Onosma fuyunensis (Boraginaceae), a new species from Xinjiang, China

Yi He¹, Xue-Min Xu¹, Yu Zhou², Quan-Ru Liu¹

¹ Key Laboratory for Biodiversity Science and Ecological Engineering, Ministry of Education, College of Life Sciences, Beijing Normal University, Beijing 100875, China ² Taiziwan School, Shenzhen, Guangdong 518067, China

Corresponding author: Quan-Ru Liu (liuquanru@bnu.edu.cn)

Abstract
Onosma fuyunensis, a new species of Boraginaceae from northern Xinjiang, China, is described and illustrated here. Onosma fuyunensis is similar to O. simplicissima and O. gmelinii; it differs in having a particularly bristly indumentum, unbranched stems, white and yellow corollas, anthers united only at base, and nutlets with a stipitate cicatrix. An updated key to the species of Onosma from Xinjiang and Altai Mountains is also provided.

Keywords
Boraginaceae, new species, Onosma fuyunensis, Xinjiang

Introduction
Onosma L. (Boraginaceae-Lithospermeae), one of the largest genera in Boraginaceae, is primarily distributed in the temperate zones of the Old-World, with the main center of diversity in the Irano-Turanian region (Weigend et al. 2016). In recent years, several new species of Onosma have been described (Riedl et al. 2004, Binzet and Orcan 2007, Kandemir and Turkmen 2010, Aytac and Turkmen 2011, Almasi and Ranjbar 2015, Tarimcilar et al. 2015, Binzet 2016a, Binzet 2016b, Cecchi et al. 2016, Binzet and Eren 2018, Dehshiri 2018, He et al. 2018, Mehrabian and Mozaffarian 2018, Mehrabian and Rad 2018), which increases the total number of Onosma species to nearly 240. The northeastern region of the geographic distribution of the genus ranges from Turkestan to Altai (Johnston 1951), with the Altai Mountains running through Russia, China, Mongolia and Kazakhstan. In this area, four species and one subspecies
of *Onosma* have been described (Krylov 1907, Popov 1953, Rybinskaya 1997, Baitulin and Kotukhov 2011, Urgamal et al. 2014). Furthermore, five species and one subspecies of *Onosma* are recorded in Xinjiang (Riedl 1995, Zhu et al. 1995, Pan and Nurbay 2004), a region of China that includes the southern part of Altai Mountains.

In Flora of the USSR, Popov (1953) provided the classification of sect. *Aponosma* DC. and sect. *Euonosma* DC (subsect. *Haplotricha* Boiss. and subsect. *Asterotricha* Boiss.), which was a combination of Candolle (1846) and Boissier (1875). On a sectional level, the morphology of the calyx in fruit and of the leaf indumentum are considered as the main diagnostic characters, but recent molecular data does not support the monophyly of these sections or subsections (Cecchi et al. 2016, Nasrollahi et al. 2019). On a specific level, the morphology of the flowers, the indumentum inside the corolla, and the morphology of the filaments and anthers have demonstrated to be useful characters (Johnston 1951, Liu 1989). Nutlet and pollen morphology also may be important characters to clarify similar species in *Onosma* taxonomy. (Binzet et al. 2014, Mehrabian et al. 2012, He et al. 2018).

In the process of a taxonomic revision of Chinese *Onosma* species, the identification of specimens from Xinjiang was extremely confusing, especially those specimens collected from Fuyun and Qinghe County, Altay City. Some of the specimens were identified as *O. simplicissima*, while others were assigned to *O. gmelinii*. However, within this group of *Onosma* is clearly another distinct taxon with a combination of characters that could not be associated with either *O. simplicissima* or *O. gmelinii*. Further detailed literature examination and field trips to Northern Xinjiang convinced us that this neglected taxon has been mistakenly mixed within those two species for more than half a century. To our best knowledge, it is not any other known species from the Altai Mountains and nearby regions. Here, we clarify the confusion by describing and illustrating this new species. An updated key of genus *Onosma* from Altai Mountains and Xinjiang is also provided for further study.

