

Vol. 24, No. 6, November-December, 1993

July, 1994

RUSSIAN JOURNAL OF
ECOLOGY

TRANSLATED FROM RUSSIAN



CONSULTANTS BUREAU, NEW YORK

**ONTOGENY, POPULATION STRUCTURE, AND DYNAMICS OF
THE SOUTHERN-URAL ENDEMIC *Onosma guberlinensis*
DOBROČZ. ET V. VINOGR.***

P. L. Gorchakovskii and V. N. Zueva

UDC 524.3:582.28:584.41

Onosma guberlinensis is a narrowly specialized local endemic represented by a few small populations subjected to intensive grazing. Phases of this species' ontogeny were revealed, and changes in the density and structure of its populations under the influence of natural and anthropogenic factors were traced.

Endemic plant species frequently exist in the form of small, isolated populations. Usually, such plants are narrowly specialized, intermittently distributed, connected with strictly specific environmental conditions, and are the most vulnerable part of regional floras. Changes, and sometimes even complete destruction of biotopes under human influence lead to a still greater reduction in the range of local endemics, and then to their complete extinction (Gorchakovskii and Zueva, 1984). Rare and endangered plants, including local endemics can be successfully protected only on the basis of knowledge of the patterns of existence, age structure, dynamics, and reaction to anthropogenic actions of their small, isolated populations.

Onosma guberlinensis Dobročz. et V. Vinogr., a narrowly local endemic of the Southern Ural foothills (Gorchakovskii, 1969; Gorchakovskii and Shurova, 1982), can serve as an example of rare plants with very limited, intermittent distribution. The known habitats of this plant are concentrated mainly in the Guberlya region of arid-denudation hills (between the villages of Podgornoe and Kazach'ya Guberlya, 5 km from the mouth of the Guberlya River on Zmeinaya mountain, in the region of Kirpichnaya ravine, and in the basin of Atamanovaya Creek), where it grows on steppified rocky slopes and the tops of hills 300-450 m above sea level. Besides that, in the herbarium of the Botanical Institute of the Russian Academy of Sciences there is a specimen of this plant collected on the Podural plateau, 55 km northeast of Aktyubinsk.

Onosma guberlinensis grows in rocky steppes on the tops and upper parts of eroded slopes of hills and knolls with thin, rocky soil. The underlying rock is porphyrite with tufaceous material; the weathering products contain Ca > 3%, Mg > 3%, Al > 3%, Ti > 1%, and a lot of Fe and Si. The species is in a critical state, subjected to danger of destruction in connection with grazing of livestock (primarily goats) and a number of other anthropogenic actions. Since 1983, the authors have been studying the growing conditions, patterns of individual development, and population structure and dynamics of this species.

The investigations were conducted in Orenburg Oblast, in the Guberlya mountains, near Kazach'ya Guberlya, on permanent sample areas each 100 m² in size. Morphological study of specimens in different phases of individual development was conducted preliminarily. The sample areas were broken up like a checkerboard, into 1 × 1 m squares; the position of the squares was designated by the indices Ia, Ib, IIc, IIId, etc. In each square, we noted the appearance, development, and death of individuals. The individuals were marked, and their position was noted on transparent overlays (a separate sheet for each year of the observations). This made it possible to trace changes in the situation in each square.

ONTOGENY, AGE STATES

Onosma guberlinensis is a perennial, † polycarpic, tap-rooted, herbaceous plant that forms a caudex (multiheaded stem-root), with a monopodial, semirosette system of shoot formation. Its lifetime is up to four-five years. Traces of last year's dead shoots are noted on the caudex.

*The work was performed with the support of the Russian Fund for Basic Research (project 93-04-6495).

†D. N. Dobrochaeva and V. M. Vinogradova (1966), who were the first to describe *Onosma guberlinensis* and only had a few herbarium specimens of young plants available, thought that it was a biennial.

