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Electronic botany in research and teaching (Case studies)

Szabó, A. T.
University of Veszprém, Institute of Biology, Hungary
szta@almos.vein.hu

Abstract. Electronic botany (E-botany) is a new phenomenon in the history of botany. It is a new approach, different from previous botanical information processing, storage and transmission possibilities. E-botany has influence on data management in taxonomy (nomenclature, systematics), plant genetics, phylogenetics and evolution, study of plant biodiversity, plant genetic resources, conservation, plant physiology, palynology, paleoclimatology global ecology, agrobotany, history of botany etc.

The paper reviews the main trends in E-botany by case studies focused on three high ranked journals: one of general international scientific information (*Science*), one of dealing with specific information in plant taxonomy (*Taxon*) and a Hungarian botanical periodical (*Acta Botanica Hungarica*), as well as presenting a case used by a graduate student writing her essay in systematic botany on *Lilium*.

The journal *Science* reviewed regularly relevant scientific websites, but was relevant for E-botany especially from an interdisciplinary point of view.

E-botany presented in the journal *Taxon* was focused on specific topics and practiced only by a restricted groups of authors.

In *Acta Botanica Hungarica* the new trends were reflected by a home page presenting the content of the journal on the Web.

The high possibilities of the E-botany was illustrated with the case of selected homepages dealing with *Lilium* cytology, anatomy, taxonomy, nomenclature, systematics, genetics, evolution and cultivation.

Introduction

Taxonomy represent the beginnings of biological informatics. But a taxonomical information is not just biological, it also a "legal" one: an official taxon name is a document of an official act ruled by international codes of nomenclature. Taxonomic papers may loose their biological content, but never will lose their formal, "legal" content as such documents. This is one

of the main differences between a conventional research paper and a taxonomical one and the main reason to adopt electronic methods in "taxonomical bioinformatics" (Gradstein et al. 2001, Minelli 2003, Wilson 2001).

Electronic botany (E-botany) is a new phenomenon in the history of botany (Szabó 1990, Szabó et Biró 2000, Tóthmérész 1999/2001, Townsend 2002). It is not just a new method, but it is a new approach, a new way of thinking, which is quite different from previous information processing, storage and transmission possibilities. Influences international research cooperation (eg. in access to scientific literature cf. Weston 2002), in computerised bryophyte collections, cf. Annon. 2003), plant molecular systematics (Crafword 2000), botanical documentation e.g. the Global Taxonomy Initiative (Creswell et Bridgwater 2000), omega taxonomy (Winsor 2000), E-publication (Ceska 1995–, Gewin 2002, Schmid 2003) , data management (Wolpert 2002), traditional and distance teaching and learning (Wilson et Manhart 2001).

E-botany has influence on data management in taxonomy (nomenclature, systematics), plant genetics, phylogenetics and evolution (Hey 2001), study of plant biodiversity (Wilson 2000), plant genetic resources, conservation, plant physiology, palynology

`www.geo.arizona.edu/palynology`,

paleoclimatology and global ecology (Adams 2001,

`www.sciencemag.org/cgu/content/full/`),

agrobotany (The Mansfeld Database:

`http://mansfeld.ipk-gatersleben.de`),

plant phenology (Fitter et Fitter 2002), history of botany (Szabó 2003a,b) etc.,

`www.esd.ornl.gov/projects/qen/`.

The first prognoses for the advent of E-botany started around 1990, but the preparatory phase for this developments has been initiated earlier by starting the periodical BioTár (1988), which developed later on *BioTár Electronic (BTE)*. E-monitoring of the Web started around 1992 with a preparatory phase in the GOPHER system. This was continued first in 1995/1996 within BTE edited in Szombathely (`http://genetics.bdtf.hu`), transferred later to Veszprém (Szabó 1983, 1988–, 1996–, 2002–).

The aim of this paper is to review the main trends in of E-botany in plant taxonomy around the turn of millennium in a case study focused on three high ranked journals: one of general international scientific information, one of dealing with specific information in plant taxonomy and a Hungarian botanical periodical of great traditions. The traditions of this periodical is derived from a period of Hungarian science history important even for world science (Smil 2001). From our point of view is worth to note

now just the 100th anniversary of the birth of the founder of the modern computer theory, that of John von Neumann (1903–1965?).

