Introduction

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This symposium at the Royal Danish Academy of Sciences and Letters presents an overview of new research on the origin and patterns of vascular plant diversity from a local to a global scale. It was planned for 2003 in order to coincide with the opening of the new building for the Global Biodiversity Information Facility (GBIF) in Copenhagen.

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Higher plants include about 220.000 or maybe 420.000 species globally but probably somewhere between these two extremes of current estimates (Scotland & Wotley 2003; Govaerts 2001). They dominate terrestrial ecosystems from deserts to rain forests and from coastlines to the margins of perpetual snowlines on high mountains. In the most lush plant communities – the tropical rain forests of SE Asia – higher plants may have an above ground biomass of 400 tonnes per hectare. Plants provide humans with food, construction materials, medicines and much more, and their genetic diversity therefore represents a major resource for human survival and well being. Understanding the origin of plant diversity, how it is maintained, and currently also how it is being eroded are therefore fundamental research questions.

It is well known that plant diversity is not evenly distributed over the Earth; rather there are gradients in diversity from higher latitudes towards the equator and from deserts to humid tropical forest (Rosenzweig 1995). When measured within communities, very humid lowland forests are known to be the most diverse among plant communities (Valencia *et al.* 1994), whereas humid montane forests are the most diverse on larger scales such as between communities or at the landscape-level (Churchill *et al.* 1995). On even larger scales there are great differences between regions and continents; South America is richer in species than SE Asia, which in turn is richer than Africa. Beyond the tropics species richness is much reduced with notable exceptions in subtropical regions of South Africa and south-western Australia.

Several of the patterns of diversity found in plants also occur in other groups of organisms such as birds, mammals, insects, etc. and therefore general explanations for species richness have been hypothesized (Hubbell 2001). It is often assumed that over time it has been the same evolutionary processes of speciation and diversification that have operated across many groups of organisms.

When it comes to geographic scale it has become increasingly clear that there is no single or simple unifying explanation or mecha-

nism that governs species richness. For South American birds it has been shown that precipitation is a more important environmental factor for species richness at small scales (12,300 km^2) whereas at larger scales (1,225,000 km^2) cloud cover and area are the most important predictors of species richness (Rahbek & Graves 2001). In temperate zone plant communities the slope of the log-species/log-area plot varies over scales from 0.01 m^2 to 100 km^2 (Crawley & Harral 2001).

The question of scale relates much to that of ranges of species distributions. Some species are widely distributed and occur under a variety of environmental conditions and others are narrowly distributed and endemic to small areas of often very uniform environmental conditions. Understanding the mixture of widespread and endemic species in the flora of a local site or of larger regions or continents is a great challenge in plant diversity research. This theme relates strongly to conservation issues and to efforts of estimating species richness or of estimating the size of the world's threatened flora (Pitman & Jørgensen 2002).

As for the time scale there is little evidence and more speculation concerning its relationship to plant diversity and complexity patterns. For instance it has not been well understood for how long the exceptional plant diversity of South America has existed although it was usually characterized as being of Neogene or Pleistocene origin (Davies et al. 1997). Recent palaeobotanical research in early Eocene deposits (52 mya) now suggests that contrary to common beliefs, South America has had unusually high plant diversity far back into the history of angiosperm evolution (Wilf *et al.* 2003).

Willis and Whittaker (2002) proposed a hierarchical framework for processes influencing biodiversity from local scales to global scales. Important local environmental variables were fine-scale biotic and abiotic interactions functioning on time scales of 1-100 years. At the other extreme, the global scale, the important environmental processes were continental plate movements and sea-level changes occurring over 10-100 millions of years. This symposium provided an opportunity to test the hierarchical framework proposed for processes influencing biodiversity.

From day one to day three we moved from local scales (a vegetation, a naturally delimited part of a country, a large island, a mountain massif, etc.) over regions and continents to the global scale and we heard presentations that described and analysed the plant diversity and complexity patterns at every geographic scale. Research groups throughout the world work at different geographic scales and they are often associated to different organisations (for instance AETFAT in Africa, The Flora Malesiana Symposia for SE Asia, The Organization for Flora Neotropica in South and Central America). For many years there has been only few attempts to transgress these limits. As organisers we found that it was time to do so and to put together researchers from a number of groups in a symposium which would compare the work carried out in the various research centres. The response to this idea was overwhelming, and almost all those we approached were eager to participate.

In recent decades plant diversity research has accelerated strongly, and the latest expression of it may be the netbased Global Biodiversity Information Facility (GBIF). Increasing amounts of data are becoming available for research and the tools to analyse them are becoming more and more sophisticated. Information concerning species and their distributions has accumulated through research and collecting since the middle of the 18th century, and now it may all be placed in a larger perspective and it may be handled with the help of relatively simple computer systems.

Methodologically the last several years has

seen a tremendous diversification in biodiversity research. Some groups base their work on advanced electronic mapping of a large number of species on global or continental scales with the help of data already existing in the literature or in museum collections. This kind of research show patterns of species richness and endemism which may be subjected to biogeographic analysis. Other researchers seek to understand the biodiversity through field based studies of sample plots in various vegetation types, such as tropical rain forests in America, Africa and SE Asia. Some combine hypothetical trees of life (cladograms) based on detailed morphological and molecular data of groups of organisms with the distribution patterns of the same organisms to obtain information concerning the geographic distribution of speciation seen in relation to species-rich centres or centres high in endemism.

Still others study patterns of diversity at different taxonomic levels (species, genera, families, etc.) and of diversity patterns in the classical phytogeographic regions. Comparisons of the results obtained with the methods described above are still in their being.

The practical aspects of biodiversity research is that it may help to pinpoint areas of importance for the preservation of important fractions of the world's biological diversity and it can also document changes in patterns of diversity and document external influence such as fragmentation of habitats for organisms with limited distributions, changes in global climate, changes of the environment because of increasing frequency and intensity of forest fires, etc.

The symposium lasted for three days, from the 25th to the 28th of May, 2003, covering one geographical scale (local, continental, global) each day with about 10 lectures. It was planned for 2003 in order to coincide with the opening of the new building for the Global Biodiversity Information Facility (GBIF) in association with the Zoological Museum of the University of Copenhagen.

It is our hope that the symposium has revealed a number of common traits within the highly dispersed research in plant diversity and complexity patterns and provides inspiration for future collaborative research. For instance it would be interesting to study plant diversity and complexity patterns in a more systematic way which would cover all biomes (alpine, Mediterranean rain forest, dry tropical forest, tropical montane forests, savannas, deserts, temperate forests, steppe, arctic vegetation, etc.) It would be even more forward looking if the symposium could formulate common research questions that could be treated in analogous ways in all continents and biomes. The complementarity of ecological process oriented views on one side and phylogenetic pattern oriented views of plant diversity on the other side came out very clearly and the discussions at the symposium demonstrated the potential benefits of further integrating these ways of viewing diversity in future research.

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