

Taxonomic investigations on *Malva cretica* s.l. (Malvaceae)

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Abstract. A morphometric analysis has been carried out for the first time in order to investigate the variability of the infraspecific taxa included in the steno-Mediterranean *Malva cretica* s.l., i.e. *M. cretica* subsp. *althaeoides*, *M. cretica* subsp. *cretica*, and the poorly-known *M. cretica* var. *montana*, described from southern Italy. According to our results, *M. cretica* subsp. *althaeoides* and subsp. *cretica* are worth of taxonomic recognition at subspecies rank and occupy respectively the western and the central-eastern sectors of the species range. Concerning *M. cretica* var. *montana*, characterized by some intermediate features, it should be included in *M. cretica* subsp. *cretica*.

Keywords. Biometry, Europe, *Malva*, Malveae, new synonymy, Spain, subspecies.

Resumen. Se ha realizado, por primera vez, un análisis morfométrico con el fin de investigar la variación morfológica de los táxones infraespecíficos actualmente reconocidos en *Malva cretica* s.l., i.e. subsp. *cretica* y subsp. *althaeoides*, incluyendo la poco conocida var. *montana* del sur de Italia. Según nuestros resultados, la subsp. *althaeoides* y la subsp. *cretica* merecen el rango de subespecie y ocupan respectivamente los sectores occidentales y centro-orientales del área de distribución de la especie. Respecto a *M. cretica* var. *montana*, caracterizada por algunos rasgos intermedios, debe ser incluida en *M. cretica* subsp. *cretica*.

Palabras clave. Biometría, España, Europa, *Malva*, Malveae, nueva sinonimia, subespecie.

How to cite this article: Del Guacchio E., Vallariello R. & Iamonico D. 2020. Taxonomic investigations on *Malva cretica* s.l. (Malvaceae). *Anales del Jardín Botánico de Madrid* 77: e095. <https://doi.org/10.3989/ajbm.2539>

Title in Spanish: Investigaciones taxonómicas en *Malva cretica* s.l. (Malvaceae).

Associate Editor: Javier Fuertes Aguilar. Received: 10 September 2019; accepted: 14 May 2020; published online: 31 August 2020.

INTRODUCTION

Molecular studies by Ray (1995) and Escobar García & al. (2009) showed that the traditional separation of *Malva* L. and *Lavatera* L., based mainly on the degree of fusion of the epicalyx bracts, is artificial and cannot be maintained, while the taxonomic significance of the fruit morphology was emphasized. The overall evolution within the complex appears to be reticulate and the genus *Malva* in a broad sense (including *Lavatera*) is presumed to be monophyletic (Tate & al. 2005). Waiting for a comprehensive taxonomic study of Malveae J.Presl, several authors accept *Malva* in a broad sense (e.g., Ray 1998; Molero & Montserrat 2005, 2006; Banfi & al. 2005; Iamonico 2010, 2017, 2018; Valdés 2011; Conti & Bartolucci 2012). However, some taxa (the “Lavateroid clade” sensu Ray, 1995) are still doubtfully placed and other authors (e.g., Bayer & Kubitzki 2003; Molero & Montserrat 2007) keep them in the genus *Lavatera*.

According to molecular data and morphological features of the fruit, *Malva cretica* Cav. is certainly

referable to the “Malvoid clade” (sensu Ray 1995). Although it is well distinct as a species, its taxonomic placement in the genus *Malva* is controversial (see below). Moreover, the infraspecific variability of this species is remarkable and at least two geographical subspecies are currently recognized: *M. cretica* subsp. *cretica* [Tunisia, Spain, France (Corse), Italy (including Sicily and Sardinia), Greece, East Egean islands, Crete, Cyprus and Turkey; naturalized in France] and *M. cretica* subsp. *althaeoides* (Cav.) Dalby [Spain, France (Corse) and doubtfully in Italy (including Sicily) and Malta; doubtfully native in Cyprus] (Valdés 2011). These two taxa have been treated differently over time, even at generic ranks. Candolle (1824) included both the taxa in the sect. *Malvastrum* DC., but placing *M. cretica* into the ser. *Cymbalariae* DC. and *M. althaeoides* into the ser. *Bismalvae* (Medik.) DC. Alefeld (1862: 258) included *M. althaeoides* in the genus *Axolopha* (DC.) Alef., while Krebs (1994) placed both taxa in the genus *Dinacrusa* G.Krebs. Nogueira & Paiva (2005) treated *M. cretica* s.l. in the sect. *Creticae* Paiva & Nogueira. At specific

