); Gareb: 21 km S of lighthouse at Cap de Trois Fourches on road to Farknana, *Carine, Ait Lafkih, Rumsey & Rutherford 330*, 13 June 2004 (BM, RNG, IAV); Gareb: 37 km W from Berkane on main road to Zaïo, *Carine, Ait Lafkih, Rumsey & Rutherford 337*, 15 June 2004 (BM, RNG, IAV); Beni Snassen: Road from Sidi-Bouhouria to Oujda, 3 km SE of Labsabsa, *Carine, Ait Lafkih, Rumsey & Rutherford 349*, 15 June 2004 (BM, RNG, IAV); R: 10 km E. of Zaïo (Nador-Berkane, *Davis 51405*, 19 April 1971 (E); Oujda: 6 km from Oujda, on the road to Taza, *Etlafski, Mateos & Valdés BV120/93*, 29 May 1993 (SEV); Between Oujda and Sidi Bouhria near the crossing to Ain Sfa, *Etlafski, Mateos & Valdés BV234/93*, 29 May 1993 (RNG, BC, SEV); Oujda. Between Beni Drar and Ahfir, Col de Guerbourss, *Etlafski, Mateos & Valdés BV278/93*, 29 May 1993 (RNG, SEV); Oujda: Ahfir, Forestry road to Monts Beni-Snassen, 6 km from Ahfir, *Etlafski, Mateos Valdés BV469/93*, 30 May 1993 (RNG); Beni-Snassen: Martinjiney, *Faure s.n.*, 7 May 1928 (MPU); Martinjiney-du-Kiss, *Faure s.n.*, 19 April 1937 (E); Beni Snasen, Taforalt a 2.1 km hacia Zegzel, *Fiz, Martinez, Valcárcel & Vargas 180PV00*, 3 May 2000 (MA); Hassi Berkan (Ulad Setut), *Font Quer 356*, 30 May 1929 (MPU, BM, MA, BC); Marsa Saguir (Bocoya), *Font Quer 489*, 10 May 1927 (MPU, BM, MA, BC); Beni Snassen: Beni Oual, *Jahandiez 48*, 22 April 1925 (E, MA); Castellum Tazzougert, *Maire & Wilczek s.n.*, 18 April 1933 (MPU); In ditione Beni-Snassen in collis Taghit, *Maire s.n.*, 2 may 1925 (MPU); Morro Nuevo, *Maire s.n.*, 19 June 1929 (MPU); Nador: near Melilla, *Mateos & Valdés BV806/93*, 1 June 1993 (RNG, SEV); Gurugu, *Maurico s.n.*, April 1931 (BM); Aïn Cheggag, *Mouret 2446*, May 1913 (P); Melilla, *Pardo & Marti s.n. (94098)*, 26 March 1933 (MA); Molilk ribanadas del rio, *Pau s.n. (94101)*, April 1918 (MA); Ghar: Rouban, *Pomel s.n.*, 10 June (MPU); 10: Beni-Snassen. Beni Oukil hacia Jbel Mrhiris, *Romo, Bouhmadi, Peris & Stubing 6556*, 10 April 1994 (RNG, BM, SEV); Beni-Snassen: Machra Homadi, hacia Jerf al Khaldi, *Romo, Bouhmadi, Peris & Stubing 6680*, 13 April 1994 (RNG, SEV); Triffa: Jebel Gounougou, paitie banc, erme ek cultures, *17206*, 13 May 1962 (MPU); Tarifa: plaine en Trifa a 9 km au S de Saïdia, *6852*, 6 April 1955 (MPU); Mellila: coteaux, *Sennen s.n. (15633)*, May 1932 (P, MAF); Melilla, *Sennen & Maurico s.n.*, May 1932 (BM); Beni Snassen: Berkane, *Sennen & Maurico s.n.*, 2 April 1934 (BM); Sidi-Auriach, Gurugu, *Sennen 7642*, 20 & 21 June 1930 (BM); Monts des Kebdana, *Sennen & Maurico 9470*, 12 June 1934 (MPU, BM, MA, MAF, BC).

SPAIN. Entre Agra y Aguadulce (Almeria), *Borja, Mansanet & Monasterio s.n.*, April 1965 (BM, RNG); Almeria: Aguadulce, *Borja, Mansanet & Monasterio s.n.*, April 1965 (SEV); Almeria, Barranco del Caballar, *s. coll. 67*, April 1890 (BM); Almeria: Barranca de "La Majora", *Jeronimo s.n.*, 23 December 1932 (BM); Almeria: Barranco del Caballar, *Lacaïta 31648 + 31897*, 16 May 1928 (BM); Juxta oppidum Benitachel prope Jàvea (Alicante), *Cavanilles s.n. (MA475578)*, May 1792 (MA); Alicante: Benitachel, *Ellman & Sandwith 1162*, 14 May 1928 (K); Alicante: Between Benitachel and the Cabo de la Nao, *Ellman & Sandwith 32992*, 14 May 1928 (BM); Barranco del Caballar, pr. Almeria, *Fluton, Porta & Figo 338*, 10 April 1879 (E); Alacant: Beniteixel (Penyals de Lorxa), *Font Quer & Gros 174/24*, 10 May 1923 (RNG); 12 km SE from Denia, Cabo de San Antonio, *Jury, Rumsey & Vagges 5163*, 7 April 1984 (RNG); Alicante, 12 km SE from Denia, Cabo de San Antonio, *Jury 7254*, 14 April 1986 (RNG); Almeria, Sierra Nevada, Las Alpujarras, above Almocita on road to Fondon, *Jury 18709*, 1 April 2001 (RNG); 7 April 1986 (RNG); Benitachel (prov.

d'Alicante), *Lager s.n.*, 27 May 1890 (BM, K); Valence: Benitachel, Cote de la Granadella, *Pau 26094 (2470)*, June 1913 (BM, RNG); Alicante: Moraira, *Peris, Stübing & Gonzalez s.n.*, 1970 (BM); Alicante: Moraira. En las orillas de la carretera sobre suelos algo removidos y nificados, *Peris, Stübing & Gonzalez 1970*, 10 April 1983 (RNG, SEV); Almeria, Barranco del Caballar, *Porta & Figo 67*, April 1890 (E); Alicante: Benitachel, *Rouy 1565*, 29 May 1883 (BM).

