Regional patterns of biodiversity in New Guinea plants

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Regional patterns of biodiversity in seven recently-studied, speciose groups of New Guinea plants (comprising 200 species, or 1–2% of the flora) are analysed with maps showing numbers of species in 1° grid cells. Patterns are correlated with the tectonic history of New Guinea. The New Guinea orogen involved rocks of the northern margin of the Australian craton as well as the terranes accreted to the margin, and the current axial range is geologically and biologically composite. The southern Nothofagus has a main massing on the Australian craton portion of the New Guinea mountains. In contrast, four typical genera of Malesian rainforest (Parsonsia, Archidendron, Aglaia, Amyema) have centres of biodiversity on the accreted terranes north of the craton. There are 32 distinct tectono-stratigraphic terranes (some composite) which have been accreted to the craton at different times through the Tertiary and these may have travelled hundreds or even thousands of kilometres before docking. Finally, the ‘decasinnoid group’ of Loranthaceae and the fern Grammitis have centres of diversity on both the craton and the accreted terranes.

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INTRODUCTION

Regional patterns of biodiversity in tropical rainforest are of interest both theoretically, for biogeographic studies in a highly diverse community, and practically, to assist in finding rational locations for reserves. How to measure biodiversity is a controversial topic, but the simple, pragmatic method used here for New Guinea has been widely used in other countries (see references in Heads, 1997).

The patterns of biodiversity described below are correlated with the tectonic history of New Guinea (Fig. 1). This island is dominated topographically by the axial mountain ranges formed by the New Guinea orogen which run the length of the island. This mountain-building involved the northern margin of the Australian craton as well as terranes accreted to the margin, and the current axial range is geologically as well as biologically composite. There are 32 distinct tectono-stratigraphic terranes (some composite) which have been accreted to the craton at different times through the Tertiary (Figrum & Davies, 1987) and these may have travelled hundreds or even thousands of kilometres before docking.

METHODS

The best data for regional studies of biodiversity are up-to-date, mapped treatments of speciose groups. There are relatively few of these available for New Guinea plants and a literature search produced only seven, namely the fern, Grammitis Sw., and dicotyledons Aglaia Lour. (Meliaceae), Nothofagus Blume (Nothofagaceae), Parsonsia R.Br. (Apocynaceae), Archidendron F.Muell. (Leguminosae), Amyema Van Tiegh. (Loranthaceae) and the Decaisnina Van Tiegh. group of genera (Loranthaceae). These groups are analysed to show their species richness in each 1° grid cell in New Guinea. This size grid (at these latitudes the cells are about 110 km × 110 km) seems a useful compromise. Units much smaller than one degree or half degree squares, such as ecological plots, are subject to greater sampling error and are not usually replicated over a wide area, while larger area units such as floral and faunal regions are not agreed on by all biologists and may obscure important smaller-scale geographic trends in diversity.
Figure 1. Geological map showing the Australian craton (stippled), the New Guinea orogen (between the heavy broken lines), and the accreted New Guinea terranes (black). The islands north of New Guinea comprise Palaeogene and Quaternary volcanic arcs (simplified from Pigram & Davies, 1987).

The island of New Guinea is currently divided into a western half, the Indonesian province of Irian Jaya, and an eastern half, the state of Papua New Guinea (PNG). Many areas in PNG, especially in the west of the country, remain poorly known botanically. Irian Jaya is even less well-explored. While the coastal areas and the mountains are relatively well-collected, the areas between are very poorly known indeed. For example, there seem to be no collections of any taxon from the degree square immediately south of Jayapura, the provincial capital. Care is obviously needed in interpreting analyses of the fairly sketchy distribution data, but these collection-based data from modern taxonomic revisions provide the best available information on biodiversity and have hitherto been seldom analysed. Instead, published research has emphasized total species numbers for particular areas of different sizes.

RESULTS

The results will be related to the geological structure of New Guinea as shown in Figure 1.

