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Filago longilanata and *F. prolifera* (Gnaphalieae: Asteraceae): two neglected species from the *Filago desertorum* clade rediscovered

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ABSTRACT
Filago longilanata was collected only once until now by Maire and Wilczek in 1934. On its side, *Filago prolifera* is a rare plant endemic to North Africa, and most of the available herbarium materials corresponding to this species were collected in the late 19th or early 20th centuries. In this work, respectively two and three new populations of *Filago longilanata* and *F. prolifera* from Morocco are reported. Additionally, the phylogenetic position of these taxa within the genus *Filago* is elucidated. Last, complete description, a nomenclatural treatment and iconographies are presented for both species.

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Introduction

The genus *Filago* L. (Gnaphalieae: Asteraceae) includes ca. 40 species in its current circumscription (Galbany-Casals et al. 2010; Andrés-Sánchez et al. 2011). It is distributed in the Northern Hemisphere: Eurasia and North Africa and introduced into North America and Australia. Generic circumscription and species delimitation in *Filago* have been problematic due to the scarcity of diagnostic features (Wagenitz 1965), homoplasy (Galbany-Casals et al. 2010; Andrés-Sánchez et al. 2015a, 2015b), and individual variability related to environmental factors (Andrés-Sánchez et al. 2015b). Identification problems in some species together with their small size, and their ephemeral life cycle resulted in overlooked species throughout history. One example of this is the case of two endemic species from NW of Africa: *F. longilanata* (Maire & Wilczek) Greuter and *F. prolifera* Pomel.

Filago longilanata [Figure 1(a) and 1(b)] is a species distributed in the semidesertic regions of Morocco. This species was described by Maire and Wilczek in 1934 as *Evax longilanata* Maire & Wilczek based on a single specimen from Tinfift (Mequinez-Tafilalet, Morocco) preserved at the herbarium MPU (acronym according to Thiers 2017; continuously updated). Maire and Wilczek (Maire 1934) recognised their new species on the basis of the lanate indument of the plant, the absence of pappus and the helicoidal arrangement of the paleae. In relation to other *Filago* species, these authors affirmed that *F. longilanata* has similar ecological requirements to *F. prolifera* but differs in the absence of the pappus, and the non-carenate paleae helicoidally arranged. Afterwards, *Filago longilanata* has been mentioned by a few authors in national or regional checklists and Floras (Emberger and Maire 1941; Fennane and Ibn Tattou 1998; Greuter 2003, 2006+, 2008; El Oualidi et al. 2012; Ibn Tattou 2014; African Plant Database 2017; continuously updated) but in all cases based on the type kept at the MPU herbarium. However, *F. longilanata* remained unmentioned in several of the most comprehensive taxonomic treatments proposed for the genus (eg Chrtek and Holub 1963; Wagenitz 1969; Andrés-Sánchez et al. 2011). Only Anderberg (1991) included *F. longilanata* in his complete revision of the whole tribe Gnaphalieae, and suggested for the first time to transfer the species from *Evax* Gaertn. to *Filago*.

Filago prolifera [Figure 1(c) and 1(d)] was described as new species in 1874 by Pomel with material from Algeria (Oued Mehaïguene and Metlili, Ghardaïa province), based on the shape and disposition of the receptacular paleae, the number of flowers of the capitula and the growth pattern. According to Greuter (2003, 2006+, 2008) it is distributed in Tunisia, Algeria and Morocco. Although several former authors had included this species in many floristic reviews, catalogues and local Floras (eg Battandier and Trabut 1888; Jahandiez and Maire 1934; Fayed and Zareh 1988; Fennane and Ibn Tattou 1998; Greuter 2003, 2006+, 2008; El Oualidi et al. 2012; Ibn Tattou 2014; African Plant Database 2017; continuously updated), all of these are based on a few individuals collected between 1874 and 1933 and lodged at MA, MPU, P and WU (acronyms according to Thiers 2017, continuously updated).

Galbany-Casals et al. (2010) provided the most extensive molecular phylogeny and the latest infrageneric rearrangement of the genus *Filago*, within which four different subgenera were recognised. One of them is *Filago* subg. *Crocidion* Andrés-Sánchez & Galbany, which includes *Filago crocidion* (Pomel) Chrtek & Holub a species distributed in Morocco, Algeria and present also at high

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Figure 1. Pictures of *F. longilanata* and *F. prolifera* Figure 1(a) and 1(b). —*Filago longilanata*, Morocco: Souss-Massa-Draa province, Ouarzazate, Amerzgane, Ighrem N'Ougdal Figure 1(c) and 1(d). — *Filago prolifera*, Morocco: Souss-Massa-Draa province, Afella Ighir: between Ait Mansour and Afella Ighir. Photos (a)–(d): S Andrés-Sanchez, C Urones & E Rico.

altitude in mountains of the C and SE of Spain. The morphological similarities of *F. longilanata* with *F. crocidion* (eg 15–20 receptacular paleae arranged helicoidally, pappus absent), along with the similar geographical distribution of both species support the hypothesis that *F. longilanata* could be a member of *F.* subg. *Crocidion*. On its side, *F. prolifera* shows morphological similarities with *F. pyramidata* L. (eg paleae arranged in rows and habit) that is included in *Filago* L. subg. *Filago*. However, the phylogenetic affinities of these species have never been tested. Additionally the phylogenetic relationships among several species of *Filago* particularly within *F*. subg. *Filago* remain unresolved. Even though recent studies have clarified the taxonomic position of some species (2015a; 2015b), the lack of information on other uncommon taxa hinder a full understanding of the evolutionary history of the genus.

The aim of the present work is to examine the phylogenetic affinities of *F. longilanata* and *F. prolifera* into the genus *Filago*. We also aim to provide complete descriptions of these often neglected species, together with a nomenclatural treatment, high quality illustrations and a chorological update (new localities are reported and added to their historical distribution) for them, as well as an identification key, which includes the closest related species.

