

ANGEL ROMO<sup>1</sup> & ADAM BORATYŃSKI<sup>2\*</sup>

## The genus *Cotoneaster* (*Rosaceae*) in NW Africa

### Abstract

Romo A. & Boratyński A.: The genus *Cotoneaster* (*Rosaceae*) in NW Africa – Willdenowia 44: 229–239. 2014. – Version of record first published online on 2 July 2014 ahead of inclusion in August 2014 issue; ISSN 1868-6397; © 2014 BGBM Berlin-Dahlem.

DOI: <http://dx.doi.org/10.3372/wi.44.44204>

The taxa of *Cotoneaster* Medik. (*Rosaceae*) from NW Africa (Morocco, Algeria and Tunisia) have been revised. The taxonomic position of *C. atlanticus* G. Klotz is justified and the occurrence of *C. granatensis* Boiss. in Morocco is confirmed. Diagnostic characters, descriptions, detailed illustrations and distribution maps are given for both taxa. Morphological characteristics of *C. atlanticus* and *C. granatensis* are compared with the related *C. nummularius* Fisch. & C. A. Mey. and *C. racemiflorus* (Desf.) K. Koch.

Additional key words: Algeria, Atlas Mountains, chorology, Iberian Peninsula, *Maloideae*, Morocco, plant taxonomy, Spain, Tunisia

### Introduction

The genus *Cotoneaster* Medik. comprises 300–450 species of winter-deciduous or evergreen shrubs and, rarely, small trees, with the highest concentration of taxa in the Himalaya and W China (Hylmö & Fryer 1999; Bartish & al. 2001; Lu & Brach 2003; Fryer & Hylmö 2009). In the Irano-Turanian and Mediterranean floristic regions (as defined by Takhtajan 1986), the genus was represented by 25 species reported in Flora Iranica (Riedl 1969) and seven species reported in Flora of Turkey (Browicz 1972).

Knowledge of the genus *Cotoneaster* in Europe has been improved, mainly due to the contributions made by Flinck & Hylmö (1966), Flinck & al. (1998), Hylmö & Fryer (1999) and Sennikov (2009+). Recently Dickoré & Kasperek (2010) reported seven species native to Europe, and Sennikov (2009+) reported 22 species native to Europe and the Mediterranean countries. In spite of that, during the last decades some new taxa have been described from W Europe, one from the French Alps by Flinck & al. (1998), close to *C. atlanticus* G. Klotz, and another from

Majorca (Sáez & Rosselló 2012), close to *C. tomentosus* (Aiton) Lindl. and *C. raboutensis* Flinck & al.

In the W Mediterranean region several indigenous species of *Cotoneaster* have been reported: three from the Iberian Peninsula (Blanca 1998), one from the Balearic Islands (Sáez & Rosselló 2012) and a few from Morocco (Achhal 2002), Algeria (Quézel & Santa 1962) and Tunisia (Le Floc'h & Boulos 2008). From the African countries the following have been reported: *C. nummularius* Fisch. & C. A. Mey. (Maire 1924; Jahandiez & Maire 1932), *C. racemiflorus* (Desf.) K. Koch (Quézel & Santa 1962; Maire 1980), *C. atlanticus* G. Klotz (Klotz 1963) and *C. granatensis* Boiss. (Jury 2001; Jury & al. 2008).

The first reports on *Cotoneaster nummularius* from Morocco were made by Jahandiez & Maire (1932). Then the plants from N Africa were included in *C. racemiflorus* (Desf.) K. Koch (Quézel & Santa 1962; Meikle 1966: 104; Riedl 1969: 17; Qutab-ud-Din 2004; Le Floc'h & Boulos 2008). In recent years Galland (1988), Fennane (1999: 438), Achhal (2002: 294) and Fennane

1 Institute of Botany, Consejo Superior de Investigaciones Científicas-Ajuntament de Barcelona, IBB-CSIC-ICUB, Passeig del Migdia s/n, Parc de Montjuïc. 08038 Barcelona, Spain; e-mail: a.romo@ibb.csic.es

2 Polish Academy of Sciences, Institute of Dendrology, Parkowa 5, 62-035 Kórnik, Poland; \*e-mail: borata@man.poznan.pl (author for correspondence).

& Ibn Tattou (2005: 341) again included the Moroccan specimens of *Cotoneaster* in *C. nummularius*. Achhal (2002), wrote that *C. nummularius* occurs in S Europe, which is of course true, but the distribution of this species in Europe is limited to the island of Crete (Boratyński & al. 1992). The information concerning the occurrence of *C. nummularius* in Sicily (Meikle 1977) also seems to be incorrect. *Cotoneaster nummularius* is an Irano-Turanian plant (Browicz 1999), which only enters the E part of the Mediterranean region and does not occur in Africa (Browicz 1986, 1991; Boratyński & al. 1992), except in the Ethiopian mountains (Hedberg 1989: 41).

Klotz (1963) reported *Cotoneaster atlanticus* from the Middle and High Atlas, and Jury (2001) reported *C. granatensis* from the C High Atlas. The name *C. atlanticus*, since its publication by Klotz (1963), has not been used until recently (Charco 1999, 2001; Sennikov 2009+). According to Sennikov (2009+), it occurs in Morocco, Algeria and Tunisia; this author also reported *C. nummularius* from Morocco.

There has been no consensus about the taxonomic treatment of the genus in Morocco. Dobignard (2009) considered that all *Cotoneaster* from Morocco should be referred to *C. granatensis*, while Taleb & Fennane (2008) and Navarro & al. (2010), referred them to *C. nummularius*. The complex of *C. nummularius* and *C. racemiflorus* is composed of different, dispersed and frequently isolated forms, while the taxonomy of the two species themselves remains problematic. Klotz (1963), Riedl (1969) and Qutab-ud-Din (2004) treated these two taxa as separate species, whereas Meikle (1966), Browicz (1972: 131), Mouterde (1970: 208) and Fennane (1999: 483) treated them as one species sensu lato. Also, Browicz (1991) included all critical forms, aggregates and microspecies described from *C. racemiflorus* within *C. nummularius*. Described from Morocco, *C. atlanticus* was included within *C. ser. Racemiflori* G. Klotz (Klotz 1963), different from *C. ser. Orbiculares* G. Klotz (Klotz 1963), to which *C. nummularius* is referred, following criteria by Flinck & Hylmö (1966).

The principal aim of this study, therefore, is a clarification of the identity of the species of *Cotoneaster* from Morocco, Algeria and Tunisia.

## Material and methods

The available African herbarium material of *Cotoneaster* was compared with samples from the Iberian Peninsula (mainly *C. granatensis*) and from Greece, Turkey and Tajikistan (*C. nummularius*–*C. racemiflorus* complex). The main collections of *Cotoneaster* (in B, BC, G, GRA, MA, MPU, RDG and SEV) that concern the African territory were revised. This material was compared with the following:

*Cotoneaster granatensis* collected from the Iberian Peninsula (in BC, G, GRA, KOR, MA and SEV);

*Cotoneaster nummularius* collected from Crete and SW Asia (in BC, G and KOR);

*Cotoneaster racemiflorus* collected from the Tien Shan mountains in Tajikistan (in KOR).

