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## Study of the vascular plants diversity in the surroundings of the Kytalyk Research Station (Arctic Yakutia)

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### Abstract

The local flora (LF) surrounding the research station at the Kytalyk Resource Reserve was studied in detail and an annotated checklist is presented. Species composition of Kytalyk area flora is compared with the LF in three neighboring areas in the lower reaches of the Indigirka River. These localities had differing topography, therefore their species richness varied. The LF of the Kytalyk Research Station area numbered 131 vascular plant species from 66 genera and 28 families. Low species richness is explained by the prevalent flat and homogenous lowland topography. We found new and the northernmost in this region locations of several boreal and hypoarctic species (*Moehringia lateriflora*, *Salix myrtilloides*, *Alnus fruticosa*, *Polygonum tripterocarpum*, *Orthilia obtusata*, *Pedicularis pennellii*, *Utricularia intermedia*, *U. minor*, *Triglochin maritima*). The taxonomic structure of all four floras is similar, however in the Kytalyk area the *Fabaceae*, *Lycopodiaceae* and *Gentianaceae* families were not found, whereas the proportion of *Salicaceae*, *Caryophyllaceae* and *Scrophulariaceae* was higher than in the other LF. We estimated species behavior with landscape activeness scores. Non-active stenotopic species with low abundance comprise 42% of the flora and species with broad-ecological tolerance comprise 18% of the flora. Phytogeographical latitudinal groups (arctic, hypoarctic and boreal) are almost equally represented in the LF. Geographical and taxonomic structure of the LF confirm its position in the bioclimatic subzone D.

**Keywords:** habitat type, landscape activeness, local flora, rare species, taxonomical and geographical structure

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### Introduction

The global problems of biodiversity conservation, the study of the impacts of climate change and the human activities on ecosystems, demand accurate background information, in particular inventories and monitoring of vegetation and flora changes (Walker et al. 2013). The local flora method has been used in the Arctic for more than 70 years. The essence of the method is that a complete assay of vascular plant species composition of a territory of ca. 100 km<sup>2</sup> in area is assessed by thoroughly searching in

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all the habitat types present in the region with consistent repetition (Khitun et al. 2016). Following the initiative of B.A. Yurtsev, a network of local floras (LF) was established in the Russian Arctic and this currently includes 318 sites and allows analysis of various floristic parameters (Yurtsev et al. 2001; Khitun et al. 2018). However, the density of this network is uneven.

The flora in the lower reaches of the Indigirka River was poorly investigated. Therefore, in 2013–2014, we carried out surveys in four localities (Fig. 1):

- 1) surroundings of Chokurdakh village on the left bank of Indigirka (70°39'N; 147°53'E);
- 2) surroundings of Kytalyk Research Station on the left bank of the Berelekh River (70°49'N; 147°48'E);
- 3) surroundings of the Burulgin Cape on the right bank of Indigirka (70°47'N; 148°45'E);
- 4) surroundings of Russkoe Ustje settlement in the Indigirka delta (71°07'N; 149°05'E).

Previous surveys in the surroundings of Chokurdakh (Boch and Tzareva 1974; Egorova et al. 1991), did not aim to assess the complete LF. Field work by Tatiana Koroleva in 2013–2014 expanded the list of species from 133–167 (Boch and Tzareva 1974; Egorova et al. 1991) to 222. Annotated species check-list from Chokurdakh was recently published (Koroleva et al. 2019). Other LF assays are not yet published.

In this paper, we describe the LF of the surroundings of the Kytalyk Research Station (hereafter “Kytalyk”), present a checklist of the vascular species and compare this LF with three others. Intensive ecological and hydrological research is ongoing at the station (van Huissteden et al. 2005; Schirrmeister et al. 2012; de Klerk et al. 2014; Iturrate-Garcia et al. 2016; and many others), however, many of these works provide only very brief characteristic of vegetation and in some of them we found misidentified species. There were no floristic inventory in this area. An anonymous list of species, circulating at the station, numbers about 40 species and contains only the most notable and dominant species. Therefore, it is important to publish the complete list of species for this area. Olga Khitun, M. Iturrate-Garcia and G. Schaeppman-Strub carried out floristic survey in the summer of 2013. Earlier, we discussed theoretical nuances of the study of this LF (Khitun et al. 2014). The area is very homogenous in topography; lacking many habitats, present in other studied localities. However, these lowland wetlands are spread throughout the area, which is much larger than the standard sampling size of LF, so there is no constraint to consider them as comparable with other LFs.

