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Article

Phenological features and perianth color diversity of *Iris pumila* L. and *I. scariosa* Willd. ex Link in the Southern Urals

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Abstract. The article presents the study results of the seasonal development in culture of the two rare species of the genus *Iris* L., i.e. *Iris pumila* L. and *I. scariosa* Willd. ex Link. In the Bashkir Cis-Urals, the studied species reached the generative phase of development and bore fruit. Because of the later onset of the flowering period, the phenological phases of *I. scariosa* depended on the growing season conditions to a lesser extent than those of *I. pumila*. Blooming of one *I. pumila* and one *I. scariosa* Willd. ex Link flower lasted –6 days and 3–5 days, respectively, whereas the flowering of the entire study group of *I. pumila* and *I. scariosa* plants – 12 and 7 days on average. Colour variability of perianth in natural cenopopulations of both species in the Southern Urals (the Republic of Bashkortostan and Orenburg Oblast) was investigated as well. We identified 30 colour forms in ten cenopopulations of *I. pumila*, 10–12 of which were concurrently recorded in the largest ones. Violet-flowered plants dominated in the northern regions, while yellow-flowered in the south. In the two studied coenotic populations, *I. scariosa* had 11 forms with a similar (6–7) number of perianth colors, where violet prevailed.

Keywords: Iridaceae, rare species, iris polychromy, seasonal rhythm

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Научная статья

Фенологические особенности и разнообразие окраски околоцветника *Iris pumila* L. и *I. scariosa* Willd. ex Link на Южном Урале

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Аннотация. Представлены результаты изучения сезонного ритма развития в условиях культуры двух редких видов рода *Iris* L.: *Iris pumila* L. и *I. scariosa* Willd. ex Link. Установлено, что в условиях Башкирского Предуралья исследуемые виды достигают генеративной фазы развития и плодоносят. Фенологические фазы у *I. scariosa* зависят от условий года вегетации, но в меньшей степени, чем у *I. pumila,* поскольку его цветение происходит в более поздние сроки. Цветение одного цветка *I. pumila* продолжается от 4 до 6 дней, всей группы наблюдаемых растений – в среднем 12 дней. Длительность цветения одного цветка *I. scariosa* составляет от 3 до 5 дней. Средний период цветения группы растений – 7 дней. Также исследована изменчивость окраски околоцветников в природных ценопопуляциях обоих видов на Южном Урале (Республика Башкортостан и Оренбургская область). У *I. pumila* в десяти ценопопуляциях выявлено 30 форм окраски, из которых в наиболее крупных ценопопуляциях одновременно встречается 10–12; в северных районах преобладают фиолетовоцветковые растения, южнее произрастает больше желтоцветковых. У *I. scariosa* отмечено 11 форм с близким (6–7) числом колеров околоцветника в двух исследованных ценопопуляциях, преобладает фиолетовая форма окраски.

Ключевые слова: Iridaceae, редкий вид, полихромность ирисов, сезонный ритм

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Introduction

Studying the biology of rare representatives of the genus *Iris* L. of the family Iridaceae Juss. in nature and in culture of the Southern Urals is of great importance both for the implementation of practical measures on their preservation and use in green spaces of populated areas. In the South Ural Region, the genus *Iris* is represented by eight species, seven of which are included in the list of the protected plants (Krasnaya Kniga..., 2019, 2021). Among the most decorative and rare species are *Iris pumila* L. (dwarf Iris) and *I. scariosa* Willd. ex Link (leathery Iris) with rarity categories 3 and 1, respectively (Krasnaya Kniga..., 2019, 2021). In nature, they form small cenopopulations (CPs) and have a rather narrow ecological range (Abramova et al., 2019). Rare species of this genus in natural habitats of the Southern Urals and under their introduction have been studied since 2012 (Kryukova and Abramova, 2015; Kryukova et al., 2014, 2018; Michaylova et al., 2019; Mustafina et al., 2019).

I. pumila grows in arid fescue-feather grass steppes on slopes, flat-elevated areas, sandstone outcrops, loose and highly eroded humus-carbonate soils, rarely on solonetz. Most populations are preserved in the forest-steppe zone at the foothills of the Southern Urals. *I. pumila* is a light-loving plant, xerophyte, and rhizome geophyte. *I. scariosa* is found on southern rocky slopes, mountain peaks, and in the petrophytic-steppe types of communities. It develops on the slopes of the eastern foothills of the Southern Urals and in solonetzic steppes on chernozem soils. *I. scariosa* is a mesoxerophyte, rhizome geophyte. In the Trans-Urals, this species is encountered in places with a sparse vegetation and has a disjunctive range (Krasnaya Kniga..., 2021; Ryabinina and Knyazev, 2009).

