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Moss diversity in the tropical rainforests of Rio de Janeiro, southeastern Brazil

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ABSTRACT – (Moss diversity in the tropical rainforests of Rio de Janeiro, southeastern Brazil). Moss diversity at various sites in the Tropical Atlantic Rainforest of southeastern Brazil is high, with 338 taxa distributed among 49 families and 129 genera. Comparisons of species richness in the Tropical Atlantic Rainforest in southeastern Brazil suggest that the moss flora is not uniform, and that lowland, montane, submontane, and upper montane Atlantic rainforests have very different moss floras. Montane Atlantic Rainforest has the largest number of exclusive species and the highest species richness, Sub-Montane Atlantic Rainforest has intermediate species richness, while the Lowland Atlantic Rainforest has fewer species. The high diversity of the Montane Atlantic Rainforest could be explained by the diversity of climatic, edaphic, and physiographic changes of the vegetation. Sematophyllaceae accounted for 19% of the taxa in lowland forest, Meteoriaceae for 10% of the taxa in montane forests, and Dicranaceae for 18% of the taxa in upper montane forests. Taxa with broad Neotropical distributions (40% of the total taxa) are important elements in all the forests, while taxa restricted to Brazil comprise the second most important element in upper montane and montane forests.

Key words - moss diversity, rainforests, southeastern Brazil

RESUMO – (Diversidade de musgos nas florestas tropicais do Rio de Janeiro, Sudeste do Brasil). A diversidade de musgos na Floresta Tropical Atlântica do Sudeste do Brasil é considerada alta, com 338 táxons, distribuídos em 123 gêneros e 49 famílias. Comparações em relação à riqueza de espécies na Floresta Atlântica do Sudeste do Brasil sugerem que a flora de musgos não é uniforme e que as florestas das terras baixas, submontana, montana e altomontana apresentam floras muito diferentes. A Floresta Atlântica Montana conta com maior riqueza específica e número de táxons exclusivos, a Floresta Submontana tem riqueza intermediária e a Floresta Ombrófila Densa das Terras Baixas apresenta menor número de táxons. A alta diversidade da Floresta Montana pode ser explicada pelos fatores climáticos, edáficos e da vegetação. Sematophyllaceae conta com 19% dos táxons na floresta de terra baixa, Meteoriaceae com 10% dos táxons na floresta montana e Dicranaceae com 18% dos táxons na floresta altomontana. Os táxons neotropicais (40% do total de táxons) são elementos importantes para todas as florestas, enquanto que aqueles restritos ao Brasil são o segundo em importância para as florestas altomontana e montana.

Palavras-chave - diversidade de musgos, florestas tropicais, Sudeste do Brasil

Introduction

The Tropical Atlantic Rainforest of Brazil extends from the State of Rio Grande do Norte to Rio Grande do Sul in the coastal regions and inland on the mountains and plateau, with high humidity and rainfall. It has been suffering an intensive process of destruction by clear-cutting, shifting cultivation and human occupation, and only 1%-6% of the original area (1.2 million km^2) persist in a mosaic of isolated fragments (Leitão Filho 1993). It is the most important ecosystem of Rio de Janeiro State (Fundação SOS Mata Atlântica 2002), and it has a rich moss flora.

In the southeast region of Brazil the forest extends further inland, where mountains can rise to 2,787 m in Itatiaia (Rio de Janeiro State) and 2,890 m on the Pico da Bandeira (Minas Gerais State). The original vegetation in this region was tropical rain forest, with small enclaves of *Araucaria* forest at higher altitudes and shrubby vegetation in the lower inland areas. The soils associated with eastern Atlantic Forest are mainly yellowish-redlatosols, clayey in texture. They occur in the half-orange mountains as well as in the watersheds of the main hydrographic basins. There are also yellowish-red clayey podzols occurring along the valleys in areas having a more pronounced dry season (Fundação SOS Mata Atlântica 2002, Leitão Filho 1993).

Regional endemism is high in the Tropical Atlantic Rainforest areas, around 55% for arboreal species and 40% for non-arboreal species (Barros *et al*. 1991, Joly *et al*. 1991, Mori *et al*. 1981, Peixoto & Gentry 1990).

Most of the bryophytes of the Tropical Atlantic Rainforest are epiphytes and some species grow on living leaves. According to Frahm & Gradstein (1991),

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bryophytes may be useful tools for the construction of a general scheme of the altitudinal zonation in tropical rainforests, because they are excellent climate indicators, they comprise rather few species (which facilitates identification), they have wide geographical ranges, and they are a characteristic structural component of the tropical rainforests.

According to Gradstein (1995), the bryophyte diversity in the Tropical Atlantic Rainforest varies considerably with altitude, both in structure and in floristic composition. This paper is the first to examine the moss diversity in the Tropical Atlantic Rainforest in southeastern of Brazil, and compares the region's lowland, submontane, montane, and upper montane moss floras. The approach is similar to that of studies carried out in other tropical rainforests (Gradstein & Salazar-Allen 1992). Some recent floristic studies have been done by the first author with the mosses of the Atlantic Rainforest in Rio de Janeiro State (Costa 1995, 1997, 1999, Costa & Yano 1995).

Material and methods

The taxa are from four different sites in the Atlantic Rainforest of Rio de Janeiro State: Poço das Antas (Silva Jardim), APA-Cairuçu (Parati), Nova Friburgo, and Itatiaia. Floristic inventories were conducted randomly by the first author at the first three sites between 1986-1993, and the data for Itatiaia are from the literature and herbarium records.

The vegetation classification applied to Atlantic Rainforest is that of Veloso *et al.* (1991), where Lowland Atlantic Rainforest = 0-50 m; Submontane Atlantic Rainforest = 50-500 m; Montane Atlantic Rainforest = 500-1,500 m; and Upper Montane Atlantic Rainforest > 1,500 m. All the taxa were separated per altitudinal intervals according to classification of Veloso *et al.* (1991), being diversity and composition analysed per interval.

Floristic similarities between forest formations were calculated by means of the Sørensen Index of similarity. To estimate the real number of taxa per altitudinal interval from the observed number of taxa, the nonparametric S_{chao} estimate was used (Chao 1984). Chao's estimator is $S_{chao} = S_{obs} + F_1^2/2F_2$, where S_{obs} is the number of observed taxa, F_1 = the number of taxa with one record, and F_2 = the number of taxa with two records (Colwell 1997).

The classification for mosses is that of Buck & Goffinet (2000). The nomenclature follows Crosby *et al.* (1999).

All the samples collected are deposited at the herbarium RB, with duplicates to other herbaria on exchange. Study areas in Rio de Janeiro State – Poço das Antas is an important wildlife refuge of Lowland Atlantic Rainforest, comprising about 5,000 ha, 40% of it degraded and in distinct successional stages. The elevation ranges from sea level to 205 m and defines a vast plain subjected to phreatic or river flooding. Annual local rainfall averages approximately 1,600 mm annually. Rounded hills emerge from these floodplains, the highest ones reaching 205 m. Mean temperature is 22 ºC, ranging from 8 ºC to a maximum of 30-32 ºC (IBDF 1981). Bryophyte cover is poor, the species are inconspicuous and mostly restricted to the canopy. Eighty six specimens of 37 taxa in 27 genera and 16 families were collected during three field trips carried out in 1994 (Costa 1999).

