



## Digital inventory of the section “Foreign Asia” in I.M. Krasnoborov herbarium collection (NS)

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### ABSTRACT

A digital inventory of the section “Foreign Asia” of the collection of vascular plants of the I.M. Krasnoborov herbarium (NS) of the Central Siberian Botanical Garden SB RAS was carried out. The workflow of converting a collection to digital form is described. The scanned material is available in the digital herbarium of the CSBG SB RAS on the Institute’s server at <http://herb.csbg.nsc.ru:8081>, as well as on the portal GBIF.org. Taxonomic, geographical and historical analyses of collections, as well as a review of leading collectors, was conducted.

**Key words:** biodiversity, catalogue, digital herbarium, flora, GBIF, history, NS collection, taxonomy, vascular plants

### РЕЗЮМЕ

Гатилова Е.А., Хан И.В., Ковтоныук Н.К. Цифровая инвентаризация секции “Зарубежная Азия” в гербарной коллекции им. И.М. Красноборова. Проведена цифровая инвентаризация отдела “Зарубежная Азия” коллекции сосудистых растений гербария им. И.М. Красноборова (NS) Центрального сибирского ботанического сада СО РАН. Описана последовательность действий при переводе коллекции в цифровой вид. Отсканированный материал доступен в Цифровом гербарии ЦСБС СО РАН на сервере института по адресу <http://herb.csbg.nsc.ru:8081>, а также на портале GBIF.org. Проведен таксономический, географический и исторический анализ сборов, а также обзор ведущих коллекторов.

**Ключевые слова:** биоразнообразие, каталог, цифровой гербарий, флора, история, коллекция NS, таксономия, сосудистые растения, GBIF

In recent years, the development of digital herbarium collections and databases with remote Internet access has become relevant and important. Creating digital herbaria is not just a modern trend in herbarium scientific work, but a process of inventory and modernization of herbarium collections of the world’s leading Botanical institutions (Seregin 2016, 2018, Kovtonyuk 2017, James et al. 2018). For researchers working with natural collections, it is especially helpful to quickly search for visual information and find studied objects in collections around the world (Nelson et al. 2012, Kislov et al. 2017, Kovtonyuk et al. 2019b). Scanned high-resolution material enables researchers to work with it remotely, which speeds up the scientific process significantly (Nelson et al. 2018).

Historically, the CSBG SB RAS herbarium consists of two collections that have their own acronyms in Index Herbariorum (Thiers 2020): the collection named after I.M. Krasnoborov (NS) and the collection named after M.G. Popov (NSK). Both collections of vascular plants together total about 680,000 herbarium specimens and form the consortium.

In the NS herbarium collection, samples of vascular plants are divided into the following sections: Siberia (this includes plant sheets from different subjects of the Russian Federation in Western, Central, and Eastern Siberia), Republic of Tuva (has a separate collection, which is the

world’s largest collection of Tuva plants), Russian Far East, European part of Russia (this also includes herbaria from Ukraine, Moldova, Latvia), America (herbarium mainly from North America – USA, Canada and Mexico), Central Asia (specimens from Kazakhstan, Uzbekistan, Tajikistan, Turkmenistan, Kyrgyzstan), Caucasus (specimens from the Caucasus), Foreign Europe (herbarium from European countries with the exception of former Soviet republics), and Foreign Asia (herbarium from Mongolia, China, Japan, Turkey, India, South Korea, Iran, etc.).

The purpose of our publication is to share the experience of digitization and creating an inventory of herbarium collections for biodiversity data mobilization using GBIF on example of our digitizing the vascular plant collection from the Foreign Asia section of the I.M. Krasnoborov herbarium (NS).

### MATERIAL AND METHODS

Before digitizing, the material was sorted by various taxonomic groups (GBIF 2020) and scanned. The Foreign Asia section was chosen as a model for working out the digital inventory process due to its small size (4794 herbarium specimens), as well as due to the significant amount of unique material (a third of the specimens was sampled by CSBG collectors).

For digital inventory of the section, we followed the workflow that included 1) transforming a paper catalog

of the section into an Open Office Calc table, 2) physical checking the section and identifying unknown taxa, 3) inserting newly collected specimens, 4) scanning, 5) verifying, and 6) final checking the section. The process is described in detail below.

