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COMMUNICATION

POPULATION CHARACTERISTICS OF *SILAUM SILAUS* (L.) SCHINZ & THELL. (APIACEAE) IN MORDOVIA, A HIGHLY THREATENED PLANT SPECIES AT THE NORTHERN LIMIT OF ITS RANGE

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Communication

Population characteristics of *Silaum silaus* (L.) Schinz & Thell. (Apiaceae) in Mordovia, a highly threatened plant species at the northern limit of its range

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Abstract: Knowledge on status of peripheral plant populations is important for understanding of species' adaptation and evolution within their ranges. There is a lack of data on the status of *Silaum silaus* (Apiaceae) populations at the periphery of its native range. One of the most northern native *S. silaus* populations is situated in the Republic of Mordovia (Central Russia). This species is considered as Critically Endangered in the region. Population-based studies of *S. silaus* have been carried out. Reproductive biology, morphometric parameters of individuals, accompanying flora, seed characteristics (mass, germination rate) were investigated. Results showed that at the northern limit of the range *S. silaus* grows in floodplain meadow community previously disturbed by livestock grazing. The area occupied by the population, however, has increased more than 12 fold over the last 15 years. Increasing fruit production together with decreasing fruit mass was established for the studied population compared to populations in the central part of its native range. In addition, germination rate was very low (2.3–16.7 % depending on edaphic conditions). Additional studies of *S. silaus* populations are needed in saline steppes of the closely located territories where it occurs as one of the dominant species in the plant community.

Keywords: Accompanying flora, Apiaceae, endangerment, habitat conditions, peripheral population, phytoindication, reproductive biology, seed ecology, seed germination.

Russian abstract: Знания о состоянии периферических популяций растений очень важны для понимания адаптации и эволюции видов в пределах их ареалов. В настоящее время имеется недостаток данных о состоянии популяций *Silaum silaus* (Apiaceae) на границе естественного его распространения. Одна из самых северных аборигенных популяций *S. silaus* расположена в Республике Мордовия (Центральная Россия). *S. silaus* рассматривается в этом регионе как таксон, находящийся на грани исчезновения. Были проведены популяционные исследования *S. silaus*. Были изучены репродуктивная биология, морфометрические параметры особей, состав сопутствующей флоры, характеристики семян (вес, всхожесть). Полученные результаты показали, что на северной границе ареала *S. silaus* произрастает в пойменно-луговом сообществе, пострадавшем от выпаса скота. Несмотря на это, площадь популяции за последние 15 лет увеличилась более, чем в 12 раз. Для изученной популяции было установлено увеличение продуктивности семян совместно с уменьшением их массы по сравнению со значениями этих параметров в центральной части естественного ареала этого вида. Кроме того, всхожесть семян *S. silaus* была очень низка (от 2.3% до 16.7% в зависимости от эдафический условий).Необходимы дополнительные исследования популяций *S. silaus* в области засоленных степных сообществ в соседних регионах, где этот вид наблюдается в качестве одного из доминантов.

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INTRODUCTION

The genus *Silaum* Mill. (Apiaceae) consists of one species *Silaum silaus* (L.) Schinz & Thell. (Pimenov & Tikhomirov 1979; The Plant List 2013) distributed from the Iberian peninsula in the southwest to western Siberia in the east. The north range's boundary passes through southern Sweden (Tutin 1968; Menglan & Watson 2005; Pimenov & Ostroumova 2012). In some regions of Europe *S. silaus* was introduced with material coming from Germany during World War II (Fröberg 2009). The species was noted as alien in Jiangsu Province, on the eastern coast of China (Menglan & Watson 2005).

In Russia native *S. silaus* populations are known in 26 regions in the middle part of European Russia. These include: Belgorod, Voronezh, Lipetsk, Penza, Tambov, Samara, Saratov, Uljanovsk, Chuvashia and Mordovia. This species is considered as alien in: Irkutsk, Leningrad and Tver (Pimenov & Ostroumova 2012; Tikhomirov 2014). Finally, one of the most northern native *S. silaus* populations in Central Russia is situated near Khadzhi Village in Lyambir District of the Republic of Mordovia (Fig. 1).