and infra-specific ranks, Paoletti (1901) reported *M. altheoides* as a variety of *M. cretica*, but Dalby (1967) and Valdés (2011) accepted the subspecies rank.

The two taxa have been often confused and their current distribution should be verified (see e.g., Serra Laiga 2005). Moreover, the rarely cited *Malva cretica* var. *montana* Lacaita, described from southern Italy (Lacaita 1925), has also to be considered. Gavioli (1929), in a comparative study between the floras of Spain and Basilicata region (southern Italy) recognized *M. cretica* var. *althaeoides*, *M. cretica* var. *cretica*, and *M. cretica* var. *montana*. He regarded var. *montana* as endemic to southern Italy. Finally, according to Dalby (1968), intermediate plants between subsp. *cretica* and *althaeoides* would occur in southern Italy and Malta, while he excluded subsp. *cretica* from Spain. Later, Krebs (1994) indicated the occurrence of both *Dinacrusa cretica* (Cav.) G.Krebs subsp. *cretica* and *D. cretica* subsp. *althaeoides* (Cav.) G.Krebs in southern Italy. Interestingly, Gavioli (1929) identified as *M. cretica* var. *althaeoides* several specimens collected by himself in southern Italy, i.e. out of the currently accepted range of the taxon.

With the aim to clarify the taxonomy of the various taxa described under *Malva cretica*, here we present a biometric study as part of an ongoing research works on Malvaceae (see e.g. Iamónico 2010, 2014, 2016; Iamónico & Peruzzi 2014) and the endemic flora of southern Italy (e.g., Vallariello & al. 2016; Iamónico & al. 2017; Santangelo & al. 2017; Erben & al. 2018).

MATERIAL AND METHODS

Specimens of *Malva cretica* subsp. *althaeoides* (below as ALTH), *M. cretica* subsp. *cretica* (CRET) and *M. cretica* var. *montana* (MONT) from herbaria B, BM, CAT, E, FI, G, ISTO, L, MA, NAP, P, RO, U, and VAL (acronyms according to Thiers 2020 [continuously updated]) and from the personal herbarium of E. Del Guacchio (below as Herb. EDG, available at NAP) were examined for a preliminary screening.

Specimens from FI, NAP, VAL and Herb. EDG, preliminary re-identified following keys and descriptions in Lacaita (1925), Dalby (1968), Krebs (1994), and Nogueira & Paiva (2005), were employed for the analyses. A morphological analysis, based on 17 characters (14 quantitative and 3 qualitative, see Table 2) was performed. Nogueira & Paiva (2005) pointed out a presumed difference in corolla colour among the studied taxa. We decided not to include this character in the analyses, because it cannot be easily observed in sicco. However, according to Lacaita (1925), and our observations in the field (Italian material) and from photographs (whole range of variation), such character would seem not to be diagnostic. The data matrix so obtained was processed using software packages NCSS 2007 (NCSS LLC, Kaysville, UT) and SPSS v. 11.5 (SPSS Inc., Chicago, IL, USA). The variability of the characters has been examined by Discriminant Analysis (DA), bi- and univariate (box and scatter plots) analyses. Whenever correlation was

Table 2. Morphological characters used in this study. Character states for the qualitative characters are listed in parentheses.

