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Floristic composition and structure of an upper montane cloud forest in the Serra da Mantiqueira Mountain Range of Brazil

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ABSTRACT

We analyzed the community structure of an upper montane cloud forest (elevation, 1900 m) in the Serra da Mantiqueira Mountain Range, in the state of Minas Gerais, Brazil. Our objective was to determine the comparative tree species richness and floristic diversity within this forest, which is at one of the higher elevations in the range, in relation to surrounding forests that are at lower elevations, adjusting for elevational gradients. Within 15 permanent plots (40 × 10 m each), we tagged all tree individuals with a diameter at breast height ≥ 5 cm, registering their height and diameter. To compare the study area with neighboring cloud forests, we used the Sørensen similarity coefficient and phytosociological parameters. We sampled 1250 individuals distributed among 89 species, 55 genera, and 34 families. Canonical correspondence analysis revealed no gradients related to the vegetation or soil. We found that tree species richness and diversity were high in the study area. There was structural and floristic heterogeneity among the communities evaluated, underscoring the importance of conservation of these high-elevation ecosystems, which are so unique and irreplaceable.

Key words: Upper montane cloud forest, mountain forest, phytosociology, tree community, Atlantic Forest.

Introduction

The Serra da Mantiqueira Mountain Range is part of the Atlantic Forest Biome, which encompasses various types of forest formations. Cloud forests constitute a type of rain forest that occurs at higher elevations and is shrouded in low-level cloud cover for most of the year (Webster 1995). In the Serra da Mantiqueira, cloud forests typically occur above 1100 m. Neotropical cloud forests are among the rarest and most threatened ecosystems in the world (Bruijnzeel *et al.* 2010), collectively occupying an estimated area of only approximately 215,000 km^2, which corresponds to only 1.4% of all tropical forests and 6.6% of all montane tropical forests (Scatena *et al.* 2010). In Brazil, cloud forests within the southern and southeastern segments of the Atlantic Forest Biome form a distinct, albeit poorly studied, floristic and phytogeographic unit (Bertoncello *et al.* 2011). At the higher elevations of the Serra da Mantiqueira, Meirelles *et al.* (2008) and França & Stehmann (2004) conducted tree community surveys at 1820-1940 m and at 1900 m, respectively. Nevertheless, the Atlantic Forest is considered a global priority area for the conservation of cloud forests (Bruijnzeel *et al.* 2010). Therefore, this study aimed to expand the knowledge of cloud forest ecosystems in Brazil, describing and analyzing the community structure of an upper montane cloud forest within the Atlantic Forest Biome, in the Serra da Mantiqueira.

Material and Methods

Study area

The study site is within the High Montane Private Nature Reserve (22°22'39"S; 44°48'55"W), located in the county of Itamonte, within the state of Minas Gerais, Brazil. The reserve comprises 672 ha of continuous forest and montane grassland, the latter restricted to the highest elevations (2100-2400 m). The area ranks eighth among the most irreplaceable ecosystems in the world in terms of the diversity of vertebrate species, which are threatened with extinction, and there have been urgent calls for additional measures to ensure its effective management and conservation (Le-Saout *et al.* 2013). The study area has a history of complex disturbance, with fewer disturbances at the upper elevations. Currently, the area is strictly protected and has been incorporated into the Serra da Mantiqueira

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Environmentally Protected Area. The study site, which is at an elevation of 1900 m, is 15 km from the entrance to Itatiaia National Park (near the Serra Fina Mountain Range). This area is part of the Atlantic Forest Biome, and the predominant type of vegetation formation is dense high montane rain forest (IBGE 2012). The area can also be classified as tropical broadleaf evergreen upper montane cloud forest (Oliveira-Filho 2009) or simply upper montane cloud forest (Bruijnzeel & Hamilton 2000; Bruijnzeel 2001; Scatena *et al*. 2010). We observed that, in comparison with the surrounding areas (at lower elevations), the study site presented greater epiphytism, with more mosses on tree trunks and in tree canopies, smaller leaf sizes and a greater abundance of vines, as well as bamboos (which do not occur at the lower elevations).

