

Alyssum smyrnaeum (*Brassicaceae*): new records for the Crimean flora

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Received: October 12, 2020 ▷ Accepted: November 15, 2020

Abstract. New localities are reported of a very rare species in the Crimean flora, *Alyssum smyrnaeum* (*Brassicaceae*), collected for the first time in Southeastern Crimea over 40 years ago. New data are provided on its habitats in the Southwestern Crimea, as well as on its ecological features and phytocoenotic range. The morphological characters of the species are described in detail and the studied herbarium specimens and geographical coordinates of the observation sites are given. Apparently, in the Eastern Mediterranean and in Crimea, *A. smyrnaeum* is an element of the xerophytic woodlands of *Juniperus excelsa* and *Pinus brutia*.

Key words: *Alyssum*, *Brassicaceae*, Crimean flora, new plant records, trichome morphology, xerophytic woodlands

Introduction

Until recently, *Alyssum* L. s. l. was the largest and most complex genus of the tribe *Alysseae* (*Brassicaceae*). It included about 200 species common to Eurasia, North Africa and North America (Dudley 1964a, b 1965; Rechinger & Dudley 1968; Ball & Dudley 1993; Al-Shehbaz 1987, 2012). Numerous molecular studies have shown that in its traditional circumscription *Alyssum* s.l. is a polyphyletic taxon (Warwick & Al-Shehbaz 2006; Beilstein & al. 2008; Warwick & al. 2008; Rešetnik & al. 2013; Cecchi 2011; Li & al. 2014, 2017; Salmerón-Sánchez & al. 2018). Three main clades were defined: (1) “*Alyssum* s.str. clade” (*Alyssum* sections: *Alyssum*, *Gamosepalum* (Hausskn.) T.R.Dudley, *Psilonema* (C.A.Mey.) Hook.f., pro parte), (2) “*A. homalocarpum* (Fisch. & C.A.Mey.) Boiss. – *A. antiatlanticum* Emb. & Maire clade” (=newly described genus *Cuprella*

Salmerón-Sánchez, Mota & Fuertes) and (3) “*Clypeola* clade” (*Alyssum* sections: *Odontarrhena* (C.A.Mey. ex Ledeb.) W.D.J.Koch, *Meniocus* (Desv.) Hook.f., and genus *Clypeola* L.) (Rešetnik & Španiel 2018). According to the currently obtaining concept, *Alyssum* (or *Alyssum* s.str.) is a monophyletic genus comprising most species of the *Alyssum* section and all species of the sections *Gamosepalum* and *Psilonema* (Španiel & al. 2015; BrassiBase: <https://brassibase.cos.uni-heidelberg.de/> access date: 09.06.2020).

Advancement provided by the results of molecular research made it possible to bring together the fields of phylogeny, phylogeography, micromorphology (Beilstein & al. 2006, 2008; Khosravi & al. 2009; Koch & al. 2007; German & al. 2009; Španiel & al. 2015; Zozomová-Lihová & al. 2020), polyploidy, hybridization, and Ni accumulation properties in *Alyssum* and other genera of *Brassicaceae* (Warwick & Al-Shehbaz 2006;

Schranz & Mitchell-Olds 2006; McNear & Kupper 2014; Arrigo & al. 2016; Geiser & al. 2015; Sobczyk 2017). Furthermore, widely discussed were the diversity, origin, and molecular bases of natural variability and environmental control of the trichomes structure (Abdel 2005; Ančev & Goranova 2006; Beilstein & al. 2006, 2008; Mirzadeh & al. 2015), which put up important physical and chemical barriers against abiotic and biotic stresses (Hauser 2014; Karabourniotis & al. 2019). Molecular phylogenetic analyses have led to taxonomic revision of the genus *Alyssum* (Karabacak & al. 2016; Španiel & al. 2017, 2018b; Cetlová & al. 2019), reconsideration of its species diversity in regional floras, new data on some very rare species and description of new species (Španiel & al. 2012, 2018a; Kavousi & al. 2014; Bartolucci & Conti 2016; Bernardo & al. 2018; Rešetnik & Španiel 2018).

In the Crimean flora, the monophyletic genus *Alyssum* is represented by three perennial and seven annual species (Ball & Dudley 1993; Jalas & al. 1996; Iljinska 2005; Iljinska & al. 2007). The annual species are: *A. alyssoides* L. (native range: Eastern Central Europe to the Mediterranean and Central Asia); *A. hirsutum* M.Bieb. (native range: Southeast and East Europe to Iran); *A. minutum* Schldtl. ex DC. (native range: South and East Europe to Northwest Afghanistan, North Africa); *A. parviflorum* M.Bieb. (taxonomic status and delimitation have not been finally determined yet (Botschantzev 1979, 1989; Schneeweiß 2000; Cetlová & al. 2019); more research is required); *A. smyrnaeum* C.A.Mey. (an Eastern Mediterranean element, Southeast Greece, West Turkey, Southern Crimea (POWO 2020)); *A. turkestanicum* Regel & Schmalh. (native range: Central (East, South), Southeast Europe; Southwestern Siberia; Southwest, Central, East (North) Asia; more research is required); *A. umbellatum* Desv. (an Eastern Mediterranean element, native range includes Southeast Europe, Southern Crimea, West Turkey, Cyprus).

Alyssum smyrnaeum was first discovered in the southeastern part of Crimea in 1974 (Ilyinskaya 1987). It was not clear whether it was an alien plant or a native species. Recently, new records of this species were made in the southwestern part of Crimea. Considering all known findings, the authors have studied in detail the morphological characters of *A. smyrnaeum*, micromorphology of trichomes, ecology and habitat preference in Crimea and the Eastern Mediterranean (based on the analysis of literature data), and have outlined its general distribution.