1	Habit (erect or ascending)
2	Plant height (cm)
3	Hair types (simple or stellate)
4	Basal leaves length (mm)
5	Basal leaves width (mm)
6	Cauline leaves length (mm)
7	Cauline leaves width (mm)
8	Ratio between characters 6 and 7
9	Peduncle length (mm)
10	Epicalyx segments length (mm)
11	Calyx segments length (mm)
12	Calyx segments width (mm)
13	Ratio between characters 11 and 12
14	Petal segments length (mm)
15	Petal segments width (mm)
16	Ratio between characters 14 and 15
17	Mericarps surface (glabrous or pubescent)

Table 1. Morphological comparison between *Malva cretica* subsp. *cretica* and *M. cretica* subsp. *althaeoides* according to literature. [1]: Nogueira & Paiva (2005); [2]: Lacaita (1925); [a]: According to Lacaita (1925), corolla colour is not diagnostic.

Character	<i>M. cretica</i> subsp. <i>cretica</i> var. <i>cretica</i> [1]	<i>M. cretica</i> subsp. <i>cretica</i> var. <i>montana</i> [2]	<i>M. cretica</i> subsp. <i>althaeoides</i> [1]
Stem length (cm)	Up to 40	Up to 40–50	Up to 80
Stellate hairs on pedicels	Present	Not recorded	Absent
Pedicels length (mm)	Up to 40–50	Not recorded	Up to 10
Petals length (mm)	10–14	15–20	20–35
Petals/Sepals ratio	1 or a little more	1½	2 or more
Sepals length (mm)	7–10	Not recorded	10–18
Corolla colour (in vivo)	Bluish–lilac	[a]	Light pink (lilac)

> |0.7|, only one per group of correlate variables was employed in the further analyses; the selected character in these cases was that with the highest sum of loads (in absolute value) on all axes. Of the surviving characters, only those loading at least |0.7| on at least one axis were kept for DA. In the practice of excluding collinear variables and choosing the most explanatory variable for each group of correlates we followed previous literature (see Del Guacchio & al. 2016 for further details), as when highly correlated variables are present, the discriminant function may not reliably predict grouping (Naes & Mevik 2001). A Discriminant Analysis (DA) was carried out, in order to clarify the relationships between the individuals, projecting Operational Taxonomic Units (OTUs) with population centroids in a two-dimensional space generated by canonical functions.

RESULTS AND DISCUSSION

The DA graph (Fig. 1) shows a rather compact ellipse, which apparently would suggest a Gaussian distribution. However, the OTUs on the right part of this cloud of points mainly represent specimens referable to ALTH and collected in Spain; while OTUs on the left can be mostly ascribed to CRET and to MONT, gathered in central and eastern Mediterranean. Therefore, a smooth West-East cline emerges. A percentage of 77.4% of cases resulted correctly classified in origin: 97.2% for CRET, 69.8 for ALTH, but only 50% for MONT. This is mainly due to specimens with some intermediate features typical of *Malva cretica* var. *montana* collected in Spain, but classified as

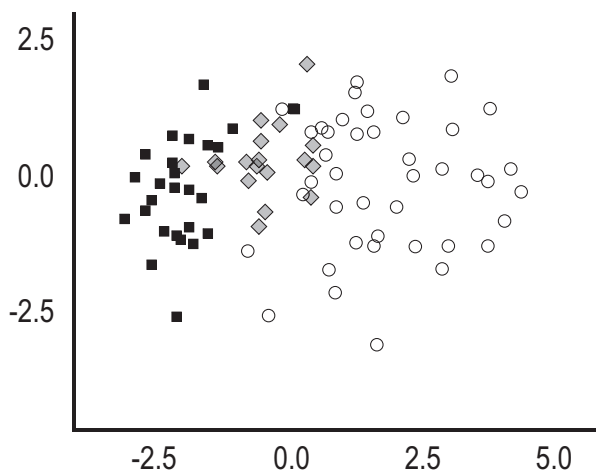


Fig. 1. Discriminant analysis per taxon showing the relationships among the examined specimens. Circles = specimens classified as *Malva cretica* subsp. *althaeoides* [ALTH]; diamonds = specimens classified as *M. cretica* var. *montana* [MONT]; squares = specimens classified as *M. cretica* subsp. *cretica* [CRET].

