Distribution patterns in Malesian *Callicarpa* (Lamiaceae)

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ABSTRACT. A revision of the 55 species of *Callicarpa* L. (Lamiaceae) in Malesia is almost complete. There appear to be two major centres of diversity, in terms of species numbers: Borneo has 23 (44%) of the species (Bramley 2009), with 19 (83%) endemic; the Philippines has 26 (50%) of the species of which 16 (61%) are endemic (Bramley, in press, a). *Callicarpa* species have an extensive variation in distribution patterns; this paper focuses on the Pan-Malesian species, and the species of Borneo and the Philippines, the two islands / island groups that are the centre of *Callicarpa* species diversity. Fifteen of the 19 *Callicarpa* species endemic to Borneo belong to the 'Geunsia' group, an informal group used here to recognise *Callicarpa pentandra* and its relatives. The Geunsia group appears to be restricted to Malesia, and is only represented by *C. pentandra* outside of Borneo, the Philippines and Sulawesi. The 16 *Callicarpa* species endemic to the islands of the Philippines represent a number of different informal morphology-based groups containing species from other areas of Malesia, China or Indo-China, or, they do not appear to belong to any particular group.

Keywords. Borneo, *Callicarpa*, centres of diversity, distribution, endemism, Malesia, Philippines

Introduction

A revision of *Callicarpa* L. (Lamiaceae) in Malesia is almost complete. It will form part of an addition and update (Bramley et al., in prep.) to Keng's Flora Malesiana account of the Labiatae (1968). *Callicarpa* and a number of other genera in the Verbenaceae, including *Vitex* L., *Premna* L. and *Clerodendrum* L., have been transferred to the Lamiaceae (Cantino et al. 1992, Harley et al. 2004) based on morphological characters, especially cymose versus racemose inflorescence, and a tubular and bilabiate versus salverform corolla; these characters are supported by embryological and pollen characters, and corroborated by analyses of cpDNA sequences (e.g., Olmstead et al. 2001).

There are about 140 species of *Callicarpa*, occurring in both temperate and tropical regions, although this number may be inflated due to currently unrecognised synonyms. In the New World there are 33 species recognised, particularly in the Caribbean Islands (24 species currently recognised on Cuba). The genus is more species rich in the Old World, with one species in Madagascar, c. 48 species in Temperate Asia, particularly China, 55 in Malesia, seven in Australia, and three in the Pacific. In general, the common and well-known species are shrubs or small trees

found in disturbed areas such as secondary forest or roadsides, but a number of lesser known species inhabit primary forest only. Due to their use in horticulture, *Callicarpa americana* L., *C. japonica* Thunb., *C. dichotoma* (Lour.) K.Koch and *C. bodinieri* var. *giraldii* (Hesse ex Rehder) Rehder are widespread.

The 55 Malesian species of *Callicarpa* are unevenly distributed across the region (Fig. 1). Only two species have a pan-Malesian distribution, being present on all islands and groups of islands: *Callicarpa longifolia* Lam. and *Callicarpa pentandra* Roxb. There appear to be two major centres of diversity, in terms of species numbers: Borneo has 23 (44%) of the species (Bramley 2009), with 19 (83%) endemic; the Philippines has 26 (50%) of the species of which 16 (61%) are endemic (Bramley, in press, a). Less species rich is the Thai-Malay Peninsula with a total of eight species, of which one is endemic. Sumatra and Java share seven of these species, neither island has any endemic species. Sulawesi has six species currently recognised, one of which is endemic, and three further endemic species are being described as new to science (Bramley, in press, b). The Lesser Sunda Islands have only three species, and the Moluccas four species, none of which are endemic; New Guinea is home to seven species.