Detailed studies were made on the characters described in the taxonomic literature on *Cotoneaster* in Europe, SW Asia and NW Africa and considered to be important in distinguishing the species (Klotz 1963; Meikle 1966; Riedl 1969; Poyarkova 1971; Browicz 1972, 1986; Blanca 1998; Hylmö & Fryer 1999; Qutab-ud-Din 2004). The comparative measurements of characters were made on well-collected specimens, which were also used as the basis for the drawings of *C. atlanticus*, *C. granatensis* and *C. nummularius* (Fig. 1–3; see Appendix 1).

## Results

The specimens of *Cotoneaster* from the Atlas, which include *C. racemiflorus* sensu Maire and *C. fontanesii* var. *tomentellus* Maire, as well as those from the Rif, should all be considered as *C. atlanticus* or *C. granatensis*. The plants from the High Atlas mentioned later by Jury (2001) and Jury & al. (2008) should be referred to *C. atlanticus*. *Cotoneaster atlanticus* and *C. granatensis* are considered to be the only taxa present in NW Africa.

***Cotoneaster atlanticus*** G. Klotz in Wiss. Z. Martin-Luther-Univ. Halle-Wittenberg, Math.-Naturwiss. Reihe 12: 759. 1963 ≡ *Cotoneaster fontanesii* var. *tomentellus* Maire in Bull. Soc. Hist. Nat. Afrique N. 14: 143. 1923 [*“tomentella”*] ≡ *Cotoneaster nummularius* subvar. *tomentellus* (Maire) Jahand. & Maire, Cat. Pl. Maroc 2: 333. 1932 [*“tomentella”*]. – **Lectotype (designated here)**: Morocco, “Grand Atlas, Ourika: rochers gréseux au-dessus d’Anfegeïn, 2400 m, exp. N.”, 9 Jul 1921 (fl.), R. Maire (MPU 000452!). – Syntype: Algeria, “Djebel Chlaalaa, Monts de Batna, prov. de Constantine”, Aug 1903, A. Joly (MPU 000453!). – Fig. 1.

**Description** — *Shrubs* 1–2(–3) m tall. *Branchlets* white tomentose in 1st year, brownish grey and sparsely tomentose in 2nd year. *Leaf blade* oblong-ovate, 1.4–2.2 × (0.9–)1.2–1.6(–1.8) cm, abaxially densely tomentose, adaxially sparsely pilose (hairs 10–15 per 1 mm<sup>2</sup>, 0.4–0.5 mm long), apex obtuse or acute, apiculate. *In-florescence* a corymb-like cyme of 2–5 flowers; *pedicels* shorter than corolla diameter; *bracteoles* reddish, 2.5–2.75 mm long. *Sepals* (0.6–)0.7–0.8 mm long. *Corolla* (6.5–)7–8 mm in diam.; *petals* 2–2.5 mm long. *Styles* 2, as long as or only inconspicuously longer than stamens. *Fruit* purplish, subglobose, (5–)6–7 × 3.5–4 mm.

**Distribution** — The total distribution area of *Cotoneaster atlanticus* includes Morocco, Algeria and Tunisia (Fig. 4). In Morocco it occurs in the Middle Atlas, where it

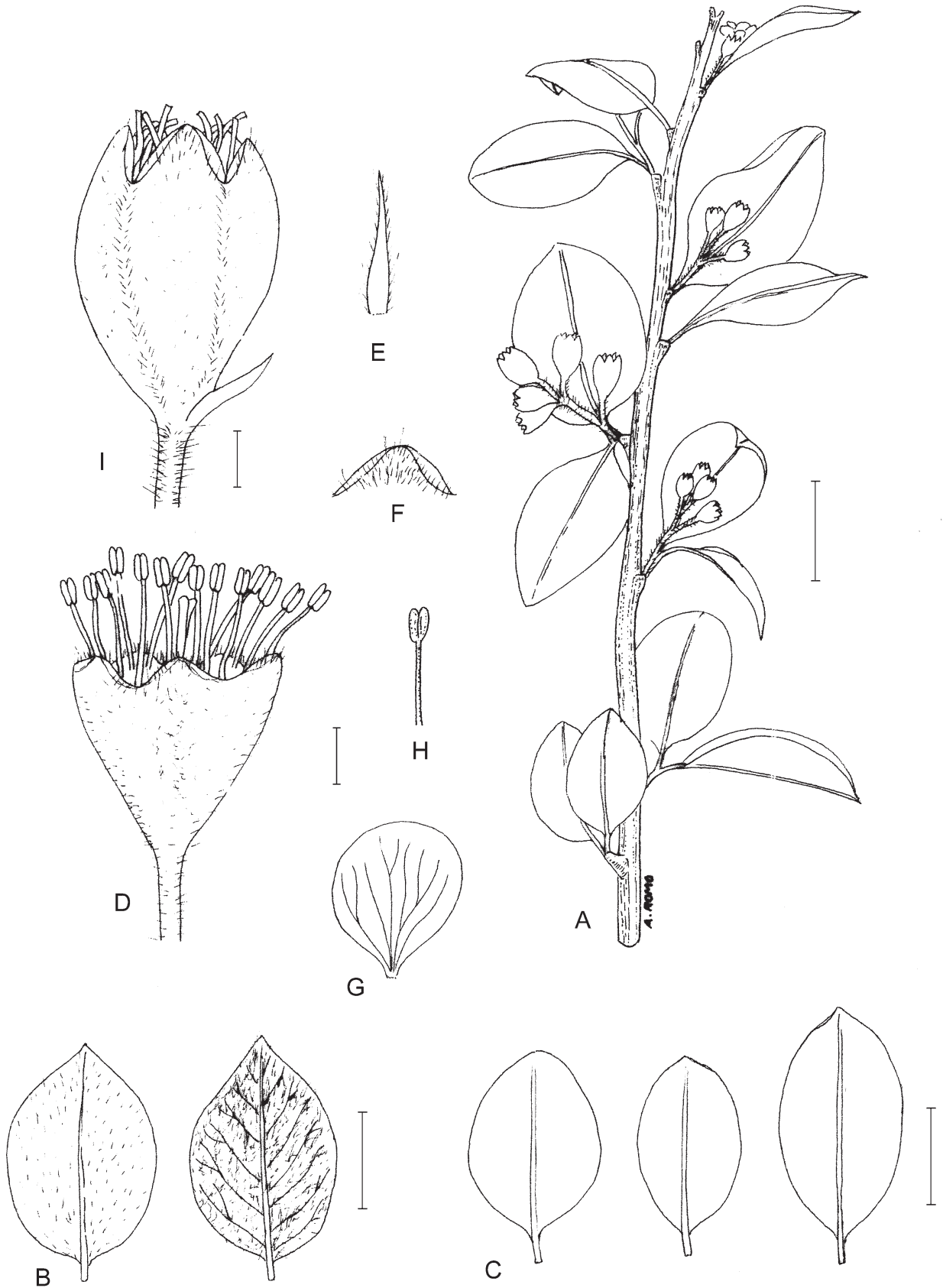


Fig. 1. *Cotoneaster atlanticus* – A: fruiting branch; B: leaves abaxial surface; C: leaves adaxial surface; D: flower with petals fallen; E: bracteole; F: sepal apex; G: petal; H: stamen; I: unripe fruit. – Scale bars: A–C = 1 cm; D–I = 1 mm. – Drawn by A. Romo based on material from Morocco: BC 21615 (see Appendix 1).

