State of Cenopopulations of *Trommsdorffia ciliata* (Thunb.) H.S. Pak (Asteraceae) in the Plant Communities of the Lower Reaches of the Ussuri River

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**Abstract.** The paper presents the results of studying the structure and state of four cenopopulations of the rare species *Trommsdorffia ciliata* (Thunb.) H.S. Pak in the valley of the lower reaches of the Ussuri River. The density of the studied cenopopulations is from 8 to 27 ind./m². All studied cenopopulations are normal and incomplete. The absence or small number of juveniles in the ontogenetic spectrum of the studied cenopopulations is associated with a high projective cover of the herbaceous layer, which prevents the survival of this age group. According to the absolute maximum of ontogenetic groups of adult plants of all cenopopulations, *Trommsdorffia ciliata* are classified as young normal ones, where the maximum falls on individuals of the virginal state. An evaluation of population and organismic signs of the state of the studied cenopopulations showed that the most favorable conditions for the growth of *Trommsdorffia ciliata* are formed in a moist sedge-grass-herb meadow in the vicinity of Lonchakov village. The measures for the protection of *Trommsdorffia ciliata* that are to include in the Red Book of the Khabarovsk krai (2019), to inhabit in a protected area and are to control the state of the known population of this species have been cited.

1. Introduction

The growing process of decline in global biodiversity and an increase in the number of plant species threatened with extinction have led to the need to study the state of cenopopulations (CP) and develop methods to predict the risks of extinction. An increasing number of studies are devoted to this problem [1]. Populations of rare plant species can exist in one of three states: a) stable, when a certain size of the population field, the number of individuals and the main structural characteristics of the local population remain for a sufficiently long period, b) progressive development with an increase in the size of the population field and the number of individuals, and c) degradation, when the size of the population field decreases, it is divided into separate loci, the number of individuals has a steady tendency to decrease, and the individuals are characterized by reduced viability [2]. Valley of the lower reaches of the Ussuri River is a territory in which the transformation of vegetation cover, especially meadow plant communities, is taking place, associated with drainage reclamation, plowing of land, firewood, cattle grazing, haymaking and the implementation of the Far Eastern Hectare program. In this regard, the study of the state of cenopopulations of plant species taking into account the organismic and population parameters [3] is currently considered relevant and timely.
Trommsdorffia ciliata (Thunb.) H.S. Pak is the Siberian-South Far Eastern species, a herbaceous perennial plant up to 60 cm tall. It inhabits herb meadows, among bushes, on open grassy slopes. On the territory of Russia, the species is distributed in the southern regions of Western and Eastern Siberia, in the Far East within Primorsk and Khabarovsk Territories, Amur and Jewish Autonomous Regions. In Khabarovsk Territory, it was noted in the valleys of the Amur, Ussuri Rivers (Khabarovsk, Lazo, Vyzemskey, Bikin districts), on the spurs of the Vandan ridge (Amur district), on the Evoron-Chukhagir lowland (Polina Osipenko district) [4]. In Khabarovsk Territory, Trommsdorffia ciliata is a rare species that occurs sporadically with a small number of populations, included in the Red Book of the Khabarovsk krai [5].

This paper presents the study of the structure and state of cenopopulations of the rare species Trommsdorffia ciliata in the valley of the lower reaches of the Ussuri River in connection with the economic development of meadows.

2. Materials and methods

Studies of the structure and state of cenopopulations of Trommsdorffia ciliata were carried out on meadow communities in the valley of the lower reaches of the Ussuri River in 2011 and 2016. The material for the research was the four cenopopulations of this rare plant species discovered in the course of field work (Figure 1).