Underdeveloped stems, perianth lobes fused at the base into a rapidly forming long floral tube (4–5 times longer than the ovary) replacing a peduncle, as well as the presence of the only flower on the generative shoot are distinctive features of *I. pumila* plants. *I. scariosa* has sickle-shaped curved leaves, almost equal to the length of a generative shoot with one, often two flowers (Krasnaya Kniga..., 2021; Ryabinina and Knyazev, 2009). According to the literature data, *I. pumila* and *I. scariosa* are spring-summer-autumn green plants with a winter dormancy period (Borisova, 1972). In terms of flowering, they are characterized by the spring development cycle (Golubev, 1965).

Both species are polychrome. They are distinguished by polymorphism, or a wide variety of perianth colours. Polychromy is explained by constantly moving pigments (anthocyanins and flavonoids) present not in the cell membranes, but in the cell sap (Brehm, 2004; Shoeva, 2013). Colour polymorphism is defined by the individuals' response to environmental conditions. The relationship between perianth colour variety and genetic polymorphism of CPs is not always confirmed by genetic studies (Kashin et al., 2022b). A great diversity of flower colours allows to use these plants in phytodesign of gardens and parks, while their hybridization abilities make it possible to employ wild species in selection of garden irises (Rodionenko, 2013). For instance, *I. pumila* gave rise to a variety of the dwarf bearded irises. Many authors report that this species is the most valuable in terms of genetic selection (Rodionenko, 2013; Mikhaylova et al., 2019; Shevchenko, 2013; Shevchenko and Sorokopudova, 2010). Though *I. scariosa* is no less decorative than *I. pumila,* we have very little information on this species.

Color polymorphism of iris perianths was previously studied in the southern regions of Russia (Indzheeva and Baktasheva, 2013; Rodionenko, 2013; Shevchenko, 1980). The greatest diversity of colours was revealed in the Ciscaucasia: 35 colour forms of *I. pumila* flowers. Yellow- and dominated violet-flowered specimens were encountered in one population (Shevchenko, 1980). In this species, the beard (a hair-like formation on the lower lobes of the perianth along a midrib) may also vary in colour. Note that colour polymorphism of *I scariosa* perianth has not been studied yet.

The aim of this work is to study the colour diversity of perianth in two iris species from natural CPs and their seasonal development in culture in the Southern Urals.

Material and methods

In 2014–2017, we conducted the studies of *I. pumila* in 10 natural CPs of Meleuzovsky, Kuyurgazinsky, Kugarchinsky, Zianchurinsky regions (Bashkortostan) and rarer *I. scariosa* in 2 CPs of Khaibullinsky (Bashkortostan) and Kuvandyksky (Orenburg Oblast) regions (Fig. 1). In addition, these species were studied (2014 - 2021) in culture by the South Ural Botanical Garden-Institute of the Ufa Federal Research Center of the Russian Academy of Sciences.

A long-term investigation of dates and duration of flowering, as well as other features of seasonal development of these species in culture was carried out in the South Ural Botanical Garden-Institute using the generally accepted methods (Beideman, 1974; Minin et al., 2020). The point is that regular phenological observations of these species in natural CPs are impossible due to great remoteness of their habitats from the city of Ufa. The plants were transferred in small pieces of rhizomes from the studied natural CPs of the Southern Urals.

Perianth colours were defined during mass flowering of plants in natural conditions of the Southern Urals based on the Colour Chart of the English Royal Horticultural Society (RHS) (Griesbach and Austin, 2005). Designated by codes phenotypes were combined into groups by primary colours.

Results and discussion

Duration of phenological phases is among the important parameters in describing the ornamental qualities of rare plants. The results of the 8-year phenological observations of the species studied in culture are given in Table 1.

Growth of *I. pumila* starts with snowmelt, most often in the first ten days of April. A flower tube develops in the third decade of this month. Single flowers of different colour appear in late April or early May. One flower blooms for 4–6 days, and the flowering of the entire group of observed plants – 12 days on average. By flowering duration and according to the N.V. Trulevich classification (1991), *I. pumila* belongs to the group of medium-long-flowering species (from 5 to 20 days). Fruit ripening begins mainly in the second decade of May, seed ripening – in the first ten days of July. A fruiting period lasts on average 58 days. The ovary is located very close to the ground and develops quickly. The period from the beginning of spring regrowth to full seed ripening takes 79 days. Duration of a vegetation season is 6.0–6.5 months (on average 181 days).

