Rare species of the genus *Oxytropis* DC. (Fabaceae) from the flora of the Republic of Bashkortostan under cultivation within the city of Ufa

N V Maslova, O A Elizaryeva, G M Galikeeva and N M Tyutyunova

Ufa Institute of Biology, RAS, prospekt Oktyabrya, 69, 450054, Russia

E-mail: maslovanv-ib-ufa@mail.ru

Abstract. This paper presents the results of investigations introducing eight rare species of the genus *Oxytropis* DC. from the flora of the Republic of Bashkortostan into the city of Ufa. Seven species are characterized as promising ornamental plants. According to the integrated evaluation scale of introduction effectiveness based on seven indices, two species were considered as very promising (*O. spicata* (Pall.) O. et B. Fedtsch., *O. knjazevii* Vasjukov), five species as promising (*O. approximata* Less., *O. baschkirensis* Knjasev, *O. hippolyti* Boriss., *O. gmelinii* Boriss., *O. kungurensis* Knjasev) and one species as non-promising (*O. sordida* (Willd.) Pers.). The ornamental quality assessment of rare species of the genus *Oxytropis* based on ten indices showed that these species can be used to create ornamental compositions in the landscape design style.

1. Introduction

The existing assortment of useful plants employed in green building is the result of a long-term introduction process. An introduction survey is an important element in the development of recommendations for management and protection of useful plants [1, 2]. The introduction of rare and endangered plants into cultivation is an important and effective measure to save their gene pool. Introduction tests showed the possibility of using rare species as ornamental plants [3, 4, 5, 6, 7].

Special programs are under development to protect the biodiversity of rare species of the genus *Oxytropis* DC. from the flora of the Republic of Bashkortostan, including their protection *in situ* and *ex situ*, as well as reintroduction techniques. Introduction is one of the ways to preserve these species [8, 9, 10]. Species of the genus *Oxytropis* DC. can be recommended as promising ornamental plants [8, 9, 11, 12, 13, 14, 15].

2. Material and methods

This paper presents the results of investigations on introducing eight rare species of the genus *Oxytropis* DC. from the flora of the Republic of Bashkortostan and gives their characteristics as ornamental plants (table 1). Six of them are included in the Red Data Book of the Republic of Bashkortostan (2011) [8] in group 2 (decreasing species): *O. kungurensis* Knjasev (figure 1), *O. approximata* Less. and *O. sordida* (Willd.) Pers. and in group 3 (rare species): *O. baschkirensis* Knjasev (figure 2), *O. gmelinii* Fisch. ex Boriss. (figure 3) and *O. hippolyti* Boriss. (figure 4). Two rare species: *O. spicata* (Pall.) O. et B. Fedtsch. (figure 5) and *O. knjazevii* Vasjukov (*O. knjazevii*...
Vasjukov, nom. nov. – *O. tatarica* Knjaz. 2001 [16] (figure 6) are included in «The List of Plants and Fungi Not Included in the Red Data Book of the Republic of Bashkortostan That Should Be Paid Special Attention to Their Environmental Conditions within the Republic and Monitored» [10]. One (*O. hippolyti*) out of eight rare species is included in the Red Data Book of the Russian Federation (2008) [14]. There are seven endemics and one relic plant among them [10] (table 1).

These species occurred in stony steppes. Regarding the moisture content of their habitats these species are classified as mesophytes (*O. sordida*), xeromesophytes (*O. spicata*, *O. knjazevii*), mesoxerophytes (*O. baschkirensis*, *O. kungurensis*, *O. gmelinii*) and xerophytes (*O. approximata*, *O. hippolyti*) [10].

Investigations on the species of the genus *Oxytropis* DC. under introduction were launched in 1997 (introduction nursery for rare plants of the South Urals, Ufa Institute of Biology, RAS). The nursery is situated in the Botanical Garden of Ufa (forest-stepp zone of the Bashkir Cis-Urals) [8, 9, 10]. It is located outdoors under full insolation and defended against winds with trees and shrubs. The soil is grey forest clayey loam. The species are introduced with seeds collected in natural habitats.

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**Figure 1.** *Oxytropis kungurensis*.  
**Figure 2.** *Oxytropis baschkirensis*.  
**Figure 3.** *Oxytropis gmelinii*.  
**Figure 4.** *Oxytropis hippolyti*.  