M. cretica subsp. *althaeoides* on account of the absence of stellate hairs. In every case, the variability of MONT is mostly included in that of CRET, only showing sometimes a higher sepal/petal length ratio (Fig. 2).

The ALTH group includes plants with longer and wider petals and higher sepals/petals ratio [petals (12)19–34 mm long, ratio petals / sepals (1.3)1.5–2.5(2.9) in ALTH vs. petals (9–)11–20(–22) mm long, 0.8–1.4(–1.9) as long as the sepals in CRET + MONT; Fig. 3]. In addition, in the ALTH group, hairs are mostly simple, while the other group (CRET + MONT) corresponds to plants with mixed hairs, both simple and stellate (Fig. 4). On the basis of the results obtained [partial overlapping of the characters and geographic cline (Fig. 5) between western and central-eastern Mediterranean], two taxa can be recognized as partly distinct. The subspecific rank is therefore the most appropriate rank for them in our opinion, according to the treatment below: *Malva cretica* subsp. *cretica*, and *M. cretica* subsp. *althaeoides*. In addition, *M. cretica* var. *montana* should be regarded as a synonym of subsp. *cretica*. As said above, apparently intermediate populations between *M. cretica* subsp. *cretica* and *M. cretica* subsp. *althaeoides* occur in southern Italy (and we identified them with “*M. cretica* var. *montana*”), but possibly also in eastern Spain. Nevertheless, it is to be noted that some Spanish records of subsp. *cretica* could be due to introduction from eastern countries, as well as those known in France (Valdés 2011). Besides, no significant ecological difference can be highlighted from the information we have recorded.

The recognition of the subspecific rank for *Malva althaeoides* implies its common origin with

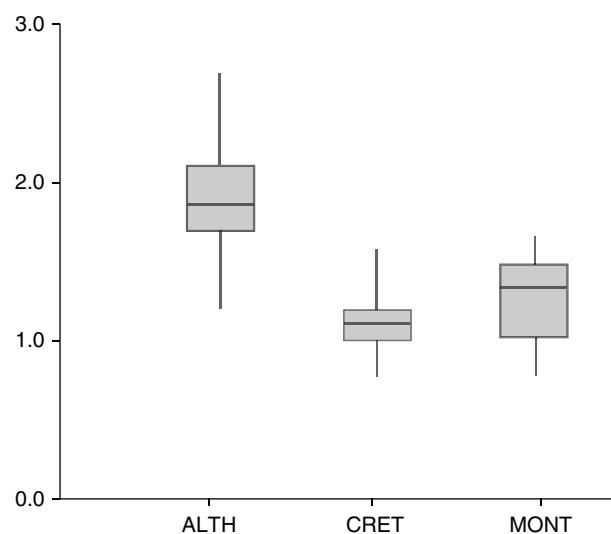


Fig. 2. Box plots illustrating the variability of the ratio length sepal/petals per taxon (ALTH = *althaeoides*; CRET = *cretica*; MONT = *montana*). Measurements are in mm.

