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Alyssum amasianum (Brassicaceae), a new species from North Anatolia, Turkey

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Abstract: Herein a new species, *Alyssum amasianum*, is described and illustrated from North Anatolia. The new species is very similar to *A. hirsutum* subsp. *caespitosum* but differs in the shape and indumentum of leaves, trichome type of the fruits, and margin of the seeds. The ecology, biogeography, and conservation status of the new species are discussed. The leaf, fruit, and seed surface micromorphology of *A. amasianum*, *A. hirsutum* subsp. *caespitosum*, *A. hirsutum* subsp. *hirsutum*, *A. strigosum* subsp. *strigosum*, and *A. xanthocarpum* were also examined by scanning electron microscope.

Key words: *Alyssum*, Alysseae, Cruciferae, SEM, Turkey

1. Introduction

The family Brassicaceae is distributed worldwide across all continents except for Antarctica (Koch and Kiefer, 2006). It consists of 49 tribes, about 321 genera, and 3660 species (Al-Shehbaz, 2012). The Brassicaceae, or mustard family, is easily distinguished from other flowering plant families with floral and fruit morphology by the cruciform corolla, tetradynamous stamens, and a siliqua often with a septum (Koch et al., 2012).

The tribe Alysseae is composed of 24 genera and about 277 species, 114 of which are placed in *Alyssum* (Warwick et al., 2006; Al-Shehbaz, 2012; Španiel et al., 2015). The genus *Alyssum* is distributed primarily in Europe, Southwest Asia, and northern Africa (Al-Shehbaz, 1987; Al-Shehbaz et al., 2006). However, a few species are dispersed in Central Asia, Siberia, and North America (Dudley, 1964a, 1964b). In a recent taxonomic and phylogenetic study of the genus (Španiel et al., 2015), two sections of *Alyssum* were raised to genus level, i.e. *Alyssum* sect. *Odontarrhena* and *A.* sect. *Meniocus*. In addition, *A. homalocarpum* and *A. antiatlanticum* were described in the new genus *Cuprella* Salmerón-Sánchez, Mota & Fuertes. Based on the latest taxonomic situation (Španiel et al., 2015) and having this new species addition, the number of *Alyssum* species has reached 54 in Turkey, 25 of which are endemic. This further stresses that Turkey is the main center of diversity for the genus (Dudley, 1965; Davis et al., 1988; Yıldırımlı, 2000; Mutlu, 2012; Özhatay et al., 2013). After separation of the genus *Alyssum*, there are 38 species in *Odontarrhena* and 7 species in *Meniocus* in Turkey.

In the latest taxonomic position, *Alyssum* s.str. includes two clades; one of them is taxa of *A.* sect. *Alyssum* that are mostly annual and perennial and the other one is *A.* sect. *Gamosepalum*, a few perennials of *A.* sect. *Alyssum*, and annual *A. dasycarpum* (Resetnik et al., 2013; Španiel et al., 2015).

The members of the section *Alyssum* are characterized by monomorphic sepals free; unilaterally or bilaterally winged, dentate, or appendaged filaments; dehiscent monomorphic or dimorphic indumentum or, rarely glabrous and valves equally or unequally inflated fruits; and biovulate loculi (Dudley, 1964a, 1964b). The section *Alyssum* contains 43 taxa in Turkey, 19 of which are endemic (Dudley, 1965; Orcan and Mısırdalı, 2000; Orcan and Binzet, 2006, 2009).

Interesting specimens of *Alyssum* belongs to the sect. *Alyssum* were collected during field trips in Borabay village (Amasya, North Anatolia) in 2013 and 2014. They were found distinct from all known species and most similar to *A. hirsutum* subsp. *caespitosum*. The present study aimed to describe a new *Alyssum* species from Turkey based on morphology and micromorphology of leaf, fruit, and seed features.

2. Materials and methods

The specimens were cross-checked with the keys from *Flora Iranica* (Hedge, 1968), *Flora of Iraq* (Townsend,

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1980), *Flore du Liban and De La Syrie* (Bouloumoy, 1930), *Flora of USSR* (Bush, 1970), *Flora of Cyprus* (Meikle, 1977), and *Flora Europaea* (Ball and Dudley, 1964) and additional literature sources were investigated (Dudley, 1965; Davis et al., 1988; Orcan and Mısırdalı, 2000; Yıldırımlı, 2000; Orcan and Binzet, 2006, 2009; Mutlu, 2012; Özhatay et al., 2013). The specimens were cross-checked with the material housed at various herbaria (E, B, W, K, GAZI, EGE, HUB, KNYA, and ANK).

For the scanning electron microscope (SEM) investigations, leaves, fruit, seed, and pollen were directly mounted on prepared stubs and coated with gold. Photographs were taken using a JEOL-JSM-6490 LV SEM after being coated with a Hummle VII Sputter Coater. The averages and standard deviations of the measurements were calculated. The terminology given by Stearn (1996), Prentince (1979), Barthlott (1981), and El Naggar (2005) was used for the description of the SEM aspects. The terminology used for pollen description has been followed as suggested by Erdtman (1952).

