NOMENCLATURE

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Third world list of cetrarioid lichens: A databased tool for documentation of nomenclatural data—lessons learned

Andres Saag,[1] Tiina Randlane,[1] Lauri Saag,[1,2] Arne Thell[3] & Teuvo Ahti[4]

1 *Institute of Ecology and Earth Sciences, University of Tartu, Lai Street 38–40, 51005 Tartu, Estonia*
2 *Estonian Biocentre, Riia 23b, Tartu 51010, Estonia*
3 *The Biological Museums, Lund University, Östra Vallgatan 18–20, 223 61 Lund, Sweden*
4 *Botanical Museum, Finnish Museum of Natural History, P.O. Box 7, 00014 University of Helsinki, Finland*
Author for correspondence: *Tiina Randlane, tiina.randlane@ut.ee*

Abstract The third version of the world list of cetrarioid lichens contains 572 names representing 149 accepted species. It is presented in a new, electronical form, based on a FileMaker-powered database, allowing users to view data in different sets and to perform searches. Type information is added for most of the names, and new information regarding the phylogenetic status of accepted taxa is introduced. Five global taxonomic databases (Catalogue of Life, Encyclopedia of Life, Index Fungorum, LIAS, MycoBank) are compared by scanning the availability of mainly nomenclatural data of 30 selected cetrarioid names (10 accepted names, 10 homotypic and 10 heterotypic synonyms); the significance of digital web resources is discussed.

Keywords *Cetraria*; cetrarioid; database; lichens; nomenclature; *Parmeliaceae*

Supplementary Material The Electronic Supplement (Tables S1–S3; Figs. S1–S4) is available in the Supplementary Data section of the online version of this article (http://www.ingentaconnect.com/content/iapt/tax).

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■ INTRODUCTION

The present situation with the scientific names of plants and fungi is aptly described by Pier Luigi Nimis, botany professor in the University of Trieste, in his one-page "A tale from Bioutopia", starting with the following narrative (Nimis, 2001): "Once upon a time, two tribes dominated Bioutopia. The small but powerful tribe of Real Taxonomists occupied several scattered ivory towers in the mountains. The huge but poor tribe of Name-users lived in the swamps. They both worshipped Names, but with different rites. The Name-users peacefully adored a huge book made of granite, in which billions of Names were inscribed for Eternity. The favourite occupation of the cruel Real Taxonomists was sacrificing a few Names every day, just by changing them."

This paper is an attempt to end the fight between the two tribes, Real Taxonomists and Name-users, by promoting modern tools, databased checklists of certain systematical taxa or groupings. Our case survey deals with nomenclatural data of cetrarioid lichens (*Ascomycota*: *Parmeliaceae*), but similar solutions concerning documentation of such information could be applicable on a much wider scale.

Historical background. — *Parmeliaceae*, the largest family of lichen-forming fungi with ca. 2700 species and ca. 80 genera, has been an object of intensive phylogenetic studies during the last decade (e.g., Blanco & al., 2004, 2006; Crespo & al., 2007, 2010; Del-Prado & al., 2010; Amo de Paz & al., 2011; Saag & al., 2011; Mark & al., 2012). Earlier the diversity of genera within the family was informally grouped according to the "gross morphology" using combinations of morphological characters such as growth form, thallus colour, position of ascocarps, etc., resulting in the segregation of alectorioid, cetrarioid, hypogymnioid, parmelioid, and usneoid groups of lichens (Randlane & Saag 1993; Kärnefelt & al., 1998; Thell & al., 2002). For example, the cetrarioid group was defined by an erect foliose or subfruticose growth form of the thallus being loosely attached to the substrate, presence of marginal apothecia and pycnidia, and production of the *Cetraria*-type lichenan (Kärnefelt & al., 1992; Elix, 1993; Randlane & Saag, 1993). Phylogenetic studies based on molecular markers have demonstrated that none of these morphologically defined groups formed well-supported monophyletic clades (Crespo & al., 2007). However, for the two most diverse and intricate assemblages, cetrarioid and parmelioid lichens, the so-called core groups have been delimited—a strongly supported clade comprising the majority of either cetrarioid or parmelioid genera but, in addition, a few representatives from other morphological groups (Crespo & al., 2001, 2007; Blanco & al., 2006; Thell & al., 2009; Nelsen & al., 2011). Thus, the current terminology is somewhat confusing, and it is crucial to distinguish between the colloquial terms "cetrarioid (or parmelioid) lichens" denoting polyphyletic groups of taxa, and the phrases "cetrarioid (or

parmelioid) core group" indicating certain phylogenetically delimited lineages (Fig. 1).

The lichen genus *Cetraria* was described by Erik Acharius in 1803, then consisting of eight species. The number of species placed in the genus gradually increased (a historical survey of the genus was summarized by Kärnefelt, 1979), achieving the biggest amount, 76, in the treatment of the Russian lichenologist Ksenia Rassadina (1950). Another expert, Veli Räsänen (1952), listed worldwide additional species, reaching 85, but divided them between three connected genera, *Cetraria*, *Cornicularia* and *Nephromopsis*. The true process of splitting the genus *Cetraria* was started by the Culbersons in the 1960s when they described the genera *Asahinea* (Culberson & Culberson, 1965), *Cetrelia* and *Platismatia* (Culberson & Culberson, 1968). A real explosion of segregating new cetrarioid taxa occurred in the 1980s and 1990s when 15 new genera were described and two old entities, *Tuckermannopsis* and *Nephromopsis*, were resurrected. Similar processes (described and references listed in Hawksworth & al., 2008) took place among parmelioid lichens in which the number of genera recognized within *Parmelia*, as it had been circumscribed in the 1960s, had risen to 36 by the end of the century (DePriest, 1999). In the group of cetrarioid lichens nearly one hundred, and among parmelioid lichens, hundreds of new names had

