10 FLORA, VEGETATION, ENDEMISM AND ALTITUDINAL GRADIENTS IN THE GUAYANA HIGHLAND AREA: A BRIEF OVERVIEW[1]

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Introduction

The Pakaraima Mts. is a region with high species richness and high endemism in Guyana (Chapter 6). Tree α-diversity, however, may be quite low (Chapter 4, Fanshawe 1952, Whitton 1962, Berry *et al.* 1995), due to high dominance of some taxa, such as *Dicymbe, Eperua,* and *Dimorphandra*. It was suggested that altitudinal zonation and isolation in mountainous areas must have contributed to the high overall species richness, compared to other regions in Guyana (Chapter 6). While little is known on the flora of this region in Guyana, we can draw on a large knowledge base built up in adjacent Venezuelan Guayana to gain some insight in the vegetation and potential richness of this region.

The Guayana floristic region can be subdivided in four provinces (Berry *et al*. 1995), of which the Eastern Guayana Province has been the subject of most of this book, as it includes the lowland forests of Guyana. The Guayana Uplands (Figure 10.1) form the Central and part of the Western province of the Guayana region, as defined by Berry *et al.* (1995). The Central Guayana Province, which consist mainly of (sub-) montane forest and shrublands from 300-1500 m altitude (Berry *et al*. 1995), extends into western Guyana (Pakaraimas and Iwokrama Mts.) with an outlier in Suriname (Tafelberg). The Guayana Highlands correspond to the Pantepui Province, which consists of the high mountain ecosystems above 1500 m (Berry *et al*. 1995), and is found almost exclusively in Venezuela but small pockets are found in Guyana (Mts. Ayangana, Wokomung, and Roraima) and northern Brazil.

The flora

The Guayana Highlands have a rich flora (Huber 1997). Venezuelan Guayana, an area roughly equal in size to the Guianas, is richer in species with 9411 reported vascular plant species (Berry *et al.* 1995) compared to the Guianas, where 7088 species have been collected (Boggan *et al.* 1997). Berry *et al.* attributed the higher number of species to the higher altitudinal variation of Venezuelan Guayana (see below).

[1] The information of this chapter is based almost entirely on the information given in Huber 1988, 1995a and Berry *et al* 1995. It presents a very brief synthesis. The reader is referred to the afore mentioned sources for further information

A number of families are more species-rich in the Guayana Highlands compared to the lowlands. Given the difference in altitude this is not surprising and many of such families are those that are ecologically adapted to (open) mountain ecosystems, such as Rapateaceae, Ericaceae, Xyridaceae. Among the woody families Araliaceae (*Schefflera*) and Aquifoliaceae (*Ilex*) are prominent (Berry *et al.* 1995).

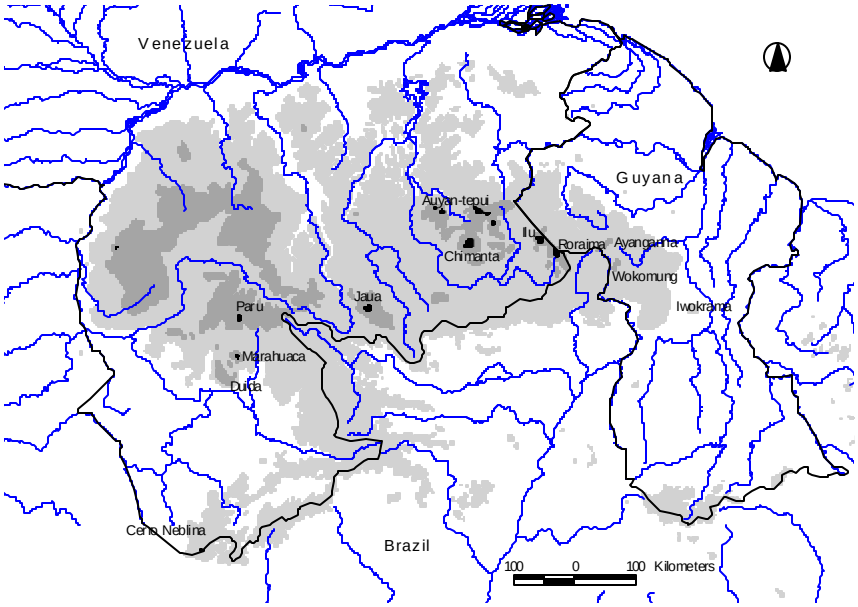

Figure 10.1 The Guayana Highlands, showing the principal mountain systems. The three major mountain systems in Guyana are Roraima, Ayanganna and Wokomung. The Iwokrama Mts. are an isolated part of these highlands. Grey shades: light grey areas are the uplands over 500 m altitude; dark grey are the highlands over 1500 m; black are areas over 2500 m (based on Digital Elevation Model of the USGS (http://edcwww.cr.usgs.gov/landdaac).

