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Onosma guniae (Boraginaceae: Lithospermeae), a new species from the serpentine area of eastern Anatolia, Turkey

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ABSTRACT: A new species, *Onosma guniae* Binzet (Boraginaceae: Lithospermae), has been described from the Erzincan province in eastern Anatolia, Turkey. This species, which inhabits serpentine soils, is classified within sect. *Onosma*, subsect. *Asterotricha*. Morphologically, *O. guniae* is closely related to *O. stenoloba*, but it exhibits several distinguishing features, including a shorter stem, longer setose and narrower cauline leaves, longer bracts and pedicels, a different corolla color, shorter filaments, and a distinct nutlet shape and size. The publication provides a comprehensive description of these diagnostic traits, along with original photographs, detailed illustrations, a distribution map, habitat information, an image of the holotype specimen, and an identification key for distinguishing *O. guniae* from *O. stenoloba*. Additionally, the vernacular name and the IUCN conservation status of *O. guniae* are included.

KEY WORDS: Irano-Turanian, new species, *Onosma*, *Onosma stenoloba*, taxonomy, Turkey.

INTRODUCTION

Throughout geological changes, Anatolia has served as a corridor for various living organisms and acted as a refuge during the glacial periods. Its strategic location at the intersection of the Iran-Turan, Mediterranean, and Euro-Siberian phytogeographical regions, the convergence of three primary climatic zones, and diverse topographical, geological, and geomorphological features have all contributed to its rich plant diversity. Notably, despite Turkey's surface area being only 7% of Europe's, according to Davis (1965), the number of plant species found there is nearly equivalent to that of Europe.

The family Boraginaceae is represented worldwide by 153 genera and more than 2000 species of trees, shrubs, and herbs (POWO, 2024). This family, considered one of the richest plant families in Turkey, is represented by 44 genera and 375 taxa in the Flora of Turkey. The rate of endemism is over 40% (Güner, 2012). *Onosma L.* (1762: 196) is the genus with the largest number of species in the Boraginaceae family, comprising approximately 298 species (POWO, 2024). It is distributed in northwestern Africa, Europe and Asia, but is mainly center of species diversity in Turkey and Iran (Johnston, 1954; Weigend *et al*., 2009; Cecchi *et al.*, 2016; Chacón *et al.*, 2016; Binzet and Eren, 2018; Firat and Binzet, 2021, 2024; Binzet *et al*., 2024).

In the last plant check-list of Turkey titled "Türkiye Bitkileri Listesi (Damarlı Bitkiler)", Binzet recognised 96 species (including one hybrid) belonging to the genus *Onosma* in Turkey (Binzet, 2012). Later, *O. atila-ocakii* Koyuncu & Yaylacı (2013), *O. demirizii* Kaynak, Tarımcılar & Yılmaz (2015), *O. malatyana* Binzet (2016a), *O. anatolica* Binzet (2016b: 41), *O. juliae* L. Cecchi & Selvi (2016), *O. erzincanica* Binzet and Eren (2018), *O. onur-koyuncui* Sezer (2021), *O. satensis* Firat and Binzet (2021), *O. korukluei* Aytaç & T.Ertuğrul (Aytaç *et al*., 2023), *O. serpentinica* Yıldırım & Binzet (Binzet *et al*., 2024), *O. vanensis* Firat & Binzet (Firat and Binzet, 2024), and *O. zaferkayae* Binzet (Binzet, 2025) were described as twelve additional members of the genus from Turkey. Together with *O. guniae* Binzet described in this study, the total number of *Onosma* species known from Turkey has increased to 108. Of these, 65 species are endemic to Turkey.