The "Área de Proteção Ambiental de Cairuçu" (Parati) is an important protected area of Submontane and Montane Atlantic Rainforest in the "Serra do Mar" range in southern Rio de Janeiro State, comprising about 33,800 ha. The elevation varies between 800-1,200 m above sea level, with the highest peak reaching 2,000 m. Air humidity averages 80%. Annual local rainfall averages 1,500-2,000 mm. Mean temperature is 22 ºC, ranging from 8 ºC to a maximum of 38 ºC (Conti *et al.* 1987). Bryophytes are abundant on tree trunks and branches. Two hundred and twenty specimens of 81 taxa in 44 genera and 20 families were collected during four field trips carried out between 1990 and 1991 (Costa 1997).

Nova Friburgo is an area of about 93,300 ha in the Montane and Upper Montane Atlantic Rainforest, in the "Serra dos Órgãos" range. Elevation varies between 850-2,000 m above sea level, with the peak reaching 2,200 m. Air humidity averages 83%. Local rainfall averages 1,500 mm. Mean temperature is 25 ºC, ranging from 9 ºC to a maximum of 27 ºC (Brasil 1970). Bryophytic vegetation is luxuriant, and the tree trunks, branches and terrestrial layer are covered with a dense layer of bryophytes, including many robust and pendant species (Meteoriaceae, Pterobryaceae). A total of 514 specimens of 152 taxa in 77 genera and 34 families were collected during twelve fields trips carried out in 1986-1990 (Costa 1995).

Itatiaia is the first national park of Brazil, and an area of the Montane and Upper Montane Atlantic Rainforest in northwestern Rio de Janeiro State, in the "Serra da Mantiqueira" range. It comprises about 30,000 ha, 22º19'-22º45' S and 44º45'-44º50' W. Elevation varies between 600-2,787 m above sea level, with the highest peaks reaching 2,408 m (Cabeça do Leão), 2,500 m (Dois Irmãos), and 2,787 m (Pico do Itatiaiaçu). Air humidity averages 85%. Local rainfall averages 2,100 mm (Hueck 1972). Mean temperature is 11 ºC, ranging from 6 ºC to a maximum of 27 ºC (Brade 1956, Hueck 1972, Pádua & Coimbra Filho 1979). The aspect of the bryophyte vegetation is similar to that of Nova Friburgo. Floristic data for Itatiaia are from Dusén (1903), Frahm (1991), Müller (1898), Reese (1993), Schäfer-Verwimp (1992), Schäfer-Verwimp & Giacontti (1993), Schäfer-Verwimp & Vital (1989), Yano (1992), and from the RB herbarium. A total of 273 samples were studied to Itatiaia. In total, 203 taxa in 95 genera and 42 families of mosses are found in Itatiaia.

Specific questions addresses here are: Does the species richness increase along an altitudinal gradient? Does the number of exclusive taxa increase along an altitudinal gradient? Does the number of endemic taxa increase along an altitudinal gradient? Can the moss flora be used to characterize the elevation belts in the Atlantic rainforest of southeastern Brazil? Could be some species considered indicators for different tropical Atlantic rainforests in southeastern Brazil?

Results and Discussion

Total diversity – In total, 338 taxa of mosses in 123 genera, and 49 families have been identified from the four study areas. We recorded, per altitudinal intervals, 68 taxa in Lowland Atlantic Rainforest, 90 taxa in Submontane Atlantic Rainforest, 202 taxa in Montane Atlantic Rainforest, and 161 in Upper Montane Atlantic Rainforest (table 1). The generic diversity is also high (123), with 55% (68) being represented by only one taxa. The differences observed in the floristic composition in the tropical rainforests of Rio de Janeiro seem to be related to habitat heterogeneity due primarily to topographic relief, which is in agreement with the conclusion of Churchill (1991). According to Churchill (1991), in the Neotropics, high diversity is related to habitat heterogeneity coupled with vegetational zonation. For this reason moss species diversity is related with the dramatic topographic relief found in this region (Churchill *et al.* 1995).

Floristics – In terms of number of taxa, Dicranaceae (45 taxa), Pilotrichaceae and Sphagnaceae (24 taxa), Sematophyllaceae (22 taxa), and Meteoriaceae (21 taxa), account for 40% (136 taxa) of the total taxa (table 1). Six taxa (9%) are exclusive to Lowland forest, and 9 taxa (10%) to Submontane forest, whereas 102 taxa (50%) were found only in the Montane forest, and 90 taxa (56%) are exclusive to Upper Montane forest (figure 1). The Montane and Upper Montane forests

Table 1. Moss bryoflora in the Atlantic Rainforest in southeastern Brazil per altitudinal intervals. 1 = Lowland Atlantic Rainforest (0-50 m); 2 = Submontane Atlantic Rainforest (50-500 m); 3 = Montane Atlantic Rainforest (500-1,500 m); 4 = Upper Montane Atlantic Rainforest (1,500-2,700 m); G.D. = geographical distribution (see table 2); w/n = without number; l.d. = literature data. Beside the families between the brackets are the number of genera and taxa.

Taxa	1	2	3	4	G.D.	Voucher
ADELOTHECIACEAE (1/1)						
Adelothecium bogotense (Hampe) Mitt.			X		PAN	Costa 476, 572
ANDREAEACEAE (1/5)						
Andreaea microphylla Müll. Hal.				X	BRA	l.d.
A rupestris Hedw.				X	W	Bandeira w/n
A. spurioalpina Müll. Hal.				X	BRA	l.d.
A. squarrosofiliformis Müll. Hal.				X	BRA	l.d.
A. subulata Harv.				X	SH	Bandeira w/n
BARTRAMIACEAE (4/10)						
Bartramia halleriana Hedw.			X	X	W	Costa 620
Breutelia grandis (Hampe) Paris				X	BRA	Costa 1.106
B. subdisticha (Hampe) A. Jaeger			X	X	NEO	Costa 508
B. subtomentosa (Hampe) A. Jaeger				X	BRA (SE)	l.d.
B. wainioi Broth.			X	X	BRA (SE)	Costa 618
Leiomella piligera (Hampe) Broth.			X		BRA	Costa 777
Philonotis cernua (Wilson) D.G. Griffin & W.R. Buck				X	W	l.d.
P. gardneri (Müll. Hal.) A. Jaeger		X	X		NEO	Costa 500, 1.195
P. pellucidiretis (Müll. Hal.) Paris			X	X	NEO	l.d.
P. uncinata (Schwaegr.) Brid.	X	X	X		W	Costa 454
BRACHYTHECIACEAE (3/6)						
Brachythecium ruderale (Brid.) W.R. Buck			X		PAN	l.d.
Palamocladium leskeoides (Hook.) Britt.			X		TSA	Costa 746
Rhynchostegium beskeanum (Müll. Hal.) A. Jaeger	X	X	X		BRA	Costa 457
R. compridense (Broth.) Paris				X	TSA	Bandeira w/n
R. rivale (Hampe) A. Jaeger				X	BRA	