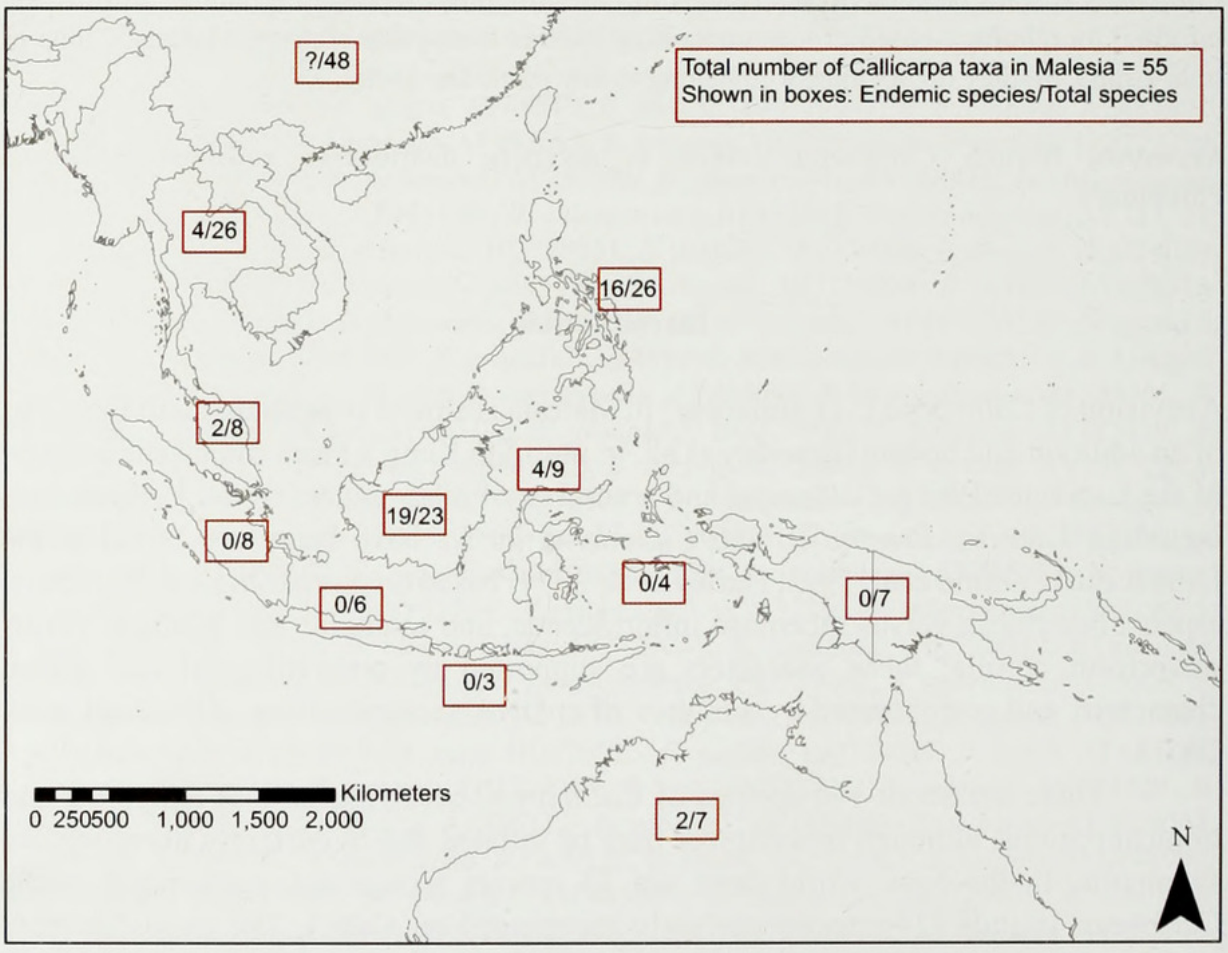

Fig. 1. Map showing the numbers of *Callicarpa* species in each island / island group across the Malesian region. In each box the number to the left represents the number of *Callicarpa* species endemic to that area; the number to the right is the total number of *Callicarpa* species found in that area.

Understanding why some species are widespread and others endemic to particular areas is becoming especially important in this era of habitat destruction and climate change. If we are to meet the targets set out by the Global Strategy for Plant Conservation, there must be an increase in the rate of production of species level conservation assessments (Nic Lughadha et al. 2005). Now that the taxonomy of Malesian *Callicarpa* has been studied, and species delimitation clarified, it is possible to map the distribution of each species based on data from Herbarium specimens. Not only does this allow preliminary conservation assessments to be undertaken, it encourages thought on what morphological characters might facilitate species to inhabit a particular environment, or enable a species to be widespread and apparently successful in more varied environments (Graham et al. 2004). Thoughts on the latter may be useful in any attempts to restore vegetation in disturbed areas.