Boissier (1875) divided the genus *Onosma* into three main groups: these are *Haplotricha* (Boiss.) Gurke, *Asterotricha* (Boiss.) Gurke, and *Heterotricha* (Boiss.) Gurke. The *Haplotricha* group includes species with glabrous setose tubercles, while the *Asterotricha* group consists of species with stellate setose tubercles. The *Heterotricha group*, on the other hand, is characterized by species with irregularly hairy setose tubercles. Riedl (1978), in the Flora of Turkey, divided the genus *Onosma* into three main sections: *Protonosma* M. Pop., *Podonosma* (Boiss.) Gurke, and *Onosma*. The *Onosma* section was further divided into two subsections: *Haplotricha* and *Asterotricha*.

During scientific field surveys conducted in the northeastern and eastern Anatolia regions, an unidentified *Onosma* taxon was collected from a serpentine area located 7–8 km northwest of Erzincan province. After a thorough examination of relevant floras (Boissier, 1875; Dinsmore, 1932; Riedl, 1967, 1978; Popov, 1974;), herbarium specimens (E, W, GAZI, ANK, and MERA), and existing systematic literature, as well as comparisons with closely related species, it was determined that this taxon does not correspond to any previously described species. This suggests that the collected specimen represents a taxon

Table 1. Morphological differences between ***Onosma guniae*** and ***O. stenoloba***

	Onosma guniae	***Onosma stenoloba***
Stem	8–15 cm, setae to 5 mm	25–30 cm, setae to 2 mm
Basal leaves	oblanceolate to linear-spathulate	linear-spathulate
Cauline leaves	15–40 × 2–5 mm,	30–45(-50) × 5–10 mm
Inflorescence	2-4 terminal, scorpioid-capitate at first scarcely accrescent in fruit	cymes scorpioid-circinate at first, becoming straight, elongated, rather lax
Bracts	10–30 × 2–7 mm, lanceolate	5–17 mm, lowermost similar to cauline leaves, uppermost narrowly linear.
Pedicels	1–3 mm	1–1.5 mm
Calyx	10–14 mm in flower, to 20 mm in fruit	15–16 mm in flower to 22 mm in fruit
Corolla	whitish to pale yellow, cylindrical, glabrous-papillose	cream, cylindrical to campanulate, subglabrous
Filaments	5 mm	7 mm
Nutlets	3–3.5 × 2–2.5 mm, prominent shoulders, acute-acuminate, cream to brownish	2–2.5 mm, bipyramidate, acute, brownish

that has not been previously recognized within the known *Onosma* diversity. Consequently, it was concluded that the proposed taxon is a new species of *Onosma*.

In this study, it was determined that the newly collected *Onosma* specimen exhibits distinct morphological differences, particularly when compared to *O. stenoloba* Hausskn. ex Riedl. As a result, the primary objective of this study is to describe *O. guniae* as a new species within the genus *Onosma*. In addition to this taxonomic description, the study comprehensively analyzes the morphological characteristics, diagnostic features, palynological properties, and conservation status of this newly identified taxon.

MATERIALS AND METHODS

Onosma guniae specimens were collected from the serpentine area at 7-8 km from Erzincan-Bayburt in the northwestern parts of Erzincan province (Eastern Anatolia, Turkey) during the flowering and fruiting periods in 2023 during a research excursion covering northern and eastern Anatolia. A total of 20 herbarium specimens were collected from one locality and deposited in MERA and ANK (acronyms according to Thiers, 2018). The *O. guniae* specimens, after being collected from the study area, were initially compared with the Flora of Turkey and the Eastern Aegean Islands, but no conclusive result was obtained. Subsequently, the floras of neighboring countries such as Syria, Palestine, USSR, Iran, and Iraq were examined (Boissier, 1849, 1879; Dinsmore, 1932; Riedl, 1967, 1978; Ball, 1972; Popov, 1974). However, the investigated samples were significantly different from all other *Onosma* species in these floras. Therefore, the unidentified samples were compared with *Onosma* taxa from herbaria; E, W, GAZI, ANK and MERA. As a result, all the examinations revealed that the samples were very similar to *O. stenoloba* but there were significant morphological differences between them (Figure 1–3 and Table 1). Pollen and nutlet samples were obtained by taking the samples into separate envelopes during field studies.