Alyssum amasianum Karabacak & A.Duran ***sp. nov.*** (Figures 1–2).

Type: Turkey. A5 Amasya: Taşova, Borabay village to Başyurt Yayla, 9 km, 1382 m, serpentine slopes, roadsides, 16.08.2013, 40°48′011″N 36°07′005″E, *A.Duran* 9733 & *O.Karabacak* (holotype: KNYA; isotypes: GAZI, ANK).

Diagnosis: *Alyssum amasianum* is similar to *A. hirsutum* subsp. *caespitosum*. It mainly differs from *A. hirsutum* subsp. *caespitosum* because it has petals 5 × 1.5–2 mm, retuse or slightly emarginate (not 4.5 × 1 mm, deeply emarginate); long filament appendage connate for about half of their length (not dilated at the base); short filament appendage apex acute (not tridentate); fruiting pedicel 3–4 mm (not 5–6 mm); fruit 8–9 mm and stellate trichomes with mostly 8–10 subequal adpressed rays and bigger tuberculate trichomes with 3–6 unequal rays (not 5–6 mm, sparsely covered with smaller stellate trichomes with 8–10 subequal adpressed rays and much longer spreading simple tuberculate trichomes); style 3–4 mm (not 2–2.5 mm); seed dark brown, 3–3.5 × 2–2.5 mm (not pale brown, 2 × 1.5 mm).

Description: Annual or rarely biennial herb, up to 7 cm long, mostly branched below. Stem erect and leaves densely covered with unequally branched stellate trichomes. Leaves oblanceolate, entire; lower surface of leaves densely stellate, 8–12 subequal rays with tuberculate; lower cauline leaves 15–20 × 6–10 mm; upper cauline leaves 6–15 × 2–8 mm. Inflorescence raceme, 5–10-flowered, condensed at anthesis, fruiting raceme slightly elongated. Sepals narrowly ovate, deciduous, 4 × 1.5–2 mm, with a thin scarious margin, outer surface sparsely stellate and branched tuberculate trichomes. Petals yellow, 5 × 1.5–2 mm, retuse or shortly emarginate, outer surface stellate trichome; limbs narrow, about twice as broad as claw. Long filaments 4 mm, appendages connate for about half of their length, acute; short filaments 3.5 mm, appendage 1 mm joined at the base then c. 1.5 mm free, acute. Anthers 1–1.25 mm, yellow. Style 3–4 mm long and dilated at the base, stellate trichome, stigma truncate. Fruiting pedicels 3–4 mm, erect to patent, densely stellate pubescent. Fruits 8–9 × 6–8 mm, suborbicular in outline, indumentum consisting of stellate trichomes with mostly 8–10 subequal subpatent rays and bigger tuberculate trichomes with 3–6 unequal rays, c. 2 mm long, loculi 2 ovulate. Seeds dark brown, elliptic, 3 × 2 mm, wing c. 0.2–0.3 mm wide, slightly undulate. Fl. & Fr. August and September.

Figure 1. *Alyssum amasianum* (photo by A Duran).

Distribution and ecology: *Alyssum amasianum* is an endemic species that is confined to the Başyurt plateau in Borabay village (Amasya Province). It is a Euro-Siberian element. *Alyssum amasianum* grows in open forest of *Pinus nigra* Arn. together with *Rubus canescens* DC. var. *canescens*, *Scutellaria salviifolia* Bentham, *Sedum pallidum* M.Bieb. var. *pallidum*, *Hypericum perforatum* L., *Astragalus plumosus* Willd. var. *nitens* (Freyn & Bornm.) Chamb. & Matthews, *Anthemis kotschyana* Boiss. var. *kotschyana*, *Salvia tomentosa* Miller, *Dryopteris filix-mas* (L.) Schott, *Linaria* sp., and *Campanula* sp.

International Union for Conservation of Nature (IUCN) red list category: *Alyssum amasianum* is known from the type locality and this area is smaller than 2.5 km^2 (Criteria B1). Animals are overgrazing in this area. Because of this, the species is under threat. Groundwater and surface streams are seasonally overflowing because of heavy rainfall. Hence, their destruction is leading to the reduction in the number of plants (Criteria A). The mature individual members of the population constitute 250 specimens of flowers (Criteria C2). Therefore, it should be considered critically endangered (CR) according to the IUCN Red List Criteria (IUCN, 2010).