Materials and methods

An exhaustive review of ca. 3500 sheets of *Filago* specimens collected in North Africa and lodged in 26 herbaria [ie ABH, ALME, BC, BCN, BM, C, COA, COI, ECWP, FG, G, GDA-GDAC, GOET, JACA, JAEN, K, MA, MAF, MGC, MJG, MPU, P, SALA, SEV, WU, Z; abbreviations according to Thiers (2017, continuously updated)] was conducted in order to identify the diagnostic characters of *F. longilanata* and *F. prolifera* and check the presence of these taxa among the collections in order to establish its distribution area as accurately as possible.

Sampling, DNA extraction, PCR amplification and sequencing

Five samples of *F. longilanata* from two populations and five of *F. prolifera* from three populations collected in Morocco in April 2015 were selected (see Appendix 1). Additionally, two samples of *F. desertorum* and one of *F. pyramidata* collected in localities where *F. longilanata* and *F. prolifera* were growing in sympatry were selected in order to confirm the genetic identity of different species from the same places. Total DNA was extracted from silica-gel leaf material following the CTAB extraction protocol (Doyle and Doyle 1987) with minor modifications. Samples were amplified and sequenced for the ribosomic nuclear regions ITS and ETS with the primers ITS5 and ITS4 (White et al. 1990) and ETS1f (Linder et al. 2000) and 18S-ETS (Markos and Baldwin 2001), as well for the intergenic spacer region *rpl32-trnL* of the cpDNA with the primers rpl32 and trnL$^{(UAG)}$ (Shaw et al. 2007). The PCR programmes used are described in Galbany-Casals et al. (2010).

Phylogenetic reconstruction

All newly generated sequences (see Appendix 1) were edited, assembled and automatically aligned using the MUSCLE algorithm with the software Geneious v.5.5.9 (Biomatters Ltd. 2005–2012). Online available sequences completing taxon sampling (species from the FLAG clade) were taken from Galbany-Casals et al. (2010) and Andrés-Sánchez et al. (2015a). The alignment was manually revised, and ambiguously aligned regions were edited. The gaps were coded with the software SeqState v1.4.1 (Müller 2005) with the simple coding of Simmons and Ochoterena (2000). ILD analysis (Farris et al. 1994) was carried out to test phylogenetic incongruent signal between markers through the script INCTST.run with the software TNT v1.1 (Goloboff et al. 2003). Evaluating the results of this test, two datasets were finally considered: one composed of the ribosomic nuclear markers and other of the plastid DNA region. Maximum parsimony (MP) and Bayesian inference (BI) analyses were performed for both datasets. Parsimony analyses were carried out using the software TNT v.1.1 (Goloboff et al. 2003) applying the traditional search option with equal character weights, 20,000 replicates of random addition sequence (RAS) and tree-bisection-reconnection (TBR) branch-swapping were performed, saving 20 trees per replicate. A majority rule (75%) consensus tree was obtained from the best score trees and Bootstrap supports (BS) were calculated with 2000 RAS replicates using TBR branch-swapping. For the MP analyses, the number of most parsimonious trees (MPTs), consistency index (CI) and retention index (RI) were calculated with PAUP* v4.0b10 (Swofford 2003). Bayesian analyses were carried out with the software MrBayes v3.2.0 (Ronquist et al. 2012). The best nucleotide substitution model was chosen for each marker using the software JModelTest 2 v2.1.4 (Darriba et al. 2012) under the Akaike information criterion (AIC) (Table 1). Metropolis Coupled Markov Chain Monte-Carlo (MCMCMC) were performed in 2 separate runs with four chains per run, computing 2,000,000 generations and sampling each 2000. The first 2000 trees of each analysis were discarded (burn-in) to avoid trees that might have been sampled before the convergence of the Markov chains. A 50% majority rule consensus tree was computed with Mr Bayes using the remaining trees for both data-set. Branches with a support value less than 0.90 Bayesian posterior probabilities (BPP) in the BI analysis and 75% BS in the parsimony analysis were collapsed.

Results

Phylogenetic analyses

Details of the sequences, alignments and results of the phylogenetic analyses are provided in Table 1, where relevant numerical results of MP and BI analyses are also shown. For each marker or combination of markers, phylogenetic relationships obtained from MP and BI are almost identical, and therefore only BI topology is shown with addition of BS values. ETS and ITS regions were significantly congruent according to ILD test ($p = 0.783$) and for this reason the results will be discussed only for the combined analysis (Figure 2). However, the plastid (*rpl32-trnL*) region was analysed separately (Supplemental data) because it shows significant incongruences with nuclear markers ($p = 0.001$) most probably due to low levels of molecular resolution (Galbany-Casals et al. 2010).

The ETS + ITS analysis (Figure 2) recovers the same clades in the phylogenetic tree as in previous work (Figures S3 and S4 of Galbany-Casals et al. 2010). All samples newly sequenced for this work are placed within *F.* subg. *Filago*, but in two different clades. Samples of *F. longilanata, F. prolifera* and *F. desertorum* are recovered into the "*F. desertorum* clade" (Figure 2). Moreover, the new sample of *F. pyramidata* is placed in another clade (Clade I in Galbany-Casals et al. 2010), in a polytomy together with the other *F. pyramidata* samples, plus *F. micropodioides* Lange, *F. duriaei* Coss. ex Lange, *F. congesta*. Guss ex DC., *F. fuscescens* Pomel and *F. inexpectata* Wagenitz, and with *F. ramosissima* as a sister group. The samples belonging to *F. longilanata* and *F. prolifera* show intraspecific variability to some extent, and within the "*F. desertorum* clade" there are four main groups, which describe a polytomy: The first one groups together almost all samples of *F. longilanata*; the second one consists of *F. prolifera* (except *F. prolifera* 5) and the sample *F. longilanata* 5; the third one is composed of *F. desertorum*, *F. mareotica* and *F. prolifera* 5; finally, a single sample corresponding to *F. castroviejoi* is recovered separated from the remaining species.

The plastid marker *rpl32-trnL* shows poor resolution, as in the results found by Galbany-Casals et al. (2010) and Andrés-Sánchez et al. (2015a) (Supplementary data).

Table 1. Summary of the sequence characteristics, results of the MP analyses and nucleotide substitution model chosen for each marker.

