

The specific features of the reproductive biology of the rare species *Gueldenstaedtia monophylla* Fisch. (Fabaceae)

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Abstract. The seed production of the rare species *Gueldenstaedtia monophylla* has been investigated in 19 coenotic populations in the territories of Russia (Central Altai) and Mongolia (the north-western part). *G. monophylla* reproduces exclusively by seeds and is characterized by the low number and density of the plants in the populations. Its populations have a high proportion of generative plants: from 31 to 84% from the total number of the plants. The plants of *G. monophylla* have a small number of generative shoots, varying from 1 to 6 per plant. The number of flowers on the plants is low, too, and varies in the populations on average from 1.2 to 15.3 per plant. The potential seed production (PSP) varies considerably from 13.5 to 308.6 ovules per plant. The real seed production is much lower, to constitute from 6.2 to 74.5 seeds per plant. The low seed production, fructification that occurs not every year, and scanty populations make the species vulnerable.

Gueldenstaedtia monophylla is a rare species which occurs in the alpine-steppe zone of central, rarer south-eastern Altai, in Tuva and in Mongolia. *G. monophylla* has a disjunctive habitat covering arid low-mountain and middle-mountain terrains of Central Asia. The species grows on dry stony and rubble-covered slopes, on rocks and rocky alluvial deposits, outcrops of limestones, on sand of low thickness and on saliferous pebble beaches [1, 2, 3]. *G. monophylla* is in the Red Book of RF [4] with the status of 3 (R) – a rare species, and in the Red Book of Mongolia [5], with the rarity category being B2ab (iii). The habitat of this species is relatively small, as well as the number of preserved populations. The peculiar biology of this species, the narrow environmental range, and the increased anthropogenic load on the habitats – all these factors lead to the risk of local reduction and extinction of individual populations and jeopardize the species as a whole.

The existence of species in nature largely depends on the specifics of seed production and reproduction, which is determined by the level of seed production, the quality of seeds, the rate of their ripening and dissemination [6]. Fructification and seed reproduction are some of the major characteristics of the biology of species and the indicators of the condition of their populations [7]. The peculiar features of the reproductive biology of a

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species are in the focus of most studies referring to rare species and to revealing their specific characteristics [8, 9].

The purpose of this study was to investigate the seed production of *G. monophylla*.

Materials and methods

19 coenotic populations (CP) of *G. monophylla* have been investigated. The studies were conducted during the vegetation seasons of 2005–2016 in the territory of Russia (western Siberia, Central Altay) and north-western Mongolia.

In each population, 25–30 plants of the middle generative age were investigated. The following parameters of seed production were considered: the number of generative shoots per plant, the number of inflorescences, the number of flowers in an inflorescence, the number of beans, and the number of ovules and seeds per bean. To characterize seed production, the following parameters were determined: potential seed production (PSP), real seed production (RSP), and the percentage of semenification (PS), showing the ratio of RSP and PSP [10].

Results and discussion

Gueldenstaedtia monophylla is a perennial grassy taproot plant with polycarpic shoots of a rosette type, incapable of vegetative reproduction. Thus, seed preproduction is the only way of reproduction and spread of this species. *G. monophylla* is a cross-pollinating species, it blossoms in May–June, and produces fruits in June–July. The beans are 2 – 3 cm long, and have a linear and cylindrical shape.

As a rule, the populations are not numerous (50 – 2000 plants), fragmented and have low density of the plants [11]. In the CPs investigated, the percentage of generative plants was 31–84% from the total number of plants in the population [12]. Fruits do not set every year on generative plants: there are cases when beans do not form on a plant during one year or several years. Breaks in fruit-bearing are related to the unfavorable conditions of the vegetation periods in some years, draughts and recurring frosts. The percentage of generative plants which did not set fruits in the population may reach 100% of the total number of generative plants, thus making a significant contribution in the total seed production. The number of non-fruit-bearing plants varies considerably in different years of study and may constitute from several plants to practically all the generative plants in individual populations. For example, in 2006, the percentage of the plants which did not form fruits varied from 12.5% (CP Bolshoy Yaloman) to 69% (CP Chuy-Oozy), on average for populations, 35.4%. In 2010, the share of plants which did not set fruits in CP Maly Yaloman was 60%, and in CP Malaya Inya, it was 70%.