Silaum silaus is a perennial *Apiaceae* with annual shoots up to 40–100 cm tall (Tutin 1968; Menglan & Watson 2005; Pimenov & Ostroumova 2012) (Image 1). Its main characteristics are as follows: leaf blade triangular-ovate, 7–20 × 6–10 cm; lateral pinnae short-petiolulate, 2–5-lobed, terminal pinnae 3–7-lobed; ultimate segments lanceolate to linear-lanceolate, 13–20 × 2–3 mm, abaxial veins prominent, margins cartilaginous, apex acute or acuminate, apiculate. Upper leaves bipinnate, narrowly linear, apical leaves reduced, segments filiform. Umbels 2.5–4.0 cm across; rays 5–10, 1–3 cm, unequal; bracteoles linear-lanceolate, 3–5 mm, shorter than flowers, margin scarious; umbellules many-flowered; pedicels 4–8 mm. Fruits 4–8 × 2–3 mm (Image 1). Within its native range it inhabits floodplain grasslands (e.g., Hölzel & Otte 2004; Borovik 2011; Guardiola et al. 2014; Willner et al. 2013). In some cases, *S. silaus* can dominate plant communities in salinised meadows (e.g., Novikova & Pankina 2013). This species, however, is considered as vulnerable due to limited dispersal and re-establishment even under favourable environmental conditions (Bischoff 2000, 2002; Donath et al. 2006; Bischoff et al. 2009).

In 2002, *Silaum silaus* was recorded near Khadzhi Village in Lyambir District of the Republic of Mordovia (GMU - Herbarium of the Mordovia State University). At that time dense *S. silaus* population occupied 800m^2. Besides, since 1994 from one to 10 individuals were observed on the railway bed in Ruzaevka City (Silaeva

Image 1. The generative individual (A), fruits (B) and umbel (C) of *Silaum silaus* in the Republic of Mordovia, at the northern limit of the species' range.