**Materials and methods**

A total of 37 herbarium specimens of *Onosma fuyunensis* were collected from four populations in Northern Xinjiang, China in July, 2017. Type photos of accepted names and their synonyms from Xinjiang and adjacent regions were examined and compared along with 133 herbarium specimens from BNU, KUN, N, NAS, PE, XJA, XJBI, YUKU and 731 specimen pictures from BM, E, FL, K, KW, L, G, MO, MW, P and W. Images of morphological features were taken by Nikon digital camera with macro lens. Dried leaves, nutlets, and pollen grains were settled on stubs using double-sided adhesive tape and were coated with gold by Hitachi E-1045 ion sputter, photographed by Cam Scan Hitachi SU4800 Electron Microscope. For pollen studies, 30 pollen grains were measured for polar axis (P) and equatorial axis (E). Voucher information for the plant materials used was shown in Table 1. Terminology for pollen was used under Erdtman (1952) and Punt et al. (1994). The main characters for comparison of related species are presented in Table 2, which were measured by Image J 1.52a (Abràmoff et al. 2004). Conservation assessments were made according to the IUCN Standards and Petitions Committee (2019) guidelines.
Table 1. Voucher information for the plant materials used.

| Taxa                      | Voucher information      | Locality                        |
|---------------------------|--------------------------|---------------------------------|
| O. fuyunensis             | Y. He & Y. Zhou XJ133 (BNU) | China, Xinjiang, Fuyun          |
| O. gmelinii (corolla and pollen) | Anonymous 80617-1 (XJU)   | China, Xinjiang, Hebuksesier    |
| O. gmelinii (nutlet)      | Anonymous 803220 (XJU)   | China, Xinjiang, Buerjin        |
| O. simplicissima          | Anonymous 19492 (YUKU)   | USSR, Voronezh                  |

Table 2. Comparison of Onosma fuyunensis with O. gmelinii and O. simplicissima.

| Organ          | Character                        | O. fuyunensis | O. gmelinii | O. simplicissima |
|----------------|----------------------------------|---------------|-------------|------------------|
| Habit          | life form                         | perennial herb with rosettes | perennial herb with rosettes | subshrub with woody branching base and sterile shoots, without rosettes |
| Leave          | indumentum                       | spreading bristles | spreading bristles | appressed bristles |
|                | venation                         | reticulate    | obscure     | obscure          |
| Inflorescence  | length (cm)                      | slightly elongating and straightening in fruit, 5–11 | markedly elongating and straightening in fruit, 10–22 | markedly elongating and straightening in fruit, 5–9 |
| Bract          | shape                            | lanceolate to linear-oblancoate | lanceolate | lanceolate to linear-oblancoate |
|                | size (mm)                        | 12–20 × 1.2–4.5 | 13–31 × 3.5–10 | 7–15 × 1.5–3.5 |
| Calyx          | lobe                             | parallel in fruit | converging in fruit | angular in fruit |
|                | size (mm)                        | 15–23 × 1–2 | 13–22.5 × 1.5–3 | 6–13 × 0.8–1.2 |
| Corolla        | length (mm)                      | 22–27         | 19–30       | 15–20            |
|                | color                            | cream and light yellow | pale yellow | cream and light yellow |
| Androecium     | anther (mm)                      | united only at base, included, 7–8 | united into a tube, apex exerted, 8–10 | united only at base, included, ca. 5 |
|                | filament (mm)                    | 9–11          | 7–9         | ca. 8             |
|                | pollen shape                     | isopolar      | heteropolar | unknown           |
|                | polar axis (μm)                  | 21.91 ± 1.19  | 14.41 ± 1.03 | unknown           |
|                | equatorial axis (μm)             | 13.83 ± 0.17  | 9.98 ± 0.12  | unknown           |
| Nutlet         | length (mm)                      | ca. 5         | ca. 5       | ca. 2.5           |
|                | cicatrix                         | stipitate     | complanate  | unknown           |
|                | epidermis cells                  | rectangular   | reticulate  | unknown           |