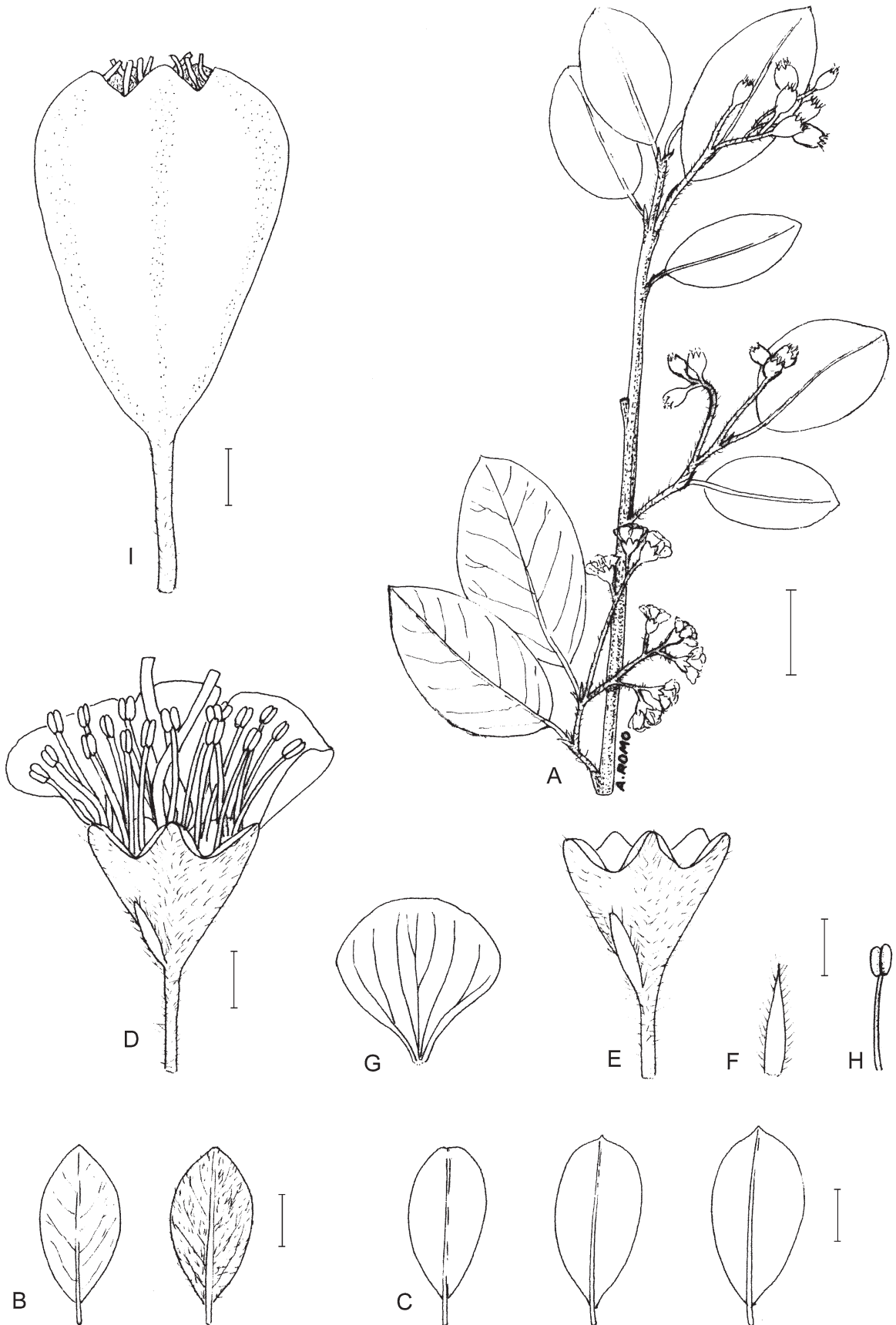


Fig. 2. *Cotoneaster granatensis* – A: fruiting branch; B: leaves abaxial surface; C: leaves adaxial surface; D: flower; E: pedicel, bracteole, hypanthium and calyx; F: bracteole; G: petal; H: stamen; I: unripe fruit. – Scale bars: A–C = 1 cm; D–I = 1 mm. – Drawn by A. Romo based on material from Morocco: G 7913/33 (see Appendix 1).