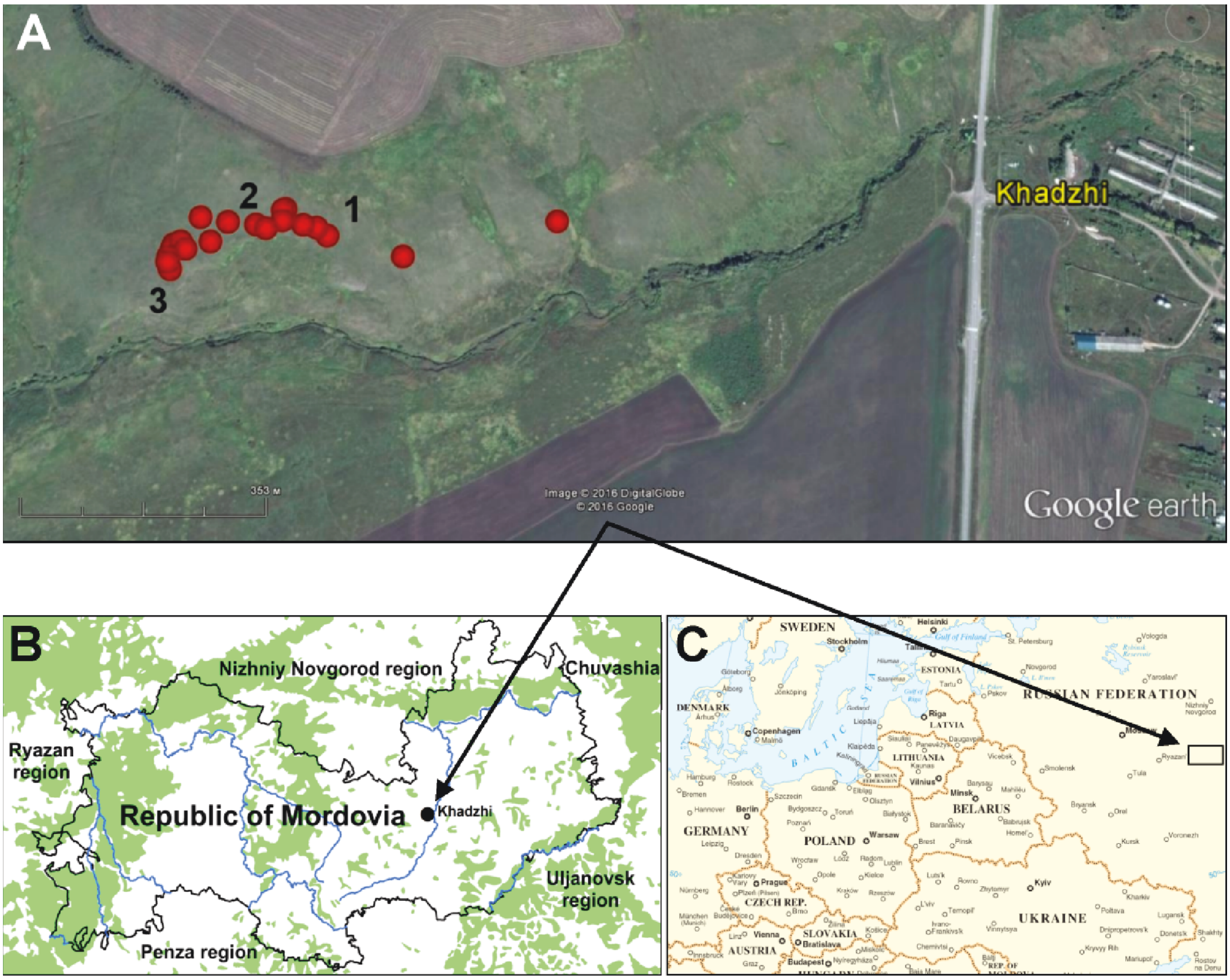

Figure 1. Geographical position of the study area (A) in the Republic of Mordovia (B) and in Europe (C) (Map of Europe with modifications from the website United Nations Geospatial Information Section: http://www.un.org/Depts/Cartographic/english/htmain.htm). Numbers on the map A indicate the three study plots. Red dots are the densest (more than 5 plants per 1m²) groups of *Silaum silaus* individuals.

& Barmin 1995). Recently, the regional status of *S. silaus* was assessed according to the IUCN Red List of Threatened Species categories and criteria (IUCN 2012a,b, 2014) as Critically Endangered (CR) (Khapugin et al. 2017a). Knowledge on structure and status of both peripheral and central plant populations and their conservation status are important to understand the adaptation and evolution within the native range (e.g., Wróblewska & Brzosko 2006; Sotek 2007; Beatty et al. 2008; Abeli et al. 2014; Khapugin & Chugunov 2015; Naik et al. 2016; Srivastava et al. 2017; Birkeland et al. 2017). Such understanding may be achieved through large-scale population-based studies of plants both in the centre and at the limits of their ranges. Until now, however, studies of peripheral *S. silaus* populations have not been carried out either in Mordovia or in any other regions at the limit of species' range.

The aim of this paper was to study the peripheral *S. silaus* population known in the Republic of Mordovia. Two main tasks were established: (i) to reveal current status of *S. silaus* population; (ii) to compare data obtained with those from populations in the centre of its range (wherever possible).

MATERIALS AND METHODS

Investigations have been carried out in the grassland community located in the valley of Lyambirka stream at the northern limit of *S. silaus*' range (Republic of Mordovia), 54.33°N & 45.23°E. This location was recommended for the establishment of a protected area (Khapugin et al. 2017b). Current population area has been estimated using portative GPS-navigator. At present, *S. silaus* population occupies 9,876m². The population-based study of *S. silaus* was carried out in August 2016. Three 10×10 m plots were randomly established in eastern, central and western parts of the population (see numbers in Fig. 1A). Red dots in Fig. 1A indicate places with highest plant density.

Environmental conditions typical for habitats with *S. silaus* were estimated using the data on environmental preferences of vascular plant species, accompanying the endangered species in the studied location. For this purpose, all angiosperm species were recorded and these data were analysed within each study plot. Biomorphological analysis of the accompanying flora was done to define species groups according to Raunkiaer's life-form classification (Raunkiaer 1934). Distribution of plant species of the accompanying flora along the ecological groups in relation to the water content in soil was carried out following the classification of Shennikov (1950) by defining of main mesophytes (plants growing on moderately moisturised soils), xerophytes (plants growing on poorly moisturised soils) and intermediate (xeromesophytes, mesoxerophytes) groups. Ecological-coenotical characteristics for each plant species that was registered in study units were determined using the literature on the flora of the Republic of Mordovia (Silaeva et al. 2010), the flora of Central Russia (Maevsky 2014) and own personal observations.