Taxonomic treatment

**Onosma fuyunensis** Y. He & Q.R. Liu, sp. nov.
urn:lsid:ipni.org:names:77208267-1
Figs 1C, D, 2, 3B, C, G, I, 4

**Onosma gmelinii** auct. non Ledeb.: Fl. Reipub. Popul. Sinicæ 64(2): 54. 1989. p.p.; Fl. China 16: 352. 1995. p.p.; Clavs Plantarum Xijiangensis. 428. 2000. p.p.; Fl. Xinjiangensis 4: 157. pl. 50. 2004. p.p.

**Onosma simplicissima** auct. non L.: Fl. China 16: 351. 1995; Fl. Xinjiangensis. 4: 157. 2004.
**Type.** China. Xinjiang: Between Fuyun County and Keketuohai Town, Y. He & Y. Zhou BNU2017XJ133, 7 July 2017, 1270 m a.s.l., rocky slopes, 46°59’01”N, 89°41’42”E. (Holotype: BNU 0041549; Isotype: BNU, PE).

**Diagnosis.** Closely allied to *O. simplicissima* L., a widespread species distributed from E Europe to E Siberia. It is differentiated by being perennial herb with rosettes (v.s. mostly subshrub with woody branching base and sterile shoots, Fig. 1B), having leaves with spreading bristles (Fig. 2 C–F, v.s. densely silky appressed pilose), larger nutlets (ca. 5 mm v.s. 2.5–3 mm), longer calyx (15–22 mm v.s. 6–13 mm) and corolla (22–27 mm v.s. 18–20 mm). Also nearly to *O. gmelinii* Ledeb., but different through having obvious reticulate venation (v.s. obscure lateral veins), slightly elongating and straightening inflorescences in fruit (v.s. markedly elongating and straightening), longer and parallel calyx lobes in fruit (1.2–2 mm v.s. ca. 4 mm, lobes converging), cream and pale yellow corolla (v.s. pale yellow), included anthers united only at base (v.s. united into a tube, Fig. 3D), nutlet with stipitate cicatrix and elongated, rectangular surfaces epidermis cells (v.s. complanate cicatrix and reticulate cells, Fig. 3A, F) and isopolar pollen grains (v.s. heteropolar, Fig. 3H).

**Description.** Herbs perennial, 15–40 cm tall, hispid, strigose. Stems single or several (1–4) arise from rosettes, capitate, erect, not branched, usually pale straw to light brown, densely covered with long white spreading bristles. Basal leaves short petiolate, linear to linear-oblanceolate, 10–23 cm × 3–10 mm, abaxially densely pubescent and hispid along rised midrib and margin, reticulate venation, adaxially densely appressed hispid and short strigose, base attenuate, apex acute; Cauline leaves sessile, lanceolate, 2–5 cm × 1.5–5 mm. Inflorescences terminal, solitary or dichotomously branched, 4–8 cm wide at anthesis, length to 11 cm in fruit, flowers 5–20; bracts lanceolate to linear-oblanceolate, 1.2–2 cm × 1.2–4.5 mm, densely hispid, short strigose. Pedicel short, ca. 5 mm. Calyx 1.5–2.3 cm × 1–2 mm, densely hispid, short strigose, parted nearly to base; lobes linear. Corolla cream above middle, light yellow below middle, clavate, 2.2–2.7 cm, base ca. 2 mm wide, gradually expanded upward; throat ca. 5 mm wide, obscurely pubescent outside, glabrous inside; lobes broadly triangular, ca. 1.5 × 3 mm. Filaments subulate, 9–11 mm, decurrent; anthers united only at base, 7–8 mm, included, apex sterile, ca. 2 mm. Style 2.4–2.8 cm, glabrous. Nectary ca. 1 mm, glabrous. Pollen grains isopolar, tricolporate and prolate, polar axis (P) 21.91 ± 1.19 μm, equatorial axis (E) 13.83 ± 0.17 μm, P/E ratio 1.58. Nutlets gray-brown, ca. 5 mm × 3 mm, lustrous, smooth, ventral keeled, stipitate cicatrix.