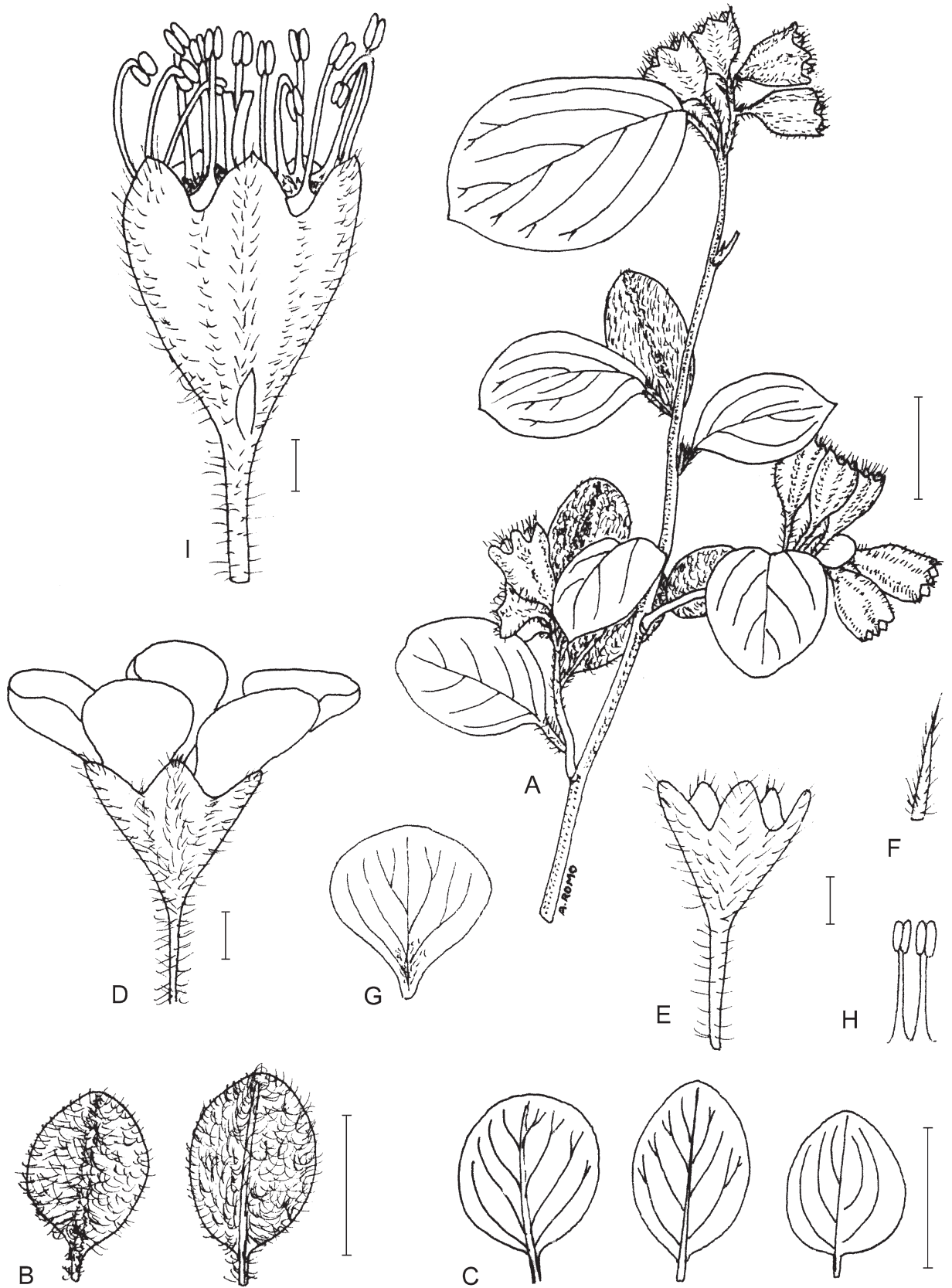


Fig. 3. *Cotoneaster nummularius* – A: fruiting branch; B: leaves abaxial surface; C: leaves adaxial surface; D: flower; E: pedicel, hypanthium and calyx; F: bracteole; G: petal; H: stamens; I: unripe fruit. – Scale bars: A–C = 1 cm; D–I = 1 mm. – Drawn by A. Romo based on material from Turkey: KOR 25089 (A & E–I) and KOR 30153 (B–D) (see Appendix 1).

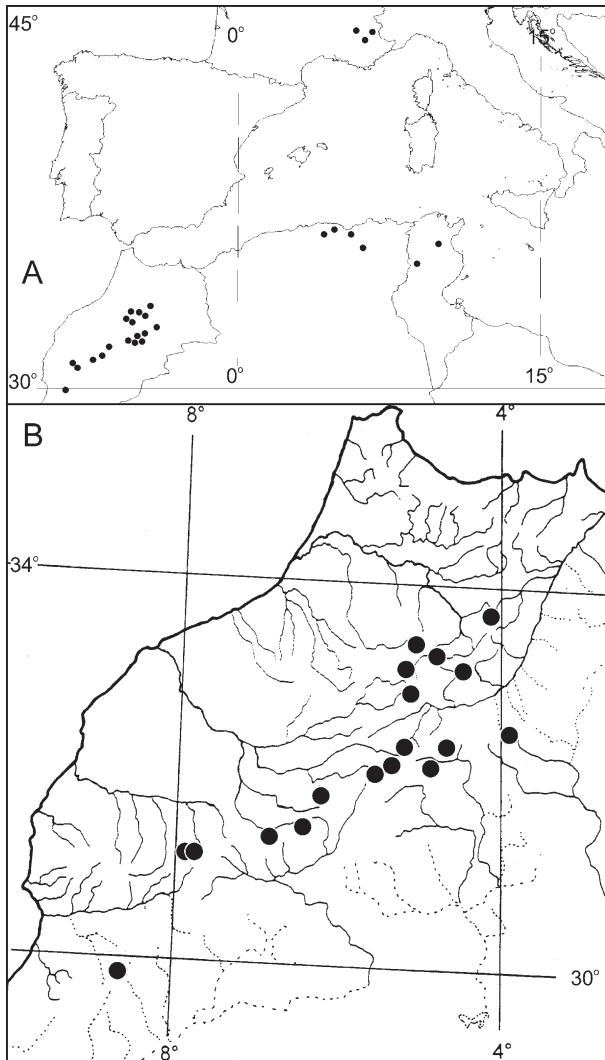


Fig. 4. *Cotoneaster atlanticus* – A: general distribution in W Mediterranean region; B: distribution in Morocco. – Based on herbarium specimens examined (see Appendix 2).

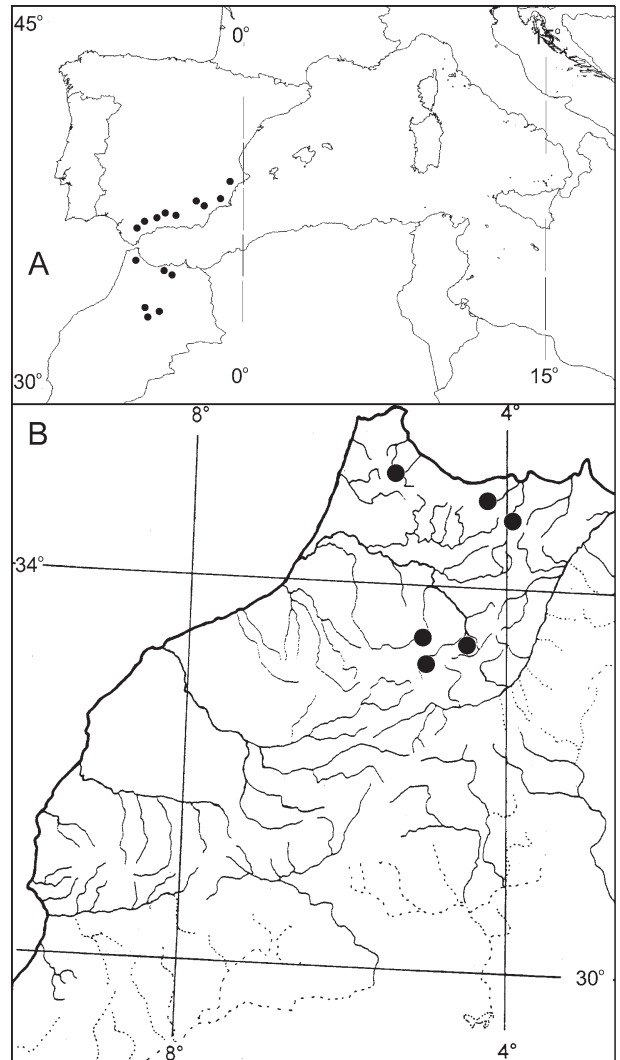


Fig. 5. *Cotoneaster granatensis* – A: general distribution in W Mediterranean region; B: distribution in Morocco. – Based on herbarium specimens examined (see Appendix 2).

is rare, and in the High Atlas, where it is more frequent (Charco 2001), as well as in the Anti Atlas (Emberger & Maire 1941: 1021, as *C. nummularius* subvar. *fontanesii* (Spach) Maire; Fennane & Ibn Tattou 2005: 341). The species attains the high basin of the Oued Sebou and the middle basin of the Oued Moulouya (pers. obs.). From Algeria it has been reported from the Tellian Atlas, Aurès and Saharian Atlas (Maire 1980). It has also been reported from the Grand and Petite Kabylie and from the High Constantinois Plateaux (Quézel & Santa 1962). In Tunisia it is present on the Dorsale Tunisienne (Pottier-Alapetit, 1981). It grows mostly in the form of single individuals dispersed in the mountains, on rocky outcrops, cliffs, rocks and/or similar site conditions. The species can be found at altitudes of (1600–)1800–2800 m (see Appendix 2) independent of the type of substrate.

*Cotoneaster atlanticus* was also recorded from France by Garraud (1998), who provided a drawing made from a specimen collected in the W Alps (Montagne de Montlaud,

commune de Sainte-Jalle, département de la Drôme) and showed only leaves and mature fruits. This illustration and the associated description did not allow verification of the presence of *C. atlanticus* in the Alps (Aeschimann & al. 2004). See also under Discussion, below.

*Cotoneaster granatensis* Boiss., Elench. Pl. Nov.: 41. 1838. – Lectotype (designated by Burdet & al. 1989: 53): Spain, Granada, “Hab. in vallibus Sierra Nevada, alt. 5000’–6000’”, Jul 1837, *E. Boissier* (G [sheet no. 1]!; isolectotypes: G [13 sheets]). – Fig. 2.