Malesia has a rich geological history and many studies have focused on distributions of plant families and genera within it, with less of a focus on species. Divisions between areas have been postulated (e.g., Wallace's line), and frontiers marked between different floristic regions (e.g. van Steenis 1950; van Welzen & Slik 2009). By examining the distributions of Malesian *Callicarpa* species, I wish to determine whether there are any common and easy to define patterns that represent groups linked by morphological characters and geography. In this way I might be able to suggest key characters that enable survival or speciation in particular environments. I will make brief comparisons between patterns within *Callicarpa* and other Lamiaceae genera in Malesia. There will be no formal analysis: following the rationale of Baker et al. (1998), this paper is a descriptive precursor to any future analytical biogeographical project.

Materials and methods

Label information from specimens of Malesian *Callicarpa* from BM, BO, C, E, GH, K, KEP, L, NY, SING, SNP, US (abbreviations following Index Herbariorum, Thiers [continuously updated]) was captured in a Microsoft Access database; collecting localities were georeferenced if latitudes and longitudes were not already provided on the specimen label. The online gazetteer GEOnet Names Server (http://earth-info.nga.mil/gns/html/index.html) was used as a source for place names as well as the Google search engine (www.google.com) and printed maps.

Specimen data was exported from Access into ArcView 3.3, and each species distribution plotted using the Conservation Assessment Tools (CATS) extension developed at RBG Kew (Moat 2007).

Distribution patterns, species groups and phytogeographical relationships

Callicarpa species show extensive variation in distribution patterns and each pattern is not described in detail here. Instead I focus on three groups of particular interest:

the Pan-Malesian species, because only this distribution is surprisingly rare, and the Bornean and Philippine species, because these two islands / island groups are the centres of diversity. For a quick reference to the distribution of individual taxa, see Table 1.

Table 1. Malesian *Callicarpa* species and the areas in which they occur (excluding three new species from Sulawesi, Bramley, in press, b). (Left to right) THA = Thailand; MLY = Peninsular Malaysia; SUM = Sumatra; BOR= Borneo; PHI = Philippines; JAW = Java; SUL = Sulawesi; LSI = Lesser Sunda Islands; MOL = Moluccas; NWG = New Guinea; AUS = Australia. Other Areas: C = China, SC = South China, PAC = Pacific, T = Taiwan, V = Vietnam.

Callicarpa species	THA	MLY	SUM	BOR	PHI	JAW	SUL	LSI	MOL	NWG	AUS	Other areas
albidotomentella					x							
angusta					x							?V
angustifolia	x	x	x									V
anomala				x								
apoensis					x							
arborea	x	x	x		x	x						
argentii				x								
badipilosa				x								
barbata				x								
basilanensis					x							
bicolor					x		x			x		PAC
candicans	x	x	x	x		x		x	x		x	C
caudata					x		x		x	x		
cinnamoea							x					
clemensorum				x								
coriacea				x								
denticulata					x							
dolichophylla					x							T, C
endertii				x								
erioclona				x	x	x	x	x	x	x		V
fasciculiflora					x							
flavida					x							
fulvohirsuta				x								
furfuracea	x	x	x			x						
glabrifolia				x								
havilandii				x								
hispida				x								
involucrata				x								
kinabaluensis				x								
longifolia	x	x	x	x	x	x	x	x	x	x	x	

longipetiolata					x						
magnifolia					x						
maingayii	x	x									
micrantha					x						
pachyclada					x						
paloensis					x						
pedunculata					x			x	x	x	SC, T
pentandra	x	x	x	x	x	x	x	x	x	x	
platyphylla					x						
plumosa					x						
ramiflora					x						
rubella	x	x	x								V, C
saccata				x							
scandens				x							
stapfii				x							
subaequalis				x							
subalbida					x						
subglandulosa					x						
subintegra					x						
superposita				x							
surigaensis					x						
teneriflora				x							

Pan-Malesian species

Only two species have a distribution that includes all areas within Malesia: *Callicarpa pentandra* Roxb., and *C. longifolia* Lam. (Fig. 2).

