Conservation and Society 14(4): 345-358, 2016

Article

Conceptualising 'Core' Medicinal Floras: A Comparative and Methodological Study of Phytomedical Resources in Related Indonesian Populations

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Abstract

Although there have been comparative studies of the botanical content and patterning of ethnopharmacopoeias across different ecological zones, there are few attempts to compare these systematically within the same ethnographic and ecological areas in Southeast Asia. This paper undertakes a simple quantitative survey of the medicinal plant resources of three populations on the island of Seram in the Moluccas, and then compares the results with those from five populations on Borneo. The comparison reveals some surprising omissions and patterns, given what is known about the medicinal use of plants in island Southeast Asia from other sources. The paper discusses ecological, cultural, and methodological reasons for the lack of expected congruence. A model of medicinal plant resource pools is developed to aid comparison, and it is suggested that we need to examine carefully what might be understood by a 'core' medicinal flora. While biodiversity loss is evident in the areas where the studies have been conducted, and this may impact some actual and more potential medicinal plants, it is less likely to erode core ethno pharmacopoeias.

Keywords: Indonesia, Borneo, Moluccas, medicinal plants, core ethnopharmacopoeias, resource pools, biodiversity loss

> Although several hundred plant species have been recorded as having medicinal uses … individual herbalists tend to focus their attention on a limited number … partly due to the locality … and partly due to his or her own special interests … although … almost every plant has potential utility.
>
> Brian Morris, *Chewa medical botany*, 1996: 60-1

INTRODUCTION

Although there are some comparative studies of the botanical content and patterning of phytopharmacopoeias across different ecological zones and between ethnolinguistic areas, these are few in number (Heinrich 1998: 1859; Moerman et al. 1999), while there are even fewer attempts to compare these systematically within the same cultural and ecological zone. This paper undertakes a simple quantitative survey of the medicinal plant resources of three populations on the island of Seram in eastern Indonesia for which we have sufficient ethnographic and environmental data, and who speak related but different Ambon-Timor languages. The three groups are: Manusela, Alune and Nuaulu. In order to further test observations based on the three Seramese studies, the results are then compared with studies from five different populations on the island of Borneo: Brunei Dusun, Ransa Dayak, two groups of Kenyah Dayak and Penan Benalui. The aim is to examine the extent to which it is possible to identify a common 'core' of plants that represent the phytomedical resource base of a wider ethnomedical tradition, and to develop a model of medicinal plant 'resource pools' to aid comparison. While we might expect close similarities between medicinal floras of populations that are geographically, ecologically, and culturally close, the paper discusses explanations (including levels

Access this article online	
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	DOI: 10.4103/0972-4923.197608

of acculturation, degree of access to biomedical provision, but above all; differing methodologies) for lack of expected congruence. Work on island Southeast Asia generally (for example the PROSEA project: Padua et al. 1999; Valkenburg et al. 2002; Lemmons et al. 2003) might lead us to expect a core of shared plants for all areas that are part of a regional folk medical tradition. To this end, we compare the lists derived from the eight field sites with a list of medicinal plants provided by Slikkerveer and Slikkerveer (1995), and as used by TOGA, an NGO committed to encouraging the use of traditional Indonesian medicinal plants, and focussed mainly on Java. Of a total estimated Indonesian flora of 28,000, 1000 species are estimated as being used as medicinals (Padua et al. 1999: 55). While biodiversity loss is evident in the areas where the studies have been conducted, and this may impact on some actual and more potential medicinal plants; we suggest in conclusion that it is less likely to impact on core ethnopharmacopoeias.

THE STUDY SITES

Seram lies in the Indonesian province of Maluku (the Moluccas), east of Wallace's line and in the Australasian floral area (Figure 1a). It has a varied forest structure and floral composition, and–for example–is characterised by few dipterocarps and more eucalypts compared with islands to the West (Ellen 2007). The Manusela study (Bell and van Houten 1993) was conducted between July-December in an ecologically diverse group of villages, ranging from Hatumeten on Teluti Bay on the southern coast, the upland villages around Manusela, and the northern lowland Huaulu villages of Huaulu and Alakamat. These are mixed animist and Christian groups living at various altitudes in central Seram who share a language, though with dialectal differences between Huaulu and Manusela. The overall population estimate is 7,300 (Atlas Bahasa Tanah Maluku 1996: 58). The second study (Florey and Wolff 1998; Wolff and Florey 1998; Florey 2001), was conducted in two Alune villages of west Seram: Lohiatala (3° 09' S, 128° 22' E) and Lohiasapalewa (2° 53' S, 128° 20' E), located respectively near the coast at sea-level, and at an altitude of 650 meters in the central mountain spine. These villages comprise acculturated Christian populations living on the rainforest edge. The number of Alune speakers is around 13,000, and the populations of Lohiatala and Lohiasapalewa, respectively 728 (1992) and 244 (1998). The third study focusses on the phytomedical resources of the Nuaulu village of Rouhua located on the south coast in the Amahai subdistrict (3° 21' S, 129° 08' E) of central Seram, but extracting from a varied forest landscape extending to the central mountain range. The Nuaulu are predominantly animist, and in 2009 numbered over 2000, the population of Rouhua being 508. Ethnobotanical data, including herbarium specimens were collected during field visits between 1970 and 2003, but mainly in 1996. Of the three studies, this last is the most comprehensive ethnobotanically, although without a specific medicinal plant focus. All three Seram cases are of populations engaged in a similar combination of subsistence practices: sago extraction, swidden cultivation, forest gathering, and hunting, although Nuaulu likely engage in more hunting than the other two. Access to modern medicines has grown over four decades, with Nuaulu and Manusela populations more reliant on herbal remedies than Alune. Overall, all three studies report data for populations that have knowledge of a range of biotopes, and where medicinal plants are theoretically available from varied habitats.

Of the five Borneo studies (Figure 1b), one (Voeks and Nyawa 2006) was conducted amongst Dusun in Brunei Darussalam from the settlements of Bukit Sawat on the Belait river and Bukit Udal on the lower Tutong, in local forest as well as at a study plot above the Tutong River near to the Sarawak frontier. The work was conducted in 1994-1995, relying mainly on two informants. The study was judged apposite given work conducted around the same time with Bernstein (Ellen and Bernstein 1994; Bernstein 1996; Bernstein, Ellen, and Antaran 1997) on the ethnobotany of another Dusun settlement, Tasek Merimbun (4°35' N, 114°40' E) on the middle Tutong. It was considered that our involvement in this work would help interpret the results more effectively.

The second study is of the Ransa Dayak of Nangka Juoi (112° 15'E and 0° 29'S) in Indonesian West Kalimantan (Caniago and Siebert 1998), a settlement of 16 households and 32 adults. This documents over 250 medicinal plants used by one local healer. The next three studies are from the Malinau Regency in the mountainous rainforest interior of Indonesian North Kalimantan.

At the time of most of these studies (1990-2005), villages were small--between 80 and 400 people--and reliant on rice swidden agriculture, gardening, hunting, fishing, and the collection on NTFPs and some government wage labour. The area is remote, not serviced by roads, and residents rely on government clinics for biomedical care, from which staff travel regularly to more remote villages. Medical ethnobotanist Leaman (Leaman 1996) worked with 19 male and female Kenyah Uma Tukung informants from the village of Long Sungai Barang (2° N 115° E) (pop. 343 in 1990) on the Apo Kayan plateau (800 msl), while Gollin (2001) worked intensively with a smaller number of Kenya Leppo' Ke healers from the village of Long Tebulo (2° 50' N, 115° 50' E; pop. 165 in 1998) on the upper Bahau River (375 m asl). The final study, of Penan Benalui, combines general ethnobotanical work done by Puri (2001, 2005) and Koizumi (2007) in the neighbouring villages of Long Peliran (2° 42' N, 115° 47' E) and Long Belaka (225-300 m asl; pop. 165 in 2002) on the Lurah River, a tributary of the Bahau River not far from Gollin's research area.