For palynological studies, we randomly selected 50 pollen grains and 30 mature nutlets from the separately placed envelopes and measured them using light microscope (LM) and stereo-binocular microscope. Also, for the analysis of some more detailed morphological characters, observations were made using scanning electron microscope (SEM). Pollen preparations were prepared from the dried specimens using the Wodehouse method (Wodehouse, 1935) and examined under a Light Microscope (LM). Parameters such as the polar axis (P), equatorial axis (E), and other palynological characteristics (see Table 2) were measured using a 100x objective on an Olympus BX51 research microscope until a gaussian curve was obtained (Table 2). For SEM observations, pollen was isolated from dried specimens without further processing. The isolated dried pollen was placed on aluminum stub holders using double-sided carbon tape and coated with platinum under vacuum. SEM micrographs of the pollen grains and nutlets were taken using a ZEISS Supra 55 microscope. Palynological terminology followed the standards set by Wodehouse (1935), Faegri and Iversen (1989), and Punt *et al*. (1994).

TAXONOMIC TREATMENT

Onosma guniae Binzet, ***sp. nov***. **Figs. 1-4 & S1**

Type: TURKEY, Erzincan, Erzincan-Bayburt 7–8 km, serpentine fields, 39º50' N, 039º23' E, 1500–1680 m, 09 vi 2023, *Binzet 202310* (holotype: MERA, isotypes: ANK).

Diagnosis: *Onosma guniae* is closest to *O. stenoloba* Hausskn. ex Riedl but can be distinguished by its shorter stem, 8–15 cm (not 25–30 cm); Basal leaves oblanceolate to linear-spathulate (not only linear-spathulate); Cauline leaves 15–40 × 2–5 mm (not 30–45(-50) × 5–10 mm); Bracts 10–30 × 2–7 mm (not 5–17 mm); Pedicels 1–3 mm (not 1–1.5 mm); Calyx 10–14 mm in flower, to 20 mm in fruit (not 15–16 mm in flower to 22 mm in fruit); Corolla whitish to pale yellow, cylindrical, glabrous-papillose (not cream, cylindrical to campanulate, subglabrous); Filaments ca. 5 mm (not ca. 7 mm); Nutlets 3–3.5 × 2–2.5 mm, (not 2–2.5 mm) (Table 1).

