

## DISTRIBUTION OF ADDER'S TONGUE (*OPHIOGLOSSUM VULGATUM* L.) IN THE VICINITY OF THE WHITE SEA BIOLOGICAL STATION OF MOSCOW STATE UNIVERSITY (KANDALAKSHA GULF)

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### ABSTRACT

*Ophioglossum vulgatum* L., a potential indicator of separating water reservoirs, has a wide distribution all over the world. However, this Pteridophyte rarely grows in large populations, its colonies generally consist of only a few or single plants and therefore this fern is considered a protected species in most of the regions.

In the vicinity of the White Sea Biological Station (WSBS) of Moscow State University, Adder's tongue is found in great density near Kislo-Sladkoye lake. In the early 2000's this species was found growing in mass in some areas around the lake. In July 2014, we found a small population near the Lower Ershovskoye lake estuary. In order to clarify the distribution of *Ophioglossum* over Kindo peninsula, a coastline registration survey was conducted in order to map the fern's populations and reveal its growth conditions.

Three new populations were found corresponding to proposed characteristic plant associations and abiotic factors supposedly limiting the fern's distribution. *Ophioglossum vulgatum* grows on slightly sloping coastal meadows near separating sea bays. It requires sufficient light, moderate moisture with low salinity (0.5-5.0 psu) and a pH of 7.37-8.65. Adder's tongue is accompanied by *Poa pratensis* L., *Blysmus rufus* (Huds.) Link., *Rhinanthus minor* L., and *Parnassia palustris* L. The population is limited by a *Dianthus superbus* L. zone from one side and *Lathyrus japonicus* Willd. with *Cornus suecica* L. from the other side.

### INTRODUCTION

Adder's tongue (*Ophioglossum vulgatum* L.) is a perennial herbaceous plant belonging to the family of Ophioglossaceae. This fern grows from a rhizome base up to 30 cm in height (5). It is native to many regions with a wide scattered distribution, sporadically found throughout the Russian Federation (1).

By the beginning of the 2000's, *Ophioglossum vulgatum* was known from four quadrates of the Kindo peninsula: 14 and 15 (Kislo-Sladkoye lake; 66.548535°N, 33.135838°E); 23 and 24 (a seaside meadow; 66.538280°N, 33.135858°E), where it grew in mass (2,3). In July 2014, we found a new *Ophioglossum* population in the quadrate 29 near Lower Ershovskoye lake estuary (66.535585°N, 33.064823°E; Figure 1). The new finding motivated us to conduct more investigations on the species distribution over Kindo peninsula. All three places have not much in common at first glance (except for two of them being separating sea bay borders). Therefore, we decided to search for new spots of Adder's tongue and investigate its growth conditions in the northern White Sea region in order to connect the known distribution with the species ecology. Our objectives were to propose both abiotic factors and plant associations characteristic of *Ophioglossum vulgatum*. The fern is quite rare, it is considered an endangered species and is listed in 35 regional Red Books in the Russian Federation (4) and some other European countries (5).