**Step one.** The paper catalog of the section is transformed into an Open Office Calc table that enables calculation of the number of new insertions automatically, adding or removal taxa, and inclusion other useful information about the collection. All taxon names are checked using the international databases Catalogue of Life (Roskov et al. 2020), World Checklist of Vascular Plants (WCVP 2020) and International Plant Names Index (IPNI 2020). The same species stored in the section under names other than accepted are marked with “s” (synonym) in the table. Some names of taxa cannot be found in any database, so the next step is physical checking of the Foreign Asia section.

**Step two.** During physical checking, species names in samples are compared with the table of taxon names (whether all present), the number of specimens is recalculated, and herbarium labels are critically reviewed. This step is for removing the plants collected in other territories (the European part of Russia, the Far East, Central Asia, the Caucasus, Altai, and Tuva), which were inserted in this section by accident. Additionally, unknown taxa listed in the paper catalog are clarified. Most of these taxa have misspellings of a few letters (e.g. “*Lycodium digitatum*” = *Lygodium digitatum* C. Presl, “*Pachypleurum grandiflorum*” = *Pachyneurum grandiflorum* (C.A. Mey.) Bunge, “*Malsa japonica*” = *Maesa japonica* (Thunb.) Moritzi & Zoll.) as well as parts of words (“*Dioscorea subglauca*” = *Dioscorea hypoglauca* Palibin), or the handwriting of the collectors is illegible (“*Ikonnikovia potaninii*” = *Incarvillea potaninii* Batalin). For some taxa, there are several variations of writing. For example, *Glycyrrhiza inflata* Batalin was named as “*G. illatica*”, “*G. illata* Bat.” and “*G. inllata* Bat.” inside one herbarium folder. This step of physical checking is necessary in preparing the section for scanning, allowing clarification of the structure of the collection, removal of alien species, and writing the correct names on the test sheets.

**Step three** is inserting new herbarium sheets into the section. In 2019–2020, we added 171 herbarium specimens with 35 new taxa for the section. Besides the recently collected plant samples, this herbarium pool included the specimens that have been stored in the collection non-inventoried for a long time. Unidentified herbarium specimens were surveyed by taxonomists: I.V. Han, N.K. Kovtonyuk, D.N. Shaulo, I.A. Artemov, I.N. Shekhovtsova, T.V. Ankova, V.I. Troshkina, V.M. Doronkin, E.A. Gatilova, E.V. Banaev, K.S. Baikov, M.N. Lomonosova, N.V. Vlasova, E.A. Pinzhenina. To identify the species, taxonomists used “Key to the vascular plants of Mongolia” (Grubov 1982) and the monographs of I.A. Gubanov (Gubanov 1996, 1999). The number of taxa also changed due to the critical revision of some genera. During checking and inserting the Foreign Asia section, the process of barcoding also took place to prepare herbarium sheets for scanning.

**Step four** is digitization of the plant sheets by two scanners (ObjectScan 1600) in accordance with international

standards: a resolution of 600 dpi, with barcode for each specimen, 24-color scale, and a scale bar. Obtained images and metadata are stored in CSBG SB RAS Database (<http://herb.csbg.nsc.ru:8081>), powered by ScanWizard Botany and MiVapp Botany software (Microtek, Taiwan) (Kovtonyuk et al. 2018, 2019a). Specimen label information is recognized automatically. Two files are saved per specimen: metadata in XML format and image. Both files are named according to the specimen’s barcode.