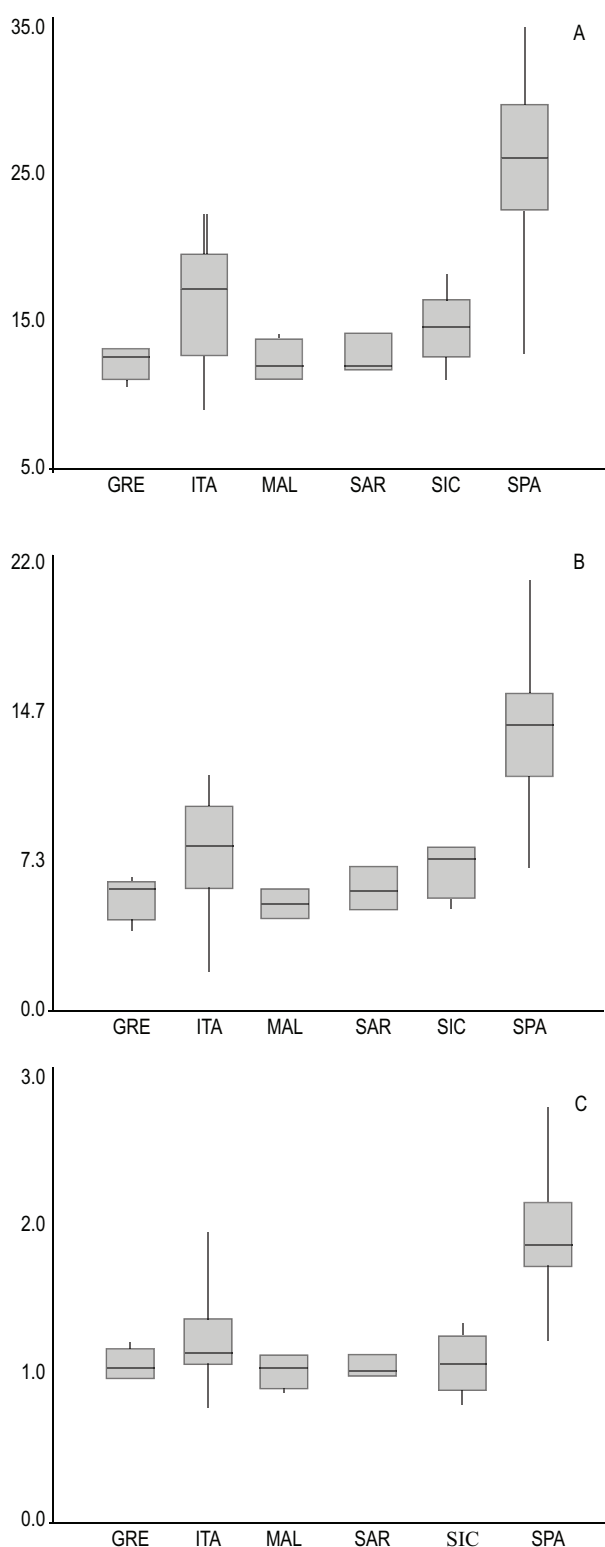


Fig. 3. Box plots illustrating the variability of several characters: **a**, length of petals; **b**, width of petals; **c**, ratio length sepals/petals per origin of specimens (GRE = Greece; ITA = Italy; MAL = Malta Archipelago; SAR = Sardinia; SIC = Sicily; SPA = Spain). Measurements are in mm.

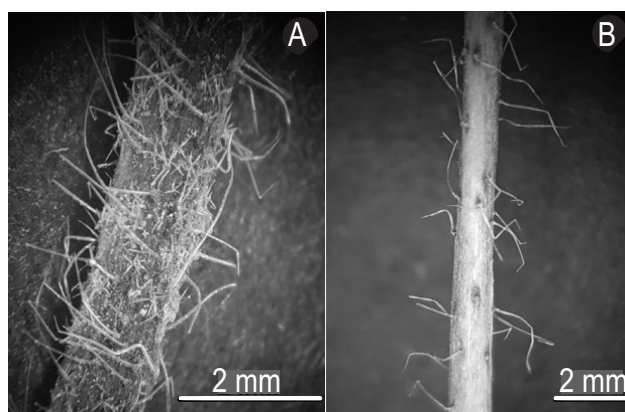


Fig. 4. Hairs type in *Malva cretica* s.l.: **a**, stem with stellate mixed with simple hairs in subsp. *cretica*; **b**, stem with only simple hairs in subsp. *althaeoides*. [a, photo by R. Vallariello from a specimen collected in southern Italy: NAP (“Gussone Generale”), Monte Caruso in Basilicata, 1841, (*G. Gussone*); b, photo by R. Vallariello from a specimen collected in Spain: NAP (“Gussone Generale”), “Valdigna”, s.d.; with permission of the Director of NAP].

