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Moscow Digital Herbarium, an online open access contribution to the flora of Turkey, with a special reference to the type specimens

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Abstract: Massive imaging of herbarium collections is performed only in a few countries, leading to disproportions in geographical coverage of the world's flora across virtual herbaria. The Moscow University Herbarium (MW) digitised all Asian collections in 2016–2017 and published them online at https://plant.depo.msu.ru/, including 3283 specimens from Turkey. These collections include important historical gatherings by P.E. Boissier, C. Haussknecht, and T. Kotschy and recent collections by the Moscow University staff members. Currently, MW holds 331 type specimens of 285 taxa described from Anatolia—19 holotypes, 47 isotypes, 48 isolectotypes, and 203 syntypes.

Key words: Asia Minor, authentic collections, historical collections, vascular plants

1. Introduction

Massive imaging of herbarium collections has changed their accessibility for researchers and wider audience throughout the world. Successful efforts on rapid scanning of more than one million specimens have been undertaken in Paris (P) (Le Bras et al., 2017), Leiden (L) (Heerlien et al., 2015), Beijing (PE) (Ma and Xu, 2014), New York (NY) (Thiers et al., 2016), Mexico (MEXU) (Gerenandt et al., 2014), Washington (US) (Orrell and Hollowell, 2018), and Meise (Engledow et al., 2017). This list should be supplemented with five herbaria from China, three from Europe, and two from the Americas with 0.5M+ scanned holdings as of early 2018 (original data). Therefore, only nine countries are currently involved into the large-scale imaging of terrifically important dry plant collections, leading to great disproportions in geographical coverage of the world's flora across virtual herbaria.

Unfortunately, plants from Turkey are not widely represented in open access digital herbaria in the form of scanned herbarium specimens. The highest number of published images from Turkey can be found at Edinburgh (E), P, Kew, Geneva, Bratislava, and British Museum herbaria as well as the JACQ-aggregator based in Vienna. Scanned holdings are largely represented by type specimens that are usually old, except those from E. We have detected only one Turkish herbarium, namely *The Virtual Herbarium of Lake Van Basin*, created at the Faculty of Education of Yüzüncü Yıl University (VANF herbarium) with 9000 scanned specimens (no label data available).

For a long time, plant collections from Asia Minor were among the most wanted materials for Russian systematic botanists. Old Russian herbaria like the Komarov Institute in St. Petersburg and Moscow University Herbarium have accumulated large holdings of plant specimens from northeast provinces of modern Turkey (Artvin, Erzurum, Kars, etc.). Hundreds of new species were discovered by Russian collectors in this area. Later on, these collections were intensively studied and fully covered by the standard *Flora Kavkaza* (Grossheim, 1934).

The Moscow University Herbarium (MW) includes 1,030,000 specimens with 40% of collections gathered beyond the modern borders of Russia. Fifty-one out of 63 species of vascular plants described by Moscow University staff members in 2013–2017 were collected outside Russia. Therefore, research, documentation, and final delivering of plant diversity data in a modern electronic form to a wider international community is an important mission of MW.

Since the 1990s, MW has received fully or partly recent collections by A.P. Khokhryakov, M.G. Pimenov, E.V. Kljuykov, and D.F. Lyskov that have supplemented complementary important classical collections of the 19th century by E. Boissier, C. Haussknecht, T. Kotschy, W.

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Siehe, and P. Sintenis and early 20th century collections by G. Woronow, B. Shishkin, D. Sosnowsky, and others. A list of MW collectors with years of activity and sources of acquisition was published by Balandin (2006).

In late 2014, MW received direct investment for digitisation within the grant l4-50-00029 from the Russian Science Foundation (Seregin, 2016). This helped us to scan 89% of herbarium specimens within the *Moscow Digital Herbarium* initiative in 2015–2017. Fast digitisation of all incoming accessions made the herbarium an attractive place for duplicate deposition and made an exceptional contribution of 22K new specimens in 2016 and 19.5K in 2017. Now all these holdings are fully available online, including interesting collections from Turkey.

2. Materials and methods

2.1. Curation of physical collections

Due to the long tradition of floristic research, MW consists of 11 regional collections of vascular plants curated as independent units: Eastern Europe (E), Asian Russia (S), Caucasus (K), Crimea (KRYM), Middle Asia (M), Mongolia (MONG), Western Europe (WEU), South Asia (ASIA), Africa (AFR), America (AMER), and Australia & Oceania (AUS). Type specimens are preserved separately. Therefore, physical collections from Turkey are splitted between four (!) units—(1) NE Turkey being part of the Caucasian herbarium and treated as K7 area, (2) the rest of Asia Minor stored among South Asian without further geographical indexation, (3) Turkey-in-Europe being part of WEU branch, and (4) type collections. The only possibility to study all Turkish material as a single unit in this sophisticated scheme was digitisation of all specimens with further retrieving of images in search results. The same is true for any requests that involve studying of plant specimens from various regions used for curation of physical collections.

