Herbarium ZAGR of the Faculty of Agriculture (Zagreb, Croatia)

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Summary

Herbarium ZAGR of the Faculty of Agriculture (Zagreb) is the youngest registered herbarium in Croatia. Currently the collection has estimated from 7.500 to 10.000 herbarium sheets of vascular plants, especially rich in specimens from the Adriatic part of Croatia, Balkan territories and other Mediterranean areas. Currently the ZAGR collection has 1275 plant taxa and covers 25% of Croatian national flora. The families with the largest number of herbarium specimens are *Poaceae*, *Fabaceae* and *Asteraceae*. A total of 1655 herbarium sheets are digitalised and are accessible online throughout ZAGR Virtual Herbarium database http://herbarium.agr.hr/. The particular interest of ZAGR collection are 26 type specimens of recently described new taxa to science from Croatia, Albania and Greece. Of important value in ZAGR herbarium are specimens of rare and endemic plants (435 sheets) out of which 101 belong to endemic taxa, which is 26% of total recorded Croatian endemic taxa. In total 1254 sheets of weed taxa and 31 invasive species are stored in herbarium. ZAGR collection contains more then 100 sheets of different specimens of agricultural important traditional and modern cultivars.

Key words

agriculture, biodiversity, botany, conservation, collections, digitalization, herbarium specimens

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Department of Agricultural Botany – history and activities

The Department of Botany was established on October 1st 1919, shortly after the establishment of the Faculty of Agriculture and Forestry of the University of Zagreb. After the Faculty was divided into the Faculty of Agriculture and the Faculty of Forestry in 1960, the Department served both Faculties for a while. Until 1969 it operated under the administration of the Faculty of Forestry, and afterwards it was established as a Department of Agricultural Botany (Maletić, 2009).

Since its establishment to present day, the scientific activities of the Department have been wide-ranged, comprising: algological, physiological, morphological, floristic and phytosociological researches, as it is evidenced by numerous published works. One of the Department's most significant projects was the *Vegetation Map of the Republic of Croatia*, which included the participation of all its employees in the period from 1976 to 1985. Special contribution to the development of scientific and expert activities of the Department was given by Academician Ivo Pevalek, Prof. Valentina Gaži-Baskova, Prof. Nevenka Plavšić-Gojković, Prof. Katarina-Danijela Dubravec, and Prof. Nada Hulina.

In more recent period, the scientific and expert activities of the Department of Agricultural Botany are oriented to floristic, morphological, anatomical and eco-physiological research of various cultivated and wild vascular plants. In this connection, special emphasis is given to the research of the influence of increased tropospheric ozone concentrations on the anatomical structure of grape leaves. An important place belongs to researching Croatian, Balkan and Mediterranean flora and vegetation with focus on grassland, weed vegetation and succession stages of grassland vegetation, as well as on grassland feed values and the impact of grazing on vegetation. New potential localities are also being explored, as well as endangered habitats and general distribution of rare and endemic plant species in Croatia. As a part of floristic research, the Departments staff is also involved in flora mapping in the Adriatic and continental areas of Croatia. Research in the field of plant systematics and taxonomy includes morphological, anatomical, cytological and molecular (phylogenetic) aspects, with special attention paid to certain plant genera, endemic and rare species of Croatian and Mediterranean vascular flora. Part of the Department's scientific work is related to the study of morphological and molecular diversity of forage species aimed at maintaining and preserving the diversity of plant genes in banks, and their *in situ* and *ex situ* conservation.

Herbarium ZAGR

Currently Croatia has ten officially registered herbarium collections (Nikolić 1996, Thiers 2016) of which ZA, ZAHO and CNHM are the largest one (Vrbek, 1999; Zavodnik et al., 2001; Ževrnja et al., 2004; Horvat and Plazibat, 2007; Barbarić-Gaćina et al., 2007; Ževrnja and Vladović, 2008). The Herbarium ZAGR of the Faculty of Agriculture, University of Zagreb, was founded in January 2013 and is the youngest Herbarium in Croatia (Bogdanović, 2013). The international acronym ZAGR is provided by Index Herbariorum (Thiers, 2016), and currently estimated collection has from 7.500 to 10.000 herbarium specimens of vascular plants, especially rich in specimens from the Adriatic part of Croatia, Balkan territories and other Mediterranean areas.