The plants *G. monophylla* form a small number of generative shoots from 1 to 6 per plant (Table). Plants from CPs growing in Mongolia form a greater number of generative shoots (from 2.3 ± 0.4 to 4.2 ± 0.2), compared to the plants from CPs from Mountainous Altay (from 1.0 ± 0.15 to 2.1 ± 0.06).

On the plants, only 2–15 flowers are formed. The number of flowers on the plants varies in populations: in the CPs from Mountainous Altay researched, the number of flowers on a plant was on average from 1.2 ± 0.21 to 5.3 ± 0.20 . In the populations from Mongolia, this characteristic is higher and varies from 6.7 ± 0.2 to 15.2 ± 0.3 flowers per plant. The percentage of flowers setting fruits varied in the populations on average from 33.5 to 91.1%. In the CPs growing in Mongolia, the share of the set fruits ranged from 33.5 to 70.4%, the average figure for the populations under study being 47.2 ± 3.6 . In CPs investigated in Mountainous Altay, the percentage of set fruits varied from 58.5 to 91.15,

on average constituting 69.0 ± 1.6 . The highest rate of fructification was noted in the populations of Chuy-Oozy 4 and Malaya Inya, 91.1 and 80%, respectively (Table).

The seeds of *G. monophilla* have a rounded kidney shape and colored light-beige and greenish-beige; the surface of the seeds is matte and without pubescence. The size of the seeds was on average 2.98 ± 0.03 mm long and 2.62 ± 0.04 mm wide. The mean weight of the seeds differed among the populations more than two times, to constitute from 0.28 ± 0.02 to 0.77 ± 0.03 g (100 seeds). Based on this sign, the populations under study may be conditionally divided into the following groups: populations in which the plants have seeds having low, medium and high weight. All the populations except one were found to belong to two groups, with seeds of high and low weight. Eight CPs (47.4%) out of 19 had low weight of the seeds, varying from 0.28 to 0.43 g, the lowest average seed weight was recorded in CP Inegen 2 (0.28 g) and Malaya Inya (0.30 g). The high weight of the seeds from 0.61 to 0.77 g was found in 10 CPs (52.6%), with the highest seed weight recorded in CPs Bolshoy Yaloman and Saldzhar – 0.77 g. And only one CP, Nizhny Inegen, may be referred to the middle group with the middle weight of the seeds, 0.54 g.