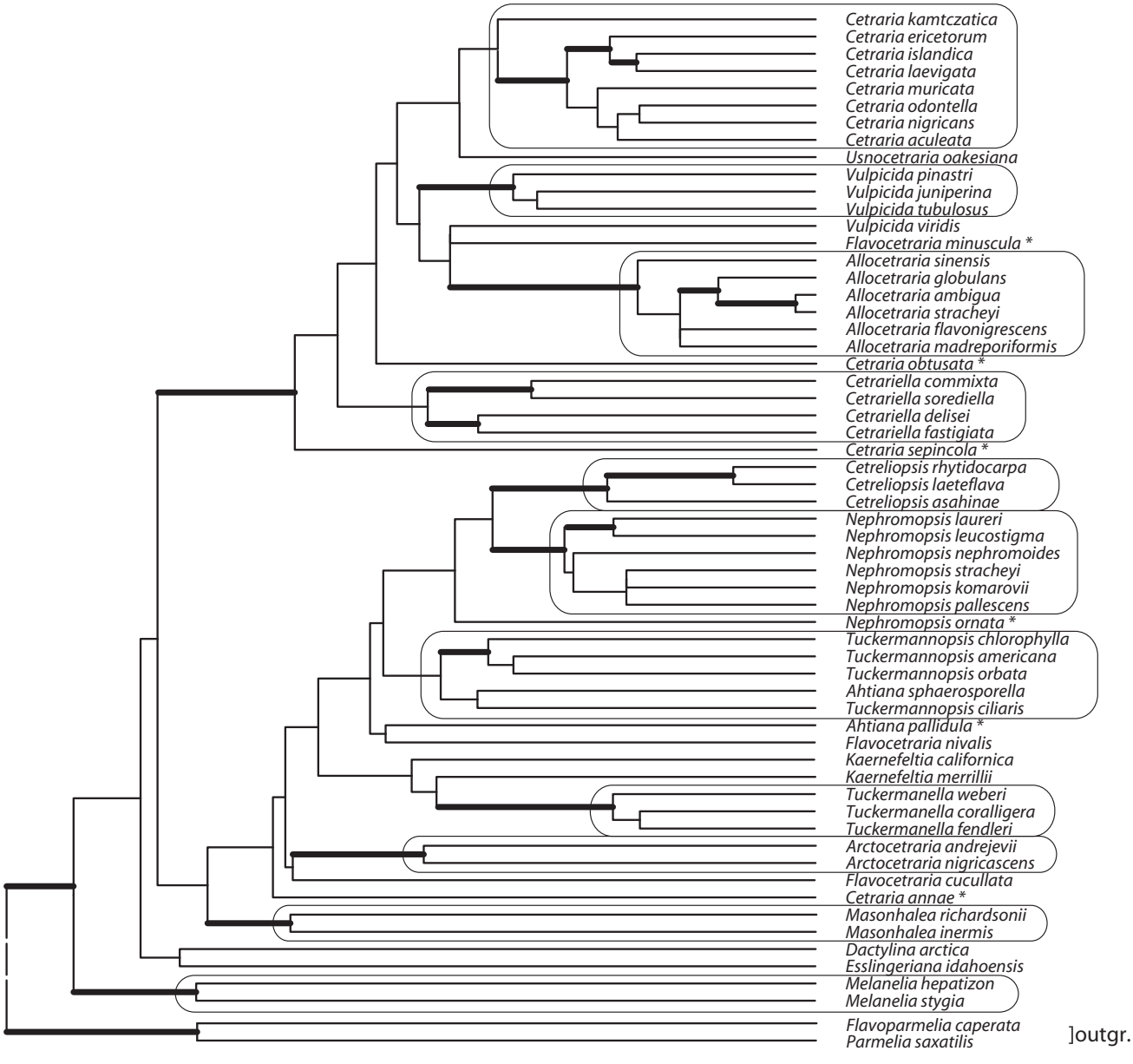


Fig. 1. Simplified phylogenetic scheme of the cetrarioid core group based on Nelsen & al. (2011: fig. 1). Branches in bold indicate supported relationships (maximum likelihood bootstrap support values ≥70 and Bayesian posterior probabilities ≥0.95). Clades containing accepted genera of the cetrarioid core group are surrounded by boxes. The names of species without phylogenetically satisfactory generic position are marked with an asterisk (*).

been proposed while a bulk of earlier names became synonyms. Understandably this caused numerous misunderstandings and errors in use of the names of cetrarioid or parmelioid lichens. The first person to improve this confusing situation of the nomenclature in *Parmeliaceae* was Mason E. Hale, the initiator of many taxonomic changes in the parmelioid lichens. In 1989 he prepared and distributed a manuscript "List of epithets in the parmelioid genera" which was later published in full (Hale & DePriest, 1999) and analysed as a reflexion of Hale's classification scheme for this group nine years after his death (DePriest, 1999).

The same manuscript by Hale inspired us to prepare a similar list of epithets for the cetrarioid species. In its first version (Randlane & Saag, 1993), over 200 species epithets were introduced in alphabetical order representing 120 cetrarioid species. For each epithet the accepted generic location and valid name was indicated. In the second printed version (Randlane & al., 1997) and its electronic updates from 2000 and 2002 (http://www.eseis.ut.ee/synonyms/cetraria.html) nearly 500 epithets representing 138 accepted species in 23 genera were listed. As a novelty compared to the first version, bibliographic data were provided for each combination. During the last ten years no updates for this checklist have been provided.

The present, third version of the world list of cetrarioid lichens contains currently 572 names representing 149 accepted species in 25 genera (Randlane & al., 2013). It is presented in a new, electronic form, based on a FileMaker-powered database, allowing users to view data in different sets and to perform searches. Type information is added for most of the names, and new information regarding the phylogenetic status of the accepted taxa, i.e., whether they belong to the cetrarioid core group or not, is introduced.

■ RESULTS

Web design of the database and operation. — The third world list of cetrarioid lichens is freely accessible at the web portal eSEIS, an Estonian information system of lichens (http://www.eseis.ut.ee/index_en.html); both the computer version (http://esamba.bo.bg.ut.ee/checklist/cetrarioid) and smartphone version (http://esamba.bo.bg.ut.ee/checklist/cetrarioid-mob) are available. As implemented at the University of Tartu (Estonia), the database runs on a tiny hardware, Mac mini Server with Intel Core Duo processor. To communicate with the FileMaker Server Advanced–powered database, the web interface uses PHP programming language. It has been tested with all major web browsers, including Google Chrome, Internet Explorer, Mozilla Firefox, and Safari on various operating systems. The current database model enables users to perform different operations described below.

(1) View data in different sets; for getting the full list of all names in alphabetical order, use the button "Find All" in the Menu bar (Fig. 2).

Cetrarioid lichens

Introduction Find List Find All

List

First | Prev | Record 1 - 25 of 572 | Next | Last

Phylogenetic status	Status of name	Name	Literature source	Accepted name	Type information
	Synonym (heterotypic)	Ahtia wallichiana (Taylor) M.J. Lai	Quart. J. Taiwan Mus. 33: 220. 1981 [1980] (nom. illeg.)	Nephromopsis pallescens (Schaer.) Y.S. Park	–
Cetrarioid core, position unclear	Accepted name	Ahtiana aurescens (Tuck.) A. Thell & Randlane	in Thell, Goward, Randlane, Kärnefelt & Saag, Bryologist 98: 599. 1995.	Ahtiana aurescens (Tuck.) A. Thell & Randlane	–
Cetrarioid core, position unclear	Accepted name	Ahtiana pallidula (Tuck. ex Riddle) Goward & A. Thell	in Thell, Goward, Randlane, Kärnefelt & Saag, Bryologist 98: 601. 1995.	Ahtiana pallidula (Tuck. ex Riddle) Goward & A. Thell	–
Cetrarioid core, position OK	Accepted name	Ahtiana sphaerosporella (Müll. Arg.) Goward	Bryologist 88: 370. 1986 [1985].	Ahtiana sphaerosporella (Müll. Arg.) Goward	–
	Synonym (homotypic)	Alectoria californica (Tuck.) G. Merr.	Bryologist 13: 29. 1910	Kaernefeltia californica (Tuck.) A. Thell & Goward	–
	Synonym (heterotypic)	Alectoria cetrariza Nyl.	Bull. Soc. Linn. Normandie 4, 1: 270. 1887	Kaernefeltia californica (Tuck.) A. Thell & Goward	USA, Oregon, Millamak; H-NYL 35973, holotype
	Synonym (homotypic)	Alectoria divergens (Ach.) Nyl.	Mém. Soc. Sci. Nat. Cherbourg 3: 171. 1855	Bryocaulon divergens (Ach.) Kärnefelt	–
	Synonym (homotypic), basionym	Alectoria satoana Gyeln.	in Satô, J. Jap. Bot. 10: 18. 1934	Bryocaulon satoanum (Gyeln.) Kärnefelt	Japan, Hondo, Nikko-Yumoto; Sato 101; BP, holotype
Cetrarioid core, position OK	Accepted name	Allocetraria ambigua (C. Bab.) Kurok. & M.J. Lai	Bull. Natl. Sci. Mus. (Tokyo), B 17: 62. 1991.	Allocetraria ambigua (C. Bab.) Kurok. & M.J. Lai	–
	Synonym (homotypic)	Allocetraria cucullata (Bellardi) Randlane & Saag	Mycotaxon 44: 492. 1992	Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell	–
Cetrarioid core, DNA not studied	Accepted name	Allocetraria denticulata (Hue) A. Thell & Randlane	in Thell, Randlane, Kärnefelt, Gao & Saag, Flechten Follmann, Contributions to Lichenology in Honour of Gerhard Follmann (Cologne): 359. 1995.	Allocetraria denticulata (Hue) A. Thell & Randlane	–
Cetrarioid core, DNA not studied	Accepted name	Allocetraria endochrysea (Lynge) Kärnefelt & A. Thell	Nova Hedwigia 62: 507. 1996.	Allocetraria endochrysea (Lynge) Kärnefelt & A. Thell	–
Cetrarioid core, position OK	Accepted name	Allocetraria flavonigrescens A. Thell & Randlane	in Thell, Randlane, Kärnefelt, Gao & Saag, Flechten Follmann, Contributions to Lichenology in Honour of Gerhard Follmann (Cologne): 359. 1995.	Allocetraria flavonigrescens A. Thell & Randlane	Nepal, Langtang, Pemdang Karpo; Miehe & Miehe 13056; 1986; GZU, holotype

Fig. 2. Users' interface of the world checklist of cetrarioid lichens generated by using the function "Find All", ordered alphabetically according to the field "Name" (excerpt from the full list containing 572 records, the beginning).