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Taxa	1	2	3	4	GD.	Voucher
R. selowii (Hornsch.) A. Jaeger			X		TSA	Bandeira w/n, Costa 2.024
BRUCHIACEAE (2/6)						
Eobruchia bruchioides (Müll. Hal.) W.R. Buck			X	X	BRA	l.d.
Trematodon brevifolius Müll. Hal.				X	BRA	l.d.
T. gymnostomus Müll. Hal.				X	BRA	l.d.
T. heterophyllus Müll. Hal.			X		BRA	l.d.
T. longicollis Michx.			X		W	Costa 871
T. pauperifolius Müll. Hal.				X	BRA	l.d.
BRYACEAE (2/13)						
Brachymenium hornschuchianum Mart.				X	BRA	Costa 1.021
B. morasicum Besch.				X	NEO	l.d.
B. radiculosum (Schwaegr.) Hampe			X	X	NEO	Costa 187, 493, 776, 788
Bryum argenteum Hedw.			X	X	W	Costa 223, 236, 505
B. beyrichianum (Hornsch.) Müll. Hal.		X	X		TSA	Costa 843, 1.300, 1.452
B. billardierei Schwaegr.	X				PAN	Costa 650, 1.523
B. conicum Hornsch.			X	X	NEO	l.d.
B. densifolium Brid.			X	X	PAN	Costa 1.166
B. limbatum Müll. Hal.	X	X	X		NEO	Costa 385, 771, 1.544, 4.591
B. pseudomarginatum Geh. & Hampe	X	X			BRA	Costa 1.236
B. roseolum Müll. Hal.				X	NEO	Costa 888
B. roseum (Hedw.) P. Gaertn.				X	HOLO	Costa 3.794
B. subverticilatum (Broth.) Ochi	X	X	X		TSA	Costa 1.194, 2.037
CALYMPERACEAE (2/12)						
Calymperes afzellii Sw.	X	X			PAN	Costa 1.231, 1.269
C. lonchophyllum Schwaegr.		X	X	X	NEO	Costa 1.125, 1.571
C. smithii Bartram	X	X			NEO	Costa 1.946
C. tenerum Müll. Hal.	X	X			PAN	Costa 1.342, 1.986
Syrrhopodon gardneri (Hook.) Schwaegr.			X		PAN	Costa 928
S. gaudichaudii Mont.		X	X		PAN	Costa 214, 421, 867, 1.173
S. incompletus Schwaegr. var. *incompletus*	X	X			W	Costa 379, 1.278
S. imcompletus var. *berteroanum* Schwaegr.	X	X			NEO	Costa 1.187, 1.521
S. parasiticus (Sw. *ex* Brid.) Paris	X	X			PAN	Costa 928
S. prolifer Schwaegr. var. *prolifer*	X	X	X		PAN	Costa 262, 824, 1.940, 2.018
S. prolifer var. *tenuifolius* (Sull.) Reese			X	X	NEO	Costa 398, 408, 862, 868, 1.125
S. tortilis Hampe			X	X	NEO	l.d.
CATAGONIACEAE (1/2)						
Catagonium brevicaudatum Müll. Hal.				X	NEO	Costa 1.098, Landrum 2.189
C. emarginatum S.H. Lin				X	NEO	Schäffer-Verwimp 11.193
CRYPHAEACEAE (2/2)						
Cryphaea malmei Broth.			X		BRA	Bandeira w/n
Schoenobryum concavifoilum (Griff.) Gangulee			X		W	Bandeira w/n
DICRANACEAE (9/45)						
Atractylocarpus brasiliensis (Müll. Hal.) R.S. Williams				X	BRA	l.d.
A. longisetus (Hook.) Bartram				X	NEO	l.d.
Bryohumbertia filifolia (Hornsch.) J.-P. Frahm var. *filifolia*			X	X	NEO	Costa 414, 907, 3.739
B. filifolia var. *humilis* (Mont.) J.-P. Frahm			X	X	NEO	l.d.
Campylopus aemulans (Hampe) A. Jaeger			X	X	NEO	l.d.
C. angustiretis (Aust.) Lesq. & James			X	X	NEO	l.d.
C. arctocarpus (Hornsch.) Mitt. var. *arctocarpus*			X	X	W	Costa 216, 332, 393a, 496, 1.538

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Taxa	1	2	3	4	GD.	Voucher
C. arctocarpus var. *caldensis* (Aongstr.) J.-P. Frahm				X	NEO	Landrum 2156
C. capitulatus Bartram			X	X	NEO	Costa 86, 224,626
C. cryptopodioides Broth.	X	X			TSA	Costa 1.928
C. cuspidatus (Hornsch.) Mitt. var. *dicnemoides* (Müll. Hal.) J.-P. Frahm		X	X	NEO	l.d.	
C. densicoma (Müll. Hal.) Paris				X	NEO	l.d.
C. dichrostis (Müll. Hal.) Paris			X		BRA	Costa 625, 626
C. fragilis (Brid.) Bruch & Schimp			X	X	W	l.d.
C. fuscocroceus (Hampe) A. Jaeger				X	BRA	Costa 882 *p.p*
C. gardneri (Müll. Hal.) Mitt.				X	NEO	Costa 989
C. gemmatus (Müll. Hal.) Paris			X	X	BRA	Costa 225, 667, 882 *p.p.*
C. griseus (Hornsch.) A. Jaeger			X	X	TSA	Costa 488, 793, 979
C. heterostachys (Hampe) A. Jaeger			X		TSA	Costa 977
C. introflexus (Hedw.) Brid.			X		W	Costa 179
C. julaceus A. Jaeger			X		TSA	Costa 217
C. julicaulis Broth.				X	BRA	Costa 1.100
C. lamellinervis (Müll. Hal.) Mitt.			X		NEO	Costa 639, 931
C. occultus Mitt.			X	X	S-SA	Bandeira, w/n, Ribeiro 308
C. pilifer Brid.				X	W	Landrum 2.190, Ribeiro 308, Soares Filho w/n
C. reflexisetus (Müll. Hal.) Broth.				X	NEO	Costa 660
C. richardii Brid.			X	X	TSA	Costa 86, 308
C. savannarum (Müll. Hal.) Mitt.			X		PAN	Costa 208, 331, 475
C. surinamensis Müll. Hal.			X		TSA	Bandeira w/n
C. thwaitesii (Mitt.) A. Jaeger			X	X	BRA	Giordano w/n
C. trachyblepharum (Müll. Hal.) Mitt.		X			NEO	Costa 1.334, 1.516
Dicranella guilleminiana (Mont.) Mitt.			X		S-SA	Bandeira w/n
D. gymna (Müll. Hal.) Broth.				X	BRA	l.d.
D. hilariana (Mont.) Mitt.		X	X		NEO	Costa 899, 1.197
D. itatiaiae (Müll. Hal.) Broth.			X	X	BRA	l.d.
D. ulei (Müll. Hal.) Broth.			X		BRA	l.d.
Dicranum frigidum Müll. Hal.			X		NEO	Costa 354
Holomitrium arboreum Mitt.			X		NEO	Costa 370, 379
H. crispulum Mart.			X	X	NEO	Costa 63a
H. olfersianum Hornsch.			X	X	NEO	Costa w/n
H. seticalyx Müll. Hal.			X	X	BRA	l.d.
Leucoloma cruegerianum (Müll. Hal.) A. Jaeger			X		NEO	Costa 571
L. serrulatum Brid.	X	X	X		NEO	Costa 743, 782, 1.570
Microcampylopus curvisetus (Hampe) Giers & J.-P. Frahm			X	X	NEO	l.d.
Pilopogon guadalupensis (Brid.) J.-P. Frahm				X	NEO	Baumgratz 310
DIPHYSIACEAE (1/1)						
Diphyscium ulei Müll. Hal.			X		NEO	l.d.
DITRICHACEAE (2/4)						
Cladastomum ulei Müll. Hal.				X	BRA	l.d.
Ditrichum itatiaiae (Müll. Hal.) Paris			X	X	BRA	l.d.
D. liliputianum (Müll. Hal.) Paris				X	BRA	l.d.
D. ulei (Müll. Hal.) Paris				X	BRA	l.d.
ENTODONTACEAE (2/5)						
Entodon beyrichii (Schwaegr.) Müll. Hal.			X		NEO	Costa 263
E. hampeanus Müll. Hal.			X		NEO	Costa 255
E. jamesonii (J. Taylor) Mitt.				X	NEO	Bandeira w/n

