

## HOT SPOTS OF MOSSES IN EAST ASIA

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### RESUMEN

Se revisó la biodiversidad de los musgos registrados de Asia oriental continental y se comparó separadamente para dos floras regionales, a saber, las floras de musgos templada y tropical del oriente asiático. Se evaluó, tabuló y discutió el número de familias, géneros y especies, así como en número de endemismos y su porcentaje en cada uno de los países de esta zona. Para ayudar a establecer prioridades en la selección de sitios importantes para conservación en el área, se analizaron las afinidades florísticas, el índice de diversidad táxica y la diversidad de hábitats de cada país. Con base en estos datos, inicialmente se seleccionaron seis sitios (tres en China y en Malasia oriental, norte de Filipinas y Papua Nueva Guinea) y uno de apoyo en el norte de Australia; todos son puntos críticos que requieren protección porque son ricos en musgos y comprenden varios elementos florísticos y geográficos en la región.

Palabras clave: Asia oriental, puntos críticos, protección, musgos.

### ABSTRACT

The biodiversity of mosses reported from continental east Asia is reviewed and compared separately to represent two broadly defined regional floras, *i.e.*, temperate and tropical east Asiatic moss floras. The number of families, genera and species, as well as the number of endemic taxa or percentage of endemism of each of the component countries in these two vast regions are assessed, tabulated and discussed. The floristic affinity, taxic diversity index and habitat diversity of each component country are analyzed to help set priority in the choice of important conservation sites in the region. Initially, based on these data, six individual sites (three in China, one in each of east Malaysia, northern Philippines and Papua New Guinea) and another back-up site in northern Australia,

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all rich in moss taxa and embracing various floristic and geographical elements in the region, are chosen as the hotspots critically in need of protection.

Key words: E Asia, hot spots, biodiversity, protection, mosses.

A biological hot spot has been defined in various ways by people engaging in natural resource conservation work. The majority define it as a locality where a high number of endemics are concentrated (Myers, 1988). Other definition requires the presence of high species number and great taxic diversity at a chosen site. Our definition of a hot spot for mosses, as employed in this paper, includes both of the above attributes, with one additional consideration, that is, the locality is under serious environmental threat and thus, needs immediate protection (cf. Myers, 1988).

This paper attempts, for the first time, to identify the hot spots of moss biodiversity in East Asia. By East Asia, we include the vast national territory of China, the Siberian and Far East regions of Russia, Japan and its adjacent islands, the Korean Peninsula, and Indochina, but exclude the Indian subcontinent. The total area under consideration is larger than either Europe or North America north of Mexico. Its geographical boundary spans the tropical, subtropical, temperate, boreal and arctic climatic zones of Asia north of the Equator and embraces several floristic regions: Asiatic portion of Circumboreal Region, Eastern Irano-Turanian Region, Sino-Japanese Region, and Indochinese Region (Takhtajan, 1978).

To identify the hot spots, we produced first a base list of all reported mosses by combining the recent checklists published for various countries in East Asia (see references for Table 1). The resulting list consists of about 3190 species in 496 genera and 72 families. A comparison of the size of the moss flora of the entire East Asia and its constituent Asiatic floras is shown in Table 1. As a result, several East Asiatic taxa were shown to have widespread Laurasian or northern hemisphere ranges. Others are less widespread and are confined to continental East Asia, with outlying localities on the adjacent Indian subcontinent or in tropical Malesia. Examples of genera with a primarily East Asiatic range are listed in Table 2. Interestingly, sixteen genera are found to have rather restricted ranges and are classified as Chinese, Russian, Japanese/Korean and Indochinese narrow endemics (see Table 3).

In order to select a hot spot, we have formulated a set of criteria following World Conservation Monitoring Centre (1992) and Vane-Wright, Humphries and Williams (1991). They are:

1. High species number and taxonomic diversity.
2. Presence of many endemics or taxa with narrow ranges.
3. Great variation in habitats and plant communities.
4. Complementarity of various floristic elements.
4. Park, nature preserve or protected area.
5. Recent survey or visitation.