Materials and methods

Materials: The following journals have been used for the case study:

1. *The NetWatch* series of the leading scientific journal Science published in Washington D.C., USA by the American Association for the Advancement of science *Science*, focused on general international scientific information (Kaiser 1998–2001, Leslie M. 2002–)

`www.sciencemag.org/cgu/content/full/`

2. *Taxon* published in Vienna by the International Association for Plant Taxonomy focused on to systematic and evolutionary biology with emphasis on botany (Editor-in-Chief T.F. Stuessy, Associate editors E. Hörandl, V. Mayer)

`http://www.botanik.univie.ac.at/iapt/taxon/index.htm`

3. *Acta Botanica Hungarica*, a Hungarian botanical periodical of great traditions, a leading Hungarian botanical periodical (Editor-in-chief A. Borhidi, Managing Editors: L. Lőkös, L. Peregovits 1999–2003)

`http://www.akkrt.hu/journals/abot.`

4. The methodology was that adopted earlier, completed recently during the editorial work of *BioTár Electronic*. *Science NetWatch* was monitored weekly beginning with 1998, *Taxon and Acta Botanica Hungarica* were monitored for E-botany quarterly beginning with 2000.

The URL addresses of botanical importance identified in peer reviewed scientific periodicals have been included in a database, monitored periodically for accessibility (including constancy and up to date actualisation), author and web master's names, as well as scientific character (high science, scientific training/teaching, popular science etc.) and content reflected by key words. Some sites have been monitored also during graduate and postgraduate teaching process jointly with our students writing their essays on plant anatomy, morphology and systematics.

Beginning with 2001 botanical E-documentation has been introduced also for our environmental science students in Veszprém among the requirements in the botanical curricula. The result was a steady raise in the level of botanical essays written by the most talented students (cf.

`http://binet-biotar.vein.hu`

BioTár Electronic – BTE, Graduate Students Works, eg. Bartl 2002, Horváth and Szabó 2003, see a sample page of the later reference also in Annexe 3.).

Students were guided to the most effective Web sites using a kind of "Internet guided tours" available at the Botanical Department of the Veszprém University, as well as searching for the scientific plant names mostly on *Yahooo* (Science → Biology → Botany → Images), or *Google* search engines (Szabó and Siki 1998–, 2003–, Lampinen et al. 2001).

In some cases comparative tables have been compiled from search results performed in Hungarian and different EU languages (cf. for example Bartl 2002, in Annexe 2.).

Results

A large number of electronic references and botanical URL addresses have been identified both in guided botanical Internet tours, as well as in the examined items of the leading international periodicals in botany (eg. Taxon, cf. Stuessy et al. 2000–2001), or in leading science journals (eg. *Science*, cf. Kaiser 1998–2001). A leading Hungarian botanical journal (*Acta Botanica Hungarica* cf. Borhidi et al. 1999–2002) has been also reviewed.

In *Taxon* URL references have been included mostly by North American and by some European authors. So for example a new Euro-Mediterranean initiative in plant systematics has been started

`http://www.euromed.org.uk`,

an Internet directory for botany has been compiled

`http://www.botany.net/IDB`

(cf. Wilson 2001), with pitfalls-specimens and databases, intellectual property and copyright (in Digitising biological collections: The 2000 meeting of the Taxonomic Database Working Group, Frankfurt,

`http://www.tdwg.org/tdwg2000/ipr.htm`,

cf. Owens et Prior 2000). E-courses were made available on the Internet by Reveal (1996, 2001), Willson et Manhart (2001) (cf. Reveal:

`http://www.inform.umd.edu/PBIO/pb450/intr.html`,

Willson et Manhart:

`http://www.csdl.tamu.edu/FLORA/tfp/tfphome1.html`).

American taxonomists initiated a series of floristic E-projects, eg. *The Flora of North America Association*, (2001), The Flora of North America

(`http://hua.huh.harvard.edu/FNA/`),

Wundelrin et Hansen (2001) The "*Atlas of Florida Vascular Plants*"

(`http://www.plantatlas.usf.edu/`,

Watson et Dalwitz 2001), the *Flora of Texas*, an Internet homepage with information on California, another for Florida plants (Wunderlin and Hansen 2001) for education, research and conservation is also available via Internet

(http://www.texasflora.org, http://www.calflora.org/).

A checklist of the vascular flora of the United States, Puerto Rico, and the Virgin Islands was published on the Net, too

(http://www.csdl.tamu.edu/FLORA/b98/check98.htm).

There is a trend to publish high ranking botanical illustrations on the web, as well

http://hua.huh.harvard.edu/HuCards/.