Organisation and maintenance of the collection

The collection is stored in a separate room within the Department of Agricultural Botany where the mean annual temperature vary from 15 to 18°C and humidity is approximately 30%. Organisation and maintenance of collection is in accordance to Nikolić (1996) and Bridson and Forman (2010). After drying, the plant material is frozen at -20°C for 3-4 days (repeated twice) to preserve it from damage of herbarium pests. After that, the plant material is mounted and fixed with pH neutral adhesive tape on herbarium sheet (42.5 x 29 cm); herbarium labels are glued with Gaylord pH neutral white adhesive and whole materials are stored in hard paper herbarium boxes (Fig. 1). The collection is organized in alphabetical order of genera and within the herbarium boxes the species folders (42.5 x 30.5 cm) are sorted also in alphabetical order of species for easier material handling.

Digitalization of ZAGR collection

Digitalisation of individual herbarium sheet is processed by scanner Microtek ScanMaker 9800 XL Plus and elaborated with ScanMicrotek software. The basic file for each herbarium sheet has 300 dpi in TIF format and max. 50 MB size. Scanned images of herbarium sheets are uploaded in ZAGR Virtual Herbarium database http://herbarium.agr.hr/ using the platform of Flora Croatica Database http://hirc.botanic.hr/fcd/ (Nikolić et al., 2001; Nikolić, 2016). Each herbarium sheet contains following metadata on herbarium label: herbarium ID, taxon name, locality, habitat, geographical coordinates, name and surname of collector(s), collecting data, name and surname of determinator, data of determination and notes if necessary (Fig. 2). Herbarium sheet also contains in left angle stamp with ZAGR herbarium ID, colour plate and ruler.

Till now a total of 1655 herbarium sheet are digitalised and are accessible online throughout ZAGR Virtual Herbarium database http://herbarium.agr.hr/.

Geographical origin of plant material

From geographical point of view, the largest number of plant specimens was collected from the Balkan and Apennine Peninsulas (Fig. 3), of which 92.4% specimens (3593 herbarium sheets) were collected in Croatia. These are mostly specimens (3102; 79.7%) from the Adriatic part of Croatia, while a smaller part (491; 12.6%) are from the continental Croatia. A smaller number of plants were gathered from Italy (129), Greece (89), Albania (36), and Montenegro (22). Other countries, Bosnia and Herzegovina, Macedonia, Bulgaria, Serbia and Slovenia are represented with a collection of 10 specimens or less each.

Overview of plant material in ZAGR

In a taxonomic way, 3890 herbarium sheets (data on March 7th 2016) belong to taxa classified into 101 families and 488 genera. Currently the ZAGR collection covers 25% of Croatian national flora. The families with the largest number of herbarium specimens are *Poaceae* (597 sheets), *Fabaceae* (436 sheets) and *Asteraceae* (301 sheets), which reflects the influence of