*Description* — Shrubs 1–3(–5) m tall. Branches erect, irregularly spreading; branchlets brown, pubescent or white tomentose in 1st year, subglabrous or sparsely tomentose in 2nd year. Petiole 4–8 mm long, glabrous to sparsely pilose; leaf blade obovate-elliptic or broadly ovate, (1–)1.5–4(–5) × (0.8–)1.2–3.2(–4.2) cm, abaxi-

Table 1. Morphological comparison of *Cotoneaster atlanticus*, *C. granatensis* (from Morocco and Spain), *C. nummularius* and *C. racemiflorus*, based on herbarium material (see Appendix 1).

Character	<i>Cotoneaster atlanticus</i>	<i>Cotoneaster granatensis</i> from Morocco	<i>Cotoneaster granatensis</i> from Spain	<i>Cotoneaster nummularius</i>	<i>Cotoneaster racemiflorus</i>
Plant height [m]	1–2(–3)	1–2	1–3(–5)	1–1.5	?
1st-year branchlets colour/indumentum	white tomentose	pubescent	white tomentose	pubescent	tomentose
2nd-year branchlets colour/indumentum	brownish grey, sparsely tomentose	subglabrous	sparsely tomentose	glabrous	dark purple, glabrous
Leaf blade shape	oblong-ovate, apex obtuse or acute, apiculate	obovate-elliptic, apex acute, apiculate	broadly ovate, apex obtuse, apiculate	obovate-elliptic or suborbicular, apex broadly rounded, subacute or emarginate	broadly ovate to broadly elliptic, apex obtuse or acute
Leaf blade length × width [cm]	1.4–2.2 × (0.9–)1.2–1.6(–1.8)	1.8–3.2 × (0.8–)1.2–1.5(–1.6)	(1–)1.5–4(–5) × (1–)1.2–3.2(–4.2)	1.1–1.3(–1.4) × (0.8–)0.9–1(–1.1)	1.1–3.8 × 0.8–2.6
Abaxial leaf surface indumentum	densely tomentose	sparsely pilose	subglabrous	densely tomentose	sparsely tomentose
Adaxial leaf surface indumentum	sparsely pilose	glabrous	glabrous	sparsely pilose, then glabrous	subglabrous
Number of hairs per 1 mm <sup>2</sup> on adaxial leaf surface	10–15	–	–	(2 or)3 or 4	–
Hair length on adaxial leaf surface [mm]	0.4–0.5	–	–	0.5–0.8(–1)	–
Number of flowers in inflorescence	2–5	6–9	3–12	(6 or)7–9	2–4
Bracteole length [mm]	2.5–2.75	c. 1.5	2.5–4	c. 1.5	?
Pedicele length ÷ corolla diameter	<1	≤ 1	≤ 1	<1	?
Sepal length [mm]	(0.6–)0.7–0.8	(0.6–)0.7–0.8	0.8–1.2	1–1.5	?
Corolla diameter [mm]	(6.5–)7–8	8–9	8–11(–12)	6–8	7–8
Petal length [mm]	2–2.5	2.5–3(–4)	2.5–4	2.5–3	?
Styles relative to stamens	subequal	longer	subequal	subequal	?
Fruit colour	purplish	purplish	purplish	purplish	purplish
Fruit shape	subglobose	subglobose	subglobose	obovate-ellipsoid	subglobose
Fruit length × diameter [mm]	(5–)6–7 × 3.5–4	(5–)6–7(–9) × 3–4	6–9 × 4–5.5	7–8.5 × 2.5–3	8–10 × 4–5.5
Distribution	Morocco, Algeria and Tunisia	Morocco	Spain	SE Europe and C and SW Asia	Caucasus and C Asia

ally sparsely pilose or subglabrous, adaxially mid-green, glabrous, veins 5–7, base acute or cuneate, apex acute or obtuse, apiculate. *Fertile shoots* 2–4 cm long; *inflorescence* lax, 6–12-flowered; *pedicels* 3–10 mm long, sparsely pilose; *bracteoles* 1.5–4 mm long. *Hypanthium* cupulate, sparsely pilose; *sepals* (0.6–)0.7–1.2 mm long, sparsely pilose, margin subvillous, apex obtuse. *Flower buds* pink-tinged. *Corolla* 8–11(–12) mm in diam.; *petals* spreading, white, 2.5–4 mm long, with a small tuft of hairs. *Stamens* 14–20; *filaments* white; *anthers* white. *Styles* subequal to or longer than stamens. *Fruit* purplish, subglobose, (5–)6–9 × 3–5.5 mm, subglabrous; *persistent sepals* suberect. *Nutlets* 2.

*Distribution* — The total distribution area of *Cotoneaster granatensis* includes Spain and Morocco (Fig. 5). It is not endemic to S Spain (Blanca 1998: 401). In Spain

it is present in the Andalusian mountains (Blanca 2009) and in the west (Sánchez & al. 2002; Serra Laliga 2007). In Morocco it occurs in the mountain zones of the Rif, where it is not very abundant, and in the Middle Atlas, where it is more frequent, especially in the high Oued Sebou basin (pers. obs.). The species grows on carbonate soils, preferably in woodland or open forest formations of *Abies maroccana* Trab., *Cedrus atlantica* (Endl.) Manetti ex Carrière or *Quercus rotundifolia* Lam., at altitudes of 1200–1800 m, although it can ascend to nearly 2000 m, as in the case of Jbel Hebri (see Appendix 2).

## Discussion

All specimens of the genus *Cotoneaster* from NW Africa revised during our study have morphological characters

sufficient to exclude them from *C. nummularius* and *C. racemiflorus*, and also to distinguish between *C. granatensis* from the Iberian Peninsula and the same species from N Africa (Table 1, Fig. 1–3).

Apart from morphological differences, the N African *Cotoneaster atlanticus* is geographically strongly isolated from the nearest localities of *C. nummularius*, which are known from Crete and the Chios islands in Greece (Boratyński & al. 1992), but with the main distribution in Turkey, the Caucasus, Turkmenistan, Uzbekistan, Tajikistan, and Kyrgyzstan, extending into Afghanistan, N Pakistan, Kashmir and Himachal Pradesh in NW India (Dickoré & Kasperek 2010), Cyprus, Syria, Lebanon, N Iraq and Iran (Browicz 1986, 1991, 1999) and Yemen and Oman (Chamberlain 1996).

The presence of *Cotoneaster atlanticus* in the French Alps (Garraud 1998) should be verified, as has been pointed out by Aeschmann & al. (2004) in the Flora Alpina. Recently the species was not reported from the Alps (Fryer & Hylmö 2009). Further studies are needed to verify the presence of *C. atlanticus* in the Alps, especially when taking into account the presence there of a close taxon, *C. delphinensis* Chatenier, an endemic from the departments of Drôme and Hautes-Alpes, with which it could have been confused. Along the same lines, with regard to species still requiring confirmation, mention must be made of Landolt & al. (2010), who referred to the presence of *C. granatensis* in the Alps. *Cotoneaster granatensis*, described from the Sierra Nevada (Burdet & al. 1989), was originally comprehended to be an endemic species of the Andalusian mountains in S Spain (Fig. 5A), reaching the Sierra Espuña and Aitana in Murcia and Alicante provinces, respectively (Blanca 1998). The Moroccan specimens can be distinguished from the Spanish ones on the basis of somewhat smaller leaves and flowers, shorter bracteoles, and styles longer than stamens (Table 1). The differences could indicate a different taxonomic position of the Moroccan specimens, but this should be verified using molecular tools.