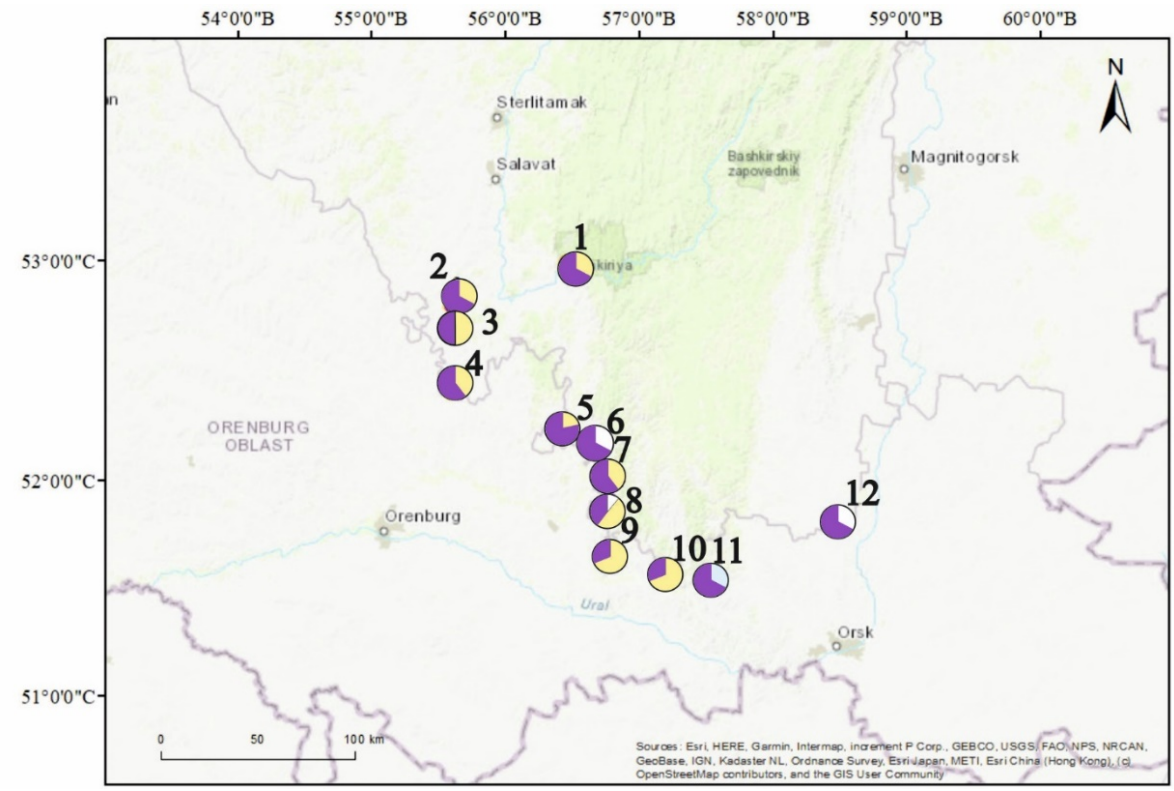

Fig. 1. Studied natural CPs of *Iris pumila* (1–10) and *I. scariosa* (11–12) in the Republic of Bashkortostan and Orenburg Oblast. Pie charts present the ratio of phenotypes with white, yellow, purple, and blue flowers.

Table 1. Start dates of phenological phases of *I. pumila* and *I. scariosa* under their introduction (2014–2021).

Phenophase	*I. pumila*	Average	*I. scariosa*	Average
Regrowth beginning	04.04–22.04	13.04	11.04–26.04	19.04
Budding beginning	20.04–04.05	27.04	01.05–10.05	05.05
Full budding	26.04–09.05	03.05	08.05–13.05	10.05
Blossoming beginning	29.04–14.05	06.05	10.05–15.05	13.05
Mass blossoming	04.05–16.05	10.05	13.05–19.05	16.05
Blossoming termination	10.05–20.05	15.05	17.05–21.05	19.05
Maturing fruits beginning	18.05–22.05	20.05	19.05–25.05	22.05
Mass ripening of fruits	21.06–10.07	30.06	10.06–24.06	17.06
Fructification termination	07.07–29.07	18.07	25.06–09.07	02.07
Vegetation termination	09.10–24.10	16.10	19.08–15.09	01.09
Blossoming duration, days	8–18	12	6–14	7
Fruiting duration, days	48–74	58	28–51	35
Vegetation duration, days	163–196	181	108–157	132

In the Bashkir Cis-Urals, *I. pumila* is resistant in culture: it annually undergoes a full cycle of shoot development, forms full-fledged seeds and provides self-seeding. In some years with unfavorable weather conditions (for example, 2018), cold and prolonged springs, all phenological phases of *I. pumila*, including flowering, can shift to later dates (by 2–3 weeks).