Callicarpa pentandra is a small tree commonly found along roadsides and in secondary forest. Its distribution extends to Thailand in the North and to New Britain in the East, it is possibly present in the Solomon Islands but the material from the area has not yet been examined closely. *Callicarpa pentandra* is distinct from typical members of the genus because it has pentamerous rather than 4-merous flowers, larger oblong rather than elliptical anthers and a fruit with five locules each with two ovules giving a total of ten seeds, rather than the typical four (Fig. 3). As discussed in Bramley (2009) it formed part of the genus *Geunsia* Blume (now included in *Callicarpa*), on the basis of the characters listed above, and others. Further reference to this 'Geunsia' group will be made in a later section on the Borneo Endemics. *Callicarpa pentandra* has been noted as a pioneer species (Tsai 1991); its bright red fruit is likely to be bird-dispersed, and given that it has more than double the typical number of seeds than other member of the genus, it is likely to have an advantage in numbers of seed in the soil seed bank.

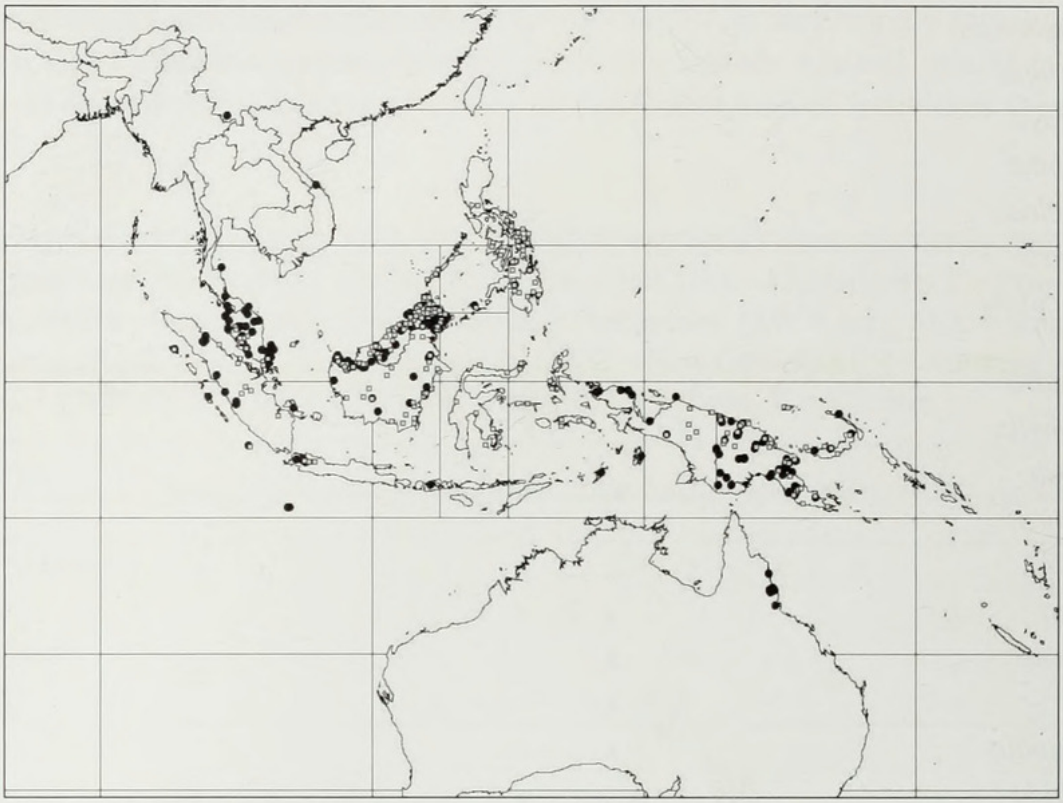

Fig. 2. Distribution of *Callicarpa pentandra* (grey squares) and *C. longifolia* (black circles).