GROUPS MASSING ON THE AUSTRALIAN CRATON

*Nothofagus* (Nothofagaceae) is found in New Guinea, New Caledonia, Australia, New Zealand and South America. In New Guinea (Read & Hope, 1996) (Fig. 2) it has a main centre in PNG, especially in the Kubor Mountains square, which is also the most diverse square for marsupials (Flannery, 1995). This lies south of the craton margin. A secondary centre for *Nothofagus* lies north of the craton margin, in the Wilhelm-Madang square. The Papuan Peninsula is surprisingly low in species diversity, but the Vogelkop, representing a detached portion of the craton (unlike the Papuan Peninsula), is relatively high.

*Amylotheca* (Loranthaceae) is a second southern group in New Guinea, and is discussed below under the ‘decaisnoid group’.

GROUPS MASSING ON THE NEW GUINEA ACCRETED TERRANES

The following four genera show a fundamentally different pattern from *Nothofagus*, being most diverse not on the craton, but north of it on accreted terranes. The pattern recalls that of the Chiroptera (Flannery, 1995; Bonaccorso, 1998).

*Parsonsia* (Apocynaceae) in New Guinea (Middleton, 1997) (Fig. 3) has centres of diversity all lying outboard of the craton margin, especially in the Wau square, and also in the Huon and Papuan Peninsulas and, notably, Biak.
Figure 2. *Nothofagus* (Nothofagaceae) in New Guinea. Numbers of species in one degree squares. Total number of New Guinea species = 14. Genus range: New Guinea, New Caledonia, New Zealand, Australia, South America.


*Archidendron* (Leguminosae) (Nielsen, Baretta-Kuijpers & Guinet, 1984) (Fig. 4), like *Parsonsia*, has all its centres of diversity north of the craton margin, especially in the Moresby, Markham-Madang and Jayapura areas. The pattern resembles that of the bowerbirds (Cooper & Forshaw, 1977; Coates, 1990), monotremes and Chiroptera (Flannery, 1995).

*Aglaia* (Meliaceae) (Pannell, 1992) (Fig. 5) has a very similar pattern to that of *Archidendron* and *Parsonsia*. It shows a strong massing in the Papuan Peninsula outboard of the craton margin, especially in the Wau square and the Huon Peninsula. There is a secondary massing around Jayapura.

*Amyema* (Loranthaceae) (Barlow, 1992) (Fig. 6), known elsewhere from Peninsular Malaysia, Australia and several Pacific islands, has centres of diversity in New Guinea north of the craton margin, with notably low levels in the Bismarck Archipelago. Its main centre is...
Figure 4. *Archidendron* (Leguminosae) in New Guinea. Numbers of species in one degree squares. Total number of New Guinea species = 33. Genus range: Sri Lanka and southern and northeastern India through to Taiwan, the Solomon Islands and New South Wales, with a marked concentration of species in New Guinea.

Figure 5. *Aglaia* (Meliaceae) in New Guinea. Numbers of species in one degree squares. Number of species in New Guinea = 22. Genus range: China through Malesia to Pacific islands and Australia.

in the Wau region, like *Parsonsia* and *Aglaia*. The second main centre is Goroka, which is also the main centre of diversity for New Guinea rodents (Flannery, 1995).

GROUPS MASSING ON THE CRATON AND ON THE NEW GUINEA OROGEN

The 'decaisninoid group' (Loranthaceae) is represented in New Guinea by four genera (Barlow, 1993), shown here on two separate maps (Figs 7 and 8) for clarity. *Amylotheca* Van Tieghem (Fig. 7) is the only 'decaisninoid' massing in New Guinea south of the craton margin. This is correlated with a distribution outside New Guinea from Peninsular Malaysia to Australia and New Caledonia.

*Lepeostegeres* Blume (Fig. 7) ranges from Malaysia through to New Guinea, but is not in Australia. There is just one New Guinea species, *L. deciduus* Barlow known only from Mount Michael, immediately adjacent to the craton margin. Its sister species is probably *L.
Figure 6. *Amyema* (Loranthaceae) in New Guinea. Numbers of species in one degree squares. Total number of New Guinea species = 23. Genus range: Thailand to Australia and Samoa.

Figure 7. The ‘decaisninoi group’ (Loranthaceae) in New Guinea (except *Decaisnina*). Numbers of species in one degree squares. Total number of New Guinea species = 5. The affinity of the *Lepeostegeres* species with a species of the Philippines is indicated by an arrow, as are the affinities of the *Cyne* species with Ceram species. The southern New Guinea *Amylotheca* species is shared with Queensland.

