

Taxonomic analysis of the family Boraginaceae in the "Flora of Uzbekistan"

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Abstract. As a result of the studies, it was revealed that on the territory of Uzbekistan Heliotropiaceae family is represented by 2 genera and 15 species and Boraginaceae family is represented by 31 genera and 118 species, distributed in 10 tribes. The largest number of species is represented by the genera from the tribes Eritrichieae (31) and Cynoglosseae (25). Tribe Lithospermeae (21) is distinguished by specificity of the species composition. The most ancient tribes Boragineae (8), Echieae (3), Trichdesmeae (3) are represented by a small number of taxa.

The studies were carried out as part of the «Flora of Uzbekistan» project, which represents a transition from the classical stage of the existence of botanical information, available in the form of herbarium collections and paper publications summarizing them, to the modern stage of electronic accumulation, processing and dissemination of information [1]. When conducting a critical revision of the species of the families Heliotropiaceae Schrad. and Boraginaceae Juss. for the next volume of the "Flora of Uzbekistan", an important stage of work was a taxonomic revision according to family classification in accordance with the latest data and original research of the authors. The manuscript was prepared taking into the size of the families within the framework of the modern system Boraginales, based on molecular genetic studies [2, 3], but in the author's edition, taking into account modern data of morphological, palynomorphological, carpological, karyological research and previously proposed systems [4-9]. All Herbarium collections of LE, MW, TASH, AA, TAD, NS, NSK, TK, P were studied. As a result of the studies, it was revealed that on the territory of Uzbekistan the families Heliotropiaceae and Boraginaceae are represented by 33 genera and 133 species, with two genera *Borago* and *Eritrichium*, and 11 species were first indicated for the flora of Uzbekistan [10].

The distribution of genera within tribes and families is given below. The name of the taxon is followed by the year of its publication and then, in brackets, the number of species in the flora of Uzbekistan.

Fam. **Heliotropiaceae** Schrad. 1819 (15).

1. *Tournefortia* L. 1753 (2), 2. *Heliotropium* L. 1753 (13).

Fam. **Boraginaceae** Juss. 1789 (118).

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Trib. 1. **Boragineae** Rchb. 1831 (8).

1. Borago L. 1753 (1), 2. Anchusa L. 1753 (2), 3. Gastrocotyle Bunge 1849 (1), 4. Nonea Medik. 1789 (4).

Trib. 2. **Lithospermeae** Dumort. 1827 (21).

5. Lithospermum L. 1753 (1), 6. Buglossoides Moench 1794 (1), 7. Ulugbekia Zakirov 1961 (1), 8. Macrotomia DC. 1840 (1), 9. Arnebia Forssk. 1775 (7), 10. Onosma L. 1762 (10).

Trib. 3. **Echieae** Dumort. 1827 (3).

11. Echium L. 1753 (3).

Trib. 4. **Trichodesmeae** Zakirov ex Riedl 1967 (3).

12. Trichodesma R.Br. 1810 (1), 13. Caccinia Savi 1832 (2).

Trib. 5. **Heterocaryinae** Zakirov ex Ovczinnikova 2007 (6).

14. Suchtelenia Karel ex Meisn. 1840 (1), 15. Heterocaryum A.DC. 1846 (5) (incl. Pseudoheterocaryum Kaz.Osaloo & Saadati 2017).

Trib. 6. **Asperugeae** Zakirov ex Ovczinnikova 2007 (2).

16. Asperugo L. 1753 (1), 17. Mertensia Roth 1797 (1).

Trib. 7. **Myosotideae** Rchb. f. 1858 (9).

18. Trigonotis Steven 1851(1), 19. Stephanocaryum Popov 1951 (1), 20. Myosotis L. 1753 (7).

Trib. 8. **Eritrichieae** (Benth. et Hook. f.) Guerke 1893 (31).

21. Eritrichium Schrad. ex Gaudin 1828 (1), 22. Lappula Moench 1794 (28), 23. Lepechiniella Popov 1953 (2).

Trib. 9. **Rochelieae** A.DC. 1846 (10).

24. Rochelia Rchb. 1824 (10).

Trib. 10. **Cynoglosseae** W.D.J. Koch 1837 (25).

25. Paracaryum Boiss. 1849 (2), 26. Mattiastrum (Boiss.) Brand 1915 (2), 27. Rindera Pall. 1771 (6), 28. Trachelanthus Kunze 1850 (2), 29. Lindelofia Lehm. 1850 (4), 30. Solenanthus Ledeb. 1829 (5) (incl. Kuschakewiczia Regel & M. Smirn. 1877), 31. Cynoglossum L. 1753 (4).

The Heliotropiaceae family is represented in the flora by 2 genera and 15 species that are found on coastal sand dunes, outcrops of variegated rocks, from plains to foothills, at an altitude of 200–1500 m. Representatives of these genera are common on all continents and are of considerable age.