Concomitantly, values of environmental factors were calculated for the studied habitat based on the accompanying flora composition. Calculations were done according to a scale where environmental indicator values (EIVs) are presented as intervals (Tsyganov's 1983). It means that we can define the range of each plant existence in relation to certain environmental factors; for example, soil nitrogen, moisture, etc. Mean EIVs were calculated using the algorithm suggested by Buzuk & Sozinov (2009). Ten EIV scales were used: thermo-climatic (TM), climate continentality (KN), climate humidity (OM), kryo-climatic (CR), soil moisture (HD), soil trophicity (TR), soil nitrogen (NT), soil pH (RC), shading (LC), soil moisture variability (FH). These calculated mean EIVs were used to characterise the conditions of the habitat with *S. silaus*.

Morphometrical parameters of *S. silaus* individuals (shoot height, number of generative shoots per individual, number of umbels, number of umbellules per umbel, number of fruits per umbellule) were measured. Number of leaves per vegetative individual was determined.

In order to estimate seed characteristics, all *S. silaus* seeds were collected from 30 randomly sampled individuals (10 umbellules from each plant). They were dried under sunlight. The seed mass was then measured using 20 samples of 50 randomly selected seeds weighed to the nearest 0.1mg. The seeds were then kept in a refrigerator at 3–4 ^{0}C for six months (cold stratification). They were sowed in growth chambers in six replications of the experiment, 50 seeds in each of three media (water, sand and soil) under t = 20–25 ^{0}C, artificial lighting, 16/8 h (2000 lux).

The seeds were considered as germinated when the radicle was longer than the seed, while the shoot was longer than half of the seed (Nikolaeva et al. 1985). Each experimental replication was conducted until the end of seed germination in the growth chamber. Both the period from seed sowing to their germination and the germination period were recorded. The energy period, germination energy, and seed germination were determined. The energy period was determined experimentally through the comparison of seed germination evenness. For this purpose, the maximum number of germinated seeds per day was recorded. The germination energy was determined as a ratio of the maximum number of germinated seeds per day to the total number of germinated seeds in a replication. Statistical analyses were carried out using PAST 3.15 (Hammer et al. 2001) and Microsoft Excel.

RESULTS

The diversity of vascular plants of this study site comprised 38 vascular plant species belonging to 35 genera from 14 families (Appendix 1). The following species had the highest cover at the different sampled sites: *Bromopsis inermis* (Leyss.) Holub (up to 80%), *Fragaria viridis* Weston (up to 60–65 %), *Echinops ritro* L. (up to 25–30 %), *Carex praecox* Schreb. (up to 15%), *Trifolium pratense* L. or even *Silaum silaus* (both - up to 6%). Amongst species of accompanying flora, hemicryptophytes dominated significantly, as well as submesophytes while subxerophytes prevailed among groups in relation to edaphotope moisture conditions (Table 1). In ecological-coenotical spectra, weed group (including weed and meadow weed subgroups) had the highest species richness (Table 1).

Mean values of environmental factors were calculated according to Tsyganov's (1983) environmental scales (Table 2). On their basis some environment characteristics of the habitat can be obtained.

Studies of individuals' morphometrical parameters have indicated that generative plants are presented by 1–7 shoots (mean 2.1). These had length from 56–131 cm (mean 92.6cm). Vegetative individuals were also

Table 1. Spectra of species groups of the flora of vascular plants accompanying *Silaum silaus* defined according to the Raunkiaer's (1934) life-form classification, Shennikov's (1950) classification, ecological-coenotical classification (Silaeva et al. 2010; Maevsky 2014; 2010–2016 pers. obs.).

Raunkiaer's classification	Shennikov's classification	Ecological-coenotical classification
Hemicryptophytes (30)	Xeromesophytes (13)	Weed (17)
Geophytes (3)	Mesophytes (12)	Steppe (11)
Phanerophytes (2)	Mesoxerophytes (7)	Meadow (7)
Chamaephytes (2)	Xerophytes (6)	Forest-meadow (2)
Therophytes (1)		Forest (1)

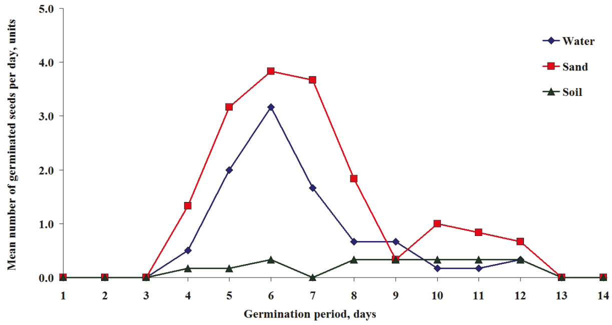

Figure 2. Mean number of germinated *Silaum silaus* seeds per day in three substrates (water: blue diamonds; sand: red squares; soil: black triangles) during the germination period at the northern limit of species' range.