## 2. *Convolvulus supinus* Cosson & Kralik (1857: 400).

Lectotype (designated by Sa'ad, 1967): ALGERIA. Oran: Ain Sefra, S.W. prov., *Bourgeau 60* (P!, duplicated C, E, GOET, W)

*Stems* with either long appressed hairs or a prominent double indumentum comprising long appressed hairs and shorter erect hairs. *Leaves* with petioles 1–2 mm long; lamina ovate, oblong, deltoid or elliptic; base cuneate, truncate or rarely attenuate; apices acute or obtuse. *Flowers* in 1–2(–3)-flowered axillary cymes. *Peduncles* 15–35 mm long at anthesis. *Pedicels* 3–30 mm long. *Bracteoles* lanceolate, 4.5–10(–15) mm long × 0.5–1(–1.5) mm wide, densely villous. *Calyx* lobes ovate, elliptic or obovate, unequal, 8–11(–12) mm long × 2.5–4.5 mm wide; apices acute, attenuate; villous. *Corolla* 20–30(–35) mm long, yellow. *Stamens* with filaments 9–10 mm long on the shorter three, 11–15 mm long on the longer pair; usually glandular pubescent for bottom  $\frac{1}{2}$ – $\frac{3}{4}$  of total length or rarely glabrous; anthers 2.5–3.5 mm long on the longer filaments, 2–3 mm long on the shorter filaments. *Ovary* narrowly conical to spheroidal, 1–1.5 mm long, glabrous or long-hairy towards the apex. *Style* 6.5–10 mm long. *Stigma* lobes 4–5 mm long, much shorter than the style.

### 2a. *Convolvulus supinus* var. *supinus*

*Convolvulus brevipes* Pomel (1874: 1). Holotype: ALGERIA. El Abiad Sidi Cheikh *Pomel s.n.*, 15 April 1862 (AL [n.v.]; isotype MPU!)

*Convolvulus leucotrichus* Pomel (1874: 1). Holotype: ALGERIA. Mitilili, *Pomel s.n.* (AL [n.v.]; isotype P!)

*Convolvulus supinus* var. *sulphurescens* Maire & Wilczek in Maire (1934: 311) ≡ *C. supinus* f. *sulphurescens* (Maire & Wilczek) Sauvage & Vindt (1954: 42). Type: MOROCCO. In rupestri calcareis, infra castellum Tazouggest, 1200 m *Maire & Wilczek s.n.*, 18 April 1933 (isotype: MPU!).

*Convolvulus supinus* var. *atrighogynus* Maire & Wilczek (1934: 25). Holotype: MOROCCO. Prope oasis Beni-Ouziem, *Maire & Wilczek s.n.*, 17 April 1933 (MPU!; isotypes P! MA!).

*Stems* with indumentum comprising long appressed hairs and more or less erect shorter hairs. *Leaves* ovate, oblong or elliptic, 8–20 mm long × 5–11 mm wide; base cuneate, truncate or rarely attenuate; apices obtuse or rarely acute; both surfaces densely pubescent.

**Distribution:**—Southern Morocco, Algeria, Tunisia and Libya (fig. 2c).

**Habitat:**—In arid stony and sandy areas.

**Phenology:**—Flowering March–June; fruiting May–June.

**Conservation:**—A widespread and common taxon, it meets the criteria for Least Concern (IUCN 2001).

**Other specimens seen:**—ALGERIA. Beni Oussif, *Allorge s.n.*, 14 April 1913 (P); Aïn Kesman au N. de Bou-Saouda [Aïn Kerma], *Battandier s.n.*, April 1882 (MPU); Aïn Sefra, *Battandier & Trabut 466*, June 1888 (P); Aïnel-Hadhadj [Aïn el Hadjadj (spring)], *Bonnet & Maury s.n.*, 13 April 1888 (P); Fezzan: Monts Messak, *Capot-Rey s.n.*, April 1946 (MPU); El-Golea, au pied de la carriere de pisse, *Chevallier s.n.*, 17 May 1899 (P); El-Golea: au pied de la premier Gara, *Chevallier s.n.*, 29 March 1904 (P); Sahara: Ghandaïa, sable a Bouchea, *Chevallier s.n.*, 1 April 1899 (P); Sahara: Ghandaïa: sable de l'oasis, *Chevallier s.n.*, 29 April 1897 (P); Sahara: Ghardaïa, lui de l'Oued Mzab a Boucher, *Chevallier s.n.*, 5 May 1899 (P); Sahara: Metlili, sables de l'Oasis, *Chevallier s.n.*, 6 May 1897 (P); Tiberkan, *Chudeau s.n.* (MPU); Aïn Sefra, prov. D'Oran, *Cosson*

*s.n.*, 6 May 1856 (MPU); Sud Oranais, Beni Ourif, *d'Alleizette s.n.* (BC139504), May 1922 (MA, BC); Sahara occidental: Tindouf [location in Algeria, Tindouf], *Estival s.n.*, March 1928 (MPU); Sud-Oranensis, Beni Ounif, *Faure s.n.*, 23 April 1938 (E); Environs de Aïn Sefra, Sud Oranais, *Faure s.n.*, 30 May 1934 (MPU); Sahara: Adrar dersfous, haute desertique [Adrar des Iforas, Tunisia ], *Gougerot-Nicot s.n.*, April 1933 (P); Col de Zenaga, *Hibon s.n.*, 13 April 1906 (P); Col de Zenaga entre Beni Ounif et figuig, *Humbert s.n.*, April 1924 (P); abrei Oued Mzab inter Kassi el Djunal et Ghar el Deba, *Kralik 68*, 7–8 May 1858 (P); Aïn Sefra sud-ouest de la Prov. D'Oran, *Kralik s.n.*, 6–7 May 1856 (MPU); Lieux incultes et cultivés a Aïn Sefra, SW Oran, *Kralik 60*, 6–7 May 1856 (E, P); Oued Mizgab inter Hassi el Djual at Ghar el Debā, *Kralik s.n.*, 7 & 8 May 1858 (MPU); Beni-Oanii de Figuig. Dept. d'Oran, *Le Cesve 148*, 4 May 1938 (P); Beni-Ounif de Figuig, *Le Cesve 148*, 4 May 1938 (MPU); Banioum, *Letourneaux s.n.*, May 1882 (P); Sahara Ageien de Biskra a Ouargla, *Letourneaux s.n.*, (MPU); Gales - Kelenata, *l'Hermite s.n.*, 8 April 1909 (P); Inisa, *l'Hermite s.n.*, April 1906 (P); supra Oasim Tindouf, *Maire & Wilczek s.n.*, 18 April 1935 (MPU); supra Oasni Jindouf, *Maire s.n.* (88288), 18 April 1935 (P, BC); Tassili n Ajzen: Aricheret, *Maire 858*, 25 April 1928 (P, MPU); Region Camp Willaya El Aïounm pres Tindouf, *Monod 19690*, 30 March 1995 (P); Sahara Algeia occidental: Tuidouf, *Morales Agacino & Rungs 21bis*, 8 April 1942 (MPU); Sahara Central: Tassili des Azdjer, *Nivelle s.n.* (MPU); Ain-Sefra, SW Algeria, *Rothschild & Hartert s.n.*, May 1913 (BM); entre Leghouat et Tadfemouthe, p. Alger, *Rowe s.n.*, 11 May 1880 (P); Environs de Leghouat [Laghouat], *Rowe s.n.*, 7 & 8 May 1880 (P); Bou Saada, *Trabut s.n.*, April 1882 (MPU); Mzab: Metlili, Algeria, *Vaccari s.n.*, 1 April 1862 (MPU); Sahara Algerien: Ghardaïa, *Volkonsky s.n.*, May 1941 (MPU).