Material and methods

The authors have identified specimens collected in the southern part of the Crimean Peninsula, compared them with the holotype (LE) and deposited them in the herbaria (YALT, MW, KWHB) as *A. smyrnaeum*. For better understanding of the species, they have studied the digital images of its isotypes (W, K, E, BM), other herbarium materials (KW, MW, YALT), and micromorphology of trichomes. For scanning electron microscopy (SEM), dry fragments of the leaf and the pedicel were mounted on plates and spray-coated with gold. A JSM-6060 LA microscope was used. Distribution and habitat preferences of *A. smyrnaeum* in Crimea have been outlined on the basis of original field surveys of the authors. Based on available literature data and Internet resources, a chorological map is presented of the general distribution and habitat patterns of the species in the Eastern Mediterranean. Furthermore, the distribution data of *Pinus brutia* Ten. according to Caudullo & al. (2017, 2018) with additions according to Taylor (2012) were considered. The names of taxa are given according to The International Plant Name Index (IPNI 2020) and Euro+Med Plant Base (2005–2020). Herbaria acronyms correspond to Index Herbariorum (Thiers 2019: <http://sweetgum.nybg.org/science/ih/>). Nomenclature and volume of the vegetation syntaxa follow *Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities* (Mucina & al. 2016) and *Prodrome of the Vegetation of Ukraine* (Dubyna & al. 2019).

Results

Alyssum smyrnaeum C.A.Mey., Bull. Sc. Acad. Petersb. 7 (1840) 132.

Described from Asia Minor (Turkey, Smyrna (now Izmir)): “*A. fulvescens* Sm. Fleischer pl. exsicc., a soc. it. Essling distr. Hab. In collibus circa urbem Smyrna”. **Holotype**: “*Alyssum fulvescens* Sm. Unio itineraria. In collibus Smyrna; 1827. Fleischer. Martio” (LE!). **Isotypes**: K000484950! (image available at <https://www.gbif.org/ru/occurrence/912403864>), E00386113! (image available at <https://www.gbif.org/ru/occurrence/574978322>), W1889-0016452A! (= *A. fulvescens* Sm.; image available at <https://herbarium.univie.ac.at/>)

database/results.php?s=s&page=1), BM (cites Dudley 1965; not see).

Note on typification. The species is described on the basis of an herbarium specimen collected in the vicinity of Smyrna by Franz Fleischer (not by Max Fleischer!), member of the Botanical Travel Society (or Unio Itineriae) from Esslingen, and identified as *A. fulvescens* Sm. A typical specimen of the species has a primary label (Fleischer's inscription in pencil) and a mark (in ink) stating that this herbarium material belongs to the Meyer collection. There are also drawings of petals, stamens, trichomes, ovaries and the whole plant. Herbarium specimen G00389039! (image available at http://www.ville-ge.ch/musinfo/bd/cjb/chg/result.php?type_search=simple&lang=en&criteria=alyssum+smyrnaeum&mode=tout) designated as "Typus of *Alyssum smyrnaeum* C.A.Mey." (Dudley 1965) differs, since that plant does not belong to *A. smyrnaeum*.

Description. Annual plant; canescent throughout, except for fruits and petals, trichomes stellate, adpressed, with (5)6–8(14) rays; rays equal or unequal (pedicels, sepals). Stems simple or few from base, erect or ascending, 5–11 cm. Cauline leaves petiolate or (distal) gradually attenuate into a short petiole or subsessile; blade obovate to oblong-lanceolate, 4–9.2 × 1.8–2 mm (gradually smaller distally), base attenuate, apex acutiuscule. Racemes simplex, 8–13-flowered, condensed at anthesis, slightly elongated to 4 cm at fruiting. Fruiting pedicels ascending or subdivaricate, straight, 3–6 mm. Flowers: sepals persistent, elliptic, 2.5–3.5 mm; petals pale-yellow, cuneate, emarginate, limb wider than and attenuate into claw, glabrous, 3–4 mm; filaments: median pairs gradually expanded to base, edentate, 2–2.5 mm; lateral pair with broadly winged appendage apically notched into 2 teeth, 1.5–2 mm; anthers small, yellow, obovate, subcordate at the base. Fruits subovate to suborbicular, 3.5–5.1 × 3–4.3 mm, rounded at the apex (seldom subtruncate), not emarginated, glabrous; valves uniformly inflated in the middle, flattened at margins; ovules 2 per ovary; style 1.7–2 mm, slender, glabrous. Seeds ovoid, 1.5–1.7 × 1–1.5 mm, yellowish, slightly compressed, margins narrow, mucilaginous when wetted. 2n=16 (Persson 1971). Flowering: March – April (Fig. 1).

Micromorphology of trichomes (Fig. 2). Trichomes were observed on all organs of *A. smyrnaeum*, with the exception of fruits and petals. They were represented by stellate hairs of two types, symmetrical (rays

of approximately the same length) and asymmetrical (rays of different lengths) stellate hairs. The surface of symmetrical stellate hairs was tuberos. Asymmetrical stellate trichomes had a smooth surface. Adpressed symmetrical stellate hairs predominated on the stem, leaves and most of the pedicels length.

They consisted of four or three (less often) primary rays. All or most of the rays were bifurcated once or twice, thus forming trichomes with 8–6 or 9–14 rays. Five-ray hairs were very seldom observed. On the sepals and on the distal part of peduncle, asymmetrical stellate hairs had two or three very long sticking out rays.