Valuable E-monographs have been compiled regarding the families of vascular and/or flowering plants, representing a real Flowering Plant Gateway (cf. eg. Carr 2003, Texas A&M Bioinformatics Working Group, 2000:

http://biodiversity.uno.edu/delta/angio/index.htm,

http://www.botany.hawaii.edu/faculty/carr/pfamilies.htm,

http://www.csdl.tamu.edu/FLORA/b98/check98.htm,

http://www.csdl.tamu.edu/FLORA/cgi/gateway_family?fam=familyname),

Beside plant systematics (eg. Watson et Dalwitz 2001), plant ecology and the E-presentation of North American biota is also on move

(http://www.bonap.org/).

The International Working Group on Taxonomic Databases (TDWG) acting beside the International Union of Biological Sciences (IUBS) also developed an international forum for biological data projects in order to promote the use of standards and facilitate international exchange of taxonomic data

(http://www.tdwg.org,
http://www.bgbm.fu-berlin.de/tdwg/2000/Presentations.htm).

The botanical URL addresses and references identified in the journal Science (Kaiser 3rd April 1998–2001, Leslie 15 June 2001–) were included in the Table 1. It is worth to note that the NetWatch edited by Kaiser was much more balanced toward plant sciences and environmental sciences as compared to the series edited by M. Leslie but both were quite irrelevant for botanical taxonomy (Szabó et Siki 2002, 2003c, cf. Annexe 1., Table 1.)

Discussions

There are signs of E-communication penetrating in the botany, but the degree of acceptance varies greatly in form and content among the journals and authors examined.

Among the authors of the journal Taxon (Stuessy et al. l.c.) those examining the changes and the progress of botanical systematics around the turn of millennium could generally not avoid completely the new pheno-

menon of E-botany, but only Wilson (2001) focuses strongly on E-botany (this will be discussed later). Generally E-botany is mentioned just sparsely by different authors. Stevens (2000) talking about electronic processing of taxonomic descriptors and about interactive keys cites the works of Dalwitz et al. (1993–, 2000–). Mishler (2000) in his table summarising the historical periods in biological systematics beginning with folk classifications (phase 1) up to cladistics (phase 6) considers the numerical phenetics (phase 5) and the arrival of computers having just a week and superficial effect on plant systematics. Even *The Tree of Life* (Maddison 1998–, Sogin and Patterson 1998–) is cited only in a figure, but not in references. Chase et al. (2000) have no E-references in their paper dealing with the effect of DNA sequence data on higher level classification of the Angiosperms.

In the first part of the "Jubilee Series" of the journal Taxon ("*New and renewed sources of comparative data from plants*", Editorial Part I. and following papers) practically no URL references are cited. Talking for example about progress in techniques and methods (Endress et al. 2000) — computer technique is considered just one of the many possible new methods for cladistics (and it is not even mentioned as an important tool for molecular systematics) with no E-references cited among the almost 500 titles referred in the paper. Similarly no E-databases on plant secondary substances are cited by Harborne (2000) among the 50 references cited in the subject.

Stace (2000), talking about plant chromosome counts, genome size, chromosome morphology, chromosome staining characteristics, chromosome and genome disposition in the cell, chromosome behaviour and homology states that classical and molecular cytogenetics produced an enormous amount of data which needs to be integrated. But no E-references are cited regarding the E-possibilities of such an integration.

Plant macromolecular systematics is traditionally focused on secondary compounds (cf. Harborne 2000), more recently on proteins and quite newly on DNA. Crawford (2000) reviewing the trends between 1950–2000 on the field stated that amino acid sequencing had little lasting impact on taxonomy and phylogeny (Maddison 1998–, Mishler 2000). Enzyme electrophoresis has been used more in microevolutionary studies with little or no effect on taxonomy.

Analysis on DNA level affected and will further affect all levels of botany: the next five decades will witness a melding of the old and new to continue the "unending synthesis" in plant sciences. There is a marked discrepancy between this statement, the E-boom of plant genomics and the lack of this perspective in the reference lists of the most botanical papers.

This discrepancy is explained perhaps by a traditional separation of classical taxonomy from molecular biology... even on DNA level.

One of the new E-methods in the study of plant biodiversity is the Geographic Information System (GIS), the tool used by plant biologists to collect and process electronically spatial data in order to gain biologically relevant information. Skov (2000) reviewed the hardware, software and other tools, but without a reference on the possible use of GIS in a networked botanical E-(e)nvironment.

