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A RAPID ASSESSMENT TECHNIQUE OF VASCULAR EPIPHYTE DIVERSITY AT FOREST AND REGIONAL LEVELS

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ABSTRACT. A rapid assessment technique for examining epiphyte diversity at both forest and regional levels is described. The technique that allows for a consistent assessment of epiphyte diversity at any locality, is based on surveying the oldest trees in a forest and can be used for comparative purposes. It is cost effective and is particularly suited to studies in Australia where subtropical and tropical rainforests are small in area and widely scattered.

INTRODUCTION

Epiphyte diversity can been examined at different spatial scales, from individuals on a branch to regional and continental scales (see Lowman & Wittman 1996, Bergstrom & Tweedie in press). TABLE 1 summarizes some of the significant epiphyte diversity studies. The majority have been confined to local scales with the most thorough, such as, Sugden & Robins (1979) and Wolf (1993) being highly detailed, but extremely time consuming. It can be seen however, that standard methodologies for studying epiphyte diversity at forest and regional levels have not been adopted.

To use detailed techniques for large scale studies of epiphyte diversity is expensive and to date, this has been a prohibitive factor in terms of studying patterns in epiphyte biodiversity at the forest and regional levels. This paper presents a rapid assessment technique for studying epiphyte diversity at the forest level and above. To justify the technique however, we initially identify some of the essential problems associated with epiphyte studies and limitations of the field environment. To illustrate these we rely on our experience of studying epiphytes in subtropical rainforests in South East Queensland, Australia.

PROBLEMS ASSOCIATED WITH EPIPHYTE DIVERSITY STUDIES

Growth Form and Abundance

Epiphytes have a variety of growth forms that affect the ease with which species can be detected and identified in the field. Those species that are pendulous, such as *Dendrobium pugioniforme* A.Cunn., or large *Dendrobium speciosum* Sm. are easily observed from the ground. Smaller branch adhering species, for example, *Dendrobium schneiderae* F.M.Bailey, are difficult to detect, particularly if they inhabit the upper surface of a branch in a tall canopy.

Abundance is difficult to measure for epiphyte species as the delineation of individual plants is often not clear, particularly with regard to rhizomatous taxa (Wallace 1982, Hietz & Hietz-Zeifert 1996). In initial distributional studies therefore, collective presence/absence data at the spatial level of the phorophyte is the most realistic option.

Canopy Zonation

Corresponding with morphological and physiological attributes such as CAM photosynthesis and basket habits, different species of epiphytes are differentially distributed within the canopy (Benzing 1990). Sampling techniques must accommodate such stratification within a phorophyte.

Forest Type and Canopy Height

Factors such as canopy height, mid-story and understory thickness, vine density, and tree size varying with forest types and forest type changes with climate and altitude. It can be seen that a standard methodology for studying epiphyte diversity at the forest and regional level has not as yet, been developed. A sampling methodology which aims to facilitate regional comparison must therefore be suitable over a range of forest structural environments.

The species composition of the forest can effect surveying abilities. In *Nothofagus* forests in South East Queensland, for example, where the canopy is low and mid-story absent, epiphytes are easily viewed from the ground. In tall, structurally complex forests (excess of 20 m) where visibility of epiphytes growing in the upper region of the canopy is limited from ground level, the use of Single Rope Technique (SRT) climb-

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TABLE 1. Summary of major studies of vascular epiphyte biodiversity.

