SHORT COMMUNICATION

Continuous change in Tanzanian moist forest tree communities with elevation

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Although some studies in tropical forests suggest the existence of elevational discontinuities, zones or critical altitudes in floristic composition (briefly reviewed by Lovett 1996) two data sets from the Usambara mountains of Tanzania independently show a continuous elevational change in moist forest large tree communities (Hamilton *et al*. 1989, Lovett 1996). However, one data set is from the West Usambara mountains (Lovett 1996) and the other is from the East Usambara (Hamilton *et al*. 1989). The junction of the two data sets at around 1000–1200 m in elevation is regarded as a critical altitude (Lovett 1996), and so neither conclusively prove continuity over the entire elevational range of the forests. The two data sets were collected using the same methodology, the twenty-tree variable-area plotless technique (Hall 1991), and together constitute a transect covering nearly 2 km in elevation. They are combined here to test for continuity in change in forest large-tree communities from lowland to upper montane forest types.

The data consist of a total of 158 plots of 20 large trees ($\geq$20 cm diameter at breast height) with an elevational range of 280 to 2180 m from the moist forests of the West Usambara (88 plots, 1760 trees, 103 species) and East Usambara (70 plots, 1400 trees, 109 species) mountains in north east Tanzania. The data cover the entire elevational range of forest on the mountains, but plots from the distinct high elevation dry *Juniperus* forest of the West Usambara were excluded (Lovett 1996). Together the plots contain a total of 3160 trees in 154 identified species (19 unknown) in 133 identified genera (four unknown) and 55 identified families (three unknown). The Usambara mountains (4°-5°S,
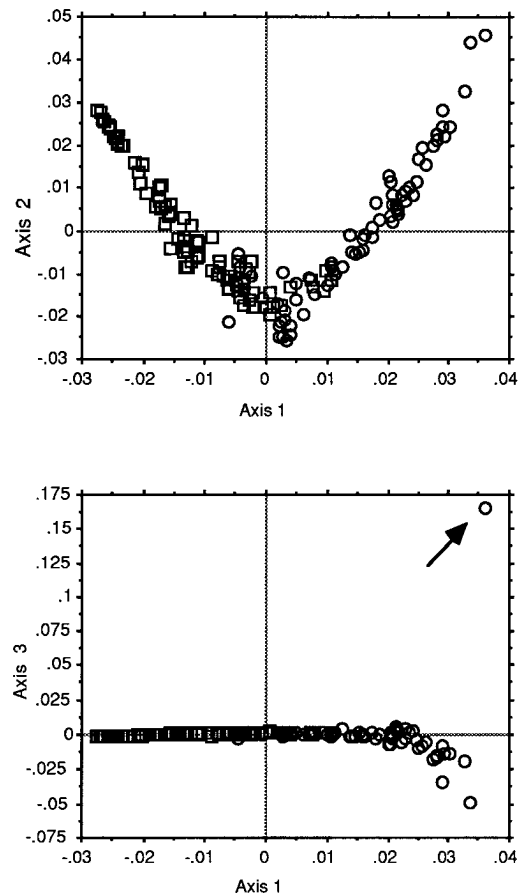
Figure 1. Relationship between axis 1, and axis 2 and 3 of an ordination based on a chi-squared similarity coefficient weighted for species frequency of tree plots from the Usambara mountains. Each point represents a sample of the nearest 20 trees to an objectively chosen point with a diameter at breast height of $\geq$ 20 cm. Circles are plots from the East Usambara mountains, squares are plots from the West Usambara mountains. The plot with the high axis-3 values arrowed is dominated by *Bridelia micrantha*.

38°-39°E) are composed of crystalline Precambrian gneiss with the East Usambara rising to 1506 m and the West Usambara peaking at nearly 2300 m. The two mountain blocks are separated by the dry Lwengera Valley. The moist forests are predominantly evergreen with a closed canopy up to 40 m tall in wetter sheltered areas with emergents exceeding 60 m in height, and a canopy 10–15 m tall on exposed montane ridges. They receive 1000–2000 mm of rain a year under a bimodal rainfall pattern with a minor rainy season in November and the main rainy season in April.