2.2. Brief description of the dataset before imaging

Before imaging and further geographical indexation, we did not have any reliable figures or even estimates on how many herbarium specimens from Turkey we have (except for types). Gubanov et al. (in Balandin, 2006) gave a geographical overview of a catalogue of type collections preserved in MW, stating that types of at least 215 taxa described from Turkey were preserved at that time in MW. Thirty taxa were described since 1993 from Turkey upon recent collections by Moscow University staff members—mainly from Apiaceae (Khokhrjakov, 1993; Pimenov et al., 1998, 2005, 2011; Akalın and Pimenov, 2004; Pimenov and Kljuykov, 2010, 2011, 2013a; Bani et al., 2012; Lyskov et al., 2017), but also from Boraginaceae, Brassicaceae, Lamiaceae, Fabaceae, and other families (Khokhrjakov, 1993, 1995, 1997a, 1997b; Podlech and Sytin, 2002). Some of these protologues were published in serials that are not available on the web or with short Latin descriptions inserted into the Russian text just to validate new taxa. Frequent requests for the specimens of these newly described taxa made us sure that published descriptions are not enough for correct interpretation of the names.

Comprehensive lists of MW collectors with years of activity and sources of acquisition were published by Shvedchikova (in Balandin, 2006) for NE provinces of Turkey intensively studied by Russian researchers and by Seregin (in Balandin, 2006) for the rest of the country. All together these lists named 37 persons who contributed to MW with specimens from Turkey, but we did not have at the time any knowledge on how large their collections were.

2.3. Technical issues of digitisation

Getting a stable budget for the next four years, we scheduled to scan 1M specimens at 300 dpi (TIFF + JPG) in 2015–2018, to image 4.6K type specimens at 600 dpi, to scan 78K labels from bryophyte capsules, and finally to database and georeference label data from as many specimens as possible until complete exhaustion of the budget (Seregin, 2016). In 2015–2017, we compiled specification and protocols for scanning of specimens following the world's best practices, selected a commercial partner, restructured old xls-database for further production of image metadata, barcoded and prepared for digitisation 953K specimens, transferred to the scanning area and filed back 911K specimens, conducted quality control of images and metadata, and finally transferred back to the scanning area 27K specimens for rescans.

2.4. Online publication

We did our best to facilitate free full online access to all imaged specimens from MW. Currently, all 910,817 images are fully available through the general Google Search and four different web addresses: Moscow Digital Herbarium (https://plant.depo.msu.ru/), Open version (https://plant.depo.msu.ru/open/), Global Biodiversity Information Facility (https://www.gbif.org/), and Yandex. Images (https://yandex.ru/images/). Each point of access has a number of tools and services for effective interaction between a researcher and content.

An operational version (https://plant.depo.msu.ru/) is the dataset homepage with a number of search tools like label search, geosearch, search on taxonomic tree, and search by Latin and vernacular names. Data administrators are managing here the content and editing the data through their accounts. IT staff are incorporating here new datasets like tables with labels, georeferences, and taxonomic treatments. Users can download xlsx-files with general metadata. Basic statistics of the Moscow Digital Herbarium are available here. Currently, it is the sixth largest imaged herbarium in the world fully available on the web after P (5.4M), L (4.6M), NY (1.7M), PE (1.7M), and MEXU (1.2M).

Taxonomy in the Moscow Digital Herbarium fully reflects names used in the collection. To make the names permanently updated we cross-linked them automatically with the *Catalogue of Life* (http://www.catalogueoflife.org/col/). We extracted from this source higher hierarchy (familial and suprafamilial names), currently accepted names, and complete synonymy.

3. Results

3.1. Library of images

In 2016, we imaged 22,649 specimens from South Asia, 378 specimens from NE Turkey, and 4640 type specimens. Western European holdings were not imaged, but there are no specimens from Turkey-in-Europe in MW at all (Balandin, 2006). After country tagging of the Asian and type collections performed in early 2017 and imaging of new accessions in late 2017, we finally got a precise number of specimens from Turkey as well as for other Asian countries.

The trickiest challenge was to perform correct country assignment of Haussknecht's 992 specimens collected during his two expeditions known as *Iter Orientale* (1865 and 1866–1869). It was not an easy job to interpret his handwriting, but using his itineraries (see map on http://www.spezbot.uni-jena.de/herbarium/sammlung/haussknechts-travel-diaries/) and collection dates 468 specimens were finally country tagged as originating from modern Turkey. Other specimens come from Iraq, Iran, and Syria. We also hold some collections by Haussknecht from Georgia and Azerbaijan, but they were curated as part of the well-managed Caucasian collections. Eighteen specimens from his collections were not assigned to any country. Baytop (2008) assumed that Haussknecht's Anatolian collections might comprise up to 2000 specimens and so MW holds roughly a quarter of his gatherings.

As of January 2018, the Turkish collections in MW include 3283 vascular plant specimens. They are all fully available in the Moscow Digital Herbarium, making it the seventh largest hub of digitised herbarium specimens from Turkey available online (Table). Our collectors M.G. Pimenov, E.V. Kljuykov, and D.F. Lyskov are still identifying and transferring their collections, and therefore Moscow University's position in the ranking will surely have strong positive dynamics in the next few years.

3.2. Taxonomic coverage

Beside some infraspecific taxa, our Turkish dataset includes 1872 species (i.e. names accepted in the collection). Some names traditionally used for curation are currently treated as synonyms. Crosslinking of the dataset with the *Catalogue of Life* gave a slightly lower figure of 1709 species from 617 genera and 103 families. Meanwhile, 263 specimens are still not identified up to species level or bearing never-published names, and so the actual number of species is ca. 10% higher.