Lowland and upland vegetation of the Pakaraima Mts.

The vegetation of the Guayana Highlands, including the Pakaraima Mts., is greatly influenced by variation in altitude and isolation caused by the rugged landscape (Huber 1995a, 1997). There are also very sharp gradients in rainfall with as little as 1700 mm y^{-1} in the south-eastern Pakaraimas (bordering the north Rupununi Savannah) to as much as 4000 mm y^{-1} on the high mountain sides facing the north-eastern trade winds (Persaud 1994). Differences in soil types (see Gross-Braun *et al.* 1965) also contribute to the heterogeneity of this area.

The forest types of this area were discussed in some detail in Chapters 4 and 5. Here we briefly recapitulate the most important features.

Lowland forests (0–500 m)

The lowland forests of the Pakaraima Mts. area can broadly be classified into two groups (Fanshawe 1952): rain forest on brown sands derived from intrusive volcanic rocks and rain forest on the sandstones and sediments of the Kaieteurian series (white sands). The lowlands of the Pakaraima region border with three major national forest regions (Chapter 4) and there is most likely a smooth gradient between them.

The lowland forests of the northern part of the Pakaraima Mts. grade into the wet forests of the Northwest of the country (Chapter 5) and are mainly dominated by *Eschweilera, Licania, Alexa* and *Mora gonggrijpii* (Chapters 4, 5, Fanshawe 1952, Huber 1995a). In the eastern parts, bordering the wet central forests, *Dicymbe* is one of the most striking components. *Dicymbe*, which is almost entirely a Guiana Shield genus (Berry *et al.* 1995), spreads eastwards into central Guyana (Chapter 4) but remains within the 2700 mm y^{-1} isohyeth (ter Steege unpubl. data). This area and especially the drainage basin of the Potaro river has very high abundance of species endemic to Guyana (Chapters 4, 5). In the southern part, where annual rainfall is much lower, dry deciduous forests with *Cordia* and *Centrolobium* can be found (Fanshawe 1952).

On the white sands typical Wallaba forest is found dominated by *Eperua falcata* and *E. grandiflora* (see Chapter 4 for more details).

Lowland (and upland) savannahs

Lowland savannahs, dominated by the grasses *Trachypogon* and *Axonopus* and the shrubs *Curatella* and *Byrsonima* are found mainly in the southern parts where the Pakaraima Mts. border the Rupununi and Rio Branco savannahs and are also scattered throughout the western part of the region (Fanshawe 1952, Huber *et al.* 1995, Chapter 11). At slightly higher altitude *Echinolaena* and *Bulbostylis* are also typical (Fanshawe 1952, Huber *et al.* 1995). Savannahs on white sands have more sedges and also include more genera typical of the alpine meadows (Fanshawe 1952, see below).

Montane or upland forests (500 - 1500 m)

Montane or upland forests (500-1500 m) cover only a very small area in Guyana and their composition remains largely unknown (but see Veloso *et al.* 1975, Huber 1995a). Sapotaceae and Lauraceae, in general, are overwhelmingly abundant at higher elevations (e.g. Table 4.1).

Legumes, such as *Eperua falcata, Eperua grandiflora, Dicymbe altsonii, D. corymbosa* and *Dimorphandra davisii*, dominate the white sands derived from the weathering table mountains (Fanshawe 1952, Whitton 1962, Chapter 4). *Micrandra glabra* is widespread and dominant on poorly drained soils, along rivers, notably the Kako R. (I. Welch pers. comm., FIDS unpubl. data), often together with *Dimorphandra macrostachya*. Fires are common in this area (Hammond and ter Steege 1998) and much of this forest is in a seral stage (*Humiria* and *Dimorphandra* scrub) recovering from fires (Fanshawe 1952, Chapter 4).