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Taxa	1	2	3	4	GD.	Voucher
E. splendidus Hampe			X		NEO	Costa 255
Erythrodontium longisetum (Hook.) Paris			X		NEO	Costa 254, 266, 270
EPHEMERACEAE (2/3)						
Ephemerum pachyneurum Müll. Hal.				X	BRA	l.d.
E. uleanum Müll. Hal.			X		S-SA	l.d.
Micromitrium austinii Sull.				X	TSA	l.d.
FISSIDENTACEAE (1/12)						l.d.
Fissidens angustelimbatus Mitt.				X	NEO	Costa 193, 1.095, 1.104
F. asplenioides Hedw.			X	X	PAN	Costa 456, 860 *p.p.*, 901, 1.153
F. bryoides Hedw.				X	W	Costa 1.093
F. flaccidus Mitt.	X	X			NEO	Costa 2.001
F. hornschuchii Mont.		X	X	X	NEO	Costa 1.370, Bandeira w/n
F. pellucidus Hornsch. var. *asterodontius* (Müll. Hal.) Pursell				X	NEO	l.d.
F. prionodes Mont.			X		NEO	Costa 1.123
F. radicans Mont.		X			NEO	Costa 1.421
F. scarious Mitt.			X		NEO	Costa 428, 573
F. zollingeri Mont.	X	X	X	X	AF-AM	Costa 1.965 *p.p.*
F. wallisii Müll. Hal.				X	BRA	l.d.
F. weirii var. *hemicraspedophyllus* (Cardot) Pursell			X		NEO	l.d.
FUNARIACEAE (2/3)						
Entosthodon bonplandii (Hook.) Mitt.				X	NEO	l.d.
F. hygrometrica Hedw. var. *hygrometrica*				X	W	Costa 228, 239
F. hygrometrica Hedw. var. *calvescens* (Schwaegr.) Mont.			X		W	Bandeira w/n
GRIMMIACEAE (2/3)						
Grimmia elongata Kauf.			X	X	W	l.d.
G. longirostris Hook.			X	X	W	l.d.
Racomitrium crispulum (Taylor) A. Jaeger				X	AF-AM	l.d.
HEDWIGIACEAE (1/1)						
Hedwigidium integrifolium (P. Beauv.) Dix.			X	X	W	Costa 70, 642, 1.020
HYPNACEAE (7/15)						
Chrysohypnum diminutivum (Hampe) W.R. Buck	X	X	X	X	W	Costa 394, 741, 958, 1.226
Ctenidium malacodes Mitt.				X	TSA	Schäffer-Verwimp 7.549
Ectropothecium leptochaeton (Schwaegr.) W.R. Buck	X	X			NEO	Costa 1.288, 1.452 *p.p.*
Isopterygium subbrevisetum (Hampe) Broth.	X	X	X		NEO	Costa 1.132, 1.925
I. tenerifolium Mitt.	X	X			TSA	Costa 1.251
I. tenerum (Sw.) Mitt.		X	X		TSA	Costa 1.189
Mittenothamnium elegantulum (Hook.) Cardot	X				W	Costa 1.373, 2.004
M. langsdorffii (Hook.) Cardot				X	NEO	Costa 196, Ferreira 171
M. reptans (Hedw.) Cardot		X	X		NEO	Costa 913, 1.433
M. simorrhynchum (Hampe) Cardot			X		BRA	Kuhlmann 84, Ochhioni w/n, Braga w/n
M. subdiminutivum (Geh. & Hampe) Cardot			X		BRA	Costa 1.395
M. submacrodontium (Geh. & Hampe) Cardot			X		BRA	Costa 674
M. versipoma (Hampe) Cardot			X		BRA	Bandeira w/n
Rhaphidostichum schwakeanum (Müll. Hal.) Broth.			X		NEO	
Vesicularia vesicularis (Schwaegr.) Broth.		X			NEO	Costa 1.227 *p.p.*
HYPOPTERYGIACEAE (2/5)						
Hypopterygium flavescens Hampe			X	X	W	Costa 1.078, 1.459, 1.505
H. laricinum (Hook.) Brid.			X		AF-AM	Costa 442, 778, 906
H. monoicum Hampe		X	X		BRA	Costa 481, 1.121, 1.462

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continuation

Taxa	1	2	3	4	GD.	Voucher
H. tamarisci (Sw.) Müll. Hal.			X		NEO	Braga 5.225
Lopidium concinnum (Hook.) Wilson	X	X	X		W	Costa 466, 936, 1.144
LEUCOBRYACEAE (2/10)						
L. albicans (Schwaegr.) Lindb.			X	X	NEO	Costa 482, Martinelli 2.533
L. albidum (P. Beauv.) Lindb.		X			NEO	Costa 1.357
L. clavatum Hampe			X		BRA	Costa 383, 1.140
L. crispum Müll. Hal.			X	X	NEO	Costa 595, 750, 846
L. giganteum Müll. Hal.			X		NEO	Costa 362, 176, 1.131
L. martianum (Hornsch.) Müll. Hal.	X	X	X		NEO	Costa 1.541, 1.936
L. sordidum Aongstr.	X	X	X		BRA	Costa 292, 779, 1.167 *p.p.*
Octoblepharum albidum Hedw.	X	X	X		W	Costa 251, 267, 425, 954
O. cocuiense Mitt.	X	X			NEO	Costa 959, 1.224, 1.935
O. pulvinatum (Dozy & Molk.) Mitt.		X			NEO	Costa 1.369, 1.379
LEUCODONTACEAE (1/1)						
Henicodontium geniculatum (Mitt.) W.R. Buck	X	X			W	Costa 1.931, 2.027
LEUCOMIACEAE (2/2)						
Leucomium strumosum (Hornsch.) Mitt.		X			W	Costa 1.506, 2.021
Philophyllum tenuifolium (Mitt.) Broth.			X		BRA	l.d.
METEORIACEAE (11/21)						
Aerolindigia capillacea (Hornsch.) M. Menzel			X	X	PAN	Costa 1.253, Ferreira 182
Cryptopapillaria penicillata (Dozy & Molk.) M. Menzel			X		BRA	Costa 422
Floribundaria usneoides (Broth.) Broth.			X		NEO	Costa 523, 576
Meteoridium remotifolium (Müll. Hal.) Manuel	X	X	X		TSA	Costa 252, 423, 1.354
Meteoriopsis aureonitens (Hornsch.) Broth.			X		BRA	Bandeira w/n
Meteorium deppei (Müll. Hal.) Mitt.		X	X		NEO	Costa 244, 484, 522
M. nigrescens (Hedw.) Dozy & Molk.		X	X		W	Costa 1.157, 1.188
Orthosthichella microcarpa Müll. Hal.			X		BRA	Costa 780, 1.565
O. mucronatula Müll. Hal.			X		BRA	Costa 749 *p.p.*, 870
O. pentasticha (Brid.) W.R. Buck			X	X	PAN	Costa 417, 825, 837
Pilotrichella flexilis (Hedw.) A. Jaeger	X	X	X	X	NEO	Costa 953, 1.071
P. nudiramulosa (Müll. Hal.)			X		BRA	Costa 376, 426, 1.116
P. squarrulosa Müll. Hal.			X	X	BRA	Costa 1.121, 1.363
P. versicolor (Müll. Hal.) A. Jaeger		X	X		NEO	Costa 388, 815, 863, 1.512
Squamidium brasiliense (Hornsch.) Broth.			X	X	AF-AM	Costa 681, 1.003, 2.090 *p.p.*
S. isocladum (Renauld & Cardot) Broth.			X		NEO	l.d.
S. leucotrichum (Taylor) Broth.	X	X	X		NEO	Costa 733, 1.410, 1.999
Toloxis imponderosa (Taylor) W.R. Buck			X		NEO	Bandeira w/n, Costa 999
Zelometeorium ambiguum (Hornsch.) Manuel			X		AF-AM	Costa 680, 1.152, 1.154
Z. patens (Hook.) Manuel			X		NEO	Costa 405 *p.p.*, 1.117
Z. patulum (Hedw.) Manuel	X	X	X		TSA	Costa 749 *p.p.*, 869, 1.223
MIELICHOFERIACEAE (1/4)						
Mielichoferia grammocarpa Müll. Hal.				X	BRA	l.d.
M. serrae Müll. Hal.				X	BRA	l.d.
M. striidens Müll. Hal.				X	BRA	l.d.
M. ulei Müll. Hal.			X		S-SA	l.d.
MNIACEAE (2/5)						
Plagiomnium rynchophorum (Hook.) T.J. Kop.			X	X	W	Costa 372, 374, 812, 820
Pohlia camptotrachela (Renauld & Cardot) Broth.			X		W	l.d.
P. crassicosta (Müll. Hal.) Broth.				X	BRA	l.d.
P. grammocarpa (Müll. Hal.) Broth.				X	BRA	l.d.
P. tenuifolia (Broth.) A. Jaeger			X	X	PAN	l.d.