Figure 1. Organisation of ZAGR collection

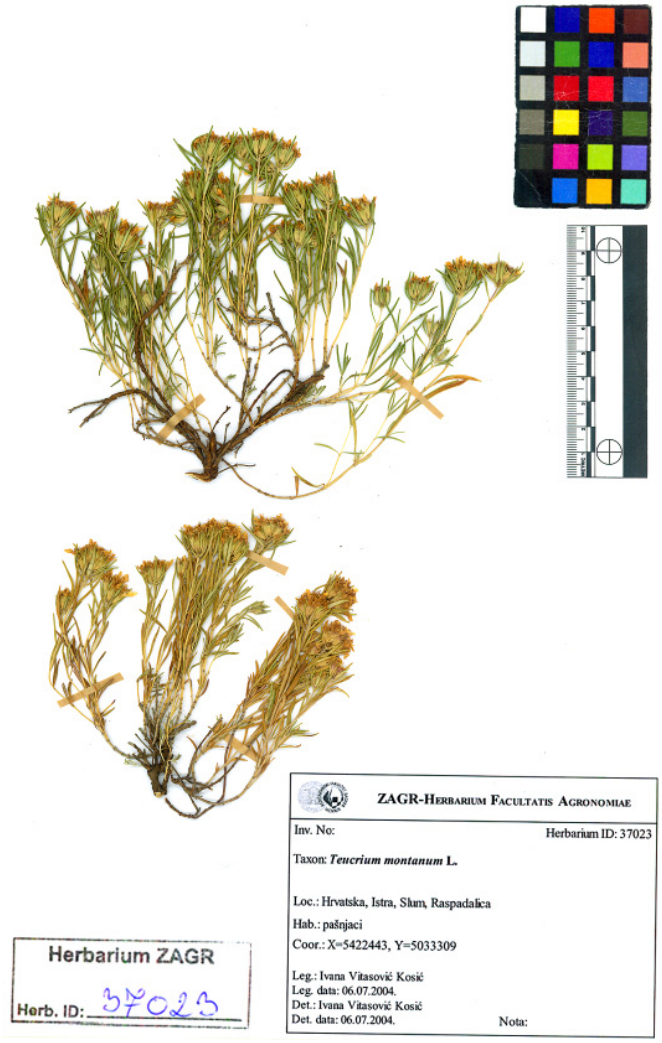

Figure 2. Scanned image of *Teucrium montanum* ZAGR-37023 specimen

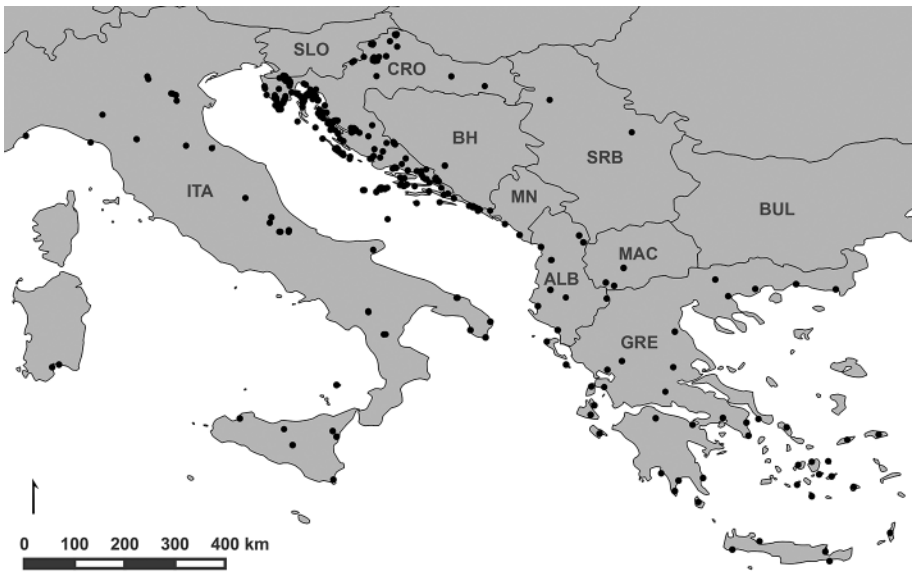

Figure 3. Geographical origin of plant material in ZAGR

Table 1. Type specimens in ZAGR collection

ZAGR ID	Taxon name	Type	Country	Locality	Collecting data	Collector(s)
40827	*Campanula aureliana* Bogdanović, Rešetnik, Brullo et Shuka	holotypus	Albania	Albania, Tomori village, calcareous places in the village, 807 m alt.	23.06.2013.	Bogdanović, Sandro; Rešetnik, Ivana; Temunović, Martina
40828	*Campanula aureliana* Bogdanović, Rešetnik, Brullo et Shuka	isotypus	Albania	Albania, Tomori village, calcareous places in the village, 807 m alt.	23.06.2013.	Bogdanović, Sandro; Rešetnik, Ivana; Temunović, Martina
32636	*Campanula skanderbegii* Bogdanović, Brullo et Lakušić	holotypus	Albania	Albania, Kruje, calcareous rocky cliff under the Skanderbeg's castle	14.07.2012.	Bogdanović, Sandro; Jug-Dujaković, Marija
32637	*Campanula skanderbegii* Bogdanović, Brullo et Lakušić	isotypus	Albania	Albania, Kruje, calcareous rocky cliff under the Skanderbeg's castle	14.07.2012.	Bogdanović, Sandro; Jug-Dujaković, Marija
32638	*Campanula skanderbegii* Bogdanović, Brullo et Lakušić	isotypus	Albania	Albania, Kruje, calcareous rocky cliff under the Skanderbeg's castle	14.07.2012.	Bogdanović, Sandro; Jug-Dujaković, Marija
32628	*Campanula teutana* Bogdanović et Brullo	holotypus	Croatia	Croatia, Island of Vis, Oključina, calcareous cliffs near Kraljičina špilja	23.05.2010.	Bogdanović, Sandro
32629	*Campanula teutana* Bogdanović et Brullo	isotypus	Croatia	Croatia, Island of Vis, Oključina, calcareous cliffs near Kraljičina špilja	23.05.2010.	Bogdanović, Sandro
33484	*Campanula teutana* Bogdanović et Brullo	isotypus	Croatia	Croatia, Island of Vis, Oključina, calcareous cliffs near Kraljičina špilja	23.05.2010.	Bogdanović, Sandro
33485	*Campanula teutana* Bogdanović et Brullo	isotypus	Croatia	Croatia, Island of Vis, Oključina, calcareous cliffs near Kraljičina špilja	23.05.2010.	Bogdanović, Sandro
40810	*Limonium astypaleanum* Erben et Brullo	isotypus	Greece	Grecia, Astipalea, Porto	07.06.1995.	Brullo, Salvatore; Minissale, Pietro
