

## **Biogeographic links between Thailand and Nepal and the potential for collaboration between their Flora projects**

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**ABSTRACT.** The Flora of Nepal Project aims to produce a complete Flora of its 7000 species within 15 years and will shortly publish the first of 10 volumes. Nepal is of particular importance in Asian botany because many widespread Asian plants were first described from specimens collected in Nepal in the early 19th century. Nepal has a huge diversity of habitats due to its enormous altitudinal range, rugged topography and consequent variety in microclimates. With its central position in Asia, Nepal has links to Thailand via the Sino-Himalayan and Indo-Malayan floristic regions. These links have been quantified by analysis of the distributions of the species in the 31 families in Volume 7 of the Flora of Thailand. Several families have large overlaps between Thailand and Nepal at both the specific and generic level, with clear implications for the production of accounts for the two Floras. Analysis of the occurrence of Nepali species within Thailand shows that they are most abundant in the Northern and North-Eastern regions.

## **INTRODUCTION**

The importance of Floras for the management and utilisation of the rich biodiversity resources of developing countries is widely acknowledged. However it is just as clear that insufficient resources and personnel are available to ensure their completion within the timescale that is required (Polhill, 1990; Roos, 1993; 1996; 2003). Traditional morphological taxonomy is poorly resourced and has to compete with phylogenetic studies (Wheeler, 2004) and large-scale biodiversity informatics projects (Flowers, 2007). Morphological taxonomy is out of favour in western countries (Landrum, 2001) and the skills required to carry out floristic work are no longer taught in the vast majority of their universities (Parnell, 1996; Middleton; 2003). Although various reports have highlighted the under-resourcing of taxonomy (House of Lords, 2002; 2008) and the global responsibility of western countries to undertake such work, western taxonomists have seen little change in the support for their work. In the face of these problems it is imperative that taxonomists' time and expertise is harnessed as efficiently as possible to maximize their outputs and ensure that their skills are taught to future generations of researchers (Funk, 2006). There is a perception that much of the effort in writing a Flora consists of reworking existing information in previously published accounts, but this discounts the importance of increasing within-country collections and generating new information about the country's plants. This activity can do much to stimulate other research into the ecology, conservation and uses of plants. The diversity of work presented at the 14th Flora of Thailand meeting is evidence of this.

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The greatest potential for increasing the capacity of Flora projects in developing countries lies in the host regions themselves (Roos, 2003), and the Flora of Thailand Project has been very successful in mobilising a new generation of Thai botanists to contribute accounts to recent volumes (Middleton, 2003). While numerous small families have been completed by Thai botanists, the Flora of Thailand Project has also developed a very successful model for the completion of accounts of large families like the Euphorbiaceae based on collaboration between experienced taxonomists and young Thai botanists (Middleton, 2003). The experienced researchers complete the larger and more complex genera, whilst the smaller genera are revised by students under their supervision, gaining experience and confidence in the process. The Flora of Thailand has encouraged collaboration with Flora Malesiana because of the considerable overlap in the floras (65% of Thai species are also found in Malesia), and a number of large groups have now been completed by the same authors in both Floras, e.g. the Apocynaceae (Middleton 1999, 2007), Sapindaceae (Adema *et al.*, 1994; van Welzen, 1999), Caesalpinioidae (Larsen *et al.*, 1984; Ding *et al.*, 1996) and Mimosoideae (Nielsen, 1985; 1992).

In this paper we will discuss how the lessons learned in the Flora of Thailand Project can be applied to the Flora of Nepal project. We will discuss the similarities and differences between the vegetation of Thailand and Nepal, give an overview of work of the Flora of Nepal Project, quantify the similarities between the two floras, and discuss the potential for collaboration between the two Flora projects.

#### *Geomorphology and Geology*

Nepal rises from an altitude of about 60 m above sea level in the lowlands of the Terai, through the Siwalik Hills to the mountains of the Mahabarat Lek, the fertile valleys of the midlands and then to the Himalayas themselves and the trans-Himalayan steppes beyond them. Limestones are found within the latter two areas, but nowhere produce the karst landscapes which are so characteristic of some parts of Thailand (Upreti, 1999).

#### *Climate*

Lying to the south of Asia's main mountain ranges, the climates of both Nepal and Thailand are dominated by the Asian monsoon weather systems, with the majority of the rain in both countries falling in the summer months, followed by a cool, dry season in winter and then a hot, dry season before the monsoon returns. There are however important differences between their climates and strong regional differences in climate within both countries. The main differences are that the monsoon is shorter and more intense in Nepal, with the majority of the rain falling from June to September and because of its more northerly latitude monthly temperatures show greater variation during the course of the year in Nepal than in Thailand. Nepal also has a much greater range of temperature regimes because of the huge altitudinal range which it encompasses, and the seasonal difference in temperatures becomes more pronounced with altitude.