**Step five.** The quality of images and metadata profiles are checked by experts. The verification process involves filling out information fields in the CSBG database. Each image is supplied with the following information: taxonomy (family name, genus name, species name, scientific name), common name, barcode, type, status, identification date (yyyy-mm-dd), identifier name, collection date (yyyy-mm-dd), collector name, field number of herbarium specimen, country, administrative area, locality, longitude (ddd°mm'ss" or dd° format), latitude (ddd°mm'ss" or dd° format), altitude, and some notes such as the accepted name in CoL, hybrid, type sheet, chromosome number, etc. The results of scanning and verification of the Foreign Asia section of NS collection were published as a separate dataset on the portal GBIF.org (Gatilova et al. 2020). Despite the step of physical checking the collection, the verification revealed new mismatches between the catalog data and the scanned material. Thus, herbarium sheets from other territories were found again (in total, more than 100 sheets from other sections of the NS collection were detected at this step and during the first physical checking step). In addition, there were 7 taxa not listed in the catalog at all. During the final check of the Foreign Asia section, these species were found in the herbarium folder of the same genera, but of other species.

**Step six** is the final physical checking of the section. At this step, sheets from other sections of the NS collection were finally removed from the Foreign Asia section, and missing taxa were added to the catalog.

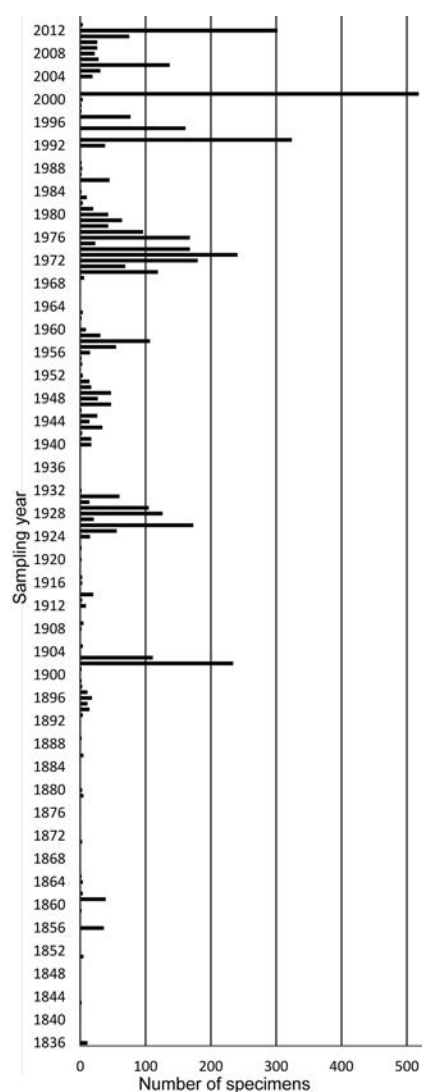
## RESULTS

According to the inventory results, the Foreign Asia section of the NS collection contains 4794 herbarium sheets belonging to 2430 species and subspecies.

Specimens from 169 families are presented. The largest families are Poaceae (592 specimens), Asteraceae (547), Rosaceae (307), Fabaceae (291), Cyperaceae (283), Ranunculaceae (227), Amaranthaceae (178), Caryophyllaceae (168), Brassicaceae (140), Lamiaceae (103), Polygonaceae (94), Orobanchaceae (86), Amaryllidaceae (85), Salicaceae (75), Gentianaceae (69), Plantaginaceae (68), Apiaceae (67), Primulaceae (61), Ericaceae (57), Betulaceae (55).

There are specimens from 11 countries in the section: Mongolia (3211), China (759), Japan (661), Turkey (75), India (35), Iran (17), South Korea (16), Afghanistan (6), Taiwan (6), Syria (5), Philippines (3).

Since the section contains plant sheets from the last two centuries (Fig. 1), there are problems with understanding the borders of some countries. For example, exsiccate № 3742 (NS0006642), collected by Alexeenko F. and Voronov Yu. in 1902, is signed “*Caucasus. Georgia, in distr. Batumensi, ad fontes fl.*



**Figure 1** Plant samples collected in Foreign Asia territory per year (www.gbif.org)

**Table 1.** Top 20 collectors of the Foreign Asia section of NS herbarium.

Collectors	Number of specimens
Krasnoborov I.M.	834
Shmakov A.I.	503
German D.A.	499
Litvinov D.I.	320
Lomonosova M.N.	316
Ikonnikov-Galitskii N.P.	312
Yunatov A.A.	282
Shaulo D.N.	280
Ikonnikova-Galitskaya V.A.	271
Konta F.	259
Karamysheva Z.V.	235
Grubov V.I.	170
Artemov I.A.	161
Banzragch D.	146
Kazantseva T.I.	144
Korolyuk E.A.	113
Volohovich S.	106
Munhbayar S.	104
Rachkovskaya E.I.	103
Ulziihutag N.	101