METHODOLOGICAL ISSUES

An appendix provides full data on medicinal floras used in this comparison. Of the species listed in the individual studies only those identified with certainty to genus level are included. Vouchers or other data indicating local names but without a scientific name at genus level or below are excluded. Plants

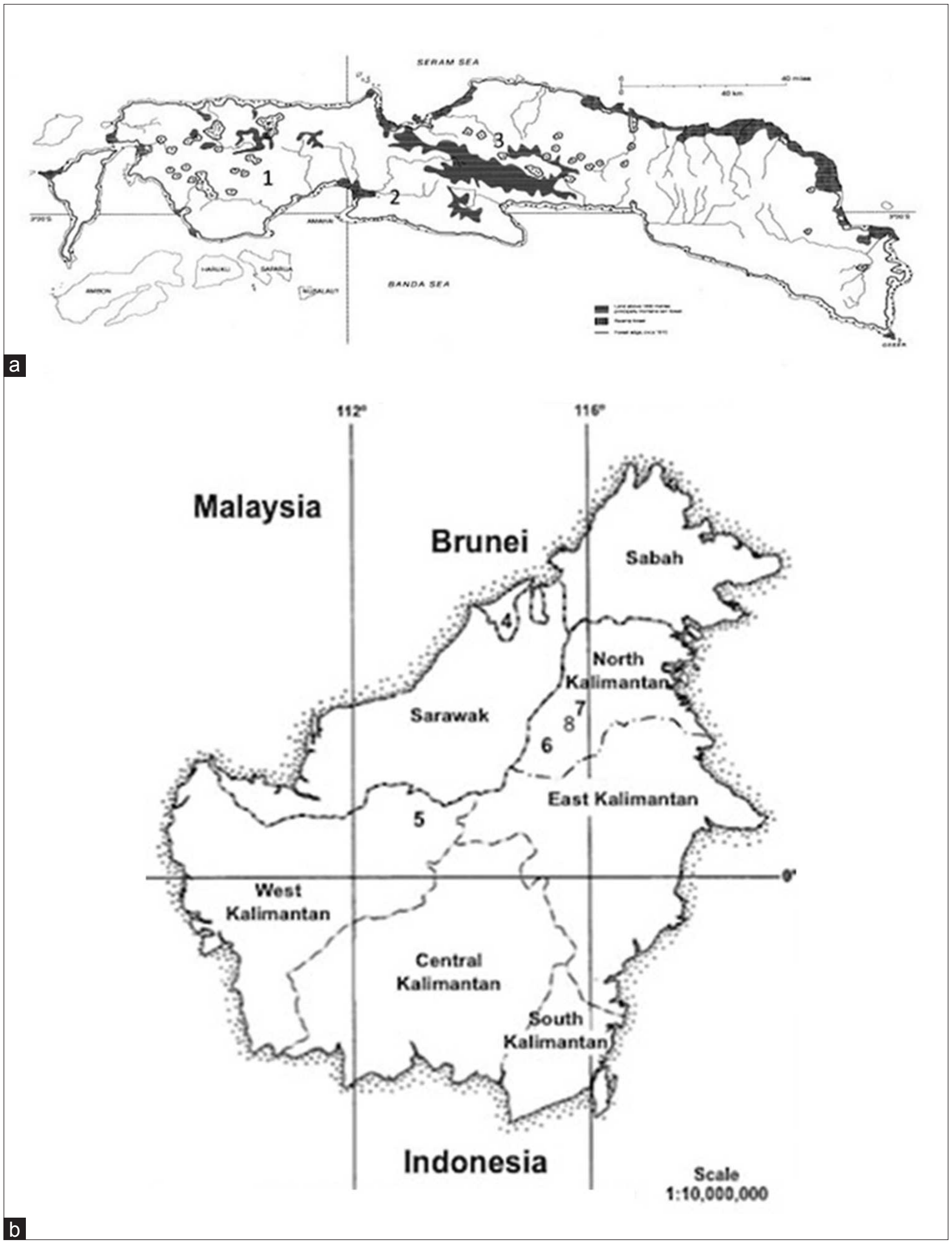

Figure 1
Location maps of field sites. (a) Seram: 1. Alune 2. Nuaulu 3. Manusela. (b) Borneo: 4. Dusun, 5. Ransa, 6. Kenyah Uma Tukung, 7. Kenya Leppo'ke, and 8. Penan Benalui

identified to species level, but listed twice because they have two different local names suggesting distinct taxa, are counted only once. Plants identified to generic level, but listed two or more times (e.g. '*Sauria* sp.'), usually with different local names, and therefore suggesting that these may represent separate species, are listed only once for each population. None of these plants are included in the comparisons across cases. For these reasons total numbers reported for each study and for particular families are lower than the numbers reported in the original sources.

Lists are restricted to vascular plants. Therefore, they exclude lichens such as *Usnea misaminensis* (listed by Slikkerveer and Slikkerveer 1995) but include ferns such as the widely used polypods. To make the taxa comparable we have departed from Cronquist's (1981) arrangement, as modified by Mabberley (1987), and have confirmed the accepted names using *The Plant List* (2013), an online collaborative effort by Royal Botanic Gardens (RBG) Kew and Missouri Botanical Garden, plus other institutions, to aggregate existing plant lists and distinguish accepted names and synonyms for all vascular plants and bryophytes.

In terms of family names, we use Asteraceae rather than Compositae, Clusiaceae rather than Guttiferae, Fabaceae rather than Leguminosae, Lamiaceae rather than Labiatae, Poaceae rather than Gramineae; and include Umbelliferae in Apiaceae, and Costaceae in Zingiberaceae. We have checked and corrected for synonyms, and updated where necessary. In cases where names have been misspelled in the original sources (sometimes leading to family misattributions) these have been changed to conform with *The Plant List*. In compiling and checking initial lists we have also used Mabberley (1987), and the PROSEA volumes (especially volumes 12(1), 12(2), and12 (3): see Padua et al. 1999; Van Valkenburg and Bunyapraphatsara 2002; Lemmens and Bunyapraphatsara 2003). The taxa in the TOGA list too have been revised in the ways described.

Given that the lists used contain relatively small numbers of species, from the point of view of statistical inference even small changes in nomenclature and taxonomic status may have a disproportionate effect on ratios and percentages calculated. This might result from a failure to recognise synonyms, or—depending on the study or method of data collection—may hinge on a decision to include or exclude a common edible plant (such as the banana *Musa x paradisiaca* L.) as a medicinal. Also, if an undetermined species of a known genus turns out to be a species that is otherwise common (e.g. if Ransa *Zingiber* sp. is really *Z. officinale* Roscoe), this may have a similar effect.

The eight studies illustrate the kinds of problems encountered in comparing medicinal floras at the local and regional level, from data collected at different times, and one might add field methodological issues and research protocols more generally in medical ethnobotany (Heinrich et al. 2009). Lemmens and Bunyapraphatsara (2003: 24-27) also acknowledge the paucity of medicinal plant data for specific locations in island Southeast Asia using modern ethnobotanical methods.

The main problem with the studies examined here, as with many others, is that data were not assembled under comparable conditions: researchers came from different disciplinary backgrounds with different research priorities, were in the field and actively collecting specimens for different lengths of time, were collecting specimens from different zones, and not according to a common and not always transparent methodology. The studies by Ellen and Puri provide a cumulative list of plants reported over a period, using data and vouchers obtained in a variety of contexts by a large number of non-specialist consumers of medicinal plants. The approach was broadly anthropological, with increasing attention being paid to ethnobotanical subjects over time. The study by Florey and Wolff is largely conducted by a linguist with the assistance of a botanist. As far as can be judged from the published output, the data were assembled in a way broadly similar to Ellen, though over a shorter time interval. We know even less of the Manusela study, though it was conducted in three locations over a relatively short period, and without mention of a particular disciplinary perspective. Of the Borneo studies, that amongst the Ransa Dayak systematically sampled forest plots, and was explicitly ecological in approach. The Dusun study used a combination of plots in different areas, and was conducted by a biogeographer with considerable experience in ethnobotany. The two Kenyah studies and Koizumi's Penan study were perhaps the most rigorous and comprehensive, conducted over a long stint of continuous fieldwork by PhD students, all with substantial botanical and ethnobotanical training, and based on systematic collection of voucher specimens and interviews with multiple informants.

