TO THE CHARACTERISTIC OF CENOPOPULATIONS
DACTYLORHIZA DACTYLORHIZA FUCHSII (DRUCE)
SOO OF THE MIDDLE AND SOUTHERN TAIGA

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Abstract: The article presents materials on the ecological and phytocenotic characteristics of Dactylorhiza fuchsii (Druce) Soo in the southern and middle taiga phytocenoses of the Kirov region. In the course of the study, the typical habitats of the species were established. Vegetation analysis carried out using phytoindication scales by D.N. Tsyganov (1983), made it possible to establish fragments of ecological niches in the conditions of the southern and middle taiga. It was found that in the middle taiga phytocenoses, the species is more sensitive to changes in soil factors given by the researcher than in the southern taiga. Analysis of vegetation in terms of hemerobicity indicates the relative resistance of the species to anthropogenic impact.

Keywords: Dactylorhiza fuchsii (Druce) Soo, bioindication, ecological-cenotic characteristics, population parameters, hemerobity, Kirov region

1. Introduction
There are 28 types of orchids in the Kirov region. The regional Red Data Book (2014) includes 23 species of the Orchidaceae family. 7 species belong to the genus Dactylorhiza (Palchatokorennik) in the Kirov region. Fuchs' fingernail (Dactylorhiza fuchsii (Druce) Soo) is a representative of the Orchidaceae family with a Euro-Asian type of range (Averyanov, 2000). In Russia, it is distributed in the European part in most of the northern and central regions, in the Trans-Volga region, in the Urals, Altai, in Western Siberia, reaches Baikal in the Irkutsk region and Buryatia (Vakhrameeva et al., 2014; Ilyina et al., 2019). D. fuchsii is included in the list of Appendix No. 2 to the Red Data Book of the Kirov Region (2014), as a species in need of constant control and observation.

The digital herbarium of Moscow State University contains 691 specimens of this species, including 2 from the Kirov region. The GBIF.org database as of April 14, 2021 contains information on 121480 finds of the species all over the world, including 2425 in Russia and 18 in the Kirov region (Verkhoshizhemsky, Zuevsky, Kirov-Chepetsky, Kotelnichsky, Sovetsky, Slobodskoy districts and the city Kirov).

Most of the representatives of the family in Russia are listed in the Red Data Books of the federal and regional levels, they are sensitive to environmental changes and to the impact of technogenic factors.
The features of the biology and ecology of wild-growing orchids are actively studied (Ishmuratova et al., 2010; Efimov, 2012; Suyundukov, 2014; Ilyina, 2019), however, studies in the Kirov region are fragmentary (Egorova et al., 2014; Kapustina, Igitova, Egoshina, 2015; Kapustina et al., 2015; Egorova et al., 2019a, b; Kosolapova, Egoshina, Luginina, 2020).

The development of criteria for determining the resistance of orchid communities, which are based on identifying the ecological and coenotic features of cenopopulations (CP) of these plants, is urgent.

2. Methods and materials

Studies of the D. fuchsii CP were carried out on the territory of the Slobodskoy and Podosinovsky districts of the Kirov region (the middle and southern taiga subzones).

The plant communities typical for the growth of D. fuchsii were described according to the methods of the ecological-phytocenotic approach to the classification of vegetation (Polevaya ..., 1964; Neshataev, 1987, Methods of studying ..., 2002). Species names are given according to The Plant List (http://www.theplantlist.org/).

The assessment of the ecological conditions of the CP habitats was carried out according to the composition of species in plant communities using the phytoindication scales of D.N. Tsyganov (1983). The ecological valence and tolerance of the species were determined in accordance with the method of L.A. Zhukova (2010).

To determine the adaptability of the cenopopulation (CP) of a species to a change in one ecological factor, the potential ecological valence (PEV) was calculated using the formula: PEV = (A_max - A_min + 1) / n, where A_max and A_min are the maximum and minimum values of the scale steps occupied by the view, n is the total number of steps in the scale. The realized ecological valence was determined by the formula: REV = (A_max - A_min + 0.01) / n, where A_max and A_min are the maximum and minimum values of the scale steps occupied by specific CPUs; n is the total number of steps in the scale.

To identify the degree of use of the ecological potential of the species, the ecological efficiency coefficient (K.e.eff.) Was determined as the ratio of the realized ecological valence to the potential one.

The tolerance index (It) of the species or its measure of steno-eurybionticity was determined by the formula: It = \sum PEV / \sum scales of factors under consideration (Zhukova, 2010).

The assessment of the resistance of species to the complex anthropogenic impact was carried out using the index of hemerobia (Ishmuratova, Ishbirdin, Suyundukov, 2003). Hemerobity in plant communities was determined by the composition of species using a modified Yalas system (Frank, Klotz, 1990), which includes the following levels: a (agmagermes, o (oligo-), m (meso-), b (eu-), c (poly -), and p (meta-) hemerobes.