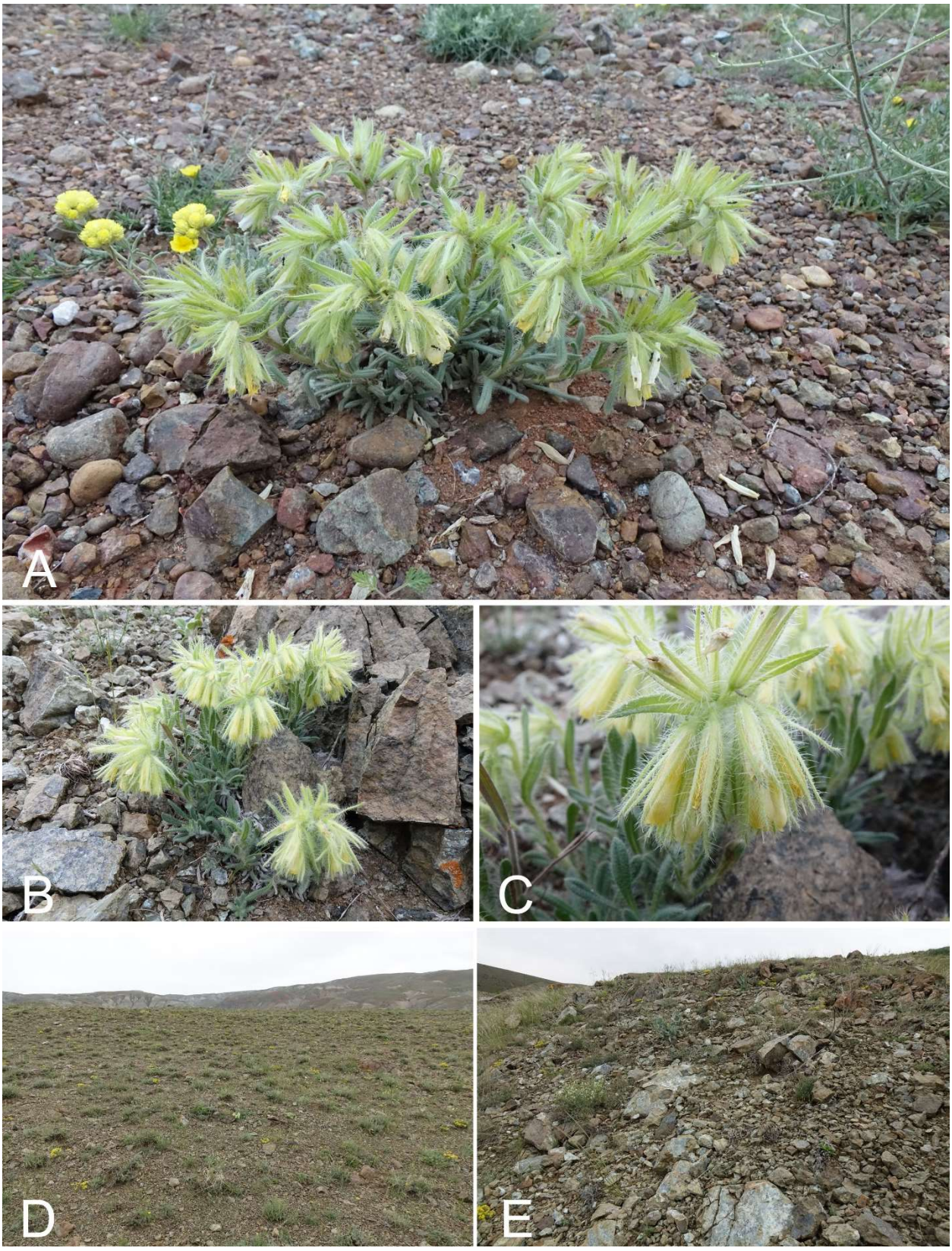

Fig. 1. ***Onosma guniae*** Binzet in its type locality, photograph by Rıza Binzet. **A & B.** General habitus **C.** Flowers (calyx and Corolla) **D & E.** habitats

Table 2. Morphological parameters of ***O. guniae*** and ***O. stenoloba*** pollen (µm)

Taxa	Pollen shape P/E	P	E	plg	plt	clg	clt	Ex	i	t
O. guniae	Subprolate 1.24	17.40 ±0.86	14.03 ±1.03	3.42 ±0.27	3.38 ±0.22	13.32 ±0.69	3.43 ±0.19	0.50	0.55	5.31
O. stenoloba	Subprolate 1.28	15.81 ±0.45	12.35±0.48	3.15±0.43	3.60±0.44	10.94±0.29	3.10±0.22	0.40	0.71	6.78

P: polar axis, E: equatorial axis, plg: pores length, plt: pores width, clg: colpus length, clt: colpus width, Ex: exine thickness, i: intine thickness, t: polar triangular edge length.

Description: Perennial, caespitose with short sterile shoots; stems numerous, 8–15 cm and to 2.5 mm diameter, ascending, covered with long patent rigid-setose (-5 mm) on glabrous or tiny stellate hairy tubercles and densely retrorse shortly hair. Basal leaves forming subcaespitose rosettes, somewhat shriveled at flowering time, 15–30 × 2–3 mm, oblanceolate to linear-spathulate, obtuse, margins subsessile, patent setose with stellate hairy on tubercles, stellate hairy with 15–30 ray. Cauline leaves 15–40 × 2–5 mm, linear to linear-spathulate, obtuse, margins revulate, covered with patent setae with ±stellate hair tubercles, somewhat covered with setae without stellate and irregular hairy between setae.