Callicarpa longifolia extends further south than *C. pentandra*, to Australia. Its morphology is more typical for the genus; it has small 4-merous flowers, it is a shrub rather than a tree, and has only 4 locules per ovary, with 1 ovule per locule. The fruit however is white, rather than the more typical purple, and very fleshy—although this is difficult to see in dry material (Fig. 3). In this case I assume its success in secondary habitats is due to the attractiveness of the juicy fruit which is readily dispersed by birds or rodents such as treeshrews (Fletcher 1938, Snow 1981).

Borneo endemics

There are 19 *Callicarpa* species endemic to Borneo. Four of these endemic species have the 4-merous flowers and four ovules that are typical for the genus. The remaining fifteen species belong to the 'Geunsia' group, an informal group that I am using to recognise *Callicarpa pentandra* and its relatives. Along with C. *pentandra*, they have features once recognised under the genus *Geunsia* Blume (see Bramley 2009: 417). Unlike C. *pentandra*, they typically have 4-merous flowers but still have two rather than one ovule per locule than typical for the genus. Unusually, *C. hispida* (Moldenke) Bramley can have up to 7-merous flowers, with a total of 14 ovules (2 in each of its seven locules) (Fig. 4). Some of these species are widespread across Borneo (*C. havilandii* (King & Gamble) H.J.Lam), others are only known from much smaller areas (e.g., *C. argentii* Bramley; *C. anomala* (Ridl.) B.L.Burtt; *C. subaequalis* Bramley). All of these species have a fruit that ripens red which is larger than typical for *Callicarpa*, presumably because of the larger number of developing seeds (Fig. 3). In addition, a number of the species have a dense ferruginous indumentum of various different hair

Fig. 3. *Callicarpa longifolia*: **A.** Flowering branch. **B.** Fruits. *Callicarpa pentandra*: **C.** Flowering and fruiting branch. **D.** Fruiting branch. **E.** Habit.

types (see Bramley 2009). All tend to be found in areas of primary forest, often with some degree of disturbance.

Of additional interest are *C. kinabaluensis* Bakh. & Heine and *C. clemensorum* Moldenke, found at high altitude (1600–2500 m) on the peaks surrounding Mount Kinabalu: they are both extremely hairy and have inflorescences made up of almost globose cymes, perhaps an adaptation to their environment.

Philippines endemics

The 16 *Callicarpa* species endemic to the islands of the Philippines represent a number of different informal morphology-based groups containing species from other