The most peculiar feature of our Turkish collection is a high proportion of *Apiaceae* specimens (Table). Moscow University is a distinguished centre of *Apiaceae* research in Asia. Large collections by Pimenov and Kljuykov's team from all over Asia form the core of our carrot-family holdings and served as a basis for the description of hundreds of new species, dozens of molecular revisions, and several monographs.

3.3. Type specimens

As of January 2018, MW holds 331 type specimens collected in Turkey—19 holotypes, 47 isotypes, 48 isolectotypes, and 203 syntypes of early authors (Appendix). We consider them to be types of 285 taxa (species, subspecies, and varieties). The names in the list below are given as published with no references on the current taxonomic status of the names.

Table. Top-10 families and genera of the imaged Turkish collections from the Moscow University Herbarium.

Rank	Top-10 families	Number of specimens	Rank	Top-10 genera	Number of specimens
1	Apiaceae	697	1	*Salvia*	72
2	Asteraceae	308	2	*Bupleurum*	66
3	Fabaceae	305	3	*Astragalus*	65
4	Lamiaceae	302	4	*Galium*	57
5	Caryophyllaceae	183	5–6	*Ferulago*	40
6	Poaceae	139	5–6	*Quercus*	40
7	Brassicaceae	105	7	*Silene*	39
8	Rubiaceae	101	8	*Campanula*	38
9	Boraginaceae	79	9	*Euphorbia*	34
10	Rosaceae	70	10	*Veronica*	34

Their modern status could be traced easily from revisions, floras, and online resources like http://www.theplantlist.org/, http://bizimbitkiler.org.tr/v3/demo/, and https://plant.depo.msu.ru/. The type statuses of some specimens of older authors are different from those indicated in the standard *Flora of Turkey*. Current regulations of type statuses led to mere absence of holotypes and isotypes in older herbaria. Types with duplicate specimens collected in the 19th century are usually regarded as syntypes, from which lectotypes are designated (Phillips et al., 1992).
Old collections from Turkey especially by Boissier and Haussknecht surely include more type specimens of various rank, but they are still not traced and need further study. Any contributions are warmly welcome.

4. Discussion

The main theme of this paper is the feeling that the international community contributes more to the digitisation of natural history collections from Turkey than the country of origin itself. It is done in a paradigm of "virtual repatriation of material to countries of origin" widely disputed and generally supported (Vollmar et al., 2010). The only imaged collection physically located in Turkey and available on the web is *The Virtual Herbarium of Lake Van Basin* created in VANF. It comprises ca. 9000 images of scanned specimens (and some living plants as well) in a gallery form, but no label details are presented. Nonetheless, it is a wonderful contribution that makes the Turkish flora more visible. Unluckily, the widely advertised project *Turkey Plant Bank* (Duzenli and Karaomerlioglu, 2012) is currently inaccessible.

The Global Biodiversity Information Facility (GBIF), available at https://www.gbif.org/, is the most successful global attempt to present in a standard manner diverse electronic resources on life on Earth. As of 28 January 2018, 966,686,831 occurrences of living beings are available via GBIF, including 1,168,052 records from Turkey (0.12%). The Moscow University Herbarium provides access to 1.2% of vascular plants occurrences from Turkey available in GBIF (273,733 in total) and for 2.2% vascular plants occurrences based upon specimens (150,039). Currently, there are no occurrence records in GBIF published by Turkish institutions.

Following P and E herbaria practices, MW imaged and published all specimens without prior databasing. We have done that in the belief that researchers will transcribe the label details themselves from a screen. In fact, we need to do label capturing as soon as possible, because year by year general skills to read older handwritten texts are disappearing.

In August 2017, we started publication of label details captured from scans or uploaded directly from the databases that are based on our specimens. As of May 2018, labels of 108,819 specimens are completely databased, including 22,423 from the Crimea, 9987 from Middle Russia (excluding Moscow area), 6647 from NW Russia, 6414 from Central Siberia (mainly Taimyr Peninsula), 5777 from the central part of the Northern Caucasus, 4276 from Krasnodar Krai and Adygeya, 2900 from Azerbaijan, 2764 from the Black Sea coast of the Russian Caucasus, 2419 from the Moscow area, 2358 from Armenia, etc. We focused on label capturing on the Cyrillic labels, which are almost unreadable for the international community. Using typed transcriptions one could at least use online translation services to read labels.

Simultaneously, we started georeferencing of collections sites. As of May 2018, 137,467 specimens received georeferences. Russia, Caucasus, Mediterranean, and Ethiopia were selected as the top priorities in geocoding. We launched the Intellectual System of Toponymic Reading and Attribution (ISTRA) for machine georeferencing of specimens grouped against captured labels. Two algorithms of further specimen grouping were programmed—(1) by matching of the collector/date pair; and (2) by matching of textual description of the collection site. Coordinates for 9.3K specimens (22%) were identified automatically by ISTRA.

Label capturing and georeferencing of the Moscow University collections from Turkey are in progress now.

