ON ASSESSING THE TREE DIVERSITY OF WESTERN GHATS

Ghate Utkarsh[1,2], N. V. Joshi[2], Madhav Gadgil[1,2,3]

1.Centre for Participatory Management of Biodiversity, Foundation for Revitilisation of Local Health and Traditions, 50, MSH Layout, 5th Main, 2nd Stage, Anandnagar, Bangalore -560024.
2.Centre for Ecological Sciences, Indian Institute of Science, Bangalore - 560 012.
3.Biodiversity Unit, Jawaharlal Nehru Centre for Advanced and Scientific Research, Jakkur, Bangalore - 560 064.
Keywords: community ecology, vegetation classification, diversity measures, biodiversity monitoring

---

ABSTRACT

Monitoring of biodiversity, which entails periodic assessment of occurrence (or abundance) of a subset of plant, animal and microbial taxa in sample localities is a significant scientific challenges. In this paper we explore the role of trees and vegetation types primarily defined on the basis of occurrences of trees in designing an appropriate sampling methodology for this purpose. Our study involves 108 belt transects, involving an average of 197 individuals per transect, in 20 localities spanning the entire length of the hill chain of the Western Ghats in peninsular India. These transects were assigned to 7 vegetation types on the basis of structure and physiognomy; we find that they are also distinctive in species composition. Dry deciduous vegetation with low levels of density and diversity harbours a rather exclusively set of species. In contrast, the most diverse tree assemblages belong to the semievergreen type which harbours widespread elements extensively shared with other vegetation types. The open evergreen vegetation resembles semi-evergreen vegetation in many ways, stunted evergreen and scrub/ savanna exhibit low densities and diversities; their component species have very weak tendencies to co-occur with each other. The evergreen moist deciduous vegetation types exhibit moderate to high densities and diversities and moderate levels of distinctiveness of composition. These

patches are interpreted in terms of the extent of spatial heterogeneity and the ecological history of the region. We also relate them to the issues of designing a sampling strategy and assigning conservation priorities.

INTRODUCTION

Inventorying the entire spectrum of diversity of life, screening (or prospecting) it for possible applications, devising measures for its conservation and monitoring to assess the efficacy of the conservation measures instituted have emerged as significant human concerns over the last decade[1]. These concerns are especially relevant to a megadiversity country like India, and in the context of biodiversity hotspots such as the Western Ghats[2]. Addressing these challenges calls for two kinds of scientific endeavors; inventorying, or documenting the entire range of variation, and monitoring or periodically assessing changes in the stock of diversity[3]. Inventorying is a large ongoing effort, the responsibility of Botanical and Zoological Surveys of India at the level of species diversity, and National Bureaus of Plant, Animal and Fish Genetic Resources at the level of intraspecific genetic diversity. This effort is especially relevant to biodiversity prospecting and must go on. But this massive effort will take decades; even for such relatively well known groups as flowering plants only some 5 of the 30 projected volumes of Flora of India have been completed over the last 5 years[4]. The Fauna of India volumes will be an even longer range effort[5].

The second scientific endeavor, namely monitoring or periodic assessment of the stock of diversity must therefore proceed side by side with the inventorying efforts, and be based on a sample of the total range of diversity in a sample of localities. Such monitoring is particularly relevant to continual assessment and appropriate mid-term corrections in conservation efforts[6]. This calls for decisions on the set of taxa and set of localities that should be sampled[3]. The set of taxa should be chosen so as to represent all major evolutionary lineages, preference for all major ecological habitat types, with due weightage for human significance such as pests, pollinators or wild relatives of cultivated plants, ecological role such as indicators or keystone resources and facility of field investigation and identification[7,8]. Trees, as a dominant plant growth form over much of India, with considerable economic uses and substantial base of information stand out as a good choice for one of the taxa to be sampled in a monitoring programme.

The second choice that needs to be made is that of localities for sampling. This choice would obviously depend on patterns of distribution of the tree species; of their tendency to be associated with or excluded by the presence of other species. These patterns are complex, especially in a highly humanized landscape such as that of the Indian subcontinent. Nevertheless, there have been several attempts to identify patterns of distribution of tree species in India, and other parts of the world in terms of forest types[9] or vegetation series[10,11] or vegetation types[12]. These attempts take the form of classification i.e. identification of discrete classes from what are largely continuous distributions. Such delineation of discrete sets of species may be based on phonology or physiognomy, levels of human disturbances, or identity of the dominant or economically important species. The choice of sampling localities may then be related to the distribution of different forest or vegetation types.