Pantepui (Highlands)

Pantepui is defined as that part of the Guiana Shield that is over 1500 m altitude (Berry *et al*. 1995). There are four main vegetation formations that make up Pantepui (Huber 1997):

1. Upper montane forests
2. Tepui scrubs
3. Alpine meadows
4. Open rock vegetation

Upper montane forests (1500 – 2000 m)
In Guyana upper montane forest are only found on the three highest table mountains - Mts. Roraima, Ayanganna, and Wokomung. Typical highland genera such as *Bonnetia, Schefflera, Podocarpus, Magnolia*, and *Weinmannia* are found here (Veloso *et al.* 1975, Huber *et al.* 1995, Huber 1995a). The cloud forests are rich in cryptogamic and vascular epiphytes and have a dense and rich undergrowth (Huber 1995a).

Tepui scrub (2200 – 2700 m)
At higher altitudes the forest finally grades into tepui scrub which, in Guyana, is only found on Mts. Roraima and Ayanganna (Huber *et al*. 1995). Most characteristic genera are *Bonnetia, Schefflera, Clusia*, and *Ilex* (Veloso *et al.* 1975, Huber *et al.* 1995, Huber 1995a). The Tepui scrub is the fomation with the highest diversity in the Guayana Highlands with different scrub types found on almost all large tepuis (Huber 1997).

Alpine meadows (c. (950) – 1500 – 2500 m)
The alpine meadows are also a very rich and distinct formation within the Guayana Highlands (Huber 1997). In Guyana it is only found in the upper reaches of the Kamarang R., Mt. Holitipu and Lamotai Mt., both along the lower Kamarang R. Grasses are usually not dominant (Huber 1995a). Their ecological niche is taken up by *Stegolepis* spp. (Rapateaceae). Other common genera include *Abolboda, Xyris, Orectanthe, Chalepophyllum, Lagenocarpus* and *Brocchinia* (Huber 1995a).

Open rock vegetation
The high summits of tepuis are mostly bare but small pockets of vegetation are present. Apart from cyanobacteria and lichens, which are often the first visible pioneers, Bromeliaceae, such as *Lindmania, Navia* and *Brocchinia*, are typical (Huber 1995a). A recent study of 33 of such vegetation 'islands' on Mt. Roraima (Michelangeli 2000) found 40 species, of which *Bonettia*, Poaceae and Rapateacea had highest cover. Orchidaceae were the most species rich, with 7 species.
Rock vegetation is also found at lower altitudes, often in small areas. *Vellozia* is a characteristic plant of such patches (Fanshawe 1952). Although too small to be mapped effectively, apparently significant stretches occur close to Mt. Ayanganna (Fanshawe 1952). Rock vegetation is also commonly found on rocky outcrops in the savannah and this type will be discussed in more detail in Chapter 11.

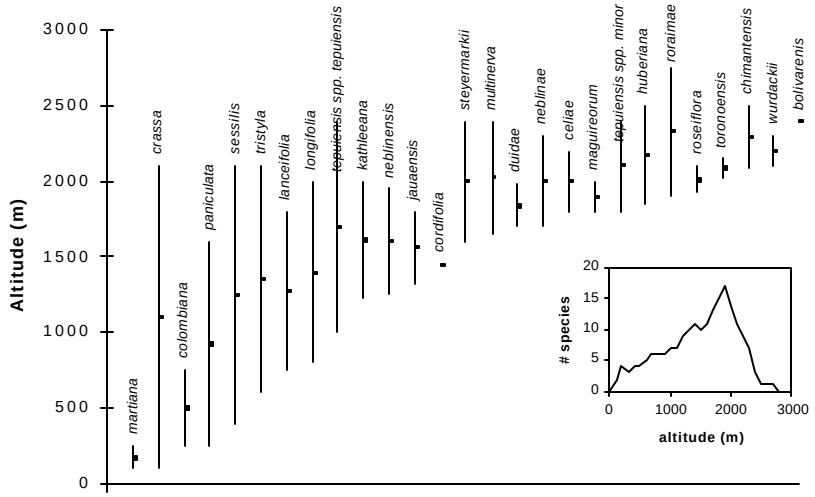

Figure 10.2 Altitudinal distribution of species of *Bonnetia* in Venezuelan Guayana (Huber 1988). The inset shows the number of species found at each altitude.