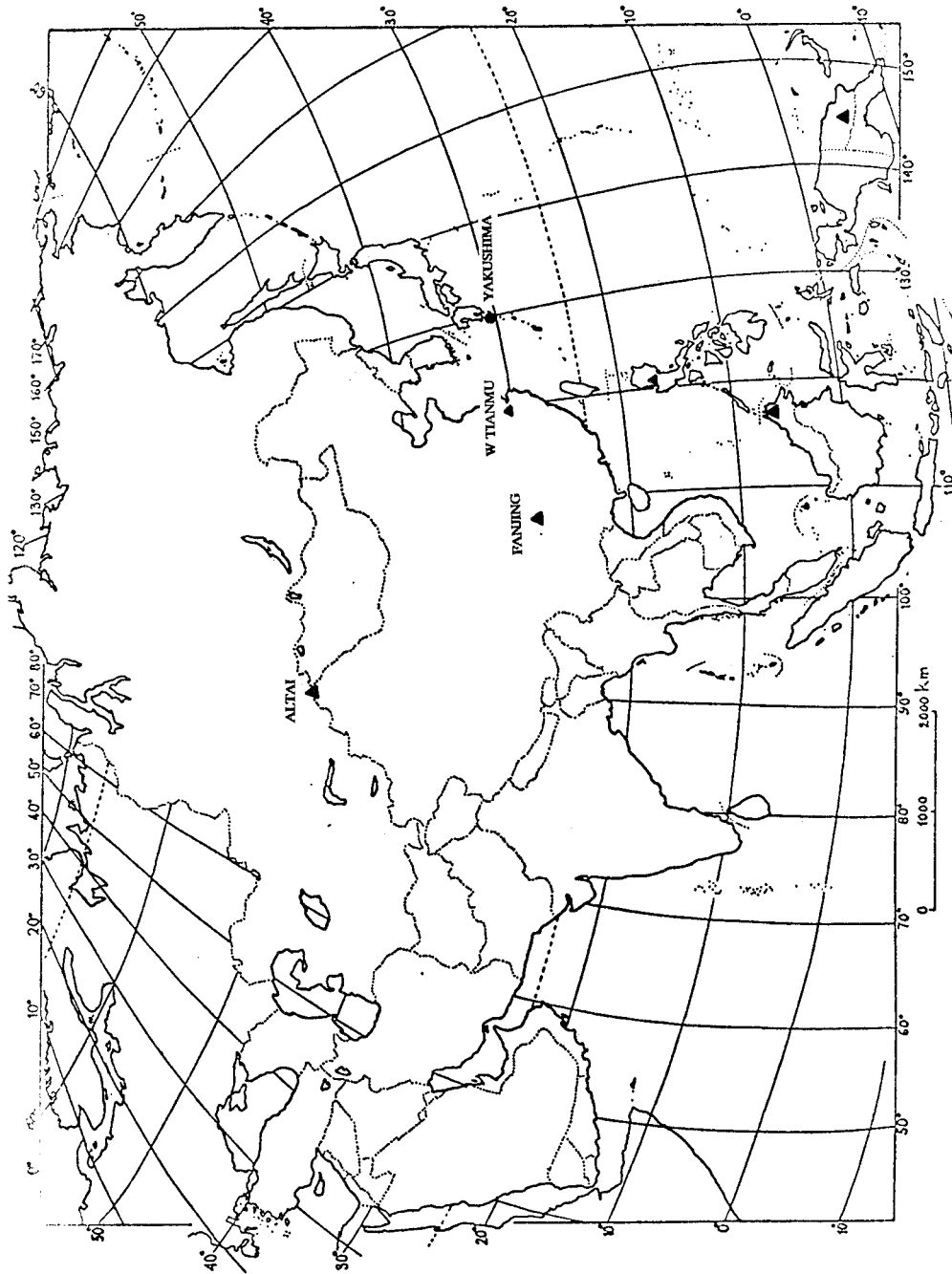


Fig. 1. Recommended hot spots in East Asia.

**Table 1.** Comparison of sizes of regional moss floras of East Asia and North America

	Families	Genera	Species	% endemic spp.
East Asia	72	496	3190	
China	67	423	2450	ca 10%
Japan	67	321	1183	ca 15%
Indochina	55	236	995	ca 7%
North America	74	317	132	ca 19%

References: Anderson, Crum and Buck (1990), Choi and Choi (1980), Gao and Chang (1983), Ignatov and Alfonina (1992), Iwatsuki (1991), Iwatsuki (1994), Redfearn, Tan and He (1996) Schofield (1995), Tan and Iwatsuki (1993).

As much as possible, a chosen locality should satisfy most, if not all, of the criteria being considered. In actual practice, the lack of information about local moss floras was a serious hindrance in our decision making.