In all cases it is impossible to make judgments about species ranking on the basis of frequency of use, as there is no evidence on harvesting or treatment episodes; neither are there data based on freelisting with healers or ordinary community members. All we have are data on the multiple use of individual species, and general qualitative statements on the importance of particular species. Nor do we have reliable data on intracultural consensus, and in only a few cases do we have plants organised according to particular categories of illness (Leaman 1996; Gollin 2001; Koizumi 2005). Moreover, the lists used are of species where there is a clear report of a medicinal use. In many cases the same species may exist at different research sites included in our study and be used in other ways although with no report that it is used as a medicinal. This is the case for *Alstonia scholaris* (L.) R. Br*, Arenga pinnata* (Wurmb.) Merr*, Bixa orellana* L. and *Carica papaya* L. among the Nuaulu, and many genera of food plants among the Kenyah, such as *Annona*, *Citrus*, *Ipomoea, Mangifera*, *Musa*, and *Oryza*. Similarly, in some cases it may be suspected that several species of a genus may substitute for one clearly reported species on the grounds of other contextual evidence for cultural uses. Thus, as many as seven closely related species of *Piper* are used by Nuaulu as occasional substitutes for *Piper betle* L. in the betel quid (Ellen 1991: 102) and it might be supposed that these potentially share many of the same medicinal uses.

As Heinrich et al. (1998: 1868) and others have pointed out, standardised methodologies are important in comparative evaluation, but we are often handicapped by the form in which our data are presented. Given the different ways data in the studies examined were assembled, and given uncertainties as to whether we are dealing with 'complete' lists, the method of calculating overlapping taxa developed here may have some advantages. It is, however, no substitute for studies conducted according to clear methodological criteria that allow us to compare the medicinal plants for particular human populations in terms of their ecological distribution, abundance, importance in terms of medicinal use categories, number of treatment episodes registered, variation in use between households, between specialist healers and non-healers, and overall cultural significance (Berlin and Berlin 2005).

DISCUSSION

The Seram studies compared

If we look at columns 1, 2, and 3 of the Appendix for the three Seram studies, only six species are reported as used medicinally in all three areas: *Areca catechu* L., *Cocos nucifera* L., *Nicotiana tabacum* L.*, Piper betle* L. *Urena lobata* L. and *Urticastrum decumanum* (Roxb.) Kuntze. This is a remarkable result given the geographical and cultural proximity of these groups, and the immediate response is that the data must be incomplete. Moreover, both *A. catechu* and *C. nucifera* are well known domesticates throughout southeast Asia, while *Urena lobata* and *Urticastrum decumanum* are pathside weeds. Comparing just Nuaulu and Alune we can add *Metroxylon sagu* Rottb., *Syzygium aromaticum* (L.) Merr. & L.M.Perry and *Clerodendrum rumphianum* de Vriesse. Comparing Nuaulu and Manusela we get an overlap of 11 species, and in comparing Manusela with Alune we get an overlap of 17 (Table 1).

There are now several studies demonstrating that in the tropics medicinal plants are disproportionately harvested from disturbed secondary forest and non-forested areas (Stepp 2004; Voeks 1996, 2004), and we might expect that on Seram the most commonly used phytomedicines would be taken from domesticates or cultivated plants, either where these are well-established domesticates with other uses, or where wild medicinals have been deliberately cultivated or managed (Heinrich et al. 1998: 1869). In their account of the Alune, Florey and Wolff single out *N. tabacum, A. catechu, S. aromaticum*, *C. nucifera* and *Aleurites moluccana* (L.) Willd. for treatment of nausea and irritant reactions caused by certain biota, while *A. catechu, P. nigrum* L., *N. tabacum* and *Z. officinale* are important in curative incantations (Florey and Wolff 1998: 46, 49). Such examples show how difficult it can be to separate plants used specifically because of their known bioactive properties from those that are important symbolically as part of a treatment, such as *A. catechu* and *P. betle*.

In the Nuaulu case (Ellen 1991) these latter are part of a complex system for symbolising social interaction. The first is used to treat diarrhoea and other intestinal disorders such as tapeworm and as a bactericide effective against dental caries and plaque, while the leaves of the second are used to treat ulcers, boils, bruises, and to clean wounds. The masticated quid comprising both, combined with mineral lime, serves as a mild antiseptic pressed into open wounds and ulcers; forming a kind of artificial scab tissue. Other species may be symbolically essential but cannot be shown to have a direct pharmacological effect, while the medicinal properties of others are concealed as the plant is used for other purposes entirely; such as for food or as a cosmetic. It is for this reason that Etkin (1994: 65) has recommended multi-contextual approaches, which have now become the ethnopharmacological benchmark (Heinrich et al. 2009).

If we examine shared taxa at the genus level, all three studies report the following: *Areca, Cocos, Piper, Hibiscus, Urena,* *Ficus, Urticastrum, Curcuma,* and *Zingiber*. If we select botanical families represented in all three studies on Seram there is even greater similarity, with 14 families: Araceae, Arecaceae, Euphorbiaceae, Fabiaceae, Lamiaceae, Malvaceae, Moraceae, Myrtaceae, Piperaceae, Rubiaceae, Rutaceae, Solanaceae, Urticaceae, and Zingiberaceae. And if we enumerate plants reported as medicinals in two out of the three areas (Table 2), the number increases to 34 (Table 3).

All the remaining species are reported in only one of the three studies (Table 1): 71 percent of all medicinal species identified for Nuaulu, 73 percent for Manusela and 60 percent for Alune.

Similarly, if we compare families (Table 4), we can see that only Zingiberaceae appears in the top-ranked five in terms of number of shared species. Intuitively, we might have assumed that given three studies undertaken in close geographic proximity there would be a large overlap, as not only is the flora similar, but medicinal plant knowledge travels. However, for the Nuaulu at least, there is a high rate of endogamy (such that most medicinal plant knowledge circulates within the community on marriage) while it is rare for medicinal plants to be exchanged at markets. Of our Borneo study populations, exogamy is not rare among Kenyah within the same region; and among Penan communities there is frequent movement of women and men, while most Penan have lived in Kenyah communities for much of their lives, intermarriage is very rare, and we do not know the extent of exchange of medicinal and healing knowledge between the two groups.

Table 1
Shared medicinal plant species-Seram cases

	Nuaulu (*n*=45)**,***	Manusela (*n*=81)	Alune (*n*=48)
Nuaulu	32*	11	8
Manusela		59	17
Alune			29

* Numbers underlined show species exclusive to each case. ** Does not include taxa only identified to genus level. *** N is the number of plants identified to species level that could be compared, and thus fewer than reported in the appendix

The Borneo studies compared

If we compare the Borneo studies with each other (Tables 5 and 6), we can see that they share 3 species, 6 genera, and 14 families (out of 35 reported for Dusun, 39 for the Penan, 71 for Ransa and Kenyah Leppo Ke', and 72 for Kenyah Uma Tukung).