This is obviously a very useful device in spite of the inevitable difficulties of drawing boundaries in continual distributions. Our attempt would be to build on this body of work in developing a scheme for monitoring biodiversity for India. A scheme devised for monitoring biodiversity should ideally fulfill the following requirements:

1) The vegetation cover of the land should be assigned to a series of types such that each type represents distinctive assemblages of species.

2) It should be possible for independent observers to assign on ground a given habitat to a particular vegetation type on the basis of specification of the attributes of the different vegetation types within acceptable limits of interobserver variation.

3) It should be possible for independent observers to assign particular picture elements in satellite imagery to particular vegetation type given some adequate level of ground truth, and then use this information to assess the distribution of the vegetation types over a wider area within some acceptable limits of error[13].

MATERIALS AND METHODS

The existing schemes although based on considerable fieldwork have not been derived objectively with the help of quantitative information. In this paper we attempt to do so for tree communities of the Western Ghats. The Western Ghats are a hill chain with a length of 1600 km running parallel to the west coast of India, with a width varying between 5 to 150km and an elevation ranging from sea level to 2800m. The higher elevations support a restricted number of vegetation types, the major types being extensively distributed at lower elevations[14]. The present study is confined to 30 localities at these lower elevations below 1200m in altitude (Table 2). Each locality supports a mosaic of vegetation types and our data is based on 108 transects each confined to a patch of a single vegetation type. Traditionally sampling studies are based on transects or quadrats totaling an area of 1000m^2 or so, which yields data on only a few trees[15,16]. Investigations by Condit et al[17] on diversity patterns of samples of varying size suggest that it is desirable to sample at least 100 trees, preferably in several replicates, at a given locality. In our studies we therefore aimed at sampling a minimum of 100 trees with a DBH (diameter at 130cm above ground) of 10cm or more in each sampling event. The width of the transects was therefore fixed at 20m and the length kept variable. The sampling effort (by G. Utkarsh) involved 108 transects ranging from 135m to 825m in length with a mean of 383m. This added to a sampling area of 75ha. In 8 out of 108 transects we failed to reach 100 individuals, so that the number of trees sampled ranged from 89 to 691 with a mean of 197 per transects. These 20785 individual trees were assigned to 398 operational taxonomic units (OTUs). Of these 370 were correctly identified to species level, 8 to genus level and the remaining 20 as morphospecies, using mostly vegetative characters[18]. There is a strong possibility that out of these twenty, the 8 OTUs identified to genus level and the other 5 OTUs assigned to morphospecies may include some more localized species, difficult to distinguish on the basis of vegetative characters alone.

These 108 transects were assigned to 7 vegetation types closely following the UNESCO classification system[12] with the addition of one type, namely open evergreen forest. As mentioned above it is desirable that such types should be characterised so that any observer on ground could assign any particular patch to the appropriate vegetation type with a high degree of reliability.

With this in view, we specify the attributes of these vegetation types focusing on structural features as follows:

a) evergreen forests with 25 - 30m tall trees, with erect, closed, dense canopy covering over 95% of the ground. Here, we wish to clarify that by canopy we mean overall vegetal cover, not just the top canopy. For due to canopy gaps that occupy about 10% of the forest[10], their complete closure is not possible. Nearly all - 95% or more trees belong to evergreen species. Leaves are thick, dark green, blackish sheering. Barks of many trees are smooth. Many trees have large buttresses. Lianas are few. Undergrowth is almost devoid of herb layer.

b) open evergreen forests with 20 - 25m tall trees but partially closed (80 - 95%) canopy. 80% to 95% trees belong to evergreen species. The canopy is much more closed than semievergreen or deciduous forests, and we have used the term open only to distinguish these from closed canopy evergreen forests. Here, it does not imply canopy closure below 40% of the ground, the connotation of the term `open' in the Forest Survey of India reports[19]. But because of the past canopy openings a few herbaceous species and many woody pioneer species, including few deciduous, invade the forest floor.

c) stunted evergreen forests with dwarf, 10 - 15m trees branching at base and having closed (80-95%), spreading canopy. Over 80% trees are evergreen. The forests are rich in undergrowth of pioneer shrubs like Strobilanthes spp. which membraneous leaves.