Diagnostic descriptors: glabrous fruits with thin, inflated valves; persistent sepals; glabrous petals; symmetrical (adpressed, with (5)6–8(14) rays) and asymmetrical (part of the rays are long, sticking out) trichomes.

Habitats: xeric Mediterranean woodlands, phrygana and grasslands, including limestone screes, damp ledges, rocky chips and clay, sandy banks (seldom), dunes, as well as roadsides, fallow fields, and graveyards (Ball & al. 1993; Snogerup & al. 2001; Ertekin 2002; Tugay & Ertuğrul 2003; Cetin & Secmen 2008; Kaya & al. 2008; Taylor 2012; Bakış & al. 2014; GBIF, 2020). Plants of *A. smyrnaeum* inhabit well-lit or not very secluded places in fairly warm or warm, dry or fresh sites, in sunny areas soils (pH 7.2–7.6), and non-saline habitats (Böhling & al. 2002).

In Crimea, *Alyssum smyrnaeum* is categorized as heliophytic, mesothermic, subxerophytic, neutrophilic, and eutrophic plant (Iljinska & al. 2007; Didukh 2011). It does not occur on limestones there, only on non-carbonate outcrops: Tavric flysch, Jurassic magmatic rocks, sandstones and conglomerates. Its main habitats are Stankiewicz Pine (*Pinus brutia* Ten. var. *pityusa* (Steven) Silba) and Greek Juniper (*Juniperus excelsa* M.Bieb.) arborescent matorral, xeric grasslands and rocky outcrops. This species has never been found in disturbed areas in Crimea.

Phytosociology. *Alyssum smyrnaeum* is the diagnostic species of *Quercetea ilicis* Br.-Bl. ex A. de Bolòs et O. de Bolòs in A. de Bolòs y Vayreda 1950 class, which includes thermo-meso-Mediterranean pine and oak forests and associated macchia of the Mediterranean (Mucina & al. 2016). It is restricted to *Pinus brutia*-, *Juniperus excelsa*- and *Quercus coccifera* L.-dominated woodlands and shrublands, but it could be also found in phrygana, grasslands, chasmophytic vegetation in

rock crevices and screes, as well as in ruderal and segetal plant communities.

In Crimea, *A. smyrnaeum* is component of the xeric low woodlands of *Juniperus excelsa* and *Pinus brutia* var. *pityusa*, belonging to the association *Achnathero-Pinetum pityusae* Didukh 1996 of the alliance *Jasmino-Juniperion excelsae* Didukh, Vakarenko et Shelyag-Sosonko ex Didukh 1996 (*Quercetalia pubescenti-petraea* Klika 1933; *Quercetea pubescentis*

Doing-Kraft ex Scamoni et Passarge 1959). It also occurs in Mediterranean grasslands of the *Stipo-Trachynietea distachyae* S. Brullo in S. Brullo et al. 2001 class and in chasmophytic communities of the *Sedo-Scleranthetea* Br.-Bl. 1955 class. Phytosociological relevés with *A. smyrnaeum* from the Crimea are given below.

Relevé 1. Crimean Peninsula, Sevastopol region, in the vicinity of Foros. Coordinates: 44°23'52"N, 33°46'50"E. Altitude 230 m a.s.l. Habitat: dry rocky