As a general conclusion, we do consider further digitisation efforts (and especially imaging of plant specimens) on floristically diverse regions of Turkey to be one of the most desirable activities in Eastern Mediterranean biodiversity projects focused on plants. Online publication of images of all Turkish plant specimens from the Moscow University Herbarium in 2017 is one of the milestones on this road. We also published scans of all collections from the Crimea, Caucasus, Iran, Syria, Israel, and Cyprus to contribute plant research of Eastern Mediterranean plants on a wider ground.

The year 2017 was exceptional in understanding of the value of digitised herbarium collections. A few studies were published discovering new horizons of deep learning and neural networks in machine identification of herbarium specimens (Carranza-Rojas et al., 2017; Schuettpelz et al., 2017). Plants from P and US herbaria were used in these challenging studies. Undoubtedly, computers will help us in the near future to check massively misnamed specimens or even to point out undescribed species preserved in world herbaria. It's awesome, isn't it?

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Appendix. List of the type specimens stored at MW.

Amaranthaceae

Noaea tournefortii var. *leptoclados* Woron.: Isotypus (MW0592050).

Amaryllidaceae

Allium myrianthum Boiss.: Syntypus (MW0591676). – *Allium tauricola* Boiss.: Isolectotypus (MW0591703).

Apiaceae

Anthriscus anatolica Boiss.: Isolectotypus (MW0593738). – *Bunium pinnatifolium* Kljuykov: Holotypus (MW0593825); Isotypus (MW0593822); Isotypus (MW0593823); Isotypus (MW0593824); Paratypus (MW0593817); Paratypus (MW0593818); Paratypus (MW0593819); Paratypus (MW0593820); Paratypus (MW0593821). – *Bupleurum andronakii* Woronow: Isotypus (MW0593785). – *Bupleurum schistosum* Woronow: Isotypus (MW0593800). – *Bupleurum terminum* A.P.Khokhr.: Holotypus (MW0593801). – *Carum microcarpum* Boiss.: Isotypus (MW0593810). – *Dichoropetalum anatolicum* Pimenov & Kljuykov: Holotypus (MW0593942); Isotypus (MW0593943); Isotypus (MW0593944); Isotypus (MW0593945); Paratypus (MW0593946); Paratypus (MW0593947); Paratypus (MW0593948). – *Echinophora radians* Boiss.: Syntypus (MW0593733). – *Eryngium kotschyi* Boiss.: Isotypus (MW0593730). – *Ferula divaricata* Pimenov & Kljuykov: Holotypus (MW0593993); Isotypus (MW0593994); Isotypus (MW0593995); Isotypus (MW0593996). – *Ferulago asparagifolia* Boiss.: Isolectotypus (MW0594047). – *Ferulago aucherii* Boiss.: Syntypus (MW0594048). – *Ferulago humilis* Boiss.: Isolectotypus (MW0594053). – *Ferulago trojana* Akalın & Pimenov: Isotypus (MW0594055); Paratypus (MW0594054). – *Oenanthe cyclocarpa* Pimenov & Kljuykov: Holotypus (MW0593892); Isotypus (MW0593893); Isotypus (MW0593894). – *Polylophium petrophilum* Boiss.: Isolectotypus (MW0594094). – *Prangos ilanae* Pimenov, Akalın & Kljuykov: Isotypus (MW0593782); Isotypus (MW0593783). – *Rhabdosciadium anatolyi* Lyskov & Kljuykov: Holotypus (MW0595616). – *Seseli marashicum* E.Doğan & H.Duman: Paratypus (MW0595662). – *Seseli paphlagonicum* Pimenov & Kljuykov: Holotypus (MW0593871); Isotypus (MW0593872). – *Seseli phrygium* Pimenov & Kljuykov: Holotypus (MW0593874); Isotypus (MW0593875). – *Seseli serpentinum* B.L.Burtt ex H.Duman & E.Doğan: Paratypus (MW0595661). – *Tordylium macropetalum* Boiss.: Isotypus (MW0594092). – *Torilis grandiflora* Boiss.: Isolectotypus (MW0593741).

Apocynaceae

Vincetoxicum tmoleum Boiss.: Syntypus (MW0594262); Syntypus (MW0594263).

Asparagaceae

Chionodoxa luciliae Boiss.: Syntypus (MW0591726). – *Ornithogalum nivale* Boiss.: Syntypus (MW0591725). – *Scilla nivalis* Boiss.: Syntypus (MW0591723).

Aspleniaceae

Asplenium haussknechtii Godet & Reuter: Syntypus (MW0591008); Syntypus (MW0591009).

