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EARLY LAND PLANTS TODAY: GLOBAL PATTERNS OF LIVERWORT DIVERSITY, DISTRIBUTION, AND FLORISTIC KNOWLEDGE

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SUMMARY

Liverworts (Marchantiophyta) are pivotal in our understanding of early land plant evolution and they form both a conspicuous and important component in many terrestrial ecosystems throughout the world. Studies of terrestrial diversity patterns on global scales, based on quantitative data, have been largely confined to vascular plants and animals. We here present a preliminary data set recording the distribution of liverwort species across almost 400 geo-political units based on almost 40,000 records from over 600 publications. This database is the most comprehensive catalogue of liverwort species worldwide, attempting to unify taxonomy, nomenclature, and distribution from the vastly scattered biological literature. The development of such a database has far reaching implications and applications, including relating biodiversity patterns to anthropogenic threats or to abiotic drivers of species richness. It also makes significant steps toward the compilation of a worldwide checklist of liverworts. Three examples are here demonstrated: i) a preliminary global map of liverwort species richness; ii) diversity patterns of the family Lejeuneaceae compared to the overall liverwort flora; and iii) we highlight centers of significant liverwort species richness that are totally neglected by well-known global diversity hotspots analyses. Although there are many challenges ahead to obtain high quality data, quantifying global liverwort diversity is a tractable, multi-faceted and scientifically important goal, and everyone stands to gain by fostering this endeavour. Web-based technology is promoted as a medium to enable the bryological community to work effectively in identifying and recording the immensely scattered data and on reaching consensus. Finally, it cannot be urged enough that there is a desperate and urgent need for survey and floristic work in many regions throughout the world as well as monographic and revision studies for many taxonomic groups.

KEYWORDS: Conservation, distribution patterns, diversity, liverworts, Marchantiophyta, species richness

Aims. The underlying objective is to work towards unifying the vastly scattered data on liverwort taxonomy, nomenclature, and distribution. Application of the preliminary unified data set is illustrated with studies of species richness, patterns of diversity, and conservation.

Methods. We compiled data on the distribution of liverwort species across almost 400 geo-political units based on almost 40,000 records from over 600 publications. Monographs and revisions coupled with contributions from colleagues were used for quality control and cross referencing for synonymy and distribution data. Global species richness maps were constructed standardizing for area using the classical species-area model of Arrhenius.

Results. We present the first-ever preliminary global map of liverwort species richness. Application of the data set to the study of diversity patterns is illustrated by examining the largest liverwort family, Lejeuneaceae, which may comprise between 50 and 90% of liverwort species present in many Neotropical and Paleotropical regions of the world. Finally, we show that many regions of the world high in liverwort diversity do not coincide with currently designated global biodiversity hotspot analyses.

Conclusions. The vastly scattered liverwort literature remains a considerable obstacle to the study of species richness, patterns and process of diversity, and conservation. The unification of nomenclature and distribution data has many implications and useful applications in these areas. This data set will also serve in taxonomists' efforts towards developing a working list of all known liverwort species – a target to be reached by 2010 set by the Global Strategy for Plant Conservation. Web-based technology will be a useful tool in this endeavour. This will be an ongoing effort as new data and information is acquired, especially as there remains an urgent need for floristic work in the many regions throughout the world that lack checklists and even records, and the many liverwort genera and families that lack a modern taxonomic treatment.

> "……Charles Darwin wrote of his desire to provide financial support 'for the formation of a perfect M.S. catalogue of all known plants' (Darwin 1881, letter 13570). It is a personal embarrassment to me, and should be chastening to us all, that more than 120 years later we still have not delivered on that commitment." (Crane, 2004).

INTRODUCTION

The natural world is changing fast (Balmford *et al*., 2005). The adoption of the Global Strategy for Plant Conservation (GSPC) as part of the Convention on Biological Diversity (CBD) has reinforced the urgent need for a global plant checklist to support, facilitate and monitor the conservation and sustainable use of plant diversity worldwide (Lughadha, 2004). Without this list many of the other objectives in the GSPC cannot be met and more broadly, in botanical science as a whole, our ability to communicate about plants on a global basis will be compromised (Crane, 2004). Detailed information about spatial patterns of phytodiversity are also a central prerequisite to reach the targets set by the CBD and the GSPC, which include protecting 50% of the most important centers of plant diversity and to conserve 60% of the world's most threatened species *in situ* by the year 2010 (Barthlott *et al*., 2005).