(2) Perform search by different fields; for conducting the search, use the button "Find" in the Menu bar. Simple search can be executed by the following fields:

(a) Accepted species—choose a name of accepted species on the drop-down list, and a catalogue of all names (heterotypic and homotypic synonyms, incl. basionyms) that ever have been applied to this species will be displayed together with additional data, such as literature source, type information, and status of the name (Fig. 3);

(b) Current status of the name—choose between "accepted name", "heterotypic synonym", "homotypic synonym" and "homotypic synonym, basionym" on the drop-down list;

(c) Phylogenetic status of accepted taxa—choose between "cetrarioid core", "cetrarioid core, position ok", "cetrarioid core, position unclear", "cetrarioid core, DNA not studied", "not in cetrarioid core", and "totally unknown" on the drop-down list;

(d) Type category—choose between "holotype", "lectotype", "neotype", "epitype", and "isotype" on the drop-down list;

(e) Type locality—choose country on the drop-down list;

(f) Genus—choose genus on the drop-down list (Fig. 4);

(g) Epithet—choose epithet on the drop-down list.

(3) Complex search is also possible when indicating certain states in more than one field (Fig. 5).

(4) Sort according to certain fields—lists compiled by functions "Find" or "Find All" can be sorted by clicking the header of any column on the list (Fig. 2).

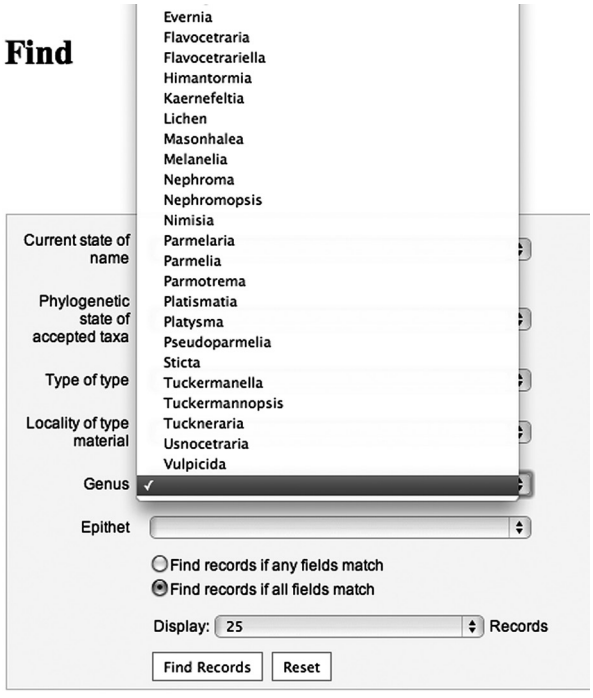
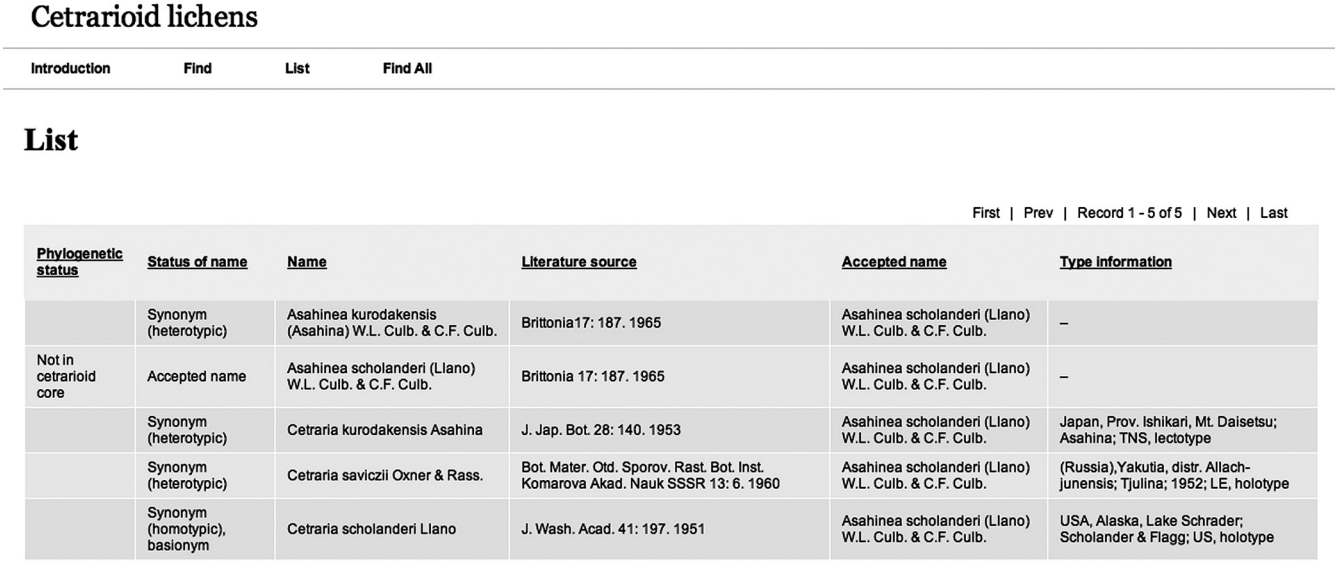


Fig. 4. Excerpt from the list of genera on the drop-down list when using the "Find" function.

■ DISCUSSION

Are checklists like these necessary at all? — Most checklists represent regional or local lists of species—usually those of countries but also of smaller administrative units, protected areas or other delimited localities (e.g., Esslinger & Egan, 1995; Coppins, 2002; Aptroot & al., 2004; Santesson & al., 2004; Urbanavichus, 2010; Feuerer, 2012). Checklists of certain systematical taxa or groupings of lichenized fungi have been compiled less frequently (Ahti, 1993; Randlane & Saag, 1993; Randlane & al., 1997; Hale & DePriest, 1999; Lücking



Phylogenetic status	Status of name	Name	Literature source	Accepted name	Type information
	Synonym (heterotypic)	Asahinea kurodakensis (Asahina) W.L. Culb. & C.F. Culb.	Brittonia17: 187. 1965	Asahinea scholanderi (Llano) W.L. Culb. & C.F. Culb.	–
Not in cetrarioid core	Accepted name	Asahinea scholanderi (Llano) W.L. Culb. & C.F. Culb.	Brittonia 17: 187. 1965	Asahinea scholanderi (Llano) W.L. Culb. & C.F. Culb.	–
	Synonym (heterotypic)	Cetraria kurodakensis Asahina	J. Jap. Bot. 28: 140. 1953	Asahinea scholanderi (Llano) W.L. Culb. & C.F. Culb.	Japan, Prov. Ishikari, Mt. Daisetsu; Asahina; TNS, lectotype
	Synonym (heterotypic)	Cetraria saviczii Oxner & Rass.	Bot. Mater. Otd. Sporov. Rast. Bot. Inst. Komarova Akad. Nauk SSSR 13: 6. 1960	Asahinea scholanderi (Llano) W.L. Culb. & C.F. Culb.	(Russia),Yakutia, distr. Allach-junensis; Tjulina; 1952; LE, holotype
	Synonym (homotypic), basionym	Cetraria scholanderi Llano	J. Wash. Acad. 41: 197. 1951	Asahinea scholanderi (Llano) W.L. Culb. & C.F. Culb.	USA, Alaska, Lake Schrader; Scholander & Flagg; US, holotype

Fig. 3. List of all synonyms that have been applied to one of the accepted species, *Asahinea scholanderi*, together with additional data, such as status of name, literature source and type information. The list is generated by quick search, choosing the name *Asahinea scholanderi* on the drop-down list of accepted species.