According to the Köppen classification system, the climate of the region under study is type Cwb, characterized by humid temperate with dry winters, the average temperature in the warmest and coolest months being < 17.3°C and > 12.7°C, respectively (Sá Júnior *et al*. 2012). The historic average annual rainfall is 1749 mm (Pane & Pereira 2005). Geologically, the study area is part of Paraíba do Sul Complex, covering a lithologic group comprising mainly gneisses and migmatites, which corresponds to an environment with extremely strong relief, with crests sectioned at the higher elevations due to faulting (Pane & Pereira 2005). The resulting soils are Inceptisols (Pane & Pereira 2005).

Sampling

We sampled the tree community in 15 permanent plots (40 × 10 m each; total area, 0.6 ha), distributed systematically at regular intervals, 15 m apart, all at an elevation of 1900 m. Using numbered aluminum tags, we tagged all trees with a diameter ≥ 5 cm with. We also measured the circumference and height of those individuals using a tape measure and a graduated pole, respectively. The reproductive material collected was processed following the usual herbarium techniques and deposited in the following herbaria: ESAL, UEC, RB; which acronyms are in accordance with the Index Herbariorum (Thiers continuously updated) plus the Herbarium at the State University of Montes Claros. For the classification of specimens down to the family level, we followed the Angiosperm Phylogeny Group III guidelines (APG III 2009).

Texture and chemical analyses of one composite soil sample from each plot, sampled in the center and vertices, were conducted at the Soil Analysis Laboratory at the Federal University of Lavras following the Brazilian Agency for Agricultural Research protocol (EMBRAPA 1997). The following soil variables were measured: pH; levels of P, K, Ca, Mg, Al, and H+Al; sum of bases; base saturation; aluminum saturation; cation exchange capacity; cation exchange capacity at pH 7.0; remaining phosphorus; organic matter; and sand, silt, and clay fractions.

Data analysis

To describe the horizontal structure of the tree community, we calculated the classical phytosociological parameters for each species (Mueller-Dombois & Ellenberg 1974): absolute and relative density; absolute and relative dominance; absolute and relative frequency; and importance value, which is the sum of the aforementioned relative values. To evaluate species diversity, we employed the Shannon diversity index and Pielou's evenness index (Brower & Zar 1997), applying a rarefaction curve, based on species richness versus the number of individuals, in the program PC-ORD, version 5.1 (Mccune & Mefford 2006). For the species with the highest importance values, we drew statistical comparisons for abundance and basal area using one-way ANOVA followed by Tukey's test (Zar 2010), which allowed us to recognize patterns of structural organization within populations. Data normality were tested, and parameters were transformed by square root functions (for abundance) or log transformed (for basal area) when necessary.

The correlations between soil variables and species abundance were analyzed by canonical correspondence analysis (CCA), again with PC-ORD. The CCA was performed to evaluate floristic patterns correlated with soil variables. From the abundance data of the 23 species represented by five or more individuals, we constructed a species composition matrix in which values were log transformed to compensate for deviations caused by outliers (ter Braak 1995). To create the soil data matrix, we performed a preliminary CCA, eliminating correlated environmental variables or those that correlated only weakly with the ordination axes. Therefore, the final CCA was calculated using the following variables: sand, silt, and clay fractions; pH, P, K, Ca, and Al; sum of bases; cation exchange capacity at pH 7.0; organic matter; and remaining phosphorus. We used the Sørensen similarity coefficient (Brower & Zar 1984) and phytosociological parameters in order to compare the study area with other cloud forests studied in the Serra da Mantiqueira: at Poços de Caldas (Costa *et al.* 2011); at Camanducaia (França & Stehmann 2004); at Monte Verde (Meireles *et al.* 2008); and at Bocaina de Minas (Carvalho *et al.* 2005).

Results

We sampled 1250 individuals distributed among 89 species, 55 genera, and 34 families (Tab. 1). The families with highest species richness were Myrtaceae, with 20 species; Melastomataceae, with nine; Lauraceae, with six; Aquifoliaceae, with four; Myrsinaceae, with four; and Rubiaceae, with four. Those six families accounted for 53% of all of the species sampled. There were 19 families that were represented by a single species. The genera with highest species richness (collectively accounting for 42% of the species sampled) were *Miconia* and *Myrcia* (six species

Table 1. List of tree species sampled in 0.6 ha of an upper montane cloud forest at 1900 m elevation in the Serra da Mantiqueira Mountain Range, Itamonte County, in the state of Minas Gerais, Brazil.