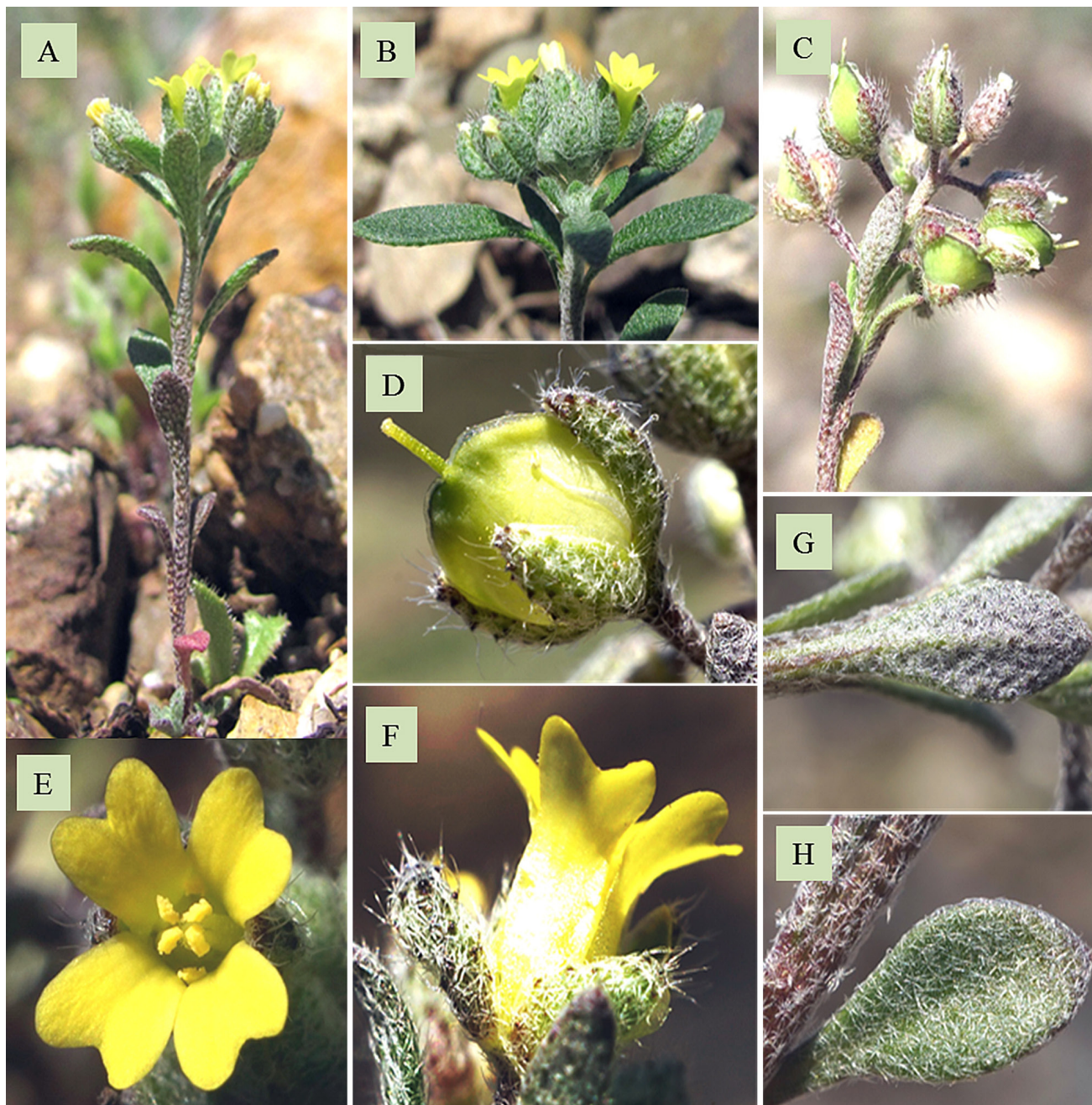


Fig. 1. *Alyssum smyrnaeum* in Crimea: **A, B** – SW Crimea, in the vicinity of Reservnoye, on scree. 11 April 2017. 44°28'10"N, 33°40'25"E (photo by P. Yevseyenkov); **C** – SW Crimea, in the vicinity of Reservnoye. 16 April 2014 (photo by P. Yevseyenkov); **D, E, F, G, H** – SW Crimea, in the vicinity of Reservnoye, Kum-Dere ravine, on southern slope talus. 11 April 2017 (foto by S. Svirin).

slope. Relevé area 4 m². Aspect: northern. Slope: 10°. Substrate: eluvial-deluvial deposits of effusive rocks with poorly developed skeletal soils. Total vegetation cover: 70%. Vegetation height 50 cm (max), 15 cm (average). Author L. Ryff, 19 May 2011.

Alyssum smyrnaeum – +, *Bombycilaena erecta* (L.) Smoljan. – 1, *Bromopsis cappadocica* (Boiss. & Balansa) Holub – +, *Coronilla scorpioides* (L.) W.D.J.Koch – 1, *Crucianella angustifolia* L. – +, *Fumana procumbens* (Dunal) Gren. & Godr. – r, *Galium tenuissimum* M.Bieb. – +, *Galium verticillatum* Danthoine – +, *Helianthemum salicifolium* (L.) Mill. – 2m, *Holosteum umbellatum* L. – +, *Medicago minima* (L.) L. – +, *Melilotus neapolitanus* Ten. – 4, *Myosotis incrassata* Guss. – +, *Ornithogalum fimbriatum* Willd. – r, *Sanguisorba minor* Scop. subsp. *balearica* (Nyman) Muñoz Garm. & C.Navarro – r, *Sherardia arvensis* L. – 1, *Stachys cretica* L. – r, *Teucrium capitatum* L. – 2a, *Teucrium chamaedrys* L. – 2a, *Thymus roegneri* K.Koch – +, *Trifolium*

scabrum L. – +, *Veronica multifida* subsp. *capsellicarpa* (Dubovik) Jelen. – 2a, *Vicia sativa* L. subsp. *cordata* (Hoppe) Batt. – +, *Valerianella coronata* (L.) DC. – +, *Vulpia ciliata* Dumort., – 2m, *Vulpia unilateralis* (L.) Stace – +.

Relevé 2. Crimean Peninsula, Sevastopol region, in the vicinity of Reservnoye. Coordinates: 44°27'58"N, 33°39'54"E. Altitude 450 m a.s.l. Habitat: rocky slope with dry grassland in a juniper-oak woodland. Relevé area 10 m². Aspect: southeastern. Slope: 20°. Substrate: colluvial and deluvial deposits of conglomerate rocks with skeletal soils. Total vegetation cover: 55%. Vegetation height 60 cm (max), 20 cm (average). Author L. Ryff, 08 June 2017.

Alyssum parviflorum Fisch. ex M.Bieb. – +, *Alyssum smyrnaeum* – 1, *Asphodeline lutea* (L.) Rchb. – 2a, *Bothriochloa ischaemum* (L.) Keng – 2a, *Centaurea caprina* Steven – +, *Cerastium brachypetalum* subsp. *tauricum* (Spreng.) Murb. – 2m, *Convolvulus cantabrica*