Our guiding principle is to have most, if not all, of the taxa present in the region under consideration preserved in one or two of the chosen sites. However, for practical reasons and ease of implementation, we considered only sites that are already under legal protection such as established park or a nature preserve. To be recommended as a hot spot, the sites must also have been visited by one of us in recent years to assure the survival of the reported moss flora. After a laborious process of elimination, we have chosen the first four hot spots for moss conservation in East Asia. They are: (1) Altai State Reserve in Russia and Lake Kanasi Nature Reserve in Xinjiang Province, China, (2) Mt. Fanjing Nature Reserve in Guizhou Province, China, (3) West Tianmu Nature Reserve in Zhejiang Province, China, and (4) Yakushima Island Protected Area, Japan (see Tables 4-7 and Fig. 1). These four sites also support a rich local hepatic flora. Of the four sites, Yakushima Island, on the basis of vascular plant diversity, was designated earlier as a Center of Plant Diversity under the IUCN Plant Conservation Programme (World Conservation Monitoring Centre, 1992). Likewise, Mt. Fanjing Nature Reserve, with its rich flora and fauna, is a recognized site of UNESCO's Man and the Biosphere Program in China. Other potential sites showing rich moss biodiversity, albeit with incomplete information at the moment, are: Mt. Emei and Mt. Jinfu in Sichuan Province, China, and Mt. Yushan in Taiwan.

The total land area of the four chosen sites is about 168 890 km<sup>2</sup> which is roughly about 1/10 of the Mexican national territory, or the size of Suriname. The combined moss flora of these four proposed hot spots consists of 1056 species in 300 genera and 63 families. This represents about 33% or one third of the species diversity, 60% of the generic diversity, and 88% of the family representation, of the entire East Asiatic moss flora. As is, nearly all the East Asiatic species of *Bryum*, *Bra-chythecium*, *Dicranum*, *Grimmia*, *Orthotrichum*, *Mnium* and *Plagiomnium* are protected.

**Table 2.** Continental East Asiatic moss genera

<i>Actinothuidium</i> (Besch.) Broth.	<i>Miyabea</i> Broth.
<i>Bissetia</i> Broth.	<i>Neobarbella</i> Nog.
<i>Boulaya</i> Card.	<i>Neodolichomitra</i> Nog.
<i>Bryonoguchia</i> Iwats. & H. Inoue	<i>Okamuraea</i> Broth.
<i>Dolichomitra</i> Broth.	<i>Orthoamblystegium</i> Dix. & Sak.
<i>Dolichomitriopsis</i> Okam.	<i>Palisadula</i> Toy.
<i>Dozya</i> San. Lac.	<i>Pilotrichopsis</i> Besch.
<i>Eumyurium</i> Nog.	<i>Podperaea</i> Iwats. & Glime
<i>Eurohypnum</i> Ando	<i>Rigodiadelphus</i> Dix.
<i>Handeliobryum</i> Broth.	<i>Reimersia</i> Chen
<i>Hondaella</i> Dix. & Sak.	<i>Struckia</i> C. Müll.
<i>Horikawaea</i> Nog.	<i>Taiwanobryum</i> Nog.
<i>Meteoriella</i> Okam.	<i>Theriotia</i> Card.
<i>Miehea</i> Ochyra	

**Table 3.** Narrow endemic moss genera of Asia

Continental China	Japan and Korea
<i>Brachymeniopsis</i> Broth.	<i>Cratoneurella</i> Robins.
<i>Giraldiella</i> C. Müll.	<i>Taxiphyllopsis</i> Higuchi & Deguchi
<i>Juratskaeella</i> Buck	
<i>Leiodontium</i> Broth.	Indochina
<i>Leptocladium</i> Broth.	<i>Microtheciella</i> Dix.
<i>Pseudopterobryum</i> Broth.	<i>Nanomitriella</i> Bartr.
<i>Scabridens</i> Bartr.	<i>Noguchiodendron</i> Pócs & T. Ninh
<i>Sciaromiopsis</i> Broth.	
<i>Sinocalliergon</i> Sak.	
Russian Siberia and Far East	
<i>Mamillariella</i> Laz.	
<i>Orthodontopsis</i> Ignatov & B. C. Tan	

That the four sites are reasonably well chosen and do not create strong overlap of floristic and taxonomic representation is evident by their strategic geographical locations (see Fig. 1) and the percentages of species and generic multiplicities which were calculated to be a low 24% at the species level and a moderate 36% at

**Table 4.** Altai State Reserve in Russia and Lake Kanasi Nature Reserve in Xinjiang Province, China

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**Geographical position:** Northern Asia, about 48°-53° N & 84°-90° E.  
**Total area:** 120,000 km<sup>2</sup> in Russia and *ca.* 20,000 km<sup>2</sup> in China.  
**Altitudinal range:** 250 m to 4506 m.  
**Mean annual temperature:** -8° to 4° C  
**Annual precipitation:** Vary from 124 ml to 1600 ml, becoming wetter northward and westward.  
**Vegetation types:** Semi-desert, steppe, boreal coniferous forest or taiga, and alpine tundra.  
**Total moss flora:** 45 families 79 genera 493 species.  
**Floristic affinity:** Boreal and circum-arctic floras.