Zingiberaceae, Fabaceae, Euphorbiaceae, Arecaceae, Poaceae and Rubiaceae are the top shared families in terms of numbers of lower taxa reported, but the ranking differs between groups: Euphorbiaceae, Fabaceae, Melastomataceae, Poaceae, and Rubiaceae are equally ranked top for Dusun; Fabaceae ranked top for Ransa; followed by Rubiaceae, Zingiberaceae, and Arecaceae ranked top for Penan; Zingiberaceae is also top for both Kenyah groups; followed by Fabaceae and Rubiaceae for Kenyah Uma Tukung; and Fabaceae, Poaceae, and Euphorbiaceae for Kenyah Leppo Ke.

There are some surprising differences between the Bornean groups, with Dusun reporting far fewer plants for top-ranked families. Arecaceae and Araceae, which are the families ranked 5 and 7 overall, are not reported for Dusun at all. Moraceae is ranked 5 for Kenyah Leppo Ke, but far down the ranking for all other groups and not reported at all for Dusun. Penan, like Kenyah Leppo Ke and Ransa, had many more species in the top-ranked families than Dusun, who appear to have a more even distribution across the families. Kenyah Uma Tukung reported 20 species of Zingiberacaeae

Table 2
Shared species in three reports of medicinal flora-Different localities on Seram

Botanical family	Species	Nuaulu	Manusela	Alune
Arecaceae	Areca catechu L	+	+	+
	Cocos nucifera L	+	+	+
	Metroxylon sagu Rottb	+	-	+
Bromeliaceae	Ananas comosus (L.) Merr	-	+	+
Caricaceae	Carica papaya L	-	+	+
Convolvulaceae	Merremia peltata Merr	+	+	-
Euphorbiaceae	Jatropha curcas L	+	+	-
Lamiacae	Orthosiphon aristatus (Blume) Miq	+	+	-
	Plectranthus scutellarioides (L.) R. Br	-	+	+
Lauraceae	Cinnamomum culilaban (L.) J.Presl	-	+	+
Fabaceae	Senna alata (L.) Roxb	+	+	-
	Desmodium sequax Wall	+	+	-
Liliaceae	Allium cepa L	-	+	+
Malvaceae	Hibiscus rosa-sinensis L	-	+	+
	Urena lobata L	+	+	+
Meliaceae	Lansium parasiticum (Osbeck) K.C. Sahni & Bennet	-	+	+
Myrtaceae	Syzygium aromaticum (L.) Merr. & L.M. Perry	+	-	+
Piperaceae	Piper betle L	+	+	+
Poaceae	Imperata cylindrical (L.) Raeusch	-	+	+
Solanaceae	Nicotiana tabacum L	+	+	+
Urticaceae	Urticastrum decumanum Wedd	+	+	+
Zingiberaceae	Costus speciosus Smith	-	+	+
	Curcuma longa L	-	+	+
	Zingiber officinale Roscoe	-	+	+

and had a less even distribution across the families than the others. *Urticastrum decumanum* (Roxb.) Kuntze is found throughout Southeast Asia but is only reported as being used in our Moluccan studies.

Medicinal plants and biodiversity across Wallacea

Overall, the eight field studies we have used comprise medicinal plants from 120 families, 367 genera, and approximately 617 separate species. The three Seram studies cover 65 families, 128 genera, and 169 species, while the five Borneo studies cover 110 families, 323 genera, and 506 species. Taken together, the eight Seram and Borneo studies share four families (Zingiberaceae, Fabaceae, Euphorbiaceae, and Rubiaceae), and no genera (*Ficus, Curcuma,* and *Costus* are found in seven out of eight; while seven species are found in six out of eight). However, if we compute taxa shared between at least one population on Seram and one on Borneo we find 55 families, 82 genera, and 56 species (Table 7).

Although we suspect that the methodology employed by Caniaga and Siebert, Leaman and Gollin has contributed to particularly long lists for the Ransa and Kenyah Dayak (expert healers interviewed over extended periods), differences between Borneo and Seram numbers reflect what we might expect given the decrease in overall biodiversity between the forests of Borneo and Seram, as we traverse the Wallace line from one centre of botanical diversity in western Malesia to New Guinea. Number of vascular plants reported for Seram is low compared with either side of Wallacea, and although the database is still poor, if we take the example of number of fern species, those for Seram are estimated at about 534, compared with 1000 for Borneo and 2000 for New Guinea. Overall number estimates for vascular plant species for Borneo are around 16,000, compared with 15-20,000 for New Guinea, and 2000 for Seram (Edwards 1993: 5; MacKinnon et al. 1997; Monk et al. 1997). Of a total estimated Indonesian flora of 28,000; 1000 species are judged as medicinals (Padua et al. 1999: 55), so we can see that the ratio for Seram at 1:12 is far higher than that for Borneo at 1:71, which is what we might expect (Figure 2).

From general accounts we might expect medicinals in Borneo to include, say, Asteraceae, Musaceae, and Piperaceae; and medicinals from Seram to include, say, Gnetaceae, Clusiaceae. Myristicaceae, and Vitaceae. After all, species such as *Piper betle* (betel pepper) are reported everywhere as having a significant role in medicinal treatments, while *Myristica fragrans* Houtt. (nutmeg) is a cultural keystone species in the Moluccas and one with many medicinal virtues (see Rumphius 2011 [1741-1750]: 33).

General studies of medicinal plants in southeast Asia

To obtain a regional overview of plant medicinals in southeast Asia we used the PROSEA (Plant Resources of Southeast Asia) series, particularly the three volumes on medicinal and poisonous plants. Lemmens and Bunyapraphatsara (2003: 23) admit that the means by which species were selected for inclusion in these volumes was on the whole subjective and

Table 3
Shared botanical families in three reports of medicinal flora from different localities on Seram

Botanical family	Nuaulu	Manusela	Alune
Acanthaceae	+	+	-
Amaranthaceae	+	+	-
Apocynaceae	-	+	+
Araceae	+	+	+
Arecaceae	+	+	+
Asteraceae	-	+	+
Begoniaceae	+	+	-
Bromeliaceae	-	+	+
Caricaceae	-	+	+
Convolvulaceae	+	+	-
Cucurbitaceae	-	+	+
Cyperaceae	-	+	+
Euphorbiaceae	+	+	+
Fabaceae	+	+	+
Gesnerisceae	+	-	+
Lamiaceae	+	+	+
Lauraceae	-	+	+
Liliaceae	-	+	+
Malvaceae	+	+	+
Meliaceae	-	+	+
Moraceae	+	+	+
Myrtaceae	+	+	+
Oxalidaceae	-	+	+
Phyllanthaceae	-	+	+
Piperaceae	+	+	+
Poaceae	-	+	+
Rubiaceae	+	+	+
Rutaceae	+	+	+
Selaginellaceae	-	+	+
Smilaceae	-	+	+
Solanaceae	+	+	+
Urticaceae	+	+	+
Verbenaceae	-	+	+
Zingiberaceae	+	+	+

Table 4
Ranking for four most important botanical families providing medicinal plants in Seram studies

	Nuaulu		Manusela		Alune	
	N species	R	N species	R	N species	R
Araceae	3	4				
Arecaceae	3	4			4	1
Asteraceae			6	1		
Euphorbiaceae	5	2	5	3		
Fabaceae	3	4	6	1		
Lamiaceae					3	3
Liliaceae					3	3
Malvaceae	4	3	4	4		
Marantaceae	3	4				
Myrtaceae					3	3
Poaceae					4	1
Urticaceae					3	3
Zingiberaceae	7	1	4	3	3	3

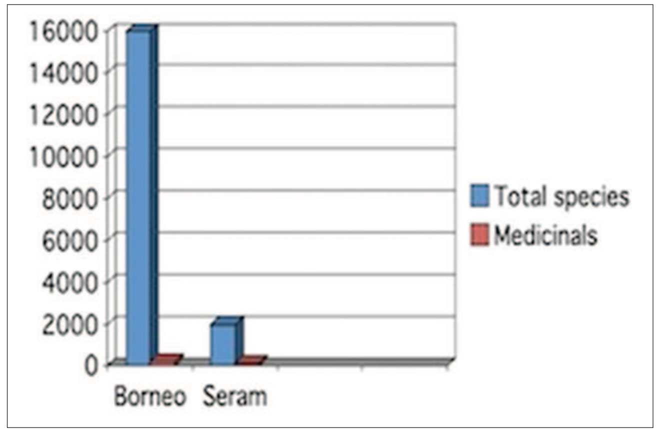

Figure 2
Total vascular plant species in relation to those reported as medicinals Comparison - Borneo and Seram (Sources: Edwards 1993, MacKinnon et al. 1997, Monk et al. 1997, Padua et al. 1999)

arbitrary, based on earlier lists such as those of Burkill (1935) and Heyne (1913-17), with most of the 'important species' described in 12(1) and the 'least important' in 12(3). There are many other important medicinal plants, but these are regarded as having other primary uses, and therefore were included in other PROSEA volumes, but summarised in volume 12(1): 425-74.