![Figure 1. Chart diagram of Trommsdorffia ciliata cenopopulations in meadow communities of the valley of the lower reaches of the Ussuri River: 1 – environs of Pokrovka village, herb meadow; 2 – environs of Kozlovka village, grass-herb meadow; 3 – environs of Lonchakovo village, moist sedge-grass-herb meadow; 4 – environs of Vidnoye village, grass-herb meadow.](image)

On meadow communities with ciliated Trommsdorffia ciliata, geobotanical descriptions were carried out using standard and generally accepted methods [6]. A separate individual was taken as a counting unit. To determine the ontogenetic state of Trommsdorffia ciliata, no plant excavation was carried out in order to preserve its natural populations. Individuals of the generative state were not divided into
young, mature and old, but were united into one age group and were considered as generative. Within each cenopopulation, five groups of age states of individuals were identified: juvenile (j), immature (im), virginal (v), generative (g), and senile (s) [7]. After identifying the age structure of the cenopopulation, the type of cenopopulation was identified using the classification of T.A. Rabotnov [8], who distinguished invasive, normal and regressive cenopopulations; A. A. Uranov and O.V. Smirnova [9] according to the absolute maximum of ontogenetic groups of adult plants; A.A. Uranov [10], who distinguished complete and incomplete cenopopulations.

The assessment of the state of cenopopulations was carried out using organismic and population characteristics [3]. The author chose the following as organismic characters: the height of the generative shoot, the length and width of basal and stem leaves, and the diameter of the basket. Population traits are the number of specimens in the cenopopulation, the density of the cenopopulation, i.e. the number of specimens of a rare species per 1 m², the proportion of specimens of the pregenerative, generative and postgenerative periods. In each cenopopulation of Trommsdorffia ciliata, the vitality of the species (the vital state of the species) was identified, which shows the degree of its development or suppression in the phytocenosis.

Species names are given according to the International Plant Name Index 2021 (IPNI. URL: http://www.ipni.org (Accessed 10.08.2021) [11].

3. Results and discussion
The studied localities of Trommsdorffia ciliata are confined to herb, grass-herb, sedge-grass-herb meadows, where anthropogenic loads are minimized – areas adjacent to the state border from the side of the Ussuri River. Below are brief characteristics of the studied cenopopulations.

Cenopopulation 1 (CP 1) is located in Bikin district of Khabarovsk Territory, in the vicinity of Pokrovka village, in a herb meadow. The undergrowth is poorly expressed; it is composed of Acer ginnala f. jeonjuana M. Kim and Maackia amurensis Maxim. & Rupr., with a total plant cover of 5%. The shrub layer is poorly expressed, represented by Salix abscondita Laksch. The herb-dwarf shrub layer is well pronounced, polydominant, with a total projective cover of 100 %. It consists of: Calamagrostis langsdorffii var. flexuosa (Rupr.) Tzvelev with a plant cover of 30 %, Carex cespitosa var. minuta (Franch.) Kük. (20 %), Filipendula palmata var. nuda Popov (5 %), Sanquisorba parviflora (Maxim.) Takeda (5 %), Patrinia scabiosifolia var. hispida (Bunge) Franch. (3 %), Viola patrinii var. minor Makino (3 %), Trifolium lapinaster var. punilum Popov (2 %), Kummerowia striata (Thunb.) Schindl. (3 %); Trommsdorffia ciliata (Thunb.); H.S. Pak (3 %). Serratula coronata was singly observed.

Cenopopulation 2 (CP 2) is located in Bikin district of Khabarovsk Territory, in the vicinity of Kozlovka village, in a grass-herb meadow. The undergrowth is poorly expressed, represented by Acer ginnala f. jeonjuana M. Kim, total projective cover is 2 %. The herb-dwarf shrub layer is well expressed, with a total projective cover of 100 %, dominated by Calamagrostis extremiorientalis (Tzvelev) Prob. with projective cover (70 %). Common species here are: Carex laevissima Nakai (3 %), Vicia cracca subsp. grossheimii (Ekutim.) Hashimov (2 %), Lysimachia davurica Ledebl. (2 %), Trommsdorffia ciliata (1 %). Tephroseris flamina was observed only once.