The general pattern of the climate in Nepal is for the monsoon to last from June to September, clear dry weather to prevail in October and November, sporadic winter rains to fall from December to March and the hot, dusty, dry season to last from March to May. Average rainfall for the whole of Nepal is 1600 mm, but there are very pronounced

regional and local differences. The monsoon develops earlier in the east and carries on longer there so there is a marked gradient of decreasing rainfall from east to west. Winter rains are stronger in the west than the east, so the overall effect is for rain to be much reduced towards the west, but slightly more evenly distributed. Local topography has very strong effects on rainfall, with moderate rainfall in the lowlands of the Terai, higher rainfall in the Siwalik hills, the highest totals on the southern slopes of the Himalayas and to their north arid conditions prevail due to the rain-shadow effect. The highest recorded rainfall is 5500 mm at Lumle, on the southern face of the Annapurna range, where the Siwaliks are rather low and little rain is intercepted before the moist monsoon air stream reaches the main Himalayan range. Throughout the country the topography is very dissected and aspect has very strong effects on climate, with south facing slopes receiving greater insolation and consequently they are noticeably drier than north facing slopes.

### *Vegetation*

Nepal has been estimated to have a flora of at least 6500 (Hara *et al.*, 1978) and possibly as many as 7000 (<http://www.floraofnepal.org>) species of flowering plants. In most of Nepal the tree-line is at about 4100 m, though there is some variation due to local climatic conditions. Above the tree line alpine scrub or meadows are found up to about 5200 m, and beyond that scattered alpine plants survive in sheltered locations. The highest records of plants come from 6350 m (Zimmerman, 1956). Nepal's east-west rainfall gradient is clearly reflected in the vegetation, with moisture-requiring species with eastern affinities gradually being replaced by more drought tolerant species which are characteristic of the western Himalayas. This is clearly demonstrated by the occurrence of *Rhododendron* spp., of which there are over eighty species in Bhutan and Sikkim, about thirty in eastern Nepal, but only five in western Nepal (Dobremez, 1976; de Milleville, 2002).

Any description of Nepali vegetation must acknowledge the huge influence of topography on climate and therefore the distributions of plant species and vegetation types at the local scale. These brief notes are intended to give a broad overview of the vegetation of Nepal as it is relevant to Thailand, but cannot consider the numerous variations in species composition which occur. Excellent accounts of Nepal's vegetation can be found in Stainton (1972) who recognised 35 forest types and Dobremez (1976) who described 75 vegetation types, including 54 different forest formations. The most widespread forest of the Terai is dominated by *Shorea robusta* Gaertn. or Sal, the single species of dipterocarp found in Nepal. This forest, which has an open understorey of *Lagerstroemia parviflora* Roxb. and *Terminalia* spp., is not particularly species-rich and is considered by Whitmore (1984) to be an extension of the tropical moist deciduous forest, which is found across India, through Burma and into western Thailand (tropical mixed deciduous forest sensu Santisuk, 1988). Tropical deciduous riverine forest is found along water courses in Sal forest, and in this more diverse formation *Bombax malabaricum* DC. is the most prominent species. In eastern Nepal tropical evergreen forest (sensu Stainton, 1972) occurs in shady ravines and north-facing gulleys. This is a much more species-rich formation than sal forest and almost all of the most important tree species of these forests are East Himalayan in distribution, with many of them occurring in Nepal only in these

places (Stainton, 1972). Of the larger trees the most prominent is *Michelia champaca* L., with various Lauraceae species and *Syzygium cumini* (L.) Skeels widespread in it, and this forest can be considered analogous to the tropical semi-evergreen forests (sensu Whitmore, 1984) of peninsular Thailand or seasonal rainforest of Santisuk (1988).

With increasing elevation the tropical and subtropical forests give way to more temperate *Schima* – *Castanopsis* (*C. tribuloides* (Sm.) A.DC. or *C. indica* (Roxb.) Miq.) forests at about 1000 m, with pine forests (*Pinus roxburghii* Sarg. up to about 2000 m and *P. wallichiana* A.B. Jacks at higher elevations) on the more exposed and drier south-facing slopes. Lauraceae are a frequent component of the wetter forests, along with *Rhododendron arboreum* Sm. and other, smaller species of *Rhododendron*. These forests have their equivalent in the lower montane forests of northern Thailand (Santisuk, 1988) with which they share species such as *Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm., *Lindera pulcherrima* (Nees) Benth. ex Hook.f., *Beilschmiedia gammelainana* King ex Hook.f. and *Neolitsea foliosa* (Nees) Gamble. In the upper temperate zone between about 2000 m and 3000 m there are various coniferous and broadleaved forest types with different combinations of conifers, Rhododendrons, Aceraceae, Fagaceae, Lauraceae. There are no direct Thai equivalents of these temperate forests, but they contain shrubby species such as *Lyonia ovalifolia* (Wall.) Drude and *Mahonia napaulensis* DC. which are characteristic of Thai upper montane forest and upper montane scrub. *Betula utilis* D.Don forest often forms a distinct belt at the upper limit of the temperate forest before it gives way to the treeless alpine slopes.

The widespread presence of tropical elements at low altitude in Nepal, and the occurrence of forests which are analogous with Thai formations clearly demonstrate that Nepal's lowlands are part of the Indo-Malayan floristic sub kingdom (Takhtajan, 1969). Likewise the frequent occurrence of temperate genera in the montane vegetation of northern Thailand is indicative of its inclusion with the Sino-Himalayan floristic region (Santisuk, 1988).

