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PLANT COLLECTIONS: POSSIBILITIES OF USING HERBARIA, DIGITAL HERBARIA AND PLANT DATABASES IN BOTANY TEACHING AT ESZTERHÁZY KÁROLY UNIVERSITY

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Összefoglalás

Hagyományosan a herbáriumokat elsősorban kutatók használják, akik egy adott terület növényvilágával foglalkoznak, vagy pedig egy adott rendszertani csoport szakértői, betekintést nyújtva a növényi fajok változatosságába és elterjedésébe. Újabban a herbáriumokban tárolt növényanyag ugyanakkor molekuláris és filogenetikai kutatásokra is felhasználható.

Ugyanakkor a tudományos kutatás mellett a herbáriumok fontos szerepet játszanak a botanika oktatásában is, és a hagyományos felhasználás mellett a virtuális növénygyűjtemények használatában is hatalmas lehetőségek rejlenek. Cikkünk célja a fontosabb magyar és a világszerte használt botanikai online platformok ismertetése, amelyek alkalmasak a botanika oktatására a hallgatók és az érdeklődő szélesebb nagyközönség számára is az Eszterházy Károly Egyetem herbáriumában (EGR).

Kulcsszavak: *botanika, herbárium, biológiaoktatás, online források, szisztematika*

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Abstract

Herbaria have been always used mostly by researchers dealing with systematic botany, taxonomy or flora of a certain area, providing insight into the variety of plant taxa and their distribution. Preserved specimens can also be used for molecular and phylogenetic research. In addition to their scientific mission, herbaria play an important role in botanical education. Besides traditional utilization of herbaria, there are a huge possibilities using virtual plant collections as well. The main target of this article is to highlight more important hungarian and worldwide-used plant online resources suitable for botany teaching to the students as well as wide public at Herbarium of Eszterházy Károly University, Eger (EGR).

Keywords: *botany, herbarium, biology teaching, online resources, systematics*

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Introduction

Herbaria around the world have been traditionally used for taxonomy and systematics studies, as well as essential tools for education in biological sciences. They were often established as a part of universities, botanical gardens, museums and other research institutes. The period of larger herbaria's foundation stretches mainly from Linnaeus's time approximately to the end of the 19th century. For the next 100 years the herbaria were expanding their collections and a lot of new ones were established. The main herbaria took parts in world floras research projects, exploring a vast parts of a continents, preserving a huge amount of specimens. (MARHOLD & FERÁKOVÁ 1993, FUNK 2017). However, these efforts had slowed and their funding was cut down in the last decades. The significance of herbaria decreased in the eyes of wide public. (FUNK 2017, JOGAN & BAČIČ 2020). Herbaria are still base for botanical taxonomy investigations, and thanks to their connection with extensive and exact historical and geographical data, they are even getting a lot of new utilization possibilities in a wide range of environmental studies. On the other hand, their participation in scholar biology education has lowered, especially nowadays when „instant“-digital information are dominant and methodology orientates to a visual-pleasant teaching tools. In this paper we would like to discuss some aspects of this situation and try to propose some new ideas how to involve herbaria in biology education or attract new users.

History of herbaria

A herbarium is a collection of dried preserved plants that are mounted on sheet of paper, stored, catalogued, and arranged systematically for study by professionals and amateurs. According to Oxford Learner's Dictionaries, the origin of word is derived from Latin *herba*, meaning 'grass or herb'. But „herbarium“ once was room in medieval monasteries where dried herbs and medicinal plants were kept, only later was used to indicate a book about medicinal plants. A well-known french botanist Joseph Pitton de Tournefort (1656-1708) was first who used the term „herbarium“ for scientific collection of dried plants. (Kew Royal Botanic Gardens, Lane 1996, Bothell herbarium 2016). The foundation of the first herbaria is firmly bound to establishment of botanical gardens (Pisa, Bologna and Padua), Italy, in the 16th century. At the time botany was not yet an independent science and the botanical gardens and herbaria were used for practical demonstrations of medicinal plants (WEBER 2020). Luca Ghini (1490-1556), a Professor at the University of Pisa, was probably the first person who tried to dry plants under pressure and mount them on paper as documentary records. This practice was later applied by his students and succesors like Andrea Cesalpino, Pietro Andrea Mattioli or Gherards Cibo. (MOLNÁR V.A. 2009, ISELY & DUANE 2002, LANE 1996). The first herbaria looked like books, where