**Phenology.** Flowering and fruiting occurs from May to July.

**Etymology.** The specific epithet of the new species refers to its type locality, Fuyun County, Xinjiang, China.

**Distribution and habitat.** *Onosma fuyunensis* is mainly distributed in Fuyun County, Qinghe County and Altay Prefecture (Fig. 4), it is also known from W Mongolia near the border (Khovd aimag), according to the photo record by Peter Kosachev (http://www.plantarium.ru/page/image/id/128255.html). It prefers dry rocky screes and upland meadows along the hillside, from 500–1400 m a.s.l. Species growing nearby are: *Echinops gmelinii* Turcz, *Goniolimon speciosum* (L.) Boiss., *Artemisia rutifolia* var. *altaica* (Kryl.) Krasch. and *Carex turkestanica* Regel.
Onosma fuyunensis (Boraginaceae), a new species from Xinjiang, China

Figure 1. Type specimens of Onosma gmelinii (A syntype, W 1899-0213498), O. simplicissima (B lectotype, LINN No. 187.1) and O. fuyunensis (C holotype, BNU 0041549 D isotype, BNU 0041547).
Figure 2. Photographs of *O. fuyunensis*. A Habitat B inflorescence during late flowering season C habit D basal leaves (show spreading bristles) E leaves in abaxial view (show netted venation) F scanning electron micrographs of leaves in adaxial view. Photo by Yi He.
Figure 3. Characters comparison of *O. fuyunensis* and related species **A** nutlets of *O. gmelinii* (in adaxial and abaxial view) **B** nutlets of *O. fuyunensis* (in adaxial and abaxial view) **C** flowers of *O. fuyunensis** D corolla of *O. gmelinii* E corolla of *O. simplicissima* F scanning electron micrograph of nutlets of *O. gmelinii* G scanning electron micrograph of nutlets of *O. fuyunensis* H scanning electron micrograph of pollens of *O. gmelinii* I scanning electron micrograph of pollen of *O. fuyunensis*. Photo by Yi He.
Conservation status. According to current data, *Onosma fuyunensis* grows in a large area of ca. 70,000 km² between N Xinjiang and W Mongolia. Similar habitats are common in this area. During our field investigation, four large populations (at least 50 mature individuals) of this species were easily found even at the end of its flowering season. *Onosma fuyunensis* could be the dominant species in some scree and meadows. In this area, human activities are infrequent, and grazing pressure is low. Historical specimens of this taxon are also abundant (from 16 different locations). According to the IUCN Standards and Petitions Committee (2019) criteria, we justify a preliminary status of ‘Least Concern’ (LC). More accurate quantitative analyses should be used for assessment after more field works in the future.

Additional specimens examined. China. Xinjiang: Altay Prefecture, Dahe forestry station, 1400 m, 5 July 1985, *Anonymous* 85-5751 (XJU00016072B); Altay Prefecture, Dahe forestry station, 1200 m, 5 July 1985, *Anonymous* 85-0225 (XJU00016073B); Altay Prefecture, Dahe forestry station, 1400 m, 12 June 1985, *Pi 85018* (XJU00016076B); Altay Prefecture, Dahe forestry station, 900 m, 6 July 1985, *Pi 85017* (XJU00016086B); Altay Prefecture, Aweitan Police checkpoint, 815 m, 8 July 2017, *Y. He et Y. Zhou* BNU2017XJ153 (BNU0041544); Altay Prefecture, Xiaodonggou forest park, 1000 m, 8 July 2017, *Y. He et Y. Zhou* BNU2017XJ159 (BNU0041543); Altay Prefecture, Xiaoixigou, 1 July 1973, *Anonymous* Altay197 (XJBI00031718); Fuyun County, roadside to Qinghe County, 1200 m, *G.J. Liu et al.* Altay901 (XJBI00031717);
Discussion