However Hagedorn (1997–), Hagedorn and Rambold (2000) in their account on a method on use of descriptive plant data available via Internet, presented a successful synthesis of traditional (printed) and modern E-references: in 9 references (out of 18) the URL addresses have been also included. The following E-contacts are mentioned:

`http://pnp.huh.harvard.edu`

(The plant names project. Access denied on 26th May 2003, szta), Cross (1998, but E-reference no more accessible in 2003!), Dalwitz et Zurcher (1995–1999), Findling (1998), Green (1997), Hagedorn (1997–2000), Hagedorn et Rambold (2000), Jacobs et al. (1996), using direct URL references even in the text of the paper.

The nomenclature *ipso facto* is a "conservative" field of botany. Even so McNeill (2000) in his paper dealing with the new trends in developing a stable and efficient plant nomenclature refers frequently on E-sources, citing Benton's work (in E-preprint) on rank-free lists and the fate of Linnean taxonomy, that of Cantino et de Queiroz (2000), de Queiroz (1996) on Phyllocode, McNeill (1996), Redhead (2000) on BioCode and/or Raveal (1996), Greuter et al. (1993, 1998), Withgott (2000) on biological nomenclature and the (sometimes quite aggressive) controversy regarding the "sunset of the Linnean nomenclature".

E-references are completely lacking from the extensive reference list of Bachman (2001) comprising about 350 titles on "*Evolution and genetic analysis of populations: 1950–2000*", as well as from the paper of Reiseberg and Burke (2001) on "*The biological reality of species: gene flow, selection, and collective evolution.*" (no E-sources in about 150 references!), that of Levine (2001) dealing with the literature of the last 50 years of plant speciation (more than 200 references), or from the paper of Arnold et al. (2001) on "*Natural hybridisation and fitness*" (no E-titles among 52 references).

Writing about "*Discovering the plant world*" at the turn of century and millennium Gh. T. Prance (2001) also avoids to cite E-references. However Heywood (2001) refers on electronic sources when writing about new electronic keys used for plant identification (PANKEY —

`http://www.rbge.org.uk/pankey.html`.

Note: address not found in 26th May 2003, szta), on CD-Rom keys (CABIKEY), on taxonomic databases (TDWG) and on progress in taxonomy (Blackmore 2002), on Euro+Med Plant Base Project (cf. Carine et al. 2000), on Flora of China (cf. Al-Shehbaz n.p., etc.), the ESFEDS database (Heywood et al. 1984, cf. Idem 1998, 2001), on *Flora of North America* (*l.c.*), ILDIS (Bisby 1994), *Species 2000* (cf. Bisby 2000, 2002), the ALL Species Project (Smith 2003), the Index of the world herbaria (Holmgren et Holmgren 2001), the use of herbaria (Metsger 1999, Miller 1999), *The Virtual Australian Herbarium* (Barker 1998), but the URL addresses of the *PhyllоCode* are referred only through Cantinbo et al. (2000) and others, with a comment that this Code "[...] would drastically affect the accessibility of the units of taxonomy to a large number of non-specialist users".

Among the authors of the "*Jubilee Review Series*" of the journal Taxon Wilson (2001) received the task to review the role of informatics in the systematics of the 21st century. His main statements may be summarised by the following quotation: "*The international community of systematic botany is in the process of entering a networked, digital environment that, after initial development [...] will dominate [...] scientific activity in the future. [...] The products of systematic botany, previously generated locally as static, hardcopy documents, can now be presented as collaborative enterprises [...] as [...] dynamic data resources [...] made available to a global user community [...] The emerging Internet standard of "usage equals value" could place the products of systematic botany in a position to draw public interest and [...] support. However [...] the digital transition" will be not realised, if [...] traditional publication and "ownership" are retained /but/ [...] via interaction and content review by professionals, that information available to the public is of the highest scientific quality.*" It is worth to note that the "reference list" of this paper cites only URL addresses (websites).

The optimism of Wilson is not really supported by our analysis. It is true that plant germplasm science is heavily represented on the web, but genetic resource items are not treated in this paper. Websites in botany are well represented on the Internet, with many URL address's with images (eg.

`http://www.csdl.tamu.edu/FLORA/`,

`http://www.helsinki.fi/kmus/botpics.html`.

Note: a search on for this site in 26th May 2003 gave the following result: The *Internet Directory for Botany – Subject Category List* and the Helsinki mirror site of the *Internet Directory for Botany – Alphabetical List* have been closed. The main page of the Internet Directory for Botany in Canada is still accessible), with images on persons, with herbals and herbal remedies (eg.