Cenopopulation 3 (CP 3) is located in Bikin district of Khabarovsk Territory, in the vicinity of Lonchakovo village, on a moist sedge-grass-herb meadow. The single-breed shrub layer is represented by Spiraea salicifolia L. The herb-dwarf shrub layer is well expressed, its total projective cover is 80-90 %. The dominant species are: Carex cespitosa with a plant cover of 40%, Calamagrostis langsdorfii (30 %). Common species here are: Trommsdorffia ciliata (6 %), Patrinia scabiosifolia (2 %), Filipendula palmata (2 %), Melampyrum roseum var. nakaiannum (Tuyama) M.Kim (2 %), Cirsium pendulum Fisch. ex DC. (2 %), Kummerowia striata (Thunb.) Schindl. (2 %).

Cenopopulation 4 (CP 4) is located in Vyazemsky district of Khabarovsk Territory, in the vicinity of Vidnoye village, in a grass-herb meadow. The shrub layer is not pronounced. The herb-dwarf shrub layer is well pronounced, the total projective cover is 100 %. The dominant species is Calamagrostis extremiorientalis with a plant cover (70 %). Common here are: Trommsdorffia ciliata (3 %),
Anemonidium dichotomum (L.) Á. Löve & D. Löve (3 %), Kummerowia striata (3 %), Artemisia stolonifera var. laciniata G.Y. Zhang (2 %), Sanguisorba parviflora (Maxim.) Takeda (2 %), Viola patrinii (1 %), Lysimachia davurica (1 %), Thalictrum simplex subsp. amurense (Maxim.) Hand (1 %). Veratrum lobelianum was observed singly.

In the studied meadow communities, Trommsdorffia ciliata was noted in the second substage with a generative shoot height of up to 67 cm and in the third substage in the form of two or three basal leaves, in the amount of 14 individuals (CP 2), 38 individuals (CP 4), 42 individuals (CP 1) and 73 individuals (CP 3) with a plant cover of 1 % (CP 2), 6 % (CP 3), and 3% (CP 1, 4). The density of cenopopulations of Trommsdorffia ciliata varies from 8 to 27 individuals per 1 m². The highest density is observed in CP 3 and is 27 individuals per 1 m², of which 24 are vegetative and 3, are generative. This is probably due to growing in more humid conditions. In other cenopopulations, the density of this rare plant species is insignificant, represented by 8 individuals – CP 4, 10 – CP 1, and 14 – CP 2, where plants of the vegetative state dominate (Table 1).

### Table 1. Population traits in cenopopulations (CP) of Trommsdorffia ciliata

| Number of CP | CP density, ind./m² | The number of cenopopulations, instances | The ratio of ontogenetic periods in the studied populations, number of individuals / % |
|--------------|---------------------|----------------------------------------|-----------------------------------------------------------------------------------|
|              |                     |                                        | pregenerative period | generative period | postgenerative period |
| CP 1         | 10                  | 42                                     | 30/71.4              | 12/28.6           | 0                    |
|              | (6 vegetative, 4 generative) |                                      |                      |                    |                      |
| CP 2         | 14                  | 14                                     | 12/85.7              | 2/14.3            | 0                    |
|              | (12 vegetative, 2 generative) |                                      |                      |                    |                      |
| CP 3         | 27                  | 73                                     | 70/95.9              | 3/4.1             | 0                    |
|              | (24 vegetative, 3 generative) |                                      |                      |                    |                      |
| CP 4         | 8                   | 38                                     | 25/65.8              | 13/34.2           | 0                    |
|              | (7 vegetative, 1 generative) |                                      |                      |                    |                      |

Studies of the ontogenetic structure of Trommsdorffia ciliata at the time of the study showed that all cenopopulations of this species are normal, incomplete, since in each cenopopulation there are no individuals of separate ontogenetic states: juvenile and senile (CP 1, 2, 4), senile (CP 3) (Table 2).