Species	CN	n	AD	ADo	AF	IV*
Roupala rhombifolia Mart. ex Meisn.	TAB 377	94	156.7	5.043	86.7	26.5
Myrsine umbellata Mart.	TAB 149	93	155.0	3.345	86.7	21.3
Pimenta pseudocaryophyllus (Gomes) Landrum	TAB 303	84	140.0	2.654	93.3	18.8
Myrceugenia miersiana (Gardner) D.Legrand & Kausel	-	90	150.0	2.067	100.0	17.7
Myrcia splendens (Sw.) DC.	TAB 276	89	148.3	1.881	86.7	16.5
Prunus myrtifolia (L.) Urb.	TAB 277	88	146.7	1.759	93.3	16.4
Ilex brevicuspis Reissek	TAB 343	58	96.7	1.469	93.3	13.1
Miconia pusilliflora (DC.) Triana	TAB 271	83	138.3	0.749	80.0	12.3
Calyptranthes brasiliensis Spreng.	-	55	91.7	1.615	66.7	12.1
Cabralea canjerana (Vell.) Mart.	TAB 323	48	80.0	1.016	86.7	10.6
Psychotria vellosiana Benth.	TAB 185	56	93.3	0.590	80.0	9.7
Lamanonia ternata Vell.	TAB 172	26	43.3	1.112	66.7	8.3
Siphoneugena widgreniana O.Berg	TAB 355	32	53.3	0.585	73.3	7.5
Miconia sellowiana Naudin	TAB 146	24	40.0	0.474	60.0	5.9
Eugenia florida DC.	-	24	40.0	0.370	53.3	5.3
Clethra scabra Pers.	TAB 168	10	16.7	0.671	40.0	4.5
Ilex paraguariensis A.St.-Hil.	TAB 344	12	20.0	0.423	40.0	4.0
Cryptocarya aschersoniana Mez	TAB 359	13	21.7	0.447	33.3	3.8
Croton piptocalyx Müll.Arg.	TAB 397	7	11.7	0.497	40.0	3.8
Piptocarpha macropoda Baker	TAB 414	10	16.7	0.208	53.3	3.7
Siphoneugena densiflora O.Berg	TAB 354	16	26.7	0.358	26.7	3.5
Tibouchina estrellensis (Raddi) Cogn.	TAB 206	19	31.7	0.257	26.7	3.4
Guatteria australis A.St.-Hil.	TAB 194	9	15.0	0.291	40.0	3.3
Symplocos insignis Brand	TAB 489	11	18.3	0.257	33.3	3.1
Byrsonima laxiflora Griseb.	TAB 338	5	8.3	0.271	33.3	2.6
Eugenia dodonaeifolia Cambess.	-	8	13.3	0.369	20.0	2.6
Cinnamomum triplinerve (Ruiz & Pav.) Kosterm.	TAB 471	8	13.3	0.275	26.7	2.6
Drimys brasiliensis Miers	TAB 491	11	18.3	0.253	20.0	2.5
Miconia castaneiflora Naudin	TAB 231	9	15.0	0.062	33.3	2.3
Solanum pseudoquina A.St.-Hil.	TAB 268	4	6.7	0.259	26.7	2.2
Rudgea jasminoides (Cham.) Müll.Arg.	TAB 334	10	16.7	0.075	26.7	2.2
Cestrum axillare Vell.	-	5	8.3	0.105	33.3	2.1
Myrcia venulosa DC.	TAB 353	6	10.0	0.064	33.3	2.1
Maytenus gonoclada Mart.	TAB 340	6	10.0	0.246	20.0	2.1
Ouratea semiserrata (Mart. & Nees) Engl.	-	10	16.7	0.077	20.0	1.9
Citronella paniculata (Mart.) R.A.Howard	TAB 339	4	6.7	0.137	26.7	1.9
Myrceugenia bracteosa (DC.) D.Legrand & Kausel	TAB 413	8	13.3	0.308	6.7	1.9
Maytenus evonymoides Reissek	TAB 267	5	8.3	0.069	26.7	1.7
Daphnopsis brasiliensis Mart. & Zucc.	TAB 336	6	10.0	0.074	20.0	1.6
Cyathea phalerata Mart.	TAB 356	7	11.7	0.178	6.7	1.4

Continues.

Table 1. Continuation.