& al., 2006; Rivas Plata & al., 2006; Hawksworth & al., 2008). Nowadays numerous checklists of both types are replaced by digital databases (e.g., Nimis & Martellos, 2008; Søchting & Alstrup, 2008; Randlane & al., 2012; Diederich & al., 2012) which have several advantages compared with the traditional, printed checklists. Among the advantages of electronic media are speed of publication and distribution, flexibility in format and display, low cost and broad accessibility (Lücking & al., 2011). Digital checklists, based on databases, allow the users to perform different operations, including search and sorting. Once published online, the resulting lists can be updated or edited easily and in real time. Furthermore, there are almost unlimited possibilities to attach additional materials (e.g., descriptions, distribution data or maps, drawings or photos, etc.) to enlarge the usage of the checklists. Practical protocols for designing and setting up data collections of species and related biodiversity information contribute to promotion of the electronic data storage and exchange also concerning lichens (Grube, 2002; Rambold, 2002).

There is no doubt about the necessity of local checklists, however, the question arises whether checklists (and databases) of separate systematical taxa offering mainly nomenclatural information have any importance at present as comprehensive information about species and genera can be obtained in different worldwide digital web resources. To answer this question, we performed a simple comparison of five well-known and widely acknowledged databases, Index Fungorum (http://www.indexfungorum.org/names/names.asp), MycoBank (http://www.mycobank.org/), LIAS *names* together with LIAS *light* (http://www.lias.net/), Catalogue of Life (http://www.catalogueoflife.org/), and Encyclopedia of Life (http://eol.org/) by scanning the availability of mainly nomenclatural and taxonomical data of 30 selected cetrarioid names (10 accepted names, 10 homotypic and 10 heterotypic synonyms) (Tables 1–3). The data were retrieved from the databases and comparisons were performed during the period 19 Nov. 2012–26 Feb. 2013. Of the ten accepted species (*Ahtiana aurescens*, *Allocetraria globulans*, *Cetraria dermatoidea*, *Cetraria islandica*, *Cetrariella sorediella*, *Cetreliopsis hypotrachyna*, *Flavocetraria cucullata*, *Nephromopsis leucostigma*, *Parmotrema thomsonii*, *Vulpicida juniperinus*), three taxa, *Cetraria islandica*, *Flavocetraria cucullata*, and *Vulpicida juniperinus*, are widely distributed and commonly known while the others are of limited distribution in different parts of the world. One species, *Cetraria dermatoidea*, has been very poorly studied and its generic position is dubious. Two accepted combinations, *Cetreliopsis hypotrachyna* and *Nephromopsis leucostigma*, were proposed within this decade, and two further

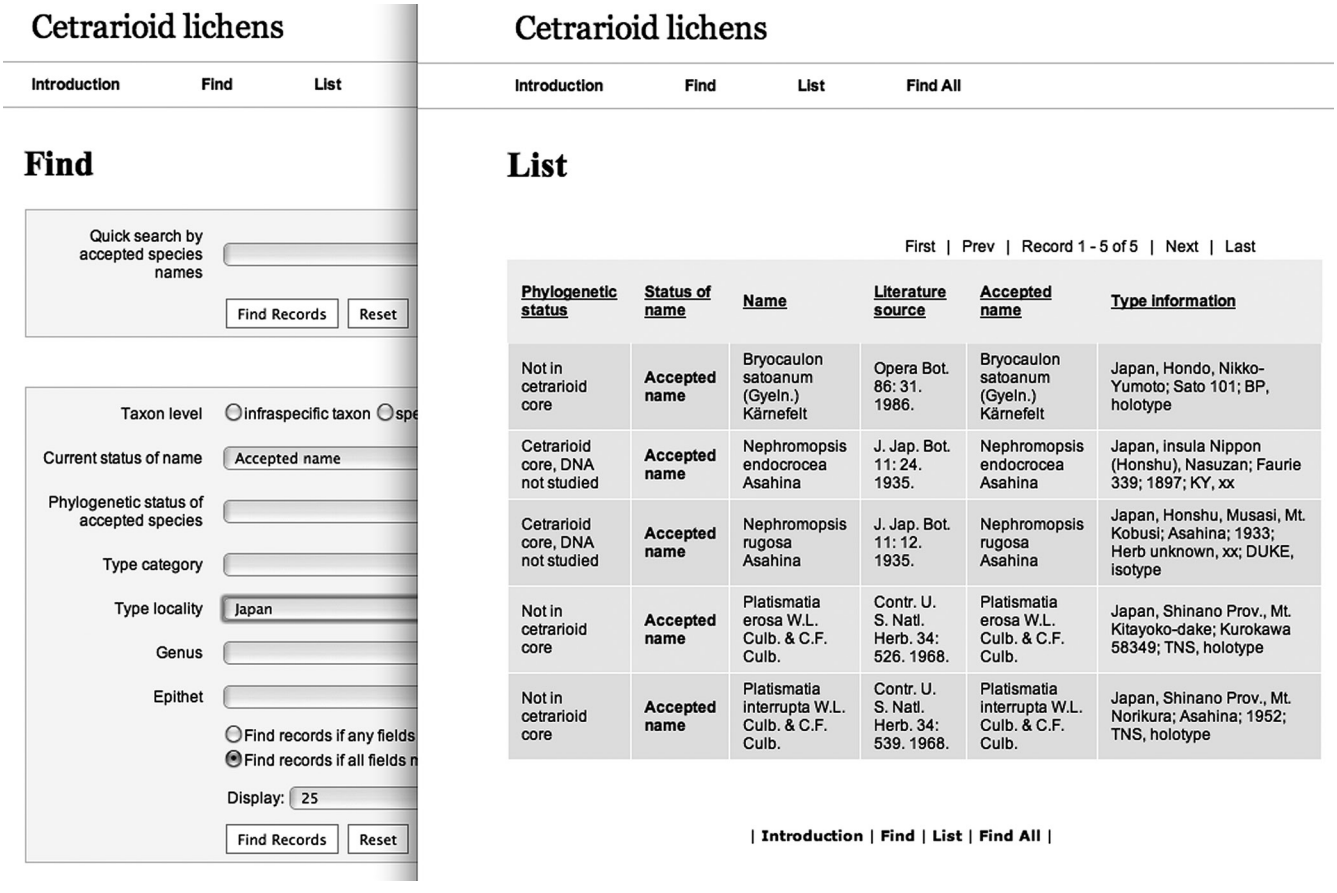


Fig. 5. An example of complex search—list of accepted species (5) when type locality is in Japan. The list is generated by complex search choosing "Accepted name" in the field "Current status of name" and "Japan" in the field "Type locality" (simple search choosing "Japan" in the field "Type locality" results in a list of 24 species).

combinations, *Parmotrema thomsonii* (Crespo & al., 2010) and *Cetrariella sorediella* (Nelsen & al., 2011), were suggested just recently. Among homo- and heterotypic synonyms both widely and scarcely known names were selected.

The scanned databases. — The five scanned taxonomic databases have been set up with different objectives which do, however, partially overlap.

(1) Index Fungorum, the global fungal nomenclature provider, is a community resource which is coordinated and supported by the Index Fungorum Partnership (with CABI and Landcare Research, New Zealand, as the custodians). It contains names of fungi (including yeasts, lichens, chroistan fungal analogues, protozoan fungal analogues and fossil forms) at all ranks. Index Fungorum declares to pursue the goal of rapid publication of new nomenclatural information, e.g., adding new names from the Index of Fungi (a print-only journal which lists recently published names of fungi compiled from world literature) every three months or incorporating names deposited within MycoBank in Index Fungorum as they are released (http://www.indexfungorum.org/). However, in practice this ambition has not been achieved yet.