d) semievergreen forests with a mixture of evergreen and deciduous trees of moderate, 15 - 20m height, closed (60-80%), dense canopy. About 40% to 80% trees are evergreen. The trees are often not growing straight and climber grow in profusion.

e) moist deciduous forests with moderate, 10 - 20m tall trees, closed but not very dense canopy (40-70%). 0 to 40% trees are evergreen. The deciduous trees mostly shed their leaves earliest. The leaves are mostly thin, pale green. Undergrowth contains many herbaceous speies. Sometimes, once encounters extensive growth weeds like Lantana, Eupatorium. Lianas very few.

f) dry deciduous forests with low, 10 - 15m tall trees, quite open (40 - 60%)canopy. Evergreen trees mostly absent. Herbaceous and grassy undergrwoth plentiful.

g) scrub/ savanna i.e. non forest formations with shrubby growth or very scattered tree canopy (0 - 40%) and grassy, herbaceous undergrowth. Trees, if present have variable heights i.e.

5 - 15m. Evergreenness varies from place to place. However, deciduous trees are generally more common.

Of these, evergreen, moist deciduous and dry deciduous forests are distributed throughout the Western Ghats and were sampled accordingly. The tall, open evergreen forests are generally absent in northern portions i.e., Maharashtra. Instead, one finds here the stunted evergreen forests which are in turn rarely found south of Maharashtra within this lower elevation zone. Hence, majority of our sampling units in open and stunted evergreen forests respectively were distributed in the southern and northern portions of the Ghats. The scrub/ savanna formations occur throughout the Ghats, but we could not sample these in Maharashtra due to logistic constraints. Table 1 shows the distribution of samples in various vegetation types, localities and latitudinal zones, alongwith sampling efforts in terms of area, indivduals etc. Further details of sampling localities, vegetation types and environmental parameters, alongwith diversity estimate measures like species richness are provided in Table 2.

We have currently under way studies involving a number of independent investigators to document the structural characteristics of these vegetation types in further detail, and to verify that given patches can be assigned to specific vegetation types within acceptable levels of interobserver variation. This co-ordinated research programme of Western Ghats Biodiversity Researcher's Network is described elsewhere[20].

RESULTS AND DISCUSSIONS

Species Composition

To be useful for the purpose of monitoring biodiversity the vegetation types thus defined should be significantly different from each other in terms of species composition. In order to explore this we define d_{ij}, the dissimilarity or turnover in species composition of a pair of transects i and j as follows[21]:

$$d_{ij} = \; 2 \;\; (1 \;\; \frac{(\;\; x_{ij} \;\; x_{ik})}{(\;\; x^2_{ij} \;\; x^2_{ik})})$$

where d_{ij} is the chord distance, x_{ij} and x_{ik} are abundance values of species in transects j and k respectively.

If the attribution of transects to particular vegetation types on the basis of structural features reflects the differences in species composition as well, we would expect mean dissimilarity of transects within a type to be smaller than across a type. We also expect geographical separation to influence the magnitude of such species turnover. To remove this effect, we can recompute within type and between type distances while only sampling pairs of transect within 1 degree of each other. Table 3 gives the results. Each cell includes the mean and standard deviation; the cells above the diagonal include all transects, those below the diagonal only transects within 1 degree. In all cases within type turnover is lower than the turnover with any other type, confirming that the types simultaneously differ in structural features as well as in species composition. It is to be noted that the latter was not used in ascribing a given locality to a vegetation type. We have also under way another investigation to verify that such structurally distinctive vegetation types can be assigned to appropriate picture elements of IRS 1C Liss 2 satellite imagery. In a case study, we could do so with an accuracy of 88% on the basis of supervised classification[13].

Patterns of Diversity

It is of interest to explore the patterns of tree density and diversity revealed by these 108 transects. Table 2 summarises the pertinent information. To correct for variable number of trees on a transects, it specifies the number of species expected in a sample of 85 successively encountered individuals as rarefied species richness[22]. Table 4 specifies a measure of distinctiveness of a given type in the form of the ratio of mean chord distance of a transect of a given type with that of all other types to the mean chord distance amongst transects of the same type. Chord distance, treated here as an estimator of species turnover, measures the dissimilarity of species composition between two sampling units, taking into account respective abundances of constituent species[21]. To assess the rarity of species at a site, we define a measure called ubiquity. It is defined as the average number of transects on which species in a given transect occur. A transect with more widespread species would have higher ubiquity and those sheltering geographically more restricted species, lower ubiquity. Pramod et al (this issue) discuss this measure in greater detail.