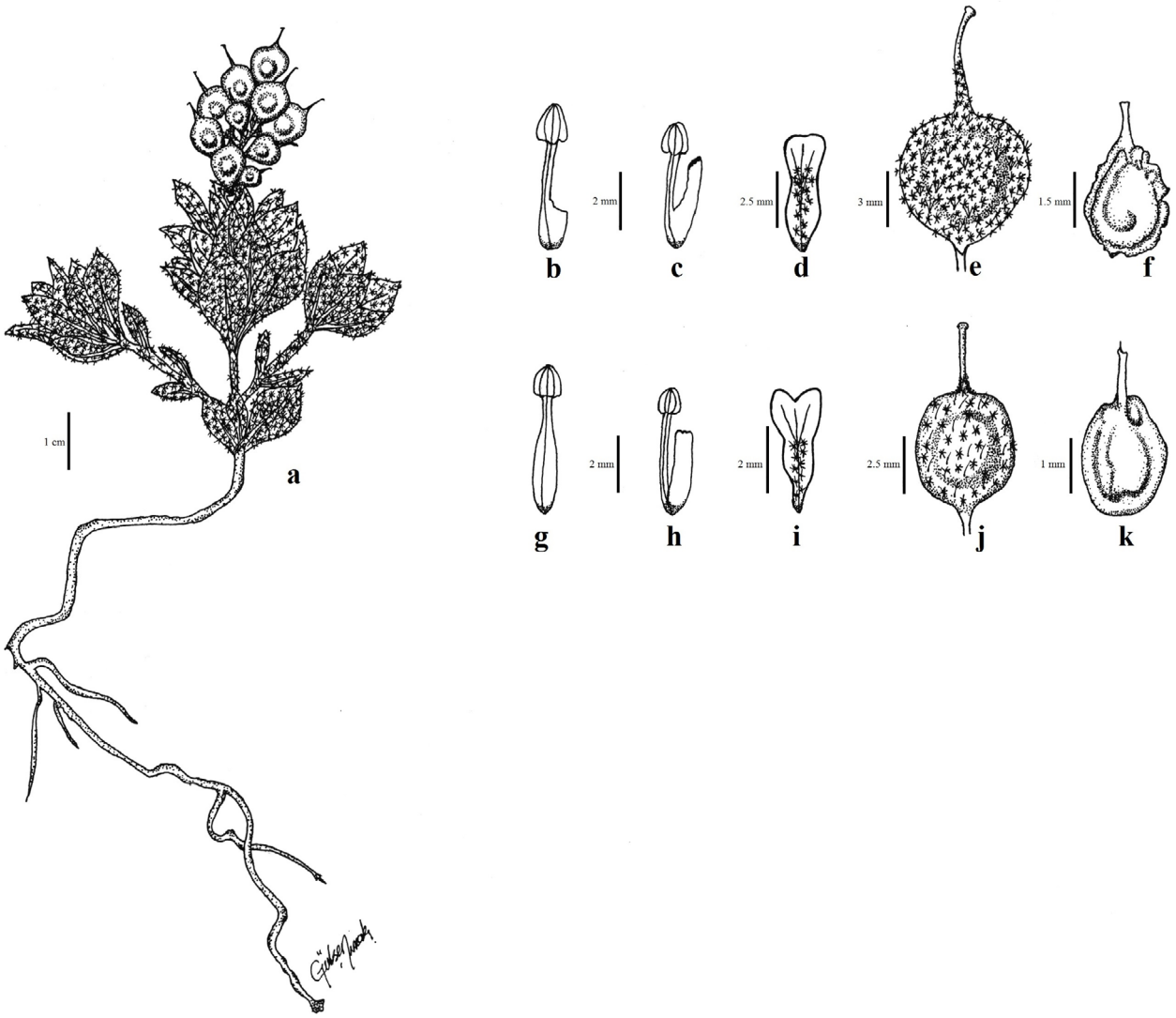

Figure 2. *Alyssum amasianum* (from the holotype). a- habit, b- long filament, c- short filament, d- petal, e- fruit, f- seed. *Alyssum hirsutum* subsp. *caespitosum*: g- long filament, h- short filament, i- petal, j- fruit, k- seed.

3. Discussion

Alyssum amasianum is very similar to *A. hirsutum* subsp. *caespitosum*. However, there are some significant morphological and ecological differences between them (Table).

In the tribe Alysseae, trichome morphology has been usually used as a diagnostic character (Dudley, 1964b; Al-Shehbaz, 1987; Ančev, 1991; Ančev and Goranova, 2006). Alysseae is characterized by having most often adpressed or subpatent stellate indumentum (trichomes with 3 or more rays originating from one point), sometimes an admixture of simple trichomes can be observed, and rarely trichomes are malpighiaceous (Warwick et al., 2008).

On fruit surface, *Alyssum amasianum* has tuberculate and stellate dimorphic trichomes. Tuberculate trichomes stalked with 3–6 unequal rays with tuberculate surface and smooth base. Stellate trichomes with subequal 8–10 rays, mostly straight and tapering on the tip. On the other hand, both *A. hirsutum* subsp. *caespitosum* and *A. hirsutum* subsp. *hirsutum* have simple, unequally bifurcate tuberculate (rare), and stellate trichomes that have 8–10 subequal rays. Both *Alyssum strigosum* subp. *strigosum* and *A. xanthocarpum* have 2 equally bifurcate tuberculate trichomes. However, the first one has stellate trichomes with 6 subequal rays; the latter one has 8–10 subequal rays (Figure 3).