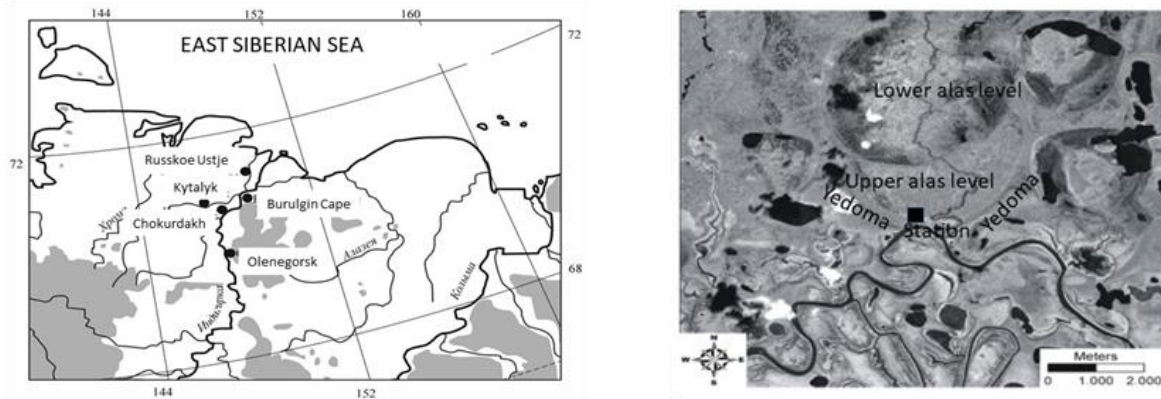
The aim of this paper is to describe the diversity and the specific of vascular plant flora of Kytalyk, show its spatial differentiation, its taxonomic, geographic and ecological structure and to compare with neighboring LFs.

## **Material and methods**

### *Study area*

The Kytalyk Research Station is located within the Kytalyk Resource Reserve. The reserve was organized in Allaikhoovskii district by the order of Yakutian government in 1996 with the financial support from the WWF. The main aim of the Resource Reserve is wetlands conservation and preservation of Yakutian populations of endangered avian species, such as Siberian Crane, Brent Goose, Spectacled Eider, Steller's Eider, Ross's Gull, etc. The Reserve consists of coastal part and the Berelekh

River valley. We studied the flora of the latter. The Kytalyk station is located on the left bank of the Berelekh River, which is a tributary of Indigirka (Fig. 1).



**Figure 1.** Location of the studied local floras (left) and satellite image of the surroundings of the Kytalyk Research Station (right).

The climate of the Indigirka Lowland is characterized by a high degree of continentality (Gavrilova 1998). Climate data for this area according to the site “Pogoda i klimat” (<http://www.pogodaiklimat.ru/history/21946.htm>) is only collected at the Chokurdakh weather station, WMO 21946. For the period 1996 to 2013, the mean annual air temperature was  $-14.3^{\circ}\text{C}$ , the mean January temperature was  $-32.9^{\circ}\text{C}$  and the mean temperature of the warmest month, July was  $+10.5^{\circ}\text{C}$ . The annual precipitation normally varies between 150–250 mm. Recent data indicates a slight warming trend (Koroleva et al. 2019). All four sites are situated in the continuous permafrost zone.

The landscapes in the surroundings of Chokurdah and Burulgin Cape are the most diverse, as outreaches of, respectively, the Allaikhovski and Kondakovski Highlands stretch there, providing greater variation of edaphic conditions. Surroundings of Russkoe Ustje and Kytalyk are monotonous lowlands. The altitude in Kytalyk varies between 3 and 30 m above sea level. The main landscape subdivisions in Kytalyk are:

- 1) floodplain and low terraces of the Berelekh River and its tributaries;
- 2) approximately 5.5 km in diameter alas depression (i.e. spacious drained lake basin) of the Holocene age with clearly pronounced polygonal structure, numerous thermokarst lakes and solitary pingos; within it two major levels with 1 to 1.5 m difference can be distinguished;
- 3) two elongated ridges 20 to 30 m above sea level height of late Pleistocene Ice Complex deposits, called Yedoma.

On the river terraces thermokarst processes are active. The riverbanks show thaw slumps. More detailed description of the periglacial and thermokarst features in surroundings of the station, is given in Schirrmeister et al. (2012).

According to the Circumpolar Arctic Vegetation Map (CAVM Team 2003), Kytalyk, Chokurdakh, and Cape Burulgin are part of bioclimatic subzone D, i.e. erect dwarf-shrub subzone; Russkoe Ustje lies at the southern border of the subzone C, i.e. hemiprostrate dwarf-shrub subzone.

### *Methods*

We thoroughly examined the localities by radial transects of various length (up to 10 km from base camp) aiming to visit all habitat types present in the region, with, if

possible, at least 5 replicas. We compiled species lists with records on species abundance in different habitats. We distinguished habitat types visually according to topography, hydrology and vegetation (Khitun 1998). Additionally, we established 5 x 5 m relevé plots in various habitat types to assess syntaxonomy of vegetation (not covered in this paper). In Kytalyk we studied spatial structure of local flora by distinguishing partial floras (Yurtsev 1987), that is sets of species of various habitat types. Similar work we did previously in the West Siberian Arctic (Khitun 1998). We obtained partial flora of certain habitat type by joining species lists compiled in habitats of this type.