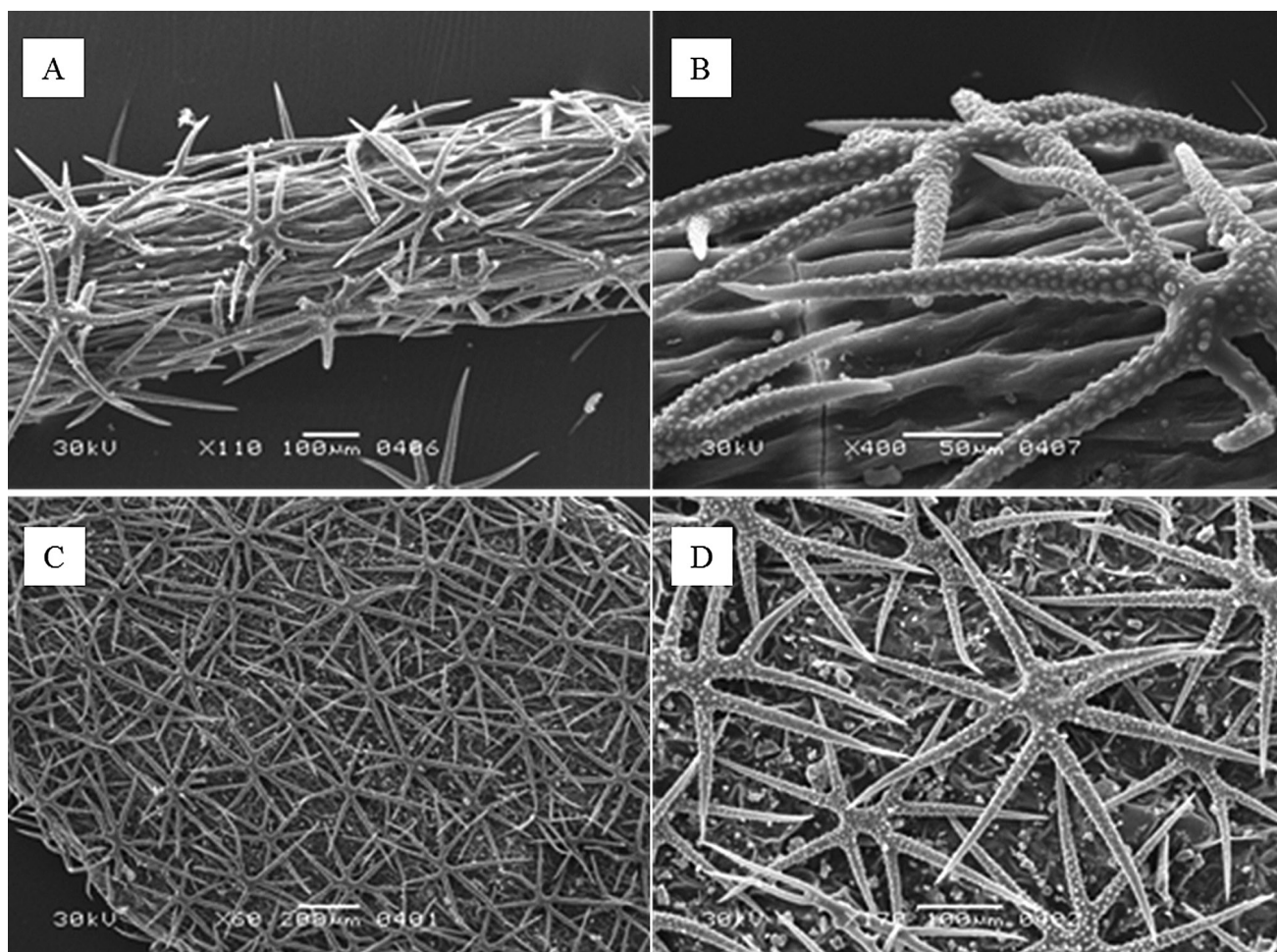


Fig. 2. Stellate trichomes of *Alyssum smyrnaeum* C.A.Mey.: A, B – on pedicels; C, D – on leaves; scale bars: A, D = 100 µm; B = 50 µm, C = 200 µm.

L. – +, *Coronilla scorpioides* – +, *Crepis sancta* (L.) Bornm. – +, *Euphorbia myrsinites* L. – +, *Euphorbia taurinensis* All. – +, *Galium tenuissimum* – 2m, *Galium verticillatum* – 1, *Helianthemum salicifolium* – 1, *Medicago minima* – +, *Melilotus neapolitanus* – +, *Nocca perfoliata* (L.) Al-Shehbaz – +, *Picris pauciflora* Willd. – 1, *Salvia tomentosa* Mill. – 2a, *Sanguisorba minor* subsp. *balearica* – r, *Sideritis montana* L. – 2a, *Teucrium capitatum* – 2a, *Teucrium chamaedrys* – 2a, *Thymus kosteleckyanus* Opiz – +.

Relevé 3. Crimean Peninsula, Sevastopol region, in the vicinity of Reservnoye. Coordinates: 44°27'57"N, 33°39'49"E. Altitude 470 m a.s.l. Habitat: rocky scree slope. Relevé area 10 m². Aspect: southeastern. Slope: 15°. Substrate: conglomerate rock with fine colluvial and deluvial deposits. Total vegetation cover: 25%. Vegetation height 50 cm (max), 15 cm (average). Author L. Ryff, 08 June 2017.

Allium marschalianum Vved. – 2a, *Alyssum parviflorum* – +, *Alyssum smyrnaeum* – 1, *Asphodeline lutea* – 2a, *Bromus japonicus* Thunb. – +, *Bromus squarrosus* L. – +, *Centaurea caprina* – r, *Clypeola jonthlaspi* L. – +, *Euphorbia taurinensis* – +, *Fumana procumbens* – +, *Galium verticillatum* – 1, *Picris pauciflora* – +, *Poa bulbosa* L. – +, *Saxifraga tridactylites* L. – 1, *Sedum acre* L. – 2a, *Sedum hispanicum* L. – 2a, *Sideritis montana* – +, *Tragopogon dubius* Scop. – r.

Distribution in Crimea: SW (Sevastopol region) and SE (Sudak area) to parts of the Crimean Mountain Range, no more than 2 km from the Black Sea coast, at up to 570 m a.s.l.

