Plant and fungal diversity in western Sichuan and eastern Xizang (Tibet), China
Biodiversity of the Hengduan Mountain Region
横断山生物多样性

http://hengduan.huh.harvard.edu/fieldnotes

David Boufford[1], Susan Kelley[1], Richard Ree[2]

[1] Harvard University Herbaria , 22 Divinity Avenue, Cambridge MA 02138; [2] The Field Museum, Botany Dept., 1400 S. Lakeshore Dr., Chicago, IL 60605

BIODIVERSITY HOTSPOT

The Hengduan Mountains region of south-central China has been designated as one of the world's 34 biodiversity 'hotspots'. These spectacular N-S-trending mountains lie between the easternmost edge of the Qinghai-Xizang (Tibetan) Plateau and the Central Chinese Plain. The temperate to alpine montane region is home to 10,000 – 12,000 plant species, almost 1/3 of the total species in China. Exceptional also are the more than 3,500 endemic species of vascular plants. The total surface area of the Hengduan Mountain Hotspot region is approximately 500,000 km^2, or roughly twice the size of California, and includes parts of Yunnan, Sichuan, Gansu, Qinghai, and Xizang Zizhiqu (Tibet Autonomous Region).

What is a 'HOTSPOT'?

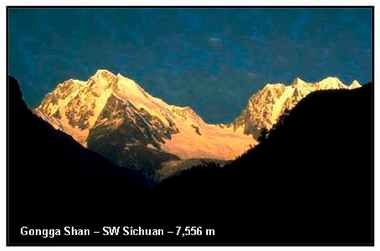
The term 'hotspot', coined in 1988 by British ecologist, Norman Myers, is applied to areas

- with high numbers of plant species
- with more than 1500 endemic species
- significantly impacted and altered by human activities

The 34 Biodiversity hotspots

- contain 44% of all plant species on earth
- contain 35% of all terrestrial vertebrate species
- occupy only 1.4% of earth's land area

Lancang Jiang (Mekong River) | Jinsha Jiang (Yangtze River)



Gongga Shan – SW Sichuan – 7,556 m

Five of Asia's major rivers – Jinsha Jiang (Yangtze River), Lancang Jiang (Mekong River), Nu Jiang (Salween River), Irrawaddy (Ayeyarwady), and Yarlungzangpo (Brahmaputra) – originate on the 5,000m high Qinghai-Tibetan plateau. Throughout their course, these rivers water approximately 1/4 of the world's population.

Elevations in the Hengduan region range from less than 2000 m in some valley floors to 7,556 m at the summit of Gongga Shan in western Sichuan.

Access to the region has been limited by the extreme topography as well as the political turmoil surrounding this largely Tibetan area. Until the late 20th century, large portions of the area were still closed to outsiders. The relaxing of restrictions, China's economic boom, infrastructure improvement projects, and growth in the tourism industry are exerting extreme pressures on the natural resources and on the very survival of the indigenous cultures there.

NOT ALL DIVERSITY IS IN THE TROPICS!!!

Diversity in this temperate to alpine montane area rivals that of the tropics. Kalimantan, Indonesia, and the Hengduan Mountains region are approximately the same size and are home to ca. 11,000 and ca. 10,000 plant species, respectively.

Six seasons of intensive exploration have yielded 10,000+ unique collections of vascular plants, which compliment the more than 180,000 historic collections in the Harvard University Herbaria. In addition, collections of almost 3,000 macro fungi and 5,000 bryophytes have been made on these expeditions.

Numbers of Species

	Hengduan Mts.	Nepal	Japan
Rhododendron	225	32	51
Pedicularis	216	63	15
Gentiana	117	43	15
Primula	113	59	14
Saussurea	101	34	25
Ligularia	70	5	8
Cremanthodium	38	13	0
Anaphalis	33	17	3
Leontopodium	25	8	8
Totals	938	274	139

Diversity in many groups declines sharply to the west in Nepal and to the east in Japan.

Approximately one-quarter (225) of the world's species of *Rhododendron* are found in the Hengduan Mountains region.

Only 25 species of *Rhododendron* are native to North America.

There are 101 species of *Saussurea*, an endemic genus of the Asteraceae.

Fungi from the Hengduan region are still relatively poorly known. Only 2,000 species of 360 genera belonging to 90 families have been reported from the region. At least 10 genera & 300 species are endemic.

The region is home to over 1,000 species of bryophytes, with 21 endemic genera and 80 endemic species.