This species is widely distributed in the middle and low altitude mountains in the eastern part of the Altai Mountains. In the past 60 years, multiple specimens of this taxon have been collected; however, they were not recognized correctly. According to its nature of indumentum, *O. fuyunensis* belongs to subsect. *Haplotricha* Boiss. Morphologically, in the color and shape of the corolla, this species is close to *O. simplicissima*. The upper part of the fresh corolla is milky white, and the part below the calyx is light yellow. The whole corolla turns pale yellow after drying. The filaments are slightly longer than the anthers, which are united only at base and not exserted from the corolla. The calyx of this species is longer, nearly half to 2/3 of the length of the corolla, while the calyx of *O. simplicissima* is shorter, only ca. 1/3 of the length of the corolla. There is a large difference in the vegetative features of the plants of this newly described species. *O. fuyunensis* is perennial herb with highly-developed rosettes, lacking sterile shoots, covered with long and spreading bristles, while *O. simplicissima* is subshrub with differentiation of flowering shoots and sterile shoots (without rosettes) and its indumentum is appressed. The vegetative parts of *O. fuyunensis* are similar to those of *O. gmelinii*. Both of these species are perennial herbs with rosettes and spreading bristles. The species could not be easily distinguished without the presence of cymes. In addition to the significant differences in aforementioned floral morphology, the stems of *O. gmelinii* are usually bluish, and those of *O. fuyunensis* are generally straw-colored to light-brown.

Geographically, *O. fuyunensis* is mainly distributed in the southeastern part of the Altai Mountains in China and Mongolia. *O. simplicissima* was recorded in Northern Xinjiang by Zhu et al. (1995) and Pan and Nurbay (2004); however, after we examined...
multiple specimens of *Onosma* collected from China, no specimen should be identified to this taxa. Those previous records were misidentified as either *O. fuyunensis* or *O. gmelinii*. According to Popov (1953), *O. simplicissima* can range eastward to the upper reaches of the Yenisei River and to the northern part of Kazakhstan, so there is no overlap between these two species. *O. gmelinii* is primarily distributed in Central Asia and Siberia. In China, this species is distributed from Kanas Lake, the junction of China and Kazakhstan, to Qinghe County, which makes it sympatric with *O. fuyunensis*.

### Key to the species of genus *Onosma* in Altai Mountains and Xinjiang

|   |   |
|---|---|
| 1 | Anthers coherent only at base .................................................................2 |
|   | Anthers coherent into a tube .................................................................6 |
| 2(1) | Subshrubs or perennial herbs, stems mostly not branched; corolla cream and pale yellow, filaments longer than anthers ...........................................3 |
|   | Biennial herbs; stems branched; corolla yellow, filaments shorter than anthers .................................................................4 |
| 3(2) | Perennial herbs with rosettes, leaves with spreading bristles, calyx lobes parallel in fruit, 15–23 mm, corolla 22–27 mm ................1. *O. fuyunensis* |
|   | Mostly subshrubs with sterile shoots, leaves with appressed bristles, calyx lobes angular in fruit, 6–13 mm corolla 15–20 mm........2. *O. simplicissima* |
| 4(2) | Plants strongly whitish gray hirsute; corolla longer than 20 mm...3. *O. setosa* |
|   | Plants yellow-green hirsute or sparse whitish hirsute; corolla shorter than 20 mm .................................................................5 |
| 5(4) | Cauline leaves lanceolate, 4–6 cm × 6–11 mm........4. *O. borysthenica* |
|   | Cauline leaves linear, 3–5 cm × 3–5 mm .................................................................5 |
| 6(1) | Bracts longer than calyx .................................................................6. *O. apiculata* |
|   | Bracts not longer than calyx .................................................................7 |
| 7(6) | Plants covered with long horizontally spreading bristles; corolla slightly longer than calyx .................................7. *O. irritans* |
|   | Plants covered with shorter bristles; corolla twice as long as calyx ................8. *O. gmelinii* |