Human impact on vegetation is heavy throughout Nepal, with the majority of the population dependant in various ways on the country's natural resources. Historically the greatest population density was in the mid-hills, with high altitude areas supporting low population densities and the malarial forests of the Terai mainly intact. In the second half of the twentieth century malaria was largely eradicated from the Terai and the majority of its forests were cleared for agriculture. The Terai now has over 50% of Nepal's agricultural land (Bhuju *et al.*, 2007) and produces the majority of the country's rice harvest. Forests cover about 29% of the land area (HMGN/MFSC, 2002), a fraction of their natural extent, and the remaining forests are under heavy pressure for timber, fuelwood, grazing, fodder and other non-timber forest products. All areas with heavy human influence contain many weedy and invasive species, and at low altitudes there are numerous introduced palaeotropical and pantropical weed species. These are rather poorly collected, and are certainly an under recorded element of Nepal's biodiversity; it is very likely that many new records could be added by collecting in populated areas (Pendry *et al.*, 2009; similarly in Thailand, several weedy, 'invasive' *Euphorbia* species were only found in cracks in the pavement concrete in cities (e.g. Esser, 2005).

### *Plant collecting in Nepal*

The first plant collector in Nepal was the Scottish-born surgeon Dr Francis Buchanan-Hamilton, who spent a year in Kathmandu from 1802 whilst on diplomatic duties for the British East India Company. He collected numerous plants in the Kathmandu Valley, many of which were new to science. In 1820 Nathaniel Wallich arrived in Kathmandu and he also spent a year collecting in the valley. His collections were more extensive than Buchanan-Hamilton's and he was also able to obtain specimens from outside the Kathmandu Valley from pilgrims travelling to sacred sites in the Himalayas. Thereafter few foreigners were permitted to enter Nepal until the middle of the twentieth century, and only limited collections were made until then. During the second half of the twentieth century Nepal was visited by a series of expeditions from the Natural History Museum, London (BM), and from the University of Tokyo. Many thousands of specimens were collected on these expeditions, and consequently the UK and Japan became the two main centres of research on the plants of Nepal. The Nepali Government established a National Herbarium (KATH) at Godavari in 1960 under the auspices of the Department of Plant Resources (DPR), and it now has over 150,000 specimens (HMGN/MFSC. 2002).

Pendry & Watson (in press) estimated that Nepal has a collecting density of about 0.7 collections per km<sup>2</sup> which is slightly higher than that of Thailand, which has about 0.5 specimens per km<sup>2</sup> (Parnell 2000). Although no analysis has yet been carried out, Nepal appears to be even more unevenly collected than Thailand, because the extreme remoteness of many areas, which makes them logistically difficult and expensive to reach. The road system penetrates the hills in only a few places, and the vast majority of the country is only accessible on foot. Access problems have been compounded by the political situation, since much of the country was virtually closed to foreigners and government officials during the decade-long Maoist insurgency, which ended in 2006. The value of plant collecting in Nepal was demonstrated by recent collecting trips to Sagarmatha (Everest) and Chitwan National Parks, which took place during the Darwin Initiative Project which ended in 2006. It was decided to restrict work to these areas because of security concerns, and although these are among the best collected areas in Nepal, 37 new records for Nepal were collected including six new genera (Watson *et al.*, 2007). The rate of collection of new records was highest in the trip to Chitwan and the surrounding areas of the Terai, where 3% of all specimens were new records (Pendry & Watson, in press). Most foreign-funded collecting efforts have concentrated on Nepal's mountains, so the Terai is particularly poorly-collected.

### *Publications on the flora of Nepal*

The *Prodromus Florae Nepalensis* (Don, 1825) was the first publication to deal with the plants of Nepal. At the time there was considerable resentment that the young David Don had been given access to Buchanan-Hamilton's collections and some of the first plants distributed by Wallich, and the *Prodromus* was not well received (Fraser-Jenkins 2005). It is a critical work, however, as Don was the first to describe many widespread Asian plants and his names take priority over later synonyms published in Hooker's *Flora of British India* (Hooker 1875–1897) and de Candolle's *Prodromus* (Candolle & Candolle 1824–1873).

Wallich himself published many new species in his *Tentamen Flora Nepalensis* (Wallich 1824-1826) and *Plantae Asiaticae Rariores* (Wallich 1829-1832), but to later botanists he is often best known for the confusion caused by his *Numerical List of dried Specimens of Plants* (1828-1849), which records the 9148 numbers representing 226,000 duplicates of collections, which he distributed throughout Europe (Fraser-Jenkins, 2005). This is commonly known as *Wallich's Catalogue* and as it was handwritten and lacks descriptions all the names in it are *nomina nuda* and are only validly published when they are taken up by later authors like Hooker or de Candolle.

Subsequently rather little was published on the plants of Nepal until after the UK and Japanese expeditions in the 1950s, and the most important work relating to this period of renewed interest is *An Enumeration of the Flowering Plants of Nepal* (Hara *et al.*, 1978–1982). The Enumeration covered about 5000 species of seed plants, and includes detailed information on their synonymies and literature citations as well as basic distribution data and keys for some genera. The information in the Enumeration was updated and databased during a Darwin Project at the Natural History Museum, London, which lasted from 1997 to 2000 and this database is now available at Missouri Botanical Garden's eFloras website (<http://www.efloras.org>).