For liverworts (Marchantiophyta), there remains no central source that provides a synthesis of nomenclatural data and global distributional data. This presents a major impediment for the study and analysis of species richness, distribution patterns, and conservation research at both regional and global scales. Yet, this group of land plants is of critical biological, ecological, and phylogenetic significance (e.g., Asakawa, 1998; Hallingbäck & Hodgetts, 2000; Longton, 1992; Gradstein *et al.*, 2001; Wellman *et al.*, 2003; Qiu *et al.*, 2006). Recently, liverworts, in concert with mosses and hornworts, have also been considered to play a significant role in the global carbon budget (O'Neill, 2000) and CO_2 exchange (De Lucia *et al.*, 2003), and have been used as indicators of past climate change, to validate climate models, and potential indicators of global warming (Gignac, 2001). Thus a global data set of liverwort species richness and global representation analyses has vast potential, not only in aiding our understanding of liverwort diversity, patterns, and processes, but also to the broader biological community.

We here introduce and promote a community approach to working towards unifying nomenclatural and distributional data on a global scale, and providing a comprehensive global liverwort checklist. In this paper we provide an overview of the preliminary data set derived from our database. We also discuss the broader implications of such a data set, and specifically illustrate its application to investigating species richness, distribution patterns, and conservation research. The quality of the underlying data is discussed along with lingering challenges in working towards a comprehensive global liverwort database. Finally, we conclude that several features of web-based technology make it an appealing tool to enable the community to work towards the production of a working list of global liverwort species.

MATERIALS AND METHODS

Data availability and information needs

A fundamental problem common to all nomenclatural indexing projects is the dispersed nature of the biological literature, some of which may date back over 250 years (Lughadha, 2005). Our own data records, from 1990 to present alone, indicate there are over 85 periodical titles and non-serials in which liverwort nomenclatural novelties were published. New records and distributional ranges are even more scattered in their occurrence, appearing in ecological treatises, non-serials, newsletters, and the mainstream taxonomic literature, not to mention unpublished data. The most useful and successful web-accessible bryophyte nomenclatural database is MOSs TROPICOS (http://www.mobot.org/MOBOT/tropicos/most/iom.shtml), which offers name data with references and type information as well as links to specimen data of its holdings. TROPICOS has therefore become an indispensable reference for anyone dealing with bryophyte names. The database is particularly strong for mosses. In contrast, nomenclatural and auxiliary data for liverworts is less comprehensive and more incomplete, especially for larger genera. Moreover, TROPICOS does not necessarily prescribe taxonomic disposition of names, i.e., there is no attempt to adopt a single consistent view on the status of any particular name (Lughadha, 2005). Data on the distributional range for a record is also completely lacking. This renders the data extremely useful to a specialist but limits its utility to users with broader interests.

A major nomenclatural work is the *Index Hepaticarum*, which includes all effectively published liverwort epithets spanning 12 volumes with the closing date of 1973. The indexes were prepared as a purely nomenclatural resource and did not claim to express any particular taxonomic concept. Recently, Crosby & Engel (2005) provide an equally valuable nomenclatural resource and catalog of names at all ranks for liverworts and hornworts published during 1974 to 2000. Subsequently, indices of the citations for names published for bryophytes have been compiled for the years 2001-2004 (Crosby & Magill, 2005) and 2005 (Crosby & Magill, 2006). The usefulness of indices is beyond dispute despite their limitations. However, a central data source that works towards reaching a consensus on accepted taxa and that unifies nomenclatural data and global distribution data remains a critical need. This disconnect is the impetus for this ongoing project.