### Acknowledgements

We would like to express gratitude to the curators of the herbaria BM, BNU, E, FL, G, K, KUN, KW, L, MO, MW, N, NAS, P, PE, W, XJA, XJBI, XJU and YUKU. We thank Feng Xue (PhD student from Faculty of Geographical Science, Beijing Normal University) for making the distribution map. This research was financed by the Fundamental Research Funds for the Central Universities (No. 310421121) and the National Natural Science Foundation of China (No. 31770213).
Onosma fuyunensis (Boraginaceae), a new species from Xinjiang, China

References

Abràmoff MD, Magelhaes PJ, Ram SJ (2004) Image processing with ImageJ. Biophotonics International 11(7): 36–42. https://doi.org/10.3233/ISU-1991-115-601

Almasi M, Ranjbar M (2015) Onosma maculata sp. nov. (Boraginaceae) from Iran. Nordic Journal of Botany 33(5): 522–525. https://doi.org/10.1111/njb.00614

Aytac Z, Turkmen Z (2011) A new Onosma (Boraginaceae) species from southern Anatolia, Turkey. Turkish Journal of Botany 35(3): 269–274.

Baitulin IO, Kotukhov YA (2011) Flora vascular plants of Kazakhstan Altai. Almaty, 124. [in Russian]

Binzet R (2016a) A new species of Onosma L. (Boraginaceae) from Anatolia. Turkish Journal of Botany 40(2): 194–200. https://doi.org/10.3906/bot-1410-23

Binzet R (2016b) Onosma anatolica, a new species of Boraginaceae from Turkey. PhytoKeys 69(69): 39–49. https://doi.org/10.3897/phytokeys.69.8360

Binzet R, Eren Ö (2018) Onosma erzincanica (Boraginaceae: Lithospermeae), a new scree species from Turkey. Phytotaxa 356(2): 117–130. https://doi.org/10.11646/phytotaxa.356.2.2

Binzet R, Orcan N (2007) A new species of Onosma (Boraginaceae) from southern Turkey. Novon 17(1): 8–10. https://doi.org/10.3417/1055-3177(2007)17[8:ANSOOB]2.0.CO;2

Binzet R, Erkara IP, Özler H, Pehlivan S (2014) Pollen morphology and systematical contribution of some Onosma (Boraginaceae) taxa distribution in Turkey. Plant Systematics and Evolution 300(10): 2135–2146. https://doi.org/10.1007/s00606-014-1030-z

Boissier PE (1875) Plantarum orientalium novarum decas secunda ex Florae orientalis volumine tertio mox exituro excerpta. H. Georg, Geneva, 9. https://doi.org/10.5962/bhl.title.52107

Candolle AP (1846) Prodromus systematis naturalis regni vegetabilis (Vol. 10). V. Masson, Parisium [Paris], 679. https://doi.org/10.5962/bhl.title.286

Cecchi L, Coppi A, Selvi F (2016) Onosma juliae (Boraginaceae), a new species from southern Turkey, with remarks on the systematics of Onosma in the Irano-Turanian region. Phytotaxa 288(3): 201–213. https://doi.org/10.11646/phytotaxa.288.3.1

Dehshiri MM (2018) Onosma zagrica (Boraginaceae), a new species from Iran. Phytotaxa 367(3): 284–290. https://doi.org/10.11646/phytotaxa.367.3.8

Erdtman G (1952) Pollen morphology and plant taxonomy: Angiosperms. Almquist and Wiksell, Uppsala, 539.

He Y, Hao JC, Ahmad L, Liu QR (2018) Onosma lhokaensis (Boraginaceae), a new species from Xizang, China. Nordic Journal of Botany 36(6): njb−01770. https://doi.org/10.1111/njb.01770

Johnston IM (1951) Studies in the Boraginaceae, XXI Sino-Indian Species of Onosma. Journal of the Arnold Arboretum 32(4): 201–225, 344–368. https://doi.org/10.5962/bhl.part.9731

Kandemir A, Turkmen Z (2010) A new species of Onosma (Boraginaceae) from eastern Turkey. Turkish Journal of Botany 34(4): 277–282.