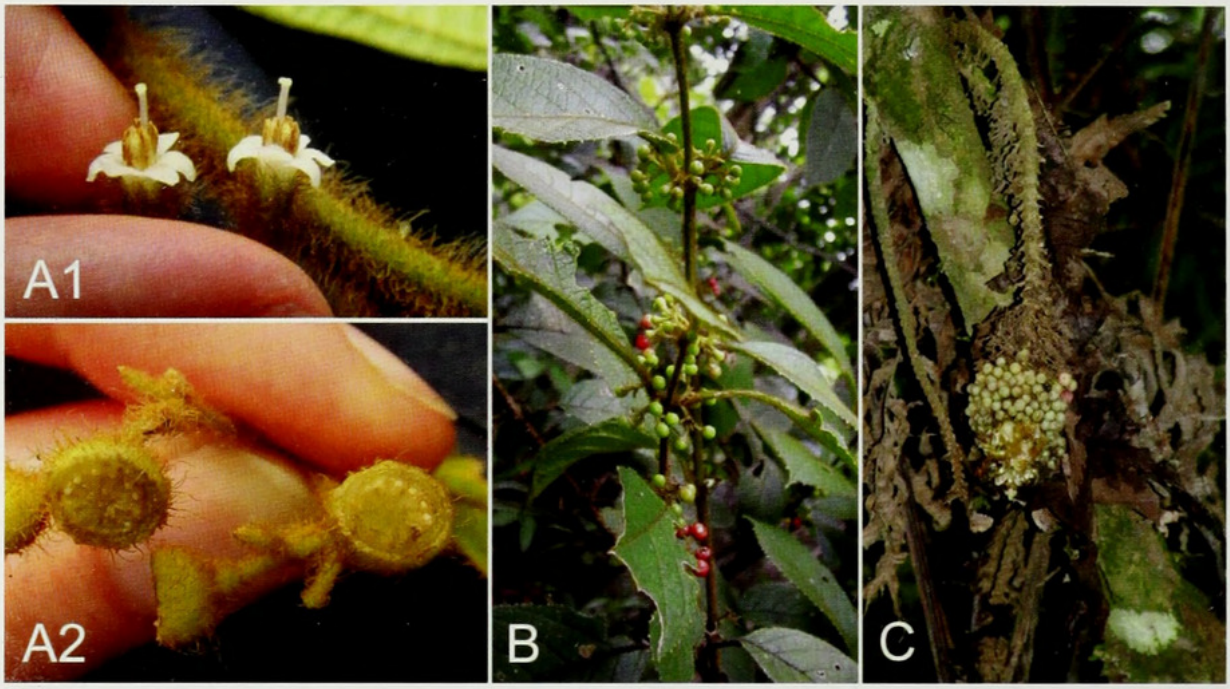

Fig. 4. Examples of Geunsia group species from Borneo. **A.** *Callicarpa hispida* (Moldenke) Bramley: A1, 7-merous flowers; A2, fruits cut open to reveal 14 ovules. **B.** *Callicarpa havilandii* (King & Gamble) H.J.Lam. **C.** *Callicarpa involucrata* Merr.

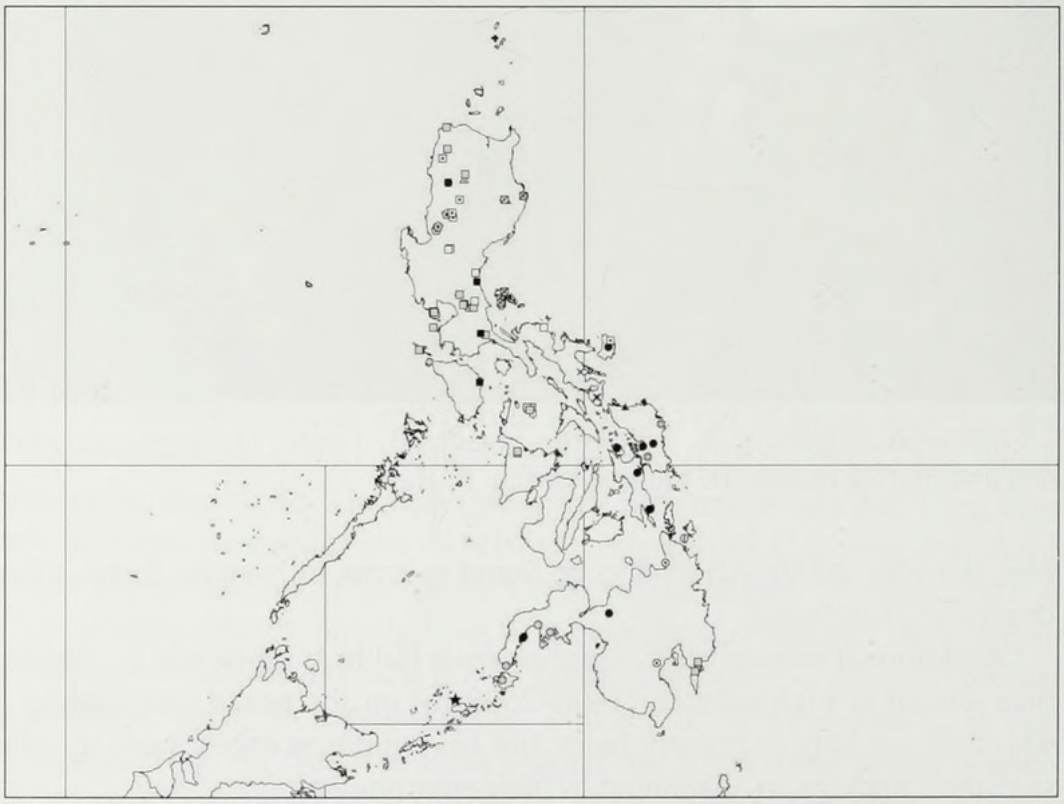

Fig. 5. Distributions of species endemic to the Philippines. Most species have narrow distributions (each species is signified by a different symbol), the exception being *C. micrantha* (grey squares). The Geunsia group of species are restricted to the southern islands (circular symbols).