LIBYA: Wadi Kabau, *Ali & Khalifa 352*, 5 May 1972 (E); Tripolitania, between Kussabat and Breviglieri before Gasr Daun, *s.coll. 595*, 14 April 1960 (P); Gebel Nefoussa, 25 km SE of Giado, *Davis 49584*, 16 March 1970 (E, RNG); Mizdah, Wadi Saf al J(T)im, *Gaston 3657*, 6 April 1979 (P); Jebel Soda., *Guichard KG/Lib/140*, 2 March 1952 (BM); Tripolitania: Garian, *Johnson 19*, 1 April 1949 (BM); Tripolitania, Tarhuna, Orban Road, Ain Huif, *Keith 638*, 16 May 1960 (P); in parte austro-orientale Oasid Tripolitana, *Letourneaux s.n.*, 8 April 1886 (P); Wadi Zemzem, 46 km East of Buviat, Misunata province, *Simpson 39043*, 28 March 1939 (BM); Fezzan, Brack, Wadi Zigzah, *Turner DT22/82*, December 1981–April 1982 (BM).

MOROCCO. En reg antis de Messonga, *Arenal s.n.* (422739), 9 May 1974 (MA); Sur la route d'Erfoud., *Bocquet 10779*, 18 June 1971 (BM); Ourzazate: cerca de Skoura, *Castroviejo Fernández Casas Muñoz Garmendia & Susanna FC4806*, 19 May 1981 (RNG, MA); 29 km of Midelt along the road, route Midelt-Azrou, *de Wilde, de Wilde & Dorgelo 2845*, 4 June 1961 (P); U. Steppes du Maroc oriental. Taourirt, *Ducellier s.n.*, 1 May 1917 (MPU); 16 km west of Goulmima, S. Morocco, *Else s.n.*, April 1993 (RNG, BM); Ourzazate: cerca de Amerzgane a 45 km de Ourzazare, *Fernández Casas, Martínez, Muñoz Garmendia & Regueiro FC8878*, 3 April 1985 (RNG, MA); Ouarzazate: cerca de Anezal, *Fernández Casas, Muñoz Garmendia, Susanna & Telleria FC6935*, 15 June 1982 (MA); c. 16 km SSW of Goulmima, along main road from Tinerhir, on way to Er Rachidia, *Jury 14592*, 25 March 1994 (RNG, BM); Prov. d'Errachidia Derkawa au SE d'Erfoud, *Lambion & van den Sande 95/Ma/306*, 16 March 1995 (RNG, MA); Anti Atlas: Tagerakht, Fund de Oued sur piste Bachkaur [Bachkoun], *l'Hermite s.n.*, April 1939 (P); castellum Tazouggest, *Maire & Wilczek s.n.*, 18 April 1933 (MPU); In pascuis deserti amnem Zerzef inter Esfoud et Bou-Denib, *Maire & Wilczek s.n.*, 15 April 1933 (P, MPU); propre castellum Mecissi, *Maire & Wilczek s.n.*, 11 April 1933 (MPU); Aoufouss, amnem Ziz, *Maire s.n.*, 2 May 1927 (MPU); Grand Atlas: Midelt, *Maire s.n.*, 20 May 1920 (P, MPU); propre Bachkoun, *Maire s.n.*, 13 May 1932 (MPU); Midelt, *Maire & Weiller 795*, 29 June 1939 (MPU); Todgha, Atlantic Majoris, *Maire & Weiller 795*, 23 June 1939 (MPU); Grand Atlas: Gorges de Tizgui au des sur des sources du Todra, *Malencon s.n.*, 11 June 1935 (MPU); Midelt, *Nain 10*, 15 June 1919 (MPU); Oued el Ma, *Puigoudeau s.n.*, 6 February 1937 (P); Haute Plat: env. De Midelt, *Sauvage 11810*, 19 June 1953 (MPU).

TUNISIA. Matmata, *Berghen s.n.*, 15 April 1992 (BM); propre El Kantara insula Djerba, *Bonnet s.n.*, 15 June 1884 (P); Djerba, Mount C(T)edouich el Kantara/Koutara, *Doumet, Adanson & Bonnet s.n.*, 10 June 1884 (P); el Kantara, (Djerba), *Doumet, Adanson & Bonnet s.n.*, 25 June 1884 (P); Matmata, *Hibon s.n.*, 8 April 1909 (P); Gabes, *Gysperger s.n.* (139505), 2 May 1911 (BC); Sebkheth Zarkin pr. Gabès, *Humbert s.n.*, 4

April 1912 (MPU); Gabes, *Kralik s.n.*, 24 April 1894 (P); in arenosi insula Djerba, *Kralik 398*, 14 June 1854 (E, MPU); In pascuis deserti propre Gabes, *Kralik 393*, 28 April 1855 (MPU); insula Djerba, *Kralik 398bis*, 19 June 1894 (P, BM); propre Gabes, *Kralik 398*, 28 April 1894 (P, BM); Mount Louk, insula Djerba [Houmt Souk], *Letourneaux s.n.*, 19–22 April 1886 (P); Oasis Tripolitana, *Letourneaux s.n.*, April 1886 (BM); Oed Oumm ed dzenar (Oum Mezonar), *Letourneaux s.n.*, 29 April 1884 (P); propre Dorared, *Letourneaux s.n.*, 9 April 1887 (P); propre Ras-ed-Djerf, *Letourneaux s.n.*, 9 May 1884 (P); Sidi Guenao, *Letourneaux s.n.*, 19 April 1884 (P); Zarzis, *Letourneaux s.n.*, 11–15 May 1884 (P); Matmata, *Gougerot-Nicot s.n.*, April 1938 (P); Tripolitania: in arenosis amnis Safedjin, *Maire & Weiller 1116*, 16 April 1938 (MPU); Jebel Dissa- Jebel Regouba, *Murbeck s.n.*, May 1896 (BM); Matmata, *North 28*, 24 March–13 April 1990 (E); Matmata, *Pitard s.n. (442)*, April 1908 (BM, E, MA, BC); Matmata, *Pitard s.n. (94114)*, April 1907 (MA); Medenive (Arad de Nefzaoua), *Pitard s.n. (94115)*, April 1909 (MA); Zebkka, *Viguier s.n.*, April 1912 (P).

## 2b. *Convolvulus supinus* var. *melliflorus* (Pau) Carine & Robba, *comb. nov.*

Basionym: *Convolvulus valentinus* var. *melliflorus* Pau (1911: 6). Holotype: MOROCCO. Zeluan, *Pau s.n.*, 2 May 1910 (MA!)