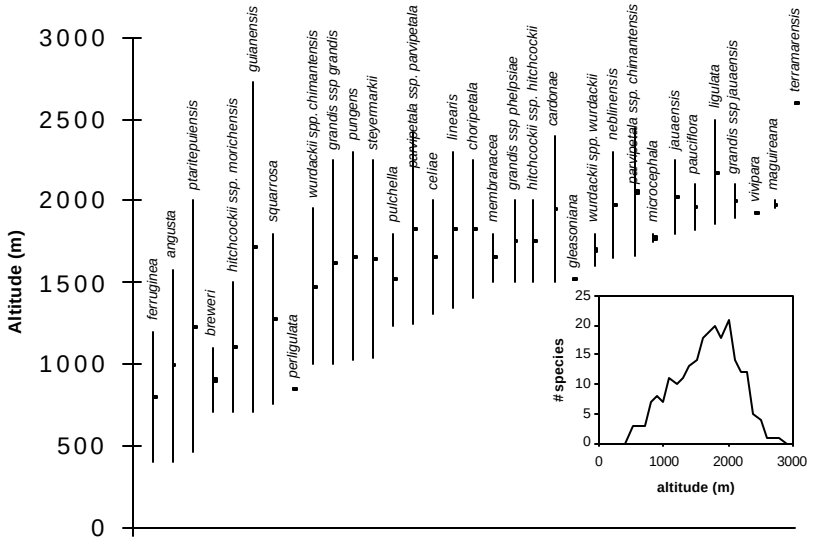

Figure 10.3 Altitudinal distribution of species of *Stegolepis* in Venezuelan Guayana (Huber 1988). The inset shows the number of species found at each altitude.

Altitudinal zonation

As is discussed above altitudinal variation in the Pakaraima Highlands, which ranges from below 500 m to close to 3000 m, adds substantially to habitat heterogeneity. Even with a set of lowland taxa the region showed very high species-richness (γ-diversity, Chapter 6). We have no firm data to suggest which altitude may harbour the highest diversity in Guyana and that is not even be possible with the set of typical lowland species used in Chapter 6 (cf. Berry *et al.* 1995). In Venezuelan Guayana the highest species diversity in two large genera (*Bonnetia* and *Stegolepis*) was found around 1800-2000 m altitude (Figures 10.2, 10.3). These two genera represent the major dominant herbaceous (*Stegolepis*) and woody (*Bonnetia*) element of Pantepui (Huber 1988).
Several species occur in rather small areas or are in fact endemic to one tepui (Huber 1988), thus also contributing to the third biodiversity component - γ-diversity.

Endemism

The Guayana Highlands region has high levels of endemism – as much as 40% of its species are endemic to the Guiana Shield area (Berry *et al.* 1995). In Venezuelan Guayana 1270 species are considered endemics of the area (Berry *et al.* 1995), which is just over 13% of the total flora. Similarly, the Pakaraima Mts. area is the area with highest endemism (9.4 %) in Guyana (Chapter 6). The concentration of endemic taxa is especially high at higher altitudes - Pantepui accounts for just 1% of the Guayana Highlands area but holds 766 species that are endemic to the Guayana Highlands (36% of the total number of endemic species and 23 of the 34 endemic genera) (Berry *et al*. 1995). Pantepui is probably one of the main centres of endemism in the neotropics (Huber 1997).
In Guyana, the area between the Kako River, the head of the Mazaruni River, and Mt. Roraima is an area with high endemism (Chapter 6). Because the drainages of the Mazaruni and Cuyuni Rivers are relatively undercollected compared to the Roraima area this may be an artefact of sampling intensity. However, also at the Guiana Shield level the Roraima-Ilu chain is one of the five concentration areas for endemics in the region (Huber 1997) and the eastern Pantepui subdivision (Huber 1988) is the also the largest centre of endemism for *Bonnetia* and *Stegolepis*. This subdivision includes major tepuis like Auyan-Tepui, Chimana, Ila and Roraima.