DNA region	ITS	ETS	ITS+ETS	rpl32-trnL
Sequence length	634 bp min (*F. pyramidata* 3)	829 bp min [*Castroviejoa montelinasana* (Em. Schmid) Galbany, L. Sáez & Benedí]		573 bp min [*Bombycilaena erecta* (L.) Smoljan.]
Sequence length	639 bp max (*F. ramossisima* Lange)	1007 bp max [*Logfia minima* (Sm.) Dumort.]		773 bp max (*F. aegaea*)
Aligned length	639 bp	1007 bp	1646 bp	773 bp
Parsimony analyses				
Parsimony informative characters			312	62
Number of MPTs			8	100000
Number of steps			949	175
Consistency index (CI)			0.6776	0.7429
Retention index (RI)			0.8395	0.8736
Homoplasy index (HI)			0.3224	0.2571
Bayesian inference				
Nucleotide substitution model	SYM+I+G	TPM3uf+I+G		TVM+G

Revision of herbarium material

After the revision of ca. 3500 specimens of *Filago* lodged in 26 herbaria, in addition to the type material deposited in MPU, two previously neglected herbarium sheets of *F. longilanata* were detected. One of them is lodged in BM and was incorrectly identified as *Bombycilaena discolor* (Pers.) M.Laínz:

MOROCCO: Souss-Massa-Drâa (Agadir); Ourzazate to Ksar-es-Souk, 20 km along track to Bou Skour from Skoura, 30.999975°, –6.499994°, 1350 m., 18-VI-1974, *823 Reading University/B.M. Expedition* (BM).

The other neglected specimen is lodged in MA, and it was labelled as *F.* cf. *desertorum*:

MOROCCO: Agadir-Melloul, Eastern Anti-atlas, 29RPP1335; 30°8.581′N, 7°49.345′O, rocky riverbank, 27-III-2007, *T. Buira & J. Calvo*, n° 46 (MA758158).

Discussion

The "F. desertorum clade" enlarged to include F. longilanata and F. prolifera.

The analysis of our data agrees with the results of previous work. The same clades found by Galbany-Casals et al. (2010) and Andrés-Sánchez et al. (2015a) are present in our phylogenetic tree (Figure 2). Our results place the species *F. longilanata* and *F. prolifera* within the "*F. desertorum* clade" together with *F. castroviejoi*, *F. desertorum*, and *F. mareotica* and confirm the monophyly of the "*F. desertorum* clade" within the *F.* subg. *Filago* (Figure 2; BPP:1, BS:87). The inclusion of these species further increases the heterogeneity of this clade, whose members are mostly represented in xerophytic places (halophytic in the case of *F. mareotica*). In fact, the species clustered in the "*F. desertorum* clade" share only one common feature; achenes covered by short clavate twin hairs. However, this character state is also present in other species of the genus and it could be considered as a plesiomorphic state.

The identification of *F. longilanata* from the other species of the "*F. desertorum* clade" is relatively easy on the basis of morphological characters. *Filago longilanata* has 15–20 receptacular paleae arranged helicoidally and the pappus absent, while the remaining species of this clade have 15–20 or 25–30 receptacular paleae arranged in five vertical rows with the pappus always present. The helicoidal disposition of the receptacular paleae is a synapomorphy of the former genus *Evax*. All the species traditionally included in this genus are currently combined under the name *Filago*. In fact, *F. longilanata* was described under *Evax*, presenting many morphological similarities with *F. crocidion* (eg 15–20 receptacular paleae helicoidally arranged, pappus absent), a species that was also described under *Evax*.

On its side, *F. prolifera* has 4 receptacular paleae per vertical row (20 paleae), while the species traditionally included in the "*Filago desertorum* clade" have these paleae arranged in 5–6 vertical rows. Moreover, *F. prolifera* presents a characteristic growing type: from a unique acaulescent cluster many decumbent branches grow, subtending a solitary apical cluster (two in rare cases), like a pleochasium, whereas the remaining species of this clade show a developed stem branched in the inflorescence like a dychasium, monochasium or pleochasium. Finally, *F. prolifera* has the leaves tapering like a petiole and they are sessile in *F. castroviejoi*, *F. desertorum* and *F. mareotica*.

Filago longilanata and *F. prolifera* share part of their distribution area with the rest of taxa included in the clade. While *F. longilanata* (Morocco) and *F. prolifera* (Morocco, Algeria and Tunisia) are the only two taxa endemic of NW Africa, the remaining species of the "*Filago desertorum* clade" are distributed also in other regions and countries: *Filago castroviejoi* SE of Spain and NW of Morocco; *F. mareotica* SE of Spain, Cyprus, Algeria, Tunisia, Libya and Egypt; and *F. desertorum* the whole N of Africa from Canary Islands to Egypt, SW Asia and SE of Spain. The difficulty to find apomorphic treats and the presence of similar features among species placed in different clades (eg 15–20 paleae arranged helicoidally and pappus absent in *F. longilanata* and *F. crocidion*) are a frequent framework in the study of Gnaphalieae, where incongruences between morphology and molecular phylogenies have been found several times (Bayer et al. 2000; Nie et al. 2013; Andrés-Sánchez et al. 2015a; Freire et al. 2015; Schmidt-Lebuhn et al. 2015). The fact that the species *F. desertorum*, *F. longilanata* and *F. prolifera* are recovered as paraphyletic in our reconstruction is most probably due to the high intraspecific sequence variation found in the genus *Filago*. This effect has usually been explained by the results of two evolutionary processes (Galbany-Casals et al. 2010; Galbany-Cassals et al. 2011; Smissen et al. 2011; Andrés-Sánchez et al. 2015a): reticulation and incomplete lineage sorting of ancestral polymorphism. These explanations were given in former studies through different examples, ie: *F. argentea* (Pomel) Chrtek & Holub and *F. pygmaea* L. (Galbany-Casals et al. 2010), *F. aegaea* Wagenitz (Andrés-Sánchez et al. 2015a), *F. desertorum* (Galbany-Casals et al. 2010; Andrés-Sánchez et al. 2015b) or in other genera belonging to Gnaphalieae as *Helychrysum* Mill. (Galbany-Cassals et al. 2011), the *Raoulia* alliance (Smissen et al. 2004), or *Leucogenes* Beauverd (Smissen and Breitwieser 2008). Recently, Andrés-Sánchez et al. (2015b) found that the assumed intraspecific variation present in *F. desertorum* is due to the occurrence of hidden unrecognized taxa previously identified as *F. desertorum*. This latter hypothesis seems unlikely for *F. longilanata* and *F. prolifera* because they are two taxa with very small populations without recognised morphological variation.