In the subzone of southern taiga forests, D. fuchsii was recorded in spruce-birch forests with an admixture of aspen and pine herbaceous, on forb-cereal damp forest glades. The undergrowth of the studied forest communities is dominated by: Salix cinerea, Viburnum opulus, Rubus idaeus, Sorbus aucuparia, Frangula alnus.

The herb-dwarf shrub layer (HSL) of the surveyed forest phytocenoses is dominated by: Maianthemum bifolium, Gymnocarpium dryopteris, Equisetum hyemale, Festuca gigantea, Juncus effusus, Comarum palustre, Deschampsia cespitosa.

The herbaceous layer of meadow phytocenoses is represented mainly by Juncus effusus, Comarum palustre, Deschampsia cespitosa. The projective cover (PC) of HSL in the studied phytocenoses varied from 60 to 90%. The participation of the species in the projective cover of the herbaceous cover ranges from 2 to 5%.

Plagiomnium undulatum, Sphagnum girgensohni, Polytrichum commune, Pleurozium schreberi were recorded in the moss-lichen layer of forest communities with the participation of D. fuchsii. In the herb-grass associations, the moss cover is poorly expressed or absent.

Cenopopulations of the species within the middle taiga subzone were noted along the edges of spruce forests, in sparse linden-spruce forests with birch, spruce-birch forests with aspen, occasionally found in aspen-spruce forests, along the outskirts of bogs and on damp meadows (Kapustina et al., 2015;
Kapustina, 2018). The undergrowth of the studied phytocenoses is composed of such species as Sorbus aucuparia, Viburnum opulus, Alnus incana, Rubus idaeus, Juniperus communis, Lonicera caerulea, etc. The HSL of the surveyed communities include *Menyanthes trifoliata*, *Eriophorum vaginatum*, *Drosera rotundifolia*, *Andromeda polifolia*, *Chamaedaphne calyculata*, *Carex acuta*, *Chamerion angustifolium*, *Lathyrus pratensis*, *Hieracium umbellatum*, *Athyrium filix-femina*, *Maianthemum bifolium*, *Angelica sylvestris*, *Listera cordata*, *Platanthera bifolia*, *Dactylorhiza russowii*, *D. maculata*, *D. traunsteineri*, *Cypripedium calceolus*. The total projective cover of HSL in communities with *D. fuchsii* varied from 30 to 90%, the proportion of *D. fuchsii* varied from 10 to 35%.

During the analysis of geobotanical descriptions using phytoindication scales, D.N. Tsyganov (1983) revealed fragments of ecological niches occupied by the species in the conditions of the middle and southern taiga (Fig. 1).

![Figure 1. Fragment of an ecological niche Dactylorhiza fuchsii (Druce) Soó (A - Slobodskoy district; B - Podosinovsky district of the Kirov region). Symbols: - range of potential ecological position of a species; - range of realized ecological position of the species.](image)

The ecological conditions determined for the studied habitats cover the central part of the potential boundaries of the ecological space on most climatic scales.

An analysis of the habitats of *D. fuchsii* in the system of ecological scales showed that in the study region in relation to climatic factors (Tm) *D. fuchsii* the species grows in conditions from subboreal to nemoral forests. According to the aridity-humidity scale (Om), *D. fuchsii* under the studied conditions prefers habitats with subarid and subhumid climates. On the continental scale (Kn), the species occupies ecological positions from sub-continental to continental climate. According to the cryoclimatic scale (Cr), *D. fuchsii* can exist in moderate winters. On the scale of illumination-shading (Lc), the view is confined to semi-open spaces and light, sparse forests.

In relation to the factor of soil moisture (Hd), the studied species is located in ecological conditions ranging from fresh-meadow to damp-meadow conditions; according to the scale of wealth (Tr), nitrogen supply (Nt), acidity (Rc), the species prefers habitats with poor, nitrogen-poor, acidic and slightly acidic soils, respectively. According to the factor of soil moisture variability (fH), *D. fuchsii* grows under conditions of slightly variable moisture.

It should be noted that, according to the scales of soil moisture (Hd) and its variability (fH), the range of the studied habitats in southern taiga conditions is close to the potential boundaries towards an increase in the factor value; according to the scale of soil acidity (Rc), the range of habitats goes beyond the potential boundaries by one step in the direction of decreasing the factor value (in the direction of acidic soils).
In the conditions of the middle taiga, according to several soil scales, the range of the studied habitats goes beyond the potentially possible boundaries (Fig. 1). So, for example, on the scale of acidity (Rc) and salt regime (Tr), the range is shifted by one step towards a decrease in the value of factors (confined to acidic, poorer soils (glycosubmesotrophic group). shifted by one step towards the increase of indicators - to moderately variable moisture.