GAZETTEER

Perhaps no region on earth presents such a confusing array of place names as does the area made up of the former provinces of Kham and Amdo in historic Tibet (Xizang). Within these areas, cities, towns, villages, mountains, lakes and other geographic features have at least two names applied to them, one Tibetan, the other Chinese. Overlying this indigenous nomenclature are the names applied by outsiders, mostly Europeans, each of whom used their native language to transliterate the names they heard or read from Tibetan or Chinese script, and names in the languages of other ethnic minorities who live within the area. Adding to the confusion are the conflicting "standards" for transliterating Tibetan and Chinese names.

A map of former boundaries of Tibet showing the provinces of Amdo, Kham and U-tsang and the Hengduan Mountains hotspot region (□).

What is a gazetteer?

- a tool for correlating the often radically different names assigned to a single place or geographic feature
- a tool to provide the geographic coordinates for places and features

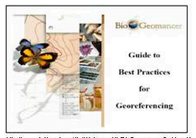
WHY? Many natural history specimens collected since the latter part of the 19th century up until the advent and widespread use of Global Positioning System (GPS) receivers lack geographic coordinates.

More than 3,600 toponyms have been added to the project gazetteer – a multi-lingual, searchable tool that is available on the project website.

Why georeference old specimens?

- Natural history specimens are a source of historical and current data on the biodiversity in this region.
- Historical distribution patterns can be plotted.
- Distribution data are important for
  - •answering phylogenetic questions.
  - •identifying areas of unusually high diversity or endemism.
  - •determining areas in need of special protection.
- Spatio-temporal data stored on the labels of herbarium specimens inform conservation organizations and government agencies as to how to best protect the biological diversity in threatened areas.

The Harvard University Herbaria house one of the largest collections in the Western world of specimens from Eastern Asia, and from the Hengduan Mountains region in particular. The label data from more than 50,000 of these historic specimens have been entered into the Herbaria's database. Using the gazetteer-thesaurus and following "Best Practices" standards recommended by *Biogeomancer*, more than 25,000 historic specimens have been georeferenced.



http://www.gbif.org/prog/digir/data_quality/BIOGeomancerGuide.pdf

The value of such a gazetteer extends beyond the field of botany. It is intended as a resource, across a variety of disciplines, for researchers, students, scholars, museum curators, government agencies and conservation organizations.

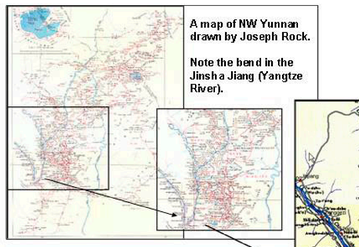
Specimen labels of several collectors.

Note the variant spellings for Lijiang: Likiang, Lidjiang, Lichiang

Place name variations from collectors and digital databases

Ser-wa Lung-pa	J. Rock	Lung-dre	J. Rock	Qinglatong	DMDC
Ser-wua-lo		Liu-tui		Chi-na-tung	C.W.Wang
Sewalongbu	T. T. Yü	Long-bi		Chiu-na-dhang	J. Rock
Saua lumba	H. Handel-Mazzetti	Londjre		Cho-na-t'ang	
色瓦洛		Lu-tui		Tjonatong	
Kan-ju Shan	J. Rock	Lo-ndêr		卓那塘	
Kaushu shan		Lung-hbrel			
Gonschiga	H. Handel-Mazzetti	Lung-te-li			
赣如山		六堆			
Benzilan		Shigu	ADLG	Zhongdian	
Pangtzula		Shih-ku		Chung-tien	
Pen-tzu-nan	ADLG*	Dongarong		Zhongxin	ADLG
Ponzela		Shih-ku-chieh		Chungtienting	
Pungtzera		La-ba	J. Rock	Ta-chung-tien	
sPong-tse-ra	J. Rock	Luba		Ndzu-du	J. Rock
Pong-tse-ra		La-pa		rGyalthang	
Pen-tzu-lan		La-ba wùa-gku		Xiangbala	
Bamzarag	DMDC**	Do-nga-rong		Xianggelila	
Pung-tzu-la	G. Forrest	Schiku	H. Handel-Mazzetti	Xianggarila	
奔子栏		石鼓		Dschungdien	H. Handel-Mazzetti
				Shangrila	
				香格里拉	

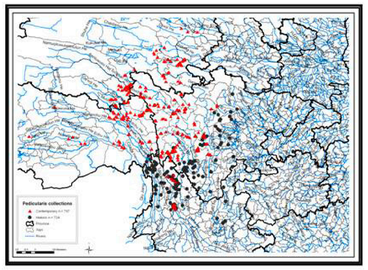
*ADLG – Alexandria Digital Library Gazetteer; **DMDC – Digital Map Database of China



A map of NW Yunnan drawn by Joseph Rock.