`http://www.amfoundation.org/herbmed.htm`),

practical conservation and natural heritage (eg.
http://splash.metroke.gov/wlr/pi/salvage.htm.
Note: access denied on 26th May 2003,
http://infoweb.magi.com/~haber/main.html),
dendrology and tree ring studies (eg.
http://www.valdosta.edu/~grissino).

Conclusions

1. Our case study demonstrates that scientific botany still avoids E-publication and E-citation both on truly international and on national/regional level (Stuessey et al. 2001–2001, Borhidi et al. 1999–2000).

2. There is an renewing trend of "new-", "bio-", "phylo-" systematics trying to shake and weaken the positions of the traditional, Linnean taxonomy, making use of (mostly uncontrolled) E-communication.

3. "Enthusiast" and visionary botanists promote E-communication in botany, but the main problem in taxonomy is the lack of constancy in E-publication vs. traditional printed publication.

4. Even so, the global accessibility of E-botany, especially E-images, E-teaching, new phylogenetic systems and taxon lists find their way toward students, teachers and research scientists.

5. Popular science, and university seminars are well supported by English E-botany at the turn of millennia. This is not the case with smaller national languages.

6. Conservative attitude (among professionals) and language barriers (among non-English students) still represent a narrow gate in E-communication among botanists.

7. There are promising signs, that botanical knowledge is growing also by translations, by passing the language barriers in E-botany (Crystal 2001, Montgomery 2001).

8. The journal *Science* reviewed regularly relevant scientific websites, but was relevant for E-botany especially from an interdisciplinary point of view.

9. E-botany presented in the journal Taxon was focused on specific topics and practiced only by a restricted groups of authors.

10. In *Acta Botanica Hungarica* the new trends were reflected by a home page presenting the content of the journal beginning with 2000.

11. The high possibilities of the E-botany was illustrated with the case of selected homepages dealing with *Lilium* cytology, anatomy, taxonomy, nomenclature, systematics, genetics, evolution and cultivation

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Note: the "Hungarian System" in the citation of the family names and given name abbreviations of the authors of papers was deliberately used in this section, because this is one to be preferred in E-botany. The editor is kindly requested to respect this advise at last in this single case (A. T. Szabó).

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Annexe 1.

Table 1.

Guided Internet Tours in Plant Sciences (1) using

Science Watching the Net

Scientific Websites presented by NetWatch (Science, Washington DC.)
Recommended for Hungarian students of environmental biology
Vol. I.: 1998–2002, Vol. II: 2002–

Compiled by:
A.T. Szabó (reviewer)
A. Siki (techical assistant)

BioTár Electronic Neumannia
BTN: 1015/2003

URL addresses of botanical relevance reviewed in Science
(Kaiser 3rd April 1998–2001, Leslie 15 June 2001–, excerpts from Szabó and Siki 2002, 2003c)

Table 1a: Excerpts from a title selection

Title and key words	Y	M	D	www.	Web – Master	Notes
Mapping Israel s Biodiversity: Databases Israel biodiversity, database, chorology, floristics R. Kadmon	01	01	26. 4	www.biogis.huji.ac.il		Accessible: 030506szta
Tree Decoders: Databases Genematics, biotechnology, dendrome, U. S. Forest Service, dendrology, Tree Genes, global warming, paleoclimate	00	11	17. 5	http://dendrome.ucdavis.edu	Dr. David Neale	Accessible: 030506szta
The Green Scene: Databases U.S. Dept. Agriculture's Plants cultivated plants, botany, horticulture, botanical illustration, evolution, food, taxonomy	00	11	03. 4	http://plants.usda.gov/plants/index.html		030526szta: No access
Crust of Life: Resources Lychens, mosses, fungi, bacteria, idessert, nitrogen fixation, soil, invasion	00	10	27. 1	www.id.blm.gov/soils www.soilcrust.org		A: 030526szta: No access
Book of plants	00	07	14	www.ipni.org		Accessible: 030506szta
California Blooming	00	07	07	http://elib.cs.berkeley.edu/photos		Accessible: 030506szta
California Blooming	00	07	07	http://elib.cs.berkeley.edu/photos		Accessible: 030506szta
Algae That Kill	00	04	28	www.redtide.whoi.edu/hab/default.html	Dr. Donald M Anderson	030526szta: Not valid
Herb garden: Index Herbariorum	00	02	11	www.nybg.org/bsci/ih		Accessible: 030506szta
Green thumbing through history: history of botany	99	09	10	www.huntington.org/BotanicalDiv/Timeline.html		Accessible: 030506szta
Plants in Glass Houses: Diatomae	99	05	07	www.BGSU.edu/departments/biology/algae/index.html		Accessible: 030506szta
Mushroom of The Month Club	99	02	05	www.wisc.edu/botany/fungi/volkmyco.html		030526szta: No access
Nurturing a Digital Tree of Life: phylogeny, taxonomy, evolution	99	01	29	http://Phylogeny.arizona.edu/tree/phylogeny.html		Accessible: 030506szta
Digital Blossoms Bioinformatics Group: plant Art Gallery Vascular plants, iconography, images	99	01	15	www.csdl.tamu.edu/FLORA/gallery.htm		Accessible: 030506szta
Flower power: history of botany, rare botanical books	98	04	10	www.mobot.org/MOBOT/research/library/kohler/welcome.html		Accessible: 030506szta