(2) MycoBank is an on-line database aimed to document mycological nomenclatural novelties (new names and combinations) and associated data, for example descriptions and illustrations. Upon registration, MycoBank issues the novelties with a unique number that must be cited in the publication where the nomenclatural novelty is introduced. These numbers are also used by the nomenclatural database Index Fungorum, with which MycoBank is associated. Nomenclatural experts are available to check the validity, legitimacy and linguistic

Table 1. Main nomenclatural data according to the third world list of cetrarioid lichens for ten accepted species used for the comparison of five taxonomic databases; acceptability of generic position of taxa is evaluated according to the phylogenetic tree of the cetrarioid core group (Nelsen & al., 2011; see also Fig. 1)

Accepted name	Authors of the species	Bibliographic data	Basionym	Synonyms	Type information	Generic position
Ahtiana aurescens	(Tuck.) A. Thell & Randlane	in Thell & al., Bryologist 98: 599. 1995	*Cetraria aurescens* Tuck.	Homotypic	U.S.A., New Hampshire, White Mts; Tuckerman, 1848; FH-TUCK, lectotype	Cetrarioid core, position unclear
Allocetraria globulans	(Nyl.) A. Thell & Randlane	in Thell & al., Flechten Follmann, Contributions to Lichenology in Honour of Gerhard Follmann (Cologne): 360. 1995	*Platysma globulans* Nyl.	Homotypic	China, Yunnan; Delavay no 1570, 1885; H-NYL 36135, holotype	Cetrarioid core, acceptable
Cetraria dermatoidea	(Stirt.) Zahlbr.	Catal. Lich. Univer. 6: 286. 1929 [1930]	*Platysma dermatoideum* Stirt.	Homotypic	Unknown	Totally unknown
Cetraria islandica	(L.) Ach.	Meth. Lich.: 293. 1803	*Lichen islandicus* L.	Homotypic, heterotypic	LINN 1273.97, lectotype	Cetrarioid core, acceptable
Cetrariella sorediella	(Lettau) V.J. Rico & A. Thell	in Nelsen & al., Lichenologist 43: 548. 2011	*Cetraria commixta* f. *sorediella* Lettau	Homotypic	(Switzerland), Engadin; Lettau, 1912; B 13052, lectotype	Cetrarioid core, acceptable
Cetreliopsis hypotrachyna	(Müll. Arg) Randlane & Saag	Mycotaxon 87: 482. 2003	*Cetraria hypotrachyna* Müll. Arg.	Homotypic	India, Manipur; Watt 6949; BM, holotype	Cetrarioid core, DNA not studied
Flavocetraria cucullata	(Bellardi) Kärnefelt & A. Thell	in Kärnefelt & al., Acta Bot. Fenn. 150: 81. 1994	*Lichen cucullatus* Bellardi	Homotypic, heterotypic	(Italy), monte Ritten presso Bolzano; Hausmann & Carestia, 1862; FI, neotype	Cetrarioid core, acceptable
Nephromopsis leucostigma	(Lév.) A. Thell & Randlane	in Thell & al., Mycol. Progr. 4: 311. 2005	*Cetraria leucostigma* Lév.	Homotypic, heterotypic	India orientalis; Léveillé; H-NYL 36083, neotype	Cetrarioid core, acceptable
Parmotrema thomsonii	(Stirt.) A. Crespo, Divakar & Elix	in Crespo & al., Taxon 59: 1746. 2010	*Platysma thomsonii* Stirt.	Homotypic, heterotypic	India, Darjeeling; Thomson no 36; GLAM, holotype	Not in cetrarioid core
Vulpicida juniperinus	(L.) J.-E. Mattsson & M.J. Lai	Mycotaxon 49: 427. 1993	*Lichen juniperinus* L.	Homotypic	Sweden, Härjedalen, Storsjö; Mattsson no 2340, 1991; LD, neotype; typ. cons.	Cetrarioid core, acceptable

correctness of the proposed names in order to avoid nomenclatural errors; however, no censorship is exerted by MycoBank. Deposited names remain strictly confidential until after publication, and will then be accessible through MycoBank, Index Fungorum, GBIF and other international biodiversity initiatives (http://www.mycobank.org/). MycoBank was launched in 2004 as a system for voluntary recording of fungal nomenclatural novelties (Crous & al., 2004). According to Art. 42 in the *Melbourne Code* (McNeill & al., 2012), on or after 1 January 2013, the publication of a new fungal name must include "the citation in the protologue of the identifier issued by a recognized repository" as an additional requirement for valid publication. Appointing one or more open and accessible electronic repositories for this purpose is in the power of the Nomenclature Committee for Fungi, which has recently supported recognition of three official repositories, Fungal Names, Index Fungorum, and MycoBank, starting 1 January 2013 (Redhead & Norvell, 2013).

(3) LIAS is a global information system for lichenized and non-lichenized ascomycetes since 1993 (editing institution Botanische Staatssammlung München, Department of Mycology). One of its goals is to establish a worldwide database of data connected with taxonomic names of all ascomycetes (http://www.lias.net/). This goal is executed through LIAS *names* while another subsystem, LIAS *light*, offers also descriptive data for species identification, and global distributional data. Therefore, all three major data domains in biology are provided by this database (Triebel & al., 2010). Furthermore, interactive keys using NaviKey application for the identification of taxa on genus and species levels are also available.

Table 2. Main nomenclatural data according to the third world list of cetrarioid lichens for ten homotypic synonyms used for the comparison of five taxonomic databases; the cell "Basionym" is marked with—for those homotypic synonyms that act also as basionyms; acceptability of generic position of taxa is evaluated according to the phylogenetic tree of the cetrarioid core group (Nelsen & al. 2011; see also Fig. 1)

Homotypic synonym	Author(s) of the synonym	Bibliographic data	Basionym	Accepted name	Type information	Generic position of the accepted name
Alectoria satoana	Gyeln.	in Satô, J. Jap. Bot. 10: 18. 1934	–	*Bryocaulon satoanum* (Gyeln.) Kärnefelt	Japan, Hondo, Nikko-Yumoto; Sato 101; BP, holotype	Not in cetrarioid core
Cetraria braunsiana	(Müll. Arg.) Zahlbr.	Bot. Mag. (Tokyo) 41: 353. 1927	*Parmelia braunsiana* Müll. Arg.	*Cetrelia braunsiana* (Müll. Arg.) W.L. Culb. & C.F. Culb.	Japan, Tokyo; Brauns 2 (p.p.); G, holotype	Not in cetrarioid core
Cetrelia rhytidocarpa	(Mont. & Bosch) Lumbsch	in Eriksson & Hawksworth, Syst. Ascom. 7: 105. 1988	*Cetraria rhytidocarpa* Mont. & Bosch	*Cetreliopsis rhytidocarpa* (Mont. & Bosch) M.J. Lai	(Indonesia), Java; Junghuhn; PC, lectotype; Herb. v.d. Bosch	Cetrarioid core, acceptable
Coelocaulon steppae	(Savicz) Barreno & Vázquez	Lazaroa 3: 239. 1981 [1982]	*Cornicularia steppae* Savicz	*Cetraria steppae* (Savicz) Kärnefelt	Ukraine, Askania Nova, Gub. Jekaterinoslav; Oxner, 1924; LE, lectotype	Cetrarioid core, DNA not studied
Evernia richardsonii	(Hook.) Nyl.	Mém. Soc. Sci. Nat. Cherbourg 5: 99. 1858 [1857]	*Cetraria richardsonii* Hook.	*Masonhalea richardsonii* (Hook.) Kärnefelt	(U.S.A.), Barren grounds; Franklin, 1820; BM, lectotype	Cetrarioid core, acceptable
Platysma lacunosum	(Ach.) Nyl.	Bot. Not. 1855: 137. 1856 [1855]	*Cetraria lacunosa* Ach.	*Platismatia lacunosa* (Ach.) W.L. Culb. & C.F. Culb.	North America; Herb. Swartzii; S, neotype	Not in cetrarioid core
Ramalina lugubris	Hue	Lich. 2. Expédit. Antarct. Franc. 1908–10: 34. 1915	–	*Himantormia lugubris* (Hue) I.M. Lamb	Antarctica, Petermann Isl., Palmer Pen.; 1908, US, isotype	Not in cetrarioid core
Tuckermannopsis oakesiana	(Tuck.) Hale	in Egan, Bryologist 90: 164. 1987	*Cetraria oakesiana* Tuck.	*Usnocetraria oakesiana* (Tuck.) M.J. Lai & J.C. Wei	U.S.A., White Mts; Oakes, 1839; FH, lectotype	Cetrarioid core, acceptable
Tuckneraria pseudocomplicata	(Asahina) Randlane & Saag	in Randlane, Saag, Thell & Kärnefelt, Acta Bot. Fenn. 150: 150. 1994	*Cetraria pseudocomplicata* Asahina	*Nephromopsis pseudocomplicata* (Asahina) M.J. Lai	Japan, Shikoku, Iyo Pref., Mt. Ishizuchi; Fujikawa; DUKE, lectotype	Cetrarioid core, acceptable
Usnocetraria weii	(X.Q. Gao & L.H. Chen) M.J. Lai & J.C. Wei	in Lai, Qian & Xu, J. Natnl. Taiwan Mus. 60(1): 59. 2007	*Nephromopsis weii* X.Q. Gao & L.H. Chen	*Tuckermannopsis weii* (X.Q. Gao & L.H. Chen) Randlane & Saag	China, Prov. Fujian, Wuyi Mt.; Gao, 1988; HMAS-L, holotype	Cetrarioid core, DNA not studied

(4) Catalogue of Life, which is a common product of the Species 2000 and ITIS organisations, is planned to become a comprehensive catalogue of all known species of organisms on Earth (Roskov & al., 2013). Its structure includes the species checklist, which contains the names that are accepted by authoritative specialists in the groups concerned, and the classification, providing hierarchical view of relationships between taxa. The web resource provides critical species information on synonymy, and distribution, identifying the global regions from which a species is known (http://www.catalogueoflife.org/info/about).