Detailed descriptions and nomenclatural treatment of F. longilanata and F. prolifera

Here, the interpretation of the structure of the capitulum follows that proposed by Holub (1975), Morefield (1992), and Galbany-Casals et al. (2010) for the genus. Following these authors, the involucre is reduced absent in the majority of the species of *Filago*. When present, it is composed of 3–5 scarious reduced filaments, and the receptacular paleae resemble involucral bracts (usually subtending or enclosing a female floret).

Filago longilanata (Maire & Wilczek) Greuter in Wildenowia 33:242, 2003.

≡ *Evax longilanata* Maire & Wilczek in Bull. Soc. Hist. Nat. Afrique N. 25:303, 1934. [basionym].

Holotype: [Morocco] In lapidosis aridis prope Tinifift, ad occident. oasium Tafilalet, solo siliceo, 1100 m. 10-IV-1933, *Maire R.* (MPU 008138! Herbier Maire; https://plants.jstor.org/stable/10.5555/al.ap.specimen.mpu008138?searchUri=filter%3Dname%26so%3Dps_group_by_genus_species%2Basc%26Query%3DEvax%2Blongilanata).

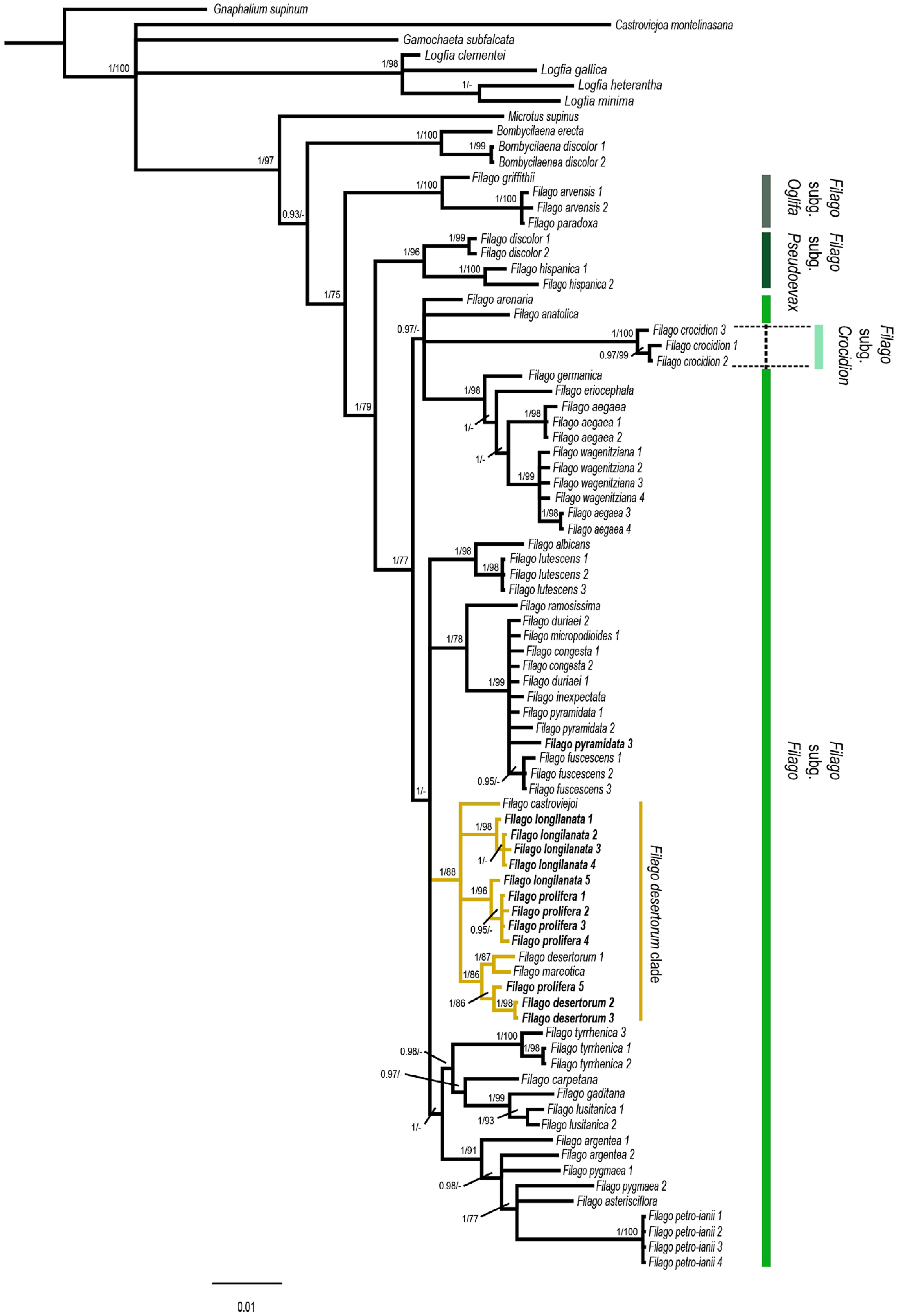

Figure 2. Phylogenetic tree drawn from the analysis of ETS and ITS nuclear markers. Topology corresponds with the 50% majority rule consensus tree resulting from the Bayesian analysis. The samples corresponding to newly generated sequences are indicated in bold. Coloured lines to the right of the tree indicate the subgeneric circumscription proposed by Galbany-Casals et al. (2010). Bayesian Posterior Probabilities (BPP): Numbers on the left above branches; Bootstrap Supports (BS): Numbers on the right above branches. Branches with a BPP value below 95 have been collapsed.