Species	CN	n	AD	ADo	AF	IV*
Miconia latecrenata (DC.) Naudin	-	10	16.7	0.074	6.7	1.3
Eugenia handroana D.Legrand	TAB 236	3	5.0	0.069	20.0	1.3
Symplocos celastrinea Mart. ex Miq.	TAB 330	3	5.0	0.162	13.3	1.3
Psidium rufum DC.	-	4	6.7	0.088	13.3	1.2
Mollinedia clavigera Tul.	TAB 326	2	3.3	0.116	13.3	1.1
Piptocarpha axillaris (Less.) Baker	TAB 342	2	3.3	0.107	13.3	1.1
Myrcia multiflora (Lam.) DC.	-	3	5.0	0.064	13.3	1.0
Euplassa organensis (Gardner) I.M.Johnst.	-	3	5.0	0.028	13.3	0.9
Calyptranthes clusiifolia O.Berg	-	2	3.3	0.054	13.3	0.9
Dasyphyllum brasiliense (Spreng.) Cabrera	TAB 341	1	1.7	0.173	6.7	0.9
Leandra quinquedentata (DC.) Cogn.	TAB 320	2	3.3	0.051	13.3	0.9
Ocotea minarum (Nees & Mart.) Mez	TAB 357	2	3.3	0.036	13.3	0.8
Myrcia retorta Cambess.	TAB 352	3	5.0	0.102	6.7	0.8
Daphnopsis fasciculata (Meisn.) Nevling	-	2	3.3	0.022	13.3	0.8
Ocotea corymbosa (Meisn.) Mez	-	2	3.3	0.020	13.3	0.8
Ilex sapotifolia Reissek	TAB 345	2	3.3	0.015	13.3	0.8
Myrsine lineata (Mez) Imkhan.	-	4	6.7	0.044	6.7	0.7
Guapira opposita (Vell.) Reitz	-	1	1.7	0.113	6.7	0.7
Myrsine coriacea (Sw.) R.Br. ex Roem. & Schult.	TAB 243	1	1.7	0.078	6.7	0.6
Agarista eucalyptoides (Cham. & Schltdl.) G.Don	TAB 322	1	1.7	0.071	6.7	0.6
Calyptranthes widgreniana O.Berg	TAB 349	2	3.3	0.040	6.7	0.6
Zanthoxylum fagara (L.) Sarg.	-	1	1.7	0.061	6.7	0.6
Dictyoloma vandellianum A.Juss.	TAB 284	1	1.7	0.050	6.7	0.5
Roupala montana Aubl.	TAB 173	1	1.7	0.047	6.7	0.5
Heisteria silvianii Schwacke	-	1	1.7	0.046	6.7	0.5
Miconia corallina Spring	TAB 239	2	3.3	0.015	6.7	0.5
Ocotea diospyrifolia (Meisn.) Mez	TAB 358	2	3.3	0.012	6.7	0.5
Myrcia guianensis (Aubl.) DC.	TAB 148	2	3.3	0.011	6.7	0.5
Sloanea hirsuta (Schott) Planch. ex Benth.	-	2	3.3	0.010	6.7	0.5
Symplocos falcata Brand	TAB 153	1	1.7	0.034	6.7	0.5
Agonandra excelsa Griseb.	-	1	1.7	0.029	6.7	0.5
Vitex megapotamica (Spreng.) Moldenke	-	1	1.7	0.027	6.7	0.4
Myrcia pulchra (O.Berg) Kiaersk.	TAB 152	1	1.7	0.023	6.7	0.4
Ilex affinis Gardner	-	1	1.7	0.019	6.7	0.4
Daphnopsis coriacea Taub.	-	1	1.7	0.017	6.7	0.4
Cordiera sessilis (Vell.) Kuntze	TAB 324	1	1.7	0.015	6.7	0.4
Miconia splendens (Sw.) Griseb.	-	1	1.7	0.011	6.7	0.4
Aegiphila integrifolia (Jacq.) B.D.Jackson	-	1	1.7	0.009	6.7	0.4
Blepharocalyx salicifolius (Kunth) O.Berg	TAB 348	1	1.7	0.009	6.7	0.4
Schefflera calva (Cham.) Frodin & Fiaschi	-	1	1.7	0.009	6.7	0.4
Annona cacans Warm.	TAB 347	1	1.7	0.009	6.7	0.4

Continues.

Table 1. Continuation.