Table 2. Mean environmental indicator values (according to Tsyganov 1983) for habitat with *Silaum silaus* population at the northern limit of its range.

	TM	KN	OM	CR	HD	TR	NT	RC	LC	FH
Intervals:	1–17	1–15	1–15	1–15	1–23	1–19	1–11	1–13	1–9	1–11
Plot 1	8.5	8.9	7.3	7.3	10.3	8.2	4.9	8.3	2.7	6.1
Plot 2	8.6	8.9	6.9	7.4	10.1	7.9	5.2	7.8	2.7	5.8
Plot 3	8.6	8.8	7.7	7.7	9.5	8.4	4.2	8.5	2.8	6.0
Mean:	8.6	8.9	7.3	7.5	10.0	8.2	4.8	8.2	2.7	6.0

Note: TM – termoclimatic, KN – climate continentality, OM – climate humidity, CR – kryoclimatic, HD – soil moisture, TR – soil trophicity, NT – soil nitrogen, RC – soil pH, LC – shading, FH – soil moisture variability

counted. These plants were presented by rosettes containing three leaves in average with variation from one to seven leaves (Table 3).

Generative reproduction has been estimated through counting the number of umbels per generative individual, number of umbellules per umbel and number of fruits per umbellule (Table 4). Fruit production of *S. silaus* individuals was determined using the product of these three parameters. As a result, in studied population mean number of fruits per plant was calculated as 10.0 × 8.2 × 61.2 = 5,018.

Seed characteristics were determined through counting of seed mass and seed germination. Seed mass was equal to 1.36mg (Table 4). Seed germination was estimated visually by removing germinated seeds out of growth chambers. Seeds started to germinate on the fourth day of the experiment. Germination period lasted 13 days independent of edaphic conditions (Table 5). The minimum period from seed sowing to its germination was three days in all variants of edaphic conditions. This parameter highly varied in different replications or the seeds, however, did not germinate completely. In six replications of the experiment, the period from seed sowing to its germination was three days; in four replications - four days; in four replications

Table 3. Some morphometrical parameters of *Silaum silaus* individuals at the northern limit of its range (Republic of Mordovia, Central Russia).

Parameter	Height of generative shoots, cm[1]	Number of leaves per vegetative plant[2]	Number of generative shoots per plant[3]
M	92.6	3.0	2.1
m	2.2	0.53	0.4
min	56	1	1
max	131	7	7

Note: *M* – mean value, *m* – standard error of the mean, *min* – minimal value, *max* – maximal value; [1]n = 75, [2]n = 44, [3]n = 40.

Table 4. Characteristics of the *Silaum silaus* generative reproduction at the northern limit of its range (Republic of Mordovia, central Russia).

Parameter	Number of umbels per plant[1]	Number of umbellules per umbel[2]	Number of fruits per umbellule[3]	Seed mass, mg[4]
M	61.2	8.2	10.0	1.36
m	1.9	0.2	0.1	0.03
min	43	4	4	1.04
max	79	17	16	1.61

Note: *M* – mean value, *m* – standard error of the mean, *min* – minimal value, *max* – maximal value; [1]n = 30, [2]n = 216, [3]n = 300, [4]n = 20.

Table 5. Seed germination of *Silaum silaus* (at the northern limits of species' range) under different edaphic conditions (Republic of Mordovia, central Russia).

Substrate	Period before germination, days	Energy period, days	Germination period, days	Germination energy, %	Seed germination, %
Water	4	6	13	10.3	9.3
Sand	4	6	13	16.3	16.7
Soil	4	6*	13	1.0*	2.3

Note: "*" designate dates adopted in analogy with the water and sandy conditions

- five days; in one replication (in soil conditions) - eight days, and no seed germinated in three replications (in soil conditions).

The maximum number of germinated seeds per day for *S. silaus* was on day six after beginning of seed germination in both water and sand conditions (Fig. 2). Thus, the energy period of *S. silaus* seeds was six days. Peak of seed germination values has not been determined in soil conditions (Fig. 2). In this case, the sixth day was used as the period to calculate energy period and germination energy in analogy with water and sand germination conditions. The maximal germination rate of *S. silaus* seeds was achieved on sand substrate (Table 5).