continue

continuation

Taxa	1	2	3	4	GD.	Voucher
MYRINIACEAE (1/1)						
Helicodontium capillare (Hedw.) A. Jaeger	X	X			TSA	Costa 1.956
NECKERACEAE (5/9)						
Homaliodendron piniforme (Brid.) Enroth.	X				BRA	Costa 1.312
Isodrepanium lentulum (Wills.) E. Britton		X			NEO	Costa 1.175
Neckera araucarieti Müll. Hal.				X	BRA	Costa 1.075, 1.082
N. caldensis Lindb. *ex* Aongstr.			X		BRA	Costa 998
Neckeropsis disticha (Hedw.) Kindb.	X	X			AF-AM	Costa 1.222, 1.979
N. undulata (Hedw.) Reichardt	X	X	X	X	TSA	Costa 893, 1.297
Porotrichum korthalsianum (Dozy & Molk.) Mitt.		X	X	X	NEO	Costa 378, 646, 852, 1.568
P. longirostre (Hook.) Mitt.		X	X	X	NEO	Costa 400, 789, 908
P. substriatum (Hampe) Mitt.			X	X	NEO	Ferreira 182
ORTHODONTACEAE (1/2)						
Orthodontium itacolumitis Müll. Hal.				X	BRA	l.d.
O. pelluscens (Hook.) B.S.G.				X	TSA	l.d.
ORTHOTRICHACEAE (5/16)						
Groutiella apiculata (Hook.) H.A. Crum & Steere	X				NEO	Costa 1.279
G. tomentosa (Hornsch.) Wijk. & Margad.	X	X			W	l.d.
Macrocoma orthotrichoides (Raddi) Wijk. & Margad.				X	DISJNeo-India	l.d.
Macromitrium argutum Hampe				X	BRA	l.d.
M. cirrosum (Hedw.) Brid.			X		NEO	Costa 335, 783
M. eriomitrium Müll. Hal.				X	BRA	l.d.
M. guatemalense Müll. Hal.			X		NEO	l.d.
M. hornschuchii Müll. Hal.	X	X			NEO	Costa 2.005
M. richardii Schwaegr.	X	X			W	Costa 1.268, 1.469
Schlotheimia crumii B.C. Tan			X	X	BRA	Costa 202, 291, 817, 1.085
S. pseudoaffinis Müll. Hal.				X	BRA	l.d.
S. rugifolia (Hook.) Schwaegr.		X	X	X	TSA	Costa 514, 878, 1.061, 1.230
S. tecta Hook. & Wilson			X	X	NEO	Landrum 2.177
S. torquata (Hedw.) Brid.			X	X	NEO	Costa 526, 1.002, 2.016
S. trichomitria Schwaegr.				X	BRA	l.d.
Zygodon reinwardtii (Hornsch.) A. Braun.				X	PAN	Bandeira w/n
PHYLLOGONIACEAE (1/1)						
Phyllogonium viride Brid.		X	X	X	NEO	Costa 472, 738, 751, 1.566
PILOTRICHACEAE (9/24)						
Callicostella martiana (Hornsch.) A. Jaeger	X	X			NEO	Costa 1.244, 1.315
C. merkelii (Hornsch.) A. Jaeger	X	X			NEO	Costa w/n
C. pallida (Hornsch.) Aongstr.	X	X			TSA	Costa 1.218
C. rufescens (Mitt.) A. Jaeger	X	X			NEO	Costa 1.407
Crossomitrium patrisiae (Brid.) Müll. Hal.	X	X			NEO	Costa 1.417, 2.036
Cyclodictyon albicans (Hedw.) Kuntze			X		NEO	Costa 447, 661
C. limbatum (Hampe) Kuntze			X		BRA	Bandeira w/n
C. olfersianum (Hornsch.) Kuntze			X		NEO	Costa 506
Hookeriopsis rubens (Müll. Hal.) Broth.			X		BRA	Costa 857
Hypnella pilifera (Hook. & Wilson) A. Jaeger				X	NEO	Costa 999
Lepidopilidium brevisetum (Hampe) Broth.	X	X			BRA	Costa 2.002, Dusén w/n
L. laevisetum (Hampe) Broth.	X	X	X		BRA	Costa 586, 877, 1.122
L. plebejum (Müll. Hal.) Sehnem			X		BRA	Costa 1.115
Lepidopilum ovalifolium (Dub.) Broth.			X		NEO	Costa 455
L. pringlei Cardot			X		NEO	Costa 740, 930
L. scabrisetum (Schwaegr.) Steere	X	X			NEO	Costa 590, 1.245, 1.479
L. stenodictyon Sehnem			X		BRA	Costa 599