Data structure and quality

The unpublished data set includes two core elements: nomenclatural data and geographical data. Nomenclatural data includes name, authority, original citation, and type data. Geographic data includes country, state/province, or a specific local region. To date data has been obtained from over 600 publications. Checklists form the foundation of the data and in this first phase were obtained from mainly post-1980 publications. An intense systematic assessment has focused on data quality. This was in an effort to reduce potential problems with synonymy arising from older literature, especially the *Species Hepaticarum* of Franz Stephani (see Gradstein, 2006a for an assessment of this publication), coupled with the assumption that concepts of taxa would be improved over time, i.e., concepts of taxa are less established in older literature because they had not been tested by the course of time. Monographs, revisions, books, and authoritative works (e.g., Crosby & Engel, 2005) are also extensively used, especially for quality control in terms of cross-referencing with checklists for synonymy and verification of distribution. Contributions were also actively encouraged from the bryological community. Specimen data cited from comprehensive catalogues and monographic and revision works are being incorporated into the data set, although this level of the data remains at an embryonic stage.

Mapping

The maps were produced from our unpublished data set and included the approximately 6500 binomials we accept at this preliminary stage. All names that could not be reconciled were excluded. Infraspecifc taxa were also excluded from the data set. The world maps of species richness were produced using the inventory-based mapping approach. Species richness here refers to an area of 10,000 km^2 standardized by the species-area relationship of Arrhenius (1920, 1921). As a first approximation, we used the value of 0.25 for the parameter z determining the slope of the species-area relationship in this formula. This value is discussed by Rosenzweig (1995) and Kier *et al.* (2005). The standard area of 10,000 km^2 offers a sufficient spatial resolution and is regarded as suitable for large scale conservation approaches (Mutke *et al.*, 2005).

RESULTS AND DISCUSSION

The underlying data set of liverwort diversity has broad and far-reaching ramifications. At its most fundamental, the data can contribute to Target 1 - towards a working list of known plant species by 2010 - as set by the Global Strategy for Plant Conservation (GSPC). Important practical, intellectual or academic applications of the data include: i) aid in herbarium curation, ii) powerfully inform biogeographical and conservation research, iii) help prioritize and identify geographical gaps in floristic knowledge for future surveys and data collection, and iv) be used for a wide set of analyses relating biodiversity patterns to anthropogenic threats or to abiotic drivers of species richness. Here we illustrate application of the data set to various elements relating to species richness, distribution patterns, and conservation.

Towards a working data set

The working data set is largely derived from over 600 publications (excluding original citations) and includes: approximately 22,000 published liverwort names (including "accepted" taxa and synonyms); over 60,000 observations (a single observation is a record of one taxon from one geo-political unit); and almost 400 geo-political units, e.g., local region, state, province, or country. To date, in this preliminary set of data we have approximately 6,500 accepted binomials. It is important to realize that the dataset is in a constant state of flux as i) new data comes to hand, ii) increased monographic and revision work takes place, and iii) data is acquired from under-collected regions of the world. Therefore, our figure may arrive closer to an estimate of roughly 5000 as proposed recently by Gradstein *et al.* (2001) and Gradstein & da Costa (2003). It is worth noting that published estimates of liverwort species richness are scant and largely confined to introductory remarks, but those that do exist have varied considerably, e.g., 4500-5000 (Forrest *et al.*, 2006), ca. 5000 (Gradstein *et al.*, 2001), 6,000 (Groombridge & Jenkins, 2002), 5000-6000 (Heinrichs *et al.*, 2005), "probably under" 6500-7000 (Schuster, 1984), 6000-8000 (Crandall-Stotler & Stotler, 2000), and 9,000 (Pearson, 1995). Our working data set provides empirical data with which to begin exploring estimates of species numbers using an evidence-based approach. The application of a confidence level to a taxon's status and whether it represents a genuine species that is reached through community consensus may go towards refining species estimates.

Implications and Applications

Species richness. Liverworts are found on soil, rocks, and trees throughout the world, from coastal Antarctica to the tundra of the Northern Hemisphere, and from semi-arid areas of Australia to the Amazon rainforests (Hallingbäck & Hodgetts, 2000). Although there are xerotolerant taxa, the majority of liverworts are found in relatively humid and shaded terrestrial ecosystems (Gradstein & da Costa, 2003). We present the first ever preliminary map of species richness of liverworts on a global scale in Figure 1. This is based on documented species numbers from mainly post-1980 publications and presents species density values for standard area sizes of 10,000 km^2 throughout the world. The known distribution of liverwort species may in part reflect research intensity rather than a pattern of genuine diversity, and we are working on disentangling these two contributing factors. Despite constraints, the present knowledge base is sufficient to begin inferring basic structure of the liverwort flora and note certain tendencies in the affinities and large scale patterns.