I. scariosa growth starts in the second decade of April, and its budding phase – at the end of April – beginning of May. The onset of the flowering period is registered in the first ten days of May, which lasts from 6 to 14 days (Table 1). In terms of flowering duration (Trulevich, 1991), *I. scariosa* also belongs to the group of medium-long-flowering species. Blooming of one flower makes up 3–5 days. The average flowering period of a group of plants is 7 days. Seeds ripen in the second decade of June. The period from the growth start to full ripening of seeds lasts on average 60 days, while vegetation within 4.5–5.0 months (on average 132 days). Phenological phases of *I. scariosa* also depend on the conditions of the growing year, but to a lesser extent than in *I. pumila* due to its later flowering period.

Introduction studies prove that *I. pumila* is undemanding to soils and faster adapts to flat well-lit fertile sites. It is more stable in culture than *I. scariosa*. The latter grows on plateau elevations with a poor soil layer containing the increased amounts of fine earth that hinders the creation of natural conditions for the species and requires the design of alpine slides (Arkhipova et al., 2019).

Perianth colours of *I. pumila* range from pale yellow, or lemon to dark purple, less often, white or pink. Closer to the outer edge of a lower lobe of perianth, a signal spot of a richer colour (to attract insects) is often present; sometimes it has a tiger mesh pattern. Beard colours of the lower lobes of perianth may be white, blue, and yellow. Perianth colours of *I. scariosa* vary from bluish to purple, very rarely – yellow; beards are white, blue, purple, and yellow. In culture, the perianth colour, characteristic of species in natural CPs, is preserved. A diversity of perianth colours contributes to better pollination of flowers (Kashin et al., 2022a).

Table 2. Perianth color of *I. pumila* in natural CPs of the Southern Urals (numbering is given by the RHS scale). *p.l.l. – lower lobe of perianth.

No.	Perianth coloration	Flower beard coloration	Cenopopulation									
			Karaultau	Lena	Kholodny Klyuch	N. Babalarovo	Vysokaya	Tazlarovo	V. Muynak	Kuytapkan	Arsenevo	Kuzhanak
		White group										
1	White (N155 B)	White (N155 C)						+				
2	White (N155 B), with dark brown spot (199 B) on p.l.l.*	Yellow (9 C)								+		
		Yellow group										
3	Pale yellow (3 D)	White (N155 C)								+		
4	Pale yellow (3 D), with tiger pattern on p.l.l.	White (N155 C)				+						
5	Pale yellow (3 D), with dark brown spot (199 B) on p.l.l.	White (N155 C)										+
6	Light yellow (4 B)	White (N155 C)						+	+		+	
7	Light yellow (4 B), with dark brown spot (199 B) on p.l.l.	White (N155 C)				+			+		+	
8	Light yellow (4 B), with dark brown spot (199 B) on p.l.l.	Blue (95 D)								+		
9	Yellow (3 B)	White (N155 C)		+	+		+	+		+	+	+
10	Yellow (3 B), with dark brown spot (199 B) on p.l.l.	White (N155 C)	+						+	+		
11	Yellow (3 B), with dark brown spot (199 B) on the edge of p.l.l.	Yellow (9 C)		+	+		+				+	+
		Green-yellow group										
12	Lemon yellow (1 B)	White (N155 C)	+								+	+
13	Lemon yellow (1 B)	Yellow (9 C)								+		
14	Lemon yellow (1 B), with dark brown spot (199 B) on the edge of p.l.l	Yellow (9 C)								+		

No.	Perianth coloration	Flower beard coloration	Cenopopulation									
			Karaultau	Lena	Kholodny Klyuch	N. Babalarovo	Vysokaya	Tazlarovo	V. Muynak	Kuytapkan	Arsenevo	Kuzhanak
		Violet group										
15	Violet (83 C)	Blue (95 D)	+		+	+	+		+	+	+	+
16	Violet (83 C)	White (N155 C)					+					
17	Violet (83 C), with tiger pattern (103 A) on p.l.l.	White (N155 C)					+					
18	Light violet (N87 B)	White (N155 C)			+		+				+	
19	Light violet (N87 B) with dark spot (79 D) on p.l.l.	White (N155 C)								+		
20	Dark violet (83 C)	White (N155 C)										+
21	Dark violet (83 C)	Blue (95 D)				+				+		
22	Dark violet (83 C) with tiger pattern (103 A) on p.l.l.	Blue (95 D)	+									
		Purple-violet group										
23	Pink (N80 A)	White (N155 C)							+			
24	Pink (N80 A), with purple spot (86 A) on p.l.l.	White (N155 C)							+			
25	Pink-violet (N81 C)	White (N155 C)				+	+					
26	Pink-violet (N81 C)	Blue	+	+			+					
27	Pink-violet (N81 C), with tiger pattern (165 A) on p.l.l.	White (N155 C)					+					
28	Pink-violet (N81 C), with dark spot (83 D) on p.l.l.	White (N155 C)							+			
		Greyed-purple group										
29	Burgundy (184 A)	Blue (95 D)	+				+			+		
30	Burgundy (184 A), with tiger pattern in the center (166 A) of p.l.l.	White (N155 C)								+		