Author	Location	Topic	Sample Size	Notes
Sanford 1969	Nigeria; east, mid-west, west, north	Distribution & ecology	31 sites	Natural history, no indication of forest types, or altitude
Johannson 1974	West African Rainforest	Ecology	not definable	Natural history
Sugden & Robins 1979	Colombian Cloud-forest [750–3200 m]	Distribution & ecology	14 plots surveyed every tree	Time consuming
Wallace 1982	Eastern Australia	Diversity & distribution	East coast	Time consuming
Kelly 1985	Jamaican Rainforest	Vertical distribution & life forms	1.8 km^2	Only lower 2 m of tree surveyed
ter Steege & Cornelissen 1989	Guyanan Lowland Rainforest [<100 m]	Distribution & ecology	25 trees	Destructive sampling, climbed trees, removed branches
Van Leerdam *et al.* 1990	Colombian Cloud-forest [3370 m]	Distribution of growth-forms	Two trees	Small sample size, removed 2 branches/tree
Bogh 1992	Ecuador Montane rainforest	Composition & distribution	39 trees	Intensive sampling
Dickinson *et al.* 1993	NZ Coastal Podocarp Forest	Diversity & ecology	One tree	Detailed survey
Wolf 1993	Colombia Lower & Upper Montane forest [1000-4130 m]	Diversity and ecology at community level	Sites every 200 m, four trees per site	Time consuming
Hietz & Heitz-Seifert 1995	Mexico [720-2370 m]	Composition & ecology of communities	Many plots, every tree	Time consuming
Jarman & Kantvilas 1995	Australia; Tasmania	Ecology and distribution	One tree	Detailed survey
Tweedie & Bergstrom (submitted)	Australia; South-east Queensland	Diversity and succession	40 trees in one forest	Time consuming
Olmstead & Gómez Juárez 1996	Yucatán Pen. Mexico	Diversity & distribution	6 forest types, regional	Sample size not defined
Zapfack *et al.* 1996	Cameroon Semideciduous rainforest	Diversity	Surveyed logged 125 trees	Broad regional study, time consuming

ing, emphasized by Lowman & Wittman (1996) is essential to assess epiphyte diversity.

THE ASSESSMENT TECHNIQUE

The aim of this methodology is to allow comparisons of epiphyte diversity across many different forest types and regions. The methodology is based on an analogy linked to island biogeography theory (*sensu* MacArthur & Wilson, 1967). A phorophyte can be viewed as an island, with similar colonization processes and patterns (Yeaton & Gladstone 1982). There are several steps in the technique. These are described below and summarized in TABLE 2.

Forest Typification

Description of forest type is essential if epiphyte communities are to be compared between locations. The structure and physiognomy of a forest community reflects the integrated impact of the physical environment, with the distribution of the same structural types indicating similar combinations of climate and soils (Webb 1978).

Site Selection

Consideration must be taken with placement of sites for survey. For example assessment of the effect of boundaries must be made. Trees situ-

TABLE 2. Steps for rapid assessment technique

Typify Forest Types
↓
Construct Forest Plots
↓
Construct a size class distribution of a forest
↓
Select biggest, rough barked trees
↓
Count number of epiphyte species in canopy of each tree
↓
Survey the crown shadow below each tree
↓
Construct species volume curve
↓
Define diversity from curve

ated in ecotones or on the periphery of a forest would in general be subjected to different microclimate regime to those which are situated in the interior or core of the forest.

Tree Choice

Although phorophyte specificity is not common, there appears to be epiphyte affinities with particular phorophyte characteristics such as rough persistent bark. To economize on survey time, only non-decorticating, rough barked trees should be selected for examination. It is recommended however, that the phorophyte be identified to allow for the recognition of rare phorophyte specificity.

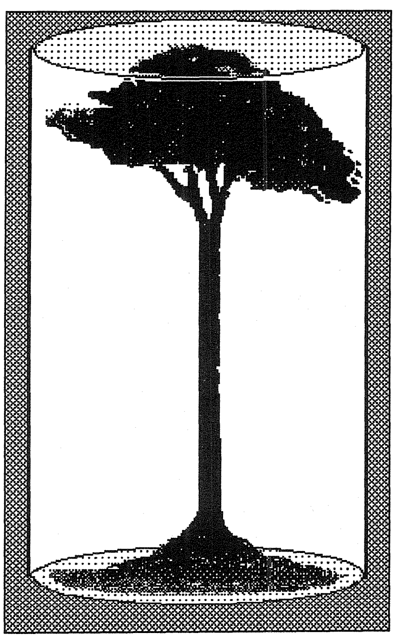

FIGURE 1. 'Tree volume' consisting of the tree and crown shadow (the surface area directly below the tree canopy).