Fig. 1 shows the absolute maximum area-based richness of liverworts peaks at less than 445 species per 10,000 km^2. Areas representing global maxima of liverwort species richness include New Zealand, New Caledonia, Japan, and Costa Rica. These areas contain 598 documented binomials for New Zealand (Glenny, 1998, with updates), 615 species for Japan (Furuki & Mizutani, 2004) and 561 for Costa Rica (Dauphin, 2005).

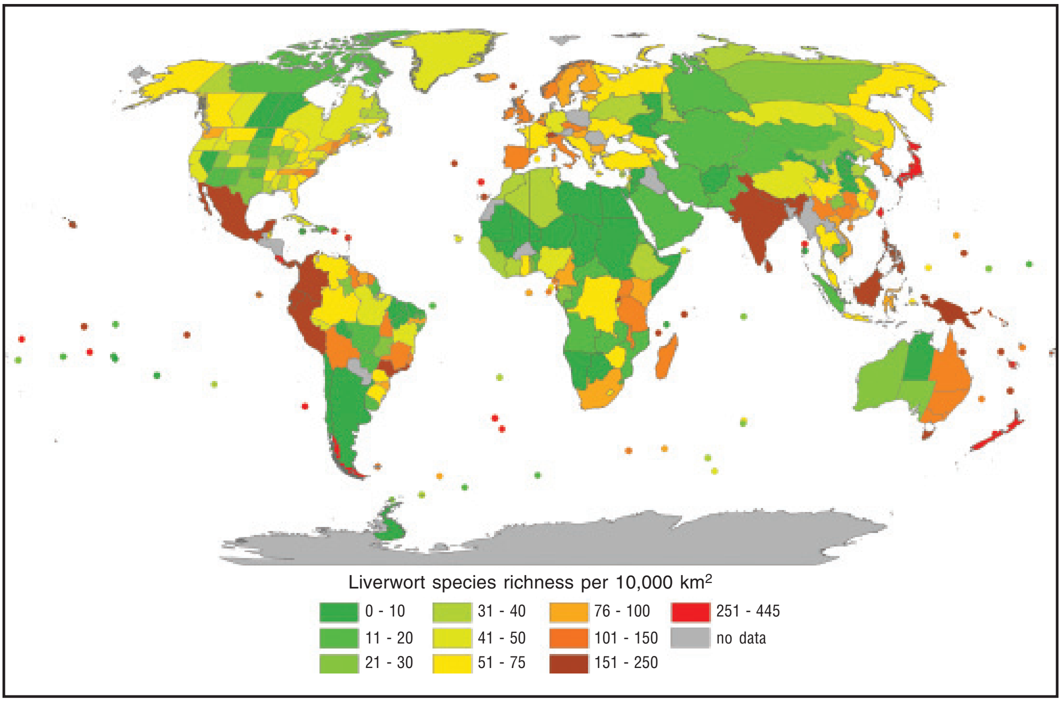

Fig. 1. World map of species richness of liverworts based on a preliminary data set. Species richness is based on density per 10,000 km^2 calculated by species-area model of Arrhenius (1920, 1921).

Centers with more than 151 species per 10,000 km^2 include: areas of the Himalayas, Indo-Malaya, and the Australasian region, e.g., Nepal, Bhutan, the Philippines, Taiwan, Borneo, New Guinea and the nearby Solomon Islands; regions of tropical America, including Colombia, Ecuador, the state São Paulo of Brazil; and several oceanic islands of the Pacific and Indian Oceans. Documented numbers of binomials for these countries or regions are 353 for Nepal (Kattel, 2002), 277 for Bhutan (Long & Grolle, 1990), 498 for Taiwan (Piippo, 1990), 514 for the Philippines (Tan & Engel, 1986), 608 for the island of Borneo (Menzel, 1988), 752 for Colombia (Bernal *et al.*, 2007), 606 for continental Ecuador (León-Yánez *et al.*, 2006), and 472 for São Paulo (Gradstein & da Costa, 2003). Other noteworthy areas exhibiting moderately high species richness with 76-150 species per 10,000 km^2 include French Guyana, Norway, the British Isles, Madagascar and the Iberian Peninsula.