General distribution: S Crimea, SE Greece (Crete, Cyclades, Eastern and Western Aegean Islands, Peloponnese, Sterea Ellas) to W Turkey (with some isolated locations in other parts of the country). The species occurs mainly in areas adjacent to the coastland of the Mediterranean, Marmara and Black Seas, in the altitude range of 30–1500 m a.s.l., in areas with thermo-, meso-, supra-, or sub-Mediterranean climate. *Alyssum smyrnaeum* is an Eastern Mediterranean element.

Examined plants. Preserved specimens. Crimea, in the vicinity of village Novy Svet, on slope in a Stankiewicz Pine grove. 25.04.1974. A. Ilyinskaya (KW, s.n.); Eastern Crimea. In the vicinity of Sudak. The crest of the Perchem Ridge. In a fescue mountain steppe. 4 May 1980. N. Shvedchikova (MW0611779, as *A. minutum*: <https://plant.depo.msu.ru/open/public/item/MW0611779-4/img/0.jpg?original>); Crimea, in the vicinity of Foros, on dry slope of magmatic rock

outcrops. 19.05.2011. L.E. Ryff (YALT, s.n., as *A. desertorum*); Crimea, in the vicinity of Balaclava, Kum-Dere ravine above Reservnoye village, on conglomerates in the lower part of Mt Kilse-Burun. 44°27'57"N 33°40'09"E, 04 Apr 2017. Pavel Yevseyenkov (KWAH, s.n.); Crimea, on southern slope of Mt Kala-Fatlar, in the vicinity of Reservnoye village (Sevastopol), 44°27'56.63"N, 33°40'8.09"E, 11 Apr 2017. S. Svirin (MW0632620; YALT, s.n.); SE Crimea, Sudak area, Novy Svet, Anastasyevskaya Balka (Nastasyan-Dere-sy) locality, in dry bed of a temporary watercourse in a *Juniperus excelsa* woodland, 220 m a.s.l., 44°50'27.68"N 34°55'17.68"E, 16 May 2019. L. Ryff (own herbarium L. Ryff).

Human observations with georeferenced records. SW Crimea, in the vicinity of Reservnoye. 16 April 2014. P. Yevseyenkov (image available at <https://www.plantarium.ru/page/view/item/2526.html>); SW Crimea, in the vicinity of Reservnoye, on scree. 17 March 2018. P. Yevseyenkov (image available at <https://www.plantarium.ru/page/view/item/2526.html>); SW Crimea, in the vicinity of Reservnoye, on scree. 11.04.2017, 44°28'10"N, 33°40'25"E. P. Yevseyenkov (image available at <https://www.plantarium.ru/page/view/item/2526.html>); SW Crimea, in the vicinity of Reservnoye, Kum-Dere ravine, southern slope talus. 11.04.2017. S. Svirin (image available at <https://www.plantarium.ru/page/view/item/2526.html>); Crimea, Sevastopol, Balaclavsky region, 44.465469N 33.668905E, 24 Apr 2020, Sergey (image available at <https://inaturalist.ca/observations/44226102>).

Discussion

Alyssum smyrnaeum has not received much botanical attention. Until recently, the description of the species was very laconic and incomplete (Dudley 1965; Ball & Dudley 1993). Only Yilmaz (2011, unpubl.: <http://acikerisim.uludag.edu.tr/jspui/handle/11452/3294>) provided a more detailed morphology, studying the taxonomy of *Alyssum* species from Bursa (Turkey) and its vicinities. Generally, the morphological characters of Crimean plants, including the microstructure of trichomes, correspond to the description of *A. smyrnaeum* by different authors (Dudley 1965; Ball & Dudley 1993; Yilmaz 2011, unpubl.), which confirms the fact that Crimean plants belong to this species.

Distribution of *A. smyrnaeum* in Crimea is very specific, it is constrained to some very limited areas in the southwest and southeast of the Peninsula. For the first time (1974) it was collected in the grove of *Pinus stankewiczii* (Sukaczew) Fomin (= *Pinus brutia* var. *pityusa* (Steven) Silba) in the vicinity of the Novy Svet (Sudak area, SE Crimea). New records of *A. smyrnaeum* in SW Crimea are also associated with the Stankiewicz Pine distribution range. In the vicinity of Reservnoye, near Balaclava, the locality of *A. smyrnaeum* is distanced about 1 km from the nearest *Pinus brutia* grove; in the vicinity of Foros the distance is about 5 km. Both localities are in the zone of *Juniperus excelsa* woodlands, and so are the new occurrences in the Novy Svet vicinities (Fig. 3).

Pinus brutia var. *pityusa* is a relict taxon of the Crimean flora. In the past, it was more widespread in the region, but subsequently destroyed in the result of

natural processes and human activities. Now Stankiewicz Pine has a disjunctive range in Southern Crimea, along the Black Sea coast, represented by two insulated sites: eastwards of Balaclava to Laspi Bay on the slopes of Aya Cape, and westwards of Sudak to Ay-Foka Cape (Yena & al. 2005). In both areas, it forms specific plant communities along with *Juniperus excelsa* – pine-juniper low woodlands. They comprise pure pine woodlands in the lowest altitude belt near the sea shore, pure juniper low woodlands predominantly in the higher belt, and mixed pine-juniper communities in the contact zone (Shvedchikova 1983). An important feature of this vegetation type in the herbaceous cover is the presence of some rare for the Crimea taxa and species with disjunctive ranges (Stankov 1933, 1939), including *Alyssum smyrnaeum*. However, this species has not been registered either in coastal or in inland massifs of juniper woodlands, far from the localities of *P. brutia*.