Identifying the Largest Trees

Patterns of epiphyte distribution identified by Johannson (1974), Wallace (1982), and Tweedie & Bergstrom (unpublished data) indicate that larger and/or older trees support more epiphyte species. This can be interpreted in terms of island biogeography theory with larger trees providing greater surface area for colonization and older trees provide a longer period for colonization. To maximize the return of information for effort the methodology presented here requires the identification of the oldest/largest

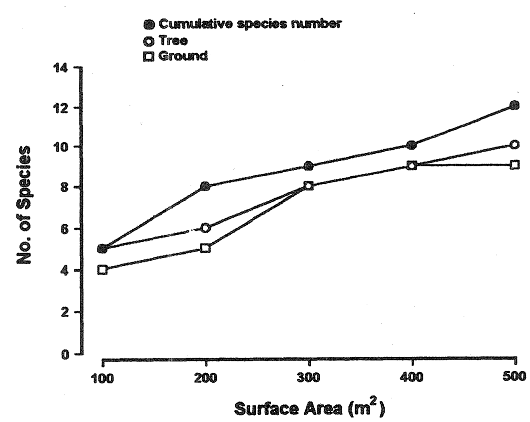

FIGURE 2. Data from a preliminary survey of forest floor and forest canopy in a depauperate sub-tropical rainforest in south east Queensland (Gambubal State Forest 28°14′S, 152° 45′E) showing that a combined survey of both is the most effective technique.

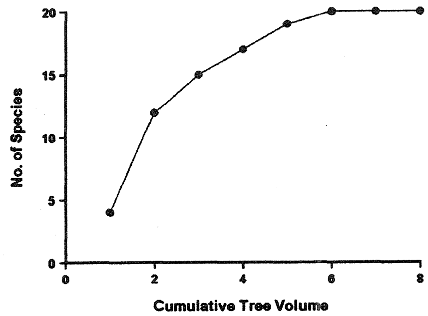

FIGURE 3. A cumulative tree volume curve for a complex notophyll vine forest in sub-tropical rainforest in south east Queensland (Lamington National Park 28° 13′S 153° 07′E).

phorophytes which are then surveyed for epiphytes.

After typification and site selection within a forest, identification of the largest trees must be made. We recommend that a 50 m × 50 m representative plot, be surveyed by measuring the girth at breast height (GBH) of all trees. A graph of size class distributions is then constructed. From the graph the GBH range which represents trees in the top 10% size class is identified. Trees whose GBH are within this size class are then deemed suitable for surveying of epiphyte diversity. The methodology assumes girth is correlated with age, height and crown size. Alternatively, use of a forester's cruising prism (Kernan 1994) may also be appropriate, provided several prisms with a range of diopters are used.

Epiphyte Survey

A decision concerning the choice of survey technique must be made in view of forest architecture, and consequently canopy accessibility. It must be initially acknowledged however that not all species will be detected. For canopies with a thick mid-story, numerous vines or abundant bryophyte (which may obscure epiphytes from view, tree climbing will be necessary. Where these structural features are not present, sampling is easier, as epiphytes are more visible. In these forests, survey using binoculars and/or telescope is sufficient.

An additional zone that should be surveyed for epiphytes is the area of ground beneath the tree. This zone can be termed the 'crown shadow' (see FIGURE 1). FIGURE 2 illustrates that epiphyte diversity surveys can be enhanced if both the canopy and crown shadow is examined: the cumulative species curve being greater than the curves for both the ground and the canopy.

Species Volume Curve

Sampling of every tree at a large site is not logistically viable if many sites are to be surveyed. The minimum number of phorophytes which should be sampled to detect a sufficient proportion of epiphyte flora of the site must be determined. A species area curve is commonly used by ecologists to define this minimum area for non-arboreal vegetation. The number of species found in an area initially increase rapidly as area increases, but eventually reaches an asymptote. The concept of species area curves however can be modified to a species volume curve where a single volume is defined as the three dimensional canopy matrix of a single tree occupied by epiphytes plus the crown shadow (FIGURE 1). FIGURE 3 illustrates a species volume curve for a site in a complex notophyll vine forest in Lamington National Park, South East Queensland, Australia. It can be seen that epiphyte species diversity increases with greater accumulative tree volume. Species diversity (20 vascular epiphytes) for the forest site was defined by the asymptote.

CONCLUSIONS

It is recognized that this methodology will successfully identify common species but may miss rare occurrence which will be encountered only by serendipity or very detailed survey. The methodology does however allow for a relative, consistent assessment of epiphyte diversity at any locality and this information can then be used for comparative purposes at the scales of regional level and above. At present it is difficult to compare epiphyte diversity data in the literature due to the range of techniques used. Furthermore the methodology is cost effective and suited for countries such as Australia, where at present only one research team is currently concerned with epiphyte diversity, and rainforest pockets are small and widely spaced on the eastern side of the continent.