Asteraceae

Achillea armenorum Boiss. & Hausskn.: Isolectotypus (MW0595018). – *Anthemis absinthifolia* Boiss. & Spruner: Isolectotypus (MW0595008). – *Anthemis albida* Boiss.: Syntypus (MW0595009). – *Anthemis auriculata* Boiss.: Syntypus (MW0595010). – *Anthemis leucanthemoides* Boiss.: Isolectotypus (MW0595012). – *Anthemis reuteriana* Boiss.: Syntypus (MW0595015). – *Anthemis smyrnaea* Boiss.: Syntypus (MW0595017). – *Centaurea cadmea* Boiss.: Syntypus (MW0595215). – *Centaurea calolepis* Boiss.: Syntypus (MW0595216). – *Centaurea goniocaula* Boiss.: Isolectotypus (MW0595217). – *Centaurea hierapolitana* Boiss.: Syntypus (MW0595221). – *Centaurea lydia* Boiss.: Syntypus (MW0595225). – *Centaurea matthiolifolia* Boiss.: Isolectotypus (MW0595226). – *Centaurea pinardii* Boiss.: Syntypus (MW0595227). – *Crepis dioritica* Schott & Kotschy ex Boiss.: Isolectotypus (MW0595345). – *Gnaphalium leucopilinum* Schott & Kotschy ex Boiss.: Syntypus (MW0594994). – *Helichrysum anatolicum* Boiss.: Syntypus (MW0594996). – *Hieracium macrotrichum* Boiss.: Syntypus (MW0595442). – *Inula acaulis* Schott & Kotschy ex Boiss.: Syntypus (MW0595000). – *Inula multicaulis* Boiss.: Syntypus (MW0595001); Syntypus (MW0595002). – *Jurinea anatolica* Boiss.: Syntypus (MW0595175). – *Jurinea cataonica* Boiss. & Hausskn.: Syntypus (MW0595177). – *Jurinea ramulosa* Boiss. & Hausskn.: Isolectotypus (MW0595185). – *Lactuca intricata* Boiss.: Syntypus (MW0595342). – *Lapsana adenophora* Boiss.: Syntypus (MW0595244). – *Phaeopappus cataonicus* Boiss. & Hausskn. ex Boiss.: Isolectotypus (MW0595233). – *Pyrethrum cadmeum* Boiss.: Syntypus (MW0595035). – *Senecio hypochionaeus* Boiss.: Syntypus (MW0595122). – *Senecio olympicus* Boiss.: Isolectotypus (MW0595128).

Betulaceae

Betula transcaucasica V.N.Vassil.: Isotypus (MW0591848).

Boraginaceae

Alkanna areolata Boiss.: Syntypus (MW0594362). – *Alkanna tubulosa* Boiss.: Syntypus (MW0594363). – *Moltkia anatolica* Boiss.: Syntypus (MW0594397). – *Moltkia aurea* Boiss.: Syntypus (MW0594398). – *Myosotis gueneri* A.P.Khokhr.: Holotypus (MW0594367). – *Myosotis olympica* Boiss.: Syntypus (MW0594374). – *Omphalodes cariensis* Boiss.: Syntypus (MW0594299). – *Omphalodes luciliae* Boiss.: Syntypus (MW0594300); Syntypus (MW0595602). – *Onosma mirabilis* A.P.Khokhr.: Holotypus (MW0594404); Paratypus (MW0594405). – *Onosma pallidum* Boiss.: Syntypus (MW0594406). – *Paracaryum reuteri* Boiss. & Hausskn. ex Boiss.: Isolectotypus (MW0594304). – Rochelia karsensis Popov: Isotypus (MW0594410). – *Symphytum anatolicum* Boiss.: Syntypus (MW0594332).

Brassicaceae

Aethionema rubescens Boiss.: Syntypus (MW0592541). – *Alyssum eriophyllum* Boiss. & Hausskn.: Syntypus (MW0592649). – *Alyssum haussknechtii* Boiss.: Isolectotypus (MW0592661). – *Alyssum minutiflorum* Boiss.: Syntypus (MW0592666). – *Arabis drabiformis* Boiss.: Syntypus (MW0592617). – *Aubrieta pinardii* Boiss.: Syntypus (MW0592615). – *Barbamine procumbens* A.P.Khokhr.: Isotypus (MW0595584); Isotypus (MW0595585). – *Camelina anomala* Boiss. & Hausskn.: Isolectotypus (MW0592592). – *Erysimum laciniatum* Boiss.: Syntypus (MW0592633). – *Heldreichia bupleurifolia* var. *subtriloba* Boiss.: Syntypus (MW0592550). – *Hesperis armena* Boiss.: Syntypus (MW0592687). – *Hesperis violacea* Boiss.: Syntypus (MW0592683). – *Isatis tinctoria* subsp. *parchalensis* A.P.Khokhr.: Isotypus (MW0595565); Isotypus (MW0595566).

Campanulaceae

Campanula olympica Boiss.: Syntypus (MW0594921). – *Campanula raveyi* Boiss.: Isolectotypus (MW0594924). – *Campanula telephioides* Boiss. & Hausskn.: Isolectotypus (MW0594932). – *Podanthum scoparium* Boiss. & Hausskn.: Syntypus (MW0594939).