Lemmens and Bunyapraphatsara (2003: 27) estimate the number of southeast Asian species with recorded medicinal uses in the literature at 2,200. Because it is precisely these multi-purpose species that are often prioritised by local people living in rural areas, the PROSEA lists are therefore biased against highlighting the most important species used medicinally overall by virtue of the grouping strategy employed. Nevertheless, if we look at PROSEA data, the most important families in terms of number of genera reporting medicinal uses are Asteraceae, Fabaceae (Leguminosae), Apocynaceae, Rubiaceae, Euphorbiaceae, Lamiaceae (Labitae), Menispermaceae, Verbenaceae, Simaroubaceae, and Amaranthaceae. Lemmens and Bunayapraphatsara (2003: 27-8) estimate that of the 'more important' medicinals (a qualitative judgment); 10 percent come from cultivated habitats, 59 percent from open habitats ('wild'), and 31 percent from forest habitats.

General studies of traditional medicines in Indonesia have suggested the use of the same species across a wide area (Slikkerveer and Slikkerveer 1995: 21). Many of these region-wide remedies have been shared for many hundreds of years if not longer, but others have spread widely in recent centuries through introductions from other parts of the world, and through dissemination of *jamu* therapy within Indonesia (Afdhal and Welsch 1988). *Jamu* are ready-made herbal medicines, both homemade and supplied by healers, nowadays produced commercially and through small-scale home industries, augmented by do-it-yourself publications (Slikkerveer and Slikkerveer 1995: 13, 15). Many plants incorporated into *jamu* preparations are contained in the TOGA list discussed by Slikkerveer and Slikkerveer and disseminated as part of NGO extension work.

The top families in the TOGA list in rank order are: Zingiberaceae (9), Euphorbiaceae (8), Fabaceae (8), Acanthaceae (4), and Cucurbitaceae (4). If we compare the TOGA list with the data so far considered for Seram and Borneo we can see that taxa shared between the TOGA list and at least one other study are: 34 families, 50 genera, and 43 species (Tables 8 and 9). Of the seven families; 29 genera, and 40 species are found only on the TOGA list (Table 10), while most of the latter are of pan-tropical distribution or introduced, and more than half either cultivated or found in disturbed areas. Part of this overlap is due not only to the movement of both plants and therapeutic knowledge between different local populations, but also to the influence of other medicinal systems, such as those of India and China, and of cosmopolitan biomedicine (Dunn 1977).

Figure 3 shows the results of a similarities test of all species identified in the eight cases plus the TOGA list. It does not include 98 taxa identified to genus level only. A simple presence/absence species-by-case matrix was created in EXCEL and imported into ANTHROPAC (Borgatti 1996), where a proximity matrix was calculated using a positive matching procedure and the cases compared, which was then graphed in two dimensional space using multidimensional scaling (MDS). In the MDS plot, the shorter the distance between cases the more similar are their lists of medicinal plant species.

Figure 4 shows the results of a correspondence analysis of the same data matrix run in ANTHROPAC (Borgatti 1996). The plot shows the distribution of 556 plant species across the nine cases, based on the first two factors produced in the analysis. Species shared by many groups are just left of centre in the plot (e.g., *A. catechu*, *C. nucifera*, *U. lobata*), while those species exclusive to each case are stacked on each other and labelled with a large black circle and the group name, and they can be taken to represent species exclusive of that group's pharmacopoeia (as in Figure 3).

In general, the shorter the distance between the cores the more similar are the group's lists of medicinal plant species, but one has to be careful because the relationships could be plotted in three dimensions rather than two, which would change the perceived distances between species. The plot highlights the 24 species shared by at least four groups, but not including TOGA. Notice how some of these cluster between different groups' cores, indicating that these are shared by these groups, for instance, *Oryza sativa* is shown to be shared by central Borneo groups and Dusun.

Based on a presence/absence matrix of 556 plant species. Large black circles are those species exclusive to each group (cores); the closer two cores are to each other, the more similar are their pharmacopoeia. Unlabelled empty diamonds are species shared by less than four groups, labeled black diamonds are species

Table 5
Shared medicinal taxa for five Borneo studies

Shared family	Shared genus	Shared species
Annonaceae		
Clusiaceae	Garcinia L	
Euphorbiaceae		
Fabaceae		
Lauraceae		
Melastomataceae	Melastoma	malabathricum L
Myrsinaceae		
Phyllanthaceae		
Poaceae		
Rubiaceae		
Schizaeaceae	Lygodium Sw	
Simaroubaceae	Eurycoma	longifolia Jack
Vitaceae	Ampelocissus	imperialis (Miq.) Planch
Zingiberaceae		

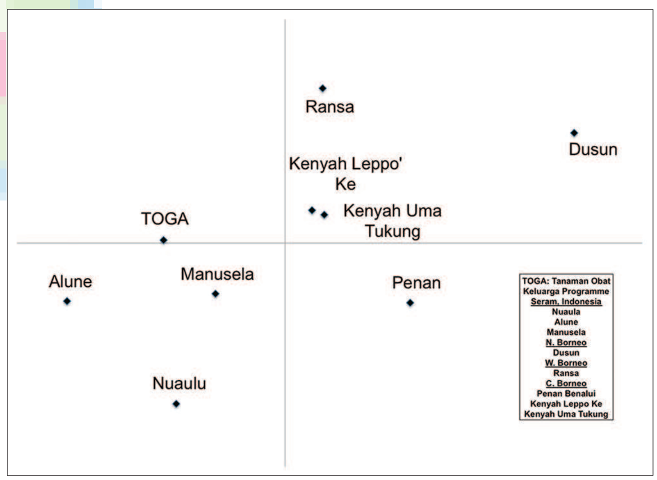

Figure 3
Similarity of ethnopharmacopoeia (plant species) among groups from Seram and Borneo, and TOGA *Multidimensional Scaling (MDS) plot produced by ANTHROPAC, based on a presence/absence matrix of 556 plant species (Stress 0.033)

Table 6
Shared medicinal plant species among Bornean cases

	Dusun (*n*=47)**,***	Ransa (*n*=153)	Penan (*n*=77)	Kenyah Leppo Ke (*n*=160)	Kenyah Uma Tukung (*n*=147)
Dusun	29*	10	7	11	12
Ransa		107	16	31	26
Penan			36	32	25
K. Leppo Ke				78	60
K. Uma Tukung					73

*Numbers underlined show species exclusive to each case. **Does not include taxa only identified to genus level. ***N is the number of plants identified to species level that could be compared, and thus fewer than reported in the appendix