In conclusion it should be stressed that in NW Africa only two species of the genus *Cotoneaster* occur: *C. atlanticus* in the Middle Atlas, High Atlas and Anti Atlas of Morocco as well as in Algeria and Tunisia, and *C. granatensis* in the Rif and Middle Atlas of Morocco. The occurrence of *C. nummularius* and/or *C. racemiflorus* in NW Africa has not been confirmed in the reviewed herbaria or during several field studies.

## Acknowledgements

The authors are grateful to curators of the herbaria B, BC, G, GRA, KOR, MA, MPU, RDG and SEV for their help during the examination of *Cotoneaster* specimens. This work was funded by bilateral cooperation between CSIC (Consejo Superior de Investigaciones Científicas) and PAN (Polska Akademia Nauk). Alexander Sennikov,

Bertil Hylmö, Moh Fennane and W. Bernhard Dickoré provided several suggestions to improve this paper. The English was revised and corrected by Samuel Pyke.

## References

- Achhal M. 2002: *Cotoneaster* Medik. – P. 296 in: Valdés B., Rejdali M., Achhal El Kadmiri A., Jury J. L. & Montserrat J. M. (ed.), Catalogue des plantes vasculaires du Nord du Maroc **1**. – Madrid: Consejo Superior de Investigaciones Científicas.
- Aeschmann D., Lauber K., Moser D. M. & Thuerillat J. P. 2004: Flora alpina **2**. – Paris: Benin.
- Bartish I. V., Hylmö B. & Nybom H. 2004: RAPD analysis of interspecific relationships in presumably apomictic *Cotoneaster* species. – *Euphytica* **120**: 273–280.
- Blanca G. 1998: *Cotoneaster* Medik. – Pp. 394–401 in: Muñoz Garmendía F. & Navarro C. (ed.), Flora iberica **6**. – Madrid: Consejo Superior de Investigaciones Científicas.
- Blanca G. 2009: *Cotoneaster* Medik. – Pp. 33 in: Blanca G., Cabezudo B., Cueto M., Fernández López C. & Morales C. (ed.), Flora vascular de Andalucía Occidental **3**. – Sevilla: Junta de Andalucía.
- Boissier E. 1838: Elenchus plantarum novarum minusque cognitarum quas in itinere hispanico, legit Edmundus Boissier. – Genevae: Typographia Lador et Ramboz.
- Boratyński A., Browicz K. & Zieliński J. 1992: Chorology of trees and shrubs in Greece. 2nd ed. – Poznań & Kornik: Polish Academy of Sciences, Institute of Dendrology.
- Browicz K. 1972: *Cotoneaster* Medik. – Pp. 129–132 in: Davis P. H. (ed.), Flora of Turkey and the East Aegean Islands **4**. – Edinburgh: Edinburgh University Press.
- Browicz K. 1986: *Cotoneaster* Medik. – Pp. 438–440 in: Strid A. (ed.), Mountain flora of Greece **1**. – Cambridge & New York: Cambridge University Press.
- Browicz K. 1991: Chorology of trees and shrubs in south-west Asia and adjacent regions **8**. – Warszawa & Poznań: Polish Scientific Publishers.
- Browicz K. 1999: Chorological connections of woody *Rosaceae* between SE Europe and SW Asia. – Acta Bot. Fenn. **162**: 185–190.
- Burdet H. M., Charpin A. & Jacquemoud F. 1989: Types nomenclatureaux des taxa ibériques décrits par Boissier ou Reuter. Ranunculacées à Rosacées. – Candollea **44**: 43–58.
- Chamberlain D. F. 1996: *Cotoneaster* Medik. – Pp. 481–482 in: Miller A. G. & Cope T. A. (ed.), Flora of the Arabian Peninsula and Socotra. **1**. – Edinburgh: Edinburgh University Press.
- Charco J. 1999: El bosque mediterráneo en el N de Africa. – Madrid: Agencia española de cooperación Internacional.