Caryophyllaceae

Alsine leucocephala Boiss.: Syntypus (MW0592093). – *Alsine pulvinaris* Boiss.: Syntypus (MW0592094). – *Arenaria balansae* Boiss.: Syntypus (MW0592103). – *Arenaria tmolea* Boiss.: Syntypus (MW0592121). – *Bufonia virgata* Boiss.: Syntypus (MW0592086). – *Cerastium coeruleum* Boiss.: Syntypus (MW0592073). – *Cerastium fragillimum* Boiss: Syntypus (MW0592075). – *Cerastium macrocarpum* Boiss. & Hausskn: Isolectotypus (MW0592077). – *Dianthus anatolicus* Boiss.: Isolectotypus (MW0592269). – *Dianthus erinaceus* Boiss.: Isolectotypus (MW0592275). – *Dianthus lydus* Boiss.: Syntypus (MW0592278). – *Gypsophila frankenioides* Boiss.: Syntypus (MW0592257). – *Holosteum tenerrimum*: Syntypus (MW0592085). – *Saponaria mesogitana* Boiss.: Syntypus (MW0592287). – *Saponaria pumilio* Boiss.: Syntypus (MW0592288). – *Silene brevicaulis* var. *latifolia* Boiss.: Isolectotypus (MW0592131). – *Silene cariensis* Boiss.: Syntypus (MW0592132). – *Silene ispirensis* A.P.Khokhr.: Holotypus (MW0592144). – *Silene olympica* Boiss.: Syntypus (MW0592155). – *Silene squamigera* Boiss.: Syntypus (MW0592165). – *Silene swertiifolia* var. *stenophylla* Boiss.: Isolectotypus (MW0592167).

Convolvulaceae

Convolvulus compactus Boiss.: Syntypus (MW0594276).

Crassulaceae

Sedum bithynicum Boiss.: Isotypus (MW0738883). – *Sedum lydium* Boiss.: Syntypus (MW0592716). – *Sedum olympicum* Boiss.: Syntypus (MW0592717). – *Umbilicus haussknechtii* Boiss. & Reut. ex Boiss.: Isolectotypus (MW0592720). – *Umbilicus pallidus* Schott & Kotschy: Isotypus (MW0738886). – *Umbilicus pestalozzae* Boiss.: Syntypus (MW0592721).

Cyperaceae

Blysmus compressus subsp. *subulifolius* A.P.Khokhr.: Holotypus (MW0591513).

Dipsacaceae

Knautia bidens Boiss.: Syntypus (MW0594897). – *Scabiosa cosmoides* Boiss.: Syntypus (MW0594904). – *Scabiosa hispidula* Boiss.: Syntypus (MW0594905). – *Scabiosa reuteriana* Boiss.: Isolectotypus (MW0594908).

Euphorbiaceae

Euphorbia altissima Boiss.: Syntypus (MW0593503). – *Euphorbia anacampseros* Boiss.: Syntypus (MW0593504); Syntypus (MW0593505). – *Euphorbia schottiana* Boiss.: Isolectotypus (MW0593527).

Fabaceae

Adenocarpus villosus Boiss.: Isotypus (MW0592996). – *Alhagi maurorum* var. *karduchorum* Boiss.: Syntypus (MW0593381). – *Astragalus anatolicus* Boiss.: Syntypus (MW0593079). – Astragalus cadmicus Boiss.: Syntypus (MW0593095). – *Astragalus flavescens* Boiss.: Syntypus (MW0593115). – *Astragalus gladiatus* Boiss.: Isolectotypus (MW0593119). – *Astragalus khokhrjakovii* Sytin & Podlech: Holotypus (MW0593143). – *Astragalus lydius* Boiss.: Syntypus (MW0593157). – *Astragalus mesogitanus* Boiss.: Syntypus (MW0593158). – *Astragalus pennatus* Bunge: Isotypus (MW0593173). – *Astragalus sibthorpianus* Boiss.: Syntypus (MW0593214). – *Cytisus chrysotrichus* Boiss.: Syntypus (MW0592998). – *Cytisus eriocarpus* Boiss.: Syntypus (MW0592999). – *Cytisus smyrnaeus* Boiss.: Syntypus (MW0593002). – *Ebenus barbigera* Boiss.: Syntypus (MW0593380). – *Genista anatolica* Boiss.: Syntypus (MW0592988). – *Genista liparioides* Boiss.: Syntypus (MW0592989). – *Genista lydia* Boiss.: Syntypus (MW0592992). – *Hedysarum callichroum* Boiss.: Syntypus (MW0593348). – *Hedysarum erythroleucum* Schott & Kotschy ex Boiss.: Syntypus (MW0593354). – *Hedysarum lydium* Boiss.: Syntypus (MW0593357). – *Hedysarum sipyleum* Boiss.: Isolectotypus (MW0593364). – *Lathyrus pseudoaphaca* Boiss.: Syntypus (MW0593400). – *Lotus sulphureus* Boiss.: Syntypus (MW0593057). – *Onobrychis cadmea* Boiss.: Syntypus (MW0593371). – *Onobrychis hypargyrea* Boiss.: Syntypus (MW0593375). – *Onobrychis lasiostachya* Boiss.: Syntypus (MW0593378). – *Ononis adenotricha* Boiss.: Syntypus (MW0593003). – *Oxytropis dioritica* Boiss.: Syntypus (MW0593282). – *Trifolium anatolicum* Boiss.: Syntypus (MW0593014). – *Trifolium glanduliferum* Boiss.: Syntypus (MW0593016). – *Trifolium mesogitanum* Boiss.: Syntypus (MW0593022). – *Trifolium pilulare* Boiss.: Syntypus (MW0593023). – *Trifolium setiferum* Boiss.: Syntypus (MW0593025). – *Trifolium smyrnaeum* Boiss.: Syntypus (MW0593026). – *Trigonella aurantiaca* Boiss.: Syntypus (MW0593006). – *Trigonella capitata* Boiss.: Syntypus (MW0593007). – *Trigonella crassipes* Boiss.: Syntypus (MW0593008). – *Trigonella spruneriana* Boiss.: Syntypus (MW0593010). – *Trigonella velutina* Boiss.: Syntypus (MW0593012). – *Vicia cuspidata* Boiss.: Syntypus (MW0593388). – *Vicia noeana* Boiss.: Syntypus (MW0593394); Syntypus (MW0595595). – *Vicia sericocarpa* var. *microphylla* Boiss.: Syntypus (MW0593396).