Note the bend in the Jinsha Jiang (Yangtze River).

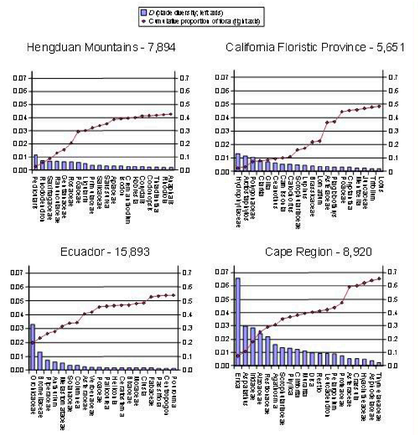
Rock's maps have been georeferenced to ESRI's Digital Map Database of China. Place and feature names from Rock's maps were entered into the gazetteer.



Distribution of recent (▲,n=797) and historic (●,n=724) collections of *Pedicularis* (Orobanchaceae).

PHYLOGENY, SYSTEMATICS, AND EVOLUTION

Like other biodiversity hotspots, the Hengduan flora contains characteristic plant clades that are exceptionally diverse in terms of regional species richness and endemism. How are such clades distributed phylogenetically?



The Hengduan flora is phylogenetically dispersed relative to other hotspots

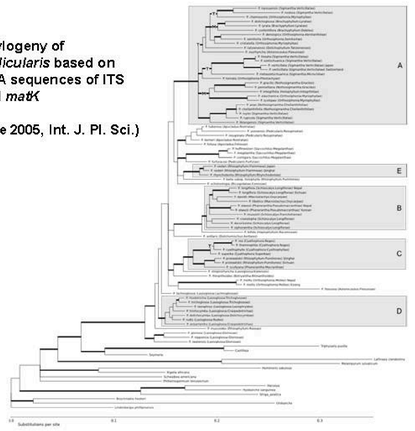
For any clade, let $D = (n/r)\times(n/c)$, where c is the global diversity of the clade, r is the angiosperm diversity for a region of interest, and n is the diversity of the clade in the region. D measures the relative contribution of a clade to a regional flora. Standardized for regional diversity and clade diversity, it allows comparisons of a clade across regions and between clades within a region.

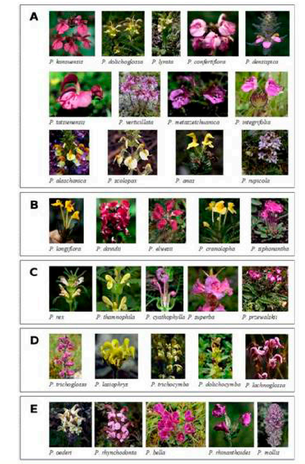
Graphs of D (purple bars) for the core Hengduan flora and three other floras are shown (left) for the 20 clades with largest D in decreasing order. The Hengduan profile is flattest, indicating phylogenetic dispersion relative to other regions. For the Hengduan region, the 20 clades account for only 42% of the flora; by contrast, for the Cape Region, the proportion is 65%. The flat profile of the Hengduan flora likely reflects the region's biogeographic connections to other areas.

Two of the region's signature clades are *Pedicularis* (Orobanchaceae) and *Corydalis* (Papaveraceae), distantly related taxa that nevertheless share many attributes: species-rich (>400 spp), herbaceous, montane, bumblebee-pollinated, with zygomorphic flowers exhibiting conspicuous interspecific differences in color and morphology.

Phylogeny of *Pedicularis* based on DNA sequences of ITS and *matK*

(Ree 2005, Int. J. Pl. Sci.)

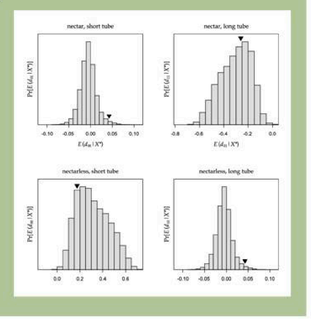




Elongated corolla tubes have evolved at least nine times within *Pedicularis*

Unlike most plants, long-tubed flowers in *Pedicularis* are not associated with specialized long-tongued pollinators; in fact, the evolution of long tubes is significantly associated with loss of nectar production.

Measuring the observed correlation between long tubes and nectar against the expected correlation from a null model (left) can be done using a simulation-based Bayesian approach called stochastic character mapping.



Acknowledgments

Funding: NSF (DEB- 9705795 (3 years), DEB-0321846(5 years)); Conservation International; National Natural Science Foundation of China (NNSFC-40332021); The Arnold Arboretum

Collaborators: Kunming Institute of Botany, Beijing Institute of Botany, Chengdu Institute of Botany