To estimate the behavior of each species within the locality, we use the concept of ‘landscape activeness’ (Yurtsev 1968). It is a complex index based on three parameters:

- 1) ecological tolerance, or range of environmental conditions, which species can tolerate, i.e. range of habitats where species occur;
- 2) abundance;
- 3) constancy of species occurrence in its habitats.

We estimated ecological tolerance as percentage of habitat types where species occur, e.g. stenotopic species occur in <25% of all habitat types; hemi-stenotopic occur in 26–50% of habitat types, etc. Species got scores according to the table (Table 1), V is extremely active, IV – very active, III – moderately active, II – low active and I is non-active.

**Table 1.** Estimation of species activeness scores (modified after Yurtsev 1968).

Abundance	Ecological tolerance									
	Eurytopic		Hemi-eurytopic		Hemi-stenotopic		Stenotopic			
							Common habitats		Rare habitats	
	Perva-sive	Spora-dic	Perva-sive	Spora-dic	Perva-sive	Spora-dic	Cons-tant	Non-constant	Cons-tant	Non-constant
Copious	V	V	IV	IV	III	II	III	II	II	I
Sparse	IV	IV	III	III	III	II	III	I	I	I
Solitary	III	II	II	II	II	I	II	I	I	I

Determination of species was mainly carried out in the field, however, herbarium vouchers were collected of all the species and these were checked in the laboratory. V.V. Petrovsky verified identification of difficult for determination species. Herbarium specimens are preserved in Komarov Botanical Institute. The nomenclature mainly follows Annotated Checklist of the Panarctic Flora (Elven 2007) as it was prepared by international team of specialists in arctic species, other databases are more focused on southern regions, however in clear cases we updated according to Plants of the World Online (POWO, 2019). All species were assigned in phytogeographical (latitudinal) groups based on their distribution ranges; this work was done previously for LF network (Khitun et al. 2016).

## Results

The species richness of the four LF varies depending on topography of the sites. LF of Chokurdakh and the Burulgin Cape surroundings are the richest (222 and 240 species). Two lowland LF are essentially poorer: we found 150 species in Russkoe Ustje and 131 species in Kytalyk. Their poverty is merely explained by low diversity of

habitats. We think, that additional 10–15 species can be found in Kytalyk if visit two remote pingos, which we did not reach.

We distinguished 12 habitat types in Kytalyk (Table 2). That is less than in lowland West Siberian Arctic, where 15–22 habitat types were distinguished and the richness of analogous types was somewhat higher there than in Kytalyk (Khitun 1998). Approximately 80% of the area in Kytalyk is occupied by polygonal tundra-mire complexes in alas depression and 20% by all other habitat types.

**Table 2.** Habitat types in Kytalyk and number of species (Nsp) in their partial floras.

ID	Habitat type and vegetation in it	Nsp
1	The top and gentle slopes of Yedomas ridge, relatively well-drained, mesic, acidic soils, with earth hummocks and thick vegetation mat; occupied by tussock tundra with <i>Eriophorum vaginatum</i> , <i>Ledum decumbens</i> , <i>Betula exilis</i> , <i>Salix pulchra</i> , <i>Calamagrostis holmii</i> .	31
2	Polygons (7 x 8, 10 x 12, 15 x 15 m) in the high-centered polygonal tundra-mire complexes, within the upper level of alas depression and on river terraces; mesic acidic soils with thick peat horizon; with dwarf birch dominated communities with thick moss mat ( <i>Dicranum</i> spp., <i>Polytrichum</i> spp.)	21
3	Oligotrophic wet troughs (depressions) between polygons, present mainly in alas depression and on lower river terraces, with shallow water, usually with dense stand of sedges ( <i>Eriophorum angustifolium</i> , <i>Carex concolor</i> ).	12
4	Rims of polygons in low centered polygonal complexes, present mainly at the lower level of alas depression; wet, with herbaceous-dwarf-shrub-moss (predominantly <i>Sphagnum</i> spp.) communities.	32
5	Ponds-like central depressions of polygons in low-centered polygonal complex, mainly at the lower alas level; occupied by mires with sedges ( <i>Carex chordorrhiza</i> , <i>C. rotundata</i> ) and <i>Amblystegiaceae</i> -mosses.	28
6	Relatively short (15–20 m), rather steep (10–12°) and dry slopes of the ridge and lower pingos are covered by ericoid dwarf-shrub dominated tundra with abundance of low willow ( <i>Salix glauca</i> ) and herbs ( <i>Pyrola grandiflora</i> , <i>Pedicularis capitata</i> , <i>Saxifraga nelsoniana</i> , <i>Bistorta plumosa</i> , <i>Valeriana capitata</i> ) and well developed moss cover.	39
7	Long (20–30 m), steep (10–12°), dry slopes of the pingo. Rare habitat, we visited only one such pingo; grass-herb-Dryas community without continuous moss cover. Many herbs and grasses were found only here.	47
8	Eroded cut riverbank, cryogenic erosion around thaw lake, landslides on the northern side of the pingo with pioneer herbaceous vegetation with <i>Arctagrostis arundinaceae</i> , <i>Puccinellia borealis</i> , <i>Equisetum arvense</i> , <i>Descurainia sophioides</i> , <i>Draba juvenilis</i> , <i>Artemisia tilesii</i> .	39
9	Wetlands on the first and second river terraces; some inclination and water flow is present; pH = ca. 6; <i>Amblystegiaceae</i> -mosses dominate, wet meadows and sedge mires with many rare species ( <i>Triglochin maritima</i> , <i>Carex marina</i> , <i>C. saxatilis</i> , <i>Juncus castaneus</i> , <i>Silene apetala</i> , <i>Minuartia stricta</i> ).	41
10	Floodplain homes two distinct vegetation types: somewhat higher parts with tall (2–3 m) dense willow thickets with <i>Salix pulchra</i> , <i>Salix lanata</i> ssp. <i>richardsonii</i> , <i>S. anadyrensis</i> and somewhat lower boggy parts with wet meadows with <i>Carex concolor</i> or <i>Calamagrostis purpurea</i> dominating.	25
11	Snowbeds at hill foots are very rare habitat, many species were found only here ( <i>Salix polaris</i> , <i>Ranunculus nivalis</i> , <i>R. pygmaeus</i> )	30
12	Aquatic habitats: low mud banks of the lakes and streams, wet sandbanks of the river, in the water. Usually few species grow but some of them can form stands or patches ( <i>Arctophila fulva</i> , <i>Ranunculus gmelinii</i> , <i>R. pallasii</i> , <i>Hippuris lanceolata</i> , <i>Caltha arctica</i> )	12