specimens were bounded together into one volume. As collections grows it was needed to keep specimens separately, which was already a common practise for Linnaeus (1707-1778) and his followers (NAGY, TAKÁCS & MOLNÁR 2017). The sheets of paper stored in cabinets had to be one sized, also because of exchanging specimens between botanists to collections remain uniform. And these standards have been used till the time (BOTHELL HERBARIUM 2016). A large number of a newly discovered plants arriving in Europe in 17th and 18th century resulted in need of plant classification system which could be in the same time base for plant organization in herbaria. So after Linaeus published his famous work, plants have been usually organized alphabetically by the plant family, the genera in which they belong, the geographic area and finally the species arranged alphabetically. All specimens used to be carefully labeled with detailed specimen information: herbarium name, plant name, collector/determinator, date and place of collection (coordinates), habitat and other supplementary data and notes. The historical collections have handwritten labels, which is often very difficult to read (BRIDSON & FORMAN 1992). The herbarium can contain more collections, for example collections of famous botanists, collections of an certain area, or collections devoted to special research topic. The most valuable sheets are often those of rare species, or very old specimens, or plants collected by famous botanists and explorers. Particularly important are the so called type specimens. Type specimens serve as reference material for describing plant taxa and they are usually specially curated and stored separately (THE NEW YORK BOTANICAL GARDEN, 2020). A new era of herbaria's utilization have been started in the 1970^{'s}. The first computer tools were introduced to help with internal management tasks (LANE 1996). A computer databasing and imagining plant specimens have grown gradually with wide use of internet in the last 25 years. Virtual herbaria connect detailed specimen photos with vast datasets which greatly extended data accessibility and in the same time help saving the original specimens, because there is not need handling them manually. This practise is widely promoted in the main North American and European herbaria (JACQ 2020, TULIG et al. 2012). Thanks to the digital information, data from computerized collections are much more often used in current researches than data from non-electronic sources (LAVOIE 2013), however still only a small fraction of specimens in the herbaria are already digitized (TULIG et al. 2012)

Uses of herbaria

According to Index Herbariorum's Annual Report 2019 (THIERS 2020), there are total of 3324 active registered herbaria in the world, containing 392.353.689 specimens (included 13 hungarian herbaria with 2.637.414 specimens). It is a large source of information which can be used to understand many aspects of historical and modern plant biology. The possibilities how herbaria could be used in the research are so wide and variable that there already appeared

some special investigations about this topic. Very briefly: herbaria are traditionally used in classical taxonomy, systematics, anatomy and morphology or to compile regional flora studies. Nowadays, herbaria are sources of information, most often for climate change and phenological studies, other research topics are: nature conservation, ecology, phytogeography, plant invasion, environmental pollution, plant disease, medicinal plants, DNA-sequencing etc. There are even papers indicate using herbarium specimens in relations with other human fields such as linguistic, ethnobotany, art, agronomy, entomology and others. (FUNK 2004, TAKÁCS et al., 2013, TAKÁCS 2016, LAVOIE 2013, CARTER et al. 2007).

Herbaria: possibilities, aspects and problems in biology education

While herbaria are often used for a lot of scientific studies, their utilization in education decreased in the last decades, probably as a consequence of the „computer information boom“. The internet sources offer visually much more colourful and pleasant way of studying botany. Photos and videos can easily replace some parts of biology teaching, and with virtual herbaria we can bring the world of exact botanical data to students. On the other hand dimensions, structure and original size of plant could not be easily recognize on photos. There are many ways how to motivate students and meantime to develop their ability on observation. As an exercise students can examine their own plant pictures and compare it in details with the plants preserved on the herbarium sheets, moreover with online examples of the same species on digital herbaria. Details should be referred at the plant colour, plant dimensions and different aspects of morphology like roots, leaf arrangements, flowers, fruits and all relevant informations found on the labels. After this in order to develop their observational skills they will compare it with the digital examples of same species stored in our herbaria and searching for samples on other herbaria too. They will notice all differences discovered during the observation between the original and digital plant sample of the same species. Another exercise is to take notes on distribution of invasive plant species (or protected plants) and searching for these species on classical and digital herbaria. This gives the most appropriate insights into the research work and inspire students to have their own new findings. Identifying plants then comparing them with original and digital plants, searching in our digital herbaria and comparing with other herbaria contributes to developing of the observational skills which is essential in the biological studies.

Herbarium collection could be meeting point for people of different needs, it is not only working place for the researchers or students. We can organize programs or exhibitions for the public as well, also preparing thematical lectures in the herbarium according to specific interests of the group. Nevertheless, in any case, the main objective is always helping people get excited about plants. Besides of a general tour around the herbarium, smaller group activities can

be taken as a part of the teaching. Examples of the educational topics include following subjects: identify of plant diagnostic features and systematics, plants of different habitats and their ecological importance - e. g. role of plants in water supply and quality, economic and medical uses of plants, negative roles of plants (weeds, invasive, toxic species) or sampling and observing methods. (GWIMBI 1996, SENCHINA 2006). The teaching can include more material on history, geography (maps), art (drawings), and other human subject generally. We can even combine the program in herbarium with visit of local botanical garden. University students should be engaged in more practical tasks, as: searching in herbarium, handling of the datasets with involving data from books, scientific papers and internet digital sources as well. The advantage of herbaria in education is that learning can be accomplished at any time of the year, even when there is no active vegetation period, nor direct field observations, since the vegetation period reaches its peak at the end of the school year.