Description: Annual herbs, densely hairy, with eglandular, lanate, greyish to grey–whitish, ± adpressed indumentum. *Stems*: 0.5–6.0 cm, ascending to erect, unbranched, branched from the base or rarely branched in the inflorescence, in this case arranged like to cymes, ie monochasium, dichasium or pleochasium. *Leaves*: of the stem 1–15 × 1–4 mm, alternate, ± adpressed, oblanceolate to spathulate, entire, obtuse to subobtuse with a small scarious brownish mucro, flat to slightly undulated along the margin, sessile; involucrant leaves 12–25 each cluster, 2–6 × 1–3 mm, similar length as the capitulum, oblanceolate to spathulate, entire, obtuse to subobtuse, with a small scarious brownish mucro, margin flat. *Inflorescence*: in subglobose clusters, solitary or rarely arranged like to cymes, ie monochasium, dichasium or pleochasium, condensed; clusters with 3 to 9 capitula, 6–12 mm in diameter. *Capitula*: 4–6 × 3–4.5 mm, disciform, heterogamous, sessile, cylindrical to obovoid, without five strongly marked angles, with densely woolly indument making it difficult to distinguish the different capitula of the clusters. *Involucre*: null. *Receptacle*: narrowly clavate. *Paleae*: 15–20 per capitulum, 4–5 × 1–1.5 mm, arranged helicoidally, not patent in fruit, green with scarious margin, herbaceous in flower and scarious in fruit; external and medium ones, elliptical to subovate, slightly concave, subtending a female floret placed in this axil, aristate with arista yellowish of 1–3 mm, with the abaxial face villose and the adaxial face glabrous; internal lanceolate to subovate, slightly concave, surrounding together the internal hermaphrodite florets, without ariste, subacute, generally slightly lacerate, green with scarious margin, with the abaxial face subglabrous to villous with a densely hairy margin and the adaxial face glabrous. *Florets*: heteromorphic; external female, in the axil of the external and medial paleae, 10–15, eppapose, corolla 3.0–3.5 mm, filiform, whitish–yellowish with inconspicuous teeth, glabrous with multicellular glandular trichomes at the apex; internal hermaphrodite, surrounded by the internal paleae, 4–8 hermaphrodite, fully fertile, corolla 2.5–3.5 mm, tubular, whitish–yellowish, with four purplish teeth, glabrous, generally with short multicellular glandular trichomes at the apex. *Achenes*: homomorphic, 0.8–1.0 × 0.3–0.4 mm, ellipsoid, slightly compressed dorsiventrally, with short clavate twin hairs. *Pappus*: absent.

Iconography: The first iconography of this plant is shown in Figure 3.

Distribution: Present in Morocco (Figure 4). Formerly known population: MOROCCO: In lapidosis aridis prope Tinifift, ad occident. oasium Tafilalet, solo siliceo, 1100 m., 10-IV-1933, *Maire R.* (MPU 008138). Population corresponding to previously misidentified material: MOROCCO: Souss-Massa-Drâa (Agadir), Ourzazate to Ksar-es-Souk, 20 km along track to Bou Skour from Skoura, 30.999975°, −6.499994°, 1350 m., 18-VI-1974, *823 Reading University/B.M. Expedition* (BM); Agadir-Melloul, Eastern Anti-atlas, 29RPP1335, 30°8.581′N 7°49.345′O, rocky riverbank, 27-III-2007, *T. Buira & J. Calvo* n° 46 (MA758158). Newly discovered populations: MOROCCO, Guelmim-Es-Semara province, Tata, Foum Zguid: N12, near Tissint, 29°45′19.5″N 07°20′44.8″W, 605 m., on dry riverbed oued Tissint, semidesertic area with *Tamarix aphylla*, 27-III-2017, *Gutiérrez-Larruscain et al.*, DG595 (SALA 160406); Souss-Massa-Draa province, Ouarzazate, Amerzgane, Ighrem N'Ougdal: N9 between Tazadoute and Targa, 31°08′45.0″N 07°25′22.1″W, 1625 m., dry slopes with *Pinus halepensis,* 28-III-2015, *Gutiérrez-Larruscain et al.,* DG685 (SALA 157369).

Filago prolifera Pomel in Bull. Soc. Sci. Phys. Algérie 11:47, 1874.

≡ *Filago germanica* L. subsp. *prolifera* (Pomel) Maire in Jahandiez & Maire, Cat. Pl. Maroc: 746, 1934.

≡ *Filago spathulata* C.Presl subsp. *prolifera* (Pomel) Maire, nom. nud., in sched. [MPU 004836!]

≡ *Filago spathulata* C.Presl var *prolifera* (Pomel) Ozenda in Ozenda, Fl. Sahara: 424, 1958, com. inval. (art. 41.5).

Lectotype (designated by Wagenitz in Wildenowia 5: 406. 1969): [Algeria] Mzab, Metlili, sables, *Pomel, A.N.* (MPU 004837! Herbier Maire; https://plants.jstor.org/stable/10.5555/al.ap.specimen.mpu004837?searchUri=filter%3Dname%26so%3Dps_group_by_genus_species%2Basc%26Query%3Dfilago%2Bprolifera).

Description: Annual herbs, densely hairy, with eglandular, woolly-villous, whitish to grey–whitish, ± adpressed indumentum. *Stem*: stemless or with a very short stem up to 3 (11) mm subtending a solitary cluster at the tip, with secondary stems growing from the base, 1.5–13.0 cm, normally subtending a solitary cluster at the tip or rarely two. *Leaves*: of the stem 5–17 × 1–3 mm, alternate, ± adpressed, oblanceolate to spathulate, entire, obtuse to subobtuse with a small scarious brownish mucro, flat along the margin, gradually tapering in the base like a petiole; involucrant leaves 8–18 per cluster, 4–10 × 1–5 mm, longer than the capitulum, obovate to oblanceolate, entire, obtuse to subobtuse, with a small scarious brownish mucro, margin flat. *Inflorescence*: in solitary subglobose clusters, the first one at the base of the plant and secondary ones at the end of the branches; clusters with 2–6 capitula, 5–10 mm in diameter. *Capitula*: 4–6 × 2–4 mm, disciform, heterogamous, sessile, cylindrical to obovoid, without five strongly marked angles, with woolly villous indument. *Involucre*: null. *Receptacle*: clavate. *Paleae*: 20 per capitula, 2.5–5 × 0.5–1 mm, arranged in five vertical rows, not patent in fruit, green with scarious margin, herbaceous in flower and scarious in fruit; external and medium ones, lanceolate to subovate, clearly concave, subtending a female floret placed in this axil, aristate with a hyaline arista of 1–1.5 mm, with the abaxial face woolly and the adaxial face glabrous; internal lanceolate to ovate, concave, surrounding together the internal hermaphrodite florets, without ariste, obtuse, entire or slightly lacerate, green with scarious margin, with the abaxial face glabrous to subglabrous including the margin, and the adaxial face glabrous. *Florets*: heteromorphic; external female, in the axil of the external and medial paleae, 15, eppapose, corolla 3.0–3.5 mm, filiform, whitish–yellowish, with inconspicuous teeths, glabrous with multicellular glandular trichomes at the apex; internal 4–12 female, similar to the external, and 4–8 hermaphrodite, fully fertile, corolla 2.5–3.5 mm, tubular, whitish–yellowish, with four brownish teeth, glabrous, generally with short multicellular glandular trichomes at the apex. *Achenes*: homomorphic, 0.8–1.0 × 0.3–0.4 mm, ellipsoid, slightly compressed dorsiventrally, with short clavate twin hairs. *Pappus*: present only in the internal florets, with 18–24 white, scabrid, free, bristles.