continue

continuation

Taxa	1	2	3	4	GD.	Voucher
Thamniopsis incurva (Hornsch.) W.R. Buck	X	X	X		TSA	Costa 784, 823, 1.294
T. langsdorffii (Hook.) W.R. Buck			X		NEO	Costa 860 *p.p.*,1.064
T. undata (Hedw.) W.R. Buck			X		NEO	Costa 790, 875
Trachyxiphium aduncum (Mitt.) W.R. Buck			X		NEO	Costa 318, 759, Santos 587
T. drepanophyllum (Geh. & Hampe) Schäfer-Verw.				X	BRA (SE)	Occhioni w/n
T. guadalupense (Spreng) W.R. Buck			X		NEO	Costa 309, 859
T. variabile (Hornsch. *in* Mitt.) W.R. Buck			X		NEO	Costa 739
PLAGIOTHECIACEAE (1/1)						
Plagiothecium novogranatense (Hampe) Mitt.	X	X	X	X	TSA	Costa 850, 1.077, 1.965 *p.p.*
POLYTRICHACEAE (6/12)						
Atrichum androgynum (Müll. Hal.) A. Jaeger			X	X	TSA	Costa 71, 900
Itatiella ulei (Broth. *ex* Müll. Hal.) G.L. Smith				X	BRA	Schäffer-Verwimp 4.168, 11.189
Oligotrichum riedelianum (Mont.) Mitt.			X		BRA	Costa 352, 880
Pogonatum campylocarpon (Müll. Hal.) Mitt.			X		NEO	Martinelli 2.460
P. perichaetale subsp. *oligodus* (Müll. Hal.) Hyvönen				X	PAN	Costa 3.788
P. pensilvanicum (Hedw.) P. Beauv.			X		W	Costa 189, 826, 854
P. tortile (Sw.) Brid.			X		NEO	Soares Filho w/n
Polytrichadelphus semiangulatus (Brid.) Mitt.			X		NEO	Costa 513, Kurtz 23
Polytrichum angustifolium Mitt.				X	BRA	Ribeiro 138
P. brasiliense Hampe				X	BRA	Costa 651
P. commune Hedw.		X	X	X	W	Costa 651, 1.207, 3.793
P . juniperinum Hedw.			X	X	W	Costa 241, 800, 980, 1.208, Martinelli 2.516
POTTIACEAE (7/9)						
Chenia leptophylla (Müll. Hal.) Zander			X		W	l.d.
Ganguleea angulosa (Broth. & Dixon) Zander			X		DISJBrazil-India	Costa 1.250
Hyophiladelphus agraricus (Hedw.) Zander	X	X			W	l.d.
Leptodontium araucarieti (Müll. Hal.) Paris			X	X	NEO	Costa 855, 1.007
L. flexifolium (Dicks.) Hampe				X	W	l.d.
L. viticulosoides (P. Beauv.) Wijk & Marg.				X	W	Costa 1.066
Pseudosymblepharis schimperiana (Par.) H.A. Crum				X	NEO	l.d.
Syntrichia fragilis (Tayl.) Ochyra				X	W	l.d.
Tortella tortuosa (Hedw.) Limpr.			X		DISJ NH-SH	Costa 445, 676
PRIONODONTACEAE (1/1)						
Prionodon densus (Hedw.) Müll. Hal.			X	X	W	Costa 758, 1.134
PTEROBRYACEAE (1/1)						
Pterobryon densum Hornsch.			X		W	Costa 387, 1.073
RACOPILACEAE (1/1)						
Racopilum tomentosum (Hedw.) Brid.		X	X		W	Costa 787, 806, 916
RHABDOWEISIACEAE (1/1)						
Rhabdoweisia fugax (Hedw.) W.R. Buck & Schimp.				X	W	l.d.
RHACOCARPACEAE (1/2)						
Rhacocarpus inermis (Müll. Hal.) Lindb.			X	X	BRA	Costa 233, 509, 853, 1.112
R. purpurascens (Brid.) Paris			X		W	Costa 1.012, 1.127
RHIZOGONIACEAE (1/1)						
Pyrrhobryum spiniforme (Hedw.) Mitt.	X	X	X		W	Costa 828, 843
RIGODIACEAE (1/1)						
Rigodium toxarium (Schwaegr.) A. Jaeger				X	W	Costa 1.068, 1.090
SELIGERIACEAE (1/1)						
Brachydontium notorogenes W.R. Buck & Schäf.-Verw.				X	BRA (SE)	l.d.

continue

continuation

Taxa	1	2	3	4	GD.	Voucher
SEMATOPHYLLACEAE (10/22)						
Acroporium catharinense Sehnem			X	X	BRA	Costa 1.083
A. exiguum (Broth.) W.R. Buck & Schäf.-Verw.	X				BRA	l.d.
A. pungens (Hedw.) Broth.			X		NEO	Costa 295, 304, 345
A. estrellae (Müll. Hal.) W.R. Buck & Schäf.-Verw.				X	NEO	Costa 1.156
Aptychella proligera (Broth.) Herz.				X	NEO	Costa 652
Aptychopsis pyrrophylla (Müll. Hal.) Wijk & Marg.				X	BRA	Schäffer-Verwimp 11.156, Bandeira w/n
Donnelia commutata (Müll. Hal.) W.R. Buck			X		TSA	l.d.
Pterogonidium pulchellum (Hook.) Müll. Hal.	X	X	X		NEO	Costa 1.990, 2.034
Rhaphidorrynchium macrorrhynchium (Hornsch.) Broth.	X	X			BRA	Costa 2.013 *p.p.*
R. symbolax (Müll. Hal.) Broth.	X	X	X		BRA	Costa 1.138.
Sematophyllum cyparissoides (Hornsch.) R.S. Williams	X	X			NEO	Costa 2.056 *p.p.*
S. panduraefolium (Broth.) Broth.				X	BRA	Costa 894, 982, 1.086
S. subdepressum (Hampe) Broth.			X		BRA	Bandeira w/n
S. subpinnatum (Brid.) Britt.	X	X	X		W	Costa 1.255
S. subsimplex (Hedw.) Mitt.	X	X	X	X	NEO	Costa 938, 1.214
S. swartzii (Schwaegr.) W.H. Welch	X	X	X	X	NEO	Bandeira w/n
Taxithelium planum (Brid.) Mitt.	X	X			AF-AM	Costa 1.213, 1.353
Trichosteleum glaziovii (Hampe) W.R. Buck	X	X			BRA	l.d.
T. hornschuchii (Hampe) A. Jaeger	X	X	X		NEO	l.d.
T. papillosum (Hornsch.) A. Jaeger		X			NEO	Costa 1.130
T. sentosum (Sull.) A. Jaeger	X	X	X		NEO	Costa 1.532, 1.884
Wijkia sp.	X	X			——	Costa 1.135, 2.085
SPHAGNACEAE (1/24)						
Sphagnum brevirameum Hampe			X		NEO	l.d.
S. capilifolium (Ehrh.) Hedw. var. *capilifolium*				X	W	Costa 3.797
S. capilifolium var. *tenerum* (Sull. & Lesq.) Crum				X	W	Costa 1.097
S. costae Crum & Costa var. *costae*			X		BRA	Costa 290
S. costae var. *confertorameum* Crum & Costa			X		BRA	Costa 301
S. costae var. *seriatum* Crum & Costa			X		BRA	Costa 602
S. cuspidatum Müll. Hal.				X	W	l.d.
S. gracilescens Müll. Hal.				X	BRA	Bandeira 589
S. lindbergii Schimp.			X	X	W	l.d.
S. longistolo Müll. Hal.				X	NEO	Costa 355, 602a,
S. magellanicum Brid.				X	W	Ule 327
S. minutulum Müll. Hal.				X	BRA	l.d.
S. oxyphyllum Warnst.			X		NEO	Landrum 2.144
S. perforatum Warnst.				X	BRA	l.d.
S. perichaetiale Hampe				X	W	Costa 238
S. platyphylloides Warnst.				X	BRA	Ule 336
S. pseudoramulinum Crum				X	BRA	Sucre 4.673, Landrum 2.153, Bandeira w/n
S. recurvum P. Beauv.			X		W	l.d.
S. rotundatum Müll. Hal.			X		BRA	Bandeira w/n, Yano 7.659
S. rotundifolium Müll. Hal.			X		BRA	l.d.
S. sparsum Hampe			X		NEO	Landrum 2.174, 2.146
S. subovalifolium Müll. Hal.			X		BRA	l.d.
S. subsecundum Nees			X		W	Costa 643, 802, 939
S. sucrei Crum			X		BRA	Costa 643, 1.102