LITERATURE CITED

BENZING D. H. 1990. Vascular Epiphytes: General Biology and Related Biota. Cambridge University Press, New York.

BERGSTROM D. M AND C. E. TWEEDIE (in press). A conceptual approach to studying epiphytes: nitrogen utilization, a case study. Australian Journal of Botany.

BOGH A. 1992. Composition and distribution of the vascular flora of an Ecquadorian montane rain forest. Selbyana 13: 25–34.

DICKINSON K. J. M., A. F. MARK. AND B. DAWKINS. 1993. Ecology of lianoid/ epiphyte communities in coastal podocarp forest, Haast Ecological District, New Zealand. Journal of Biogeography 20: 687–705.

HEITZ P. AND U. HEITZ-SEIFERT. 1995. Composition and ecology of vascular epiphyte communities along an altitudinal gradient in central Veracruz, Mexico. Journal of Vegetation Science 6: 487–498.

——— AND ———.1996. Intra- and interspecific relations within an epiphyte community in a Mexican humid montane forest. Selbyana 16: 135–140.

JARMAN S. J. AND G. KANTILAS. 1995. Epiphytes on an old Huon Pine tree Legarastrobos in Tasmanian rainforest. New Zealand Journal of Botany 33: 65–78.

JOHANSSON D. 1974. Ecology of vascular epiphytes in West African rainforest. Acta Pytogeographica Suecica, 59: 1–136.

KELLY D. L. 1985. Epiphytes and climbers of Jamaican rainforest: vertical distribution, life form and life histories. Journal of Biogeography 12: 223–241.

KERNAN C. 1994. A method for estimating bark surfaces in forest canopies. Selbyana 15: 14–17.

LOWMAN M. D. AND P. K. WITTMAN. 1996. Forest canopies: methods, hypotheses, and future direction. Annual Review of Ecological Systems 27: 55–81.

MACARTHUR R. H. AND E. O. WILSON. 1967. The Theory of Island Biogeography. Princeton Monograph in Population Biology, Princeton University Press, Princeton, New Jersey.

OLMSTED I. AND M. G. JUAREZ. 1996. Distribution and conservation of epiphytes on the Yucatán Peninsula. Selbyana 17: 58–70.

SANFORD W. W. 1969. The distribution of epiphytic orchids in Nigeria in relation to each other and to geographic location and climate, type of vegetation and tree species. Biological Journal of the Linnean Society 1: 247–285.

SUGDEN A. M. AND R. J. ROBINS. 1979. Aspects of the ecology of vascular epiphytes in Colombian cloud forests, I. The distribution of epiphytic flora. Biotropica 11: 173–188.

TER STEEGE H. AND J. H. C. CORNELISSEN. 1989. Distribution and ecology of vascular epiphytes in lowland rainforest of Guyana. Biotropica 21: 331–339.

VAN LEERDAM A., R. J. ZAGT AND E. J. VENEKLAAS. 1990. The distribution of epiphyte growth-forms in the canopy of a Colombian cloud-forest. Vegetatio 87: 59–71.

WALLACE B. 1982. The Australian Vascular Epiphytes: Flora and Ecology. Unpublished PhD thesis, University of New England, Armidale, Australia.

WEBB L. J. 1978. A general classification of Australian rainforests. *In:* Australian Plants. Society for Growing Australian Plants.

WOLF J. H. D. 1993. Epiphyte communities of tropical montane rainforests in the northern Andes 2. Upper montane communities. Phytocoenologia 22: 1–52.

YEATON R. I. AND D. E. GLADSTONE. 1982. The pattern of colonisation of epiphytes on calabash trees (*Crescentia alata* HBK.) in Guanacaste Province, Costa Rica. Biotropica 14: 137–140.

ZAPFACK L., A. B. NKONGMENECK, J. F. VILLIERS AND M. LOWMAN. 1996. The importance of pteridophytes in the epiphytic flora of some phorophytes of the Cameroonian semi-deciduous rain forest. Selbyana 17: 76–81.