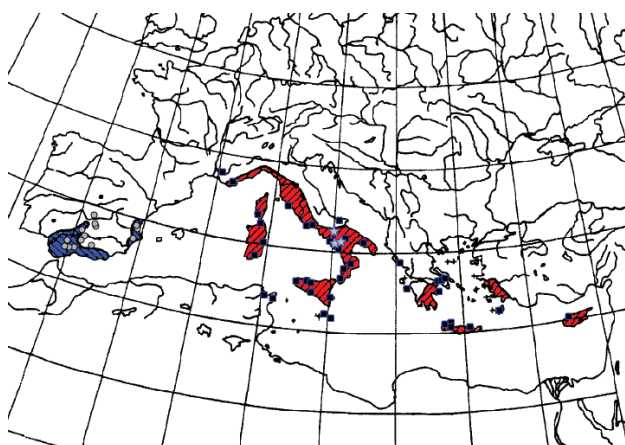


Fig. 5. Distribution map of *Malva cretica* subsp. *cretica* (red areas and black squares), and *M. cretica* subsp. *althaeoides* (blue areas and grey circles). Stars (light grey) indicate localities of specimens labelled as *M. cretica* var. *montana* (modified from Krebs, 1994).

M. cretica subsp. *cretica*. These two taxa likely originated by an ongoing splitting of a single South-Mediterranean species into two groups of populations, after the rise of the sea level in the central part of its area (Fig. 5). Obviously, verifying our hypothesis would require a separate study on population dynamics on the whole. Finally, the inclusion of *Malva cretica* s.l. in the genus *Dinacrusa* (including annual taxa now located both in *Malva* and *Althaea*) by Krebs (1994) is a very interesting issue, but worth of further study with a larger sampling.

Malva cretica Cav., Diss. 5: 280 (1788); *Dinacrusa cretica* (Cav.) G. Krebs, Feddes Repert. 105(5-6): 309 (1994). Type: [France] Jardin du Roi, s.d., Isnardi s.n. (holotype see Iamonico & Del Guacchio, 2017: 282: P 00662859!).

Annual scapose herb, hairy. Stem 5–80 cm tall, up to 2.5 mm in diameter, erect or prostrate-ascending, hairy by pustulate simple hairs up to 2 mm and often with shorter stellate hairs. Basal leaves 5–40 × 5–41 mm, rotundate-lobate, crenate, with a peduncle up to 4 cm, hispid, pubescent or softly villous. Upper leaves similar to the basal ones but more divided, serrate, with 3–5 acute lobes, with a shorter peduncle. Stipels 5–6 mm long, linear-lanceolate. Flowers solitary, with peduncle longer than the axillary leaf. Epicalyx with 3 linear segments, 3–9 mm long, hispid to villous. Sepals 5, linear-lanceolate, up to 8–19 × 1–4 mm in fruit, hispid to villous. Petals 5, with a glabrous limb from obtuse to slightly retuse, 9–34 × 4–21 mm, and a ciliate awn. Mericarps glabrous and smooth or slightly rugose, 1.5–2.5 mm in diameter.

Malva cretica subsp. *cretica*

= *Malva hirsuta* Ten., Prodr. Fl. Nap. 1(3): LX (1812), nom. illegit. (Art. 53.1 of ICN, Turland & al. 2018).

= *Malva althaeoides* Cav. var. *hirsuta* DC., Prodr. 1: 432 (1824).

Type: [Italy] Sicilia, prope Agrigentum [= Agrigento], Schouw s.n. (lectotype designated by Iamonico & Del Guacchio, 2017: 282: G 00218376!).