It is with certainty there will be many more regions that will have higher liverwort species richness than illustrated here. For instance, bryological exploration of tropical America has been very uneven with many areas of the Neotropics still remaining without a single bryophyte record (Gradstein *et al.*, 2001). The unrealistically low figure of only less than 20 species per 10,000 km^2 in areas such as the states of the Gulf of Guinea and Equatorial Guinea of West Africa, the island of Sumatra, and others, is a direct reflection of our data set that illustrates a lack of adequate information on liverworts from those regions. In some of these areas, the number of vascular plant species per 10,000 km^2 is over 1500 and as high as over 4000 in places like Sumatra (Mutke & Barthlott, 2005). Similarly, regions of central Africa, e.g., the Democratic Republic of Congo, and the Malayan Peninsula have a seemingly low and unrealistic figure of 51-75 species per 10,000 km^2. Conversely, the numbers of vascular plant species per 10,000 km^2 for parts of the Malayan Peninsula are as high as 3000-4000 (Mutke & Barthlott, 2005).

For countries such as Paraguay, Nicaragua, Honduras, Guatemala, Cuba, and countries of central Asia, e.g., Kirgizistan, Tadzhikistan, and Uzbekistan, data is almost completely lacking. Equally, Fig. 1 illustrates areas without or with very few species, i.e., absolute minima of species richness, including large parts of the Sahara and the arid and semi-arid regions of central and south Australia that almost certainly reflect genuine lack of diversity. These minima coincide with either a lack of available ambient energy or humidity, which limits plant growth and vascular plants (Barthlott *et al.*, 2005).

The political units of state and country as our operational units certainly oversimplifies distribution and diversity patterns because in many cases they are based on vast land areas. For example, in Mongolia, the vast majority of the liverwort diversity occurs in the Altai Mountain complex that lies in the eastern corner of that country, but has very low liverwort diversity in the vast desert zones (Abramova & Abramov, 1983). However, we are now beginning to compile data on finer geographical entities such as national parks, mountain ranges, biogeographic regions, ecoregions, and longitude and latitude references. These narrower geographical units coupled with additional data on vegetation, climate, topography, and other parameters, will enable the production of more detailed diversity maps of finer resolution.

Distribution patterns. With a comprehensive data set one can begin to utilize various mapping tools, cluster and statistical analyses, to aid in visualizing data and investigating global diversity and distribution patterns based on quantitative data. We illustrate this here by calculating the percentage of the family Lejeuneaceae compared to the overall liverwort flora (Fig. 2). Lejeuneaceae is the largest family of liverworts with an extant diversity of approximately 1000 species in some 75-80 genera (Gradstein *et al.*, 2003, with updates). The family is not only the most species rich family of liverworts but is also very abundant in the humid tropics where they make up an important component of cryptogamic, and especially epiphyllous, diversity (Gradstein, 1997; Gradstein, 2006b). This is exemplified in Fig. 2 where the greatest percentage of Lejeuneaceae compared to the overall liverwort flora, i.e., between 50 and almost 90%, are in areas of tropical Africa, the Neotropics, tropical Australia, and regions of Indo-Malaya. This concurs with several studies that have shown that in tropical lowland forests, Lejeuneaceae can make up 70% of all liverwort species present (Cornelissen & Ter Steege, 1989; Gradstein, 2006b; Zartman, 2003).