Table 1b:
Excerpts from a Keyword Search Key words used in searching: titles in bold lines

Botany:

A Garden of Links: Links	01	08	17.2	www.ou.edu/cas/botany-micro/bot-linx		Dr. Scott Russel	Notes
Mushroom of The Month Club	99	02	05	www.wisc.edu/botany/fungi/volknwo.html			No access 030526szta
Plants of Paradise: Resources	03	01	31.5	http://rathbun.si.edu/botany/pacificislandbiodiversity/hawaianflora/index.htm http://rathbun.si.edu/botany/pacificislandbiodiversity/marianasflora/index.htm			Accessible: 030506szta

Plant:

Getting Hip to Plant Hormones	01	03	16.4	www.plant-hormones.bbsrc.ac.uk		Steve Croker	Notes
The Science of Sick Plants	98	06	12	www.ifgb.uni-hannover.de/extern/ppiab/ppiab.htm			Accessible: 030506szta
Garden of Vanishing Plants: Database Veszélyeztetett növény fajok, USA, természetvédelem	02	11	01.3	http://plants.usda.gov/cgi_bin/topics.cgi?earl=threat.html	021106 030107szta		Accessible: 030506szta
Dissecting the Cell's Power Plant: Database Mitokondrium, energia, gén, betegség, egér, élesztő, mutáció, sejt	02	09	13.2	http://mips.gsf.de/proj/medgen/mitop	030108szta1		Accessible: 030506szta
Gateways to the Plant Cell: Database	02	06	14.4	http://plantsci.cshl.edu			Accessible: 030506szta
Plant Versus Plant: Resources	02	05	24.4	www.science.siu.edu/parasitic-plants	020608	Dan Nickrent	Slow 030526szta
Plant's family Tree: Resources	02	04	03.1	www.mobot.org/MOBOT/Research/APweb/welcome.html	020302neml		Accessible: 030506szta
Stressed-Out Plants: Resources Feszültségkeltő növények: Fonások feszültség, termésellátás, növényzet	01	09	21.5	www.plantstress.com			Accessible: 030506szta
Peek-a-Boo Leaves: Images Cleared leaves, Paleobotany, Levélszerkezet	03	02	14.5	www.ucmp.berkeley.edu/collections/plants/clearedleaf.html			Accessible: 030506szta
Plants of Paradise: Resources	03	01	31.5	http://rathbun.si.edu/botany/pacificislandbiodiversity/hawaianflora/index.htm http://rathbun.si.edu/botany/pacificislandbiodiversity/marianasflora/index.htm			Repeated ! Accessible: 030506szta

Flower:

Watch the Grass Grow: Images Plants in motion, növényi mozgások	02	01	18.1	http://sunflower.bio.indiana.edu/~rhanpart www.plantsci.cam.ac.uk/Haseloff/MOVIES/In-depMOVs.html			Accessible: 030506szta B: not found 030526szta

Pollen:–
Angiosperm: –
Gymnosperm: –

Biodiversity

Tour the Strongholds of Biodiversity: Resources Biodiverzitás, forró pontok, természetvédelem, endemizmusok	02	10	11.4	www.biodiversityhotspots.org/xp/Hotspots	030108 szta		Accessible: 030506szta
The Business of Conservation: Resources	02	03	15.2	http://biodiversityeconomics.org	020425		Accessible 030506szta
Plants of Paradise: Resources	03	01	31.5	http://rathbun.si.edu/botany/pacificislandbiodiversity/hawaiianflora/index.htm http://rathbun.si.edu/botany/pacificislandbiodiversity/marquesasflora/index.htm			Repeated !