Species	CN	n	AD	ADo	AF	IV*
Aiouea saligna Meisn.	-	1	1.7	0.008	6.7	0.4
Maytenus salicifolia Reissek	-	1	1.7	0.006	6.7	0.4
Marlierea excoriata Mart.	-	1	1.7	0.005	6.7	0.4
Leandra aurea (Cham.) Cogn.	TAB 237	1	1.7	0.005	6.7	0.4
Meliosma sellowii Urb.	-	1	1.7	0.004	6.7	0.4
Myrsine gardneriana A.DC.	TAB 434	1	1.7	0.004	6.7	0.4
Euplassa legalis (Vell.) I.M.Johnst.	-	1	1.7	0.004	6.7	0.4
Rhamnus sphaerosperma Sw.	TAB 332	1	1.7	0.004	6.7	0.4
Total		1250	2083	33.0	2340	300

CN – collector number; n – number of individuals sampled; AD – absolute density (ind./ha); ADo – absolute dominance (m^2/ha); AF – absolute frequency (%); IV – importance value (%).
* Species are listed in decreasing order by IV.

each); *Ilex* and *Myrsine* (four species each); and *Calyptranthes*, *Daphnopsis*, *Maytenus*, *Symplocos*, *Eugenia*, and *Ocotea* (three species each). Abundance (n of individuals) was greatest in the family Myrtaceae (n = 434), which was followed by Melastomataceae (n = 151), Myrsinaceae (n = 99), Proteaceae (n = 99), and Rosaceae (n = 88), those five families accounting for 70% of the individuals identified.

Among the tree species with the highest VIs in the sampling area, we found no significant differences in terms of abundance ($F_{0.05, 5.84} = 0.05$; $p = 0.99$). However, *Roupala rhombifolia* showed a greater basal area than did *Myrceugenia miersiana* (q = 4.15, $p = 0.04$), *Myrcia splendens* (q = 4.4, $p = 0.02$), and *Prunus myrtifolia* (q = 4.5, $p = 0.02$), resulting in significant dissimilarities among basal areas of the main populations of the tree component ($F_{0.05, 5.84} = 3.09$; $p = 0.01$).

The tree community had an absolute density of 2083 ind.ha^{-1} and absolute dominance of 33 $m^2.ha^{-1}$. Among the individuals sampled, the mean height was 10.4 m and the mean diameter was 12.14 cm. The Shannon diversity index was 3.49, and Pielou's evenness index was 0.78. The rarefaction curve (Fig. 1) showed that most species were sampled, because the curve tended to reach an asymptote.

The results of the soil texture and chemical analyses of the 15 plots sampled are shown in Tab. 2. The eigenvalues for the first three axes of the CCA were low (0.189; 0.109; 0.103 respectively), indicating low species turnover in the sampled area (< 0.5; *sensu* ter Braak 1995). In addition, the structural organization of the tree community did not correlate significantly with any of the soil attributes (P = 0.2953), underscoring the homogeneity of the tree community in the cloud forest under study.

The comparisons among Itamonte and the other cloud forests in the Serra da Mantiqueira, in terms of structure, diversity, species richness, and most important species, are shown in Tab. 3. There were variations in basal area and abundance among the forests evaluated, basal area being greatest in Camanducaia and density being greatest in Monte Verde, whereas both were lowest in Poços de Caldas. The Sørensen similarity index indicated that there was little similarity, in terms of species composition, among the areas, the index being highest for the pairs Itamonte-Poços de Caldas (0.36), Camanducaia-Monte Verde (0.35), and Poços de Caldas-Bocaina de Minas (0.30), whereas it was lowest for the pairs Camanducaia-Poços de Caldas (0.07), Bocaina de Minas-Camanducaia (0.09), Bocaina de Minas-Monte Verde (0.09), and Poços de Caldas-Monte Verde (0.09). The species *Cabralea canjerana*, *Lamanonia ternata*, *Myrcia splendens*, *Myrsine umbellata*, and *Prunus myrtifolia*, were sampled at all study sites.

Discussion

Some of the richest families in our study, including Myrtaceae, Melastomataceae, Aquifoliaceae, and Symplocaceae, have been classified as typical of neotropical cloud forests (Webster 1995). In a study that investigated

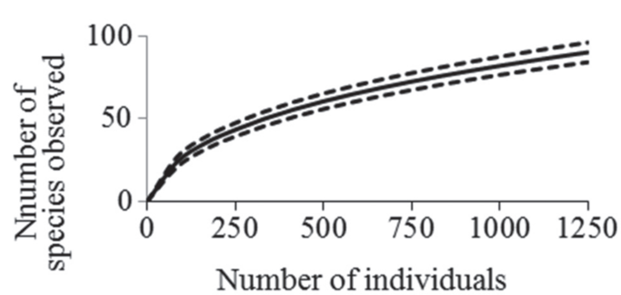

Figure 1. Tree species accumulation curve in an upper montane cloud forest at 1900 m elevation in the Serra da Mantiqueira Mountain Range, Itamonte County, in the state of Minas Gerais, Brazil.