Krylov PN (1907) Flora Altaiya i Tomskoi gubernii [in Russian] (Vol 4). Tomsk, 881–883.
Liu YL (1989) *Onosma* L. In: Kong XW, Wang WT (Eds) Flora Reipublicae Popularis Sinicae (Vol. 64, Part 2). Science Press, Beijing, 45–66.

Mehrabian AR, Mozaffarian V (2018) Seven New Species of *Onosma* L. (Boraginaceae) with emphasis on their habitats in Iran. Taiwania 63(4): 366–388.

Mehrabian AR, Rad MA (2018) *Onosma moussavi* sp. nov. (Boraginaceae) from Zagros Mountain (s), Iran. Feddes Repertorium 129(4): 304–311. https://doi.org/10.1002/fedr.201700020

Mehrabian AR, Sheidai M, Noormohammadi Z, Mozaffarian V, Asrei Y (2012) Palynological diversity in the genus *Onosma* L. (Boraginaceae) of Iran. Annals of Biological Research 3(8): 3885–3893.

Nasrollahi F, Kazempour-Osaloo S, Saadati N, Mozaffarian V, Zare-Maivan H (2019) Molecular phylogeny and divergence times of *Onosma* (Boraginaceae s.s.) based on nrDNA ITS and plastid *rpl32-trnL(UAG)* and *trnH-psbA* sequences. Nordic Journal of Botany 37(1): njb.02060. https://doi.org/10.1111/njb.02060

Pan XL, Nurbay (2004) *Onosma* L. In: Hudaberdi M, Pan XL (Eds) Flora Xinjiangensis, Tomus 4. Xinjiang Science & Technology Publishing House, Urumchi, 156–159.

Popov MG (1953) Family CXXXVIII. Boraginaceae G. Don. In: Shishkin BK (Ed.) Flora URSS (Vol. 19). Akademia Nauk, Moscow, 97–690. [in Russian]

Punt W, Blackmore S, Nilsson S, Le Thomas A (1994) Glossary of Pollen and Spore Terminology. LPP Foundation, Utrecht, 71.

Riedl H (1995) *Onosma apiculatum* (Boraginaceae), a new species from China. Novon 5(1): 19. https://doi.org/10.2307/3391822

Riedl H, Binzet R, Orcan N (2004) A new species of *Onosma* (Boraginaceae-Lithospermeae) from southern Turkey. Edinburgh Journal of Botany 61(2–3): 127–130. https://doi.org/10.1017/S0960428605000211

Rybinskaya EV (1997) *Onosma* L. In: Malyschev LI (Ed.) Flora of Siberia (Vol. 11). Science Publishers, Enfield, 118–120.

IUCN Standards and Petitions Committee (2019) Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Committee. http://www.iucnredlist.org/documents/RedListGuidelines.pdf

Tarimcilar G, Yılmaz Ö, Kaynak G (2015) *Onosma demirizii* (Boraginaceae), a new species from central Anatolia, Turkey. Bangladesh Journal of Botany 44(2): 261–265. https://doi.org/10.3329/bjb.v44i2.38515

Urgamal M, Oyuntsetseg B, Nyambayar D, Dulamsuren C (2014) Conspectus of the vascular plants of Mongolia. In: Sanchir C, Jamsran T (Eds) Ulaanbaatar, Mongolia. Admon, 158–187.

Weigend M, et al. (2016) *Onosma* L. In: Kadereit JW, Bittrich V (Eds) The Families and Genera of Vascular Plants (Vol. 14). Springer, 72.

Zhu GL, Riedl H, Kamelin RV (1995) *Onosma* L. In: Wu ZY, Raven PH (Eds) Flora of China (Vol. 16). Science Press, Beijing & Missouri Botanical Garden Press, St. Louis, 348–357.