Annotated list of species found in Kytalyk in the summer of 2013

Local flora "Kytalyk" numbers 131 species from 66 genera and 28 families. Families are assembled in Engler system order, and within families, species are listed in an alphabetic order. Each species name is followed by activeness score (Latin numerals), comments, habitat types IDs as in Table 2 (Arabic numerals), latitudinal phytogeographic subgroup. Abbreviations for latitudinal groups and subgroups are the following:

the arctic group (A) includes three subgroups: A, arctic; MA, metaarctic; AA, arctic-alpine;

the hypoarctic group (HA) includes two subgroups: HA, hypoarctic, HAM, hypoarctic-montane;

the boreal group (B) includes B, boreal and AB, arctic-boreal subgroups.

Fam. Equisetaceae

1. *Equisetum arvense* L. III. Mostly on eroded surfaces. 7, 8. HA.

2. *E. variegatum* Schleich. ex F. Weber & D. Mohr. I. Rare. 9. HAM.

Fam. Sparganiaceae

3. *Sparganium hyperboreum* Laest. ex Beurl. II. Sporadically in little lakes. 12. AB.

Fam. Juncaginaceae

4. *Triglochin maritima* L. I. Rare. Not reported earlier for this part of the Arctic.  
9. AB.

Fam. Poaceae

5. *Alopecurus alpinus* Vill. subsp. *borealis* (Trin.) Jurtz. II. Rather common. 7, 8. MA.

6. *Arctagrostis arundinaceae* (Trin.) Beal. III. Abundant on eroded surfaces. 7, 8.  
HAM.

7. *A. latifolia* (R. Br.) Griseb. III. Common, sparse. 1, 2, 6, 7, 8. AA.

8. *Arctophila fulva* (Trin.) Andersson. II. Rather rare, but abundant. 12. HA.

9. *Calamagrostis holmii* Lange. IV. Common and rather abundant. 1, 2, 4, 5, 6, 7,  
8. MA.

10. *C. purpurea* (Trin.) Trin. [syn. *C. langsdorffii* (Link) Trin.]. II. Abundant. 10,  
12. AB.

11. *Dupontia fisheri* R. Br. II. Common, but not abundant. 3, 5, 10. A.

12. *Elymus macrourus* (Turcz.) Tzvelev. I. Rare, solitary. 7. B.

13. *Festuca brachyphylla* Schult. et Schult. fil. II. Sporadically. 6, 7, 9. AA.

14. *Hierochloa pauciflora* R. Br. II. Sporadically. 4, 5. HA.

15. *Poa alpigena* (Blytt.) Lindm. subsp. *alpigena* [Syn. *Poa pratensis* L. subsp. *alpigena* (Lindm.) Hiitonen]. I. Rare. 7. HAM.

16. *P. alpigena* subsp. *colpodea* (Th. Fries) Jurtz. et Petrovsky [Syn. *Poa pratensis* subsp. *colpodea* (Th. Fr.) Tzvelev] II. Sporadically. 7, 8. MA.

17. *P. arctica* R. Br. III. Common, but not abundant. 1, 2, 4, 6, 7, 9, 10. AA.