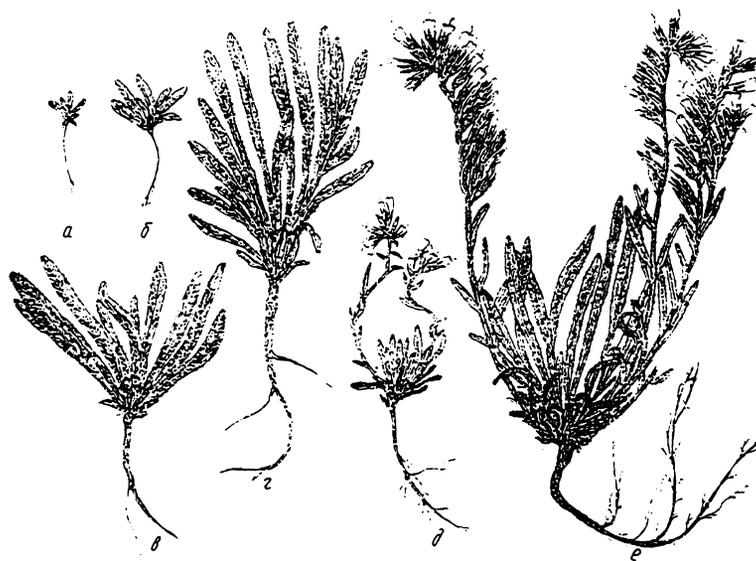


Fig. 1. Phases of ontogeny of *Onosma guberlinensis*: a) plantlet; b, c, d) juvenile; e, f) generative (vitality levels II and III, respectively).

In the ontogeny of this species (Figs. 1, 2, and 3), the following phases (age states) are distinguished: sprouts, plantlets, juvenile, generative, and senile individuals (the latter form only in rare cases; usually the plants die after completion of their generative cycle).

In the habitats of *Onosma guberlinensis*, there is usually a sufficient reserve of viable seeds in a dormant state in the soil. However, in the rocky steppe their germination is limited by the unstable hydrothermal conditions, mainly by a moisture deficiency. Conditions are favorable for the seeds' germination for only a short period, a few times in the course of a growing season (usually in the beginning of spring, when the soil is still sufficiently moistened by snow waters; in the summer, after downpours; and during the fall, when the rate of evaporation lessens).

The sprouts are small, with two cotyledons on the soil surface.

The plantlets are small plants up to 2-2.5 cm tall, with a rosette of 4-8 leaflets prostrate on the soil surface (by this time the cotyledons have died back), with a thin tap root reaching a length of 8-10 cm.

Juvenile phase. The plants have a well developed rosette of leaves (diameter from 2 to 12 cm, height from 3 to 11 cm), and a slightly branched tap root up to 15 cm long. In this stage of ontogeny, formation of the caudex begins. In the fall, the growing point is drawn into the soil to a depth of as much as 1 cm. At the beginning of the second growing season, last year's leaves continue to function for some time, until a new leaf rosette forms. In the summer and fall, remains of last year's leaves are noted on the lower part of the stem.

Generative Phase. The plants have a rosette of radical leaves, several flower-bearing stems, a more or less developed caudex, and a branched tap root reaching a length of 40-50 cm. The degree of development of generative individuals depends on which particular generation of sprouts and plantlets they belong to, soil conditions, competition with other plants, the effect of grazing, steppe fires, etc. In accordance with this, we distinguish three levels of vitality for individuals in the generative stage. Individuals with the first level of vitality are larger, the diameter of the bush is as much as 25 cm; the number of generative shoots is 5-10, and their length is up to 25-30 cm; the number of flowers per shoot is as many as 25; and the root is well developed, turning into a clearly expressed caudex. Individuals with the second level of vitality have a bush up to 10-12 cm in diameter, 3-4 generative shoots up to 20 cm long, and as many as 17 flowers per shoot; their roots are thinner; and the caudex is moderately developed. Individuals with the third level of vitality have a bush no more than 5 cm in diameter, 1-2 generative shoots up to 10-12 cm long, 3-6 flowers per shoot, a slightly developed caudex, and a thin root.

Senile Phase. Individuals classified in this phase are rarely found; they only form as a result of disruption of the generative cycle, when generative shoots are eaten by livestock (primarily goats) or the flowers are damaged by frosts or insect pests. In this case, individuals are formed with a very large bush, up to 30 cm in diameter and up to 25 cm tall, with numerous rosettes bearing large leaves up to 20 cm long, a strongly developed caudex, and a thickened root (see Fig. 3).



Fig. 2. *Onosma guberlinensis* — generative phase
(vitality level I).