Table. Certain parameters of seed production of *Gueldenstaedtia monophilla*

| Population | The year of the study | NGSH* | NBIN | NOB | NSB | PSP | RSP | PS, % |
|--------------|-----------------------|----------|----------|-----------|-----------|-------|-------|-------|
| Chuy-Oozy 1 | 2008 | 1.1±0.05 | 1.3±0.16 | 12.5±0.63 | 6.1±0.56 | 27.0 | 8.3 | 30.7 |
| Chuy-Oozy 2 | 2010 | 2.1±0.06 | 1.0±0.05 | 10.3±0.75 | 5.7±0.95 | 37.6 | 12.2 | 32.4 |
| Chuy-Oozy 3 | 2010 | 1.2±0.14 | 1.6±0.14 | 17.6±0.90 | 11.3±0.83 | 52.4 | 23.0 | 43.9 |
| Chuy-Oozy 4 | 2010 | 1.0±0.15 | 1.4±0.20 | 14.4±1.16 | 8.0±0.95 | 21.7 | 11.4 | 52.6 |
| Chuy-Oozy 5 | 2010 | 1.0±0.18 | 1.0±0.16 | 10.5±0.52 | 5.5±0.85 | 15.7 | 5.5 | 34.4 |
| Chuy-Oozy 6 | 2010 | 1.3±0.27 | 1.3±0.16 | 13.2±0.87 | 8.3±0.86 | 38.8 | 14.24 | 36.7 |
| Inegen | 2010 | 1.4±0.11 | 1.3±0.12 | 14.1±0.68 | 8.7±0.81 | 39.1 | 16.2 | 41.5 |
| N. Inegen | 2010 | 1.0±0.12 | 1.1±0.14 | 18.4±1.12 | 11.5±1.18 | 34.1 | 13.1 | 38.4 |
| M. Yaloman | 2010 | 1.0±0.16 | 1.0±0.18 | 22.7±1.13 | 10.0±0.93 | 45.3 | 10.0 | 22.1 |
| B. Ilgumen | 2010 | 1.0±0.17 | 1.0±0.13 | 9.0±0.98 | 6.2±1.10 | 13.5 | 6.2 | 46.3 |
| B. Yaloman | 2010 | 1.9±0.26 | 1.7±0.15 | 10.6±0.48 | 4.8±0.34 | 49.9 | 16.3 | 32.6 |
| B. Yaloman 2 | 2010 | 1.2±0.15 | 1.5±0.27 | 13.0±1.14 | 7.6±1.17 | 33.3 | 14.0 | 42.0 |
| Inya | 2010 | 1.4±0.18 | 1.8±0.17 | 13.7±1.01 | 7.7±0.90 | 47.3 | 20.3 | 42.8 |
| M. Inya | 2010 | 1.0±0.07 | 1.0±0.12 | 15.2±1.10 | 11.0±1.18 | 19.1 | 11.0 | 57.7 |
| Saldzhar | 2006 | 1.4±0.12 | 2.2±0.21 | 14.8±0.46 | 8.7±0.41 | 45.8 | 26.8 | 58.6 |
| Hovd 1 | 2015 | 4.2±0.20 | 1.3±0.21 | 13.9±1.50 | 7.2±0.72 | 216.6 | 37.4 | 17.3 |
| Hovd 2 | 2015 | 4.2±0.32 | 1.3±0.30 | 19.1±0.79 | 13.2±1.00 | 308.6 | 74.5 | 24.2 |
| Hovd 3 | 2015 | 2.4±0.21 | 2.0±0.62 | 16.9±1.40 | 12.0±1.12 | 116.5 | 58.1 | 50.0 |
| Hovd 4 | 2015 | 2.3±0.43 | 1.8±0.30 | 16.8±2.10 | 8.6±1.30 | 140.9 | 36.1 | 36.1 |

* – NGSH – number of generative shoots; NBIN – number of beans per inflorescence; NOB – number of ovules per bean; NSB – number of seeds per bean; PSP – number of ovules per plant; RSP – number of seeds per plant; PS – percentage of semenification

In the investigated coenopopulations of *G. monophilla*, significant variation in the parameters of seed production has been revealed. Potential seed production (PSP) far exceeds the real seed production. Essential variations in PSP have been revealed not only

among the populations but also in different years of the study (Fig. 1). In CP Chuy-Oozy, PSP varied from 17.6 to 40.9 in different years of observations. Maximum PSP was observed in the populations from Mongolia: 116.5 – 308.6, on average being 195.6. In the populations of Mountainous Altay, PSP was found to be much lower, to constitute from 13.5 (CP Bolshoy Ilgumen 2010) to 87.8 (CP Inegen 2006), being on average 39.3.

The real seed production (RSP) varied from 6.2 to 74.5%. The lowest RSP, 5.5 and 6.2%, was found in CP Chuy-Oozy 5 (2010) and Bolshoy Ilgumen (2010). This is related to the small number of generative shoots on a plant, totaling on average 1.0, and to the small number of ovules developing into seeds. The highest RSP was recorded in CPs from Mongolia Hovd 2 and Hovd 3 – 74.5 and 58.1, respectively. Among the CPs growing in Mountainous Altay, the highest RSP was recorded in CP Inegen – 48.7% (2005), 41.9% (2006) and in Chui-Oozy 2 – 32.3 (2010).