Consequently, the species, according to D.N. Tsyganova, prefers similar habitat conditions, assimilating acidic soils, poor in nutrients, with a stable moisture regime. In the middle taiga phytocenoses, the species is more sensitive to the conditions of the salt regime of the soils, and in the southern taiga, to the conditions of soil moisture.

According to the totality of climatic factors and the factor of illumination-shading, D. fuchsii belongs to the hemi-eurybiontic (It = 0.61) and eurybiontic (It = 0.67) species; in the generalized spectrum of soil scales, the species acts as a hemistenobiont (It = 0.40), and, therefore, has a medium range of adaptation to soil factors. In relation to the complex of all ecological scales, D. fuchsii belongs to the mesobiontic species (It = 0.51), that is, the species is characterized by an average level of tolerance in relation to the considered ecological factors.

The realized ecological valence values varied in the southern taiga conditions from 0.35 to 0.73, in the middle taiga conditions - from 0.12 to 0.23, respectively, which suggests a higher ecological valence of the species in the southern taiga conditions.

The ecological efficiency coefficient reached higher values in the conditions of the southern taiga, the highest values of the indicator were noted on the scale of soil moisture, the lowest on the scale of continental climate (from 84 for medium taiga conditions to 169% for southern taiga conditions, and from 26 to 52%, respectively).

To identify the anthropotolerance of plant communities with the participation of D. fuchsii, the index of hemerobia was used (Fig. 2). When assessing the vulnerability of the species within the middle taiga, it was found that in all CPs with the participation of D. fuchsii, o- and m-hemerobic species prevail, that is, species experiencing insignificant and moderate human influence. Southern taiga communities are characterized by a predominance of m-hemerobes (38.65%), middle taiga communities - o-hemerobes (42%). The share of b-hemerobic species in the studied communities does not exceed 20%. An insignificant share was made by a-hemerobic species (1-3%), which do not tolerate anthropogenic influences and are not resistant to insignificant sporadic influences. C- and p-hemerobes (weed species of natural and anthropogenic communities that endure regular severe disturbances) accounted for 3.7 and 0.61% in the CP of the southern taiga; 2.1 and 0.5 - in the CPU of the mid-taiga subzone.

![Figure 2. Hemeroby spectre of communities with Dactylorhiza fuchsii](image)

Note: x-axis - hemeroby leves; y-axis - share of a-o-m-b-c-p-t – hemeroby, %
In general, in the conditions of the middle and southern taiga, the sensitivity of the species to anthropogenic influences is close. An insignificant proportion of b-c-p-t-hemerobes indicates a rather low resistance of D. fuchsii to anthropogenic impact. The predominance of the a-o-m-segment in the general spectrum of hemerobia indicates the relative resistance of the species to human influence, which was also confirmed in the works of other researchers (Vakhrameeva and Varlygina, 1996).

3. Conclusion

1. In the conditions of the southern and middle taiga zones of the Kirov region, the cenopopulations of Dactylorhiza fuchsii are confined to boreal coniferous forests, secondary post-forest meadows of the temperate zone of Eurasia. In the conditions of the middle taiga, the species prefers well-lit edges of spruce forests with a sparse canopy, mixed linden-spruce forests with an admixture of birch, spruce-birch forests with an admixture of aspen, occasionally found in aspen-spruce forests, along the outskirts of swamps and on damp meadows. In the subzone of southern taiga forests, D. fuchsii is recorded in spruce-birch forests with an admixture of aspen and pine, occurs in forb-cereal forest glades, along overgrown forest edges.

2. It was revealed that under the conditions of the research region, the range of the studied habitats of D. fuchsii occupies an average position from the potentially possible ones according to the ecological scales of D.N. Tsyganov (1983), except for some soil scales. In relation to the complex of all ecological scales, D.N. The Tsyganov species belongs to the mesobionts (It = 0.51). The limits of the ecological space of the species in the middle taiga are characterized by a shift in the boundaries of the range beyond those potentially possible on the acidity scale (the range is shifted towards acidic soils), on the soil variability scale (the range is shifted towards moderately variable moisture content), on the salt regime scale (the range is shifted towards poor soils). In southern taiga habitats, D. fuchsii goes beyond the potential boundaries on the acidity scale (towards acidic soils). The data obtained indicate that the species is very sensitive to changes in these parameters under the studied conditions, and in the middle taiga conditions the complex of factors influencing the growth of the species is wider than in the southern taiga.

3. In the studied cenopopulations of the southern and middle taiga, D. fuchsii is a species with a low adaptive potential in relation to anthropogenic impact, but tolerates weak recreational loads. In general, the growing conditions of the species in the studied region can be assessed as satisfactory.

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