Table 2. Texture and chemical analysis of soil samples from 15 plots (10 × 40 m each) in an upper montane cloud forest at 1900 m elevation in the Serra da Mantiqueira Mountain Range, Itamonte County, in the state of Minas Gerais, Brazil.

Plot	Sand (%)	Silt (%)	Clay (%)	pH	P (mg× dm−3)	K mg× dm−3)	Ca (cmol× dm−3)	Mg (cmol× dm−3)	Al (cmol× dm−3)	H+Al (cmol× dm−3)	SB (cmolc× dm−3)	t (cmolc× dm−3)	T (cmolc× dm−3)	V (%)	m (%)	OM (dag×kg−1)	P-rem (mg×L−1)
P1	20	30	50	4.3	2.6	78	0.1	0.1	2.8	19	0.4	3.2	19.5	0.02	0.88	9.2	3.4
P2	20	47	30	4.4	3.1	67	0.1	0.1	2.7	17	0.4	3.1	17.5	0.02	0.88	10.0	3.8
P3	30	49	30	4.6	3.1	56	0.1	0.1	4.3	24	0.3	4.6	24.3	0.01	0.93	10.0	2.4
P4	40	36	20	4.6	3.1	45	0.1	0.1	3.1	17	0.3	3.4	17.4	0.02	0.91	10.3	2.6
P5	50	34	20	5.0	4.0	61	0.1	0.1	1.4	14	0.4	1.8	14.1	0.03	0.80	14.6	2.5
P6	30	31	40	5.0	2.0	80	0.1	0.1	2.1	15	0.4	2.5	15.7	0.03	0.84	8.7	11.0
P7	10	45	40	4.4	4.3	61	0.2	0.1	2.9	15	0.5	3.4	15.8	0.03	0.86	9.7	2.5
P8	20	42	40	4.4	4.3	76	0.1	0.1	3.0	19	0.4	3.4	19.5	0.02	0.88	11.5	1.9
P9	10	46	40	4.4	4.0	51	0.1	0.1	2.7	17	0.3	3.0	17.5	0.02	0.89	11.8	1.7
P10	10	38	50	4.5	3.1	64	0.1	0.1	3.2	19	0.4	3.6	19.5	0.02	0.90	10.0	2.3
P11	20	31	50	4.3	2.6	78	0.1	0.1	2.8	19	0.4	3.2	19.5	0.02	0.88	9.2	3.4
P12	20	30	50	4.4	3.1	67	0.1	0.1	2.7	17	0.4	3.1	17.5	0.02	0.88	10.0	3.8
P13	10	39	50	4.6	3.1	56	0.1	0.1	4.3	24	0.3	4.6	24.3	0.01	0.93	10.0	2.4
P14	20	35	40	4.6	3.1	45	0.1	0.1	3.1	17	0.3	3.4	17.4	0.02	0.91	10.3	2.6
P15	30	49	30	5.0	4.0	61	0.1	0.1	1.4	14	0.4	1.8	14.1	0.03	0.80	14.6	2.5
Mean	23	39	39	4.6	3.3	63	0.1	0.1	2.8	18	0.4	3.2	18.2	0.0	0.9	10.7	3.3
SD	8.9	6.1	8.4	0.2	0.5	9.1	0.0	0.0	0.5	2.3	0.0	0.5	2.3	0.0	0.0	1.3	1.2

V – base saturation; m – aluminum saturation; SB – sum of bases; t – cation exchange capacity; T – cation exchange capacity at pH 7.0; OM – organic matter); P--rem – remaining phosphorus; SD – standard deviation.

Table 3. Comparison between an upper montane cloud forest at 1900 m elevation in the Serra da Mantiqueira Mountain Range, Itamonte County, in the state of Minas Gerais, Brazil (present study) and other cloud forests in the Serra da Mantiqueira.