Iconography: A new iconography of this plant is shown in Figure 5. Previous iconography (partial): Ozenda, Fl. Sahara: 424 fig. 156. 1958 (sub *F. spathulata* var. *prolifera*)

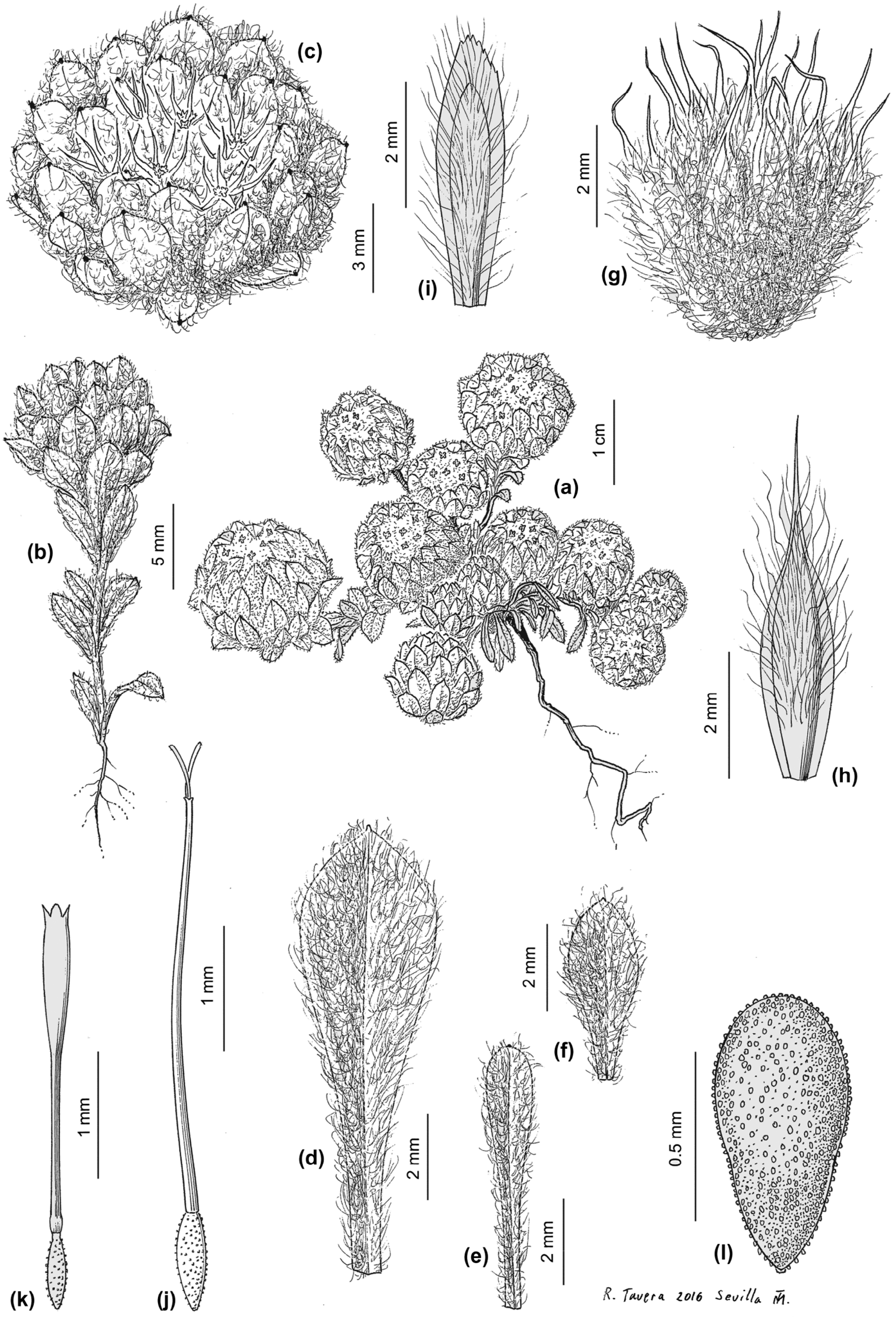

Figure 3. *Filago longilanata*, Morocco: Souss-Massa-Draa province, Ouarzazate, Amerzgane, Ighrem N'Ougdal (SALA 157369): (a)–(b) habit; (c) cluster of capitula; (d)-(e) caulinar leaves; (f) involucrant leaf; (g) capitulum; (h) external palea; (i) internal palea; (j) external floret, filiform, female; (k) internal floret, tubular hermaphrodite; (l) achene.