### Table 2. Ontogenetic composition of cenopopulations of Trommsdorffia ciliata

| Number of CP | Ontogenetic composition of cenopopulations of Trommsdorffia ciliata, number of individuals / % |
|--------------|-----------------------------------------------------------------------------------------------|
|              | juvenile (j) | immature (im) | virginal (v) | generative (g) | senile (s) |
| CP 1         | 0            | 11/26.2      | 19/45.2      | 12/28.6          | 0          |
| CP 2         | 0            | 3/21.4       | 9/64.3       | 2/14.3           | 0          |
| CP 3         | 5/6.8        | 18/24.7      | 47/64.4      | 3/4.1            | 0          |
| CP 4         | 0            | 7/18.4       | 18/47.4      | 13/34.2          | 0          |

In all cenopopulations of the studied rare plant species, the proportion of individuals of the pregenerative period is a significant part ranging from 65.8 % to 95.9 % (Table 1). The absence or small number of juveniles in the ontogenetic spectrum of the studied cenopopulations is associated with a high plant cover of the grass layer, which prevents the survival of this age group.
The accumulation of virginal plants in each of the four cenopopulations is probably due to the young age of the cenopopulations. According to the absolute maximum of ontogenetic groups of adult plants, all cenopopulations of *Trommsdorffia ciliata* belong to young normal cenopopulations, where the maximum falls on individuals of the virginal state: 19 individuals (45.2%) in CP 1, 9 individuals (64.3%) in CP 2, 47 individuals (64.4%) in CP 3 and 18 individuals (47.4%) in CP 4 (Table 2), that is, the accumulation of young individuals occurs in cenopopulations.

The proportion of individuals of the generative period in the studied cenopopulations of the studied rare plant species is insignificant and ranges from 4.1% to 34.2%. Individuals of the postgenerative period are absent in all cenopopulations of *Trommsdorffia ciliata* (Table 1).

To assess the state of *Trommsdorffia ciliata* cenopopulations, the following were used as organismic characters: the height of generative shoots the length and width of basal and stem leaves, and the diameter of the basket (Table 3).

At the time of the study, *Trommsdorffia ciliata* was in good condition, no damage was noted. The height of the generative shoot is from 54.0 cm (CP 2) to 67.0 cm (CP 3), the length of the basal leaves is from 3.5 cm (CP 4) to 26.0 cm (CP 3), the width of the basal leaves is from 0.5 cm (CP 3) to 5.2 cm (CP 3), the stem leaf length is from 3.0 cm (CP 1) to 26.0 cm (CP 3), the stem leaf width is 0.8 cm (CP 1) up to 5.5 cm (CP 3), the basket diameter is from 3.5 cm (CP 1, 3) to 6.2 cm (CP 3). Vitality in general for *Trommsdorffia ciliata* is assessed as good, adults reach normal sizes for this species.

In general, according to organismic characters, the highest indices are observed in CP 3, which grows in conditions of high humidity. The maximum value is reached here: plant height (up to 67 cm), length of basal leaves (up to 26.0 cm), width of basal leaves (up to 5.2 cm), length of stem leaves (up to 26.0 cm), width of stem leaves (up to 5.5 cm), basket diameter (up to 6.2 cm).

**Table 3. Organismic characters in cenopopulations of *Trommsdorffia ciliata***

| Characters                     | Character significance in CP |
|-------------------------------|------------------------------|
|                               | CP 1 | CP 2 | CP 3 | CP 4 |
| Height of the generative shoot, cm; | 56.0–66.0 | 54.0–58.0 | 58.0–67.0 | 64.0 |
| Length of basal leaves, cm;   | 10.0–19.0 | 4.0–24.0 | 4.0–26.0 | 3.5–25.0 |
| Width of basal leaves, cm;    | 1.5–3.0  | 1.0–3.5  | 0.5–5.2  | 0.8–5.0  |
| Length of stem leaves, cm;    | 3.0–25.6 | 7.0–25.6 | 3.5–26.0 | 5.0–25.4 |
| Width of the stem leaves, cm   | 0.8–5.2  | 1.5–3.8  | 1.0–5.5  | 1.0–3.5  |
| Diameter of the basket, cm.   | 3.5–6.0  | 4.0–6.0  | 3.5–6.2  | 4.0     |