Fagaceae

Quercus cedrorum Kotschy: Syntypus (MW0591850); Syntypus (MW0591851). – Quercus haas Kotschy: Syntypus (MW0591854).

Gentianaceae

Gentiana boissieri Schott & Kotschy ex Boiss.: Syntypus (MW0594209).

Geraniaceae

Erodium leucanthum Boiss.: Syntypus (MW0593413). – *Erodium sibthorpianum* Boiss.: Syntypus (MW0593418). – *Geranium macrostylum* Boiss.: Syntypus (MW0593403).

Hypericaceae

Hypericum crenulatum Boiss.: Syntypus (MW0593608). – *Hypericum kotschyanum* Boiss.: Syntypus (MW0593609). – *Hypericum leprosum* Boiss.: Syntypus (MW0593610). – *Hypericum lydium* Boiss.: Syntypus (MW0593611).

Lamiaceae

Ajuga mesogitana Boiss.: Syntypus (MW0594423). – *Calamintha florida* Boiss.: Syntypus (MW0594598). – *Lamium demirizii* A.P.Khokhr.: Holotypus (MW0594524). – *Lamium microphyllum* Boiss.: Isotypus (MW0594531); Isotypus (MW0594532). – *Lamium tschorochense* A.P.Khokhr.: Holotypus (MW0594544); Isotypus (MW0594545); Paratypus (MW0594546). – *Lamium violaceovelutinum* A.P.Khokhr.: Holotypus (MW0594547). – *Lamium vreemanii* A.P.Khokhr.: Holotypus (MW0594548); Isotypus (MW0594549). – *Marrubium lutescens* Boiss. & Heldr.: Syntypus (MW0594453). – *Micromeria congesta* Boiss. & Hausskn. ex Boiss.: Isolectotypus (MW0594599). – *Nepeta tmolea* Boiss.: Isolectotypus (MW0594462). – *Phlomis*

oppositiflora Boiss. & Hausskn.: Isolectotypus (MW0594504). – *Salvia cadmica* Boiss.: Syntypus (MW0594572); Syntypus (MW0594573). – *Salvia cedronella* Boiss.: Syntypus (MW0594574). – *Salvia chionantha* Boiss.: Syntypus (MW0594575). – *Salvia frigida* Boiss.: Syntypus (MW0594578). – *Salvia macrochlamys* Boiss. & Kotschy: Isolectotypus (MW0594580). – *Salvia smyrnaea* Boiss.: Syntypus (MW0594584). – *Salvia tmolea* Boiss.: Isolectotypus (MW0594585). – *Scutellaria uzunderensis* A.P.Khokhr.: Holotypus (MW0594448). – *Sideritis sipylea* Boiss.: Isolectotypus (MW0594456). – *Stachys bithynica* Boiss.: Syntypus (MW0594567). – *Stachys tmolea* Boiss.: Syntypus (MW0594571). – *Teucrium ozturkii* A.P.Khokhr.: Isotypus (MW0595568). – *Thymus sipyleus* Boiss.: Syntypus (MW0594629).

Liliaceae

Gagea cespitosa Hausskn. ex Boiss.: Syntypus (MW0591647). – *Tulipa aleppensis* Boiss. ex Regel: Syntypus (MW0591711). – *Tulipa undulatifolia* Boiss.: Syntypus (MW0591720).

Linaceae

Linum anatolicum Boiss.: Syntypus (MW0593422). – *Linum aretioides* Boiss.: Isolectotypus (MW0593423). – *Linum hirsutum* var. *alpinum* Boiss.: Syntypus (MW0593426). – *Linum olympicum* Boiss.: Syntypus (MW0593430).

Orobanchaceae

Pedicularis cadmea Boiss.: Syntypus (MW0594740). – *Pedicularis sibthorpii* Boiss.: Syntypus (MW0594761).

Oxalidaceae

Oxalis violacella A.P.Khokhr.: Isotypus (MW0595561).

Plantaginaceae

Linaria pterospora Boiss.: Syntypus (MW0594662); Syntypus (MW0594663). – *Veronica caespitosa* Boiss.: Syntypus (MW0594683). – *Veronica cariensis* Boiss.: Syntypus (MW0594684). – *Veronica kotschyana* Benth.: Syntypus (MW0594692).

Plumbaginaceae

Acantholimon breviscapum Boiss. & Hausskn. ex Boiss.: Syntypus (MW0594159); Syntypus (MW0594160). – *Acantholimon phrygium* Boiss.: Syntypus (MW0594165); Syntypus (MW0594166).