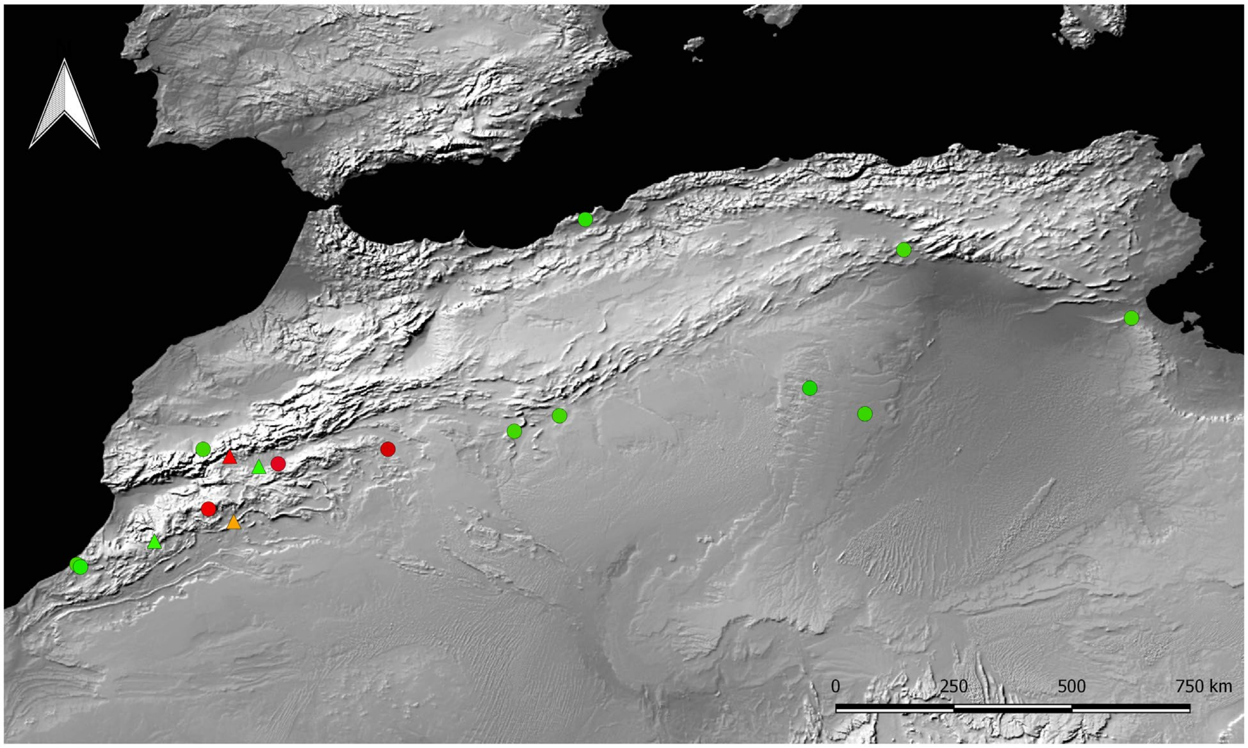

Figure 4. Distribution map of *F. prolifera* and *F. longilanata* in Morocco, Algeria, and Tunisia. Circles:presence points taken from herbarium material; triangles: new presence points provided in this work. The colour of the circles or triangles indicates: green, *F. prolifera*; red, *F. longilanata*; and orange, both species growing in sympatry.

Distribution: Present in Morocco, Algeria and Tunisia (Figure 3). Newly discovered populations: MOROCCO: Souss-Massa-Draa province, Ouarzazate, Tarmigte: N10 near Ouarzazate to Afra, 30°57′12.2″N 06°52′06.4″W, 1141 m., on dry riverbed, 28-III-2017, *Gutiérrez-Larruscain et al.*, DG674 (SALA 157357); Souss-Massa-Draa province, Afella Ighir: between Ait Mansour and Afella Ighir, 29°31′57.1″N 08°51′16.5″W, 1195 m., on rocky slopes, 25-III-2015, *Andrés-Sánchez et al.,* SA964 (SALA 157497); Guelmim-Es-Semara province, Tata, Foum Zguid: N12, near Tissint, 29°45′19.5″N 07°20′44.8″W, 605 m., on dry riverbed oued Tissint, semidesertic area with *Tamarix aphylla*, 27-III-2017, *Gutiérrez-Larruscain et al.*, DG595 (SALA 160408).

Identification key for the species of "F. desertorum clade"

1. Capitula solitary; paleae 15–25 per capitulum; internal paleae glabrous ....*F. mareotica*.

–. Capitula arranged in subglobose clusters; paleae 20–30 per capitulum; internal paleae glabrous to villous or with hairs near the margin.. 2.

2. Paleae arranged helicoidally; pappus absent .... *F. longilanata*.

–. Paleae arranged in 5 vertical rows; pappus present in the internal florets.. 3.

3. Receptacular paleae 20, the internal ones glabrous; plant usually stemless or rarely with a very short stem up to 0.3 (1.1) cm; clusters in solitary subglobose clusters, the first one at the base of the plant and secondary ones at the end of the branches; leaves tapering at the base like a petiole ....*F. prolifera*.

–. Receptacular paleae 25–30, the internal ones with hairs near the margin; plants with well-developed stem of 7–16.5 cm; clusters arranged like a cyme, ie monochasium, dichasium or pleochasium; leaves not tapering at the base like a petiole ....4.

4. Clusters, capitula and external paleae glabrous or subglabrous; capitula pyramidal with five strongly marked angles ....*F. castroviejoi*.

–. Clusters, capitula and external paleae villose-tomentose; capitula ovate with five slightly marked angles .... *F. desertorum***.**