At Herbarium of Eszterházy Károly University (EGR) vascular plants are stored separately from the cryptogam part of the herbarium. Bryophyte and lichen collections are in a two separate rooms with research rooms and the botanical library. Moreover students have at their disposal special morphological and taxonomical herbarium for botany studies and in case of damage of these sheets they can be easily replaced. The vascular herbarium is of historical importance, as most of the herbarium sheets are dating back from the 1860's to 1950's and there more than half (51%) of species from the Hungarian flora can be found. The database created for vascular plants is available in electronic form and can be freely used (E. Vojtkó A. et al. 2014). This MS Excel-based database is recommended only for researchers at the moment, because the images are currently stored on a separate storage media and unfortunately not available online. The herbarium collection of EKV is open to the general public at different thematic days (e.g. Researchers Night) and during special periodic events such as the Botanical Week organised by the Botanical Department of the Eszterházy Károly University. The authors would like to highlight some web pages and online databases suitable for botany teaching.

A very nice presentation of hungarian flora is on the site of TERRA Foundation (TERRA 2020), which contains 573 digitized plant species with photos, detailed description, involving flowering times and plant habitats. This page also provides images of fungi and herbarium sheets of plants. Terra Foundation webpage is already not updated in the last years, but the data are more than sufficient. The second popular hungarian online site is the non-profit Botanical Forum (BOTANIKAI FÓRUM 2020), founded in 2010 containing a large digital photo collection of nearly 40 000 photos of plants. The big advantage of the site is that the photos are arranged according plant classification system. While the vascular plants are richly represented, many of cryptogam species of hungarian flora are still missing. Besides to the named plant groups, it also contains photograph collections of buds, barks, fruits, seeds, bulbs and tubers. The aim of the Botanikai Fórum is to provide an interactive, public communication plat-

form for those people interested in botany, in order to protect local flora more effectively. The page is freely usable (with eg. plant identification or other botanical issues) and expandable (eg. uploading own images). After several years of work, the digital herbarium of Pál Kitaibel was completed (ARCANUM DATABASE Kft. 2020). Pál Kitaibel was a founder of botanical research in the Carpathian Basin at the turn of the 18th and 19th century. Thanks to the database, his enormous work can become visible to university students and to the general public. The virtual database contents about 15.000 photos of Kitaibel's specimens. The flowering plants are sorted by Linne's system. There are also photos of mosses, lichens and fungi as well. Great possibilities for browsing digital herbarium both for research and education purposes offers Jacq (<https://www.jacq.org/home>). Jacq is a jointly supervised europaean herbarium system and database comprising nearly forty herbaria. Most of them are herbaria from europaean and asian countries. Unfortunately there no hungarian herbarium is represented, but there can be found specimens containing many plants collected in Hungary.

One of the largest digitized plant collection in the world is the New York Botanical Garden Herbarium (NEW YORK BOTANICAL GARDEN 2020). The herbarium contains 7.800.000 specimens of which 50% have been digitized and is searchable online. Among 4.000.000 digitalized images are approximately 175.000 algae, 164.000 lichens, 450.000 mosses, 470.000 mushrooms, 255.000 ferns and 2.800.000 vascular plants (numbers are constantly updated). Digitized plant images are of high-resolution and quality, as they are prepared according to high quality standart protocols for digitalization. The photos can be magnified to provide even finer details, they can even be compared to real herbarium specimens used in education, where observations can be made and experiences recorded. There should be mentioned the National Museum of Natural History, Paris (MUSEUM NATIONAL D'HISTOIRE NATURELLE 2020). The herbarium includes a large number of important collections with 8.000.000 million plant specimens. The collection contains 500.000 algae, 900.000 bryophyts, 600.000 lichens and fungi and 6.000.000 vascular plants. 92% vascular and 25% cryptogam plants have been digitized.

Summary

In the past herbaria was almost exclusively visited by researchers and only a small percentage of interested had insights into collections. Digitization opened up completely new perspectives on the collections visibility. Nowadays herbaria could have an active role in the education of botany, specially in several secondary and higher educational institutions. The Herbarium of Eszterházy Károly University (EGR) is involved in student education since many years. The combination of studying „real” and virtual herbaria together can be much more interesting educational approach in botany. The digital collections can bring

students as well as public closer to the world of scientific research and help preserve herbaria for the next generation.

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