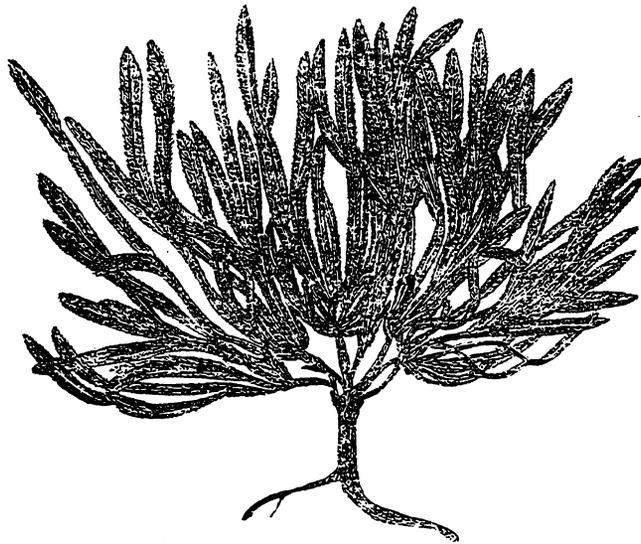


Fig. 3. *Onosma guberlinensis* — senile phase.

POPULATION STRUCTURE AND DYNAMICS

In the Guberlya mountains, we found and studied populations of *Onosma guberlinensis* that were arbitrarily named for the place where they grow: "Zmeinaya mountain," "Kirpichnaya mountain," "Kalinovka," "Baranii Rog," and "Sopochka." The total average number of generative individuals in all of the studied populations together is about 250, with variations in one direction or the other in individual years. The age structure, density, and dynamics of the onosma populations can be con-

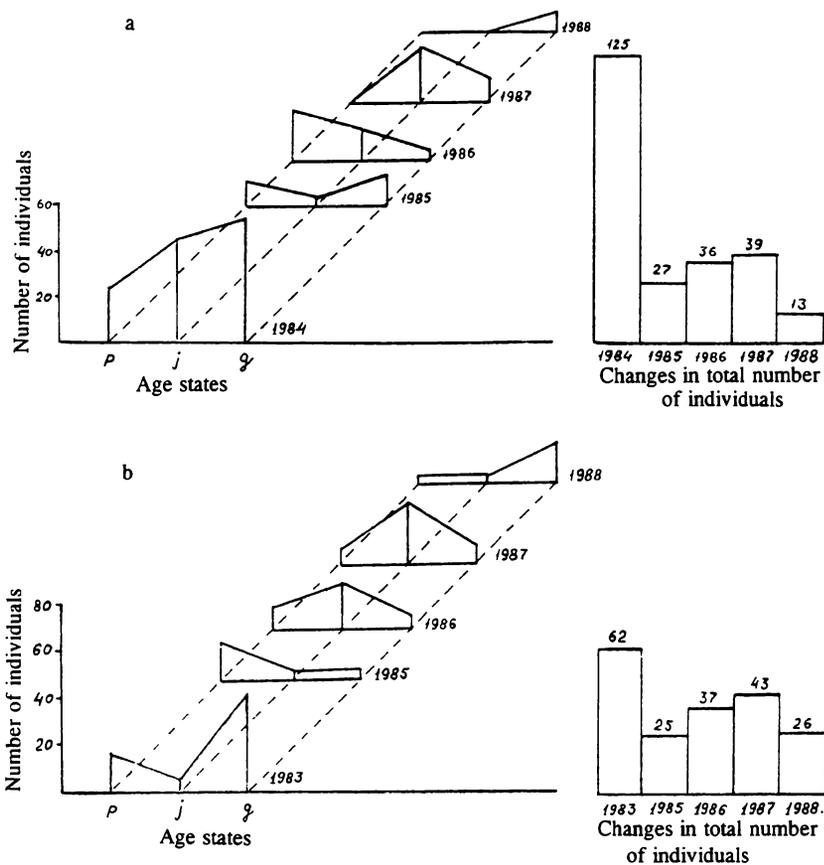


Fig. 4. Dynamics of the "Kirpichnaya mountain" (a) and "Zmeinaya mountain" (b) populations of *Onosma guberlinensis*. p) Plantlet; j) juvenile plants; g) generative plants.

sidered on the example of two local populations: "Zmeinaya mountain," and "Kirpichnaya mountain," taking for comparison the most indicative period from 1983 through 1988.