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Table 1. Some biological and introduction characteristics of rare species of the genus *Oxytropis* DC. under introduction.

| Year of introduction | Number of samples | Flowering time | Flowering season | Corolla colour | Group of promising potential |
|----------------------|-------------------|----------------|------------------|----------------|-----------------------------|
| *O. kungurensis*; 2 – decreasing species, endemic plant of the South Urals and Central Cis-Urals | 1997 | 3 | Fast-flowering | Spring and summer-flowering | Pink violet | P |
| *O. baschkirensis*; 3 – rare species, endemic plant of the South Urals and Trans-Volga Region | 2000 | 3 | Long-flowering | Summer and autumn-flowering | Purple | P |
| *O. approximata*; 2 – decreasing species, endemic plant of the South Urals | 2000 | 2 | Medium-flowering | Summer-flowering | Pale yellow | P |
| *O. gmelinii*; 3 – rare species, endemic plant of the South Urals | 1997 | 4 | Medium-flowering | Summer-flowering | Pale yellow | P |
| *O. hippolyti*; 3 – rare species, endemic plant of the Trans-Volga Region | 2000 | 4 | Medium-flowering | Summer-flowering | Pale yellow | P |
| *O. sordida*; 2 – decreasing species, periglacial Pleistocene relic plant | 2009 | 1 | Non-flowering | Non-flowering | Pale yellow | NP |
| *O. spicata*; species under observation, endemic plant | 1997 | 3 | Long-flowering | Spring, summer and autumn-flowering | Pale pink or bluish pink | VP |
| *O. knjazevii*; species under observation, endemic plant of the Trans-Volga Region and South Cis-Urals | 1997 | 2 | Long-flowering | Spring, summer and autumn-flowering | Pinkish blue | VP |

Note. The conservation status of the species is specified according to the Red Data Book of the Republic of Bashkortostan [10]. Groups of promising potential are given according to Karpisonova [3]: non-promising species (NP) – less than 10 points, not very promising species (NVP) – 10–13 points, promising species (P) – 14–17 points, very promising species (VP) – 18–21 points.
This paper applies conventional research methods [3, 5]. The assessment of the introduction success was performed using the integrated scale developed in the Main Botanical Garden of the Russian Academy of Sciences (Moscow) [3].

The assessment of the ornamental quality was performed using a standard method with our own modifications (table 2) [17] with regard to such assessment indices as winter hardiness and ornamental quality of fruit-bearing plants. Also, changes were made with regard to such indices as corolla colour, its intensity and inflorescence length and density. During the development of the scale we used the point-based assessment card of the ornamental quality of a variety (species) with using a conversion factor for each index so that the maximum index expression would eventually be 100 points [17].

3. Result and discussions

Long-term phenological observations showed that according to their phenorhythmic type all Oxytropis species are spring, summer and autumn-flowering plants with a long vegetative period and winter dormancy. Under cultivation they have a steady-state type of phenological development. According to their flowering season, the species are classified in the following way: O. kungurensis as spring and summer-flowering (May – June); O. approximata, O. gmelinii and O. hippolyti as summer-flowering (June – July); O. baschkirensis as summer and autumn-flowering (July – September); O. spicata and O. knjazevii as spring-summer and autumn-flowering (May – September) (table 1). According to their flowering time, they are classified in the following way: O. kungurensis as fast-flowering; O. approximata, O. gmelinii and O. hippolyti as medium-flowering; O. baschkirensis, O. spicata and O. knjazevii as long-flowering.

Secondary flowering in August and September is characteristic of fast and medium-flowering species providing there is a wet and warm autumn. Phenological stages of the Oxytropis species overlap each other. Thus, summer-flowering species may have buds, flowers and fruits on one and the same plant from July to August (figure 2). In this connection various Oxytropis species can be used for compositions in gardens of continuous bloom.

According to the corolla colour the introduced Oxytropis species are subdivided into two groups: “pink flowering” and “yellow flowering.” The “pink flowering” group includes O. baschkirensis, O. kungurensis and O. spicata (corolla colour is from pale pink to light blue or violet). The “yellow flowering” group contains O. approximata, O. gmelinii and O. hippolyti (corolla colour ranges from almost white to yellowish) (table 1). Intra- and inter-population corolla-colour polymorphism is noted under introduction in O. gmelinii, O. kungurensis and O. spicata. These species fall within the group of ornamental flowers, with the period of the highest ornamental quality during their flowering stage.