Table 7

Taxa found in at least one Borneo study and one Seram study

Botanical family	Genus	Species
55	82	56
Acanthaceae	Gendarussa	vulgaris Nees
	Justicia	gendarussa Burm.f
	Pseuderanthemum Radlk	-
Amaranthaceae	Celosia	argentea L
	Cyathula	prostrata Blume
Anacardiaceae	-	
Annonaceae	Polyalthia Blume	
Apiaceae	-	
Apocynaceae	Alstonia	scholaris (L.) R. Br
Araceae	Acorus	calamus L
	Aglaonema	simplex (Blume) Blume
	Colocasia Schott	
	Scindapsus Schott	
	Schismatoglottis Zoll. & Moritzi. sp	
Araucariaceae	Agathis Salisb	
Arecaceae	Areca	catechu L
	Caryota L	
	Cocos	nucifera L
	Salacca Reinw.	
Asteraceae	Ageratum	conyzoides L
	Emilia	sonchifolia (L.) DC ex DC
	Tagetes	erecta L
Begoniaceae	Begonia	isoptera Dryand
Blechnaceae	Stenochlaena	palustris (Burm. f.) Bedd
Bombaceae	Ceiba	pentandra (L.) Gaertn
Caricaceae	Carica	papaya L
Combretaceae		
Connaraceae		
Convolvulaceae	Ipomoea L	
	Merremia	peltata Merr
Cucurbitaceae		
Cyperaceae	Rhynchospora	colorata (L.) H. Pfeiff
	Scleria	purpurascens Steud
Ebenaceae	Diospyros L	
Euphorbiaceae	Aleurites	moluccanus (L.) Willd
	Croton L	
	Jatropha	curcas L
.	Macaranga Thouars	
	Manihot	esculenta Crantz
	Ricinus	communis L
Fabaceae	Bauhinia	semibifida Roxb
	Senna	alata (L.) Roxb
	Desmodium Desv	
	Vigna Savi	
Flagellariaceae		
Gesneraceae	Cyrtandra Forster & Forster f	
Gleicheniaceae	Dicranopteris Bernh	
Hypoxidaceae	Molineria Colla	
Lamiaceae	Clerodendrum L	
	Orthosiphon	aristatus (Blume) Miq

Contd...

Table 7

Contd...

Botanical family	Genus	Species
	Plectranthus	scutellariodes (L.) R. Br
Lauraceae	Cinnamomum	culilaban (L.) J.Presl
Leeaceae	Leea	indica (Burm. f.) Merr
Liliaceae	Allium L	
	Crinum L	
Lycopodiaceae	Lycopodium	cernuum L
Malvaceae	Abelmoschus	manihot (L.) Medik
	Hibiscus	rosa-sinensis L
	Sida	rhombifolia L
	Urena	lobata L
Marantaceae	Phyrinium	capitatum Willd
Melastomataceae		
Meliaceae	Lansium	parasiticum (Osbeck.) K.C. Sahni & Bennet
Moraceae	Ficus L	
Musaceae	Musa L	
Myristicaceae	Myristica Gronov	
Myrtaceae	Psidium	guajava L
	Syzygium Gaertn	
Oleaceae		
Onagraceae	Ludwigia L	
Orchidaceae	Calanthe	veratrifolia (Willd.) R.Br. ex Ker Gawl
Oxalidaceae		
Phyllanthaceae	Phyllanthus	niruri L
	Phyllanthus	urinaria L
	Sauropus	androgynus (L.) Merr
Piperaceae	Piper	betle L
Poaceae	Cymbopogon	citratus (DC.) Stapf
	Imperata	cylindrical (L.) Raeusch
Rubiaceae	Coffee	canephora Pierre ex A. Froehner
Rutaceae	Citrus	hystrix DC
	Citrus	x aurantium L
Selaginellaceae	Selaginella	willdenowii (Desv. Ex Poir.) Baker
Smilaceae	Smilax L	
Solanaceae	Nicotiana	tabacum L
	Solanum L	
Thelypteridaceae	Sphaerostephanos	unitus (L.) Holttum
Urticaceae		
Verbenaceae	Premna L	
Zingiberaceae	Alpinia	galangal (L.) Willd
	Costus	speciosus (J. Koenig) C.D. Specht
	Curcuma	longa L
	Globba L	
	Kaempferia	galangal L
	Zingiber	officinale Roscoe
	Zingiber	cassumunar Roxb

shared by four or more of the eight cases analysed, but not TOGA. Note similarity in shape of relationships among group cores to shape of similarity of total pharmacopoeia shown in Figure 3.

The results in Figures 3 and 4 clearly show the similarity of the central Borneo studies in comparison to the rest, which are

Table 8

Taxa common to TOGA list (Slikkerveer and Slikkerveer 1995) and at least one field study

Family	Genera	Species
34	50	43
Acanthaceae	Justicia	gendarussa Nees
Apiaceae	Centella	asiatica (L.) Urb
	Foeniculum	vulgare Mill
Apocynaceae		
Arecaceae	Areca	catechu L
	Cocos	nucifera L
Asteraceae	Blumea	balsamifera (L.) DC
	Pluchea	indica (L.) Less.
	Gynura	procumbens (Lour.) Merr
Boraginaceae	Cordia L	-
Caricaceae	Carica	papaya L
Combretaceae	Combretum Loefl	
Convolvulaceae	Ipomoea	batatas (L.) Lam.
Crassulaceae	Bryophyllum	pinnatum (Lam.) Oken
Cucurbitaceae	Cucumis	sativus L
	Cucurbita	moschata Duchesne
	Momordica	charantia L
Euphorbiaceae	Aleurites	moluccanus (L.) Willd
	Euphorbia L	-
	Jatropha	curcas L
	Ricinus	communis L
Fabaceae	Senna	alata (L.) Roxb
	Erythrina	subumbrans (Hassk.) Merr
	Parkia	R. Br
Lamiaceae	Plectranthus	scutellarioides (L.) R. Br
	Orthosiphon	aristatus (Blume) Miq
Lauraceae	Cinnamomum Schaeffer	-
Liliaceae	Allium	cepa L
Malvaceae	Hibiscus	rosa-sinensis L
	Sida	rhombifolia L
Marantaceae	Donax	canniformis (G. Forst.) K. Schum
Menispermaceae	Tinospora	crispa (L.) Hook.f. & Thomson
Moraceae		
Musaceae	Musa L	-
Myrtaceae	Melaleuca	quinquenervia (Cav.) S.T. Blake
	Psidium	guajava L
	Syzygium	aromaticum (L.) Merr. & L.M. Perry
Oxalidaceae	Averrhoa	bilimbi L
Phyllanthaceae	Glochidion Forster & Forster f	
	Phyllanthus	niruri L
	Sauropus	androgynous (L.) Merr
Piperaceae	Piper	betle L
Poaceae	Oryza	sativa L
Polygonaceae		
Punicaceae	Punica	granatum L
Rubiaceae	Paedaria	foetida L
	Uncaria Schreber	

Contd...

Table 8

Contd...

Family	Genera	Species
Rutaceae	Citrus	aurantiifolia (Christm.) Swingle
Solanaceae	Nicotiana	tabacum L
Sterculaceae		
Verbenaceae		
Zingiberaceae	Curcuma	longa L
	Etlingera	elatior (Jack) R.M.Sm
	Kaempferia	galangal L
	Zingiber	officinale Roscoe
	Zingiber	zerumbet (L.) Roscoe ex Sm

Table 9

Shared medicinal plant species among Seram, Borneo, and TOGA cases

	TOGA (n=84)**,***	SERAM (n=144)	BORNEO (n=426)
TOGA	<u>41</u>*	29	34
SERAM		<u>80</u>	55
BORNEO			<u>357</u>

*Numbers underlined show species exclusive to each case. **Does not include taxa only identified to genus level. ***N is the number of plants identified to species level that could be compared, and thus fewer than reported in the appendix

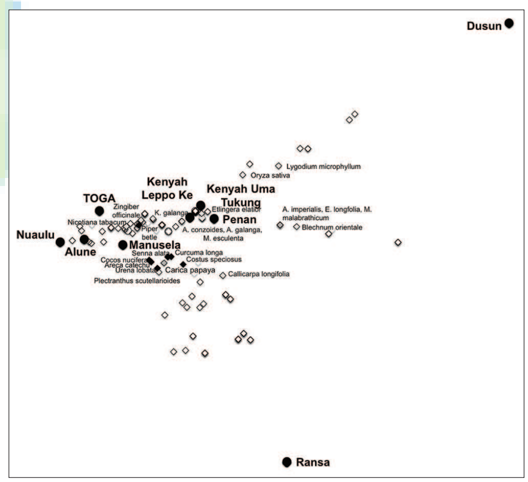

Figure 4

Correspondence analysis plot of two factors showing distribution of plant species among groups from Seram and Borneo, plus TOGA

perhaps equally different from each other, including the TOGA list. The central Borneo studies are all within 50 kilometres of each other in similar environments, though Kenyah Uma Tukung live on the Apo Kayan plateau above 900 metres a.s.l., while the other groups live between 250 and 400 m a.s.l.; but have access to surrounding hills and mountains reaching up to 1500 m a.s.l.