*Convolvulus suffruticosus* var. *sulfureus* Battandier (1919: 61) ≡ *C. valentinus* var. *sulfureus* (Battandier) Maire & Wiczek in Maire (1934: 25). Holotype: *Ducellier s.n.*, 1 May 1917 (MPU!)

*Convolvulus valentinus* var. *simulans* Maire (1936: 27) ≡ *Convolvulus valentinus* f. *simulans* (Maire) Sauvage & Vindt (1954: 2). Lectotype (designated by Sa'ad, 1967): *Nain 10*, 15 June 1919 (MPU!).

*Convolvulus valentinus* var. *transiens* Maire & Wilczek in Maire (1934: 25). Isotype: MOROCCO. Castellum Tazzougert, 1200 m, *Maire & Wilczek s.n.*, 18 April 1933 (AL, MPU!)

*Convolvulus valentinus* var. *adpressipilis* Maire & Wilczek in Maire (1934: 25) Isotype: MOROCCO. In pascuis deserti annem Zerzef inter Esfoud et Bou-Denib, 950 m, *Maire, & Wilczek s.n.*, April 1933 (P! MPU!).

*Convolvulus valentinus* var. *embergeri* Sauvage & Vindt (1954: 2), *nom. nud.*

Stems usually villous, rarely glabrous or glabrescent. Leaves ovate, narrowly elliptic or rarely deltoid, 10–25 mm long × 2–9 mm wide; base cuneate or truncate; apices acute or rarely obtuse; sparsely to densely villous on lower leaf surface, glabrous or glabrescent above. (fig. 1e)

**Distribution:**—Morocco, extending northwards from the Western Sahara to the Beni Snassen mountains; outlying populations also occurring in Algeria (fig. 2c).

**Habitat:**—Arid gravel, stony or sandy habitats.

**Phenology:**—Flowering March–July(–August); fruiting June–July(–August?).

**Conservation:**—Least Concern (IUCN 2001).

**Other specimens seen:**—ALGERIA. Sidi-Makloulf, route de Laghirive, *Chevallier s.n.*, 8 April 1897 (P); Laghouat, *Chevallier 223*, 12 April 1897 (P); Laghouat, col des sables, *Chevallier s.n.*, 17 April 1897 (P); Laghouat, plaine entre l'Oued Mzi et le Dj. Mileb, *Chevallier s.n.*, 17 April 1897 (P); AS2: E. foot of Dj. Amour, 50 km from Laghouat to Aflou, *Davis 58667*, 3 June 1975 (BM); Bou-Saada (wilaya de M'Sida) a 2km au S d'Ain-Khermane et a environ 30km au N de Bou-Saada, *Dubuis 13437*, 3 May 1986 (RNG, MA, BC); Djebel Sahar, environs de Djelf(s)a, Prov. Alger, *Reboud s.n.*, May 1854 ( P ); Ras-el-ma pres Bou Saada, Contantine [Bou Saada], *Reboud s.n.*, 7 May 1865 (P).

MOROCCO. Ouarzazate, pr. oppidium Tifoultout, *Blanché, Fernández-Casas, Molero, Montserrat, & Romo 9664*, 31 May 1985 (E). NW Sahara: Sand dune vegetation of Goulimina, *Bramwell, Richardson & Murray 586*, 2 April 1972 (RNG); Beni Snassen: 23 km from Uojda on road to Taza, *Carine, Ait Lafkih, Rumsey & Rutherford 365*, 16 June 2005 (BM, RNG, IAV); 49 km from Oujda on road to Taza. 1 km before road crosses Oued Bourdim. *Carine, Ait Lafkih, Rumsey & Rutherford 368*, 16 June 2005 (BM, RNG, IAV); 6 km E of Taourirt on Taourirt-El Ayoun Road. *Carine, Ait Lafkih, Rumsey & Rutherford 370*, 16 June 2005 (BM, RNG, IAV); Beni Snassen: 23 km W. from Oujda on road to Taza. *Carine, Ait Lafkih, Rumsey & Rutherford 366*, 16 June 2005 (BM, RNG, IAV); Sahara: El Abiod Sidi Cheikh, ravines, route de Gergville, *Chevallier s.n.*, 9 May 1899 (P); Plateau de l'arid, N. de Midelt, *Damblon 79/159*, 24 June 1979 (RNG); ED.



Goulmima to Ksar-es-Souk, *Davis & Davis 49063*, 4 April 1969 (BM, E); Ksar-es-Souk to Erfoud., *Davis & Davis 49093*, 5 April 1969 (BM, E); ED. Ziz Gorge (Ksar-es-Souk to Rich), *Davis & Davis 49179*, 7 April 1969 (BM, E); ED: 2 km NE of Goulmima, *Else s.n.*, 1 April 1995 (RNG, BM); Gorges du Ziz, *Else s.n.*, 6 April 1995 (RNG, BM); Ksar Es Souk, entre Er Rachidia y Midelt, *Fernández Casas, Muñoz Garmendia, Susanna & Telleria FC7088*, 18 June 1982 (RNG, MA); in lapidosis calcareis Atlantis Majorii orientalis propre Rich, *Humbert s.n.*, April 1927 (MPU); Bou Denib: bords de l'oed Guir, 5–6 km from Bou Denib, *Humbert s.n.*, April 1923, (P); R to Noulouya: Misour, *Jahandiez 93*, 28 April 1925 (BM, E, MA); R to Noulouya: Midelt, gorges de Oued Outat, *Jahandiez 144*, 2 May 1925 (BM); 51 km ENE of Ouarzazate, 8 km ENE of Skoura, on road to Boumalne du Dadès, *Jury 14524*, 24 March 1994 (RNG, BM); 121 km from Midelt along the road to Guercif, *Jury 16928*, 26 April 1995 (BM, RNG, MA); SE of Guercif, 1.8 km S of junction of Guercif - Oujda main road, *Jury 16911*, 26 April 1995 (BM, RNG, MA, BC); Prov. Er Rachida, road N. from Erfoud, 59 km from Rissani, 1 km N of Ksar Jdid, *Jury 19114*, 19 February 2002 (RNG); 89 km from Midelt on Azrou-Midelt road, just south of Boulojoul, *Jury 19461*, 30 May 2002 (RNG); Prov. Er Rachida, road N. from Erfoud, 36 km before Er Rachidia, above village of Ait Amira, *Jury 19156*, 19 February 2002 (RNG); Meski Spring, 11 km S.E. of Ksar-es-Souk, O. Ziz, *Lambert 357*, 20 April 1969 (BM); Prov d'Errachidia, Vallee de Ziz, Ksar Jdid (5 km au N. d'Aoufous, route 567 Errachidia-Erfoud, a env. 23 km du carrefour de la P32), *Lambion & van den Sande 95/Ma/212*, 14 March 1995 (RNG, MA); Prov. De Taza, Ighoudane, oued Boulajraf, *Lambion & van den Sande 94/MA/176*, 30 May 1994 (RNG); RICH (Errachiaouat), *Lewalle 10526*, 8 July 1982 (BM); Boudenit (Prov. Emachitie), *Lewalle 13658*, 3 April 1992 (BM); 10 km N de Midelt, *Lewalle 9131*, 2 July 1979 (P); Misour Gurcif, piste Moulaya, *l'Hermite s.n.*, April 1939 (P); Beni-Ouziem, *Maire & Wilczek s.n. (94112)*, 17 April 1933 (MA); propre Guercif, *Maire & Wilczek s.n.*, 25 April 1933 (P, MPU); Bou-Denib-Salei, *Maire & Wilczek 414*, 17 April 1933 (MA); Teniet Zerzef (Tafilaet), *Maire & Wilczek 312*, 15 April 1933 (MA); Inter Erfoud et BenDenib, *Maire & Wilczek s.n. (139502)*, 15 April 1933 (BC); In glareis torrentium vallei Dades inter Ikoura et Ait Yaga, *Maire & Weiller 395*, 21 June 1939 (MPU); Guercif, Carreterra a Outat-Oulad-el-Haj, a 4 km de Mahirija, *Mateos 6809/95*, 11 June 1995 (RNG); between Mertigmer and Mechra-Homadi 69 km from Nador, *Mateos & Valdés BV636/93*, 31 May 1993 (RNG, BC); Fes Misour- Aïn Guettara, plateau, *Mordant 1100*, 9 May 1969 (P); Guercif Tafrata, *Mordant 1195*, 14 May 1969 (P); Qsar-Es-Souq Outskirts of Midelt, on track to Cirque du Jaffar, Jbel Ayachi. Locality 6, *OPTIMA ITER V 289*, 10 June 1992 (RNG); Zeluan, *Pau s.n. (94102)*, 2 May 1910 (MA); In montibus Largko/Sargho, *Peltier s.n.*, 10 April 1939 (MPU); Mgoun/Haut Atlas oriental: vallei du Dadès en amour du Boumalne, *Sauvage 12277*, 1 April 1954 (MPU).