In stark contrast, entire regions of the Nearctic and Palearctic of the Northern Hemisphere have less than 10% of the flora that is comprised of Lejeuneaceae. The mostly cool temperate region of New Zealand also has a similarly small percentage of Lejeuneaceae compared to the overall known liverwort flora. One could question whether these patterns reflect a genuine lack of Lejeuneaceae or has the family been understudied? For regions such as New Zealand, the answer may well be a combination of both. It is apparent that Lejeuneaceae has not been a research focus. For instance, over the

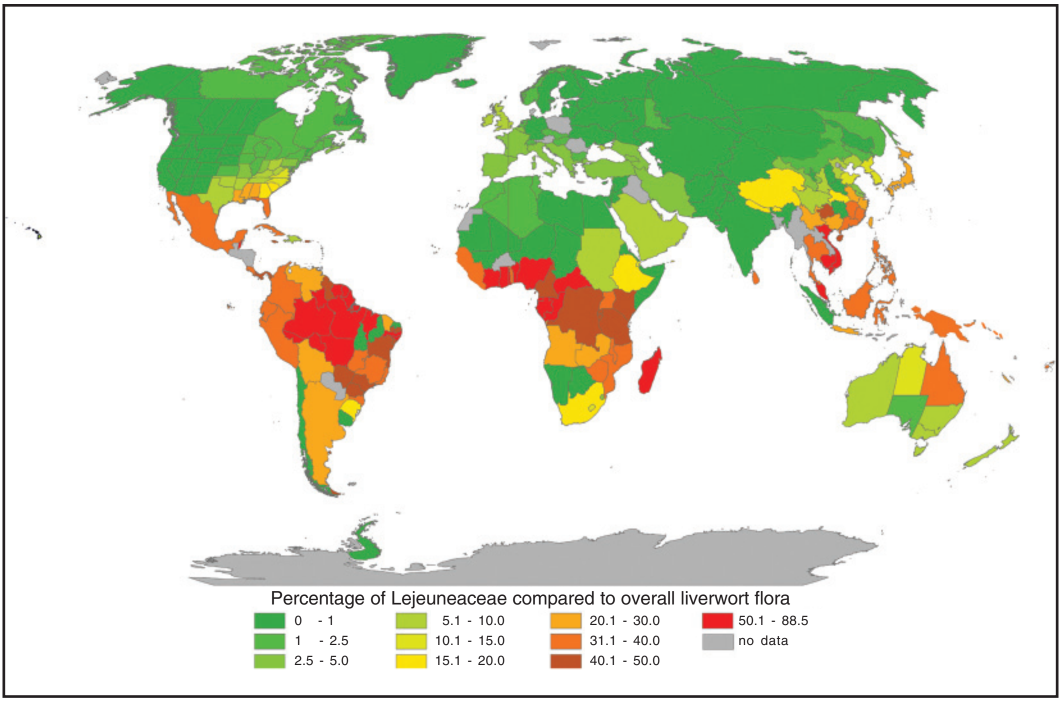

Fig. 2. World map of the percentage of Lejeuneaceae species compared to the overall liverwort flora for each political unit.

last two decades, a selection of families that have received intensive interest in New Zealand include Lepidoziaceae (e.g., Engel & Merrill, 2004), Schistochilaceae (e.g., Schuster & Engel, 1986), Geocalycaceae (e.g., Engel, 1991, 1992, 1999), and Balantiopsiaceae (Engel & Merrill, 1997). Yet, as evident from the literature, the family Lejeuneaceae simply has not currently been a primary research focus. After such an effort has been made, the pattern may well be different, but is unlikely to be comparable to those patterns illustrated in the tropics.

Implications for Conservation. Knowledge on spatial distribution of biodiversity is crucial for its further exploration, use, and conservation (Mutke & Barthlott, 2005). Prominent large research programs of several large international NGOs demonstrate the significance of this in the context of political decision making and conservation. The hotspot analyses of Myers and Conservation International (Myers *et al.*, 2000; Mittermeier *et al.*, 2005), the Global 200 programme by the WWF (Olson & Dinerstein, 1998), or the Endemic Bird Areas by Birdlife International (e.g., Bibby *et al.*, 1992) may be some of the most well-known examples. Typically, these analyses center around species richness, endemism and presence of rare species, and habitat threat. However, it remains controversial to what extent different types of hotspots are congruent for, at least in some taxa, global hotspots do not coincide with endemism or threat (Prendergast *et al.*, 1993; Orme *et al.*, 2005).

Vascular plants and animals have typically been used for priority setting of global scale conservation networks.