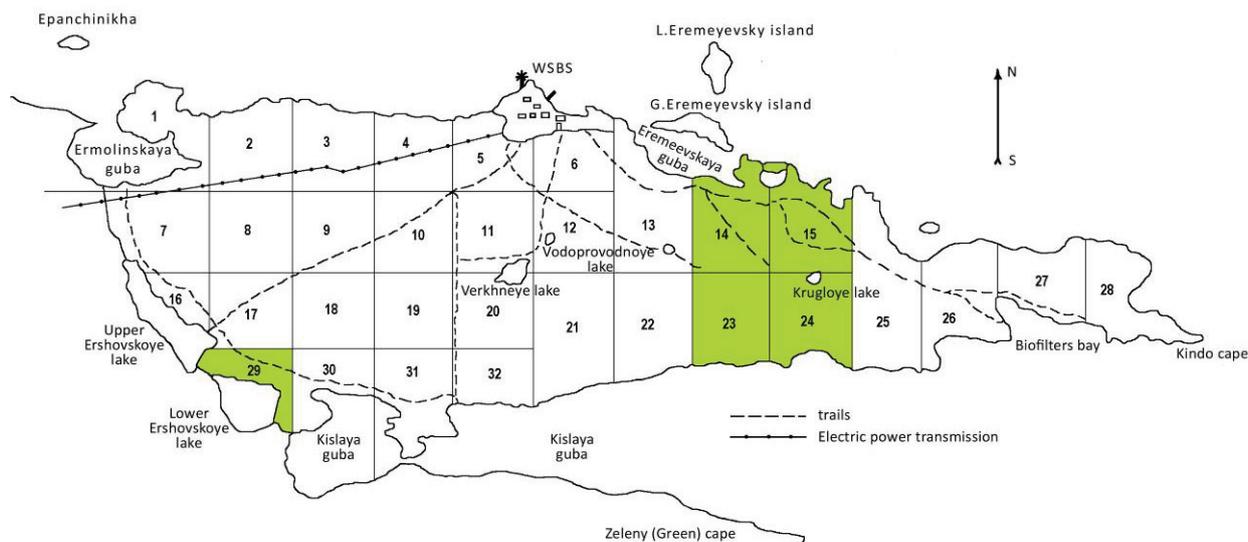


Figure 1: Map of the vicinity of the Nikolai Pertsov White Sea Biological Station. By the beginning of the 2000's, *Ophioglossum vulgatum* was known from the quadrates 14, 15, 23, 24. In July 2014, we found a new population in the quadrate 29 near the Lower Ershovskoye lake estuary.

## METHODS

Five sites with *Ophioglossum vulgatum* populations were studied for plant communities and abiotic factors. The primary research was focused on the greatest population around Kislo-Sladkoye lake. Phytosociological relevés were conducted in order to reveal the most characteristic associations in typical habitats. Corresponding keys were used for species identification (6,7). After characteristic zones had been revealed, indicator species were used to disclose new *Ophioglossum* populations. A few abiotic factors were studied within seven areas where Adder's tongue was present and at three sites with similar conditions. Salinity in soil waters and nearby reservoirs and temperature were measured using a conductometer WTW Cond 315i. For acidity determination, a pH-meter WaterLiner WMM-73 was used. A standard reaction with hydrochloric acid was performed for qualitative presentation of in-soil carbonates.

## RESULTS

A coastline registration of the fern population around Kislo-Sladkoye lake was performed to localize the growth spots of *Ophioglossum* (Figure 2). The same species associate with *Ophioglossum* at all sites investigated. Adder's tongue is accompanied by *Poa pratensis* L., *Blasmus rufus* (Huds.) Link., *Rhinanthus minor* L., and *Parnassia palustris* L. The population is limited by a *Dianthus superbus* L. zone from the lake side and by *Lathyrus japonicus* Willd. with *Cornus suecica* L. from the other side.

Characteristic plant associations were used as indicators to find new fern populations. A stretch of 16.5 km of the White Sea coastline was examined from Ermolinskaya Guba to Zeleny (Green) Cape. Two new populations were found near the Green Cape lagoon (66.531362°N, 33.093701°E; 66.530415°N, 33.092937°E), which is also a separating sea bay.

While investigating different Adder's tongue populations, and assumed there might be a connection between the fern distribution and soil water features. The root length was measured which is around 8-10 cm and is situated in soil with low water salinity (0.5-5.0 psu), not reaching the salty layers (8-10 psu waters can be found within a few cm from the root system). Coastal waters of Kislo-Sladkoye lake of 11.6-22.0 psu are found about one meter from the lower population border.

Acidity measurements in soil water near *Ophioglossum* roots and at control points with similar conditions are shown in Table 1.



Figure 2: Distribution of *Ophioglossum vulgatum* L. around Kislo-Sladkoye lake (populations shown in lime green). Stations where abiotic factor were measured are shown (Table 1).

Table 1: pH and salinity measurements in soil water under *Ophioglossum vulgatum* roots and in nearest water bodies.