In leaf indumentum, *A. amasianum* has stellate trichomes with 8–12 subequal rays, but *A. hirsutum* subsp. *hirsutum* has stellate trichomes with 6–8 subequal rays. *Alyssum hirsutum* subsp. *caespitosum*, *A. strigosum* subsp. *strigosum*, and *A. xanthocarpum* have stellate trichomes with 6 subequal rays and tuberculate trichomes with 2 (–4) arms and smooth surface (Figure 4).

Table. Diagnostic characters of *Alyssum amasianum* and *A. hirsutum* subsp. *caespitosum*.

Characters	*Alyssum amasianum*	*Alyssum hirsutum* subsp. *caespitosum*
Stems	to 7 cm tall, branched	3–4 cm tall, unbranched
Leaves	oblanceolate, densely stellate trichome, lower 15–20 × 6–10 mm and upper 6–15 × 2–8 mm	lower obovate and upper oblanceolate, sparsely stellate and 2 (–4) arms tuberculate trichome, 8–10 × 2–3 mm
Sepals	4 × 1.5–2 mm, deciduous, outer surface sparsely stellate and branched tuberculate trichomes	3 × 1 mm, deciduous, outer surface sparsely stellate trichomes
Petals	5 × 1.5–2 mm, retuse or shortly emarginated	4.5 × 1 mm, deeply emarginated
Long filaments	4 mm and appendages connate for about half of their length	3.5 mm dilated at the base
Short filaments	3.5 mm and appendage free, acute	c. 3 mm and appendage free, tridentate
Anthers	1–1.25 mm	0.5–0.6 mm
Fruit pedicels	3–4 mm	5 mm
Fruits	8–9 mm, stellate and 3–6 unequal rays with tuberculate trichomes	5–6 mm, sparsely stellate and simple or rarely unequally bifurcate tuberculate trichomes
Styles	3–4 mm	2–2.5 mm
Seeds	dark brown, 3–3.5 × 2–2.5 mm, margin irregular	pale brown, 2 × 1.5 mm, margin smooth

Alyssum amasianum, *A. hirsutum* subsp. *caespitosum*, and *A. hirsutum* subsp. *hirsutum* have tricolpate apertures with reticulate tecta and perprolate pollen grains (Figure 5). Based on the exine sculpturing pattern, size, and shape of the pollen grains, there are no significant differences among the taxa.

Alyssum amasianum has dark brown seeds with irregular margins. On the other hand, *A. hirsutum* subsp. *caespitosum*, *A. hirsutum* subsp. *hirsutum*, *A. strigosum* subsp. *strigosum*, and *A. xanthocarpum* have pale brown seeds with smooth margins. Based on the epidermal cell patterns of testae obtained from SEM, three different surface sculpturing patterns are seen: reticulate, reticulate–papillate, and papillate. While *A. amasianum*, *A. hirsutum* subsp. *hirsutum*, and *A. xanthocarpum* have reticulate sculpturing patterns, *A. hirsutum* subsp. *caespitosum* has a reticulate–papillate and *A. strigosum* subsp. *strigosum* has only a papillate sculpturing pattern. While *Alyssum amasianum* and *A. xanthocarpum* have similar anticlinal cell boundaries (i.e. flat and raised), their periclinal cell walls differ from one another. For example, *A. amasianum* has flat, but *A. xanthocarpum* has convex periclinal cell walls. Both *A. hirsutum* subsp. *caespitosum* and *A. hirsutum* subsp. *hirsutum* have raised anticlinal cell boundaries; however, they differ from one another by their periclinal cell wall development as *A. hirsutum* subsp. *caespitosum* has a papillate pattern and *A. hirsutum* subsp. *hirsutum* has concave periclinal cell walls with some intercellular area. In addition, *A. strigosum* subsp. *strigosum* has channeled anticlinal cell boundaries and raised-papilate periclinal cell walls (Figure 6).

Alyssum amasianum is located in a transitional zone between the Euro-Siberian and Irano-Turanian phytogeographical regions. However, *A. hirsutum* subsp. *caespitosum* and *A. hirsutum* subsp. *hirsutum* are distributed in the Irano-Turanian phytogeographical region. In addition, there is a phenologic difference between *A. amasianum*, *A. hirsutum* subsp. *caespitosum*, and *A. hirsutum* subsp. *hirsutum*. While *Alyssum amasianum* flowers in August, the latter two taxa flower from May to June.

3.1. Additional specimens examined (paratypes): Turkey: A5 Amasya: Taşova, Borabay village to Başyurt Yayla, 9 km, 1363 m, 26.08.2014, 256966 N, 4520721 E (UTM), *O.Karabacak* & *M.Çelik* 9294 (GAZI, KNYA).