Chorology: –
Floristics: –

Forest: –

Phylogeny Forest: Resources Evolution, evolúció, törzsfejlődés	02	03	01.1	www.treebase.org/treebase			Accessible: 030506szta
Forest Gallery: Images Esőerdő képtár: Képek ostrom alatt, dögvész, fertőzés, edzés invaziv fajok, gyomok stb.	01	09	07.3	www.forestryimages.org www.bugwood.org	2001.06.26 2001.05.28		Accessible: 030506szta
Network to Log World Forest Loss Renewable resources, természeti erőforrások, erdők,	00	03	10	www.globalforestwatch.org			Accessible: 030506sztn

Dendrology: –
Cultivated plants: –
Horticulture: –
Botanical illustration: –

Taxonomy

Taxonomists at Play: Fun Taxonomiai, nevezéktani furcsaságok	03	01	31.1	http://home.earthlink.net/~misak/taxonomy.html	030310	Mark Isaak	Accessible: 030506szta

***Lychens:* –**
***Mosses:* –**

Fungi:

Mushroom of The Month Club	99	02	05	www.wisc.edu/botany/fungi/volkmyco.html			No access 030526szta

***Bacteria:* –**
***Nitrogen fixation:* –**
***Soil:* –**
***Invasion:* –**

Alga:

Off he Trail of Rogue Algae: Education Toxinok, vörösmoszat, alga, vízvirágzás	02	10	18.1	www.bigelow.org/link/index.html	030108 szta	Dr. Maureen Keller	Accessible: 030506szta
Algal Bloom: Resources	**02**	**05**	**17.2**	http://seaweed.ucg.ie	020704	**Michael D. Guiry**	No access 030526szta

Algal Bloom: Resources	02	05	17.2	http://seaweed.ucg.ie	020704	Michael D. Guiry	No access 030526szta
Plants in Glass Houses	99	05	07	www.BGSU.edu/departments/biology/algae/index.html	Repeated site		Accessible: 030506szta

Garden:

Garden of Vanishing Plants: Database Veszélyeztetett növény fajok, USA, természetvédelem	02	11	01.3	http://plants.usda.gov/cgi_bin/topics.cgi?earl=threat.html	021106 030107/szta		Repeated !
A Garden of Links: Links	01	08	17.2	www.ou.edu/cas/botany-micro/bot-linx		Dr. Scott Russel	Repeated !
Botanical Garden: Resources Botanikuskertek: Adatforrás Online botanika, P v. zengbus evolúció, botanikaleckék	01	02	02.4	www.rrz.uni-hamburg.de/biologie/b_online/e00/contens.htm	010322 nem!		No access Szta030526

Bioinformatics:

Bioinformatics Workshop: Tools Bioinformációs műhely: Eszközök szabad eszközök, visszacsatolás	01	09	21.4	www.bioinformatics.org	Accessible: 030506 szta		Low botanical relevance
Bioinformatics cornucopia	00	08	11	http://genome.cornell.edu/index.html			Decomissioned on 15 April 2002 !!!
MEDLINE robot	99	08	27	www.bioinformatics.weizmann.ac.il/cms			Access denied

Annexe 2.

Lilium on the Internet according to search results of Bartl (graduate student) and Szabó (tutor) 2002

Total number of hits: 59900

Evaluated web sites: first 40 (Note: some taxa were searched also separately)

1. Search results for *Lilium* (Yahoo, Science, Botany)

Keyword	Nr. of hits	Keyword	Nr. of hits	Keyword	Nr. of hits
L. martagon	4510	L. pyrenaicum	768	L. rhodopaeum	78
L. longiflorum	3260	L. pumilum	757	L. henrichi	57
L. elegans	3260	L. brownii	455	L. kesselringianum	19
L. davidii	2270	L. parkmanum	432	L. leichtlinii	9
L. tigrinum	2230	L. distichum	419	L. tigridum	5
L. canadense	1870	L. panyi	314	L. philadelphicum	5
L. superbum	1720	L. parvum	273	L. georgicum	3
L. speciosum	1510	L. amabile	267	L. chalcedonicum	2
L. bulbiferum	1380	L. dauricum	208	L. pyri	2
L. japonicum	1310	L. humboldtii	188	L. thunbergianum	1
L. regale	1300	L. polyphyllum	180	L. bolanderi	0
L. concolor	1190	L. hansonii	176	L. vollmeri	0
L. lancifolium	1120	L. nepalense	164	L. fragesii	0
L. columbrianum	1090	L. callosum	143	L. bakerianum	0
L. cernuum	969	L. pomponium	128	L. heldreichii	0
L. auratum	872	L. alexandrae	110	L. formosanum	0