Inflorescence of 2–4 terminal, scorpioid-capitate, at first, becoming elongated, rather lax. Bracts lanceolate, 10–30 × 2–7 mm, obtuse-acute. Pedicels 1–3 mm. Calyx 10-14 mm in flower, to 20 mm in fruits, lobes 5, divided to base, linear to linear-lanceolate, acute, cover with patent setose and short hair on outside, shortly hair on inside. 1–2 mm wide. Corolla whitish to pale yellow, 16–18 mm, cylindrical, glabrous-papillos except on lobes, lobes 5, reflexed, 1.5 mm wide and 1 mm long, widely triangular, acute. Nectarifer annulus glabrous. Anthers sagittate, included, longer than filament, linear, 7 mm long, connate at base, bidentate apical sterile appendage. Filaments ca. 5 mm, arising from the corolla tube. Style 2–4 mm protruding outside the corolla limb, stigma distinctly bilobed. Nutlets 3–3.5 × 2–2.5 mm, ovoid with minutely beaked and prominent shoulders, acute-acuminate, ventral keeled, smooth, shine cream to brownish.

Etymology: The species name *Onosma guniae* is derived from the name of the collector's wife, Gün Binzet, an inorganic chemist. *Onosma guniae*'s vernacular name in Turkish is "Emzikotu" or "Emcek". In this context, the Turkish name of this species is proposed as "gün şincarı", according to the guidelines of Menemen *et al*. (2016).

***Phenology*:** Flowering from May to July and fruiting from june to August.

***Palynology*:** Pollen grains are heteropolar, trisyncolporate and subprolate P/E (Polar axis/Equatorial axis) ratio 1.24. The exine ornemantation is scabrate. The term scabrate was used for the exine sculpturing elements smaller than 1 µm. The average means of the number of scabrae in 1 µm^2 ranges from 15 to 20. The main palynological characters and SEM micrographs of *O. guniae* and *O. stenoloba* are presented in Table 2 and Fig. 2.

***Nutlet morphology*:** Nutlets 3–3.5 × 2–2.5 mm, ovoid with minutely beaked and prominent shoulders, acute-acuminate, ventral keeled, smooth, shiny cream to brownish. Nutlet cells are characterized by large epidermal cells with a pentagonal-polygonal shape and a flat surface. The walls of the epidermal cells are usually concave (Fig. 3).