DISCUSSION

The dominance of hemicryptophytes group in life-form spectrum and sub-mesophytes and sub-xerophytes groups in relation to moisture conditions is considered as typical for similar habitats in forest-steppe zone of Eastern Europe (Lisetskii et al. 2016). Furthermore, a high number of meadow and steppe species indicates affiliation of studied habitat to the northern meadow steppes. Highest species richness in the weed group indicates the significant disturbance of vegetation cover (e.g., Lososová et al. 2006). This is caused by grazing pressure in the last years (Silaeva et al. 2008; 2010–2016 pers. obs.). At present, grazing is less intense due to decrease in cattle population by more than 50% (Pavlov 2013). This may be the reason why *S. silaus* occupation has increased more than 12 times (from 800–9876 m^2) over the last 15 years. Also, populations' vitality of other regionally rare species (e.g., *Echinops ritro* L., *Stipa tirsa* Steven) has also increased in this location (2016 pers. obs.), as it was shown for another steppe plant, *Scutellaria baicalensis* Georgi (Sandanov et al. 2017).

Interpretation of environmental factors' values in the studied habitat, obtained using phytoindication method has allowed the brief description of *S. silaus* habitat according to Tsyganov's (1983) classification. According to climatic scales, the studied habitat is ranked between values typical for habitats in sub-boreal and nemoral termozones with tendency towards the latter. It belongs to the mainland climate group in sub-arid (water balance (difference between amounts of precipitation and evapotranspiration) is about 100mm per year) conditions of temperate winters (the lowest temperature of coldest month is equal to -12^0C). The latter result is close to that presented in recent publications on climate of Mordovia (Yamashkin 2012; Bayanov 2015). According to edaphic scales, *S. silaus* grows on sub-acidophilous (pH ≈ 6.6), nitrogen-poor soils with sub-eutrophic salt regime (salt availability ≈ 200mg/l) under weak to moderately variable humidification. In relation to water content, this habitat has sub-meadow water regime of soils. It occurs when water income (outflow) exceeds precipitation; e.g., the transit surface runoff at slopes. Ground waters lie at a depth of up to 8–10 m. According to coenotic scale (shading), the studied location falls between groups of open and semi-open habitats. Low variation of environment factors' values may be explained by proximity of sampled plots.

According to Bischoff (2002), the maximum number of *S. silaus* seedlings is observed within a radius of 1.5m around the mother plant. This seems to be related with limiting values of shoot height, obtained in *S. silaus* population studied in Mordovia (Table 3). Therefore special investigations of this issue are needed in habitats with different abundance degrees of *S. silaus*.

Fruit production (5,018 fruits per plant) is much higher than the 1,067 to 2,077 fruits per plant in the Saale River floodplain near Holleben (Bischoff 2000). The large number of fruits in the population studied may represent an adaptation to unfavourable conditions under grazing pressure at the studied locality. Large numbers of small seeds and their dispersal by livestock could be a reason driving expansion of the *S. silaus'* population. This is indirectly confirmed by the conclusion that flooding, mowing machinery and grazing animals may disperse seeds over much longer distances

(Bischoff et al. 2009). But they are efficient only if they coincide with large seed set and act in the right direction. The latter conditions are consistent with the data obtained on *S. silaus* seed mass. It has amounted to 1.36mg in Mordovian population, while seeds from flood-meadows in the northern Upper Rhine River (Germany) had mass of 2.43mg (Hölzel & Otte 2004). This may be another reason driving the population to expand over the last 15 years. An almost twofold difference of this parameter cannot be explained only by environment conditions due to their similarity. Perhaps, it is explained by peripheral location of studied *S. silaus* population. Additional studies are needed to understand this phenomenon.

Seed germination study in experimental conditions has demonstrated low germination rates (from 2.3% on soil to 16.7% on sand) of seeds from Mordovia, while this parameter has varied from 26.8–66.6 % in field conditions in the Saale River floodplain near Holleben (Bischoff 2000). Further studies of seed germination ecology are needed to understand the environmental preferences of *S. silaus* seeds. Furthermore, it was found that seeds of the endangered plant germinated best on sand substrate. Most likely, this result is not associated with ecological preferences of this floodplain meadow species. That is rather an indication that sand is the most appropriate substrate for seed germination in relation to any plant as it was shown in experiments with both alien and native species (e.g., Gladunova et al. 2014, 2016; Dutra et al. 2016; Radivojevic et al. 2016).