Berry *et al.* (1995) found 138 genera to be endemic to the Guiana Shield, 61 of which occur in Guyana. Most of the genera have a fairly wide altitudinal distribution (Figure 10.4). The main peak of generic diversity is found around 1300 m altitude (Figure 10.4 inset). However, out of the 61 genera, 8 are restricted to altitudes over 1000 m altitude, and 14 below 500 m. Ten genera are fully restricted to Guyana: *Gynocraterium, Thysanostemon, Boyania, Maguireanthus, Ochtephilus, Tryssophyton, Maburea, Whittonia, Potarophytum, Windsorina* (Berry *et al*. 1995).

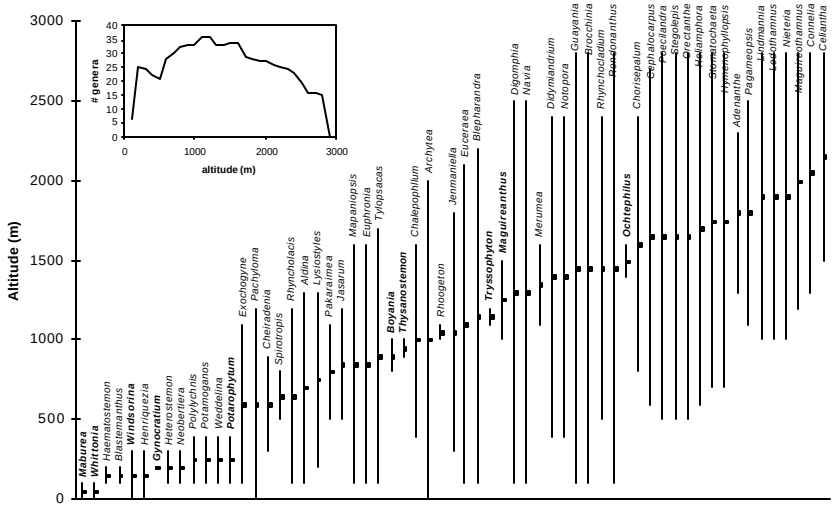

Figure 10.4 Altitudinal distribution of 61 genera, endemic to the Guiana Shield area and occurring in Guyana (data from Berry *et al*., 1995). The genera are ordered based on an increasing 'geometric mean' (horizontal line) of their altitudinal range. The first 14 genera are confined to altitudes below 500m. **Inset**: The number of genera present as a function of altitude. Genera endemic to Guyana are given in bold. **Note!** This is a regional average: not all genera will generally be present at one single site.

Conclusions and some implications for conservation

The Guayana Highlands are one of the important centres of plant diversity and endemism in the neotropics. The Pakaraima Mts. Region in Guyana has very high regional species-richness and the highest level of endemism of the country. A concentration of endemic species was observed in the Upper Mazaruni-Kako-Roraima area, making it the second most important area for endemism in Guyana, after the Berbice Formation area in central Guyana (Chapter 6). However, more rigorous collecting may change the levels of endemism substantially.

Endemic species are very abundant in the Potaro R. basin (Chapter 5), which forms a part of the lowlands (0-500 m) and uplands (500-1500 m) of this region. Although this area has relatively low α-diversity, its high abundance of endemic species is of great conservation value.

Altitudinal variation adds greatly to the diversity at the family, generic (Figure 10.4) and species (Figures 10.2 and 10.3) level. It is therefore important that not only the high altitude areas are preserved, even though the data may suggest that they harbour the greatest concentration of typical species. In addition to that single high mountains often have a set of unique species, not found on other mountains.

Thus, to preserve a large proportion of the plant diversity in this region, a single small area will not be sufficient. Rather, the full altitudinal range *and a substantial geographical range* should be taken into account. A large area with the major 'mountain islands' may satisfy both of the above requirements in Guyana viz. Mts. Roraima, Ayanganna, and Wokomung

Substantial parts of the Guayana Highlands have been conserved in Venezuelan Guayana (Huber 1995b, 1997). The inclusion of the Upper Mazaruni-Kako-Roraima area in the already protected parts of Venezuelan Guayana will help to protect one of the major regions of endemism and species richness in the Guiana Shield, the Guyanan Highlands and Guyana.

Although substantial collecting has been carried out in the area no synthesis on the botanical data is easily made at present. To gain further insight in the vegetation and flora of the region a further analysis of collections made in the area and ecological and botanical field studies are very necessary.