3.2. Additional specimens examined (similar taxa):

A. hirsutum subsp. ***caespitosum*:** Turkey: C2 Muğla: Köyceğiz, Sultaniye, Günlük bucağı çevresi, 15 m, aluviyal düzlük, 15.04.1991, *A. Güner* 8610 & *M. Vural, H.Duman, A.Dönmez, B.Mutlu* (HUB); C2 Muğla: Köyceğiz Sultaniye arası, Günlük bucağı çevresi, 10 m, metamorfik çakıllı arazi, aluviyal düzlük, 17.03.1991, *A.Güner* 8209 & *H.Duman, H.Şağban* (GAZI); C2 Muğla: Köyceğiz, Sultaniye, Kersele köyü, 20 m, serpentin taşlık arazi, 14.04.1992, *A.Güner* 10426 *&* *H.Duman, A.Dönmez, H.Şağban* (HUB); C2 Muğla: Köyceğiz, Ekincik köyü, İskele-Kurşuncuk feneri-Karaçay arası, 0–30 m, kayalık yamaçlar, kızıl çam ormanı, 05.04.1991, *A.Güner* 8293 *&* *H.Duman, H.Şağban* (HUB);

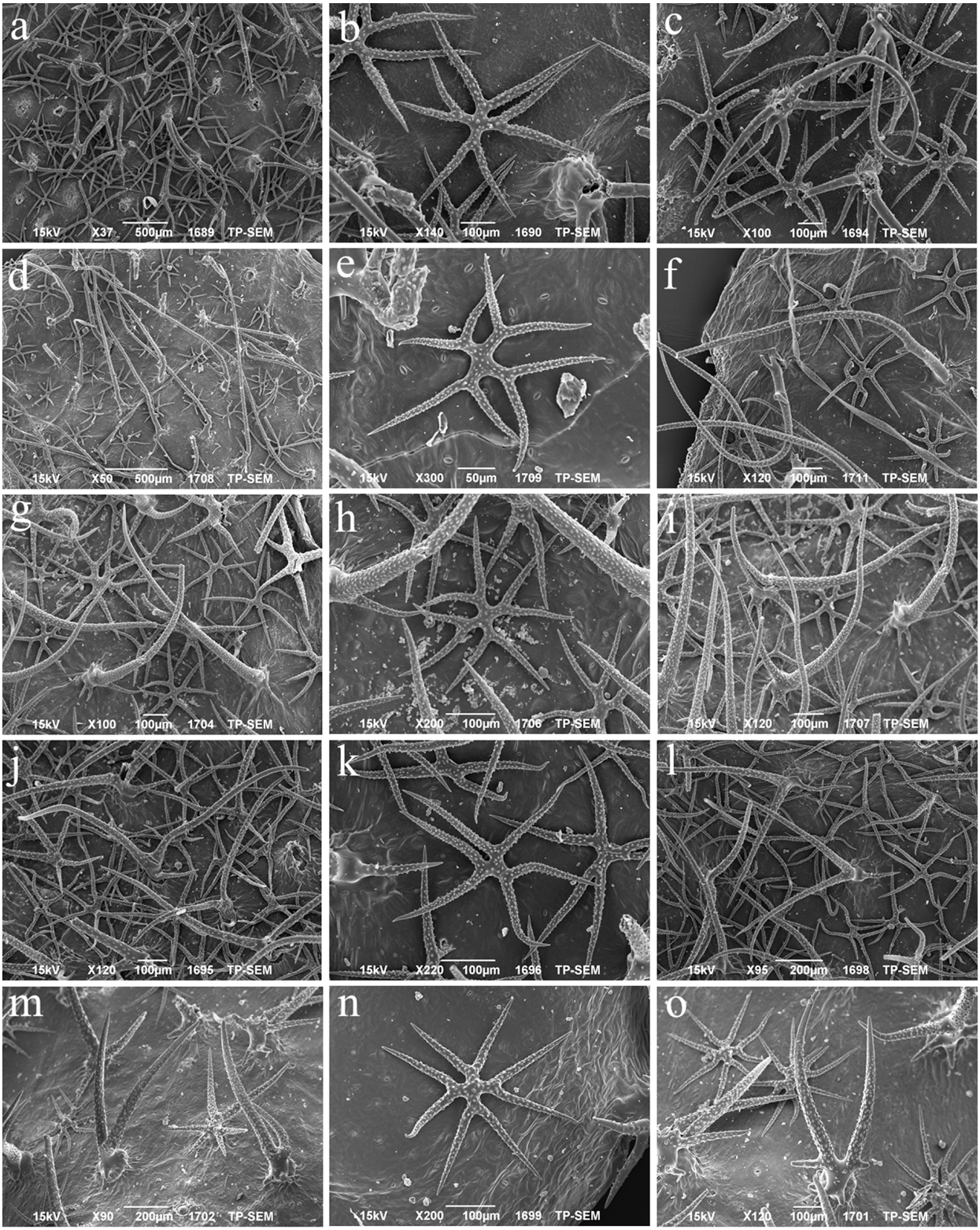

Figure 3. Scanning electron micrographs of the fruits. *Alyssum amasianum*: a- indumentum of fruit, b- stellate trichomes, c- tuberculate trichomes; *A. hirsutum* subsp. *caespitosum*: d- indumentum of fruit, e- stellate trichomes, f- tuberculate trichomes; *A. hirsutum* subsp. *hirsutum*: g- indumentum of fruit, h- stellate trichomes, i- tuberculate trichomes; *A. strigosum* subsp. *strigosum*: j- indumentum of fruit, k- stellate trichomes, l- tuberculate trichomes; *A. xanthocarpum*: m- indumentum of fruit, n- stellate trichomes, o- tuberculate trichomes.