*Murgul-Su supra pasqua Egrisin, in rupibus, 2500 m*”. Actually, this territory belonged to Russian Empire from 1828, as a part of Batum Oblast, until it was retaken by Turkey during World War I and finally officially returned to Turkey in 1921 with signing of the Treaty of Kars. This specimen was stored in NS herbarium in the Caucasus section, so we suppose other specimens from Turkey can also be found in Caucasian and European sections of the NS collection.

More than 250 collectors contributed to the Foreign Asia section of the NS herbarium (Table 1). CSBG staff collected about 30 % of the section (Table 2).

Comparing Fig. 1 and Table 2, it is obvious that the CSBG collectors are most active in the territory of Mongolia and China for recent years (see also: Doronkin et al. 2015, Erst et al. 2017, Ankova et al. 2019).

The collection includes some older exsiccates from Moscow and Saint Petersburg herbaria. For example, 12 early specimens from India (in Bengal circa Calcuttam) were collected by J.W. Helfer in 1836–1838. J.W. Helfer was a Bohemian physician, explorer and naturalist, living in Kolkata since 1836. After his death, all his collections, including 6086 herbarium specimens, were given to the Bohemian Museum (Wolcott & Renner 2017).

We found 41 herbarium specimens that have labels “*Fl. Pekin. Tatarinow*”, from 1851 and, mostly, 1856. A.A. Tatarinow (Tatarinow) lived in Pekin in 1840–1850 as a doctor at the Russian Ecclesiastical Mission. He also studied Chinese medicinal plants and compiled an atlas of them with his own drawings. In 1851 he was appointed as Russian Consul in Chuguchak (now known as Tacheng, in Xinjiang). Later (1857–1858), he accompanied E.V. Putyatyn on his diplomatic missions (Anonymous 1912).

Thirty seven specimens have the labels “*Japonia. Insula Jesso, circa Hakodate. Dr. Albrecht. 1861–1863*”. Doctor M. Albrecht came to Japan in 1858 with Consul I. Goshkevich, who helped him to open a hospital in Hakodate (Tatsumi 2014).

Of 8 specimens collected by N.M. Przhevalskii (Przewalski) in 1871–1873 and 1880, some were signed as “*China*”, others as “*Mongolia occidentalis*”, although most likely some of those territories (Alashan Mountains, for example) also belong to China now. G.N. Potanin collected 11 specimens in 1877–1879 and 1886 in Mongolia.

Fourteen specimens collected in 1884–1885 from Korea (Seoul) were signed “*Sontag*”, “*A. Sontag*” or “*M.A. Sontag*”. Marie Antoinette Sontag was a distant relative of the Russian Ambassador in Korea, Karl Weber, and lived in Seoul from 1884 to 1909. She is known as a skilled chef, hotel owner and diplomat, but little is known about her botanical studies (Braesel 2014).

Elizaveta Klements (E. Klementz), wife of ethnographer and archeologist Dmitry Klements, gathered 39 specimens of the Foreign Asia section in 1893–1898. She accompanied her husband in his travels to Mongolia helping with his work, making meteorological observations and collecting flora (Adrianov 1917).

The Foreign Asia section contains also specimens collected in 19th century in China by A.G. Schrenk (1841 – 1 specimen), P. Kirilov (Kirilow) (1843 – 2 spec.), W.J. Roberovski (1889–1895 – 4 spec.), V. Kachkarov (1893 – 2 spec.), S. Jano (1897 – 1 spec. and 1887 from Taiwan), V. Komarov (1897 – 1 spec.).