We therefore evaluate the relationship between the top 20% centers of liverwort species richness and global biodiversity hotspots (Fig. 3). The global biodiversity hotspots illustrated are those 35 throughout the world defined by Conservation International (Myers *et al.*, 2000; Mittermeier *et al.*, 2005); the top 20% centers of liverwort species richness equates to >110 sp./10,000 km² and the top 10%, which is also illustrated equates to >251 sp./10,000 km². Many centers with outstanding liverwort species richness are congruent with designated biodiversity hotspots, e.g., New Zealand and Japan. Similarly, other areas with high liverwort species richness such as Costa Rica, the Himalayas, and the island of Borneo also coincide with already designated global biodiversity hotspots.

Disturbingly, it is also apparent that there are many regions and habitats that seemingly exhibit significantly high levels of liverwort species richness, but are not part of the global network of biodiversity hotspots. These areas include southern Chile, the British Isles, Taiwan, New Guinea, and Tasmania and Queensland of Australia. In terms of habitats, Gradstein (2006b) had already identified the lowland cloud forest of French Guiana as an important liverwort hotspot. Considering that bryophytes are a conspicuous and dominant feature in many ecosystems throughout these regions, further analysis is warranted. This should include reexamination of habitat threat and degree of endemism. In summary, clearly, a drawback of current approaches to identifying global biodiversity hotspots is the total neglect of some very important centers of liverwort diversity.

Key challenges

Unmistakably, there is an urgent need for augmented monographic and revisional work for many taxonomic

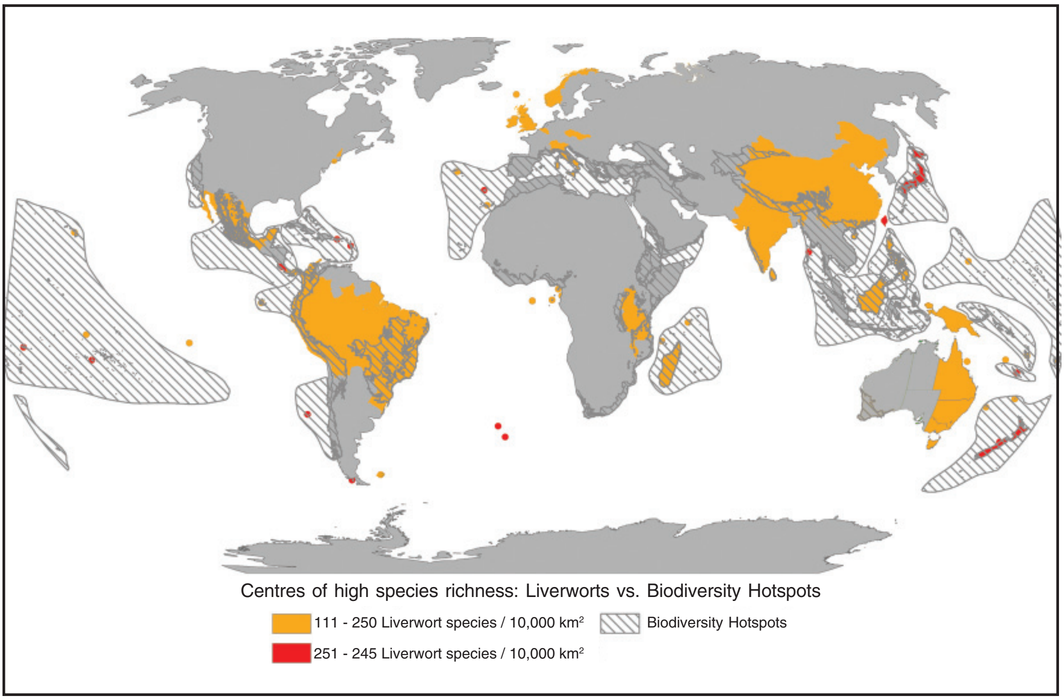

Fig. 3. World map of the top 20% centers of liverwort species richness compared to global biodiversity hotspots as defined by Myers *et al.* (2000) and Mittermeier *et al.* (2005).

groups and for increased floristic and survey work in many regions throughout the world. Some areas, habitats and taxa are inevitably better documented than others (Balmford *et al.*, 2005) and in many countries and regions throughout the world, liverwort records and checklists are completely lacking or are obsolete (e.g., Gradstein *et al.*, 2001; Matteri, 2000; Hodgetts *et al.*, 2000; Söderström *et al.*, in press). On the other hand, there has also been a tremendous wealth of information acquired over the last 250 years, but the dispersed nature of the literature remains a fundamental problem. In particular, identifying and documenting synonymies and distribution ranges on a global scale is a massively challenging task. This has been a major impediment for the compilation of a global species checklist and to the study of global richness patterns. We contend that increased collaboration, working as a community and reaching consensus on taxonomy, nomenclature, and distribution will help overcome these challenges.