2. Yahoo results for Lilium (excerpts from the URL addresses of the first 32 hits)

(Bartl and Szabó 2002)

	URL address	Notes
2.	http://groups.yahoo.com/group/Lilium/	Gardening association
3.	http://rareplants.co.uk/lilium/gallery.htm	Pictures and short descriptions
4.	http://www.botany.com/lilium.html	Idem, a botanical gateway
5.	http://images.usprr.org/lily/male.html	Meiosis in the Lilium microspore
7.	http://www.veseys.com/store.cfm?product=2092	Catalogs of a garden
8.	http://www.plants-magazine.com/newplants/newplant34.shtml	Plants-magazine
10.	[illegible]keep.ca/bulbs%20lilium.htm	Detailed descriptions
11.	http://www.lillaflickaregatanstradgardsbutik.se/grupp4/lilium.htm	Swedish, gardening
13.	http://www.pridon.com/	A large database on cultivated Lilium
14.	[illegible].htm	Virus infections in Tulipa and Lilium
21.	http://www.ungarden.com/groepen/enliliumindex.html	Detailed description of five Lilium taxa
22.	http://hortplex.gardenweb.com/plants/p1/gw20020614.html	Good botanical links (Plants Database, Plants For A Future, Plants Viruses Online stb.)
25.	http://www.infoagro.com/flores/flores/lilium.asp	Portugál nyelvű részletes fajleírások képek nélkül.
26.	http://botit.botany.wisc.edu/images/130/Angiosperm/Lilium/	Lilium macro- and micromorphology, anatomy (pictures)
31.	http://www.nanp.org/ess000/pages18.html	Pictures of many Lilium taxa

Best sites for Lilium

- http://images.usprr.org/lily/male.html
- http://botit.botany.wisc.edu/images/130/Angiosperm/Lilium/
- http://www.bulb.com/summerguide98/lilium/index.asp
- http://www.ungarden.com/groepen/enliliumindex.html
- http://www.pridon.com/

Annexe 3.

A sample page from the essay of E. Horvath (2003) on E-learning in systematic botany using the standard Hungarian botanical textbook edited by G. Turcsányi (2001)

III. PH.: Angiospermatophyta — Zárvatermők 260
CL.: *Dicotyledonopsida* – *Kétszikűek* 261
SUBCL.: Magnoliidae – *Liliomfa-alkatúak* 263
ORD.: Magnoliales – Liliomfa-virágúak 263
Fam.: Magnoliaceae – Liliomfafélék 263
Liriodendron tulipifera – amerikai tulipánfa
Carr G. D., 2003, Vascular Plant Family Access Page. University of Hawaii.
http://www.botany.hawaii.edu/faculty/carr/magnoli.htm
Fam.: Annonanceae – Annónafélék 263
Annona
muricata – tüskés annóna
Annona cherimola
Xylopia fajok
http://www.botany.hawaii.edu/faculty/carr/annon.htm (Carr G. D., 2003)
Fam.: Myristicaceae – Muskátdiófélék 263
Myristica fragrans – valódi muskátdió
http://www.botany.hawaii.edu/faculty/carr/myristic.htm (Carr G. D., 2003)

ORD.: Aristolochiales – Farkasalma virágúak 263
Fam.: Aristolochiaceae – Farkasalmafélék 263
Aristolochia clematitis – közönséges farkasalma
További farkasalma fajok: A. galeata, A. bracteata,
http://www.botany.hawaii.edu/faculty/carr/aristolochi.htm (Carr G. D., 2003)

ORD.: Laurales – Babérvirágúak 264
Fam.: Lauraceae – Babérfélék 264
Laurus nobilis – babér
Cinnamomum aromaticum – kínai fahéjfa
Cinnamomum camphora – kámforfa
Persea americana – avokádó
http://www.botany.hawaii.edu/faculty/carr/laur.htm (Carr G. D., 2003)

ORD.: Piperales – Borsvirágúak 264
Fam.: Piperaceae – Borsfélék 264
Piper nigrum – fekete bors
http://www.botany.hawaii.edu/faculty/carr/piper.htm Carr G. D., 2003)

ORD.: Nymphaeales – Tündérrózsa-virágúak 264
Fam.: Nymphaeaceae – Tündérrózsafélék 264
Nymphae alba – fehér tündérrózsa
Nymphaea lotus – hévízi tündérrózsa
var. thermalis
Victoria amazonica – amazoni tündérrózsa
http://www.botany.hawaii.edu/faculty/carr/nymphae.htm (Carr G. D., 2003)