continue

continuation

Taxa	1	2	3	4	GD.	Voucher
SPLACHNACEAE (2/2)						
Tayloria arenaria (Müll. Hal.) Broth.				X	NEO	l.d.
Tetraplodon itatiaiae Müll. Hal.				X	BRA	l.d.
STEREOPHYLLACEAE (1/1)						
Pilosium chlorophyllum (Hornsch.) Müll. Hal.	X	X	X	X	NEO	Costa 814, 819, 2.028
SYMPHYODONTACEAE (1/1)						
Symphyodon machrissianus (Crum) W.R. Buck & Ireland				X	NEO	l.d.
THUIDIACEAE (2/7)						
Cyrtohypnum involvens (Hedw.) W.R. Buck & Crum			X		W	Costa 453, 460
C. minutulum (Hedw.) W.R. Buck & Crum		X	X	X	W	Costa 85, 811, 1.008
C. schistocalyx (Müll. Hal.) W.R. Buck & H.A. Crum			X		NEO	Landrum 2.185
Thuidium brasiliense Mitt.		X			NEO	Costa 1.454, 1.531
T. delicatulum (Hedw.) Warnst.	X				W	Costa 735, 856
T. recognitum (Hedw.) Lindb.	X	X	X	X	NEO	Costa 666, 1.317, Martinelli 2.438
T. urceolatum Lorentz.			X		NEO	Bandeira w/n
Total (49 families, 129 genera, 338 taxa)	68	90	202	161		

have the largest number of exclusive species. Similar results were obtained by Gradstein & Salazar-Allen (1992) in a montane rainforest in Panama.

Many families found in the Upper Montane forest are lacking in the Lowland forest (*e.g.* Andreaeaceae, Bruchiaceae, Catagoniaceae, Ditrichaceae, Entodontaceae, Hypopterygiaceae, Miniaceae, Phyllogoniaceae, Polytrichaceae), in the Montane forest (*e.g.* Andreaeaceae, Splachnobryaceae and Symphyodontaceae), and in the Submontane forest (*e.g.* Andreaeaceae, Bruchiaceae, Catagoniaceae, Ditrichaceae, Entodontaceae, Ephemeraceae, Funariaceae, Grimmiaceae, Mielichoferiaceae, Mniaceae, Rigodiaceae, Seligeriaceae, Sphagnaceae, Splachnaceae, and Symphyodontaceae).

Sematophyllaceae is the largest family in the Lowland and Submontane forests, fifth in importance to Montane and Upper Montane forests. Dicranaceae is the largest family in the Montane and Upper Montane forests. Meteoriaceae is an important family to Montane forest but its importance decreases significantly in the Lowland forest because this family has predominantly pendent species that require lower temperature, higher light levels, and higher air humidity not found in the lowland (Richards 1984).

Some genera have their highest diversity in Submontane forest (*e.g. Calymperes*, *Callicostella*), in Montane forest (*e.g. Bryum*, *Campylopus*, *Leucobryum*) or in the Upper Montane forest (*e.g. Breutelia*, *Bryum*, *Campylopus*, *Fissidens*, *Schlotheimia*, *Sphagnum*).

Nine taxa were common to four sites (figure 1): *Chrysohypnum diminutivum*, *Fissidens zollingeri*, *Neckeropsis undulata*, *Pilosium chlorophyllum*, *Pilotrichella flexilis*, *Plagiothecium novogranatense*, *Sematophyllum subsimplex*, *S. swartzii*, and *Thuidium recognitum* (2.6% of the total taxa). Meanwhile, 30 taxa were common to three sites (8.9% of the total taxa) and 97 taxa were common to two sites (28.6% of the total taxa).

General distribution patterns – Analysis of the species distributions showed ten distribution patterns: widespread (57 taxa), pantropical (17 taxa), Holarctic (1 taxa), Southern Hemisphere (1 taxa), Afro-America (7 taxa), tropical and subtropical America (27 taxa), neotropical (125 taxa), southern South America (4 taxa), disjunct: Neotropics-India, Northern and Southern hemisphere, and Brazil-India (3 taxa), and endemic to Brazil (95 taxa). Taxa with broad neotropical distributions comprised about 37.1% of the total, those restricted to Brazil about 28.2%, and widespread about 16.9% (table 2), which is similar with the results found by other authors for tropical rainforests (Gradstein & Salazar-Allen 1992, Gradstein *et al.* 1989).

In the lowland Atlantic rainforest, characteristic Neotropical taxa (35%) include *Groutiella apiculata*,

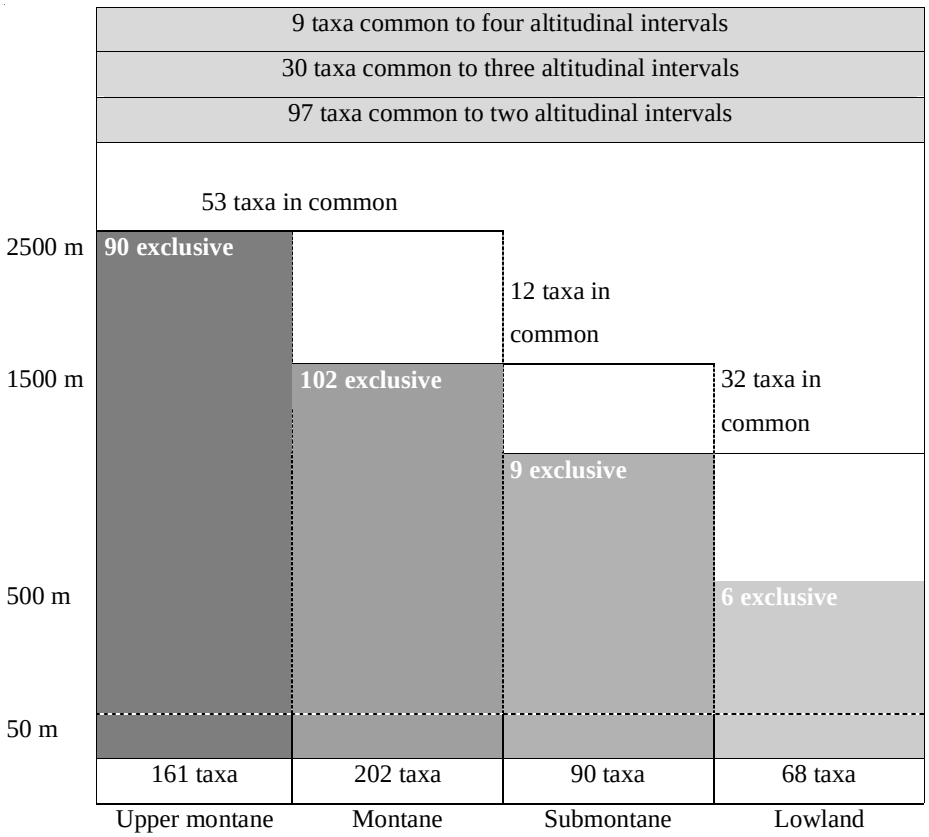

Figure 1. Taxa richness along an altitudinal gradient in Atlantic rainforests of the Rio de Janeiro State.

and tropical and subtropical American taxa (13%) include *Thamniopsis incurva*. In the submontane Atlantic rainforest, Neotropical taxa (46%) include *Calymperes lonchophyllum*, and the widespread taxa (17%) include *Meteorium nigrescens*. In the montane Atlantic rainforest, Neotropical taxa (40%) include *Bryohumbertia filifolia*, widespread taxa (17%) include *Hedwigidium integrifolium*, and taxa restricted to Brazil (23%) include *Mittenothamnium submacrodontium*. In the upper montane Atlantic rainforest, taxa restricted to Brazil (33%) include *Breutelia grandis*, while Neotropical taxa (32%) include *Campylopus capitulatus*, and widespread taxa (18%) include *Sphagnum capilifolium*. It thus appeared that in the lowland, submontane and montane floras, species are usually widespread in the Tropical America, while the upper montane forests contain more taxa with restricted distribution. This is in agreement with the pattern in the Colombian Andes (Gradstein *et al.* 1989). Species richness – The total number of species in each elevational interval supports the notion that tropical Upper Montane and Montane forests are more diverse than the Submontane and Lowland forests (Richards 1984). The differences observed in the moss taxa richness for the four sites analyzed probably are due to habitat heterogeneity coupled with the vegetational zonation provided by topographic relief (Churchill *et al.* 1995).