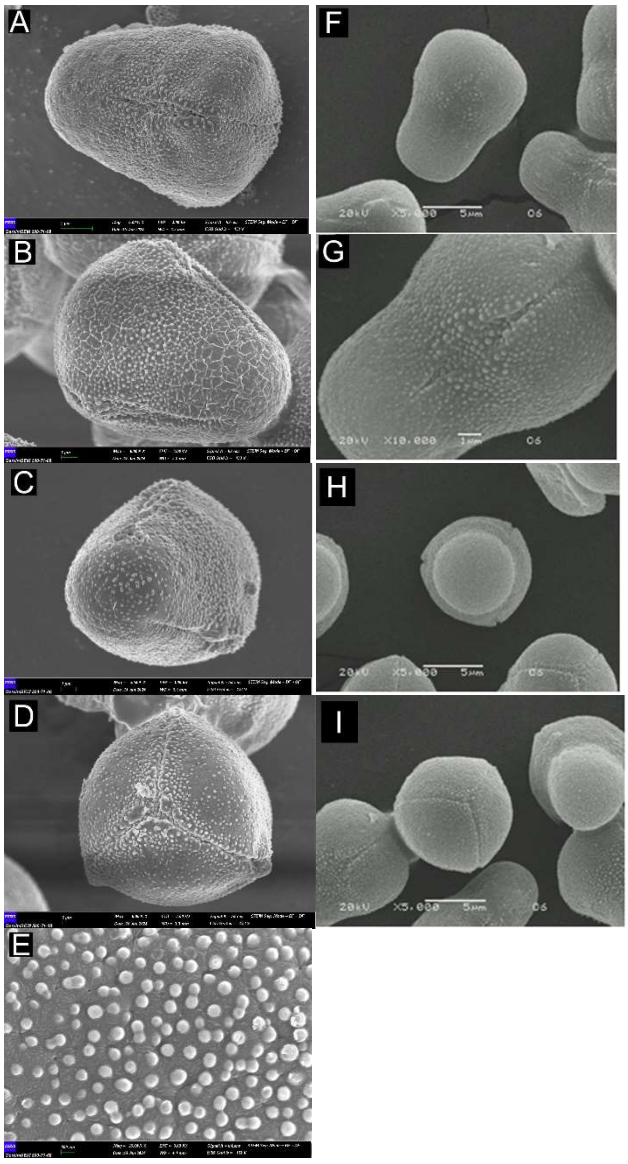

Fig. 2. SEM (**A-E**) micrographs of ***Onosma guniae*** pollen (Coll. no: *Binzet 202310*, MERA). **A & B.** profile view. **C.** proximal pole. **D.** distal pole. **E.** ornamentation; **F-I.** micrographs of ***O. stenoloba*** pollen (Coll. no: *Binzet 44*, MERA). **F & G.** profile view. **H.** proximal pole. **I.** distal pole.

***Distribution and habitat*:** Endemic to eastern Anatolia, Turkey, it belongs to the Irano-Turanian

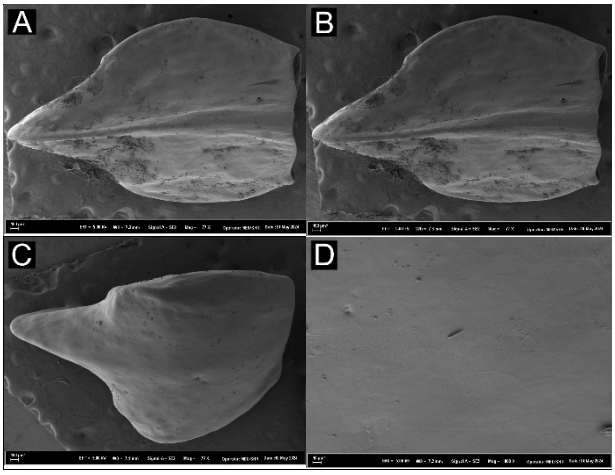

Fig. 3. SEM micrographs of ***Onosma guniae*** nutlets **A, B.** ventral view, **C.** dorsal view, **D.** ornamentation

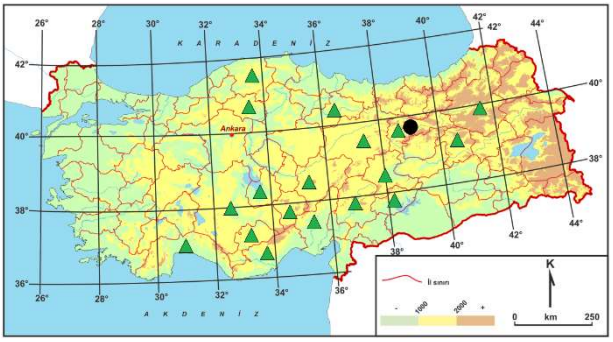

Fig. 4. Distribution map of ***Onosma guniae*** (black circle) and ***O. stenoloba*** (green triangle).

floristic region. It is only known from the type locality, located 7–8 km northwest of the province of Erzincan (Fig. 4). The species is found in serpentine rocky areas at elevations between 1500 and 1680 m.