#### *The Flora of Nepal Project*

Although the need for a Flora of Nepal has been recognised by the Government of Nepal since the early 1960s, progress towards it was slow for many years. DPR has published several florulas such as the Flora of Phulchoki and Godawari (Malla, 1969), the Flora of Langtang and Cross Section Vegetation Survey (Central Zone) (Malla *et al.*, 1976) and the Flora of the Kathmandu Valley (Malla *et al.*, 1986) and since 1995 it has been publishing family revisions as *Fascicles of Flora of Nepal*. The Government of Nepal identified the lack of a Flora as a problem in its National Biodiversity Strategy (HMGN/MFSC. 2002). While the *Fascicles* are a useful basis for the Flora, they are limited because DPR staff only have access to the collections at KATH, it was therefore decided that an international approach was needed so that the Flora could benefit from the collections, literature and expertise not available within Nepal. The current Flora of Nepal Project dates from a meeting held in Edinburgh in 2002 between the Royal Botanic Garden Edinburgh (RBGE), the Royal Nepal Academy of Science and Technology (RONAST, now NAST), Tribhuvan University Central Department of Botany (TU-CDB), DPR, the University of Tokyo (TI) and the Natural History Museum (BM). It was decided that RBGE should coordinate the production of the Flora under the leadership of Mark Watson, with one editor coming from each of DPR, TI and TU-CDB. RBGE's support for the Project consists of a nucleus of two full time members of staff (Mark Watson and Colin Pendry), fundraising on an *ad hoc* basis.

The Flora of Nepal will be published in 10 volumes, each of about 700 species and will follow the same modified Englerian family order as in the Flora of China and the Flora of Bhutan. In order to maintain a concise format family, genus and species descriptions will be about 150 words and literature citation will be minimal. More detailed information including images will be made available online via the Padme database which is used to manage all data involved in the generation of accounts, and accounts will be made available online before they are published. The volumes will be published as they



are completed, and the first will be Volume 3 (Magnoliaceae – Rosaceae) followed by Volume 7 (Boraginaceae – Carlemanniaceae). It is hoped that Volume 3 will be published in 2010, and it is anticipated that the complete Flora will take about 15 years to complete. Further details can be found at <http://www.floraofnepal.org>.

### *Darwin Project*

The need for staff and institutional capacity building was identified as a priority at the Edinburgh meeting, and RBGE obtained funding from the UK's Darwin Initiative to carry out a three year project to work with RONAST, DPR and TU-CDB, training 16 Nepalese botanists in flora writing skills, plant collecting techniques and herbarium management and by improving the infrastructure at the three institutions. Each participant joined one of the three training expeditions to Sagarmatha and Chitwan National Parks, and carried out a personal research project to produce an account for the Flora, some of which will appear in Volume 3. The project also included short study visits to the UK to access collections and literature to help completion of these accounts. Four of the participants in the Darwin Project have subsequently taken part in training and research at RBGE, including one PhD and one MSc, and research towards completion of the accounts of the Orchidaceae and Begoniaceae.

## METHODS

The occurrence of Thai plants in Nepal (and *vice versa*) was quantified using the families in Volume 7 of the Flora of Thailand. The families in Volume 7 form a diverse assemblage which is considered a fairly representative sample of the plants of Thailand as it includes both large and small families and a wide diversity of growth forms including herbs, shrubs, trees and terrestrial and aquatic plants. Families with generally temperate distributions are present, as well as those with cosmopolitan and exclusively tropical distributions. Genera and species were placed in three categories: present only in Thailand, present only in Nepal and present in both. If the type specimen of a Thai species had been collected in Nepal this was also noted. Type information is not recorded in the Annotated Checklist, so it was not possible to collect comparable information for Nepalese species.

The relative importance of species present in both countries in the seven floristic regions used in the Flora of Thailand was assessed by calculating Kroeber coefficients for the species of Volume 7 using the formula  $KC = 50 \times C \times (A + B) / (A \times B)$  where A is the number of species in Nepal, B is the number of species in the Thai floristic region and C is the number of species they have in common.

## RESULTS

The thirty one families examined range in size from the Apocynaceae with a total of 129 species in both countries, to the Ctenolophonaceae, Hydrophyllaceae, Myricaceae, Salvadoraceae and Saururaceae, which have a single species each. Between them the

Flora of Thailand and the Annotated Checklist contain a total of 208 genera and 948 species in the thirty one families. Of these 98 genera were restricted to Thailand, 22 were restricted to Nepal and 88 were found in both countries, while 557 species were restricted to Thailand, 279 were restricted to Nepal and 108 were common to both. Three small families with a total of four species (the Ctenolophonaceae, the Cymodoceaceae and the Salvadoraceae) were present in Thailand, but not in Nepal and are not considered further. In twelve families all of the genera were present in Thailand, but not all were found in Nepal, while nine families showed complete overlap between Thailand and Nepal and in two families (Oleaceae and Hydrocharitaceae) there was an even distribution of genera in common and genera unique to the two countries (Fig. 1). These families can be considered to have cosmopolitan or primarily tropical distributions. In five families all or the great majority of genera were present in Nepal but not Thailand, and these families can be considered to be primarily temperate.