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**Floristically important moss taxa** (\* indicates local endemics): *Aloina brevirostris*, \**Andreaea heinemannii*, *Aplodon wormskjoldii*, *Arctoa hyperborea*, *Bryobrittonia longipes*, *Buxbaumia minakatae*, *Callialaria curvicaule*, *Cinclidium arcticum*, *Cinclidotus riparium*, *Conardia compacta*, *Myrinia pulvinata*, \**Orthodontopsis bardunovii*, *Orthotrichum hallii*, *Orthotrichum dasymitrium*, *Psilopilum laevigatum*, *Pylaisiella falcata*, \**Podperaea krylovii*, *Schistostega pennata*, *Splachnum rubrum*, *Struckia argentata*, \**Taxiphyllum wissgrillii*, *Tetradontium brownianum* and *Voitia nivalis*.

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References: Ignatov (1994), Tan, Zhao and Hu (1995), Zhao, Pi and Li (1989).

the generic level. To illustrate the point further, if Mt. Jinfu in southeastern Sichuan Province, China, with a reported moss flora consisting of 245 species and 133 genera (Wu and Hu, 1991), is added as the fifth hot spot, the increment of protected species diversity is only 1.6%. Likewise, the increment of protected generic diversity is 2.3%. However, three Chinese endemic genera, *i.e.*, *Scabridens*, *Pseudopterobryum* and *Sciaromiopsis*, will come under protection. The last mentioned genus, with only one species, *Sciaromiopsis sinensis* (Broth.) Broth., is presently listed in the World Red List of Bryophytes (Tan, Geissler and Hallingbäck, 1994).

Of the 27 primarily East Asiatic genera (Table 2), five genera (*Handeliobryum*, *Horikawaea*, *Miehea*, *Orthoamblystegium* and *Rigodiadelphus*) are not protected; in other words, about 81% of these important East Asiatic genera are preserved within the four chosen sites. Contrastingly, because of the rather restricted range of the 16 narrow endemics in East Asia (Table 3), only *Giraldiella* and *Orthodontopsis* are protected under the present scheme. This shows the need to identify additional hot spots for conservation if the entire diversity of moss genera in East Asia is to be considered. Since all the Chinese endemic genera have their ranges confined or extend to southwestern China, especially to western Sichuan and northern Yunnan, which, incidentally, is also an area of high bryophyte endemism (Wu, 1992), there is an urgent need to identify one hot spot in this part of China for immediate protection. Likewise, there should at least be one other hot spot chosen to conserve the biodiversity of Indochinese mosses. Unfortunately, the absence of

**Table 5.** Fanjing Mountain Nature Reserve in Guizhou Province, China

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**Geographical position:** Eastern Guizhou in central China, about 27°-28° N & 108°45' - 108°48' E.  
**Total area:** 27,300 km<sup>2</sup>.  
**Altitudinal range:** 400 m to 2570 m.  
**Mean annual temperature:** 6° to 17° C.  
**Annual precipitation:** 1100 ml to 2600 ml.  
**Vegetation types:** Subtropical evergreen broad-leaved forest, mixed deciduous broad-leaved hardwood forest, mixed broad-leaved-conifer forest, subalpine fir-spruce forest, and subalpine bamboo groves.  
**Total moss flora:** 30 families, 90 genera and 268 species  
**Floristic affinity:** Asiatic temperate flora, mainly Sino-Japanese elements with Himalayan and tropical Malesian taxa.