### 3. *Convolvulus sabatius* Viviani (1824: 67)

Holotype: ITALY. West Liguria, Capody Noli near Vada Sabatia, *Viviani s.n.* (GE; isotype: G-DC (microfiche!))

*Stems* villous. *Leaves* with petioles up to 3 mm long; lamina broadly oblong, elliptic or orbicular, up to 18 mm long × 18 mm wide; apices obtuse, occasionally emarginated or acute; pilose on lower leaf surface; upper surface variable, from glabrous to pilose. *Flowers* solitary or rarely paired. *Peduncles* 5–25(–31) mm long, villous. *Pedicels* 2–10 mm long, villous. *Bracteoles* lanceolate to elliptic, 3–12 mm long × 1–3.5 mm wide. *Calyx* lobes narrowly elliptic to lanceolate, 4.5–8 mm long × 1.5–3.5 mm wide; apices acute. *Corolla* 12–22 mm long, lilac-blue or blue-pink above, with a yellow centre and a white ring separating the two. *Stamens* with filaments 6–8 mm long on the shorter three and 7.5–10 mm long on the longer pair, variable for pubescence with some individuals apparently glabrous and others glandular pubescent for two thirds of total length; anthers 2–3 mm long on the longer filaments; 1.5–2.5 mm on the shorter filaments. *Ovary* narrowly conical, 1–1.5 mm long, white, glabrous. *Style* white, 3–4 mm long. *Stigma* lobes 4–5 mm long, longer than the style.

### 3a. *Convolvulus sabatius* subsp. *sabatius*

*Calyx* indument comprising of short, appressed hairs.

**Distribution:**—Apparently confined to Cabo di Noli in Liguria (fig. 2b).

**Habitat:**—In stony pastures and rock fissures.

**Phenology:**—Flowering May–June.

**Conservation:**—Given the extremely restricted distribution of this taxon, it meets the criteria for Vulnerable (IUCN 2001)

**Other specimens seen:**—ITALY. Noli headland in Western Liguria, *Bastreri s.n.*, May 1892 (BM); Liguria occidental, Circond di Savona, in rupibus calcareis apricis ad promontorium di Noli, *Béguinot & Pampanini 328*, 4 June 1905 (K); Capo di Noli, *Bernoulli s.n.*, 11 June 1890 (K); Liguria, prope "Capo di Noli", *Bicknell s.n.*, May 1895 (BM; E, K); Capo di Noli, Liguria, *Bicknell s.n.*, 3 June 1890 (BM, E); Capo di Noli, Liguria, *Bicknell & Collins s.n.*, 12 May 1903 (E); Rachers du cap Noli/vada *sabatius*/Italic septuionale, *Burnat s.n.*, 27 April 1872 (BM); Entre Noli et cap Noli, *Burnat s.n.*, 2 June 1872 (E); Liguria occid.- Circond. di Savona: in rupibus calcareis apricis ad promontorium di Noli, *Fiori, Béguinot & Pampanini 8617*, 4 June 1905 (BM, E); Capo di Noli, Liguria, *Churchill s.n.*, 20 April 1868 (K); Noli, N.W. Italy, *Jebbs s.n.*, May 1875 (K); Capo di Noli, Western Liguria, *Joad 1882*, 28 April 1870 (K); Capo di Noli, Riviera, *Maw s.n.*, April 1875 (K); Capo di Noli, E. of Finale, *Moggridge s.n.* 20 April 1868 (K); Capo di Noli, Noli, Liguria, *Moggridge s.n.*, 21 April 1868 (K); Capo di Noli, Liguria occ., *Piccone s.n.* 23 May 1869 (E).

### 3b. *Convolvulus sabatius* subsp. *mauritanicus* (Boissier) Murbeck (1923: 2)

Basionym: *C. mauritanicus* Boissier (1839: 418). Holotype: ALGERIA. Constantine, *Sejourne, s.n.* (G-Boiss)

*Convolvulus sabatius* var. *atlantius* Ball (1878). Basionym: *C. mauritanicus* Boissier (1839: 418). Holotype: Morocco, in covalle Ait Mesan, *Ball s.n.*, 13–16 May 1871 (P!)

*Convolvulus sabatius* f. *genuinus* Maire in Emberger & Maire (1929: 43), *nom. non rite public.*

*Calyx* lobes sparsely to densely villous.

**Distribution:**—Morocco (western Rif, and the High and Middle Atlas mountains) and Algeria (Kabylie and Mts de Bibans areas of Algeria; fig. 2b). This subspecies is widely cultivated as an ornamental. A specimen from Rome (*Heard s.n.*, BM) is referable to this subspecies. We were unable to see any material from Sicily, but *C. sabatius* is considered introduced there (Giardina *et al.* 2007) and it is possible that plants from Sicily are escapes from cultivation also referable to subsp. *mauritanicus*.