areas of Malesian, China or Indo-China, to be detailed in the forthcoming revision of Philippine Callicarpa (Bramley, in press, a), or, they do not appear to belong to any particular group.

Most of the endemic species appear to have narrow ranges (Fig. 5). Only *C. micrantha* Vidal occurs throughout the Philippine islands. It is morphologically similar, through its delicate inflorescence, to the widespread *C. japonica*, native to China and Japan. There is a general divide between the Luzon and the Mindanao island groups. Most species present in the Luzon area are not present further south than the northern tip of Samar, with the exception of *C. micrantha*. The species endemic to the Mindanao islands are members of the Geunsia group (Basilan and Mindanao—*C. basilanensis* Merr., *C. flavida* Elmer, *C. ramiflora* Merr., *C. surigaensis* Merr.; Samar—*C. ramiflora*), with the exception of *C. apoensis* Elmer (endemic to Mount Apo). The furthest north the Geunsia group extends is Morong, in Rizal Province, Luzon (14°31'N 121°14'E; *Vidal 3430*), represented by the widespread C. *pentandra*. The Geunsia group appears to be restricted to Malesia, and is only represented by *C. pentandra* outside of Borneo, the Philippines and Sulawesi.

The species that occur in the Philippines as well as other areas appear to have eastern Malesian distributions, sometimes extending to Indo-China, but they do not occur in Sundaland (Fig. 6). For example, *C. pedunculata* R.Br. is a widespread species that does not occur further west than the Philippines. Perhaps this can be explained by a habitat requirement for seasonality: as described by van Steenis (1979), the western side of the Philippines, as well as parts of Sulawesi and New Guinea, are considered