Sixteen per cent of the species in Volume 7 of the Flora of Thailand are found in Nepal, while twenty eight per cent of the species in the Annotated Checklist grow in Thailand. However, the distribution across the families is extremely uneven (Fig. 2 and Table 1). Excluding the three monotypic families, in four families (Hamamelidaceae, Limnocharitaceae, Myristicaceae and Zygophyllaceae), 100% of the species in the Annotated Checklist are found in Thailand, and in a further six families (Apocynaceae, Sapindaceae, Myrtaceae, Alismataceae, Lemnaceae and Sterculiaceae) at least 70% of the Annotated Checklist species were recorded in Thailand. Likewise, in four polytypic families (Buddlejaceae, Callitrichaceae, Hydrangeaceae, Monotropaceae) all of the Flora of Thailand species are included in the Annotated Checklist, and in one other family (Lemnaceae) over 70% of the Thai species grow in Nepal. Eighteen Thai species were found to be typified or to have synonyms typified by specimens collected in Nepal, with the highest number in the Melastomataceae in which four of the eight Thai species found in Nepal had Nepali types. The strongest link between Nepal and the Thailand is via the northern region which had a Kroeber coefficient of 26% (Fig. 3), followed by the north-eastern region with a coefficient of 22%. The weakest link was with the peninsular region with a coefficient of 11%. The Peninsular region had the lowest coefficients with the other regions.

## DISCUSSION

### *Floristic overlaps and the potential for collaboration*

Although the two Floras shared only 11% of the species in this study, some families show much higher levels of overlap and clearly show the potential for collaboration between the two projects. The collaboration between the Flora of Thailand and Flora Malesiana has proved to be a valuable one, and if we use the overall figure of 65% overlap between them as the basis for comparison it can be seen that there are equivalent or higher levels of overlap for nineteen families in the Flora of Thailand and the Flora of Nepal (Table 1). It is clear that after completing an account of one of these families for one Flora it would be an efficient use of the author's expertise to go on to either write the account for the other Flora or to oversee its production.



The overlap between the two Floras is unequal, with more Nepali species growing in Thailand than *vice versa*. Fourteen of the 29 Volume 7 families have high proportions (>65%) of the Nepali species growing in Thailand, whereas only nine of the families have equivalent proportions of the Thai species growing in Nepal. The general pattern observed for the families of Volume 7 is that species-rich families with primarily tropical distributions extend their range into subtropical Nepal, while species-rich temperate families like the Primulaceae and Saxifragaceae have few species in Thailand and they tend to be mostly Thai endemics or to have limited distributions, which do not reach as far as Nepal.

Six of the families with high levels of overlap have only a single species in the two Floras, so while collaboration on those families would be useful the saving of time would be trivial. However for the Apocynaceae, Sterculiaceae, Myrtaceae and Polygalaceae Flora of Thailand authors have already revised a total of 46 Nepali species in the preparation of these accounts and they could significantly accelerate the completion of these accounts in the Flora of Nepal.

Nepal is of particular importance in the preparation of South East Asian Flora accounts because of the comparatively high number of type collections made there by Buchanan-Hamilton and Wallich in the early 19th century (e.g. *Holarrhena pubescens* Wall. ex G.Don, *Polygala arillata* Buch.-Ham ex D.Don, *Melastoma normale* D.Don). While this will necessitate Flora of Thailand authors checking Nepali material in the preparation of their accounts, the reverse is less likely to occur because of the relatively late commencement of plant collecting in Thailand in the early 20th century. By this time most of the widespread plants found in both countries were already described, and most new species described from Thailand are endemics or relatively uncommon species. If the figure of 19 families out of 31 were extrapolated to the Floras as a whole it suggests that some form of collaboration would be of value in at least half of the families covered by the Floras. It is however necessary to examine each family individually before deciding how useful it would be to collaborate over the accounts. The easiest way for a Flora of Thailand author to check the potential for collaboration is consult the Annotated Checklist of the Flowering Plants of Nepal on the eFloras website (<http://www.efloras.org>) to see which species are present in both countries. If any author wishes to contribute to the Flora of Nepal they should contact the Flora of Nepal team at RBGE. TU-CDB has an MSc course which trains students in taxonomy, and several recent graduates have contributed accounts for the Flora of Nepal. Thus there is a ready source of Nepali co-authors for accounts, and collaboration with them is an excellent way of sharing expertise and building Nepal's capacity to complete its Flora. We are pleased to note that following the presentation at the Flora of Thailand Meeting the Vitaceae were identified as a family with high degree of overlap, with 75% of the Nepali species covered in the Flora of Thailand (Trias Blasi, pers. comm.), and work is soon to begin on the Flora of Nepal account. We hope that this will be the first of many collaborations between the two Floras.

#### *Biogeographic links between Nepal and Thailand*

The analysis of the Nepali component across the floristic regions of Thailand found that of the 99 native species recorded in volume 7 of the Flora of Thailand sixteen are recorded in all regions, and a further thirteen are known from six of the seven regions.