**Habitat:**—Dry, rocky, limestone slopes.

**Phenology:**—Flowering and fruiting April–August.

**Conservation:**—Whilst this subspecies has a highly disjunct distribution, it is locally common or abundant and meets the criteria of Least Concern (IUCN 2001).

**Other specimens seen:**—ALGERIA. Roches maritimes a l'Ouest de Tines, prov. D'Alger, *Cosson s.n.*, 3 June 1875 (E, P); Montagnes du Djurdjura, pres de Bordj-Boghni, *Cosson s.n.*, 20 June 1854 (P); Constantine, *Cosson s.n.*, 14 May 1853 (P); Djebel Masouf pres El Miliyah, *Cosson s.n.*, 14 July 1861 (P); H2: 30 km from Constantine to Setif, *Davis 52087*, 8 May 1971 (BM, E, RNG); K2: Chabet el Akra Gorge (Jurassic limestone) below Kherrata (Setif-Bejaïa), *Davis 52654*, 23 May 1971 (E); K2: Pic de Singes, above Bejaïa (Bougie), *Davis 52982*, 29 May 1971 (BM, E, RNG); K1: Djurdjura: E. side of Lalla Khedidja, S. of Tizi-N'Kouillal pass, *Davis 59461*, 23 June 1975 (BM); Chabet el Akra Gorge (Jurassic limestone) below Kherrata (Setif-Bejaïa), *Davis 52654*, 23 May 1971 (BM, RNG); K1: Dj. Djurdjura, near Tikjda, *Davis 53070*, 3 June 1971 (BM, E, RNG); C1/K2: Lower part of Ben Haroun gorge, above El Milia, *Davis 58195*, 22 May 1975 (BM); K1: Djurdjura: between Boghni and Tala Guilef, *Davis 59309*, 20 June 1975 (BM); Constantine, *de la*

*Perraudiere s.n.*, 14 May 1853 (MPU); Zénez, *de Marsilly s.n.*, 1847 (P); Bougie, *Delacour s.n.*, 29 April 1893 (P); Parc national de Djurdjura (dep. Bouira, Kabylie), flanc sud du Ras Timedouine a env. 4 km a l'est de Tikjda, *Dubuis 11537*, 11 June 1982 (MA, MAF, BC, RNG); Bougie, *Durieu s.n.*, 23 March 1840 (P); Bougie, *Durieu s.n.*, June 1839 (P); Mansourah, *Durieu s.n.*, 22 May 1840 (P); Constantine, *Durieu s.n.*, 27 May 1840 (P); Milah, *Durieu s.n.*, (P); Milah, montagnes, *Durieu s.n.*, 16 June 1840 (P); Col de Girourda/Birourda, *Gombault s.n.*, 10 June 1939 (P); Djemila, *Gombault s.n.*, 13 May 1939 (P); Constantine, *Joly s.n.*, 19 May 1911 (MPU); Busdj bua Areridj, *Letourneaux s.n.*, May 1881 (P); Bougie, Sidi Afahia, *Letourneaux s.n.*, 29 May 1889 (P); Djebel Chuya, *Letourneaux s.n.*, 12 May 1887 (P); C. Bougie. Cap Casbon, *Maire s.n.*, 5 April 1912 (MPU); Tala Ir'zer (Ouled-Massaoud), ad rupes, *Paris 116*, 13 June 1865 (BM); Constantine, *Pomel s.n.*, June 1874 (MPU); Bougie, *Pugsley s.n.*, 14 April 1922 (BM); Constantine, *Reboud 184*, May 1873 (P); Constantine, *Reboud 184bis*, May 1874 (MPU, P); Constantine: Sidi Mécid, *Reboud 185*, June 1873 (P); Djebel Sgao, Prov. Constantine, *Reboud s.n.*, August 1880 (P); Massif du Chattaba [Chettaba], *Reboud s.n.*, May 1898 (P); Bougie. (Kabylie), *Reverchon 166*, May 1896 (BM, E); Bougie, *Reverchon (Kabyle) 166*, May 1896 (MPU); Kessata (Kerrata) [Kerrata], *Reverchon (Kabyle) 166*, June 1897 (P); Kabylie di Collo, foret des Beni-Touffoute, tales in liseu du foret (suberaie) [Foret des Beni Toufout, Collo], *Sauvage 143*, 27 April 1964 (MPU); Cherchel, *Turner s.n.*, April 1926 (BM); Colline du Konviat-ati, *Bourjol s.n.* (MPU); Constantine, *Beguet s.n.*, 6 April 1861 (P); Constantine, *Poisson s.n.*, April 1892 (P); Constantine, *Gougerot-Nicot s.n.*, April 1936 (P) propre Bougie, *Letourneaux s.n.*, 20 July 1884 (P).