The Boraginaceae family includes 118 species and 31 genera, distributed in 10 tribes. Let's consider each of them in more detail. The tribe Boragineae is represented by 4 genera and 8 species. The distribution of most species is intrusive, the species are found in fields, wastelands, fallow lands, along roads and irrigation ditches, weed on rainfed crops, rise to the lower belt of the mountains, to an altitude of 300-1700 m. Representatives of the tribe are mostly distributed in the Mediterranean region and the Front Asia, but some are common in the Irano-Turan region.

The tribe Lithospermeae is represented in Uzbekistan by 6 genera and 21 species. The only species of the genus *Ulugbekia* was considered earlier as part of the genera *Lithospermum*, *Macrotomia*, *Arnebia*. However, according to the structure of the corolla and eremocarp, the species differs markedly from the species of closely related genera and in 1961 was described as an independent genus [11]. The xerophytic genus *Arnebia* is heterogeneous in composition: the species belong to 4 sections. Representatives of the sections *Munbya* (Boiss.) Popov and *Cyananthae* Popov ex Riedl are common in the highlands, while *Cyananthae* species are endemic to the Tien Shan and Pamir-Alai mountain systems. The species of the *Cornuta* Popov section occupy vast areas on the loess slopes of the foothills and low mountains, less often on the stony-gravelly slopes of the remnant mountains, at an altitude of 500–1200 m. Species of the genus *Onosma* according

to the M.G. Popov [6] can be divided into two subsections and 7 kinship groups within the type section. On the territory of Uzbekistan, the genus is characterized by endemism: 8 species are endemic to Central Asia, 2 species are limited in their distribution by the Irano-Turan region. It should be noted that this tribe is distinguished in Uzbekistan and throughout Central Asia by a special specificity of the species composition.

The Echieae tribe was previously recognized as an independent [4, 6, 12]. The presence of zygomorphic flowers and absence of calciumcarbonate in the fruit wall also support the retention of genera in tribe Echieae [13]. Pollen grains of Echieae are tricolporate, heteropolar and triangular in equatorial view, ora more or less circular, while pollen of *Lithospermum* is 6–8-zonocolporate, usually isopolar and with colpi rhombic in outline [14]. In Uzbekistan, the tribe is represented by one genus *Echium* with 3 species. The South European-Mediterranean species *E. maculatum* L. is a stenotopic psammophyte found in Uzbekistan at the eastern limit of its distribution [10]. Two other species were introduced into this territory, apparently, a very long time ago, naturalized and occupy vast areas and natural ecotopes.

The tribe Trichodesmeae was first isolated by K.Z. Zakirov [5] in his system using the example of Zeravshan plants, but was not published. It was validated by H. Riedl [7]. The tribe includes 2 genera *Trichodesma* and *Caccinia* and 3 species. This tribe is one of the oldest in the family. The species are found in Africa, Southeast Asia and Australia. The genus *Trichodesma* includes species with woody, bushy and herbaceous life forms. Perennial *T. incanum* (Bunge) A.DC. – the youngest member of the genus.

The tribe Heterocaryinae was also first isolated by Zakirov [5] and recently validated [9]; it includes 2 genera and 6 species, while the position of the genus *Suchtelenia* is still controversial. In the modern system, on the basis of molecular genetic analysis, it is assigned to the same clade with some species of the genus *Heterocaryum*, in connection with which a new genus *Pseudoheterocaryum* was distinguished [15]. We do not share this point of view. Fetal signs: tetrahedral gynobasis with depressions in the edges, in which the eremocarps are densely placed; eremocarpes attached to the gynobasis with the entire abdominal side and growing with it; sharp-lumpy, granular-lumpy or hairy-pubescent surface of eremocarp; short column, capitate stigma - characterize all species of the genus *Heterocaryum*, and the results of molecular analysis only show that the genus can be divided into two sections and that the genus *Suchtelenia* is close to the species of one section: sect. *Pseudoheterocaryum* (Kaz.Osaloo & Saadati) Ovczinnikova, comb. et sect. nov. (= genus *Pseudoheterocaryum* Kaz.Osaloo & Saadati 2017, in Australian Systematic Botany 30: 109. – Type: *Heterocaryum szovitsianum* (Fisch. & C.A. Mey.) A.DC. This genera combines a similar range and ecological confinement. M.G. Popov [16] suggested that representatives of the genera *Caccinia*, *Suchtelenia*, and *Heterocaryum* are descendants of various early representatives of the genus *Trichodesma*. And we think that he was right.

The tribe Asperugeae was also first isolated by Zakirov [5] and recently validated [9]; in the modern system, it includes the monotypic genus *Asperugo* and the genus *Mertensia*, represented in Uzbekistan by one unique species *M. dshagastanica* Regel from the *Mertensianthe* Popov section. The unification of these genera in one tribe seems to us artificial, since these taxa do not have a single common morphological character, and they also differ in ecological characteristics and ranges. Popov [6] brought the genus *Mertensia* closer to the genera *Trigonotis* and *Eritrichium*. It has been proven that *Mertensia* is close to the genus *Anoplocaryum* Ledeb. by the traits of pollen grains, the structure of the fruit and molecular genetic data [2, 17-19]. And it would be more correct to attribute these genera to the tribe Myosotideae within the subtribe Anoplocaryinae Ovczinnikova.