18. *Puccinellia borealis* Swallen. I. Rare. 8. A.

19. *Trisetum spicatum* (L.) K. Richt. I. Rare, solitary. 7. AA.

Fam. Cyperaceae

20. *Carex bigelowii* Torr. ex Schwein. subsp. *arctisibirica* (Jurtz.) A. et D. Löve.  
IV. Common and rather abundant. 1, 2, 6, 7. MA.

21. *C. concolor* R. Br. [Syn. *Carex aquatilis* Wahlenb. subsp. *stans* (Drej.) Hult.].  
IV. Very common and abundant species. 1, 3, 4, 5, 9, 12. MA

22. *C. chordorrhiza* Ehrh. II. Sporadically, can be abundant. 5, 9. AB.

23. *C. juncella* Th. Fries. I. Found once. 12. B.

24. *C. marina* Dew. [syn. *C. amblyorhyncha* V. Krecz.]. I. Rare. Solitary. 9. AA.

25. *C. rariflora* (Wahlenb.) Smith. I. Rare, not abundant. 9. MA.

26. *C. rotundata* Wahlenb. II. Rather common. 5, 9. HAM.



27. *C. saxatilis* L. subsp. *laxa* (Trautv.) Kalela. I. Very rare. 9. HAM.  
28. *C. vaginata* Tausch var. *vaginata* I. Rare. 6. HAM.  
29. *Eriophorum angustifolium* Honck. IV. Common, abundant. 3, 5, 10, 12. AB.  
30. *E. brachyantherum* Trautv. & C.A. Mey. I. Very rare, solitary. 9. HAM.  
31. *E. × medium* Andersson. I. Rare. 5. HAM.  
32. *Eriophorum russeolum* Fr. ex Hartm. subsp. *leiocarpum* M.S. Novos. II. Scattered. 3, 5. HA.  
33. *E. scheuchzeri* Hoppe. I. Rare. 8. AA.  
34. *E. vaginatum* L. IV. Common, abundant. 1, 2, 4, 6. AB.  
Fam. Juncaceae  
35. *Juncus castaneus* Smith. I. Very rare. 9. HAM.  
36. *J. triglumis* L. I. Rare. 9. AA.  
37. *Luzula cofusa* Lindb. II. Rather common. 1, 2, 6, 7. AA.  
38. *L. nivalis* (Laest.) Spreng. I. Rare. 6, 7. AA.  
39. *L. tundricola* Gorodk. ex V. Vassil. I. Rather rare, solitary. 6, 7. MA.  
40. *L. wahlenbergii* Rupr. II. Common, solitary. 3, 4. HA  
Fam. Tofieldiaceae  
41. *Tofieldia coccinea* Richardson. II. Scattered. 1, 6, 7. AA.  
Fam. Salicaceae  
42. *Salix boganidensis* Trautv. I. Very rare. 6. HA.  
43. *S. fuscescens* Andersson. II. Common. 3, 4. AB.  
44. *S. glauca* L. III. Common, abundant on slopes. 1, 2, 6, 7, 8, 10. HAM  
45. *S. hastata* L. II. Rather rare. 8, 11. AB.  
46. *S. myrtilloides* L. I. Rare. 4. B.  
47. *S. pulchra* Cham. IV. Common, often abundant. 1, 2, 3, 4, 6, 7, 8, 9, 10. HA.  
48. *S. reptans* Rupr. I. Rare. 7. MA.  
49. *Salix richardsonii* Hook. II. Rather common. 10. HA.  
Fam. Betulaceae  
50. *Alnus alnobetula* (Ehrh.) K. Koch subsp. *fruticosa* (Rupr.) Raus. [*Alnus fruticosa* Rupr.]. I. Found once. Probably introduced by humans. 6. AB.  
51. *Betula nana* subsp. *exilis* (Sukaczew) Hultén]. V. Everywhere, except 12. HA.  
Fam. Polygonaceae  
52. *Bistorta plumosa* (Small.) Greene. II. Rather common. 1, 6, 7. MA.  
53. *B. vivipara* (L.) S.F. Gray. I. Rather rare. 7, 9. HAM.  
54. *Aconogonon tripterocarpum* (A. Gray) Hara. I. Found once. 6. HA.  
55. *Rumex arcticus* Trautv. II. Rather common, solitary. 4, 9, 11. HA.  
Fam. Caryophyllaceae  
56. *Cerastium jenisejense* Hult. I. Rare. 8, 11. HAM.  
57. *C. maximum* L. II. Rare. 7. AB.  
58. *C. regelii* Ostenf. I. Rare. 8. A.  
59. *Minuartia rubella* (Wahlenb.) Hiern. I. Found once. 7. AA.  
60. *M. stricta* (Sw.) Hiern. I. Found once. 9. HAM.  
61. *Moehringia lateriflora* (L.) Fenzl. I. Rare. 10. AB.  
62. *Silene uralensis* (Rupr.) Bocquet. [Syn. *Gastrolychnis apetala* (L.) Tolm. et Kozhan.] I. Rare. 9. AA.  
63. *Stellaria ciliatocephala* Trautv. II. Rather common, solitary. 1, 6, 7, 8. HA.  
64. *S. crassifolia* Ehrh. II. Rather rare. 9, 12. AB.  
65. *S. peduncularis* Bunge. I. Rare. 8. AB.  
66. *S. edwardsii* R. Br. I. Found once. 8. MA.  
Fam. Ranunculaceae  
67. *Caltha arctica* R. Br. II. Rather common. 3, 10, 12. MA.