MOROCCO. GA: 7 km from Asni on road to Imlil, *Ait Lafkih, Jury, Peris & Stübing 699*, 19 July 1989 (RNG); Ametrasse, up track from Charafat on Bab Taza to Bab Berred road, *Ait Lafkih, Carine, Jury & Rumsey 67*, 4 June 2005 (BM, IAV, RNG); Above Tarhlite, on track to Talassemtane, from main Bab Taza to Bab Berred road near Charafat, *Ait Lafkih, Carine, Jury & Rumsey 92*, 4 June 2005 (BM, IAV, RNG); Western Rif: above Chefchaouén and Ras el Maa, on track to Ain Tissimlane between Jbel Kelaa and Jbel Tissouka, *Ait Lafkih, Carine, Jury & Rumsey 133*, 6 June 2005 (BM, IAV, RNG); Western Rif Mountains, Oued Laou, Oued Tassikeste, *Ait Lafkih, Carine, Jury & Rumsey 191*, 7 June 2005 (BM, IAV, RNG); Western Rif, track N. of Chefchaouén around Jbel El Kelaa to Tarhzoute, *Ait Lafkih, Carine, Jury & Rumsey 235*, 8 June 2005 (BM, IAV, RNG); Xauen: Jbel Lakra, Hauta-el-Kasdir, *Aedo, Güemes, Muñoz Garmendia, Pedrol, Rico & Sequeira CA4128*, 22 June 1997 (MA); au sud de Keira, *Balansa s.n.*, May 1867 (P); Djebel Toubkal, *Balls B2858*, 21 June 1936 (BM, E); Tizi'n'Test, *Balls B2934*, 26 June 1936 (K); Gorge of Iminouaka [Imi n' Ou Akka], *Balls B.3038*, 10 July 1936 (E, K); Chenoua, *Battandier s.n.*, April 1889 (MPU); Agadir: environs 2 km avant le col du Tizi n'Test versant Taroudant (Haut Atlas), *Charpin, Fernández Casas, Jacquemond & Jeanmonod MAR322*, 30 May 1980 (MA); High Atlas, near Imlil Djebel Toubkal Massif, *Clayton & Brinklow 11*, Aug–Sept 1970 (E); GA: High Atlas. Assif-n-Ait Hkim. 0.5 km W.S.W. of Ifrane, *Crane R. U. Biol. Exped. 110*, 14 August 1975 (BM, RNG); J. Tisouka, above Xauen, *Davis 54809*, 5 July 1973 (BM, E); Maison forestiere Talate-n-Nos. Between Youkak [Ijjoukak] and Asni road Taroudant-Marrakech, *de Wilde, de Wilde & Dorgelo 2174*, 7 May 1961 (BM); Ait-Oudinar, el Norte de Boumalne, en las Gargantas del Dades, *Fernández Casas, Muñoz Garmendia, Susanna & Telleria FC6965*, 16 June 1982 (MA); Montis Kalaa, *Font Quer 319*, 25 May 1928 (MPU, BM, MA, BC); Magot, *Font Quer s.n. (809019)*, 21 May 1928 (BC); Grand Atlas: talus herbeux, gorges Imi n'Ou Akka (Dj. Ghât), *Gattefossé s.n.*, 3 Aout 1935 (MPU); Grand Atlas, Imi n'ouaka (Djebel Ghat), *Gattefossé s.n. (195636)*, 3 August 1939 (P, MAF, BC); High Atlas, Imlil area, *Goodchild 82*, 22 August 1968 (BM); Ayachi: J. Ayachi, Imi n'Thand, *Guinet, Sauvage & de Vilmorin 805*, 3 July 1952 (MPU); Province of Beni Mellal. At entrance to Asif Arous, *Harley & Lankester 105*, 8 August 1964 (BM); Djebel Afrugueur, Montagnes au sud-ouest de la ville de Maroc, *Ibrahim s.n.*, 1876 (P); Grand Atlas, Azilal a Sfrane, *Jahandiez 308*, 31 May 1927 (BM, E); Grand Atlas: Azilal a Ifrane, *Jahandiez 308*, 31 May 1927 (MA, BC); M. Grand Atlas, Reraya: Asni graviens de la riviere, *Jahandiez 715*, 11 June 1921 (MPU); c. 15 km from Imilchil, along track to El-Ksiba, *Jury 17634*, 7 July 1997 (BM, RNG, MA); 41 km north of Midelt, along road to Azrou, *Jury 17852*, 13 July 1997 (RNG); Gorges de l'acif-n-Ait-Oufad, piste de Demnat aux Ait Tamellil (Haute Tessaout), *'Hermite s.n.*, 14 July 1941 (P); Atlas Moyen, in convalle fr. Ait Menaux in siccis pr. Pag. Timitine, *Lindberg 3902*, 12 June 1926 (K; MPU); Azilal, High Atlas, *Lynes 142*, (BM); Ifrane (Rox),

High Atlas, *Lynes 192* (BM); Atlantis majoris monte Erdouz supra oppidum Amismiz, *Maire s.n.*, 2 July 1925 (P, MPU); Atlante rifian, in rupestre calcareis, vallii Ametrar infra Bab Rouida, *Maire s.n.*, 16 June 1928 (MPU); Atlas rifiano, montis Tissouka, supra Chaouen, *Maire s.n.*, 14 June 1928 (P, MPU); Atlantis Medii montidus: An(h)ermoumou [Ahermoumou], *Maire s.n.*, 17 June 1927 (MPU); Atlantis Medii montibus montis Sidi Ahmen [Beni Ahmed], *Maire s.n.*, 19 June 1927 (P, MPU); Grand Atlas: Anamrou au pied du Mont Erdouz, *Maire s.n.*, June 1925 (MPU); Atlantis majoris valle Reraya: propre Arround, *Maire s.n.*, 19 July 1924 (P, MPU); Atlantis medi ad Tizi-n-Iselit, *Maire s.n.*, 21 June 1936 (MPU); M Grand Atlas Reraya, rocailles posphyriques pres d'Assound, *Maire s.n.*, 23 June 1922 (MPU); Djebel Afougueur, Sud-Ouest du Maroc, *Mandochée s.n.*, 1875 (MPU, BM); Chefchaouene. Carril de Bab taxa al Djbel Bouhalla, *Mateos, Ortega & Pina 6979/97*, 23 July 1995 (RNG); Chefchaouene, Djbel Bouhalla, *Mateos, Ortega & Pina 7236/97*, 25 July 1995 (RNG); Chefchaouen. Assifane. Taria, ascenso al Djebel Kharbouch, *Mateos, Ramos & Villareal 6116/95*, 3 May 1995 (RNG); Asni Valley, *Newbould 436*, 16 September 1955 (BM); c. 34 km from Chefchaouèn, 10 km above Bab Taza on track, to Jbel Talamssemtane, *OPTIMA ITER V 2155*, 26 June 1992 (RNG); c. 38 km from Chefchaouèn, 14 km above Bab Taza on track, to Jbel Talamssemtane, *OPTIMA ITER V 2276*, 26 June 1992 (RNG); Beni Snassen: Al'Youn, Aïn al Gattara, *Romo, Bouhmadi, Peris & Stubing 6659*, 13 April 1994 (RNG, SEV); Mgoun: Iouaridine au SE de Demnate; prive de l'Asif n Rhezef, *Sauvage 11036*, 20 May 1953 (MPU); Rif sur: massif calcaire central, Talekhenntjoute sur le piste de Talassenntane, *Sauvage 13454*, 8 June 1955 (MPU); Rif sur: J. Louizja pres Talasenntane [Talassemtane], *Sauvage 13718*, 10 June 1955 (MPU); Ayachi: Imi n'Shand, sochers a exposition S et S-E, *Sauvage 805*, 23 July 1923 (MA); Grand Atlas: Renaya, Plateau d'Asni, *Sauvage 893*, 2 June 1939 (MPU); Grand Atlas, near lower village of Asif Azous, *Spence S.84*, 31 July 1951 (E); Jebel Tisuka, *Stocken 64/16*, 16 May 1964 (E); Xauen, *Vidal Lopez s.n. (94157)*, 9 June 1921 (MA); Attour, Grand Atlas, *Weiller 596*, 15 October 1927 (P); collines situees au sud de Keira, *s.coll. s.n.*, May (MPU); A. Djurdjura: Tizi-n-Kouïdal, *Battandier s.n.* (MPU).