CONCLUSIONS

The results showed that the *S. silaus* population at the northern limit of its range inhabits the floodplain meadow community. According to observations over 15 years, significant disturbance of vegetation cover caused by grazing impact does not limit population vitality. On the contrary, the area occupied by the population had increased by over 12 times over this period. Small size and large number of seeds, as well as moderate levels of livestock grazing may be key reasons behind this change.

Perhaps, such prosperous status of the plant population at the limit of the species' range may be explained by changing of K-strategy to the r-strategy according to MacArthur & Wilson (1967) concept. Our results on the increase of *S. silaus* seeds' number together with their smaller mass may be considered as a support of this view. Similar results are true for some invasive plant species in their introduced range (e.g., Gladunova et al. 2014). Despite high seed number, their germination rate and the germination energy were very low irrespective of edaphic conditions. It is interesting that seed germination was very low in rough substrate (soil), although this substrate should be typical for *S. silaus* in floodplain meadows in contrast to other germination media (water, sand).

Additional studies on the population of *S. silaus* in different parts of its range are needed. Particularly, population-based studies would be appropriate and indicative in saline steppes of closely located territories (e.g., Penza region) where *S. silaus* occurs in high abundance.

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Appendix 1. List of plant species and their characteristics in studied location with *Silaum silaus* (Apiaceae) at the northern limit of its range (Republic of Mordovia, central Russia)

Family and Species	Life form	Ecological group in relation to soil water	Ecological-coenotical group
Apiaceae			
Dianthus campestris M. Bieb.	H	X	S
Silaum silaus (L.) Schinz & Thell.	H	Xm	S
Asteraceae			
Achillea millefolium L.	H	Xm	M
Artemisia absinthium L.	Ch	X	W
Artemisia vulgaris L.	H	Xm	W
Cichorium intybus L.	H	Xm	W
Cirsium vulgare (Savi) Ten.	H	M	W
Echinops ritro L.	H	X	S
Erigeron acris L.	H	Mx	F-M
Picris hieracioides Sibth. & Sm.	H	Mx	W
Taraxacum officinale F.H. Wigg. sensu lato	H	Xm	W
Brassicaceae			
Berteroa incana (L.) DC.	H	X	W
Convolvulaceae			
Convolvulus arvensis L.	G	Mx	W
Cyperaceae			
Carex praecox Schreb.	H	Xm	M
Equisetaceae			
Equisetum arvense L.	G	M	W
Fabaceae			
Genista tinctoria L.	Ch	M	S
Lotus corniculatus L. sensu lato	H	M	M
Medicago falcata L.	H	Mx	W
Melilotus albus Medik.	H	M	W
Trifolium montanum L.	H	Xm	S
Trifolium pratense L.	H	M	M
Trifolium repens L.	H	M	M
Vicia cracca L.	H	M	W
Lamiaceae			
Salvia dumetorum Andrz. ex Besser	H	Mx	S
Plantaginaceae			
Plantago media L.	H	Xm	W
Poaceae			
Bromus inermis Leyss.	H	Xm	W
Calamagrostis epigejos (L.) Roth	H	Xm	F-M
Festuca valesiaca Schleich. ex Gaudin sensu lato	H	X	S
Rosaceae			
Agrimonia eupatoria L.	H	Xm	M
Filipendula vulgaris Moench	H	Xm	S
Fragaria viridis Weston	H	Mx	S
Malus domestica Borkh.	Ph	M	W
Potentilla argentea L.	H	M	W
Pyrus communis L.	Ph	Xm	F
Rubiaceae			
Galium verum L.	H	Mx	S
Scrophulariaceae			
Linaria vulgaris Mill.	G	M	W
Odontites vulgaris Moench	Th	M	M
Veronica spicata L.	H	X	S

Notes: Life forms (according to Raunkiaer (1940)): G – Geophytes, Ph – Phanerophytes, H – Hemicryptophytes, Th – Terophytes, Ch – Chamaephytes; Ecological groups in relation to soil water (according to Shennikov (1950): Xm – Xeromesophytes, M – Mesophytes, Mx – Mesoxerophytes, X – Xerophytes; Ecological-coenotical groups (according to Silaeva et al. 2010; Maevsky 2014; pers. obs.): W – Weed, S – Steppe, M – Meadow, F-M – Forest-meadow, F – Forest

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