The "Kirpichnaya mountain" population (Fig. 4a) is located on a gentle south slope and is part of a fescue—feather-grass mountain steppe community. The predominant species are *Stipa capillata*, *Festuca sulcata*, *Helictotrichon desertorum*, *Artemisia austriaca*, *Galium verum*, *Linaria altaica*, and *Silene baschkirorum*. In 1984, the population had fairly high density (125 individuals in 100 m²), and normal, full-range age structure with a predominance of generative and juvenile individuals. In 1985, it was subjected to the effect of rather intensive goat grazing, as a result of which the juvenile individuals died, (as many as 27 individuals in 100 m²) and the number of plantlets and generative individuals decreased. In 1986, an invasion cycle began; many plantlets appeared; the number of juvenile individuals rose; and part of the generative ones died. In 1987, regression of the population set in; the number of generative and juvenile individuals increased as a result of their transition from preceding age states, but there was no replenishment with plantlets, due to spring frosts, a dry summer, and grazing, and in the following year, 1988, only generative individuals were left.

The "Zmeinaya mountain" population (Fig. 4b) is on a south slope with a 25° gradient, near a goat pen, and is subjected to grazing. The vegetation is rocky steppe with the shrub *Spiraea crenata*; the main components of the herbage are *Stipa capillata*, *S. zalesskii*, *Artemisia austriaca*, *Orostachys spinosa*, and *Elytriga pruinifera*. In 1983, the population bore the imprint of grazing action, which was manifested in low density (62 individuals in 100 m²), a small number of juvenile individuals, and a predominance of plants in the generative state. In 1985, suppression by grazing continued; the population was of an invasion nature; the density dropped to 20 individuals in 100 m²; there were few juvenile individuals; and a significant part of the generative ones died. In 1986 and 1987, it became a normal, full-range population, with a predominance of juvenile individuals; however, in 1988 it acquired a regressive nature.

CONCLUSIONS

Onosma guberlinensis is a rare, endemic species, a petroxerophyte, narrowly specialized for growth in mountain and foothill steppes on a rocky substrate with thin soil enriched with calcium compounds, in conditions of little snow in the winter, a hot dry summer, erratic moistening, and a periodic moisture deficiency. The size and density of populations of this plant are subject to wave fluctuations in connection with the pluviothermal conditions in individual years, as well as under the influence of anthropogenic factors. The structure of the population as a whole has a wavy invasion-regression nature; stages of rejuvenation are quickly followed by aging stages, with disruptions of the structure often occurring as a consequence of intensive grazing.

In its life strategy, *Onosma guberlinensis* is an explerent (Ramenskii, 1971), or an R-strategist (Grime, 1979), that does not withstand competition on the part of sod grasses. Where dense herbage forms, with a predominance of grasses, this plant ceases to regenerate, but moves to places with a thinned (as a result of erosion or moderate grazing) plant cover. However, an overload of steppe plants leads to its extinction.

The Guberlya mountains, where the sites of this plant are concentrated, are a region of traditional goat herding (the local breed of goats is distinguished by high quality down). In recent decades, the habitats of *onosma* have been subjected to especially intensive grazing, leading to often repeated disruption of the structure, and reduction in the size and density of its populations.

A large part of the populations of *Onosma guberlinensis* in the Southern Urals is in a critical state. It is necessary to organize special sanctuaries for protecting this rare plant, using measures assisting its regeneration (loosening of the soil, removal of sod).

REFERENCES

- Gorchakovskii, P. L., Basic Problems of Historical Phytogeography of the Urals [in Russian], Ural. Filial AN SSSR, Sverdlovsk (1969).
- Gorchakovskii, P. L., and Zueva, V. N., "Age structure and dynamics of small isolated populations of Ural endemic *Astragalus* species," *Ékologiya*, No. 3, 3-11 (1984).
- Gorchakovskii, P. L., and Shurova, E. A., Rare and Endangered Plants of the Urals and Ural Region [in Russian], Nauka, Moscow (1982).
- Grime, J. P., *Plant Strategies and Vegetation Processes*, Wiley, Chichester etc. (1979).
- Dobrochaeva, D. N., and Vinogradova, V. M., "A new species of *onosma Onosma guberlinense* Dobroc. et Vinogr. from the Southern Ural region," *Urainskii Botanich. Zh.*, **23**, No. 3, 96-99 (1966).
- Ramenskii, L. G., *Problems and Methods of Studying Plant Cover* [in Russian], Nauka, Leningrad (1971).