(5) The fifth of the scanned databases, Encyclopedia of Life (EOL), attempts to centralize information on the biodiversity and to provide means of quality control, in order to present the compiled information in a concise form which appeals to a wide audience. Thus EOL has the ambitious goal to serve both the scientific community and the public (Lücking & al., 2011). When complete, EOL is supposed to provide trusted comprehensive information for every named species on Earth. Besides textual information, the importance of pictures is highlighted (http://eol.org/).

The scanned data. — The results (Electr. Suppl.: Tables S1–S3) demonstrate that none of the scanned databases comprises the complete and correct set of nomenclatural data for the scanned names; "complete and correct" is a relative assessment,

Table 3. Main nomenclatural data according to the third world list of cetrarioid lichens for ten heterotypic synonyms used for the comparison of five taxonomic databases; the cell "Basionym" is marked with—for those synonyms that act also as basionyms; acceptability of generic position of taxa is evaluated according to the phylogenetic tree of the cetrarioid core group (Nelsen & al. 2011; see also Fig. 1)

Homotypic synonym	Author(s) of the synonym	Bibliographic data	Basionym	Accepted name	Type information	Generic position of the accepted name
Ahtia wallichiana	(Taylor) M.J. Lai	Quart. J. Taiwan Mus. 33: 220. 1981 [1980]	*Sticta wallichiana* Taylor	*Nephromopsis pallescens* (Schaer.) Y.S. Park	Nepal; Wallich; G 2003/2, lectotype	Cetrarioid core, acceptable
Asahinea culbersoniorum	Trass	Folia Cryptog. Estonica 29: 31. 1992	–	*Asahinea chrysantha* (Tuck.) W.L. Culb. & C.F. Culb.	Russia, Primorsky Territory, Kitovoye Rebro; Trass As-3, 1977; TU, holotype	Not in cetrarioid core
Cetraria alvarensis	(Wahlenb.) Vain.	in Lynge, Bergens Mus. Aarb. 9: 76. 1910	*Lichen juniperinus* var. *alvarensis* Wahlenb.	*Vulpicida tubulosus* (Schaer.) J.-E. Mattsson & M.J. Lai	(Sweden), Öland; Wahlenberg; UPS, lectotype	Cetrarioid core, acceptable
Cetraria capitata	Lynge	Rep. Sci. Results Norw. Exped. Nov. Zemlya 43: 208. 1928	–	*Cetraria nigricans* Nyl.	(Russia), Novaya Zemlya, Goose Bay; Lynge, 1921; O, holotype	Cetrarioid core, acceptable
Cetraria straminea	Kremp. ex Schwend.	in Nägeli, Beitr. Wiss. Bot. (Leipzig) 2: 154. 1860	–	*Nephromopsis laureri* (Kremp.) Kurok.	Unknown	Cetrarioid core, acceptable
Cetraria straminea (nom. illeg.)	Vain.	Philipp. J. Sci. Bot. 4: 657. 1909	–	*Cetreliopsis rhytidocarpa* (Mont. & Bosch) M.J. Lai	Philippines, Luzon, Prov. Laguna, Mt. Banajao; Curran & Merritt 7988; US, isotype	Cetrarioid core, acceptable
Cornicularia gracilenta	(Kremp.) Zahlbr.	Catal. Lich. Univer. 6: 414. 1929 [1930]	*Cetraria aculeata* var. *gracilenta* Kremp.	*Coelopogon epiphorellus* (Nyl.) Brusse & Kärnefelt	(Chile), Sandy Point; Lechler; W, lectotype	Not in cetrarioid core
Nimisia fuegiae	Kärnefelt & A. Thell	Lichenologist 25: 370. 1993	–	*Himantormia deusta* (Hook. f.) A. Thell & Søchting	Argentina, Isla Grande de Tierra del Fuego, Sierra Alvear; Nimis & Tretiach, 1987; LD, holotype; TSB, DUKE, isotypes	Not in cetrarioid core
Parmelia rubescens	(Th. Fr.) Vain.	Bot. Mag. (Tokyo) 35: 47. 1921	*Parmelia perlata* f. *rubescens* Th. Fr.	*Cetrelia olivetorum* (Nyl.) W.L. Culb. & C.F. Culb.	Switzerland; H-ACH, lectotype	Not in cetrarioid core
Platysma triste	(Weber ex F.H. Wigg.) Nyl.	Syn. Lich. 1: 81. 1860	*Lichen tristis* Weber ex F.H. Wigg.	*Cornicularia normoerica* (Gunnerus) Du Rietz	Herb. Dillenius, illustr. in Hist. Musc. 17, fig. 37; OXF, lectotype	Not in cetrarioid core

rated by the comparison to the data available in the third world list of cetrarioid lichens (Tables 1–3), which, however, itself may contain gaps and errors. Descriptional, distributional and illustrative materials are less often presented than nomenclatural data. Different types of data are provided on different levels in the tested nomenclatural databases (Figs. 6–9; coloured versions as Figs. S1–S4 in the Electr. Suppl.).

(1) Accepted names together with the authors' names and bibliographic data are available for most scanned species; only one species, *Cetraria dermatoidea*, a poorly studied taxon with dubious generic position, was missing in all databases. Index Fungorum and MycoBank present correct nomenclatural data for more taxa than other databases. EOL has currently also a good representation of the species but bibliographic data are not available for all of them. In LIAS *names* two species are missing and for other two the generic position is not updated according to the latest phylogenies. Catalogue of Life is currently deficient concerning the scanned group of lichenized fungi.

(2) The status of the name is clearly declared only occasionally in all tested databases; LIAS *names* offers this information more often than others. We consider that kind of

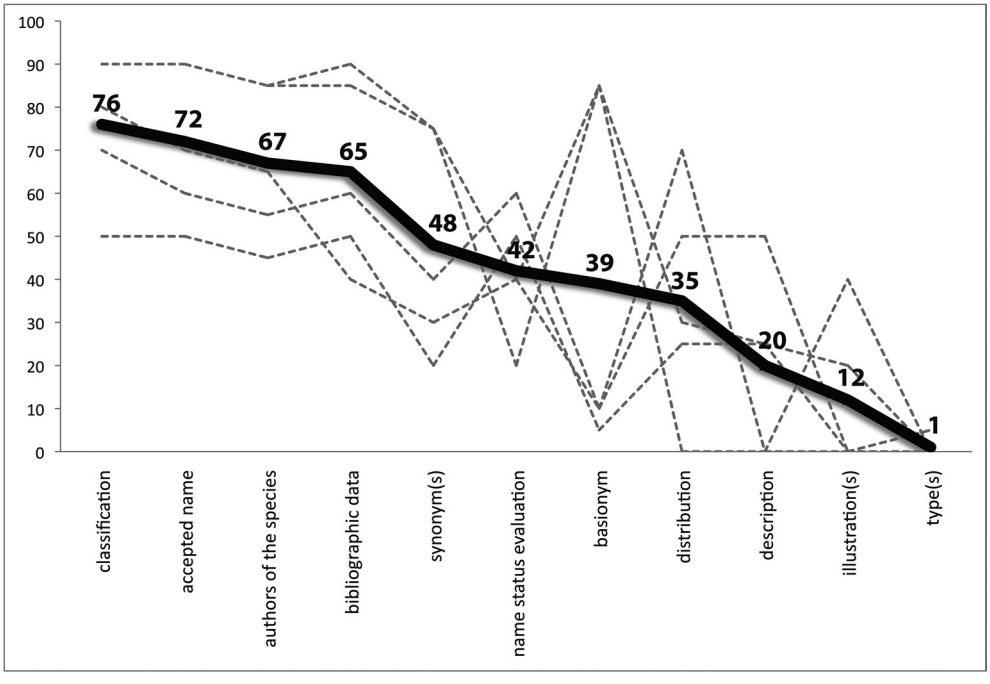


Fig. 6. Availability of nomenclatural, descriptive and distributional information about ten scanned accepted species (see Table 1) in five widely used global databases, in percentages, from maximum possible information (see Electr. Suppl.: Table S1); the bold line indicates mean values for each scanned data. Available also in coloured version as Fig. S1 in the Electronic Supplement.