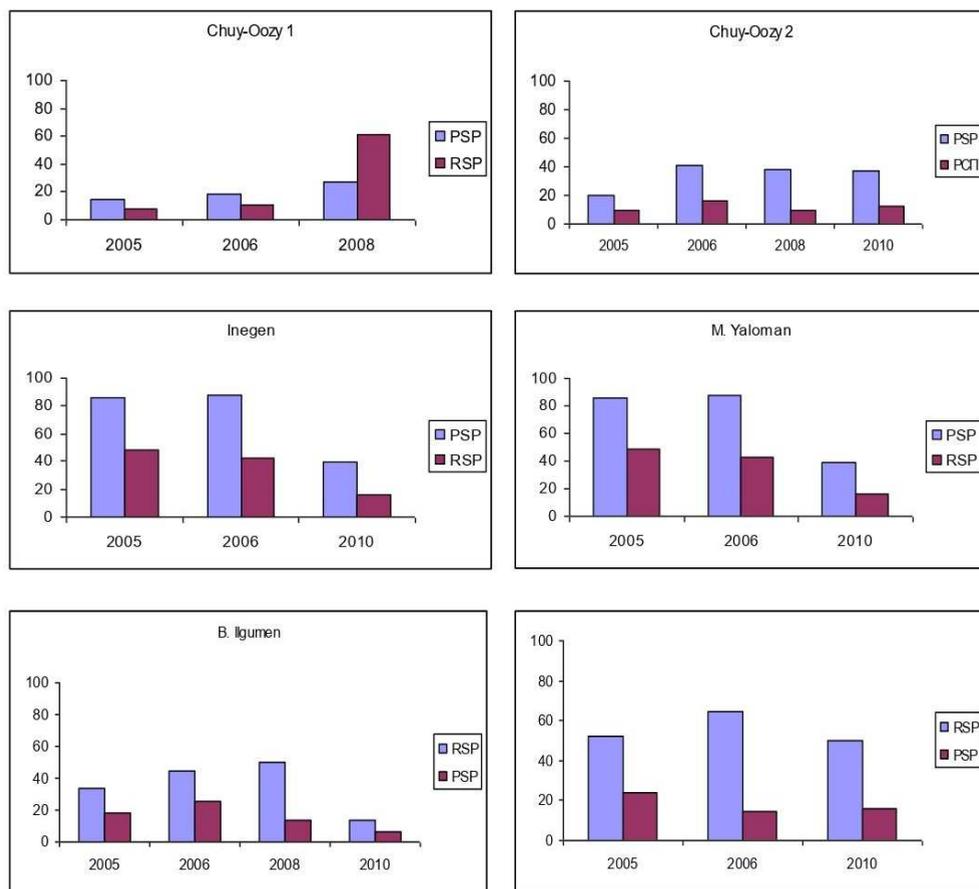


Figure 1. Indicators of seed production of *Gueldenstaedtia monophillia*

Generally in legumes, a gap is characteristic between potential and real seed production. The following factors may be indicated among the causes of the low RSP: unfavorable weather conditions in the period of blossoming, restraining the flight of pollinating insects and the damage inflicted to the fruits and seeds by pests [.

The percentage of semenification, showing the ratio of RSP to PSP, is one of the parameters of success of seed reproduction in the given conditions of habitat. The percentage of semenification in the populations investigated varied in the range from 17.3 to 61.4%. The populations from Mongolia differ by the higher percentage of

semenification: for example, in CPs Hovd 2 and Hovd 3, the percentage of the set seeds was 74.5 и 58.1%, respectively.

The study of the seed production of *G. monophylla* has shown that the real seed production of this species is rather low. Fructification occurs not every year and depends on favorable weather conditions in the vegetation period. The highest seed production has been revealed in populations from Mongolia. This is likely to be related to more favorable climatic conditions for this species in this territory.

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