Station number and description		Under <i>Ophioglossum</i> roots		Nearest water body	
Kislo-Sladkoye lake (Figure 2)		pH	Salinity, psu	pH	Salinity, psu
Y1	Kislo-Sladkoye old isthmus	8.61	0.5	8.95	10.3
Y2	KS Northern sandy coast	8.65	5.0	8.66	11.7
Y3	KS Eastern meadow	7.37	0		
Y4	KS near the creek flow	8.04	0	5.86	4.2
Y5	KS Willow	7.85	0	7.38	10.6
K1	KS Eastern seaside			7.87	0
Other reservoirs					
Y6	"Old Kislo-Sladkoye Swamp"	7.99	0.5	6.29	0
S1	Sea near the swamp			8.04	24.2
K2	Vonyuchaya bay			8.11	18.6
K3	Orchid creek			7.56	0

Both soil water pH in Adder's tongue settlements and qualitative carbonate analysis allow us to assume that carbonates are among the main growth factors for *Ophioglossum*. This is also indirectly verified by the absence of the fern near swampy terrains, even when all the other abiotic factors are satisfactory and key species accompanying *Ophioglossum* are present. In very few populations inhabiting swamp-like marches with high water acidity, Adder's tongue grows sufficiently close to *Hydrobia ulvae* shell burial spots, where the pH directly under the roots is 1-2 units higher than in surrounding waters.

## DISCUSSION AND CONCLUSIONS

During the White Sea coastal survey in the vicinity of the WSBS from Ermolinslaya Guba to Zeleny (Green) Cape, three new *Ophioglossum vulgatum* populations were found and mapped (Figure 3). Plant associations characteristic of the fern were revealed. Adder's tongue is accompanied by *Poa pratensis* L., *Blysmus rufus* (Huds.) Link., *Rhinanthus minor* L., and *Parnassia palustris* L. The population is limited by a *Dianthus superbis* L. zone from one side and *Lathyrus japonicus* Willd. with *Cornus suecica* L. from the other side. In earlier studies of seashore vegetation, Adder's tongue was also recorded with gramineous plants and *Parnassia palustris* (8). Other *Ophioglossum* species are also found in gramineous associations (9).

Abiotic factors of Adder's tongue growth were proposed (Figure 4).