68. *C. palustris* L. II. Rather rare. 5, 12. B.  
69. *Delphinium chamissonis* G. Pritz. ex Walp. II. Rather common. 7, 8. MA.  
70. *Ranunculus arcticus* Richardson [Syn. *R. pedatifidus* subsp. *affinis* (R. Br.) Hult.]. I. Rare. 7, 9. MA.  
71. *R. gemelini* DC. II. Sporadically, can be abundant. 12. AB.  
72. *R. lapponicus* L. II. Sporadically. 4. AB.  
73. *R. nivalis* L. I. Very rare. 11. MA.  
74. *R. pallasii* Schlecht. II. Sporadically. 5, 12. A.  
75. *R. pygmaeus* Wahlenb. I. Very rare. 11. A.  
Fam. Papaveraceae  
76. *Papaver lapponicum* (Tolm.) Nordh. subsp. *orientale* Tolm. I. Very rare. 7. MA.  
Fam. Brassicaceae  
77. *Cardamine bellidifolia* L. I. Found once. 8. AA.  
78. *C. pratensis* L. subsp. *angustifolia* (Hook.) O.E. Schulz. II. Sporadically. 9, 10. HA.  
79. *Cochlearia arctica* Schlecht. I. Found once. 8. A.  
80. *Draba hirta* L. I. Rather rare. 7, 8. HAM.  
81. *D. juvenilis* Kom. II. More common than previous. 7, 8. HA.  
82. *D. nivalis* Lilj. I. Found once. 7. A.  
83. *Descurainia sophioides* (Fisch. ex Hook) O.E. Schulz. I. Rare. 8. HA.  
84. *Eutrema edwardsii* R. Br. I. Rare. 6. AA.  
85. *Parrya nudicaulis* (L.) Regel. III. Common, not abundant. 1, 6, 7, 8. AA.  
Fam. Saxifragaceae  
86. *Chrysosplenium alternifolium* L. subsp. *sibiricum* (Ser. ex DC.) Hulten. II. Sporadically. 9, 10. AB.  
87. *C. tetrandrum* (Lund ex Malmgr.) Th. Fries. I. Rare. 8. MA.  
88. *Saxifraga cernua* L. III. Sporadically. 4, 5, 8. AA.  
89. *S. foliolosa* R. Br. III. Rather common. 3, 4, 5, 10. AA.  
90. *S. hieracifolia* Waldst. et Kit. III. Common. 6, 7, 8, 9, 11. AA.  
91. *S. hirculus* L. II. Sporadically. 4, 5, 9. AB.  
92. *S. nelsoniana* D. Don. III. Very common. 1, 4, 6, 7, 8, 9, 10. MA.  
93. *S. radiata* Small. I. Rare. 9. HA.  
Fam. Parnassiaceae  
94. *Parnassia kotzebuei* Cham. et Schlecht. I. Found once. 11. MA.  
Fam. Rosaceae  
95. *Comarum palustre* L. II. Sporadically. 3, 5, 9, 12. AB.  
96. *Dryas punctata* Juz. III. Common. Abundant on slopes. 1, 6, 7. AA.  
97. *Potentilla stipularis* L. I. Very rare. 7. HAM.  
98. *Rubus chamaemorus* L. II. Rather rare. 2, 4. AB.  
Fam. Empetraceae  
99. *Empetrum nigrum* subsp. *subholarcticum* (V.N. Vassil.) Kuvaev. II. Common. 1, 2, 6, 7. AB.  
Fam. Onagraceae  
100. *Epilobium davuricum* Fisch. ex Hornem. I. Sporadically. 4, 5, 8, 9. HAM.  
101. *E. palustre* L. II. Rather common. 5, 9, 10, 12. AB.  
Fam. Hippuridaceae  
102. *Hippuris lanceolata* Retz. II. Sporadically. 12. HA  
103. *H. vulgaris* L. II. Sporadically. 12. AB.  
Fam. Pyrolaceae  
104. *Orthilia obtusata* (Turcz.) H. Hara. II. Sporadically. 1, 6. AB.  
105. *Pyrola grandiflora* Radius. III. Common. 1, 2, 4, 6, 7, 10. AB.



Fam. Ericaceae

106. *Andromeda polifolia* L. subsp. *pumila* V. Vinogr. II. Sporadically. 2, 4, 5, 9. HAM.