40803	*Limonium atticum* Erben et Brullo	isotypus	Greece	Grecia, Attica, Akr. Kavouri	26.08.2002.	Brullo, Salvatore
40815	*Limonium contractum* Erben et Brullo	isotypus	Greece	Grecia, Astipalea, Ormos Andreou	07.06.1995.	Brullo, Salvatore; Minissale, Pietro
40784	*Limonium diomedeum* Brullo	isotypus	Italy	Italia Meridionale, Tremiti, S. Domino	18.07.1985.	Brullo, Salvatore; Signorello, Pietro; Minissale, Pietro; Spampinato, Giovanni
40763	*Limonium dolihiense* Erben et Brullo	isotypus	Greece	Grecia, Ikaria, Kampos	29.08.2003.	Brullo, Salvatore; Giusso del Galdo, Gianpietro
40762	*Limonium ikaricum* Erben Brullo	isotypus	Greece	Grecia, Ikaria, Aulaki-Eudilos	29.08.2003.	Brullo, Salvatore; Bacchetta, Gianluigi
40806	*Limonium kirikosicum* Erben et Brullo	isotypus	Greece	Ikaria, presso il porto Agios Kirikos	30.08.2003.	Brullo, Salvatore; Bacchetta, Gianluigi
40769	*Limonium microcycladicum* Erben et Brullo	isotypus	Greece	Grecia, Schinoussa, Mersini Ainickolas	31.08.1998.	Brullo, Salvatore; Bartolo, Giuseppina
40761	*Limonium parosicum* Erben et Brullo	isotypus	Greece	Grecia, Paros, Aliki	28.08.2003.	Brullo, Salvatore; Bacchetta, Gianluigi
40780	*Limonium pusillum* Erben et Brullo	isotypus	Greece	Grecia, Astipalea (Stavros)	30.08.1994.	Brullo, Salvatore; Scelsi, Fabrizio
40821	*Limonium recticaule* Erben et Brullo	isotypus	Greece	Creta, Hersonissos	08.06.2000.	Brullo, Salvatore; Giusso del Galdo, Gianpietro
40794	*Limonium samium* Erben et Brullo	isotypus	Greece	Grecia, Samos, Potami	01.07.2003.	Brullo, Salvatore; Giusso del Galdo, Gianpietro
40798	*Limonium sartorianum* Erben et Brullo	isotypus	Greece	Grecia, Andros, Kalamaki, Akr. Thiari	30.08.2002	Brullo, Salvatore; Sciandrello, Saverio
40747	*Limonium sirinicum* Erben et Brullo	isotypus	Greece	Grecia, Sikinos, Alopronia	27.08.1994.	Brullo, Salvatore; Scelsi, Fabrizio
40796	*Limonium taenari* Erben et Brullo	isotypus	Greece	Grecia, Peloponneso, Marmari, Akro Tenaro	04.09.2002.	Brullo, Salvatore; Sciandrello, Saverio
40793	*Limonium thirae* Erben et Brullo	isotypus	Greece	Grecia, Santorini, Akro Koulombo	11.06.2000.	Brullo, Salvatore; Giusso del Galdo, Gianpietro
40804	*Limonium vanandense* Erben et Brullo	isotypus	Greece	Grecia, Karpathos, Vananda	03.07.2002.	Brullo, Salvatore; Giusso del Galdo, Gianpietro