Finally, table 2 also specifies a new measure termed hospitality. Hospitality reflects the tendency of species encountered on a given transect to co-occur on other transects as well. If the species found on a transect tend to occur together wherever they are found on other transects as well, then that transect may be said to harbour a cohesive set of species. It is then assigned a low hospitality value. On the other hand, high hospitality transects harbour species drawn from a number of variable assemblages. Pramod et al (this issue, a) furnish further details of computation of this measure of hospitality. While table 2 provides transectwise details of these diversity measures, table 4 provides their typewise summary.

It is evident that the dry deciduous type of vegetation is made up of a small distinctive set of species, many of them exclusive to this type. Some of the species characteristic of this type include Anogeissus latifolia, Lannea coromandelica and Lagerstroemia parviflora. This type of vegetation has the lowest tree densities, lowest levels of diversities, highest levels of distinctiveness and lowest levels of hospitality and ubiquity. This is expected since the unfavourable dry and hot climate permits only a limited number of trees species to co-exist. Further, the species that inhabit this zone are all well adapted to harsh environment and have in all probability co-evolved over long time periods[24]. They however do not much penetrate into other vegetation types, especially of the evergreen - semievergreen type.

Of the other six types of vegetation, the two more natural types - evergreen and moist deciduous and the four types derived from these viz. open evergreen, stunted evergreen, semievergreen or scrub/ savanna are much less distinctive from each other. The semievergreen vegetation type is the other extreme from dry deciduous. It harbours a much larger set of species extensively shared with other vegetation types, hence its high ubiquity and hospitality. It has fairly high tree densities, highest level of diversity, lowest level of distinctiveness and highest level of hospitality. In areas where rainfall is just sufficient for the growth of few, more tolerant evergreen species, such semievergreen forest pockets may occur naturally on suitable soils. However, the semi-evergreen vegetation encountered today has largely arisen in areas with high rainfall due to human destruction of evergreen forests followed by colonisation by evergreen as well deciduous species[10]. Characteristic species of the semievergreen forests include Olea dioica, Mallotus philippensis, Macaranga peltata and Terminalia paniculata.

In many ways the open evergreen vegetation type resembles the semi-evergreen. This is related to the fact that most of the open evergreen forests are the result of selective logging a few decades ago[10,15]. Hence, it shows a few large openings in the canopy, extensive growth of climbers and other pioneer species growing in earlier canopy gaps and scarcity of trees with large girth. The vigorous colonisation of the once logged evergreen forests by pioneer species, including a few deciduous ones, has lead to a higher level of packing of species, several of which do not co-occur normally. This results in the high hospitality observed. However, ubiquity is rather low as the species mostly belong to those of evergreen forests, with narrow distribution. As Chandran (1993) and Pascal (1988) have shown, these forests may later progress towards more stable, less diverse composition. Species characteristic of this type include Artocarpus hirsutus, Hopea parviflora and Holigarna arnottiana.

The other two types derived from evergreen, namely scrub/ savanna and stunted evergreen resemble the dry deciduous type in low levels of tree densities and diversities. However the set of species they harbour is not a distinctive one, these species have little affinity for each other, so that these two vegetation types are assigned high levels of hospitality. These perhaps represent earlier (scrub/ savanna) and later (stunted evergreen) phases of succession on lands cleared of forests for shifting cultivation or for extraction of timber and fuelwood[15]. The colonization in relatively recent past favoured initially by canopy opening and later by canopy heterogeneity, might have allowed species with divergent niche requirements to temporarily co-exist. Because of drier conditions, these vegetation types are poor in number of species. Ubiquity is however high due to prevalence of widespread hardy species. Some of the characteristic species of stunted evergreen forests include Actinodaphne angustifolia, Memecylon umbellatum and Syzygium cumini. Characteristic species of scrub savanna include Aporosa lindleyana, Ixora brachiata and Syzygium caryophyllatum.