107. *Arctous alpina* (L.) Niedenzu. II. Common. 6, 7. HAM.

108. *Cassiope tetragona* (L.) D. Don. II. Sporadically. 1, 6. MA.

109. *Rhododendron tomentosum* Harmaja [Syn. *Ledum palustre* L. subsp. *decumbens* (Ait.) Hult. IV. Common, abundant. 1, 2, 4, 6, 7. HAM.

110. *Vaccinium uliginosum* L. subsp. *microphyllum* Lange. III. Rather common. 1, 2, 6, 7. HAM.

111. *V. vitis-idaea* L. subsp. *minus* (Lodd.) Hulten. IV. Common. 1, 2, 4, 6, 7, 10. HAM.

Fam. Primulaceae

112. *Androsace septentrionalis* L. I. Found once. 7. AB.

Fam. Polemoniaceae

113. *Polemonium acutiflorum* Willd. ex Roem. & Schult. III. Rather common. 5, 9, 10, 11, 12. HAM.

Fam. Orobanchaceae

114. *Pedicularis capitata* Adams. II. Rather rare. 6. MA.

115. *P. hirsuta* L. II. Rather rare. 6, 7. MA.

116. *P. labradorica* Wirsing. II. Rather rare. 4. HAM.

117. *P. langsdorffii* Fisch. ex Steven. I. Rare. 6, 7. MA.

118. *P. lapponica* L. III. Common. 1, 2, 4, 6, 7. HAM.

119. *P. pennellii* Hultén. II. Rather rare. 3, 4, 5. HA.

120. *P. interior* (Hultén) Molau & D.F. Murray [Syn. *Pedicularis sudetica* subsp. *interior* (Hultén) Hultén]. III. Common but solitary. 1, 3, 4, 5, 8, 10, 11. HA.

121. *P. gymnostachya* (Trautv.) A.P. Khokhr. I. Rare. 7. HA.

Fam. Lentibulariaceae

122. *Utricularia intermedia* Hayne. I. Rare. 5, 12. B.

123. *U. minor* L. I. Rare, but more often than previous. 12. B.

Fam. Adoxaceae

124. *Adoxa moschatellina* L. II. Sporadically. 7, 8, 10. B.

Fam. Valerianaceae

125. *Valeriana capitata* Pall. ex Link. III. Scattered. 1, 2, 4, 6, 7, 8, 9, 10. HAM.

Fam. Asteraceae

126. *Artemisia tilesii* Ledeb. II. Sporadically. 8. MA.

127. *Petasites frigidus* (L.) Fr. IV. Almost everywhere. 1, 2, 4, 6, 8, 9, 10, 11, 12. AB.

128. *Taraxacum longicorne* Dahlst. I. Very rare. 7. HA.

129. *Tephroseris integrifolia* subsp. *atropurpurea* (Ledeb.) B. Nord. II. Scattered. 1, 2, 6. MA.

130. *T. palustris* (L.) Rchb. I. Rare. 8. AB.

131. *Tripleurospermum hookeri* Sch. Bip. II. Sporadically. 8. A.

The set of the top 10 richest by the number of species families is the same in all four studied LFs, however the position of families in this set varies between localities. Naturally, absolute number of species in these families in two poor LFs (Kytalyk and Russkoe Ustje) is less, than in two richer floras (Chokurdakh and Cape Burulgin). That is especially notable in the *Poaceae* and *Cyperaceae* families, 35 and 24 species respectively in Chokurdakh, and 24 and 15 species in Kytalyk. Due to rarity of well-drained habitats, xerophylic species of grasses and sedges were totally absent in Kytalyk. For the same reason fam. *Asteraceae* is poorly represented, it is the third richest in Chokurdakh and only on the 10<sup>th</sup> place in Kytalyk. Relatively bigger is the portion (but not the absolute number) of fam. *Salicaceae*, *Caryophyllaceae* and *Scrophulariaceae*.

Leading families in Kytalyk LF are the following: 1) *Poaceae* – 16 species; 2) *Cyperaceae* – 15; 3–4) *Caryophyllaceae* and *Salicaceae* – 10 species in each; 5) *Brassicaceae* – 9; 6–8) *Saxifragaceae*, *Ranunculaceae*, *Scrophulariaceae* – 8 species in each; 9–11) *Asteraceae*, *Juncaceae* and *Ericaceae* – 6 species in each. LF Kytalyk differs from neighboring floras by complete absence of families *Fabaceae*, *Lycopodiaceae*, *Gentianaceae*.