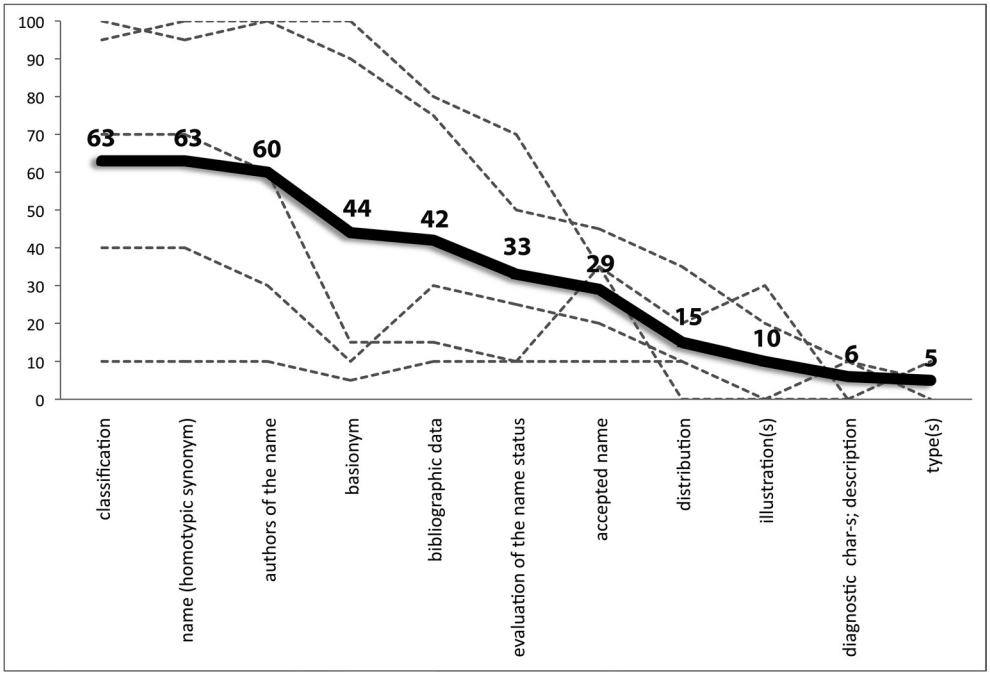


Fig. 7. Availability of nomenclatural, descriptive and distributional information about ten scanned homotypic synonyms (see Table 2) in five widely used global databases, in percentages, from maximum possible information (see Electr. Suppl.: Table S2); the bold line indicates mean values for each scanned data. Available also in coloured version as Fig. S2 in the Electronic Supplement.

evaluation most important as this might be of great help for non-specialists ("the tribe of Name-users").

(3) Basionyms are usually presented in Index Fungorum and MycoBank, and absent in LIAS *names*, Catalogue of Life and EOL. In a few cases, the basionym is listed among other synonyms but it is not indicated as the basionym.

(4) Homotypic synonyms are very well represented in Index Fungorum and MycoBank, partly in EOL and LIAS *names*, and poorly in Catalogue of Life.

(5) The representation of heterotypic synonyms is good in Index Fungorum, MycoBank and EOL, rather poor in LIAS *names* and very poor in Catalogue of Life. However, in most cases it is not indicated that these names appear as synonyms to other, accepted names, therefore, a misleading impression is created as if those names represent independent species.

(6) Type information is almost not available in any of these databases.

(7) Classification above genus is presented for all taxa in all databases.

(8) Information about the distribution is totally absent in Index Fungorum and partially presented in other four databases. MycoBank provides links to other web resources,

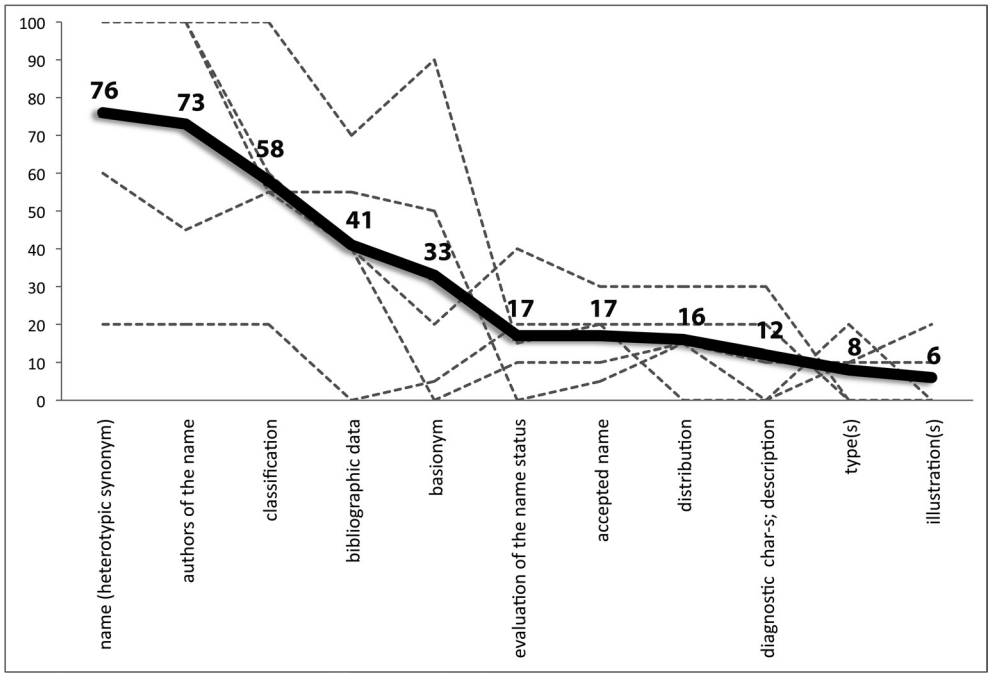


Fig. 8. Availability of nomenclatural, descriptive and distributional information about ten scanned heterotypic synonyms (see Table 3) in five widely used global databases, in percentages, from maximum possible information (see Electr. Suppl.: Table S3); the bold line indicates mean values for each scanned data. Available also in coloured version as Fig. S3 in the Electronic Supplement.