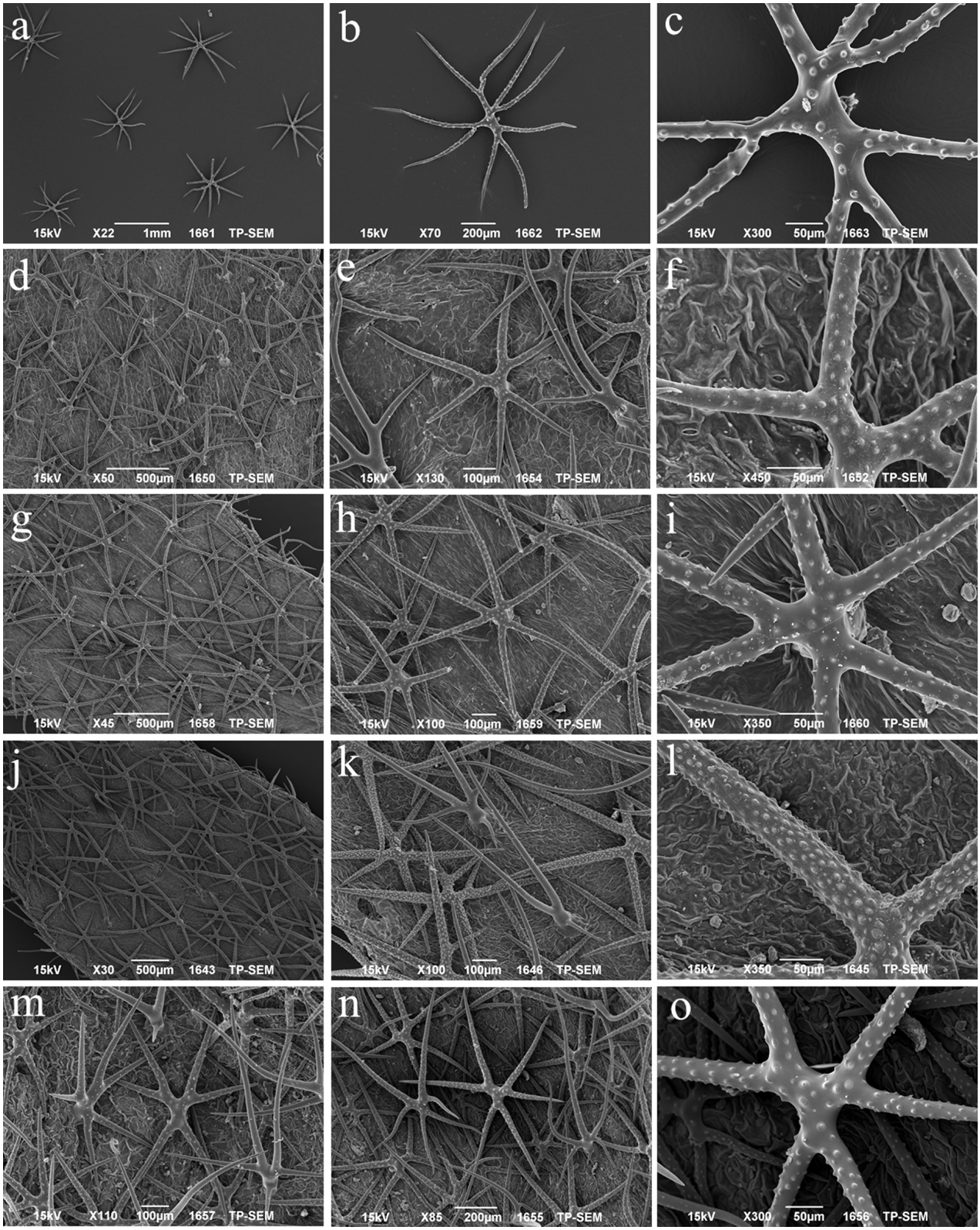

Figure 4. Scanning electron micrographs of the leaf trichomes. *Alyssum amasianum* (a–c); *A. hirsutum* subsp. *caespitosum* (d–f); *A. hirsutum* subsp. *hirsutum* (g–i); *A. strigosum* subsp. *strigosum* (j–l); *A. xanthocarpum* (m–o).