The Oxytropis species are propagated only by seeds formed every year. Freshly collected seeds are of good quality. Their germination capacity is 80–100%. Under storage conditions the hardness of the seed coat tends to increase up to 70–90 % and is broken by scarification (germination capacity shows an increase up to 80–90 %). The germination capacity is maintained for five years in O. kungurensis, eight years in O. gmelinii and O. baschkirensis, twelve years in O. hippolyti and thirteen years in O. spicata.

All species were propagated using the seedling technique. The adaptability of seedlings was 60–100 % depending on the year of observation and time of planting. Self-seeding was also observed in all species. The most frequent and viable self-seeding occurred in O. spicata and O. knjazevii.

The preservation of plants after transplanting the seedlings may vary over several years depending on the origin of the samples. Thus, for example, the preservation of O. hippolyti in the third year of its life was as follows for different populations: 33.3 % of seedlings from the vicinity of the village of Starye Kandry (Tuymazinsky District), 23.5 % from Gurovskaya Mountain (Kushnarenkovsky District), 12.5 % from the eastern bank of Asylkul Lake (Davlekanovsky District) and 0 % from Izmailka Mountain (Bizhubulyksky District) and from the vicinity of the village of Kanly-Turkeev (Buzdyaksky District).

The rate of ontogenesis in the Oxytropis species under cultivation is faster compared to natural populations. Its duration is short (2–5 years) in O. approximata, O. baschkirensis, O. gmelinii, O.
hippolyti, *O. spicata* and *O. kungurensis* and longer (5–15 years) in *O. gmelinii*, *O. kungurensis* and *O. spicata*. The flowering stage begins after two to five years of development.

The vital status of the *Oxytropis* species under cultivation is good. Annual observations show that their biometric indices are equal to or even exceed those found in nature. An increase is seen in their height, number of inflorescences, number of flowers in an inflorescence and so on. For example, in *O. gmelinii* under cultivation the height was 40.5 cm, the number of leaves was 91.5 and the number of inflorescences averaged 33.4 versus 28.4, 67.7 and 17.4 under natural conditions, respectively. In *O. baschkirensis* under cultivation the height was 33.9 cm, the number of leaves was 54.5 and the number of inflorescences was 30.8 versus 25.3, 21.5 and 6.5 under natural conditions, respectively. The vital form of the plants remains the same (taproot caudiciform herbaceous perennials with polycarpic rosette-type shoots). The indices of seed productivity in the *Oxytropis* species under cultivation are higher than those in nature. For example, in *O. gmelinii* the fruit formation under cultivation was 41.8 % and the productivity factor was 10.2 %, whereas in nature these indices turned out to be equal to 28.3 % and 4.6 %, respectively. In *O. baschkirensis* the same indices are equal to 55.9 % and 7.6 % under cultivation and 35.6 % and 4.0 % in nature.

According to the integrated assessment scale of introduction success (according to assessment indices: fruit bearing intensity, seed germination capacity, seed propagation capability under cultivation through self-seeding, vegetative propagation capability, plant status under cultivation, pest and disease resistance, winter hardiness [3] and also due to their ornamental quality) *O. spicata* and *O. knjazevii* are characterized as very promising; *O. approximata*, *O. baschkirensis*, *O. hippolyti*, *O. gmelinii* and *O. kungurensis* as promising; *O. sordida* as non-promising (the plants are developed until the immature and virginal states and preserve on the trial plot up to three years).

The plants are winter-hardy in introduction nursery conditions; (they are able to survive winter months without covering) and are frost-resistant. No frost damages were observed in spring or autumn. Vegetative parts of the plants were not injured by pests and diseases, although fruits and seeds were affected by insect pests.

The assessment of the ornamental quality of seven species of the genus *Oxytropis* DC. using ten assessment indices is given in table 2. The most intensely coloured corolla is seen in *O. baschkirensis*. This species is also characteristic of the tightest inflorescences with few flowers. The most profusely flowering species with a great many of inflorescences are *O. hippolyti*, *O. approximata* and *O. gmelinii*. These species are also noted for the length and strength of their flowering shoots. *O. kungurensis* forms second-generation grey-green densely pubescent leaves that make its vegetative sphere attractive throughout the entire vegetation season. *O. baschkirensis* does not become less attractive during its fruit-bearing stage. *O. spicata* and *O. knjazevii* are noted for their winter hardiness. They also have the longest flowering period. The total number of points for each species was as follows: *O. baschkirensis* – 81, *O. kungurensis* – 76, *O. spicata* and *O. knjazevii* – 74, *O. hippolyti* – 73, *O. approximata* and *O. gmelinii* – 72. The maximum number of points was received by *O. baschkirensis*.