*congestiflora* (Merrill) Merrill of the Philippines. Both share deciduous involucral bracts unique in the genus. A very similar tie is seen between *Nyctimene* buts at Crater Mountain and Philippines populations (Nancy Irwin, pers. comm. Dec., 1999).

*Cyne* Danser (Fig. 7) ranges in the Philippines and Moluccas (not in Australia), with disjunct records around Port Moresby and its hinterland, outboard of the craton.

*Decaisnina* (Fig. 8), like *Cyne* and *Lepeostegeres*, has all its New Guinea centres outboard of the craton margin and notably disjunct at: north-east Cendrawasih (the Tamrau and Arfak Mountains), Wissel Lakes, Markham and Port Moresby areas. This is the
only plant genus analysed here that has a primary massing in Irian Jaya. Although the province is notoriously poorly known it does seem that many groups really are more diverse in PNG, for example the well-collected birds of paradise. Perhaps this is explained by the high number of accreted terranes in PNG compared with most of Irian Jaya, apart from the Vogelkop/Biak area which is a major centre of endemism and massing.}

\textit{Grammitis} (Pteridophytes) (Parris, 1983), like the 'decaisinoid' genera of Loranthaceae, has centres both on the craton and outboard of it on the New Guinea accreted terranes (Fig. 9). It has a clear main centre on the Hagen-Wahgi square, straddling the craton margin, with secondary centres in the neighbouring Mendi square, and also far to the west in the Mt. Carstensz and Mt.Wilhelmina squares. There is also
an eastern disjunct massing around Tufi on the Papuan Peninsula. The genus is diverse both south of the craton margin (e.g. at Carstensz, Wilhelmina, and Mendi centres) and north of the craton margin (especially the Hagen-Wahgi, Madang, Huon and Tufi squares). The main centre lies right on the boundary of the craton and the accreted terranes. This is the same square that is most diverse for birds of paradise and bowerbirds (Frith & Beehler, 1998; Cooper & Forshaw, 1977; Coates, 1990; Heads, 2001).

CONCLUSIONS

The New Guinea genera show centres on and/or outboard of the craton margin. In much the same way, New Zealand groups showed two main centres: one in Nelson province on Lower Paleozoic rock, the other on the opposite side of the Median Tectonic Zone in Otago, on accreted Permian and Mesozoic terranes (Heads, 1997). Thus New Guinea and New Zealand both show a major median split in their tectonic and biogeographic structure between cratonic and accreted terrane provinces, reflecting a long history of separate biotic regions before accretion.

The locations of the groups’ massings within New Guinea appear to correlate with the distributions outside New Guinea: Nothofagus and Amylotheca are mainly southern in New Guinea, and also have major centres in New Caledonia and Australia, while groups that are mainly northern in New Guinea (on the accreted terranes) are most diverse in Malesia and the Bismarck Archipelago-Solomon Islands.

Assessing regional levels of biodiversity is probably best done by analysing and synthesizing available data, rather than actually going into the field and counting species in plots. This is what many biologists enjoy doing, of course, but biogeographers have scarcely begun to analyse the thousands of distribution records already available in, for example, van Royen’s (1979–1983) Alpine Flora of New Guinea. Such works provide the raw data of biodiversity and often indicate surprisingly low differentiation. Examples include three well-marked centres of endemism around Goroka (Mounts Kerigomna, Otto and Michael), and the extremely high numbers of endemic and bizarre forms around Mount Doorman in Irian Jaya. These centres are not discussed or related to each other or other centres in any biogeographic literature I know of. Most workers are aware of taxonomic and distributional flaws in such massive works as van Royen’s (e.g. in Thymelaeaceae, Heads, 1990) but the vast numbers of records means that these problems of detail cannot prevent effective, albeit preliminary, biogeographic analysis and biodiversity assessment. Nevertheless, it is not always easy to visualize a distribution from a list of localities, let alone compare many patterns, and so detailed mapping of specimens, a traditional systematic approach, is suggested as a main priority for biodiversity and conservation work in New Guinea.

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REFERENCES