Site (Reference)	Elevation (m)	S	H'	J'	D	ADo	Species with the highest IV*
Itamonte (Present study)	1890-1925	89	3.49	0.78	2083	33.0	*Roupala rhombifolia* *Myrsine umbellata* *Pimenta pseudocaryophyllos* *Myrceugenia miersiana* *Myrcia splendens* *Prunus myrtifolia*
Monte Verde (Meireles *et al.* 2008)	1820-1940	64	3.28	0.78	3403	37.7	*Pimenta pseudocaryophyllus* *Roupala rhombifolia* *Drimys brasiliensis* *Miconia cinerascens* *Myrceugenia myrcioides* *Myrceugenia brevipedicellata*
Camanducaia (França & Stehmann 2004)	1900	58	2.9	0.71	2001	48.1	*Ocotea lancifolia* *Cabralea canjerana* *Psychotria vellosiana* *Myrcia splendens* *Drimys brasilienis* *Myrsine umbellata*
Bocaina de Minas (Carvalho *et al.* 2005)	1210-1360	221	4.15	0.82	2475	33.3	*Vochysia magnifica* *Psychotria vellosiana* *Lamanonia ternata* *Alchornea triplinervia* *Tibouchina pulchra* *Casearia arborea*
Poços de Caldas (Costa *et al.* 2011)	1200-1575	156	4.26	0.56	1783	29.9	*Alchornea triplinervia* *Pera glabrata* *Calyptranthes widgreniana* *Eugenia dodanaefolia* *Myrsine umbellata* *Cyathea phalerata*

S – number of species sampled; H' – Shannon diversity index; J' – Pielou's evenness index; D – density (number of individuals sampled); ADo – absolute dominance (m^2/ha).
* Species are listed in decreasing order by IV (top six for each site).

36 areas of montane forest in the Andes, Gentry (1995) reported that the three richest families between 1500 m and 2500 m in elevation were Lauraceae, Melastomataceae, and Rubiaceae. The families Myrtaceae, Aquifoliaceae, and Lauraceae have also been shown to be highly representative of the structure of upper montane cloud forests in the state of Paraná, Brazil (Scheer *et al.* 2011). In the upper montane cloud forest at Camanducaia, which, like our study area, is at an elevation of 1900 m, França & Stehmann (2004) found that the richest families were Myrtaceae, Solanaceae, Lauraceae, Rubiaceae, Symplocaceae, and Asteraceae. In another study conducted in the Serra da Mantiqueira, Meireles *et al.* (2008) found that, along an elevational gradient ranging from 1820 m to 1940 m, the richest family was Myrtaceae, followed by Asteraceae, Lauraceae, Aquifoliaceae, Melastomataceae, Solanaceae, and Cunoniaceae. In the upper montane cloud forest at Bocaina de Minas, where the elevation ranges from 1210 m to 1360 m, Carvalho *et al.* (2005) found Melastomataceae and Myrtaceae to be the richest families, followed by Fabaceae, Lauraceae, Annonaceae, Solanaceae, Euphorbiaceae, Asteraceae, Cyatheaceae, and Rubiaceae. Other authors have also identified Myrtaceae as the richest family in montane forests within the Atlantic Forest Biome of Brazil, including other forests in the Serra da Mantiqueira (Pereira *et al.* 2006; França & Stehmann, 2004; Meirelles *et al.* 2008), as well as in other regions of the country, including the south (Scheer *et al.* 2011) and southeast (Oliveira-Filho & Fontes 2000; Costa *et al.* 2011). Conversely, the family Fabaceae was not found in our study area, and its absence at higher elevations has also been noted in other studies (Oliveira-Filho & Fontes, 2000; Gentry 1995; França & Stehmann, 2004; Meireles *et al.* 2008; Scheer *et al.* 2011). In addition, certain ecological patterns observed in our study area, such as the presence of bamboos and epiphytes (e.g., bromeliads, mosses, and orchids) are also typical of tropical cloud forests (Stadtmüller 1987; Bruijnzeel & Hamilton 2000; Bruijnzeel 2001; Scatena *et al.* 2010).

