Floral resources of Karnataka: A geographic perspective

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We compiled the data on the floral resources of Karnataka from diverse published sources and analysed the geographic patterns of distribution of floral diversity. Our database shows that Karnataka harbours 4758 species from 1408 genera and 178 families and accounts for about 27 per cent of the country's floral diversity. We computed the 'endemicity value' of different districts based on the number of endemic species (those restricted to a maximum of five districts) harboured by them and found that the most species-rich districts (viz. Uttara Kannada, Dakshina Kannada, Mysore, Hassan, Udupi and Kodagu) were also characterized by high values of endemicity while the species-poor districts had low values of endemicity. However, the relation between the species richness and endemicity of the districts was not linear; the species richness increases abruptly at lower levels of endemicity but plateaus off later at high levels of endemicity. Based on the number of species packed into the families, all the 27 districts segregated distinctly into three clusters that geographically correspond with the three major agro-climatic zones of the state. Our analysis showed that though the districts along the Western Ghats are florally rich, those along the dry tracts also harbour certain unique elements of the flora; thus these dry zone districts appear to be as important as those along the Western Ghats in conserving the floral resources.

BIOLOGICAL diversity is being viewed as the potential 'resource capital' of a state, region, or country that possesses it. Preserving and protecting this potential resource base for posterity is both a profitable venture for, and an imminent responsibility of, the states. Achieving this requires a clear understanding of what resources we have and where they exist[1–5]. Such information base on the biological resources and their geographic distribution, besides helping the states in deciding a need-based allocation of conservation efforts, facilitates ascribing and claiming, appropriate rights over these resources.

In this direction, we have launched a major programme on developing a comprehensive database to document the biological resources and their geographic distribution for the entire country. As an essential first step, we are compiling information on the distribution of flowering plants from different sources. To begin with, we have concentrated on South India and we have now compiled a database from about 200 flora and related literature. This article offers a summary of the major patterns emerging from the analysis of the compiled data from over 30 flora on Karnataka's angiosperm diversity.

The number of species in each district was arrived at in two ways. The first was on the basis of species recovery data: All the species for which the specimen has been reported from a district were assigned to that district. The second was on the basis of the habitats and biotic zones: If any of the grids ($0.1° \times 0.1°$) of the district conformed to the biotic zone and/or contained the set of habitats and/or vegetation types in which the species is stated to be commonly occurring, that species was listed under that district. The total number of species in a district was arrived at from the unique set derived from these two methods. Accordingly, our database indicates that Karnataka has 4758 species[6] from 1408 genera and 178[a] families and accounts for 27% of the floral richness of the entire country[7] (17,500 species). Our database thus suggests that Karnataka is richer by about 800 species and 50 genera than reported earlier[8,9].

Among the 4758 species, 275[b] species are found only in one to five districts (Table 1). While most of these species with 'very restricted' distribution are found in and around the Western Ghats (Dakshina Kannada, Mysore, Hassan, Kodagu, Uttara Kannada and Udupi

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[a,b]The lists of families and species with 'very restricted' distribution are available on the *Current Science* web site.

districts), dry tract districts such as Kolar, Tumkur, Dharwad, Bidar and Bijapur also have a few species that exhibit 'very restricted' distribution in the state (Figure 1). On the basis of the frequency distribution of such 'very restricted' species, we computed an endemicity value for the districts as

$$\text{Endemicity value} = \sum_{i=1}^{5} (n_i/i),$$

where n_i is the number of 'very restricted' species (see Table 1) of the focal district spread over i number of districts. The index cumulates the proportion (n_i/i) over five categories of 'very restricted' species, i.e. species spread over one to five districts only (see Table 1). Thus the endemicity value of a given district is directly proportional to the number of 'very restricted' species in it (n_i), and inversely to the spread or occurrence of these species (i).

Table 1. Angiosperm richness of Karnataka segregated into the extent of distribution in different districts

Category	No. of districts available in	No. of species	No. of genera	No. of families
Very restricted	≤ 5	275	33	0
Restricted	6–10	918	124	2
Common	11–26	1270	261	11
Very common	27	2295	990	165
Total		4758	1408	178

Accordingly, Dakshina Kannada, Uttara Kannada, Mysore and Hassan districts were found to have the highest endemicity values (Figure 2). Since endemicity value of the districts was also found to be correlated with the species richness (though the relation was nonlinear Figure 2), these same districts stand out as being the most speciose[10].