In the remaining cenopopulations, the indices of the organismal characters of *Trommsdorffia ciliata* are lower than in CP 3 (Table 3).
4. Conclusion

Thus, the assessment of the population and organismic characteristics of the state of the studied cenopopulations showed that the most favorable conditions for the growth of *Trommsdorffia ciliata* are formed in a moist sedge-grass-herb meadow in the vicinity of Lonchakovo village.

The state of rare plant species in meadow communities is negatively affected by the economic development of territories: plowing of land for agriculture, haymaking, drainage, cattle grazing, and burns. Large areas of meadow territories near settlements are annually exposed to fires in the summer-autumn period, which leads to a decrease in the number of rare plant species. In this regard, for the conservation of biological diversity, Red Books of various levels and protected areas with nature protection regimes have been created. *Trommsdorffia ciliata* is included in the Red Book of Khabarovsk krai [5]. The natural habitats of the rare species *Trommsdorffia ciliata* are protected on the territory of the Bolshekhekhtsirsky State Nature Reserve [12] and are located in areas adjacent to the state border from the Ussuri River, where anthropogenic pressures are minimized. In order to preserve this highly decorative plant in meadow communities, it is necessary to control the state of known populations, organize monitoring and search for new places of growth.

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References

[1] Schwartz M W and Brigham C A 2003 Why plant population viability assessment? Population Viability in Plants. Ecological Studies (Analysis and Synthesis) vol 165 ed C A Brigham and M W Schwartz (Berlin, Heidelberg: Springer) pp 3–15

[2] Klimenko A A and Zlobin Yu A 2014 Stability and dynamics of populations of rare plant species in protected natural areas Achievements of modern biology 134(2) pp 181–91 (in Russian)

[3] Zaugolnova L B, Denisova L V and Nikitina S V 1993 Approaches to assessing the state of plant cenopopulations Byull. MOIP. Ed. biol. 98(5) pp 100–8 (in Russian)

[4] Barkalov V Yu, Korobkov A A and Tsvelov N N 1992 Famile Asteraceae – Asteraceae Dumort. Vascular plants of the Soviet Far East vol 6 ed A E Kozhevnikov (Saint-Petersburg: Nauka) pp 9–428 (in Russian)

[5] Red Book of the Khabarovsk Krai: Rare and endangered species of plants, fungi and animals 2019 ed B A Voronov, M V Kryukova et al (Voronezh: LLC «Mir») (in Russian)

[6] Field Geobotany 1964 vol 3 ed A A Korchagin et al (Moscow-Leningrad: Nauka) (in Russian)

[7] Coenopopulations of plants (Basic concepts and structure) 1976 ed A A Uranov and T I Serebryakova (Moscow: Nauka) (in Russian)

[8] Rabotnov T A 1950 Questions of studying the composition of populations for the purposes of phytocenology Problems of botany 1 pp 465–83 (in Russian)

[9] Uranov A A and Smirnova O V 1969 Classification and main features of the development of populations of perennial plants Byull. MOIP. Ed. biol. 79(1) pp 119–35 (in Russian)

[10] Uranov A A 1975 Age spectrum of phytocenopopulations as a function of time and energy wave processes Biological sciences 2 pp 7–34 (in Russian)

[11] IPNI: International Plant Name Index 2021 http://www.ipni.org (Accessed 10.08.2021)

[12] Flora and vegetation of the Bolshekhekhtsirsky Nature Reserve 2011 ed A B Melnikova (Khabarovsk: Publishing house «Private collection») (in Russian)