The genera *Drimys*, *Ilex*, *Clethra*, *Meliosma*, *Cyathea*, *Miconia*, *Prunus*, *Roupala*, and *Rhamnus*, all of which were sampled in our study, are considered diagnostic of neotropical cloud forests (Webster 1995). One of those genera (*Miconia*) has been listed as typical of montane forests in southeastern Brazil, as have the genera *Eugenia*, *Ocotea*, *Myrcia*, *Mollinedia*, *Solanum*, *Tibouchina*, *Psychotria*, *Maytenus*, *Marlierea*, *Myrsine*, *Myrceugenia*, *Rudgea*, and *Symplocos* (Oliveira-Filho & Fontes 2000). At the Itamonte site, we sampled several of the species listed by Oliveira-Filho & Fontes (2000) as indicator species of montane forests (semideciduous and ombrophilous forests) within the Atlantic Forest Biome: *Byrsonima laxiflora*, *Calyptranthes clusiifolia*, *Clethra scabra*, *Daphnopsis fasciculata*, *Drimys brasiliensis*, *Heisteria silvianii*, *Maytenus salicifolia*, *Ouratea semiserrata*, *Pimenta pseudocaryophyllus*, *Siphoneugena widgreniana*, and *Symplocos celastrinea*. Some of the species found to be common to all of the cloud forests compared in the present study—*Cabralea canjerana*, *Lamanonia ternata*, *Myrcia splendens*, *Myrsine umbellata*, and *Prunus myrtifolia*—were not mentioned by Bertoncello *et al.* (2011) or Oliveira-Filho & Fontes (2000) as being preferred species of cloud forests. However, our findings suggest that these species are in fact associated with such forests. The fact that *Myrsine umbellata* had high importance values in three of the cloud forests evaluated demonstrates the importance of this species not only floristically but also in the structural organization of these communities. In a study employing two-way indicator species analysis, Bertoncello *et al.* (2011) identified the species *Blepharocalyx salicifolius*, *Citronella paniculata*, and *Rhamnus sphaerosperma* (all sampled in the present study) as preferred species for occurrence in cloud forests within the Atlantic Forest Biome in southern and southeastern Brazil, as well as identifying *Drimys brasiliensis* as indicative of cloud forests. The authors demonstrated that cloud forests form a distinct floristic and phytogeographic unit.

The CCA failed to detect any gradients of vegetation or soil, indicating the homogeneity of the community studied, in terms of those variables. However, Meirelles *et al.* (2008) found variations in forest structure and high species turnover along a short elevational gradient (1820-1940 m) in Monte Verde. According to the authors, that is due to the fact that the plots located at the lower elevations were close to a stream, whereas those located at the higher elevations were more exposed to the wind. In the forest communities of Bocaina de Minas and Poços de Caldas, both of which are at the lower elevations of the Serra da Mantiqueira, Carvalho *et al.* (2005) and Costa *et al.* (2011), respectively, also found low species turnover, even when the plots were distributed along a soil gradient. Therefore, we can classify the Serra da Mantiqueira as environmentally heterogeneous, which makes it difficult to standardize the behavior of its tree community.

The forest in Itamonte is among the richest and most diverse cloud forests in the Serra da Mantiqueira, as previously demonstrated by Scheer *et al.* (2011). However, at Camanducaia—under like environmental conditions (at an elevation of 1900 m, over comparable soil, with a similar microclimate, and without an elevational gradient)—França & Stehmann (2004) reported low diversity and species richness, despite having evaluated a larger sample (1378 trees in a 0.75-ha area). Such a decrease in diversity at the upper elevations has been reported for other tropical mountain ranges (Gentry, 1995). Furthermore, the heterogeneity in the spatial organization in abundance and basal area of cloud forests communities evidence the importance of conservation of distinct remnant in function of structural variability.

Scheer *et al.* (2011) used cluster analysis to determine the importance of tree species in upper montane cloud forests of the Serra do Mar Mountain Range in the state of Paraná, the Aparados da Serra Geral Mountain Range in the state of Santa Catarina, and the Serra da Mantiqueira. The authors recognized the vegetation of the Serra da Mantiqueira as a distinct floristic group. However, our study showed that the tree communities of the Serra da Mantiqueira are characterized by high vegetation heterogeneity, indicating the need for further studies in the region.

The tree community in Itamonte is characterized by high species richness and diversity. The structural and floristic heterogeneity among the various communities compared makes it is difficult to categorize the cloud forests of the Serra da Mantiqueira by floristic or structural patterns. Therefore, there is a need for larger, more detailed floristic studies of these areas. Our findings also underscore the need for better conservation of these ecosystems that are unique and irreplaceable, especially at their upper elevations.

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