= *Malva cretica* var. *montana* Lacaita, N. Giorn. Bot. Ital., n.s. 32(2): 209 (1925), syn. nov.

Type: [Italy] Basilicata, valle del Basiento [= Basento], sopra la stazione di Salandra, inter segetes, 150–200 m, 20 May 1920, Lacaita 22429 (lectotype designated by Iamonico & Del Guacchio, 2017: 285: BM 000751626!).

– “*Althaea hirsuta* Sieber” in Steudel (1840: 66), nom. inval. pro syn. (Art. 36.1b of ICN, Turland & al. 2018).

– “*Malva cretica* var. *typica*” Paoletti (1901: 265), nom. inval. (Art. 24.3 of ICN, Turland & 2018).

Diagnostic features.—Petals (9–)11–20(–22) mm long; 0.8–1.4(–1.9) as long as the sepals; stellate hairs present, often abundant.

Preferential habitat.—Open woods, shrublands, meadows; from sea level to 1100 m elevation.

Distribution.—Central and eastern Mediterranean Basin (from Corse and Sardinia to Cyprus and Turkey, including Tunisia; some populations in Spain maybe introduced (cf. Valdés 2011). We confirm its presence in Malta.

Malva cretica subsp. *althaeoides* (Cav.) Béguinot, N. Giorn. Bot. Ital., n.s. 16: 111 (1909); *Malva althaeoides* Cav., Icon. [Cavanilles] 2: 30 (1793); *Axolopha althaeoides* (Cav.) Alef., Oesterr. Bot. Z. 12: 259 (1862); *Dinacrusa cretica* subsp. *althaeoides* (Cav.) G. Krebs, Feddes Repert. 105(5–6): 311 (1994).

= *Malva anodaeformis* Lagasca, Periód. Soc. Méd.-Quir. Cádiz 4(1): 2.

Type: Spain, San Juan de Alfarache, s.d., Rojas Clement s.n. (neotype designated by Iamonico & Del Guacchio, 2017: 285, Figure 1: MA 73338!).

– “*Malva cretica* subsp. *althaeoides*” Dalby (1967: 26), isonym (Art. 6, Note 2 of ICN, Turland & al. 2018).

Diagnostic features.—Petals (12)19–34 mm long; ratio petals/sepals (1.3)1.5–2.5(2.9); stellate hairs usually absent, or scarce.

Preferential habitat.—Fallow lands, dry places, open habitats; from sea level to 1000 m elevation.

Distribution.—Spain (also northwestern Africa, according to Nogueira & Paiva 2005; also Corse, according to Valdés 2011, see also Jeanmonod 2002).

ACKNOWLEDGEMENTS

Thanks are due to directors and curators of all quoted herbaria for the loans of relevant specimens. We also thank L. J. García-Morales (Museo de Historia Natural de Tamaulipas, Ciudad Victoria, Mexico) for his help with the Spanish translation, and P. Caputo (University of Naples “Federico II”) for his precious suggestions and the permission to publish the photographs from NAP.

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APPENDIX 1. SELECTED SPECIMENS STUDIED.

***Malva cretica* subsp. *altheoides*:** SPAIN.— **Alicante:** Tabena, Castell de Castells, 7 May 1990 (L). **Barcelona:** Catalonia, “plaine du Besos”, 1914 (P). **Cádiz:** Algodonales: Sierra de Lijar, 500–1000 m, 31 May 1979 (SIV); Grazalema, 2 Jun. 1982 (SIV). **Ciudad Real:** 19 June 1946 (SIV); Sierra morena, Despeñaperros, 11 Jun. 1962 (U). **Córdoba:** Sierra de Rute, 19 May 1974 (SIV); Priego de Córdoba, 27 May 1978 (SIV); Adamuz: Arroyo de San Anton, 26 May 1979 (SIV); Zagrilla, 7 May 1983 (SIV). **Granada:** 1250–1300 m, s.d. (SIV). **Jaén:** Sierra Morena, Jun. 1923 (SIV). **Málaga:** Betica, Tajo de Ronda, 900 m, 30 Jun. 1922 (SIV); Sierra de Aguas, 800 m, 14 Jun. 1973 (SIV); Serrania de Ronda, 1849 (NAP). **Sevilla:** Algemitas, 22 May 1981 (SIV). **Valencia:** “In regno Valentino [...] Sierra de Chieva”, 750–1000 m, 2 Jun. 1844 (P); Cape S. Antonio, 20 m, 10 May 1923 (SIV); Serra de la Murta May 1946 (SIV); Albufera, 31 May 1962 (U).