Finally, evergreen and moist deciduous, the two other natural vegetation types exhibit an intermediate behaviour, with high (evergreen) and moderate (moist deciduous) tree densities, moderately high diversity, and moderate levels of distinctiveness and hospitality. The evergreen forests may locally well represent tightly packed assemblages of co-evolved species due to the cool and moist microclimate under homogeneous, shady canopy, preventing invasion of deciduous or opportunistic species. However, there is considerable change in species composition from south to north, due to increasing length of the dry season, leading to persistence of only the more tolerant species towards the northern latitudes[10,24]. Consequently, there is greater endemicity in the southern ranges resulting in considerable non- overlap of northern and southern species. This accounts for the moderate hospitality and the low ubiquity of evergreen forest type. The significantly higher hospitality of northern transects in contrast to the southern ones results in the large variance of the hospitality values. Characteristic species of the evergreen forests include Calophyllum polyanthum, Cinnamomum malabathrum, Holigarna grahamii, Holigarna beddomei, Diospyros spp., Dipterocarpus indicus, Dimocarpus longan, Syzygium gardneri and Vateria indica.

The moist deciduous forest represents a transitional type from dry deciduous to semievergreen vegetation. Thus, they have intermediate values of density, diversity and hospitality. The high variance of density and diversity parameters reflect considerable variation in the environmental parameters such as altitude, rainfall and influence of species from neighbouring vegetation types. Ubiquity is high as most of the species are widespread. Some of the characteristic species of this type include Terminalia crenulata, Lagerstroemia lanceolata, Grewia tiliaefolia, Dillenia pentagyna, Careya arborea and Xylia xylocarpa.

Sampling Strategy

Monitoring biodiversity is a new scientific challenge; the methodology therefore largely remains to be worked out[3]. We suggest that such monitoring may be based on a two-phase sampling; sampling for the occurrence of vegetation types on the basis of satellite imagery coupled to field studies to obtain ground truth, and sampling of representative patches of the different vegetation types for the occurrence or abundance of some focal taxa[13]. The objective of the second type of sampling needs to be defined: one possibility is that it may be designed so as to maximize the number of species encountered. In terms of our results this would imply a stress on sampling the semi- evergreen vegetation type, since it is highly diverse in terms both of number of species within a transect i.e. alpha diversity, and the extent of species turnover from one transect to another of the same type i.e. beta diversity. We plan to explore this issue elsewhere as a part of a subsequent investigation. However, our results that the different vegetation types structurally identified harbour distinctive sets of species even at a small sampling size of few hundred individuals is both interesting and useful. It is of interest since, given the large species pool of over 500 species that colonize the Ghats[18] only a limited set is expected to be encountered in a small sample at any site given the tremendous variation in relative abundances of species within a community.

Conservation Prioritization

The objectives of conservation prioritization may similarly be stated as choosing a set of localities to be protected so that they habour as large a number of species per given area as possible[25]. That would again suggest a focus on the semi- evergreen vegetation type. There are however other considerations; some of these are captured by our measure of hospitality[23]. Semievergreen vegetation is not only highly diverse, it is highly hospitable as well. This high level of hospitality and ubiquity implies that it may harbour many widespread, commoner species characteristic of several other vegetation types. We may wish to assign lower conservation values to such widespread, commoner species in comparison to rarer species or species of more restricted occurrence[26]. While this needs to be assessed more specifically, it is possible that lower hospitality and low ubiquity vegetation types such as dry deciduous or evergreen may be richer in such high priority species. On the other hand, high hospitality sites like semievergreen forests, and scrub savanna might represent temporary chance assemblages which give way to less hospitable, more stable communities in course of progressive succession. The tendency of an assemblage to harbour its constituent species on a long term basis is obviously relevant in assigning conservation values. Low hospitality sites probably represent habitats with such tendencies for long term persistence of their assemblages. Hospitality may therefore turn out to be a quite useful measure in setting conservation priorities.

REFERENCES:

1. UNEP-CBD, Convention on Biological Diversity (CBD), Secretariat on CBD, United Nations Environment Programme, Montreal, 1991.

2. World Conservation and Monitoring Centre (WCMC), Global Biodiversity - Status of Earth's Living Resources, World Conservation Monitoring Centre and Chapman and Hall, London, 1988.

3. Noss, R., Conservation Biology, 1990, 4(3): 355-364.

4. Botanical Survey of India (B.S.I.), The list of publications. B.S.I., Calcutta, 1993.

5. Zoological Survey of India (Z.S.I.), History and Progress, 1916-90, Z.S.I., Calcutta, 1990.

6. Goldsmith, B. (ed.), Monitoring for Conservation and Ecology, Chapman and Hall, London, 1991, 275.

7. Gadgil, M., Current Science, 1996 a, 71(9): 688-697.

8. Pearson, D. L., Selecting Indicator Taxa for the Qualitative Assessment, in Biodiversity Measurement and Estimation, (Ed. D. L. Hawskworth), The Royal Society and Chapman and Hall, London, 1995, 75-80.