A cluster analysis of the districts, based on the species richness of all the 178 families recorded in them, was attempted. The inter-district similarity values were estimated as Squared Euclidean Distances of differences in the number of species in the families between any pair of districts. These were subjected to unweighted pair-group average analysis for clustering. The clustering resulted in a clear segregation of the districts (Figure 3) into three zones approximately corresponding with the agro-climatic and bio-geographic zones: (a) the high rainfall, Western Ghats zone (cluster 1) with an average of 22.65 ± 0.53 species per family (average of 177 families per district, total 178 families); (b) low rainfall, dry tract districts (cluster 3) with 16.61 ± 0.75 species per family (average of 168 families per district, total 172 families); and (c) the transitional zone of nine districts (cluster 2) with 20.29 ± 0.58 species per family (average of 174 families per district, total 178 families). This grouping of districts was reflected in their segregation along the endemicity gradient and species richness of the district as well (Figure 2).

Segregation of districts on the basis of species packing of the families suggests that even major taxonomic groups (such as families) exhibit differential preference

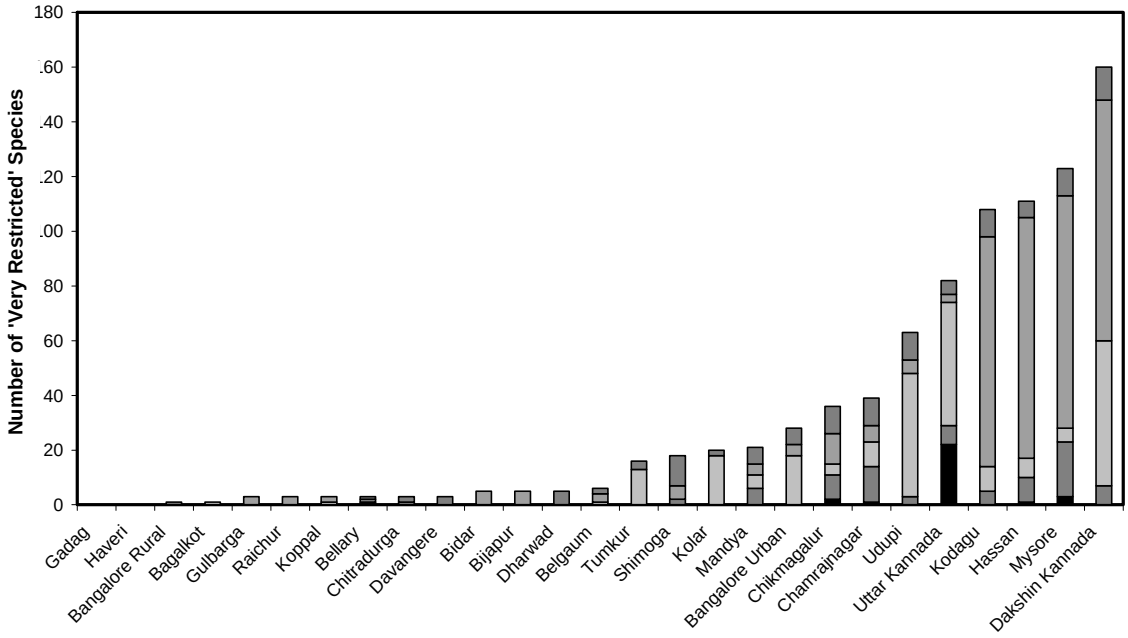

Figure 1. Frequency of 'very restricted' species in all districts of Karnataka. The 'very restricted' species refer to those restricted to one (black), two (dark grey), three (light grey), four (diagonal lines) and five (dots) districts. Note that dry districts such as Kolar and Tumkur also have certain species that are restricted to four and five districts only.

to specific geo-climatic zones. Leguminosae and Gramineae, the most species-rich families, had relatively uniform richness of species across districts (low SD, Figure 4). However, certain families, e.g. Orchidaceae, Acanthaceae, Euphorbiaceae, Cyperaceae, Asteraceae and Rubiaceae showed relatively higher variation across districts for species packing in the families, suggesting their specialization to specific zones than to others (Figure 4). Such predominance of families in specific areas and segregation of districts based on the species richness within families suggest that even the species-poor dry tracts have distinct floral assemblages uniquely different from those of the species-rich areas such as the Western Ghats. Thus these dry-tract districts also demand conservation attention, as do the biotically-rich areas of the Western Ghats.