All the species in the nursery were grown in monoculture. In addition., some of them were tested in Alpine rock gardens and mixed plantings. For example, *O. gmelinii* was tested in an artificial phytocoenosis together with such rare species as *Allium nutans* L., *Globularia punctata* Lapeyr., *Iris pumila* L., *Dianthus uralensis* Kocs., *Helichrysum arenaria* (L.) Moench, *Helianthemum bashkirorum* (Juz. ex Kupatadze) Tzvel., etc. and also in the Alpine rock garden (figure 3). Such conditions do not hinder the species from blooming, bearing fruits and producing full-fledged seeds.

With due consideration for ornamental properties, environmental features and development rhythms, it is possible to create multi-component compositions of rare plants for landscaping. Based on our research experience we think it reasonable to combine the species of the genus *Oxytropis* DC. with those of the genera *Allium* L. (*A. flavescens* Bess., *A. nutans* L.), *Iris* L. (*I. pumila* L., *I. scariosa* Willd. ex Link.), *Hedysarum* L. (*H. grandiflorum* Pall. and *H. razoumovianum* Fisch. et Helm.).
Table 2. Assessment of the ornamental quality of rare species of the genus *Oxytropis* DC. under introduction.

| Species                      | Corolla colour, intensity (20) | Flower size (5) | Floriferous shoot (length and strength) (10) | Inflorescence (number of flowers) (10) | Inflorescence density and length (10) | Abundance of flowering (10) | Ornamental quality of the vegetative sphere (10) | Winter hardiness (5) | Duration of the flowering period (10) | Ornamental quality of fruit-bearing plants (10) | In total (100) |
|------------------------------|--------------------------------|-----------------|---------------------------------------------|--------------------------------------|--------------------------------------|-------------------------|-----------------------------------------------|-------------------|-------------------------------------|-----------------------------------------------|-------------|
| *O. kungurensis*             | 17                             | 5               | 8                                           | 7                                    | 9                                    | 5                       | 9                                             | 3                 | 5                                   | 8                                             | 76          |
| *O. baschkirensis*           | 18                             | 5               | 4                                           | 8                                    | 7                                    | 6                       | 8                                             | 3                 | 8                                   | 8                                             | 81          |
| *O. approximata*             | 12                             | 4               | 9                                           | 8                                    | 7                                    | 8                       | 7                                             | 3                 | 7                                   | 7                                             | 72          |
| *O. gmelinii*                | 12                             | 4               | 9                                           | 8                                    | 7                                    | 8                       | 7                                             | 3                 | 7                                   | 7                                             | 72          |
| *O. hippolyti*               | 12                             | 4               | 9                                           | 8                                    | 7                                    | 8                       | 7                                             | 3                 | 7                                   | 7                                             | 72          |
| *O. spicata*                 | 16                             | 4               | 7                                           | 8                                    | 7                                    | 7                       | 7                                             | 3                 | 7                                   | 7                                             | 73          |
| *O. knjazevii*               | 16                             | 4               | 7                                           | 8                                    | 7                                    | 7                       | 7                                             | 3                 | 7                                   | 7                                             | 74          |

Note. The maximum number of points is given in brackets for each assessment index.

All the assessment data show that the species of the genus *Oxytropis* DC. in question are of practical interest as promising ornamental plants and can be applied in such phytocompositions as rock gardens. These compositions may not only make wonderful park and garden decorations in urban areas, but also fulfill educational and nature-protection functions. The urban environment can give shelter to rare species that will contribute to their conservation.

Thus, according to a set of biological and economic indices seven rare species of the genus *Oxytropis* from the flora of the Republic of Bashkortostan hold promise for growth in the Botanical Garden of Ufa and cultivation under urban conditions of the forest-steppe zone of the southern Cis-Urals. This makes it possible to preserve the species ex situ, obtain seeds and planting materials for reintroduction and use them to create ornamental compositions in the landscape design style.

Acknowledgements

The research was performed in 2017–2019 with partial financial support from the Russian Foundation for Basic Research and Government of the Republic of Bashkortostan, Project 17-44-020506 п.а.

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