The tribe Myosotideae includes 3 genera and 9 species. The genus *Trigonotis* is represented by one annual *T. peduncularis* (Trevir.) Benth. ex S. Moore et Baker with a sporadic range from the Caucasus to Japan, is very rare in Uzbekistan. The genus

Stephanocaryum is a remarkable endemic genus of the Western Tien Shan. The author of the genus Popov [20] not without reason included him in the tribe Eritrichieae. In the modern phylogenetic system, it is assigned to the tribe Myosotideae. In fact, the brachymorphic corolla with a short tubule and a flat bend, with the lobes twisted in the buds, is similar in structure to the corolla of *Myosotis*; common features are also guessed in the structure of their inflorescences. According to the recently proposed system of the genus *Myosotis* [8], in the flora of Uzbekistan, we divided 7 species into 5 sections, with 3 species cited by us for the first time [10]. All of these species of *Myosotis* have extensive ranges, but in Uzbekistan they are confined only to the mountains of the Western Tien Shan and Pamir-Alai.

The tribe Eritrichieae in the modern phylogenetic system is devoid of independence and is united with the genus *Rochelia* in the tribe Rochelieae. The genus *Rochelia* comprises 22 species of annual ephemeral villous or hispid herbs with a small corolla with scaly vaults, the presence of a prominent binder on the anthers, and a bilobed stigma, with a pseudo-monomeric dieremic coenobium, dense intergrowth of eremocarps with gynobasis, a special stellate-hairy surface of eremocarp [21]. The fruits of the genus *Rochelia* differ from the typical coenobium in that only the adaxial carpel forms two non-falling eremes, and the fruit is separated from the mother plant, representing a diaspora, together with the calyx and peduncle [22]. In Uzbekistan, there are 10 species classified in 2 sections.

We consider the tribe Eritrichieae to be independent [9]. In Uzbekistan, it includes 3 genera and 31 species. It is the largest tribe in the Boraginaceae flora of Uzbekistan. The genus *Eritrichium* with the species *E. pseudostrictum* Popov was first discovered in Uzbekistan [10]. The species is found on rocky slopes, talus and rocks of the subalpine and alpine belts, at an altitude of 2800–4000 m in the Pamir-Alai mountains [6, 23, 24]. It was first found on the Alai and Turkestan ridges within the Fergano-Alai and Kuhistan districts, which are distinguished by a large number of endemic and subendemic taxa. The genus *Lappula* is represented by 28 species. Species of all 8 sections of the genus are represented on the territory of Uzbekistan. The genus *Lappula* comprises over 70 species of hispid small to medium-sized annual or perennial herbs with distribution in the northern Hemisphere and has several representatives in Africa and Australia [25]. In contrast to the genus *Rochelia*, it is characterized by the following characters. The calyx is dissected almost to the base into linear lobules, stellate-prostrate under the fruit or ascending and adjacent to the fruit, sometimes exceeding it in length. The anthers are small, almost sessile in the corolla tube. Gynobasis is anchor-shaped, subulate, narrow-conical or narrow-pyramidal, equal to the height of the eremes or somewhat rises above them. Eremocarps are straight, ovoid, dorsiventrally compressed, triangular in cross-section, with an abdominal keel ending in a cicatrix. The cycatrix is lanceolate, ovoid or triangular, convex, located basally or subbasally. The flat dorsal platform (disc) is bounded by two ribs, or edges. Along the edges of the disc there are usually 1–3 rows of anchor spines, spines or tubercles without an anchor head. Less often, a narrow or wide leathery edging rises along the edge of the disc, along the edge of which anchor spines sit. The wing is cupped, widened in the basal part, curved into a disc. Many species are characterized by heteroeromocarpia, when the eremocarps in one coenobium differ morphologically and anatomically. The surface of the erem is lumpy, with different heights of tubercles, which most often have a pointed top (sharp-tuberous surface) or end with a crochet, less often it is even or folded. The genus *Lepechiniella* is represented by 2 closely related alpine species from the type section.

The tribe Cynoglosseae is represented by 7 genera and 25 species. It is the second largest tribe Boraginaceae in the flora of Uzbekistan. The modern system does not recognize the independence of all genera of the tribe that are found on the territory of Central Asia. All species were transferred to the genus *Cynoglossum* [26]. In this matter, we

adhere to the opinion of the monograph "Flora of the USSR" by Popov [6]. Modern palynomorphological studies have proved the independence of all genera of this tribe using the example of Iranian plants [27]. It was shown that the genera *Paracaryum*, *Mattiastrum*, and *Cynoglossum* with the brachymorphic corolla type are similar in the traits of pollen grains, while the genera with the tubular corolla type differ noticeably in the traits of pollen.

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