The highest diversity is found in Montane and Upper Montane forests (202 and 161 taxa, figure 1), and may be explained by the higher rainfall, humus-rich soils, greater topographic relief, constantly high air humidity,

Table 2. Geographical distribution patterns.

Patterns	Number of taxa	%
1 - Widespread (W)	57	16.9
2 - Pantropical (PAN)	17	5.0
3 - Afro-American (AF-AM)	7	2.1
4 - Holarctic (HOLO)	1	0.3
5 - Tropical and subtropical America (TSA)	27	8.0
6 - South Hemisphere (SH)	1	0.3
7 - Neotropical (NEO)	125	37.1
8 - Southern south America (S-SA)	4	1.2
9 - Restricted to Brazil (BRA)	95	28.2
10 - Disjunct (DISJ)	3	0.9
Total	337	100.0

lower temperatures, and higher light intensities, providing a diversity of microclimates and microhabitats inside these forests.

The lower number of taxa in the Lowland Forest can be explained by the open structure, absence of topographic relief, higher temperatures, higher light intensities, that affect the structure and internal microclimate in the forest.

The intermediate taxa diversity found in the Submontane forest (90 taxa, figure 1), could be explained by the intermediary conditions of this forest.

The high taxa richness of the forests above 500 m supports the notion that the Tropical Montane and Upper Montane forests have more moss taxa than Lowland forest under some conditions (Churchill *et al.* 1995, Vitt 1991).

The richness of mosses in the four altitudinal intervals ranged from 41-93 to the genera and 68-202 to the taxa (table 3). The highest richness is found in the Montane (93 genera and 202 taxa) and Upper Montane forests (77 genera and 161 taxa), and the lower in the Lowland forest (41 genera and 68 taxa). The Submontane forest (50 genera and 90 taxa) has intermediary richness. Using the nonparametric S_{chao} estimate, to extrapolate the real number of taxa per altitudinal interval from the observed number of taxa, we found that the real number is almost the same the observed number in the Lowland and Submontane forests, although is underestimated in the montane and Upper Montane forests (table 4).

It appears that in the Atlantic Rainforest of Southeastern of Brazil, high moss diversity commences in the montane zone between 500-2,700 m. According to Churchill *et al.* (1995), Frahm & Gradstein (1991), and Gradstein (1995), the causes of the change with the elevation of epiphytic bryophytes in the tropical rain forests are incompletely understood, and altitudinal related climatic factors such as the frequency of fog, high air humidity, air temperature or light intensity in the forest, or combinations of these factors, have been considered important.

Taxa × vegetational formations – Some taxa are here considered useful for the construction of a general scheme of the altitudinal zonation in the Tropical Rainforests in Rio de Janeiro, in another words, a characteristic structural component of the different vegetational formations along the elevational gradient (mainly based on the elevation ranges and geographical distributions).

Lowland – *Acroporium exiguum* and *Homaliodendron piniforme*.

Submontane – *Campylopus trachyblepharum, Fissidens radicans*, *Isodrepanium lentulum*, and *Leucomium strumosum*.

Montane – *Campylopus dichrostis, Cryphaea malmei, Cryptopapillaria pennicilata, Cyclodictyon limbatum, Diphyscium ulei, Hookeriopsis rubens, Leiomella piligera, Lepidopilum plebejum, L. stenodictyon, Neckera caldensis, Oligotrichum riedelianum, Orthostichella microcarapa, O. mucronatula, Philophyllum tenuifolium, Pilotrichella nudiramulosa, Toloxis imponderosa, Sphagnum costae, S. rotundatum, S. rotundifolium, S. subovalifolium*, and *S. sucrei*.

Upper Montane – *Andreaea microphylla, A. spurioalpina, A. squarrosofiliformis, Aptychopsis pyrrophylla, Atractylocarpus brasiliensis, Brachydontium notorogenes, Brachymenium hornschuchianum, Breutelia grandis, B. subtomentosa, Campylopus fuscocroceus, C. julicaulis, Cladostomum ulei, Dicranella gymna, Ditrichum liliputianum, D. ulei, Ephemarum pachyneurum, Fissidens wallissii, Itatiella ulei, Macromitrium eriomitrium, Mielichhoferia grammocarpa, M. serrae, M. stridens, Neckera araucarieti, Orthodontium itacolumitis, O. pelluscens, Pohlia crassicostata, P. grammocarpa, Polytrichum*

Table 3. Comparison of the moss floras at the four forests. Boldface = number of taxa and genera at each site; without boldface = number of taxa and genera in common between pairs of sites; italics = indices of similarity (Sørensen coefficient). Sites. 1 = lowland forest; 2 = submontane forest; 3 = montane forest; 4 = upper montane forest. (Tax. = taxa; Gen. = genera).

Site	1		2		3		4	
	Tax.	Gen.	Tax.	Gen.	Tax.	Gen.	Tax.	Gen.
1	**68**	**41**	*0.79*	*0.90*	*0.21*	*0.34*	*0.07*	*0.30*
2	63	41	**90**	**50**	*0.32*	*0.50*	*0.12*	*0.34*
3	29	23	48	36	**202**	**93**	*0.38*	*0.61*
4	9	18	16	22	70	52	**161**	**77**

Table 4. Estimation of the real number of taxa per altitudinal interval from the observed number of taxa using the nonparametric S_{chao} estimator.

Altidunal intervals	Observed taxa number	Real number of taxa $S_{chao}= S_{obs}+ F_1^2/2F_2$
Lowland (0-50 m)	68	68.56
Submontane (50-500 m)	90	90.96
Montane (500-1,500 m)	202	282.03
Upper Montane (>1,500 m)	161	237.41
Total	338	

angustifolium, *P. brasiliense*, *Rhynchostegium rivale*, *Schlotheimia pseudoaffinis*, *S. trichomitria*, *Sematophyllum panduraefolium*, *Sphagnum gracilescens*, *S. minutulum*, *S. perforatum*, *S. platyphylloides*, *S. pseudoramulinum*, *Tetraplodon itatiaiae*, *Trachyxiphium drepanophyllum*, *Trematodon brevifolius*, *T. gymnostomus*, and *T. pauperifolius*.

Excluded taxa – Here are included taxa not found in the Mosses World Checklist (Crosby *et al.* 1999) and in the literature or that are considered insufficiently known taxonomically: *Bartamia rufescens* Hampe (Itatiaia), *Campylopus canalliculatus* (Geh. & Hampe) Par. (Itatiaia), *C. collinus* Par. (Itatiaia), *Eurhynchium riparioides* (Hedw.) Richs. (Friburgo), *Fissidens obtusatus* Hampe (Itatiaia), *F. longifalcatus* Müll. Hall. (southeastern and southern Brazil), *Mielichhoferia linearis* Müll. Hall. (Itatiaia), *Trematodon brevifolius* Müll. Hall. (Itatiaia), *T. gymnostomus* Lindb. (Itatiaia), *T. heterophyllus* Müll. Hall. (Itatiaia), *T. pauperifolius* Müll. Hall. (Itatiaia).

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