Conservation: *Onosma guniae* is an endemic species found in only a single location, with an area of occupancy (AOO) and extent of occurrence (EOO) estimated at 8 km². The population of this species is estimated to consist of approximately 200-300 individuals, suggesting a limited genetic diversity. The species occurs in an area close to a road, which has altered part of its habitat due to road expansion projects. Although no significant threats are currently evident in the species' distribution area, its proximity to an urban center raises concerns about potential future threats from urban development and construction. Such developments could increase the risk of habitat loss and degradation, threatening the species' long-term survival. According to IUCN (2024) criteria, *O. guniae* is classified as Critically Endangered (CR) under the B2ab(i,ii,iii) criteria, due to its occurrence in a single location and its very restricted distribution. This classification highlights the serious threats to the species' survival, stemming from its small habitat size, limited population, and narrow genetic diversity. Therefore, urgent conservation measures and strategies are essential to ensure the persistence of this species for future generations.

Examined representative specimens of related species: Onosma stenoloba: ***Type***: Turkey A5 Kastamonu: Tossia (Tosya) in montosis, 30 vi 1892, *Sintenis 5270* (holo W!); Kahramanmaraş, Kahramanmaraş-Göksun 65 km, roadside and rocky and stoney slopes, 1320 m, 37°54′625″ N, 036°35′033″ E, 27 May 2004, *Binzet 41* (Herb. MERA); Kahramanmaraş, Göksun-Sarız 10 km, roadside and slopes, 1500 m, 38°05′915″ N, 036°28′257″ E, 27 May 2004, *Binzet 42* (Herb. MERA); Kahramanmaraş, Göksun-Sarız 45 km, roadside and slopes, 1627 m, 38°21′768″ N, 036°26′510″ E, 27 May 2004, *Binzet 40* (Herb. MERA); Kahramanmaraş, Yeşilkent-Tufanbeyli 5 km, roadside, 1700-1800 m, 38°14′985″ N, 036°22′019″ E, 28 May 2004, *Binzet 43* (Herb. MERA); C5 Mersin: Yeniköy-Arslanköy 3 km, roadside, rocky and stoney slopes, 1050-1200 m, 37°00′121″ N, 034°29′366″ E, 13 June 2004, *Binzet 44* (Herb. MERA)

DISCUSSION

One of the primary causes of biological diversity is the adaptation of plants to extreme edaphic conditions, referred to as "edaphic islands." The high levels of endemism observed in soils derived from rocks such as gypsum and serpentine have been characterized as "geological endemism," and these areas are termed "geological islands" or "edaphic islands." Only plants that have genetically adapted to these extreme edaphic conditions have been able to survive in these soils (Reeves *et al*., 1999; Rajakaruna, 2004).

Serpentine soils host extraordinarily high levels of plant endemism in many regions; for example, 215 taxa in California, 854 in Cuba, and 1150 in New Caledonia are recorded as species found exclusively on serpentine soils (Anacker *et al*., 2011). Studies on the flora of Turkey, particularly those based on Flora of Turkey Volumes I-XII and other sources, have identified 223 taxa growing on ultramafic serpentine rocks. Among these taxa, 142 are endemic, and 8 are classified as rare on national and international scales (Kurt *et al*., 2013). The unique chemistry of serpentine rocks and the exceptional levels of plant endemism have stimulated extensive research on plant adaptation, speciation, species invasions, interspecific interactions, ecosystem degradation, plant diversity, and climate change.

Turkey's ophiolitic series (Serpentine Series, Greenstone Series) consists of ultrabasic extrusive rocks and associated sedimentary rocks, forming a characteristic component of the country's Alpine orogeny. These rocks, considered a typical geosynclinal formation, are among the regions in Turkey rich in endemism. Ultramafic rocks are widely distributed across various geographical regions of the country, except for the eastern and southeastern Anatolian regions. These rocks are found along several areas, including the mountains of Antalya, Muğla, Hatay, and Amanos, the Eastern Taurus Mountains, within the Aladağ massif between Niğde and

Adana, to the north and northeast of Mersin, and along a stretch from Kütahya, Balıkesir, and Adana to Erzincan, spanning hundreds of kilometers (Kurt *et al*., 2013).