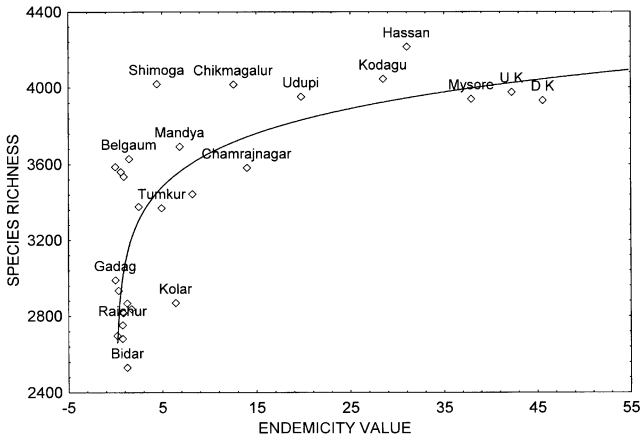

Figure 2. Relationship between endemicity value and species richness of the 27 districts. Note that Hassan, Kodagu, Uttar Kannada (UK), Mysore and Dakshina Kannada (DK) districts are highly species-rich and also have more number of endemic species.

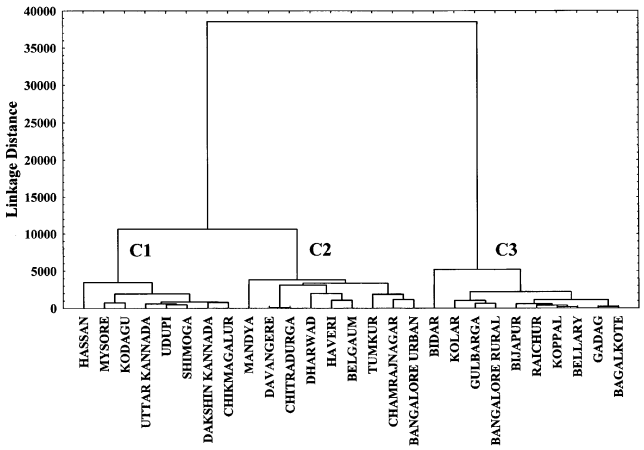

Figure 3. Cluster diagram (dendrogram) of the 27 districts on the basis of richness of species in different families in different districts. Three distinct clusters can be identified, corresponding to the Western Ghats (cluster 1, C1), transition zone (cluster 2, C2) and dry tract (cluster 3, C3) of Karnataka.

Most of the floras provide the habitats of the species and this information was used in developing the maps depicting the 'probable distribution' of the species. For this purpose, we divided the entire state into 0.1° × 0.1° grids and attached them with the habitat types available in each grid using digitized maps. Based on these layers and the information derived from the flora, we have been able to develop the maps for each species that depict the 'recovery probability' of the species. Using these maps, we computed the richness in terms of number of species, number of genera and number of families for each grid. 'Average Taxonomic Diversity (ATD)' of the constituent species of each grid was then computed, by modifying the Avalanche Index[11,12] as:

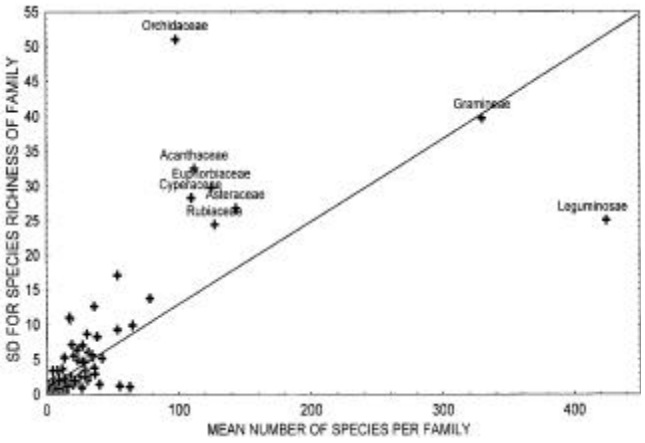

Figure 4. Relationship between mean and SD of the number of species per family across 27 districts. Our database follows the family names and their classification according to Cronquist[13].