The plots were weighted by frequency of species in each plot and similarity between the plots calculated using a chi-squared similarity coefficient (Legendre & Legendre 1983, Legendre & Vaudor 1991). In a search for elevationally determined zones this method of analysis was used because it is particularly sensitive to the most abundant species in each plot and so is less likely
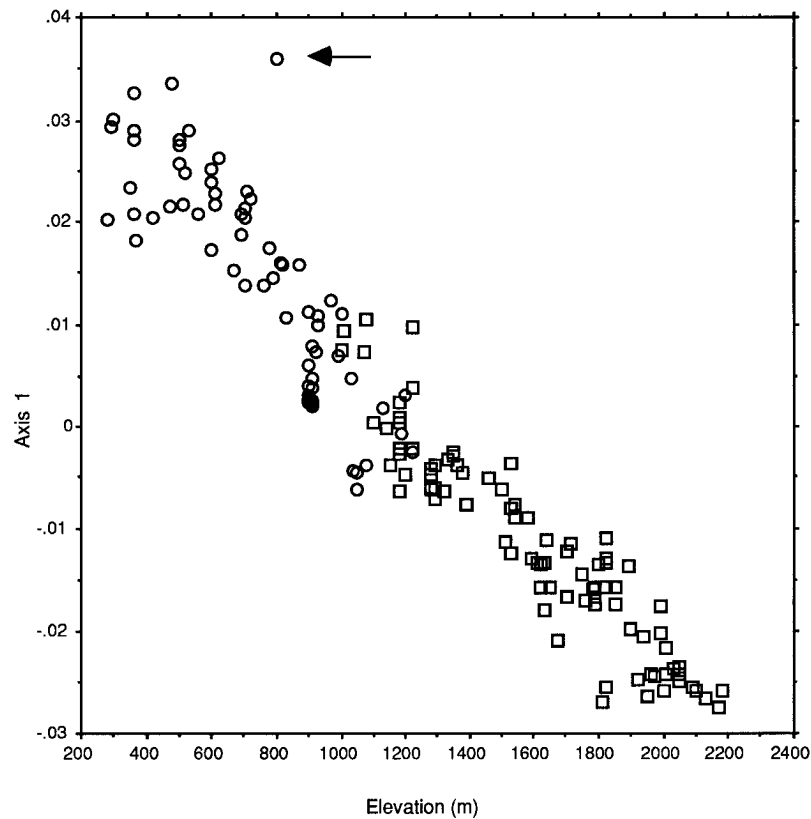
Figure 2. Relationship between axis-1 scores of the ordination and plot elevation (m, asl). Circles are plots from the East Usambara mountains, squares are plots from the West Usambara mountains. The plot arrowed is dominated by *Bridelia micrantha*.

to be influenced by the small scale spatial and temporal gradients or stochastic events that might influence the occurrence of the majority of low density species in a diverse tropical forest. The similarity matrix was ordinated using a principal co-ordinates analysis (Figure 1). The method of analysis is not detrended, so the 'U' shaped pattern of relationship between axis 1 and axis 2 is a function of the analysis and is not ecologically meaningful. There are however, no obvious clusters that would signify discontinuities in similarity between groups of plots. Axis 3 contains some apparently meaningful variation, but without detailed ecological information, interpretation of this remains supposition. One plot (arrowed in Figure 1) is a clear outlier distinguished by a markedly different axis 3 value. This plot is dominated (11 individuals out of 20) by the pioneer species *Bridelia micrantha* (Hochst.) Baill. (Euphorbiaceae) and presumably represents regrowth over a past disturbance. The three plots with low axis-3 values and high axis-1 and 2 values are all diverse without a clear dominant, but are the only three plots in the data set to contain *Lecaniodiscus fraxinifolius* Bak. (Sapindaceae), and have a suite of species that suggest

these plots represent a dry lowland forest type (forest type 'I' of Hamilton 1989) that may be differentiated from moist forest.

Within the limits of the data collected the only clearly defined ecological parameter available for each plot is elevation. There is a good correlation between axis-1 values and elevation ($r^2 = 0.92$; Figure 2). The outlying plot on axis-3, dominated by *Bridelia*, is again arrowed. If this plot is removed, and the data ordinated again, the correlation between axis 1 and elevation improves slightly (157 plots with 171 species, $r^2 = 0.93$). Ordination of the East Usambara and West Usambara data sets independently reveals that the East Usambara plots are not as tightly correlated with elevation (without the *Bridelia* plot, 69 plots with 107 species, $r^2 = 0.74$) as those of the West Usambara plots alone ($r^2 = 0.89$). This may represent greater elevation-independent heterogeneity at lower altitudes, though further sampling would be needed to elucidate this. The data presented here do, however, conclusively demonstrate that there are no elevation related discontinuities in moist forest large-tree community associations in the Usambara mountains, even across the critical medium altitudes.

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