- Charco J. 2001: Guía de los árboles y arbustos del norte de Africa. – Madrid: Agencia española de cooperación Internacional.
- Dickoré W. B. & Kasperek G. 2010: Species of *Cotoneaster* (*Rosaceae*, *Maloideae*) indigenous to, naturalising or commonly cultivated in Central Europe. – *Willdenowia* **40**: 13–45.
- Dobignard A. 2009: Contributions à la connaissance de la flore du Maroc et de l’Afrique du Nord. Nouvelle série 2. La flore du Nord-Maroc. – *J. Bot. Soc. Bot. France* **46–47**: 3–136.
- Emberger L. & Maire R. 1941: Catalogue des plantes du Maroc (Spermatophytes et Ptéridophytes) **4**. Supplément aux volumes I, II et III. – Alger: Imprimerie Minerva.
- Fennane M. 1999: *Cotoneaster*. – P. 483 in: Fennane M., Tattou Ibn M., Mathez J., Ouyahya A., El Oualidi J. (ed.), Flore pratique du Maroc: manuel de détermination des plantes vasculaires 1. – *Trav. Inst. Sci. Univ. Mohammed V, Sér. Bot.* **36**.
- Fennane M. & Ibn Tattou M. 2005: Flore vasculaire du Maroc: inventaire et chorologie 1. – *Trav. Inst. Sci. Univ. Mohammed V, Sér. Bot.* **37**.
- Flinck K. E., Fryer L., Garraud L., Hylmö B. & Zeller J. 1998: *Cotoneaster raboutensis*, espèce nouvelle de l’ouest des Alpes, et révision du genre *Cotoneaster* dans les Alpes. – *Bull. Mens. Soc. Linn. Lyon* **67**: 272–282.
- Flinck K. E. & Hylmö B. 1966: A list of series and species in the genus *Cotoneaster*. – *Bot. Not.* **119**: 445–463.
- Fryer L. & Hylmö B. 2009: *Cotoneasters*. A comprehensive guide to shrubs for flowers, fruit and foliage. – Portland: Timber Press.
- Galland N. 1988: Recherches sur l’origine de la flore orophile du Maroc: étude caryologique et cytogéographique. – *Trav. Inst. Sci. Univ. Mohammed V, Sér. Bot.* **35**.
- Garraud L. 1998. *Cotoneaster atlanticus* Klotz un novel arbuste pour la flore française. – *Monde Pl.* **463**: 11–12.
- Hedberg O. 1989: *Rosaceae*. – Pp. 31–43 in: Hedberg I. & Edwards S. (ed.), *Flora of Ethiopia* **3**. – Addis Abeba: National Herbarium, Biology Department, Asmara University; Uppsala: Department of Systematic Botany, Uppsala University.
- Hylmö B. & Fryer J. 1999: *Cotoneasters* in Europe. – *Acta Bot. Fenn.* **162**: 179–184.
- Jahandiez E. & Maire R. 1932: Catalogue des plantes du Maroc (Spermatophytes et Ptéridophytes) **2**. Dicotylédones Archichlamydées. – Alger: Imprimerie Minerva.
- Jury S. L. 2001: Moroccan Plant Diversity. – *Diversity & Distrib.* **7**: 155–157.
- Jury S. L., Rutherford, R. W., Rejdali M., Rankou H. & El Atechi T. 2008: The vascular flora of Oukaïmeden, in the Moroccan High Atlas, ed. 2. – Published at [http://bibdigital.rjb.csic.es/PDF/Jury\\_Vasc\\_Fl\\_Oukaïmeden\\_Ed2\\_2008.pdf](http://bibdigital.rjb.csic.es/PDF/Jury_Vasc_Fl_Oukaïmeden_Ed2_2008.pdf)
- Klotz G. 1963: Neue oder kritische *Cotoneaster*-Arten. – *Wiss. Z. Martin-Luther-Univ. Halle-Wittenberg, Math.-Naturwiss. Reihe* **12**: 753–767.
- Landolt E., Bäumler B., Erhardt A., Hegg O., Klötzli F., Lämmler W., Nobis M., Rudmann-Maurer K., Schweingruber F. H., Theurillat J.-P., Urmi E., Vust M. & Wohlgenuth Th. 2010: Flora indicativa. Ökologische Zeigerwerte und biologische Kennzeichen zur Flora der Schweiz und der Alpen. – Bern, Stuttgart & Wien: Haupt.
- Le Floc’h E. & Boulos L. 2008: Flore de la Tunisie. Catalogue synonymique commenté. – Montpellier.
- Lu L. D. & Brach A. R. 2003: *Cotoneaster* Medikus. Pp. 85–108 in: Wu Z. Y., Raven P. H. & Hong D. Y. (ed.), *Flora of China* **9**. – Beijing: Science Press; St. Louis: Missouri Botanical Garden Press.
- Maire R. 1923: Contributions à l’étude de la flore de l’Afrique du Nord. – *Bull. Soc. Hist. Nat. Afrique N.* **14**: 118–159.
- Maire R. 1924: Études sur la végétation et la flore du Grand Atlas et du Moyen Atlas Marocains. – *Mém. Soc. Sci. Nat. Maroc.* **7**: 1–220 + 16 pl.
- Maire R. 1980: Flore de l’Afrique du Nord 15 – Paris: éditions Lechevalier.
- Meikle R. D. 1966: *Rosaceae*. – Pp. 102–171 in: Townsend C. C. (ed.), *Flora of Iraq* **2**. – Baghdad: Ministry of Agriculture of the Republic of Iraq.
- Meikle R. D. 1977: *Flora of Cyprus* **2**. – Kew: Royal Botanic Gardens.
- Mouterde P. 1970: Nouvelle flore du Liban et de la Syrie **2**. – Beyrouth: Dar El-Machreq Editeurs.
- Navarro T., El Oualidi J., Taleb M. S. & Pascual V. 2010: Leaf patterns, leaf size and ecologically related traits in high Mediterranean mountain on the Moroccan High Atlas. – *Plant Ecology* **210**: 275–290.
- Poyarkova A. I. 1971: *Cotoneaster* Medik. – Pp. 246–257 in: Komarov V. L. (ed.), *Flora of the USSR* **9** [translation]. – Jerusalem: Israel Program for Scientific Translations.
- Quézel P. & Santa S. 1962: Nouvelle flore de l’Algérie et des régions désertiques méridionales **1**. – Paris: CNRS.
- Qutab-ud-Din M. 2004: Taxonomic studies of the genus *Cotoneaster* Ruppert ex Medikus of Pakistan and Azad Kashmir. – Department of Biological Sciences/Quaid-i-Azam University Islamabad, Ph.D. thesis. – Published at <http://eprints.hec.gov.pk/2391/1/2246.htm> [accessed 12 Dec 2012].
- Riedl H. 1969: *Cotoneaster* Medik. – Pp. 13–26 in: Rechinger K. H. (ed.), *Flora Iranica* **66**. – Graz: Akademische Druck- und Verlagsanstalt.
- Sáez L. & Rosselló J. A. 2012: *Cotoneaster majoricensis* L. Sáez & Rosselló (*Rosaceae*), a new species from Majorca (Balearic Islands, Spain). – *Candollea* **67**: 243–253.

- Sánchez P. Carrión M. A., Hernández A. & Guerra J. 2002: Libro rojo de la flora silvestres protegida de la región de Murcia. – Murcia: Consejería de Agricultura. Agua y Medio Ambiente.
- Sennikov A. 2009+: *Cotoneaster*. – In: Kurtto A. (ed.), *Rosaceae*. Euro+Med PlantBase – the information resource for Euro-Mediterranean plant diversity. – Published at <http://ww2.bgbm.org/EuroPlusMed/> [accessed 2 Sep 2013].
- Serra Laliga L. 2007: Estudio crítico de la flora vascular de la provincia de Alicante: aspectos nomenclaturales, biogeográficos y de conservación. – *Ruizia* **19**.
- Takhtajan A. 1986: Floristic regions of the world. – Berkeley: University of California Press.
- Taleb M. S. & Fennane M. 2008: Diversité floristique du Parc National du Haut Atlas Oriental et des Massifs Ayachi et Maâsker (Maroc). – *Acta Bot. Malac.* **33**: 125–145.

## Appendix 1: Specimens used in preparing Fig. 1–3 and Table 1

### *Cotoneaster atlanticus* G. Klotz

MOROCCO: MIDDLE ATLAS: Col du Taghzeft, pentes calcaires, 2200 m, 25 Jun 1924, *E. Jahandiez* 723 (BC 21615).

### *Cotoneaster granatensis* Boiss.

MOROCCO: MIDDLE ATLAS: Ain Leuh, bois des montagnes calcaires, 1550 m, 23 May 1924, *E. Jahandiez* (G 7913/33).

SPAIN: GRANADA: in vallibus Sierra Nevada, 5000–6000 ft., Jul 1837, *E. Boissier* (G lectotype).

### *Cotoneaster nummularius* Fisch. & C. A. Mey.

TURKEY: between Azdavay and Elmassoko, NW of Kastamonu, 16 Jun 1988 (fl.), *A. Boratyński & al.* (KOR 30153); Vakivkoy, c. 20 km SE of Tavşanlı W of Kutahya, 16 Jun 1989 (fr.), *A. Boratyński & al.* (KOR 25089).

### *Cotoneaster racemiflorus* (Desf.) K. Koch

TAJIKISTAN: Zachodni Tian-Szan [Tien Shan], Mielowjy Pass below Mt Chimgar (pod górą Czimgar "Mielowjy pieriewal"), 16 Oct 1957, *K. Browicz* (KOR).