We did not find several very common species (*Huperzia arctica*, *Hierochloa alpina*, *Deschampsia borealis*, *Parnassia palustris*, *Astragalus alpinus*), which were present in other localities, although we were specifically looking for them. On the other hand, we found new and the northernmost for this region locations of several boreal and hypoarctic species (*Moehringia lateriflora*, *Salix myrtilloides*, *Alnus fruticosa*, *Polygonum tripterocarpum*, *Orthilia obtusata*, *Pedicularis pennellii*, *Utricularia intermedia*, *U. minor*, *Triglochin maritima*). The latter three species were not previously recorded in Yana-Indigirka region at all (Sekretareva 2004) *Parnassia kotzebuei* and *Pedicularis pennellii* are included in Yakutian Red Data Book (Dolinin 2001). The latter was absent in Chokurdakh, but other red-listed species (*Platanthera oligantha* and *Vicia macrantha*) were found there.

Distribution of species according to the scores of activeness resemble the pattern, which we found in the West Siberian Arctic in subzones E and D (Khitun 1998). Non-active and low active (I and II) species are the most numerous groups (55 and 52 species), they comprise 82% of total LF. In Kytalyk, species with broader ecological tolerance (III–V) comprise 18% of total flora, in West Siberian Arctic their proportion is 14%. Only one species (*Betula exilis*) obtained score V, it was growing practically in all habitats, except aquatic. Interestingly, that although Kytalyk lies only 30 km NW from Chokurdakh, behaviour of certain species (which are not rare species in this region) is very different at these localities. For example, *Eriophorum vaginatum* is one of the most widespread species in Kytalyk, but occurs sporadically in Chokurdakh; the same about *Salix pulchra*; on opposite, *Salix boganiensis* and *Luzula nivalis* are common in Chokurdakh, but rare in Kytalyk. However, really rare species (score I), as a rule, are rare at both sites.

All latitudinal groups are almost equally represented in the flora of Kytalyk, with slightly prevailing arctic group (Table 3). This regularity was also found in more diverse floras of Chokurdakh and Burulgin, whereas in LF of Russkoe Ustje, which is located 80 km to the north from Kytalyk, the arctic group was more notably prevailing.

**Table 3.** Proportion of species in various latitudinal groups in four local floras.

Latitudinal group	Kytalyk	Chokurdakh	Burulgin Cape	Russkoe Ustje
Arctic	40	37	41	49
Hypoarctic	33	32	30	28
Boreal	27	31	29	23

## Conclusion

The LF of Kytalyk numbers 131 species, in spite of such paucity, it exhibits all the features typical for its region. It is representative of wet lowland areas in the low reaches of the Indigirka River. We discovered new, and the northernmost for this region, locations of several boreal and hypoarctic species (*Moehringia lateriflora*, *Salix myrtilloides*, *Alnus fruticosa*, *Polygonum tripterocarpum*, *Orthilia obtusata*, *Pedicularis pennellii*, *Utricularia intermedia*, *U. minor*, *Triglochin maritima*). Additionally, we found two endangered species (*Parnassia kotzebuei* and *Pedicularis pennellii*). The low diversity of flora is connected with poorly differentiated topography, wetland areas and shortage of slopes and well-drained surfaces. The main part of species diversity in this area is formed by rare stenotopic species with low abundance. Therefore, it is especially actual to maintain regular surveys and monitoring.

In Chokurdakh we carried out our survey 45 years after the first survey by Boch and Tzareva (1974). We recorded the presence of 57 previously unreported species and changes in the frequency of occurrence of 73 species (Koroleva et al. 2019). Analysis of these new species revealed an increased proportion of boreal species among them, besides many new boreal species are anthropochores. In Kytalyk there were no surveys previously. We did not record obviously introduced species. However, we can only speculate about the presence of a few alder shrubs on the ridge slope near the abandoned muskox coral, which was established there in late 1980's. It is possible that seeds arrived with the forage; but it is also possible that the alder spread naturally as there is plenty of alder on the banks of the Indigirka.

According to the species composition of this LF, it belongs to East-Siberian hypoarctic floras. The almost equal proportions of arctic and non-arctic latitudinal groups in this flora confirm its hypoarctic position. In the East Siberian Arctic, in contrast to the West Siberian, bioclimatic subzones distribution is uneven. In some areas, subzone E exists as a very narrow stripe and forest-tundra rapidly transfers into subzone D. That is connected with the high degree of continentality of the climate, which makes it unfavorable for shrubs to grow on watersheds. However, along rivers tall willow and alder thicket spread far to the north. Sharp changes of climatic conditions and vegetation was shown along the 110 km longitudinal transect in the lower reaches of the Kolyma River, there the zonal vegetation changed from northern forest-tundra via very narrow belts of subzones E and D to subzone C (Koroleva and Petrovsky 2000). Similar changes in the Indigirka lower reaches occurred along a *ca.* 200 km profile. By comparison: in Yamal and Taymyr, similar zonal changes occur along a *ca.* 700 km transect. Therefore, it is difficult to determine the zonal position of any site in the Indigirka-Kolyma region. Analyzing the proportions of latitudinal elements, taking into account that in partial floras of wetlands boreal features are more expressed, and looking at the vegetation on the hills (tussock tundra with abundant ericoid dwarf-shrubs) we confirm the position of this locality in subzone D.

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