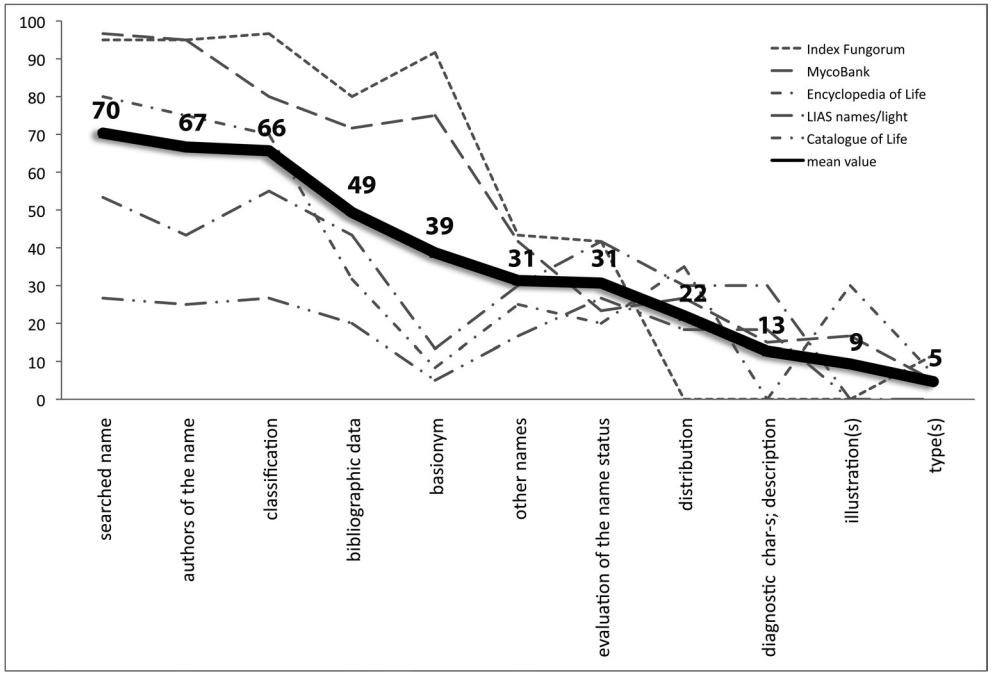


Fig. 9. Summary – availability of nomenclatural, descriptive and distributional information about 30 scanned cetrarioid names in five widely used global databases, in percentages, from maximum possible information; the bold line indicates mean values for each scanned data. Available also in coloured version as Fig. S4 in the Electronic Supplement.

including LIAS *light*, Catalogue of Life and EOL. EOL presents original global distribution maps (occasionally of deficient data) for all included species.

(9) Diagnostic characters are originally compiled for half of the accepted species in LIAS *light*, and the same information is distributed through links also by MycoBank and Catalogue of Life.

(10) Illustrations (photos) are originally presented exclusively in EOL (for nine species of the tested 30 taxa), and are distributed through links also by MycoBank.

In conclusion, it is fairly easy to obtain trustworthy information about the accepted scientific names with their authors and bibliographic references, and about classifications above genus. The status of the name is not often evaluated and this is especially misleading in the case of synonyms; basionyms are presented in some databases; homotypic and heterotypic synonyms are differently represented in different bases while the information about types is not available in any of the tested web resources. Additional data, such as descriptions, global distribution maps or illustrations are not common (Figs. 6–9).

The aim of this comparison is not to rank the databases within a grading system according to their "completeness and correctness" as the objectives of these resources are declared to be divergent, and the selection of scanned species is not wide enough for generalization. However, the useful traits of each database have been revealed (Fig. 9; Electr. Suppl.: Figs. S1–S4). Index Fungorum and MycoBank are both essential but still not identical resources for various nomenclatural data. Besides nomenclatural data, MycoBank provides several links to other biodiversity databases offering thus additional knowledge. LIAS *names* together with LIAS *light* forms a complex system supplying nomenclatural information together with descriptive and distributional data, and identification tools. These three databases are specifically focused to gather the information about fungal species. Two further networks, Catalogue of Life and EOL, attempt to provide comprehensive information for species of all organism groups on Earth. Therefore it is quite understandable that not all scanned cetrarioid species are represented there. In both of them medium amount of nomenclatural data is available for the species included; in addition, Catalogue of Life offers descriptions and distribution information (compiled by LIAS *light*). EOL presents global distribution maps for most included species, and is the single one providing illustrations.

Towards a worldwide checklist of *Parmeliaceae*. — The necessity for a reliable source of nomenclatural data related to the species names within families was clearly expressed in 1990s by calling into existence the project Names in Current Use (NCU). For lichenized fungi, a single list was compiled in the framework of this project, for the family *Cladoniaceae* (in the ranks of genus to variety) (Ahti, 1993). Although the proposal to protect listed names as if conserved by the *Code* (Greuter, 1991) was regretfully not accepted, lists with detailed nomenclatural data (including precise type information) had been compiled and published for some plant and fungal families, demonstrating thus, among other issues, the importance of nomenclatural knowledge.

The fact that nomenclatural information concerning cetrarioid lichens, a small and relatively well studied group of lichenized fungi, is still incomplete in the leading global databases, leads us to the conclusion that comparatively small taxonomic databases containing certain systematical taxa, e.g., genera and families, or other suggestively phylogenetic groupings, and providing optimal set of nomenclatural, continuously updated data controlled by recognized specialists, are still required—as an interim stage. An objection to this conclusion could be that specialists should contribute to existing worldwide databases instead. A future challenge in biodiversity informatics would be that a specialist submits the same data only once to the leading global database. This, however, requires an integrated data flow between different data repositories, networks and portals (Triebel & al., 2010).

The development of the world checklist of the family *Parmeliaceae* was discussed during the two workshops which were held as Encyclopedia of Life BioSync meetings in Chicago in May 2010 ("*Parmeliaceae*: Improving our understanding of taxonomy, classification and biogeography of the largest family of lichen-forming fungi") and in Bangkok in January 2012 ("*Parmeliaceae*: Towards a worldwide checklist and a phylogenetic classification of the largest family of lichen-forming fungi") (see also the Editorial and papers published in *The Lichenologist*, vol. 43, part 6, 2011).

As one outcome of the first meeting, it was agreed to produce sample species pages for each accepted genus within *Parmeliaceae*, to be imported into the EOL. Once these sample pages have been created, groups of specialists will assume responsibility to add further species pages to all genera, to gradually extend and complete the dataset (Lücking & al., 2011). In this way, the system of EOL species pages will also serve for a worldwide checklist of the whole family in the future. However, creating such species pages for each of the ca. 2700 species in *Parmeliaceae* is a time-consuming process. Meanwhile the solid collections of nomenclatural data, which have been critically evaluated by the specialists in the form of checklists might be a useful transitional stage towards a worldwide checklist of the entire family *Parmeliaceae*.

Lessons learned. — Our experience with preparing the third world checklist of cetrarioid lichens clearly pointed to a number of shortcomings—listed below—in nomenclature and/or phylogenetic studies of this group of lichenized fungi, as well as in the accuracy of different widely used nomenclatural web resources. We hope that knowledge about the shortage in information would help to improve the situation.

(1) Some species (6) which formally belong to the cetrarioid genera have been totally "forgotten"—they are known only by the original description or have been only superficially examined meaning that these names could be synonyms of other species or even the taxa may belong to genera outside of the cetrarioid core group. The list of such taxa can be obtained from the digital checklist (http://esamba.bo.bg.ut.ee/checklist/cetrarioid), by performing the search in the field "Phylogenetic status of accepted taxa", when choosing the option "totally unknown".

(2) Some species (9) have the generic position which is not satisfactory according to molecular phylogenetic analyses,

still, they are not yet converted as it is not clear where they belong. The list of such taxa can be obtained from the digital checklist, by performing the search in the field "Phylogenetic status of accepted taxa", when choosing the option "cetrarioid core, position unclear".

(3) For several species from the cetrarioid core group (29) DNA has not yet been studied and phylogenetic analyses performed. This means that the generic position of these taxa has not been confirmed and may possibly change in future; the list can be obtained from the digital checklist, by performing the search in the field "Phylogenetic status of accepted taxa", when choosing the option "cetrarioid core, DNA not studied".

(4) For several species (26) the type information is still not presented. It is possible that part of these taxa lack typifications, and for another part the according information has not been detected yet.

(5) Almost any kind of information about almost any species is available in the Internet, while no one web resource contains the complete and correct information. Different databases should be visited and data compared and double-checked for filtering precise information.

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"Name-users gain knowledge by learning and using names. But the Real Taxonomists produce brand new knowledge for mankind. Why should these tribes fight against each other? Do we really need this conflict?" asked Nimis (2001) and proposed drastic solutions to settle the war—"get rid of the binomials" and provide "a number or barcode, the best food for computer" for the species, while existing Latin names "could find a place in the list of "mid-level names" for half-educated people, like most of us". More than a decade passed since this radical vision was put forward, and the situation with scientific names is still exactly the same. Our proposal is modest and simple compared to that by Nimis—compile and use checklists as dictionaries for translating the names of taxa from one tribe language into another!

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