Collecting densities are very uneven across Thailand (Parnell *et al.*, 2003) so it is likely that the absence of otherwise widespread species from these regions reflects a lack of collections rather than a true absence from these regions and these species can be considered ubiquitous throughout Thailand. This suite of widespread plants represents species typical of disturbed vegetation such as *Ichnocarpus frutescens* (L.) R.Br. or those with wide ecological tolerances such as *Syzygium cumini*. The most widespread species were the common understorey tree *Sterculia balanghas* L. and the weedy *Pentapetes phoenicia* L., both of which were recorded in 68 of the 76 Changwats (provinces), followed by the widely-cultivated *Syzygium jambos* (L.) Alston in 66 Changwats. Many species are introduced and widely cultivated in tropical and subtropical countries, and their inclusion in both the Floras tends to reinforce the links between them. This was particularly noticeable in the Apocynaceae, in which five of the eighteen species common to both the Floras are introduced.

At the regional level the strongest links with Nepal are to the Northern (88 species in common) followed by the North-eastern (63 species in common) regions with diminishing coefficients of overlap to the south (Table 2 and Fig. 3). The higher level of overlap with the Northern region reflects its closer geographical proximity to Nepal, its higher latitude and the presence of Thailand's highest mountains there, with a distinct temperate element occurring in the Northern region and not elsewhere in Thailand. This unique, temperate, Sino-Himalayan component includes species such as *Lysimachia congestiflora* Hemsl. (found at 1200 m in Thailand), *Astilbe rivularis* Buch.-Ham ex D. Don (found at 2500 m in Thailand), *Chenopodium ambrosioides* L. (found at 1200 m in Thailand), *Alisma plantago-aquatica* L. (found at 1200 m in Thailand), *Symingtonia populnea* (R.Br. ex Griff.) Steenis (found at 1600 m in Thailand), *Osmanthus fragrans* Lour. (found at 2400 m in Thailand), and *Monotropa hypopitys* L. (found at 1250 m in Thailand), which were recorded in Chiang Mai, Chiang Rai and Mae Hong Son, and which are all known to reach similar or higher altitudes in Nepal.

The strong links between Nepal and the North-eastern region and between the North-eastern and Northern regions (Kroeber coefficient > 20%) are probably due to similarities in the more continental climate of these regions, compared with the more tropical climates to the south, which support fewer of the Nepali species. While links between Nepal and the Northern region could conceivably be an artefact of the higher collecting density there the same cannot be said of the rather poorly collected North-eastern region (Parnell *et al.*, 2003), and the pattern does appear to be real. Although the Peninsular region has the lowest Kroeber coefficients linking it to other regions it has numbers of Nepali species similar to the Eastern, South-Western and South-Eastern regions and more species than the mainly cultivated and hardly collected Central region (Table 2 and Fig. 3). The low coefficients are because it has the greatest species richness of all the regions.

Some of the connections between the Thai and Nepali vegetation types are shown by various species recorded in volume 7 of the Flora of Thailand and these can be considered to represent the Indo-Malayan component of the Nepali flora. For example *Firmiana pallens* (Wall. ex King) Stearn, *Sterculia villosa* Roxb. and *Holarrhena pubescens* are recorded in Thai tropical mixed deciduous forest and Nepali sal forest and tropical deciduous riverine forest, and *Alstonia scholaris* (L.) R.Br. and *Knema tenuinerva* W.J.de Wilde are found in Thai seasonal rainforest and Nepali tropical evergreen forest, while

*Fraxinus floribundus* Wall. ex Roxb. grows in Thai lower montane forest and Nepali oak-laurel forest, *Melastoma normale* and *Osbeckia nepalensis* Hook.f. are found in Thai lower montane oak forest and Nepali *Schima-Pinus* forest (sensu Dobremez, 1976). *Syzygium cumini* has a very wide distribution and in Thailand it is found in both seasonal rainforest and tropical mixed deciduous forest while in Nepal it is known from tropical evergreen forest, sal forest and *Schima-Castanopsis* forest.

## CONCLUSIONS

Despite the geographical separation of Nepal and Thailand some plant families show considerable overlap at both the generic and species level, and as their floras become more comprehensively collected and better understood it is likely that such links will be shown to be even stronger. The output of Flora projects is constrained by paucity of skilled personnel to write accounts for them, and we have a responsibility to find ways to increase their speed of completion. Greater cooperation between Flora projects in the same region can do much to speed their completion and spread taxonomic expertise, and we hope that this paper will encourage this type of collaboration between botanists working in Thailand and Nepal.