A model of medicinal plant resource pools

On the basis of these data from island Southeast Asia, we can see that as the comparison becomes increasingly wide ethnographically, geographically, and ecologically; the shared taxa are increasingly concentrated on species of pan-tropical distribution and introduced species. To make sense of the overlaps we have described for local medicinal plant inventories, we suggest that it is useful to use a modified version of Bates' (1985) plant resource pools hierarchy, distinguishing three pools (or tiers) of medicinal plants.

Table 10
Medicinal plants appearing only in TOGA list

Botanical family	Genus	Species
7	29	40
[Acanthaceae]	Andrographis	paniculata (Burm.f.) Nees
	Barleria	prionitis L
	Graptophyllum	pictum (L.) Griff
Aloeaceae	Aloe	vera (L.) Burm.f
[Apiaceae]	Coriandrum	sativum L
[Apocynaceae]	Alyxia R. B	
[Asteraceae]	Eclipta	prostrate (L.) L
[Boraginaceae]	[Cordia]	dichotoma G. Forst
Brassicaceae	Raphanus	raphanistrum subsp. sativus (L.) Domin
	Nasturtium	officinale R. Br
[Combretaceae]	[Combretum]	indicum (L.) DeFelipps
[Cucurbitaceae]	Lagenaria	siceraria (Molina) Standl
Elaeocarpaceae	Elaeocarpus	grandiflorus Sm
[Euphorbiaceae]	[Euphorbia]	prostrata Aiton
		pulcherrima Willd. Ex Klatzch
[Fabaceae]	Abrus	precatorius L
	Butea	monosperma Kuntze
	Cassia	fistula L
	[Parkia]	timoriana (DC.) Merr
	Pterocarpus	indicus Willd
	Tamarindus	indica L
[Lamiaceae]	Mentha	arvensis L
[Liliaceae]	[Allium]	sativum L
[Marantaceae]	Maranta	arundinacea L
[Moraceae]	Morus	alba L
[Musaceae]	[Musa]	x paradisiaca L
[Phyllanthaceae]	[Glochidion]	molle Blume
[Piperaceae]	[Piper]	nigrum L
Plantaginaceae	Plantago	major L
Plumbaginaceae	Plumbago	zeylanica L
[Poaceae]	Zea	mays L
[Polygonaceae]	Rheum	officinale Baill
Ranunculaceae	Nigella	sativa L
[Rubiaceae]	Gardenia	jasminoides J. Ellis
	[Uncaria]	gambir (Hunter) Roxb
[Solanaceae]	Datura	metel L
[Sterculiaceae]	Helicteres	isora L
Theaceae	Camellia	sinensis (L.) Kuntze
[Verbenaceae]	Lantana	camara L
[Zingiberaceae]	[Curcuma]	heyneana Valeton & Zijp
		zanthorrhiza Roxb

*[ ] indicates taxa shared with lists for other studies

The primary resource pool is a small group of largely domesticated and cultivated species of general application, including medicinal plants used over a wide ecological and biocultural range. These have, in large part, come to define a distinctive regional phytomedical repertoire. We suggest that island Southeast Asia is one such region. Here we take 'culturally important medicinal plants' to be those used by a large number of healers for the same categories of local use (Heinrich et al 1998: 1864). Primary resource pool plants include *Areca catechu, Piper betle, Curcuma longa, Senna alata, Costus speciosus, Urena lobata* and *Cocos nucifera*, all found in six of our eight studies. Until we have good quantitative data on number of occasions used for treatment it will be difficult to measure precisely how important these are in treatment, but it may be that they are often ingredients providing a base for other medicinals that carry the greater targeted bioactive burden.

The secondary resource pool or tier comprises species that are widely used, though not shared by all. This will include the majority of common species used, most of which will be cultivated or from disturbed areas. It has been suggested that medicinal plants found only in early successional stages are common elsewhere in Indonesia. In our data, this is true for *Senna alata* (6/8) and *Urena lobata* (6/8), but we note that species reported by Caniaga and Siebert (1998: 233) for Ransa as being in this category, and possibly in Wijayakusuma et al. (1992-4), are not reported for the other studies. This may be because the Caniaga and Siebert study was more thorough, but here we are focussing on common plants in disturbed areas that we would regard as being amongst those less likely to be omitted.

One problem in quantitative work of this kind is that for many users of medicinal plants, all are potentially useful. Some users or healers (e.g. plate/Figure 5) will stress one species, others another. Many species known to other populations are known to Nuaulu, but are not reported as being used

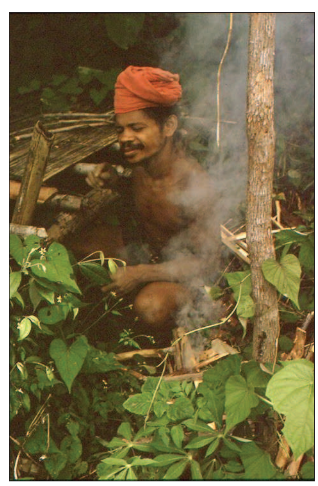

Figure 5
Tuisa Neipani-tomoien, Nuaulu healer and spirit-medium, preparing medicinal herbs at a garden hut, near Rouhua, South Seram (Maluku, Indonesia), August 1973: (Source: Roy Ellen)

medicinally. The fact that particular species are not used does not mean that they are not available. The same species may be available locally, or may be obtainable as a branded preparation. Thus, *Melaleuca leucadendra* (L.) L. is widely known on Seram (and nearby Buru) but the species is only reported in the lists used for Alune, and then as the purchased distillate. There are many species serving the same medicinal purpose, and those indicated locally may be used out of habit and availability, even though other species are known to have the same effect are present.

The tertiary resource pool contains fewer plants, most of which are still from disturbed vegetation, but with a higher proportion from primary vegetation zones. A greater proportion of species will be unique to the locality. Tertiary resource pool plants in our data are those often found in only one study and which are most likely to contain species harvested from least disturbed vegetation. There are more of these reported for Ransa than for any of the others.

In many cases tertiary resource pool medicinals are related species of the same genus with the same therapeutic effect. Thus, the aroid *Aglaonema commutatum* Schott. is reported amongst Alune as used to treat muscular pains and sprains, while Nuaulu use *A. simplex* (Blume) Blume to treat the same range of symptoms. On Seram, while Manusela report *Cucurbita moschata* Duchesne and *Plectranthus scutellariodes* (L.) R. Br., Alune report *C. pepo* L. and *P. amboinicus* (Lour.) Spreng.; while Nuaulu report *Erythrina variegata* L., Manusela report *E . subumbrans* (Hassk.) Merr.