**Table 2.** The CSBG collectors of the Foreign Asia section of NS herbarium.

Collectors	Year	Country	Specimens
Lashchinskii N.N.	1983–1984	Mongolia	9
Krasnoborov I.M., Lomonosova M.N.	1993	Japan	316
Artemov I.A.	1995	Mongolia	161
Krasnoborov I.M., Shmakov A.I., German D.A.	2001	Mongolia	499
Krasnoborov I.M., Ershova E.A.	2001	Mongolia	19
Korolyuk A.Yu.	2004	Mongolia	16
Korolyuk E.A.	2006	Mongolia	109
Agafonov A.V.	2006	Mongolia	1
Korolyuk E.A., Korolyuk A.Yu.	2009	China	2
Korolyuk E.A.	2009	South Korea	1
Korolyuk A.Yu.	2011	China	49
Shaulo D.N.	2012	Mongolia	234
Shaulo D.N., Smirnov S.V., Erst A.S.	2012	China	46



Herbarium specimens from Japan were also collected by Ph.F. de Siebold (1859, 1861 – 3 specimens), K.I. Maximowicz (1861–1862 – 6 specimens), S. Tenosuke (須川長之助) (1864–1866, 1888 – 8 specimens), from Turkey – by W. Massalsky (1885 – 1 specimen), from Iran – by B. Levandovskii (1898 – 1 specimen), from Mongolia – by I.V. Palibin (1899 – 1 specimen).

NS herbarium includes 321 specimens of D.I. Litvinov (Litvinov) brought from China in 1902 and 1903 (Gatilova et al. 2020) and collected around stations along the newly built Chinese Eastern Railway from Inner Mongolia to Heilongjiang and Liaoning (Fig. 2). Litvinov visited Manchuria twice (Gorodkov 1929), and 2589 herbarium specimens were collected by him in 1902 (Litvinov 1909).

The most recent materials in the section are 4 specimens collected in Mongolia by A.I. Shmakov and A.A. Kechaikin in 2013.

## CONCLUSION

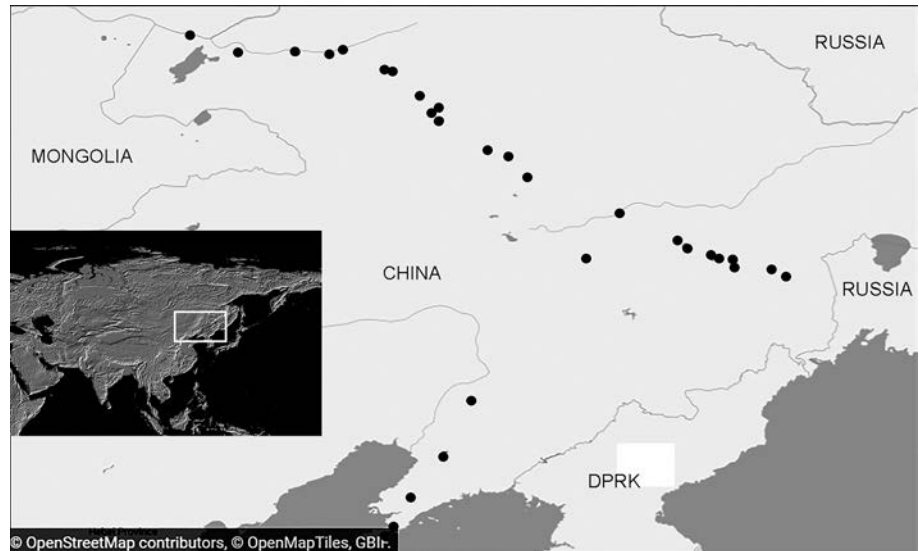
We shared our first experience of the digital inventory of the separate section of the herbarium collection. The digitization of whole section allowed to analyze its taxonomic structure as well as identify interesting facts of plants collecting process through the years. The inventarization process showed that it is quite important to check whole section physically before scanning. Thus, all specimens from the Foreign Asia section of the NS herbarium were digitized, and good quality images with herbarium label information were published as a dataset in GBIF portal and were placed in the CSBG SB RAS Digital Herbarium. Biodiversity data mobilization using GBIF is very valuable tool for sharing biological information worldwide.

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**Figure 2** Locations of D.I. Litvinov's gatherings in 1902–1903, kept at the Foreign Asia section in the NS herbarium collection (<https://www.gbif.org/dataset/45d532d3-ced7-4856-8590-705bc8b244a1>)

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