**Doubtfully native:**—ITALY. Forum, Rome, *Heard s.n.*, 1 May 1930 (BM).

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## References

- Arroyo, J., Aparicio, A., Albaladejo, R.G., Muñoz, J. & Braza, R. (2008) Genetic structure and population differentiation of the Mediterranean pioneer spiny broom *Calicotome villosa* across the Strait of Gibraltar. *Biological Journal of the Linnean Society* 93: 39–51.
- Ball, J. (1878) Spicilegium Florae Maroccane. *Journal of the Linnean Society of London* 16: 569–772.
- Battandier, J.A. (1919) *Contributions à la flore atlantique*. Librairie Klincksieck, Paris, 91 pp
- Boissier, E.P. (1839) *Voyage Botanique dans le Midi de l'Espagne pendant l'année 1837*. Vol 2, part 1. Gide, Paris, 480 pp
- Carine, M.A., Francisco-Ortega, J., Santos-Guerra, A. & Russell, S.J. (2004) Relationships of island and continental floras: molecular evidence for multiple colonisations into Macaronesia and subsequent back-colonisation of the continent in *Convolvulus* L. *American Journal of Botany* 91: 1070–1085.
- Carine, M.A., Robba, L., Little, R., Russell, S.J. & Santos Guerra, A. (2007) Molecular and morphological evidence for hybridization between endemic Canary Island *Convolvulus*. *Botanical Journal of the Linnean Society* 154: 187–204.
- Catalán, P., Kellogg, E.A. & Olmstead, R.G. (1997) Phylogeny of Poaceae subfamily Pooideae based on cp *ndhF* gene

- sequences. *Molecular Phylogenetics and Evolution* 8: 150–166.
- Cavanilles, A.J. (1793) *Icones et descriptiones plantarum quae aut sponte in Hispania crescunt, aut in hortis hospitantur: volumen II*. Regia Typographia, Madrid, 4+79+5 pp.
- Cosson, E. & Kralik, L. (1857) Notes sur quelques plantes rares ou nouvelles de la régence de Tunis. *Bulletin de la Société botanique de France* 4: 400–410.
- Desfontaines, R.L. (1798) *Flora Atlantica: sive historia plantarum quae in Atlante, agro tunetano et algeriensi crescunt*. Volume 1. Blanchon, Paris, 444 pp.
- Emberger, L. & Maire, R. (1929) Matériaux pour la flore Marocaine (Fascicule 1). *Mémoires de la Société des Sciences Naturelles du Maroc* 21–22: 21–53.
- Farris, S. (1989) The retention index and the rescaled consistency index. *Cladistics* 5: 417–419.
- Font Quer, P. (1927) *Iter Maroccanum* N° 489 exsiccate.
- Font Quer, P. (1930) *Iter Maroccanum* N° 356 exsiccate.
- Giardina, G., Raimondo, F.M. & Spadaro, V. (2007) A catalogue of plants growing in Sicily. *Bocconea* 20: 5–582.
- Greuter, W., Burdet, H.M. & Long, G. (1986) *Med-checklist: a critical inventory of vascular plants of the circum-Mediterranean countries. Vol.3: Dicotyledones (Convolvulaceae-Labiatae)*. Conservatoire et Jardin botaniques de la Ville de Geneve, Geneve, 395 pp.
- IUCN (2001) *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK, 30 pp.
- Jahandiez, E. & Maire, R. (1934) *Catalogue des plantes du Maroc (Spermatophytes et Ptéridophytes)*. Volume 3. Imprimerie Minerva, Alger, 560–913 pp.
- Linnaeus, C. (1753) *Species Plantarum*, vol. 1. Laurentius Salvius, Stockholm, 560 pp.
- Kluge, A.G. & Farris, J.S. (1969) Quantitative phyletics and the evolution of anurans. *Systematic Zoology* 18: 1–32.
- Maire, R. (1934) Contributions à l'étude de la flore de l'Afrique du Nord. Fascicule 22. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord* 25: 286–326.
- Maire, R. (1936) Contributions à l'étude de la flore de l'Afrique du Nord. Fascicule 24. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord* 27: 203–233.
- Maire, R. (1938) Contributions à l'étude de la flore de l'Afrique du Nord. Fascicule 26. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord* 29: 403–458.
- Médail, F. & Diadema, K. (1999) Glacial refugia influence plant diversity patterns in the Mediterranean Basin. *Journal of Biogeography* 36: 1333–1345.
- Mendoza-Heuer, I. (1983) El genero *Convolvulus* en Macaronesia. In: *Comunicacoes apresentadas ao 2 congresso internacional pro flora Macaronesica, Funchal, 19-25 de Junho de 1977*, 23–30. The Congress, Funchal, 470 pp.
- Murbeck, S.S. (1923) *Contributions à la connaissance de la flore du Maroc. Vol 2*. C.W.K. Gleerup, Lund, 76 pp.
- Pau, C. (1911) Una visita botánica al ríff. *Annaes scientificos da Academia Polytechnica do Porto* 6: 96–99.
- Pignatti, S. (1982) *Flora d'Italia*. Vol. 2. Edagricole, Bologna, 732 pp.
- Pomel, A.N. (1874) *Nouveaux matériaux pour la flore Atlantique. Part 1*. Savy, Alger 256 pp
- Sa'ad, F. (1967) The *Convolvulus* species of the Canary Islands, the Mediterranean region and the Near and Middle East. *Medelingen van het Botanisch Museum en Herbarium van de Rijksuniversiteit te Utrecht* 281: 1–288.
- Sáez, L. & Roselló, J.A. (2001) *Llibre vermell de la flora vascular de les Illes Balears*. Conselleria de Medi Ambient, Palma de Mallorca, 232 pp.
- Sauvage, C. & Vindt, J. (1954) *Flore du Maroc 2: Tubiflorales*. Editions Internationales, Tanger, 267 pp.
- Sennen, F. & Mauricio, F. (1933) *Catálogo de la flora del Rif Oriental y principalmente de las cabilas limitrofes con Melilla, Melilla*: Graficas la Iberica Marina, Melilla, 159 pp.
- Sennen, F. (1934) *Plantes d'Espagne* N° 9470 exsiccate.
- Silvestre, S. (in press) *Convolvulus*. In: *Flora Iberica*. Vol. XI. Accessed on line at: [http://www.floraiberica.es/floraiberica/texto/borradores/vol\\_XI/11\\_135\\_01\\_Convolvulus.pdf](http://www.floraiberica.es/floraiberica/texto/borradores/vol_XI/11_135_01_Convolvulus.pdf) (last accessed 4th September 2009).
- Stace, C.A. (1971) *Flora Europaea notulae systematicae ad floram Europaeam spectantes no.8*. Notes on the European species of *Convolvulus*. *Botanical Journal of the Linnean Society* 64: 56–60.
- Swofford, D.L. (1998) *PAUP\*: phylogenetic analysis using parsimony and other methods, version 4.0β8 for Macintosh PPC*. Sinauer, Sunderland, Massachusetts, USA.
- Viviani, D. (1824) *Florae Libycae Specimen: sive, Plantarum enumeratio Cyrenaicam, Pentapolim, Magnae Syrteos desertum et regionem tripolitanam incolentium quas ex siccis speciminibus delineavit, descripsit et ære insculpi curavit Dominicus Viviani*. Genuae (Genova), 68 pp.
- Young, N.D. & Healy, J. (2003) GapCoder automates the use of indel characters in phylogenetic analysis. *BMC Bioinformatics* 4: 6.