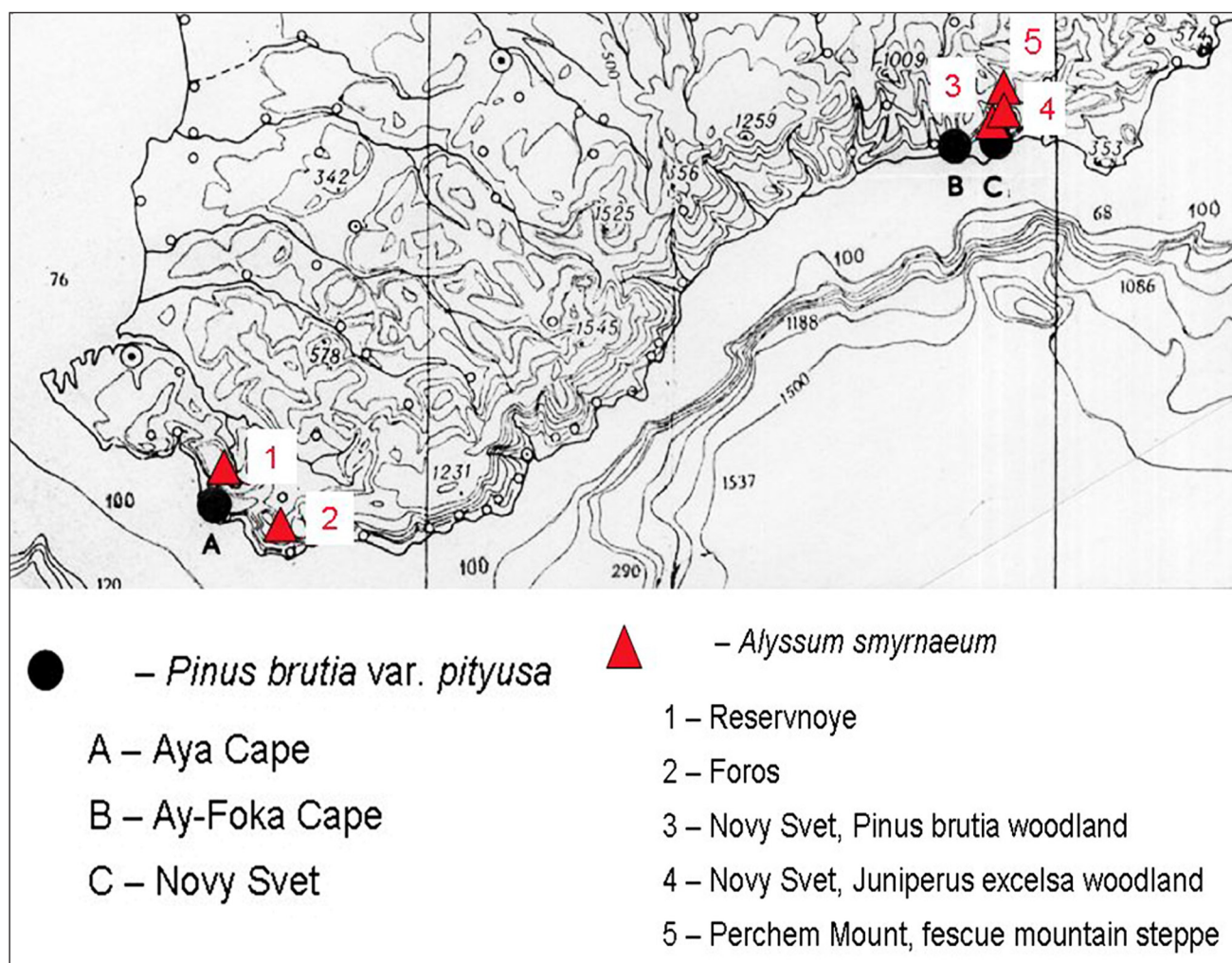


Fig. 3. Distribution of *Alyssum smyrnaeum* C.A.Mey. (according to the authors' data) and of *Pinus brutia* Ten. (according to Yena & al. 2005) in Southern Crimea.

The authors have assumed that the overlap of *A. smyrnaeum* with the range of *P. brutia* in Crimea is not accidental. Analysis of the spread of these two species in the Eastern Mediterranean has generally confirmed their hypothesis. Distribution of *A. smyrnaeum* has been compared with information provided by different authors and databases (Dudley 1964, 1965; Jalas & al. 1996; Snogerup & al. 2001; Ertekin 2002; Tugay & Ertuğrul 2003; Strid & Kit Tan 2005; Cetin & Secmen 2008; Kaya & al. 2008; Taylor 2012; Bakış & al. 2014; Vladimirov & Kit Tan 2014; Mermygkas & Yannitsaros 2015; *Alyssum smyrnaeum* in GBIF 2019; Flora Hellenica 2020; Flora of Greece Web 2020), and that on *Pinus brutia* according to Caudullo & al. (2018), with some additions according to Taylor (2012) (Fig. 4). In most cases, the localities of *A. smyrnaeum* have been accommodated within the *P. brutia* range. Southeast Greece makes an exception: there *A. smyrnaeum* is associated mainly with *Quercus coccifera* L. and *Pinus halepensis* Mill. woodlands, but is record-

ed only in the coastal areas, where perhaps *P. brutia* might have occurred earlier, because that pine species was generally more widespread in the Mediterranean in the past (Panetsos 1975). Furthermore, *P. halepensis* and *P. brutia* are vicariant taxa, very similar ecologically and genetically (Barbéro & al. 1998; Eckert & Hall 2006). According to some authors, small isolated populations of *P. brutia* are still present now in Attica and on the Cyclade Islands (Türkmen & Düzenli 2011; Caudullo & al. 2018), close to the known localities of *A. smyrnaeum*. In Central Turkey, where *P. brutia* is absent obviously for climatic reasons, *A. smyrnaeum* is recorded only in anthropogenic habitats (at roadsides and in fallow fields) and is probably an alien species there.