## Appendix 2: Additional specimens examined

### *Cotoneaster atlanticus* G. Klotz

MOROCCO: MIDDLE ATLAS: Immouzer (Marmoucha), 1900 m, in rupibus calcareis, 29 Jun 1927, *R. Maire* (MPU); Olghalou Larbi, 2200 m, coteaux calcaires secs, 25 Jul 1924, *E. Jahandiez* (MPU); Aguelmane, Sidi-Aliou-Mohand, 2100 m, rocailles basaltiques, 30 Jun 1923, *R. Maire* (MPU); Chemin Boudy, éboulis des pentes nord du Jbel Ikhoud, vers 2000 m, 26 May 1938, *L. Furel*

(MPU); Tizi n'Ouirral forêt, 27 Jun 1939, *J. Galtefosse* (MPU); Ari Hebbri, 2000–2100 m, cédraies du cratère, 25 Jun 1923, *R. Maire* (MPU); Bou Iblan, Beni Abdallah, 1800–2200 m, in pinetis et cedretis, 28 Jun 1927, *R. Maire* (MPU); Moyen Atlas Oriental, rochers des pentes nord du Dj. Tankrarant, vers 1800 m, 3 Jul 1938, *R. Maire* (MPU); Col du Taghzeft, 2200 m, pentes calcaires, 25 Jun 1924, *E. Jahandiez* (MPU). — HIGH ATLAS: Ourika, prope Agaiouar, 1600–1800 m, in rupibus calcareis, 12 Apr 1929, *R. Maire* (MPU); Grand Atlas Oriental, flanc sud du Dj. Ayachi, vers 2800 m, pentes rocailleuses, 25 Jul 1938, *Humbert* (MPU); in faucibus Akka-n-Ouyad, 2000 m, solo calcareo, 26 Jun 1939, *M. Weiller* (MPU); infra Bab n Ouyad, in cedretis faucium Akka-n-Ouyad, 2300 m, solo calcareo, 21 Jun 1936, *R. Maire* (MPU); infra Bab n Ouyad, 2300 m, in quercetis, solo calcareo, 21 Jun 1936, *R. Maire* (MPU); M'goum, Gorges d'Amejjag, 1800–1900 m, calc., 16 May 1933, *L. Emberger* (MPU); Dj. Mekter, Ras Chergui, 2000 m, 3 Jul 1913, *R. Maire* (MPU); sur l'Ighil, 2600 m, calc., 18 Oct 1933, *L. Emberger* (MPU); Gorges de Zoura (près Ghar-Rouban), 20 Jul 1899, Herb. Pomel (MPU); gorges calc. d'Imi-n-Ouka, près Tirsal (Ghat), 1800 m, 29 Jun 1931, *L. Emberger* (MPU); Marrakech, N slopes of Oukaïmeden, 31°13'N, 07°15'W, 2100 m, scrub on sandstone rocks, 26 Jul 2002, *A. Boratyński & A. Romo, Romo 10575* (BC); Marrakech, road to Oukaïmeden, 31°12'N, 07°49'W, 2490 m, scrublands on sandstone, 26 Jul 2002, *A. Boratyński & A. Romo, Romo 10623 bis* (BC); Ayachi, massif de l'Ayachi à l'Akka-n-Ijimi, 2200 m, 19 Jun 1953, *Ch. Sauvage* (MPU); Marrakech, route de l'Oukaïmeden, 31°12'N, 07°52'W, 2000–2300 m, dans les rochers, *A. Charpin & al.* (MA 305072); Monts des Ait-Mesrouh, 2000 m, rochers calcaires, Jun 1926, *H. Humbert* (MPU). — ANTI ATLAS: no specimens seen, but recorded from Jbel Kest (Emberger & Maire 1941: 1021, as *C. nummularius* subvar. *fontanesii* (Spach) Maire) and Jbel Ouloussir (Fennane & Ibn Tattou 2005: 341).

ALGERIA: Mechmal des Aich Douan, environs de Jurjura, Durando, Aug 1869 (MPU); Oranais, Djebel Megris, s.d., *J. A. Battandier* (MPU); Oranais, Mazer, Jun 1881, *J. A. Battandier* (MPU); Djurjura, Anon Azoukor, près de Thabbourt-Bou-Iguer, 1700 m, 11 Jul 1914, *R. Maire* (MPU); pente Nord du Jbel Toumour, près Batna, 1900 m, 4 Jul 1853, *B. Balansa* (B, G).

TUNISIA: Jbel Chambi, 1500 m, crestones cacuminales, 15 Jun 2008, *A. Romo* (BC).

### *Cotoneaster granatensis* Boiss.

MOROCCO: RIF: SW, massif calcaire central, Bab er Rouida, 8 Jun 1955, *S. Jovet-Ast & al.* (MPU); Bab Rouida, 1400–1500 m, in faucibus umbrosis, solo calcareo, 16 Jun 1928, *R. Maire* (MPU); Jbel Azrou, 1800–2000 m, in rupestr. calcareis, 26 Jun 1926, *R. Maire* (MPU); Jbel Lakraa, 30 Aug 2005, *A. Boratyński & al., Romo 13331* (BC); Jarmgud (Tasaot), Sep 1955, *Isidro Bueno* (MA 169395); Ybel Quelti, 22 Jul 1955, *A. Serrano* (MA

169394); Bab Ruida, 1500 m, 15 Jul 1932, *Font Quer* (BC 809058); Agarutguires, 1900 m, 3 Jul 1932, *Font Quer* (BC 809057); Buhala, 1700 m, 12 Jul 1932, *Font Quer* (BC 809056); Azru (Akchar), 2000 m, 11 Jun 1929, *Font Quer* (BC 809059); Tizi-Ouzli, Jbel Azrou Akchar, 1400–1500 m, 26 May 1994, *M. J. Díez & al.* (SEV s/n). — MIDDLE ATLAS: prope pag. Azrou, in *Quercetum ilicis vallis Tioumeliline*, 27 Jun 1926, *H. Lindberg* (B); prope pag. Azrou, in *Quercetum ilicis vallis Tioumeliline*, c. 1400 m, 23 Jun 1924, *H. Lindberg* (MPU); Ain Leuk, 1550 m, bois des montaignes calcaires, 23 May 1924, *E. Jahandiez* (MPU); Azrou, 1400 m, in quercetis calc., 25 Jul 1921, *R. Maire* (MPU); M. Azrou, forêts de *Quercus ilex*, 26 Mar 1921, *R. Maire* (MPU); Bekrit, bords de l'Oued Amengous, 1800 m, 1 Jun 1924, *E. Jahandiez* (B); Jbel Hebri, 31 Aug 2005, *Boratyński & al.*, *Romo 13348* (BC).

SPAIN: GRANADA: Sierra Nevada, Cortijo de la Vibora, region montanosa, 8 Aug 1851, *E. Bourgeau* (G

7913/19); Sierra Nevada, Montes Dornajo, cerca del Cortijo de la Vibora, 1000–1600 m, 9 Jul 1879, *Huter & al.* (G 7913/12); Sierra Nevada, region alpine, au Barranc de Banalcaza, 4 Jul 1851 (fl.), 20 Aug 1851 (fr.), *E. Bourgeau* (G 7913/6); Sierra Nevada, subida al Veleta, Venta del Nogal, 1200 m, 21 Jul 1978, *S. Talavera & al.* (SEV 91149); Sierra de la Yedra, 23 Oct 1980, *F. Valle* (SEV 76912); Sierra del Pozo, subida al Pico Cabanas, 1700 m, calizas cársticas, *M. J. Díez & al.* (SEV 91150); Aldeira, gorge of Gallego, 1650–1700 m, banks and sides of gorge, 6 Jun 1998, *B. Valdés & al.* (G 413462, G 7913/23). — ALMERIA: Sierra de Maria, 23 Jul 1845, *M. Willkomm* (G 7913/16); Sierra de Maria, 12 Jun 1960, *E. F. Galiano* (SEV 7647, SEV 1744); Sierra de Maria, 1600 m, bosquecillos de pinos en la solana, 4 Jun 1986, *F. Gómiz* (BC 659938); Dotor, 1500 m, in nemoralibus cum *Pinus pinaster*, 2 Jul 1981, *Segura Zubizarreta* (G 213535).