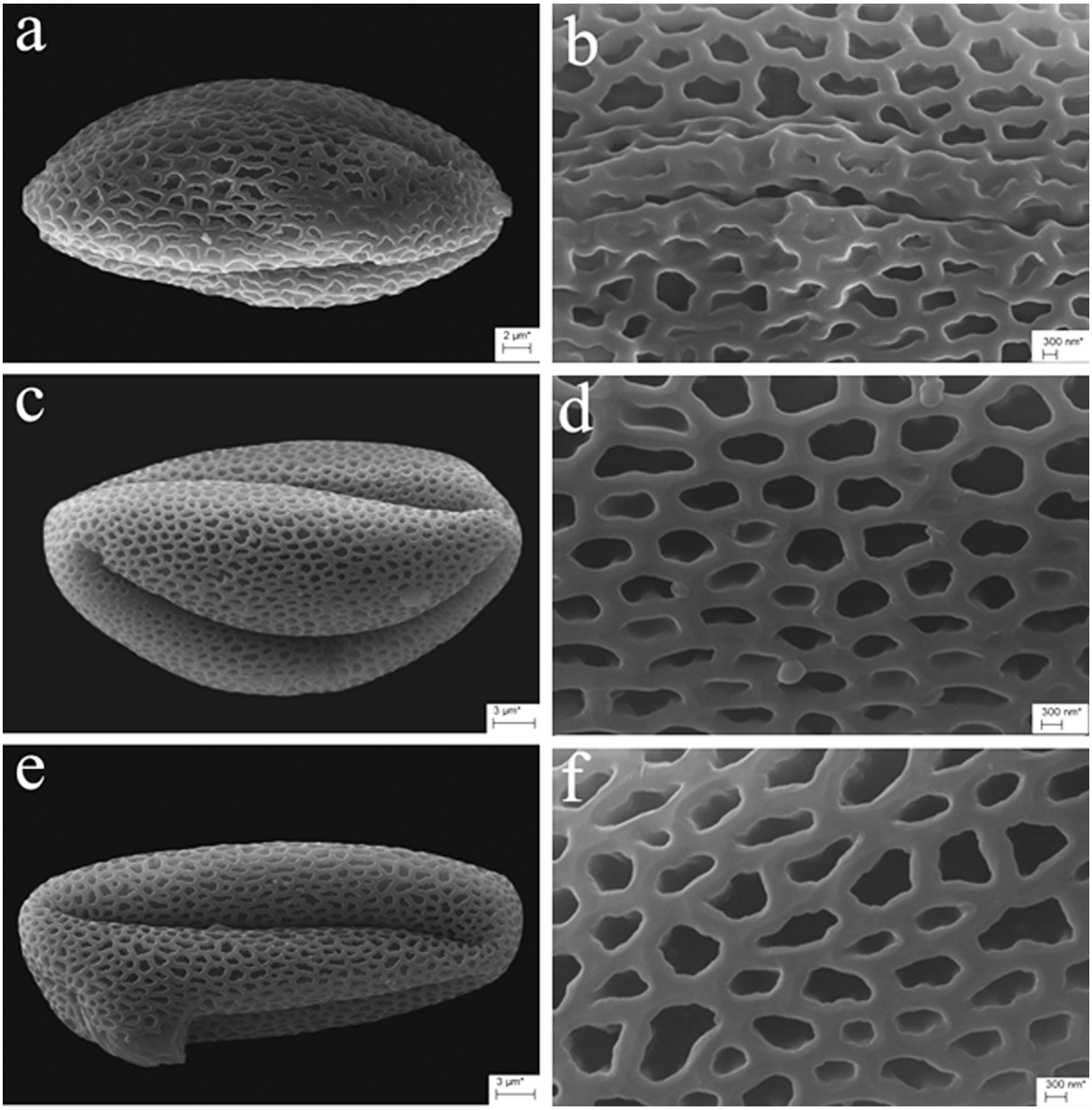

Figure 5. Scanning electron micrographs of the pollens. *Alyssum amasianum*: a- general shape of pollen, b- pollen ornamentation; *A. hirsutum* subsp. *caespitosum*: c- general shape of pollen, d- pollen ornamentation; *A. hirsutum* subsp. *hirsutum*: e- general shape of pollen, f- pollen ornamentation.

C4 Konya: Beyşehir, 1 km E of Nazım Bey tepesi, 1150 m, stony pastures, among *Astragalus,* 29.04.1961, *H.Demiriz* 4459 (E).

A. hirsutum subsp. ***hirsutum***: Turkey: B5 Niğde: Aksaray, Ihlara vadisi, 17.06.1986, *S.Erik* 3844 & *İ.Verten* (HUB); B3 Ankara: Polatlı, Polatlı'nın 18 km batısı, Acıkır mevkii (topçu atış okulu), 850 m, korunmuş step, 16.05.1991, *T.Ekim* 3793 & *Z.Aytaç, H.Duman* (GAZI); B5/6 Yozgat: *Pinus sylvestris* orman açıklığı, c. 1400–1500 m, kalkerli alan, 04.06.1980, *T.Ekim* 4953 (ANK); B3 Akşehir: Sultan dağları, Cankurtaran köyü karşısı, 1600–1700 m, *Y.Akman* 13830 (ANK); B4 Ankara: Elmadağ-Kırıkkale, approx. 7–10 km W of Kırıkkale, on S side of river, serpentine rock slope above highway, 21.05.1996, *R.D.Reeves* 1678 & *U.Krämer* (E).