In Borneo, whereas Dusun report *Tetracera fagifolia* Blume, *T. macrophylla* Wall. ex Hook. f. & Thoms. and *Melastoma beccarianum* Cogn., Ransa report *Tetracera sarmentosa (L.) Vahl.* and *Melastoma malabathricum* L., and the Kenyah Leppo Ke' report *T. macrophylla*, *M. malabathricum*, and the Kenyah uma Tukung report *Tetracera scandens* (L.) Merr. and *M. malabathricum*. *Tetracera* species are used to treat eye disorders, while *Melastoma* species are commonly used for gastrointestinal and dental illnesses.

Ransa report *Selaginella magnifica* Bonap. *and Smilax zelanica* L., while Penan report *S. plana* (Desv. ex Poir.) Hieron. and the Kenyah Leppo Ke', *Selaginella willdenowii* (Desv. ex Poir.) Baker and *Smilax odoratissima* Blume, all to treat dermatological illnesses. Ransa report *Zingiber officinale* Roscoe, Kenyah Leppo Ke report *Z. officinale* and *Z. ottensii* Valeton., and the Kenyah Uma Tukung report *Zingiber montanum* (J.Koenig) Link ex A.Dietr.*,* *Z. longipendunculatum* Ridl., and *Z. officinale*, for a wide range of treatments, including gynaecological, gastrointestinal, respiratory and muscular problems. Ransa report *Macaranga brevipetiolata* Airy Shaw while Dusun report *M. gigantea* (Rchb.f. & Zoll.) Müll.Arg. for dental needs; while Kenyah also use *M. pearsonii* Merr. and *M. costulata* Pax & K.Hoffm. for dermatological illnesses.

There are at least 25 instances of substitution between the Borneo studies and 33 in the Seram studies. On the other hand, different species of the same genus may be harvested by the same population. This was found to be the case for nine genera in the Seram populations, and for 65 genera in the Borneo populations, reflecting higher overall biodiversity. In some cases species may be of genera represented in primary and secondary resource pools, often as rarer substitutes of commoner medicinal species. Thus, for Nuaulu *Curcuma aurantiaca* Zijp. seems to substitute for *C. domestica* Valeton., although *C. domestica* may eventually come to replace it through greater selective pressure arising from perceptions of its increased effectiveness.

Tertiary resource pools tend to provide medicines for less common ailments, and although the pool is an important repository for conservation, it does not provide the greater part of peoples everyday plant medicinal needs.

We would expect to find secondary and tertiary resource pools composed of more local endemics. Indeed, the ratios of species distributed across one, two, and three of the Seram studies approximately correspond to the definitions of tertiary, secondary, and primary resource pools provided here. The core medicinal flora of any population will contain plants from all three resource pools, but heavily biased towards primary and secondary pools.

CONCLUSION

Medical anthropologists have been criticised for being insufficiently systematic and comprehensive in listing medicinal plants, while ethnobotanists have often provided inadequate socio-cultural and ecological contextual data and interpretation, both to some extent victims of their different methodologies. This is consistent with general critiques of the inadequacy of the conceptual and methodological bridges between medical anthropology and medical ethnobotany (Ellen 2006; Waldstein and Adams 2006; Hsu 2010), which have made it difficult to attach measures of plant significance for particular species that make sense multi-contextually.

Each of the eight field studies examined here was conducted using rather different assumptions and asymmetric methodologies. There is a strong likelihood that using different approaches has biased the data. Thus, in the Ransa study we would expect a higher proportion of forest species from relatively undisturbed areas given the explicit focus on forest plots and specialist healers. Had the study focussed more on consumption of medicines and treatment episodes we would have expected more common and accessible plants (often those from cultivated and disturbed areas nearer the village). Consequently, medicinal species actually used, as measured–say–by inclusion in treatment episodes, or species culturally considered important in general descriptions of therapeutic practices, have been omitted because of the sampling strategy employed, or because of how a medicinal plant is defined. In general the comparison indicates the frequent absence of common species that we would otherwise expect to be present. On the other hand, Gollin's study focussed on elucidating in detail the local medical system from a smaller sample of well qualified Kenyah Leppo' Ke healers, and collected data based on actual treatments as well. It is therefore not surprising that she has many more uses and many more medicinal plants from cultivated land. Leaman's study is similarly village-focussed though she uses a Western medical classification to describe plant use, but like the Ransa study, has used a substantial number of informants to be able to quantify both consensus and variation in knowledge of reported uses.

On the basis of our data, it seems plausible to group floras in terms of medicinal plant resource pools, with a core of commonly used plants that are often widely shared regionally, a secondary pool of locally important plants, and a tertiary pool of lesser used species, comprising the greater proportion of endemics. In addition, the simple method proposed for calculating overlapping taxa may have certain advantages, and we are not aware that it has so far been developed widely or systematically. It helps us to identify possible omissions in the lists that we would predict on other grounds, and it begins to reveal patterns which, using the precedent of the plant resource pool model, are useful in comparative work.

Selection of plants in traditional medicine is complex, depending not only on composition of the flora but also on culture-specific factors (Amiguet et al. 2006). The method adopted supports the idea of the specificity of local medicinal floras, with a high proportion of non-overlap at the species level. To more confidently generalise about regularities in patterns of medicinal plant use we need more meta-analyses of larger datasets of medicinal ethnofloras comparing populations within a single region. We also need studies with explicit protocols that are directly comparable.

Finally, evidence for aggregate measurable loss of medicinal species worldwide and of phytomedicinal diversity, and the need to coordinate place-based conservation action (Padoch et al. 1991; Hamilton 2004), must not be downplayed. Secondary and tertiary resource pool species in particular are being depleted in island Southeast Asia due to forest conversion, habitat destruction, and over-extraction for commercial *jamu* and for export (Rifai and Kartawinata 1991). Moreover, genetic erosion through depletion of local populations of the same species may well potentially lead to loss of additional bioactivity of pharmacological interest (Rifai and Kartawinata 1991: 283). Our data suggest that, given low levels of overlap in medicinal species, even for populations closely related linguistically, culturally, and ecologically; as is the case with our three Seram studies and the five Borneo studies, the knowledge of many medicinal species is highly local. Therefore transmission of knowledge is correspondingly precarious. It is precisely where there is overlap between separate domains of use (here, between different medicinal uses and between medicinal and other uses) that knowledge transmission is most robust (Ellen 2009; Ellen and Fischer 2013: 26), that is in primary and secondary resource pool species.

However, there is little evidence that any of the species listed in the Seram and Borneo studies are under threat for any of these reasons. Although we recognise that there are many benefits in the maintenance of floral diversity, and that habitat loss and over-extraction may have led to the disappearance of some potentially interesting medicinal plants, there is surprisingly little direct evidence for medicinals of any regular importance for local populations in island Southeast Asia having been lost through ecological conversion and over-extraction (Lemmens and Bunyapraphatsara 2003: 24).

It does the case of plant conservation no good to exaggerate the consequences for genetic erosion in local ethnopharmocopoeias, and it is probably fortunate that most people who do not have regular or sufficient access to synthetic drugs can rely on large numbers of local species that are accessible and not in danger of disappearing, partly through processes of inadvertent management and the circulation of plant material throughout the region. While biodiversity loss is evident in the areas where the eight studies were conducted, and while this may impact on some actual and more potential medicinal plants, it is less likely to impact on core traditional pharmocopoeaias, which are disproportionately composed of common plants from cultivated and disturbed areas.

ACKNOWLEDGMENTS

Fieldwork in Maluku was conducted by Ellen under the auspices of Pattimura University within the terms of a Memorandum of Understanding with the University of Kent, and supported by ESRC grants: R000 236082, RES 000 221106. Fieldwork in Kalimantan between 1990 and 2000 was conducted by Puri under the auspices of the Institute for Ecology in Bandung, the Centre for International Forestry Research (CIFOR) in Bogor and the East-West Center in Honolulu. We thank Miyako Koizumi for access to research materials.

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Received: November 2015; **Accepted**: September 2016