Table 3. Perianth colour of *I. scariosa* in natural CPs of the Southern Urals (numbering is given by the RHS scale).

No.	Perianth coloration	Flower beard coloration	Cenopopulation	
			Ramazanovo, Orenburg Oblast	Aktum, Republic of Bashkortostan
Purple-violet group				
1	Pink-violet (N81 A)	Blue (95 D)		+
2	Pink-violet (N81 A)	White (N155 C)	+	
Violet group				
3	Violet (N87 A)	White (N155 C)		
4	Violet (N87 A)	Blue (95 D)	+	+
5	Pale violet (N87 B)	Blue (95 D)	+	+
6	Pale violet (N87 B)	White (N155 C)	+	
7	Dark violet (83 B)	Violet (88 C)	+	+
Blue-green group				
8	Bluey (113 D)	White (N155 C)		+
9	Bluish pale green with yellowish tint (130 D) at the base of the petal	Yellow (9 C)	+	
White group				
10	Whitish (N 155)	Yellow (9 C)		+
11	Whitish with yellow spot (15 C)	Yellow (N155 C)	+	

Fig. 2. Flowering phase of *I. pumila* in the South Ural Botanical Garden-Institute.

Fig. 3. Flowering phase of *I. scariosa* in nature (Ramazanovo CP).

In *I. pumila*, 30 colour phenotypes were identified (Fig. 2; Table 2); most of them was recorded in Kuytapkan (12) and Vysokaya (10) CPs (Table 2). In Karaultau, Verkhny Muynak, and Arsenevo CPs 7 phenotypes were noted, in Kuzhanak – 6, in Nizhnee Babalarovo – 5, in Kholodny Klyuch – 4, and in Tazlarovo – 3. Found solely in two CPs (Tazlarovo and Kuytapkan) plants with white and pale yellow perianth colours are quite rare. In each specific CP, either pale yellow or pink-violet shades predominate. The number of yellow-flowered individuals of *I. pumila* increases from north to south (Fig. 1).

In *I. scariosa*, 11 phenotypes were identified (Fig. 3; Table 3), 7 of which were found in Ramazanovo CP (Orenburg Oblast) and 6 in Aktum CP (Bashkortostan). Plants with violet-colored perianths dominated; white and blue flowers were less common. A yellowish tint stood out at the base of bluish petals. Yellow-flowered individuals grow in nature as well, however, we have not explored such CPs. White-flowered plants were encountered in Aktum, but not in Ramazanovo CP.

Conclusion

The studies of the two rare species of the genus *Iris* conducted in the Southern Urals suggest that under introduction both species undergo a full life cycle, annually bloom and bear fruit. Their phenological rhythm of development depends on weather conditions of the growing season. In years with unfavourable meteorological conditions, the shift (most pronounced in *I. pumila*) of phenophases is occurs later. Species vegetation lasts from 4 to 6.5 months.

Of the two studied species, *I. pumila* is distinguished by a greater colour polymorphism. It has 30 perianth shades: from blue-violet to yellow, less often cream or white. Yellow- and violet-flowered specimens can present in one CP. The greatest colour diversity (10–12 phenotypes of perianth colour) is noted in the larger *I. pumila* CPs of the Zianchurinsky region of Bashkortostan (Kuytapkan and Vysokaya). In the northern and central areas of the studied region, violet-flowered forms of *I. pumila* generally dominate, while in the southern part – yellow-flowered ones. *I. scariosa* has 11 shades with the prevalence of blue-violet colour.

Iris pumila has a great variety of perianth colours, bears fruit well and, therefore, can be recommended for a wide use in culture in the Southern Urals. *Iris scariosa* is less resistant in culture and requires the creation of special conditions (alpine slide construction), including the improvement of agricultural practices.

Involvement in selection tests of local species rich in flower colours enables both to obtain original specimens of high ornamental value and to increase their resistance to local cultivation conditions.

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