Detailed observations made during field studies have revealed that *O. guniae* is distributed exclusively on serpentine substrate, located 7–8 km northwest of Erzincan province. This finding indicates that *O. guniae* is a strict serpentine endemic species and can be classified as a serpentinophyte. These results could be further confirmed through more comprehensive and in-depth research on the genetic solutions, adaptive expansions, and life strategies developed by these taxa to adapt to their habitat. Such studies would allow a better understanding of how species evolve in response to environmental factors, what genetic changes occur, and how these changes relate to their survival strategies. Furthermore, these studies could shed light on how species respond flexibly to changes in ecosystems and habitat loss, thereby contributing to the development of strategies for biodiversity conservation. In Turkey, *O. sericea* Willd. is considered a serpentinovag, while *O. cappadocica* Siehe ex Riedl., *O. mitis* Boiss. & Heldr., *O. serpentinica* Yıldırım & Binzet and *O. guniae* are classified as serpentinophytes (Kurt *et al*., 2013 and Binzet *et al*., 2024).

Considering the field studies and literature reviews conducted so far, although serpentine areas were initially not thought to be part of the distribution range of *O. stenoloba*, Binzet's field studies conducted in 2007 in the regions between Yeniköy and Arslanköy districts of Mersin province revealed that the species actually spreads in serpentine areas. Additionally, as seen in Figure 3, the distribution areas of *O. guniae* and *O. stenoloba* species are close to each other. Although *O. stenoloba* has more tolerant ecological conditions, one of the common features of both species is that they spread in similar edaphic conditions.

In recent years, many new *Onosma* taxa have been described in Turkey (Koyuncu *et al*. 2013; Tarımcılar *et al*., 2015; Cecchi *et al*., 2016; Binzet, 2016a,b, 2024; Binzet and Eren, 2018; Sezer, 2021; Fırat and Binzet, 2021, 2024; Aytaç *et al*., 2023; Binzet, 2025). These studies reveal the rich diversity of the *Onosma* genus in Turkey and the increase in the number of endemic species. In this study, *O. guniae*, defined as a new species, was compared with other *Onosma* taxa recently described in Turkey and it was determined that *O. guniae* was different from these species. With the description of *O. guniae*, the number of *Onosma* species distributed in Turkey increased to 108, revealing that Turkey is the most important biodiversity center for the *Onosma* genus. 65 of these species are endemic, with an endemism rate of approximately 60%. The high endemism rate emphasizes that Turkey is the gene center for *Onosma* and the critical importance of this region in understanding the evolutionary history and biodiversity of the genus.

O. guniae belongs to the *Onosma* sect., *Asterotricha* subsect. It is distributed in East Anatolia (Erzincan) and grows in serpentine areas. It is an element of the Irano-Turanian phytogeographical region. *O. guniae* is a locally endemic species, morphologically isolated in the serpentine substrates of Eastern Anatolia, and is closely related to *O. stenoloba*.

It shows some affinity to *O. stenoloba*, which is placed in the Asterotricha subsect. and can be easily distinguished from *O. stenoloba* by several distinctive properties. *O. guniae* is characterized by the shorter stem, longer setose and narrower cauline leaves, longer bracts and pedicels, a different corolla color, shorter filaments, distinct nutlet shape and size, and bigger pollen. The other details of the differences between *O. guniae* and *O. stenoloba* are listed in Table 1.

The necessary detailed key to *O. guniae* and *O. stenoloba* is proposed below. The characters given in the key mainly consider the type specimens studied as well as the relevant taxonomic literature (Riedl, 1978).

Key to *Onosma guniae* and *O. stenoloba*

1. Stem 25–30 cm, cauline leaves 30–45(-50) × 5–10 mm, bracts 5–17 mm, pedicels 1–1.5 mm, nutlets 2–2.5 mm ……. ***O. stenoloba***
1. Stem 8–15 cm, cauline leaves 15–40 × 2–5 mm, bracts 10–30 mm, pedicels 1–3 mm, nutlets 3–3.5 mm …… ***O. guniae***

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