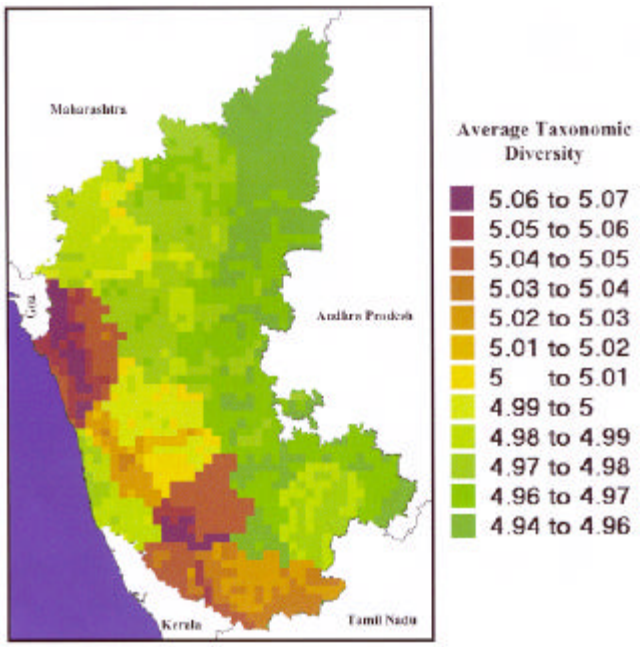

Figure 5. Average Taxonomic Diversity of 0.1° × 0.1° grids of Karnataka.

Box 1. Flora of Karnataka on an interactive CD-ROM

The compiled data are now available on an interactive CD from which the distribution of the species can be generated up to taluka level. The CD has three search modules:

(1) The first module offers geographic richness and distribution of species, genera and families at the state, district and taluka levels. The program offers spatial zooming functions to different geographic levels and also telescoping back and forth along the taxonomic hierarchies.
(2) The second module facilitates acquisition of details on plant species and geographic distribution based on common and scientific names, eventually linking it to module 1. The common names for the 4758 species are compiled in 32 languages and dialects. The module also offers the taxonomic classification of species up to phylum level according to Cronquist[13].
(3) In the third module, line diagrams of floral features, colour photographs and other relevant images of about 1000 species are made available.

The self-extracting and installing CD, which runs on Windows (1998 onwards), requires no special programs for its spatial distribution component. For further information, contact S.K. at sagarkathuria@yahoo.com or K.N.G. at kng@vsnl.com.

$$\mathrm{ATD} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij}}{n(n-1)},$$

where n is the total number of species in the grid and d_{ij} is the taxonomic distance between the ith and the jth species. Taxonomic distance (d_{ij}) was calculated based on the taxonomic level at which the ith and the jth species differ. If two species i and j belong to the same genus then $d_{ij} = 2$, while if they belong to different genera but the same family then $d_{ij} = 3$; and so on. ATD sums these differences for all possible combinations of species and weighs it for the total number of combinations (the denominator). Thus ATD reflects the mean taxonomic distance between any two randomly picked species in the grid.

We find that, as expected, the Western Ghats range is taxonomically more diverse and floristically rich (Figure 5). In fact, the floral diversity distribution appears to strongly follow the climatic zones of the state; the transitional belt being richer than the dry tracts, but poor compared to the Western Ghats.

The data set we have compiled, and now available on an interactive CD (Box 1), would be useful in formulating appropriate conservation strategies, and for developing bio-diversity atlases for the entire region. The spatial information packaged in the CD helps assigning property rights over the economically important plant resources to specific areas and in managing the utilization of the plant resources.

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