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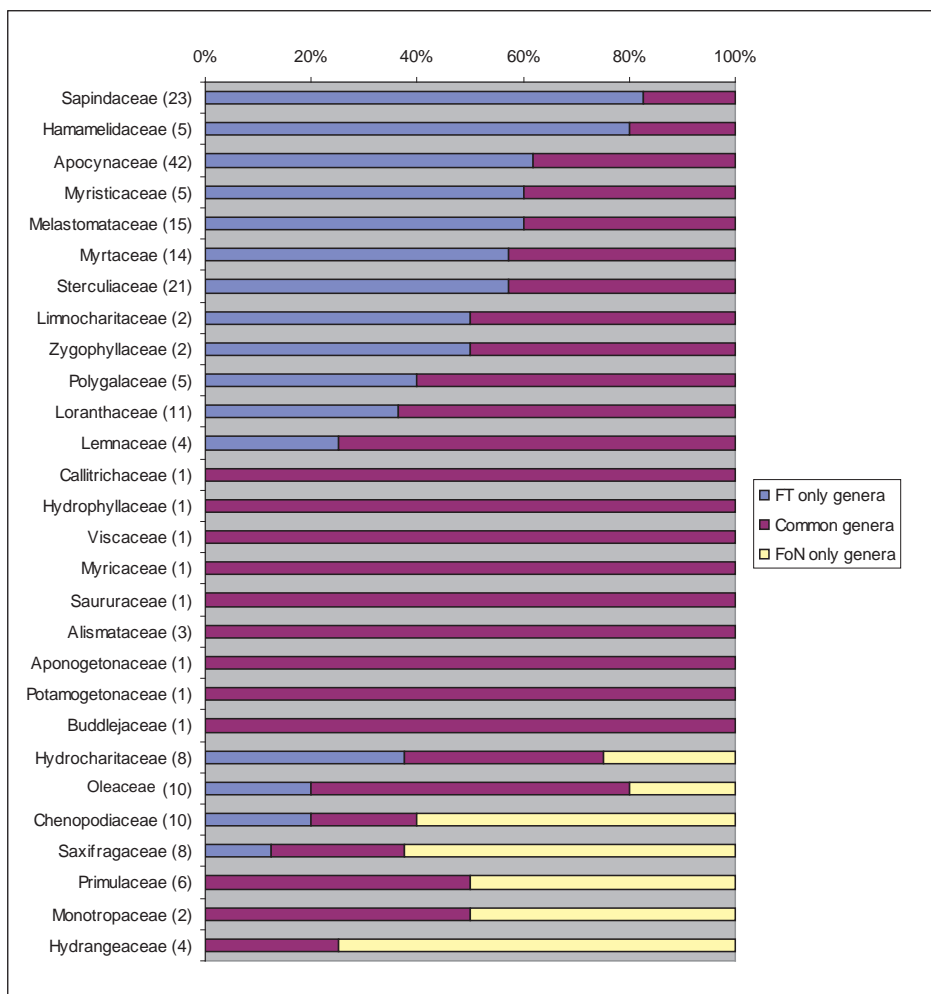


Figure 1. The total numbers of genera recorded in the Flora of Thailand and in the Annotated Checklist of the Flowering Plants of Nepal and the percentages of genera found only in Thailand, only in Nepal or common to both countries.



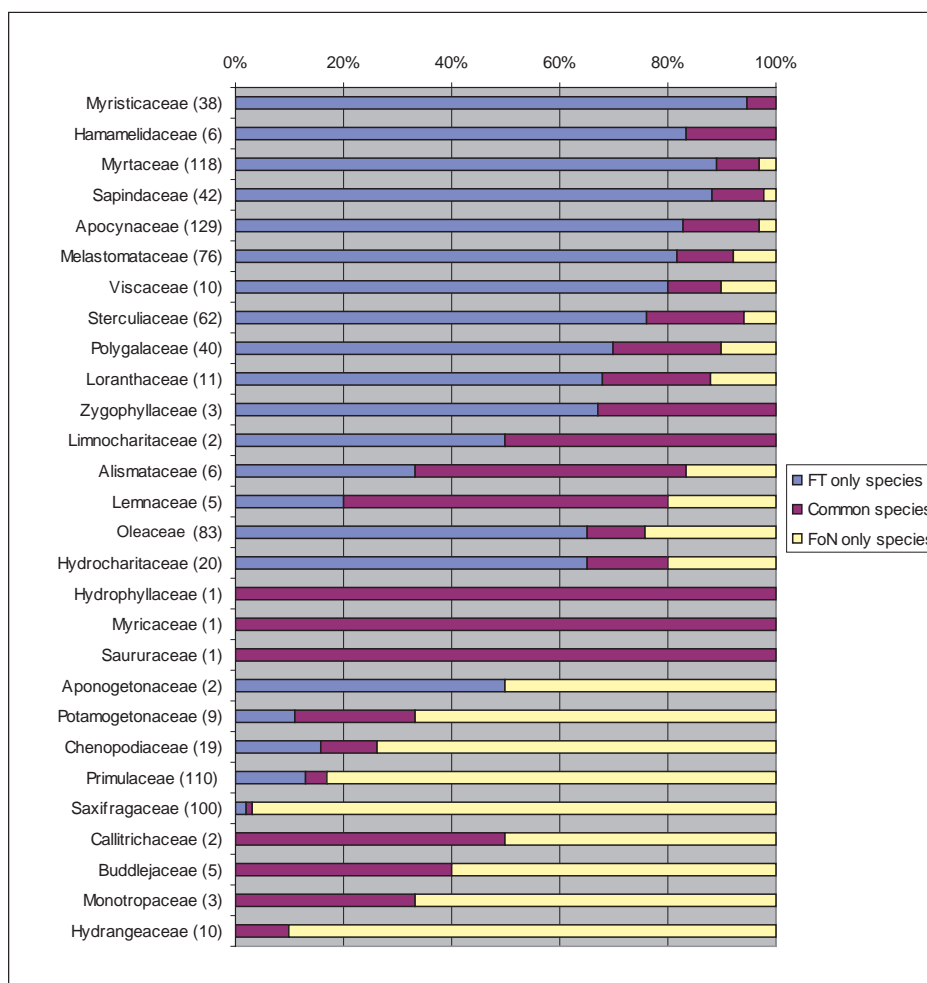


Figure 2. The total numbers of species recorded in the Flora of Thailand and in the Annotated Checklist of the Flowering Plants of Nepal and the percentages of species found only Thailand, only in Nepal or common to both countries.