Web 2.0: Community, collaboration & consensus

O'Reilly (2003) is widely credited with coining the phrase Web 2.0, referring to a perceived second generation of web-based communities, hosted services, and user-generated content. Scoble (2004) reviewed web-based taxonomic information systems concluding that the web offers taxonomists a very different medium with special advantages for providing wide access to data. In developing our own database targeted at achieving a working list of global liverwort species with auxiliary information, we have launched a web-based prototype version to aid in this endeavour. Several features of Web-based technology make it an appealing tool to develop such a list; these include the web 1) as a vehicle to facilitate data access, 2) to unify the vastly scattered data on distributional information and nomenclature, 3) offering dynamic rather than static data in a searchable forum. Most importantly, it offers an efficient means of *harnessing* our greatest resource – the *collective taxonomic intelligence of bryologists.* Specialist taxonomic input continues to be the limiting factor in the production of an authoritative working list (Lughadha, 2005).

Interested parties are invited and facilitated at a variety of levels to ensure the broadest possible participation in the work. Community participation is critical to the quality of the finished product since it is at this stage that the project can receive critical taxonomic judgment, addressing the problem of differing taxonomic opinions. We advocate that in cases of taxonomic disagreement or controversy an attempt should be made to arrive at a community based consensus. This approach is concordant with a series of recommendations made by Lughadha (2005) with respect to the development of a global plant checklist. Where such attempts fail, the working list will indicate a single view, or, if alternatives are presented, one internally consistent set of names will be flagged as the preferred view within the list. In disputed cases, the basis of the conflict could be made publicly accessible. This would empower users to adopt their own position on which names to accept. A wider community involvement also provides an opportunity for experts to draw attention to synonymies published in obscure literature, which may have been overlooked by the initial compilers.

We contend a web-based system is the most efficient and effective means of arriving at a reliable measure of global liverwort species richness. We also believe wider participation and community ownership of the data might increase its prestige and encourage more specialists and their institutions to contribute more time to this important process.

At present, the web-based dataset, served by DiscoverLife (www.discoverlife.org), is accessible to the community by invitation, remaining password protected, as we are conscious that the Web is as effective a means of disseminating misinformation as it is of providing access to high-quality data (Scoble 2004). A first working global checklist list with distributional range will go public after a consensus has been reached within 24 months. Features of the web-based data set include links to MOSs TROPICOS, a global mapper to visualize distribution (powered by www.TopoZone.com), and data served from other sites as it relates to a particular taxon, should it exist. After which time names have been validated the data can be utilized by GBIF, TROPICOS, and the recently launched Encyclopedia of Life (www.eol.org).

CONCLUSIONS

Liverworts, in concert with mosses and hornworts, are of great ecological significance in many terrestrial biotic systems throughout the world. Yet, global biodiversity hotspot analyses have largely been confined to diversity patterns of vascular plants and animals. In working towards the development of a comprehensive catalogue of liverwort species worldwide, uniting taxonomy, nomenclature, and distribution, the preliminary data set can be applied to test the congruence of biodiversity hotspots with patterns of liverwort species richness. More broadly, the data set has far reaching implications and applications, including working towards developing a worldwide checklist, analyzing phytogeographic and diversity patterns based on quantitative data, aid in assessing the state of floristic and taxonomic knowledge, and identifying geographical gaps in our understanding of the global liverwort flora. Although there are many challenges ahead to obtain high quality data, quantifying global liverwort diversity is a tractable, multi-faceted and scientifically important goal, and everyone stands to gain by fostering this endeavour. The success of the project will lie on strong collaboration between institutions and the bryological community in general.

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