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Disclosure statement

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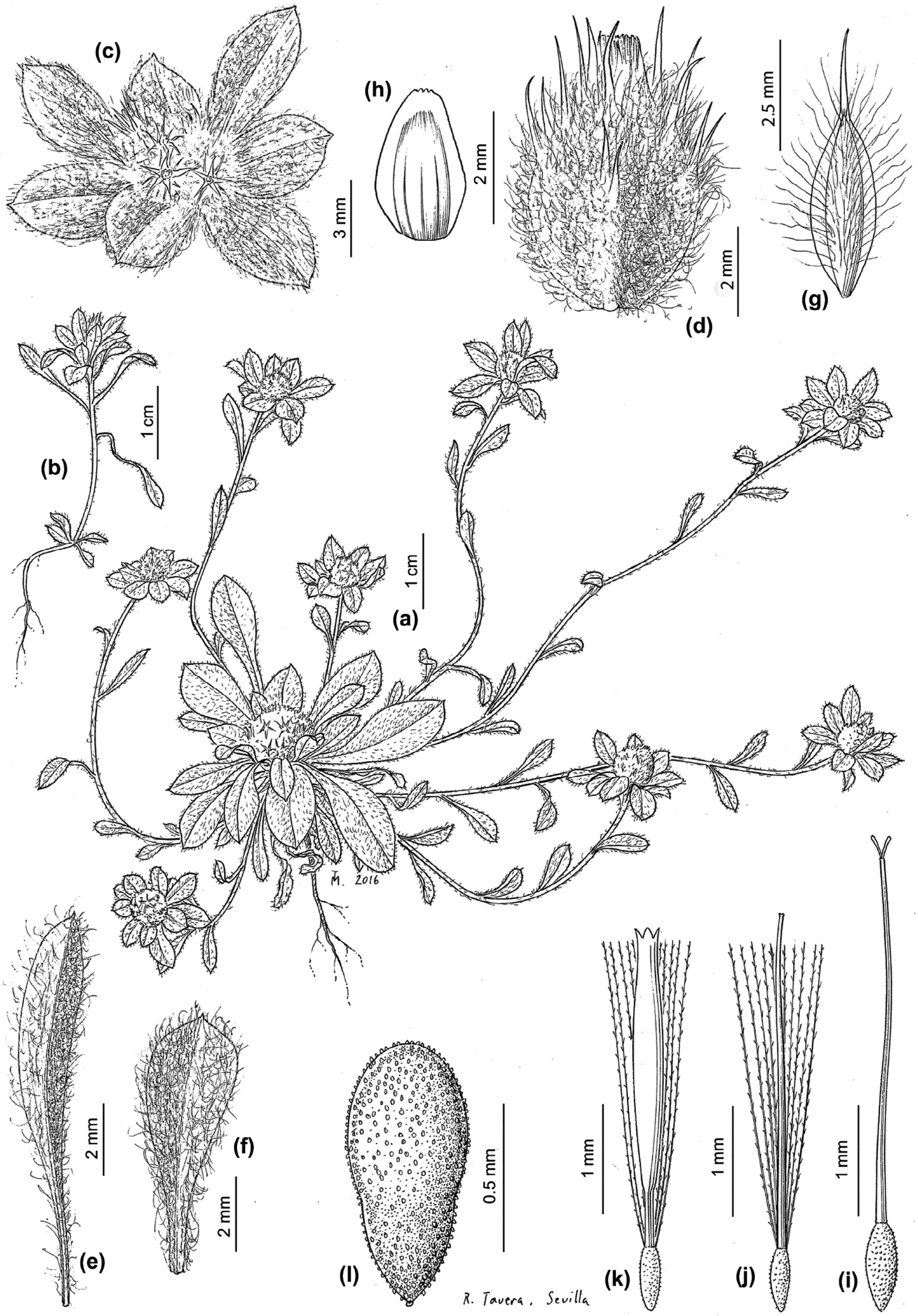

Figure 5. *Filago prolifera*, Morocco: Souss-Massa-Draa province, Afella Ighir: between Ait Mansour and Afella Ighir (SALA 157497): (a)–(b) habit; (c) cluster of capitula; (d) capitulum; (e) caulinar leaf; (f) involucrant leaf; (g) external palea; (h) internal palea; (i) external floret, filiform, female; (j) internal floret, filiform, female; (k) internal floret, tubular hermaphrodite; (l) achene.

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Appendix 1

Samples (only unpublished ones) included in the molecular analyses with voucher information and GenBank accession numbers (ITS, ETS, *rpl32-trnL*). See Galbany-Casals et al. (2010) and in Andrés-Sánchez et al. (2015a) for information on the remaining samples included in the analyses presented here.

Filago desertorum Pomel: (2) Morocco, Guelmim-Es-Semara, Tata, Foum Zguid: N12, near Tissint, Gutiérrez-Larruscain et al., DG595-6, SALA 157278 (KY824529; KY824542; KY824555); (3) Morocco, Souss-Massa-Draa, Ouarzazate, Tamigte: N10 near Ourzazate, Gutiérrez-Larruscain et al., DG674bis, SALA 157358 (KY824520; KY824533; KY824546). *Filago longilanata* (Maire & Wilczek) Greuter: (1) Morocco, Guelmim-Es-Semara, Tata, Foum Zguid: N12, near Tissint, Gutiérrez-Larruscain et al., DG595-3, SALA 160406 (KY824526; KY824539; KY824552); (2) Gutiérrez-Larruscain et al., DG595-7, SALA 160406 (KY824527; KY824540; KY824553); (3) Morocco, Souss-Massa-Draa, Ouarzazate, Amerzgane, Ighrem N'Ougdal: N9 between Tazadoute and Targa, Gutiérrez-Larruscain et al., DG685-1, SALA 157369 (KY824522; KY824535; KY824548); (4) Gutiérrez-Larruscain et al., DG685-2, SALA 157369 (KY824523; KY824536; KY824549); (5) Gutiérrez-Larruscain et al., DG595-2, SALA 160406 (KY824521; KY824534; KY824547). *Filago prolifera* Pomel: (1) Gutiérrez-Larruscain et al., DG595-1, SALA 160408 (KY824519; KY824532; KY824545); (2) Gutiérrez-Larruscain et al., DG595-10, SALA 160408 (KY824528; KY824541; KY824554); (3) Gutiérrez-Larruscain et al., DG595-5, SALA 160408 (KY824530; KY824543; KY824556); (4) Morocco, Souss-Massa-Draa, Ouarzazate, Tarmigte: N10 near Ouarzazate to Afra, Gutiérrez-Larruscain et al., DG674-1, SALA 157357 (KY824525; KY824538; KY824551); (5) Morocco, Souss-Massa-Draa, Afella Ighir: between Ait Mansour and Afella Ighir, Andrés-Sánchez et al., SA964-1, SALA 157497 (KY824524; KY824537; KY824550). *Filago pyramidata* L.: (3) Morocco, Guelmin-Es-Semara, Tata: N12 from Tata to Tissint, Gutiérrez-Larruscain et al., DG566-2, SALA 157249 (KY824518; KY824531; KY824544).