Poaceae

Agrostis karsensis Litv.: Isotypus (MW0591245); Isotypus (MW0591246). – *Catabrosa variegata* Boiss.: Isotypus (MW0591323). – *Hordeum lycium* Boiss.: Isotypus (MW0591482). – *Melica cappadocica* Boiss.: Syntypus (MW0591325). – *Nephelochloa orientalis* Boiss.: Syntypus (MW0591326). – *Stipa pontica* P.A.Smirn.: Paratypus (MW0591222). – *Stipa sibthorpii* Roem. & Schult.: Syntypus (MW0591226). – *Triticum thaoudar* Reut. ex Boiss. nom. inval.: Syntypus (MW0591481).

Polygalaceae

Polygala pruinosa Boiss.: Syntypus (MW0593466).

Primulaceae

Androsace olympica Boiss.: Syntypus (MW0594155).

Ranunculaceae

Delphinium cinereum Boiss.: Isotypus (MW0592320). – *Delphinium oliganthum* Boiss.: Syntypus (MW0592332). – *Delphinium raveyi* Boiss.: Syntypus (MW0592333). – *Delphinium sulphureum* Boiss. & Hausskn.: Isolectotypus (MW0592334). – *Nigella elata* Boiss.: Syntypus (MW0592294). – *Ranunculus cadmicus* Boiss.: Syntypus (MW0592416). – *Ranunculus isthmicus* Boiss.: Isolectotypus (MW0592419). – *Ranunculus reuterianus* Boiss.: Syntypus (MW0592436). – *Ranunculus vermirrhizus* A.P.Khokhr.: Holotypus (MW0592445); Isotypus (MW0592446); Isotypus (MW0592447).

Rosaceae

Amelanchier parviflora Boiss.: Syntypus (MW0592219). – *Cerasus tortuosa* Boiss. & Hausskn. ex Boiss.: Syntypus (MW0592973). – *Cotoneaster peduncularis* Boiss.: Syntypus (MW0592211).

Rubiaceae

Asperula brunnea Boiss.: Syntypus (MW0594820). – *Asperula mutica* Boiss.: Syntypus (MW0594824). – *Asperula nitida* var. *puberula* Boiss.: Syntypus (MW0594825). – *Asperula stricta* var. *scabrida* Boiss.: Syntypus (MW0594826). – *Asperula tenuifolia* Boiss.: Syntypus (MW0594828). – *Galium aretioides* Boiss.: Syntypus (MW0594829). – *Galium aureum* var. *scabrifolium* Boiss.: Syntypus (MW0594830). – *Galium bornmuelleri* Hausskn. ex Bornm.: Syntypus (MW0594831). – *Galium caudatum* Boiss.: Syntypus (MW0594832). – *Galium concinnum* Boiss.: Syntypus (MW0594833). – *Galium coronatum* var. *lasiocarpum* Boiss. ex Pojark.: Syntypus (MW0594834). – *Galium dumosum* Boiss.: Syntypus (MW0594836). – *Galium effusum* Boiss.: Syntypus (MW0594837). – *Galium musciforme* Boiss.: Syntypus (MW0594839). – *Galium nebulosum* Boiss.: Syntypus (MW0594840). – *Galium olympicum* Boiss.: Syntypus (MW0594842). – *Galium orientale* var. *alpinum* Boiss.: Syntypus (MW0594843). – *Galium penduliflorum* Boiss.: Syntypus (MW0594844). – *Galium peplidifolium* Boiss.: Syntypus (MW0594845).

Rutaceae

Haplophyllum pumilum Boiss.: Syntypus (MW0593442).

Salicaceae

Salix pseudodepressa A.K.Skvortsov: Isotypus (MW0591818).

Santalaceae

Thesium graecum Boiss. & Sprun.: Syntypus (MW0591926). – *Thesium tauricolum* Boiss. & Hausskn.: Syntypus (MW0591929).

Saxifragaceae

Saxifraga corymbosa Boiss.: Syntypus (MW0592727). – *Saxifraga olympica* Boiss.: Isolectotypus (MW0592175). – *Saxifraga scotophila* Boiss.: Syntypus (MW0592179).

Scrophulariaceae

Celsia luciliae Boiss.: Isolectotypus (MW0594653); Isolectotypus (MW0594654). – *Scrophularia depauperata* Boiss.: Syntypus (MW0594665). – *Scrophularia olympica* Boiss.: Syntypus (MW0594670). – *Scrophularia pinardi* Boiss.: Syntypus (MW0594671). – *Scrophularia smyrnaea* Boiss.: Isolectotypus (MW0594673). – *Scrophularia tmolea* Boiss.: Syntypus (MW0594674). – *Scrophularia xylorrhiza* Boiss. & Hausskn.: Syntypus (MW0594676). – *Verbascum cheiranthifolium* Boiss.: Syntypus (MW0594642). – *Verbascum glomeratum* Boiss.: Syntypus (MW0594644). – *Verbascum infidelium* Boiss. & Hausskn.: Isolectotypus (MW0594645). – *Verbascum lydium* Boiss.: Isolectotypus (MW0594646). – *Verbascum napifolium* Boiss.: Isolectotypus (MW0594647). – *Verbascum salviifolium* Boiss.: Syntypus (MW0594649). – *Verbascum smyrnaeum* Boiss.: Isolectotypus (MW0594650); Isolectotypus (MW0594651). – *Verbascum taraxacifolium* Lam.: Syntypus (MW0594652).

Violaceae

Viola yuzufelensis A.P.Khokhr.: Isotypus (MW0595567).