Alyssum smyrnaeum has not been recorded yet from North Greece (where *Pinus brutia* subsp. *brutia* is widespread), neither from the Black Sea Coast of the Caucasus (another locality of *Pinus brutia* var. *pityusa*), nor from Southern Transcaucasia, Northwest Iran, North

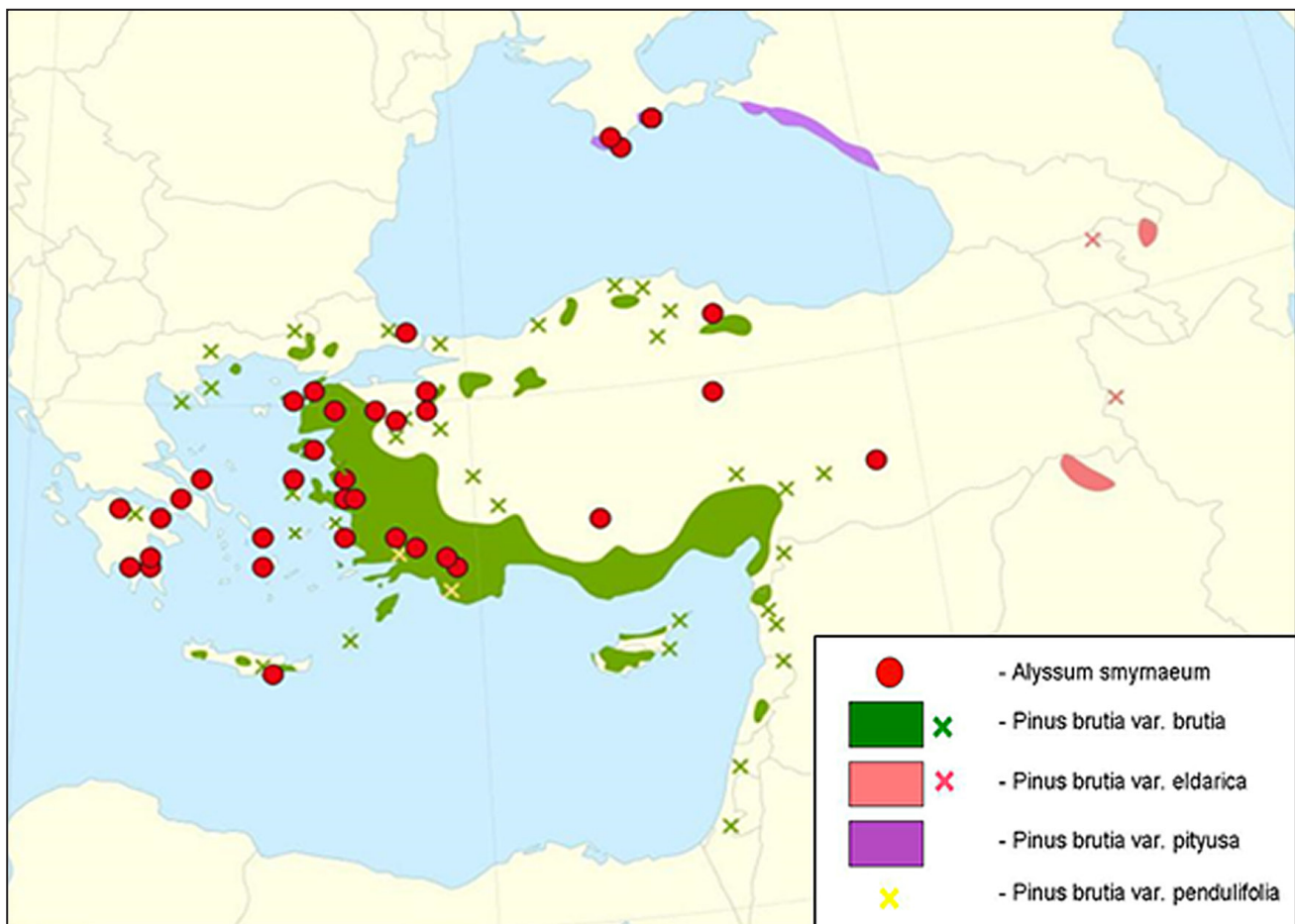


Fig. 4. General distribution of *Alyssum smyrnaeum* C.A.Mey. (according to different authors) and of *Pinus brutia* Ten. (according to Caudullo & al. (2018), with some additions according to Taylor (2012)).

Iraq, and extreme Southeast Turkey (area of relict *P. brutia* var. *eldarica*). The authors do not exclude that *A. smyrnaeum* could be found there in the future. The localities where *A. smyrnaeum* occurs in natural habitats outside the *P. brutia* distribution area (particularly, in continental South Greece, East Turkey) presumably can be regarded as relict. Turkish pine woodlands may have grown there in the past.

Thus, the results of our analysis have shown that *A. smyrnaeum* is much more widespread in the Eastern Mediterranean and Black Sea region than so far known. They also confirmed the relations of this species with communities of the class *Quercetea ilicis*, particularly the *Pinus brutia* woodlands.

Acknowledgements. M.G. Kholodny Institute of Botany NAS of Ukraine for correcting the English text and to the anonymous reviewer for the valuable comments and friendly attitude to their work.

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