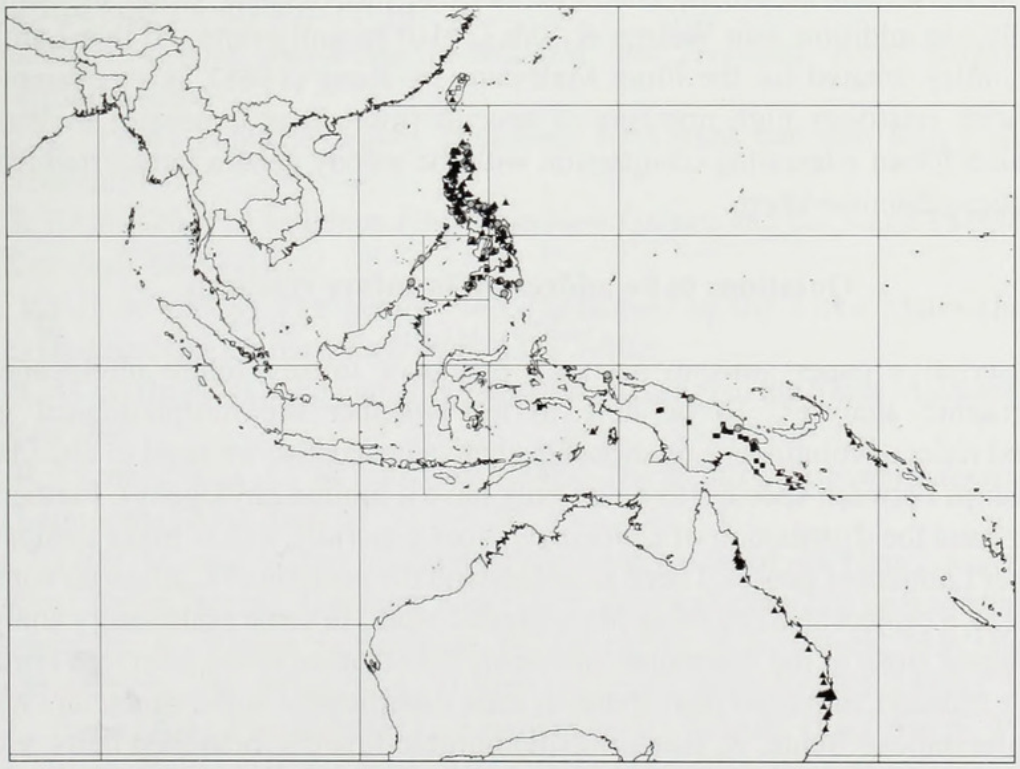

Fig. 6. Examples of *Callicarpa* species with Eastern Malesian distributions: *C. pedunculata* R.Br. (triangles), *C. erioclona* Schauer (grey circles), *C. caudata* Maxim. (black squares), *C. dolichophylla* Merr. (grey squares).

seasonal or monsoon areas. Likewise, *C. erioclona* Schauer is found from Vietnam, through the Philippines, on Java, in Sulawesi and New Guinea and has been recorded once from each of Kudat and Banggi Islands off Sabah. Lack of spread to the west is again perhaps likely to be a result of a preference for a degree of seasonality.

Callicarpa in comparison to other Lamiaceae genera

Callicarpa can be described as a Sunda Shelf and Wallacea oriented genus, with little presence in the Sahul Shelf (regions as defined by van Welzen & Slik (2009)). *Premna* (14 spp.; de Kok, in press), *Vitex* (16 spp., de Kok (2008)), *Teijsmanniodendron* (23 spp., de Kok et al. (2009)) are other Lamiaceae genera with similar distributions but are much smaller than *Callicarpa* in terms of species numbers in Malesia. Only *Clerodendrum* (65–70 spp., J. Wearn, pers. comm.) surpasses *Callicarpa* in terms of species numbers. *Premna* and *Vitex* have been revised by Rogier de Kok (2007, 2008; submitted), and *Clerodendrum* is under revision (Wearn & Mabberley, in prep.).

In terms of the numbers of species endemic to islands or island groups, *Callicarpa* is unusual. For example, there are only seven out of 22 species of *Clerodendrum* endemic to the Philippines (J. Wearn, pers. comm.). On Borneo, the only comparable genus may be *Teijsmanniodendron*: all of its 23 species occur on the island, and 11 of these are endemic (de Kok et al. 2009).

A team of volunteers have begun to database the Malesian Lamiaceae collections at K: once all specimens have been georeferenced and distribution maps completed for each genus, the baseline data for a comparative study of generic distributions will be provided. A particularly interesting question is why some genera appear to have radiated on the island of Borneo, the Geunsia group of *Callicarpa* especially. In addition, van Welzen & Slik (2010) recently reported that Lamiaceae *sensu* Lindley, treated for the Flora Malesiana by Keng (1968), is an example of a family with relatively high numbers of species (more than expected) in Wallacea. This makes for an interesting comparison with the woody genera transferred from the Verbenaceae discussed here.

Questions to be addressed in future research

This descriptive paper aims to act as a precursor to any future phylogenetic or biogeographic analyses. To be able to test whether the morphological groups discussed reflect evolutionary relationships between species, we need to elucidate the relationships between species (to date I only have a limited phylogeny). Furthermore, to understand the distribution of *Callicarpa* more generally, and to make comparisons with other Lamiaceae genera, I need to understand the position of *Callicarpa* within the Lamiaceae, a project also requiring phylogenetic work. In some preliminary analyses it has appeared close to the Australian subfamily Prostantheroideae Luerssen (Bramley, unpubl.). Indeed *Callicarpa* does share, at least superficially, some characters with the tribe Chlorantheae Benth. & Hook.: actinomorphic flowers, branched hairs, variable number of stamens. There is currently no solid evidence to support this position but it would be interesting to pursue this line of investigation, and also the developmental basis of the actinomorphic flower structure, rare within the Lamiaceae as a whole.

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