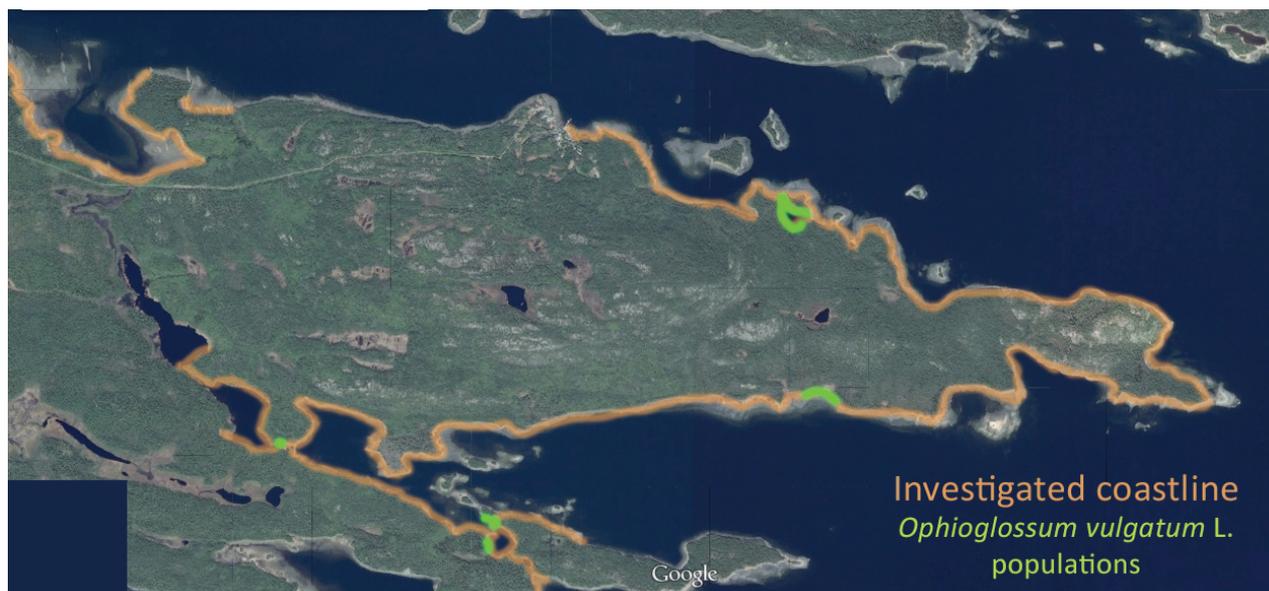


Figure 3: WSBS vicinity satellite map (maps.google.com). A stretch of 16.5 km of the White Sea coastline was examined from Ermolinskaya Guba to Zeleny (Green) Cape (shown in orange). *Ophioglossum* populations are shown in lime green.

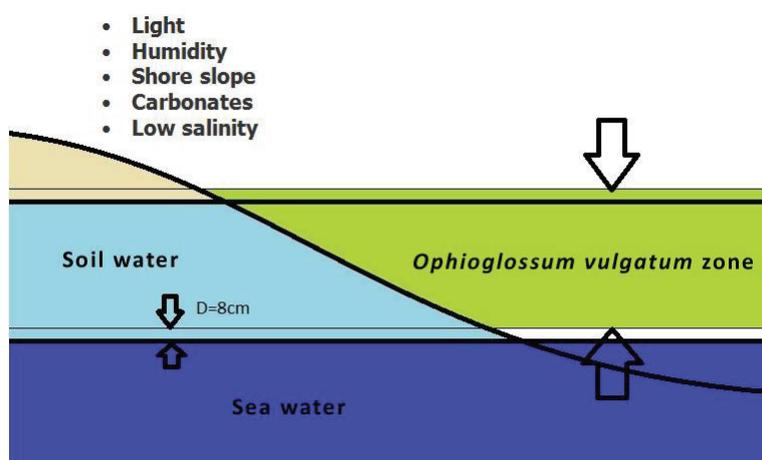


Figure 4: *Ophioglossum vulgatum* growth conditions. The fern grows on slightly sloping coastal meadows near separating sea bays. It requires sufficient light, moderate moisture with low salinity (0.5-5.0 psu) and pH 7.37-8.65.

Moderate light, moistening and slightly alkaline or salty soil water are also mentioned as abiotic conditions characteristic of *Ophioglossum* by other authors (5,10).

Four out of five populations were found near separating sea bays, so-called "kislo-sladkie", "sour-and-sweet" lakes (11) named after famous Kislo-Sladkoye lake situated near the White Sea Biological Station. After some hydrological studies, the fifth place (swampy marsh on the southern peninsula side) appeared to be a shallow lagoon separated for a long time, with sea mollusc shells and salty water at the bottom. Low depth led to a marsh way of evolution, so the water body bypassed the meromictic stage.

We assume that the relation between *Ophioglossum* and separating water bodies is due to the unique abiotic conditions that are created when the sea coast rises (12). Rising seashore vegetation is exposed to both general land uplift factors and local disturbance of waves and tide fluctuations (8).

Carbonates crucial for the fern growth (13) are found at high concentrations in the sea water, and in separating bays, mass dying of molluscs appears to be pretty usual. Therefore, thick layers of empty shells provide sufficient amounts of carbonates to the soil waters. For a better understanding, we suppose that quantitative analyses for carbonates should also be conducted in future.

Ten monitoring grounds were set, including areas where *Ophioglossum* had not yet been found. In some places, the fern was not revealed, but we predict its appearance in the near future. Long-term monitoring will help us track individual development of separate populations; and morphometric analysis should allow us to estimate the habitat convenience for the species under Kido peninsula conditions.

More separating water bodies have to be observed for the presence of Adder's tongue. Also, more phytosociological relevees have to be conducted in order to find characteristic key species for such reservoirs. Some of the species, presumably including *Ophioglossum*, could be used as indicators of the separation stages.

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