Table 1. (a) The numbers of species in the Nepal and the percentage of those species which have also been recorded in Thailand, and (b) the numbers of species recorded in Thailand and the percentage of those species which have been recorded in Nepal.

(a) Number of species per family in Nepal	% of Nepali species in Thailand	(b) Number of species per family in Thailand	% of Thai species in Nepal
Hamamelidaceae (1)	100	Buddlejaceae (2)	100
Hydrophyllaceae (1)	100	Callitrichaceae (1)	100
Limnocharitaceae (1)	100	Hydrangeaceae (1)	100
Myricaceae (1)	100	Hydrophyllaceae (1)	100
Myristicaceae (2)	100	Monotropaceae (1)	100
Saururaceae (1)	100	Myricaceae (1)	100
Zygophyllaceae (1)	100	Saururaceae (1)	100
Apocynaceae (22)	82	Lemnaceae (4)	75
Sapindaceae (5)	80	Potamogetonaceae (3)	67
Myrtaceae (13)	77	Alismataceae (5)	60
Alismataceae (4)	75	Limnocharitaceae (2)	50
Lemnaceae (4)	75	Chenopodiaceae (5)	40
Sterculiaceae (15)	73	Saxifragaceae (3)	33
Polygalaceae (12)	67	Zygophyllaceae	33
Loranthaceae (13)	62	Loranthaceae (36)	22
Melastomataceae (14)	57	Polygalaceae (36)	22
Callitrichaceae (2)	50	Primulaceae (18)	22
Viscaceae (2)	50	Sterculiaceae (58)	19
Hydrocharitaceae (7)	43	Hydrocharitaceae (16)	19
Buddlejaceae (5)	40	Hamamelidaceae (6)	17
Monotropaceae (3)	33	Apocynaceae (125)	14
Oleaceae (29)	31	Oleaceae (63)	14
Potamogetonaceae (8)	25	Melastomataceae (70)	11
Chenopodiaceae (16)	13	Viscaceae (9)	11
Hydrangeaceae (10)	10	Sapindaceae (41)	10
Primulaceae (96)	4	Myrtaceae (115)	9
Saxifragaceae (98)	1	Myristicaceae (38)	5
Aponogetonaceae (1)	0	Aponogetonaceae (1)	0

Table 2. Distribution of the 98 species of native plants from volume 7 of the Flora of Thailand which are found in Nepal, showing their occurrence in the floristic regions of Thailand and the numbers of those species shared between the floristic regions. The numbers in brackets indicate the total number species in the families of volume 7 found in that floristic region.

	Northern (309)	North- Eastern (218)	Eastern (195)	South- Western (198)	Central (137)	South- Eastern (215)	Peninsular (396)
<b>Nepal (377)</b>	88	63	47	45	36	47	44
Northern		60	42	43	34	44	41
North-Eastern			37	37	30	38	36
Eastern				30	24	32	25
South-Western					26	34	32
Central						31	26
South-Eastern							34

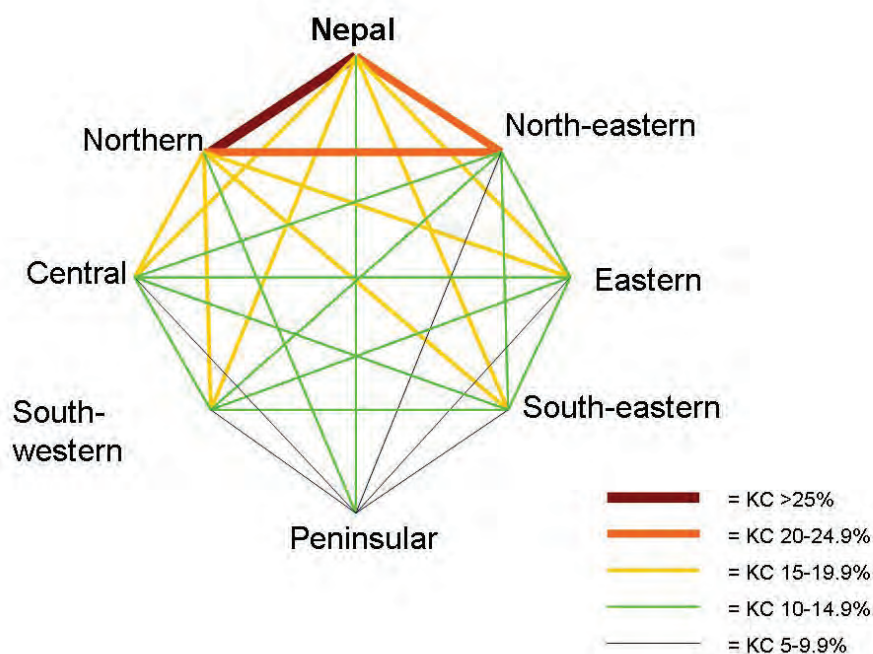


Figure 3. The Kroeber Coefficient of overlap for 377 species of plants native to Nepal and Thailand. The width of the lines corresponds to the level of overlap between Nepal and the floristic regions of Thailand and among the floristic regions.