A. strigosum subsp**. *strigosum***: Turkey: B4 Ankara: Polatlı, Mehmet Akif mahallesi çevresi, step, 17.04.2015, 39°35′922″N 32°08′331″E, 923 m, G134 (KNYA).

A. xanthocarpum: Turkey: B9 Van: Erciş, Şehirpazarı köyü çevresi, step, 26.06.2005, 39°13′935″N 43°25′725″E,

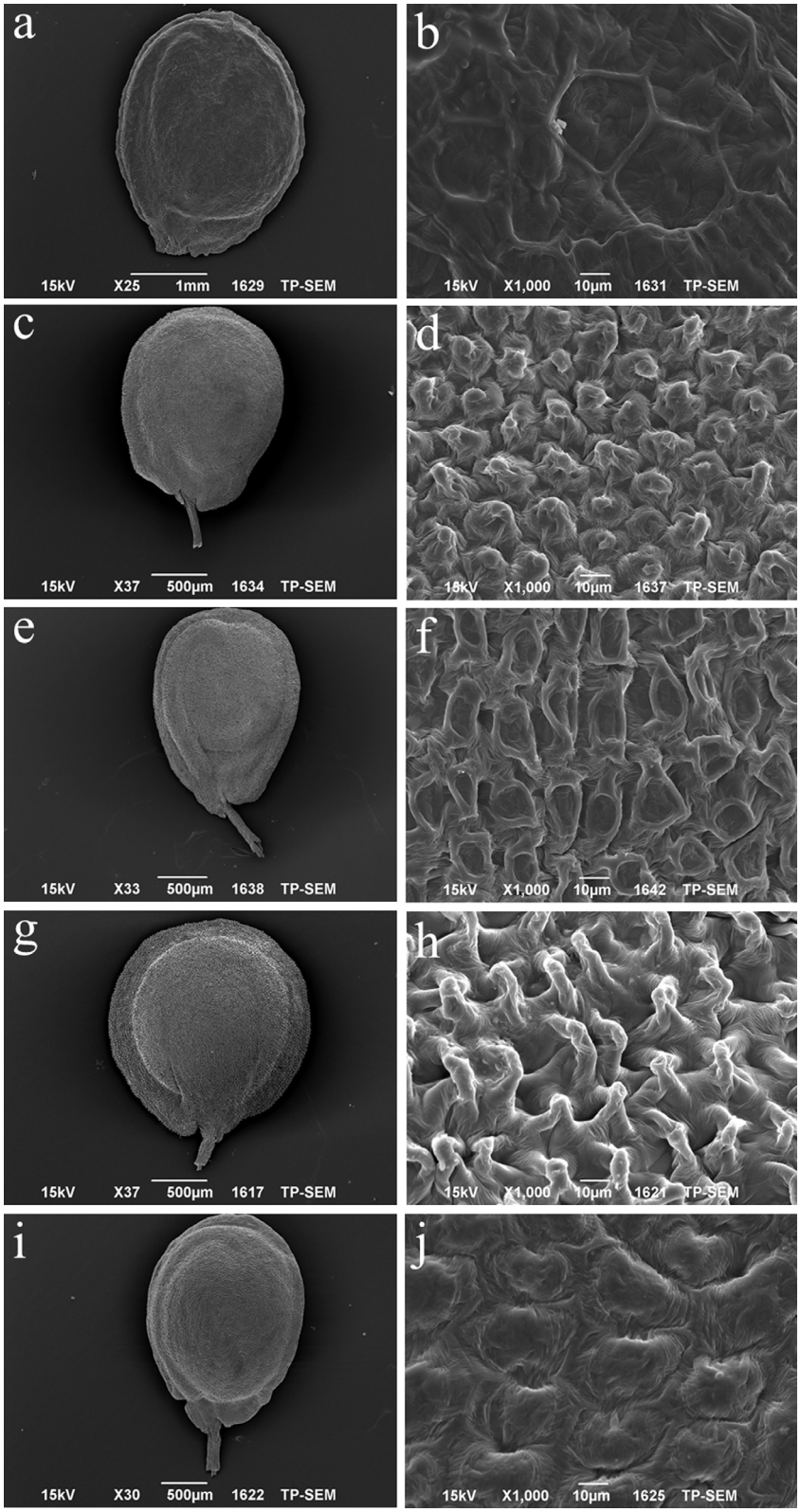

Figure 6. Scanning electron micrographs of the seeds. *Alyssum amasianum*: a- seed shape, b- seed ornamentation; *A. hirsutum* subsp. *caespitosum*: c- seed shape, d- seed ornamentation; *A. hirsutum* subsp. *hirsutum*: e- seed shape, f- seed ornamentation; *A. strigosum* subsp. *strigosum* g- seed shape, h- seed ornamentation; *A. xanthocarpum* i- seed shape, j- seed ornamentation.

2250 m, OK 3722 (KNYA); Taşkapı köyü ile Ganissipi Y. arası, step, 29.06.2006, 39°18′158″N 43°26′648″E, 2200 m, OK 4854 (KNYA).

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