9. Champion, H. G. and Seth, S. K., A Revised Survey of Forest Types in India & Burma, Manager of Publications, New Delhi, 1968.

10. Pascal, J. P., Wet Evergreen Forests of the Western Ghats: Ecology, Structure, Floristic Composition and Structure, French Institute, Pondicherry, 1988., 365.

11. Puri, G. S., Meher-Homji, V. M., Gupta, R. K. and Puri, S., Forest Ecology: Phytogeography and Forest Conservation, Oxford and IBH, New Delhi, 1983.

12. Mueller Dombois, D. and Ellenberg, J. H., Aims and Methods of Vegetation Ecology, John Willey, New York, 1974.

13. Nagendra, H. and Gadgil, M., Satellite Imagery as Tool for Monitoring Species Diversity - An Assessment, MSS, Centre for Ecological Sciences, Indian Institute of Science, Bangalore, 1997.

14. Blasco F., Montagues de sud de la Inde: Forets, Savanes, Ecologie, Institut Francaise, Pondicherry, 1971.

15. Chandran, M. D. S., Vegetation changes in the evergreen forest tract of Uttar Kannada district of Karnataka state, Ph. D. Thesis, Karnataka University, Dharwad, 1983.

16. Hubbell, S. P, Towards a theory of biodiversity and biogeography on continuous landscape, in Preparing for Global Change: A Midwestern Perspective, (Ed. G. R. Carmichael et al), Academic Publishing, Amsterdam, 1995.

17. Condit, R. S. Loo de la Lao Susan, Leigh, E. G., Foster, R. B., Sukumar, R., Mamokaran, N. and Hubbell, S. P., Assessing Forest Diversity from small plots: Callibration using species-individual curves from 50 ha plots, in Proceedings of the SI\MAB conference on Measuring and Monitoring Forest Diversity: The International Network of Biodiversity Plots, (Ed. F. Dallmeier), Smithsonian Institution, Washington, D. C., 1995

18. Pascal, J. P. and Ramesh, B. R., A field key to the trees and lianas of the evergreen forests of the Western Ghats. Institute Francise, Pondicherry, 1987, 234.

19. Forest Survey of India (FSI), State of the Forest Report-III. Dehradun, 1993.

20. Gadgil, M., Current Science, 1996 a, 70(1): 36-44.

21. Ludwig, J. A. and Raynolds, J. F., Statistical Ecology: A Primer on Methods and Computing, John Wiley and Sons, New York, 1988.

22. Krebs, C. J., Ecology: the Experimental Analysis of Distribution and Abundance, Harper & Row, New York, 1985.

23. Pramod, P., Joshi, N. V., Utkarsh, G., Gadgil, M., On the Hospitality of Western Ghats habitats for Bird Communities, This volume, a.

24. Meher Homji V. M., Man and Env. XIII, 1989, 1-10.

25. Johnson, N., Biodiversity in the balance: Approaches to setting geographic conservation priorities, Biodiversity Support Programme, WWF-US, Washington, 1996.

26. Pramod, P., Daniels, R., Joshi, N. V. and Gadgil, M., Evaluating Bird Communities of Western Ghats to Plan for Biodiversity Friendly Developmen, this volume, b.

ACKNOWLEDGEMENT

We are grateful to all the members of the Western Ghat Biodiversity Network, for their local support. We thank the Ministry of Environment and Forest, Government of India and the local forest department officials for their continued co- operation. The PEW Foundation is acknowledged for providing flexible financial support towards this endeavour. This constitutes contribution No. 4 from the Western Ghat Biodiversity Network.

TABLES

1) Summary of sampling efforts i.e., all the transects and vegetation types indicating latitudinal zonation of localities and transects, area and individuals sampled and the environmental parameters.

2) List of all sampling localities indicating environmental parameters, vegetation types, population censused, species richness, hospitality and ubiquity.

3) Distinctiveness of species composition of vegetation types measured in terms of mean chord distance between all pairwise comparisons of transects within each type and other types.

4) Summary of tree density, species richness, turnover, distinctiveness, hospitality and ubiquity of each vegetation type and all transects pooled together.