Malva cretica* subsp. *cretica (* = specimens with features of *M. cretica* var. *montana*): FRANCE.— **Bouches-du-Rhone:** Marseille, 3 May 1914 (P), (casual alien). **Corse-du-Sud:** Bonifacio, May 1917 (P). ITALY. **Basilicata:** Potenza, 3 Jun. 1928 (FI) *; Potenza, Monte Caruso, 1841 (NAP). **Calabria:** Catanzaro, Tiriolo, 15 Jun. 1899 (FI); Reggio Calabria, Capo d’Armi, 3 May 1824 (NAP); Vibo Valentia, 25 May 2009 (W). **Campania:** Avellino, Villamaina, 20 May 1832 (NAP)*; tra Sacco

e Teggiano [*locus classicus* of var. *montana*!], 1000 m, 23 June 2001 (*Herb.EDG*)*; Felitto, 250 m, 30 May 2002 (*Herb.EDG*)*; **Lazio:** Circeo, 1832 (P); Sperlonga, 21 Apr. 1968 (FI). **Puglia:** Taranto, Manduria, 10 May 1924 (FI); Foggia, S. Nicandro, 12 May 1893 (FI). **Sardinia:** Cagliari, 3 May, 1829 (FI); Oristano, Monte Pinu, 2 May 18?? (FI); Nuoro, Baunei, 19 May 1980 (FI). **Sicily:** Palermo, Boccadifalco-Baida, s.d. (NAP); Palermo, Villabate, s.d. (P); **Sicily:** Palermo, Sclafani, May XIX century (date illegible) (P); Agrigento, 26 Apr. 1840 (P); Siracusa, Jul. 1845 (NAP); Trapani, 25 Apr. 1974 (P). **Toscana:** Porto San Stefano, 9 May 1890 (FI). TUNISIA. **Djebel Boukornine:** 25 Apr. 1909 (P). **Nabeul:** Kourba, 14 May 1883. GREECE. **Attica:** Athens, M. Lycabetti, 21 Apr. 1848 (P); Pikermi, 9 May 1856 (P); Hydra island, Apr. 1876 (P); Salamis island, Apr. 1892 (FI). **Corfu island:** 7 May 1878 (W). **Crete:** Khania, 400–600 m, 1845 (P); Kissamos, 16 May 1884 (P); Arrhanes, 7 May 1982 (P); Hagia Roumelis, 27 Apr. 1976 (P). **Rhodos island:** 70 m, 25 Mar. 2009 (B); **Zakinthos island:** 200–220 m, 6 May 2014 (W). MALTA. **Gozo:** Insula Gauolos, 24 Apr. 1907 (FI). **Malta:** San Paolo a Mare, 3 May 1907 (FI). CYPRUS (including the Turkish administration); **Bellapais:** 27 May 1880 (FI); M. Pentadaktylos, Jun. 1880 (P). TURKEY. **Aydin:** Dydima, 10 m, 9 Apr. 1965 (E). **Izmir:** Çeşme, 10–50 m, 24 Apr. 1965 (E); Kuşadası, 8 May 1965 (ISTO). **Muğla:** Bodrum to Müsgebi, 50–100 m, 12 Apr. 1965 (E).