**Floristically important moss taxa** (\*indicates East Asiatic taxa or local endemics): *\*Actinohydium hookeri*, *Breutelia dicranacea*, *Clastobryopsis planula*, *Cyathophorella hookeriana*, *\*Dolichomitriopsis diversiformis*, *\*Dozya japonica*, *Drummondia cavaleriei*, *\*Eumyurium sinicum*, *Fauriella tenerrima*, *Homaliadelphus targionianus*, *\*Hypopterygium japonicum*, *Leptodontium squarrosum*, *\*Meteoriella soluta*, *\*Neobarbella pilifera*, *\*Neodolichomitria yunnanensis*, *\*Okamuraea hakoniensis*, *Pilotrichopsis dentata*, *\*Pogonatum pergranulatum*, *Rhabdoweisia crispata*, *\*Sakuraia conchophylla*, *\*Schlotheimia pungens*, *\*Taiwanobryum speciosum* and *\*Trachycystis ussuriensis*.

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References: Zhong and Jiang (1990), Tan, Lin, Crosby and Wu (1994).

**Table 6.** West Tianmu Mountain Nature Reserve in Zhejiang Province, China

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**Geographical position:** Coastal Zhejiang Province in eastern China, about 30°18'-30°21' N & 119°24'-119°27' E.  
**Total area:** 1,050 km<sup>2</sup>.  
**Altitudinal range:** 150 m to 1506 m.  
**Mean annual temperature:** 8° to 14° C.  
**Annual precipitation:** 1300 ml to 1870 ml.  
**Vegetation types:** Subtropical broad-leaved hardwood forest, *Cryptomeria* forest, mixed conifer-deciduous broad-leaved forest, and subalpine *Rhododendron* shrubs. Reportedly with a wild population of *Ginkgo biloba*.  
**Total moss flora:** 38 families, 112 genera and 252 species.  
**Floristic affinity:** Mainly Sino-Japanese taxa, with tropical Asiatic and oceanic elements.

**Floristically important moss taxa** (\*indicates East Asiatic endemics): *Brotherella falcata*, *Campylopus gracilis*, *Calyptothecium crispulum*, *\*Climacium japonicum*, *Dicranoloma cylindrothecium*, *\*Eurolypnum leptothallum*, *\*Felipponea esquirolii*, *Gollania varians*, *Haplolymenium triste*, *Hookeria acutifolia*, *\*Miyabea fruticella*, *Neckera yezoana*, *Pseudosporidontopsis horrida*, *Rhodobryum giganteum*, *Schwetschkeopsis japonica*, *Thamnobryum subserratum*, *\*Thuidium kanedae* and *Venturiella sinensis*.

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Reference: Wang and Tao (1992).

**Table 7.** Yakushima Island Protected Area, Japan

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**Geographical position:** 60 km south of Kyushu Island; about 30° N & 130° E.  
**Total area:** 540 km<sup>2</sup>.  
**Altitudinal range:** 0 m to 1935 m.  
**Annual temperature:** Warm and humid, with snow at mountain summit during winter months.  
**Annual precipitation:** More than 2000 ml.  
**Vegetation types:** Lowland subtropical and montane temperate broad-leaved forests.  
**Total moss flora:** 37 families, 128 genera and 297 species.  
**Floristic affinity:** Mixture of temperate Asiatic mosses, rich in Japanese endemics and the Northern Pacific taxa.

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**Floristically important moss taxa** (\*indicates Japanese/Korean endemics): *Anacamptodon fortunei*, *Aulacopilum trichophyllum*, *Bartramiopsis lescurei*, *Boulaya mittenii*, *Calyptrochaeta japonica*, *Claopodium aciculium*, *Clastobryopsis robusta*, *Clastobryum glabrescens*, *Dicranum nipponense*, *Entodon luridus*, *Fissidens obscurus*, *Fleischerobryum longicolle*, *Gammiella tonkinensis*, \**Glossadelphus yakushimae*, *Glyphomitrium minutissimum*, *Neckeropsis obtusata*, *Palamocladium nilgheriense*, *Palisadula katoi*, *Pogonatum inflexum*, *Pseudoleskeopsis zippellii*, *Pterobryum arbuscula*, *Stereodontopsis pseudorevoluta*, *Symphyodon perrottetii*, *Syrrophodon kiiensis*, \**Syrrophodon yakushimensis*, *Therotia lorifolia* and \**Ulota yakushimensis*.

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Reference: Iwatsuki and Sharp (1967).

floristic information and field observation have prevented us from making additional site nominations.

What do we do after identifying the important hot spots with high bryophyte diversity and endemism? The logical action to take is to campaign for their full protection from environmental disturbance. Nonetheless, we still face a daunting obstacle in our attempt to identify more hot spots, which is, the lack of bryophytic information for many national parks and nature reserves established in Asia. It is important that we continue to conduct floristic field work before the rich diversity of the local moss floras disappears altogether with the destruction of natural vegetation.

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