indigenous flora and bio-ecological characteristics of these families in Croatian flora (Nikolić 2001). There are families with numerous herbarium sheets as *Lamiaceae* (279 sheets) and *Plumbaginaceae* (159 sheets) that reflect the scope and interest of individual researchers work.

It is interesting to point out that from 488 genera occurring in ZAGR the genera *Campanula* and *Limonium* are represented each with more than 130 sheets, the genus *Knautia* with 95 sheets and the genus *Centaurea* with 78 herbarium sheets that reflects collectors' affinity and ongoing taxonomical studies.

Of particular value in ZAGR herbarium are specimens of rare and endemic plants (435 sheets; 11.18%) out of which 101 belong to endemic taxa (62 genera), that is 26% of total recorded Croatian endemic taxa. The largest representation of 231 specimens (56 taxa) belongs to endemic species in broader sense, followed with 162 specimens (31 taxa) of stenoendemic species, and 42 specimens (14 taxa) of subendemic species. Endangered taxa of the Croatian flora in Herbarium ZAGR are represented with 359 specimens (128 taxa) that cover 7.66% from the total of ZAGR specimens. Among rare species, Herbarium ZAGR hosts specimens of recently new discovered species in the Croatian flora e.g. *Cardamine fialae* Fritsch, *Ornithogalum sibthorpii* Greuter and *Luzula divulgatiformis* Bačić et Jogan.

The particular interest of ZAGR collection are 26 type specimens (Table 1) of recently described new taxa to science from Croatia and Albania, such as *Campanula teutana* Bogdanović et Brullo; *C. aureliana* Bogdanović, Rešetnik, Brullo et Shuka and *C. skanderbegii* Bogdanović, Brullo et Lakušić, and many new *Limonium* taxa described mainly from Croatia and Greece. Type specimens cannot be sent on loan, but scanned images and photographs, as well as other herbarium specimens are available for exchange and examination upon a request, and are accessible throughout ZAGR Virtual Herbarium database http://herbarium.agr.hr/.

Our collection contains specimens of agricultural important cultivars (over 100 sheets) such as different crop landraces, traditional and modern cultivars belonging to genera *Prunus*, *Pyrus*, *Malus*, *Olea*, *Vitis*, *Triticum*, *Hordeum*, *Juglans*, *Ribes* and *Vaccinium*. Traditional local crop landraces and cultivars play important role in biodiversity and in phylogeography as plant genetic resource that reflects historical patterns from use to cultivation (Lister et al. 2010). On the other hand, weeds are plants that can interfere with cultivated ones, can obstruct human activity or are simply unwanted in some habitats; on the other hand, they may have many different use values. In total, 426 weed taxa from 60 families are stored in ZAGR herbarium and are represented with 1254 sheets. Thirty one invasive species are also deposited in herbarium.

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