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Original Article

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Lauraceae Along an Altitudinal Gradient in Southern Brazil

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ABSTRACT

We performed a phytosociological study on an altitudinal gradient in Lauráceas State Park (*Parque Estadual das Lauráceas*/PR), aiming to describe the Montane Atlantic Rain Forest, to verify the importance of Lauraceae, and to evaluate the communities' successional stage. We distributed survey units (2,000 m² quadrats) along an altitudinal gradient and surveyed all individuals with DBH ≥ 10 cm, which composed the arboreal component. In smaller quadrats (250 m²), we surveyed regeneration individuals. The community at 800 and 900 m a.s.l. shows typical characteristics of Montane forest in an advanced successional stage, and the abundance of *Ocotea catharinensis* is its main indicator. At 1,000 and 1,100 m a.s.l., the forest is characterized as Montane with short stature in an advanced successional stage, with the occurrence of typical upper montane species such as *O. porosa* and *O. vaccinioides*.

Keywords: Atlantic forest, Lauráceas State Park, phytosociology.

1. INTRODUCTION AND OBJECTIVES

The eastern portion of the Paraná State has currently the largest extension of forests and conservation units of integral protection in the state. Among the largest areas, the Lauráceas State Park (*Parque Estadual das Lauráceas - PEL*) harbors an important area of the Atlantic Rain Forest (ARF, or Dense Ombrophilous Forest – DOF, in the Brazilian classification system). The name of this conservation unit refers to the high frequency of trees from Lauraceae family, popularly called "*canelas*" (Paraná, 2002).

Studies have shown that this family is one of the major botanical families in the Atlantic Rain Forest domain in Paraná, either in number of individuals or in species richness, sharing this dominance with Fabaceae, Melastomataceae, Myrtaceae, and Rubiaceae (Oliveira-Filho & Fontes, 2000; Scheer & Blum, 2011).

According to Klein (1984), who studied the ARF in southern Brazil with Veloso, a slow succession tending to form the association named as *Ocotietum* was noted among almost all plant communities. In this successional stage, *Ocotea catharinensis* Mez has marked dominance in the forest structure, which seems to be the most evolved stage of the forest succession and the best representation of the dynamic balance under the regional soil and the current climate conditions (Klein, 1984).

Despite the good conservation conditions of the ARF in eastern slope areas of "Serra do Mar" in Paraná, there are still few studies on its structure, on its floristic composition, and, mainly, on its differentiation along environmental gradients (Blum & Roderjan, 2007).

Besides this, a large gap in knowledge is observed regarding the flora at *PEL*, even after 38 years of its creation. So far as we know, the only systematic study carried out in the *PEL* was the Rapid Ecological Assessment, a document that allows the preparation of Conservation Unit Management Plan (Paraná, 2002). Considering these scenarios, this study primarily aimed to describe the structure and the floristic composition of a Montane ARF gradient in this Conservation Unit. As secondary objectives we sought: a) to verify whether Lauraceae was the most expressive family along the gradient; b) to evaluate the successional stage of the forest communities studied to contribute to reference information about these forest formations.

2. MATERIALS AND METHODS

The *PEL* occupies an area of 32,256 ha in part of the municipalities of Adrianópolis, Tunas do Paraná, and Bocaiúva do Sul, between the coordinates 24°40'44"S-25°00'48"S and 48°32'17"W-48°44'29"W, at altimetric levels ranging between 100 m and 1,226 m a.s.l. Its vegetation cover is composed of ARF in its lowland ("Aluvial"), lower montane ("Submontana"), Montane ("Montana") and upper montane ("Altomontana") formations, with transition zones contact with Mixed Ombrophilous Forest (a typical temperate forest with *Araucaria,* which occupies the high plateaus of South and Southeastern regions of Brazil) and Rupicolous Vegetation at high altitude. Due to the great altimetric amplitude, the *PEL* is under the influence of the Cfa and Cfb climate types according to Köppen's classification (Kottek et al., 2006), with the dominance of the Cfb climate type (Paraná, 2002).

The sampling system was composed of four conglomerates of 2,000 m² each, systematically allocated at every 100 m altitudinal interval (altimetric zone A – 1,100 m a.s.l., B – 1,000 m a.s.l., C – 900 m a.s.l., and D – 800 m a.s.l.). Each conglomerate was subdivided into ten 10 × 20 m plots, forming a 20 × 100 m rectangle. All trees with DBH (Diameter at Breast Height) ≥ 10 cm were surveyed and included in the arboreal component. Inside each sample plot subdivided, a smaller quadrat was allocated (2.5 × 10 m) aiming at regeneration component sampling (saplings with DBH ≥ 1). In addition to the DBH and the taxonomic identification, crown diameter and total height were estimated with a hypsometer.

The conglomerates were allocated in places where the forest had approximately primary structure. Taxa identification was carried out by comparison with exsiccates in the Botanical Municipal Museum of Curitiba (MBM). The collected data were processed in the EXCEL program. The phytosociological parameters were calculated as described in Mueller-Dombois & Ellenberg (1974), and the Shannon diversity index (H') according to Magurran (1988). The ecological group of the species was determined considering Vibrans et al. (2013), with adaptations based on Budowski (1965). For simple comparison with volume results obtained by Klein (1980), the model "stem with bark volume", adjusted by Vibrans et al. (2013, p.116) was used for "all species":

$\ln(Vf/1000) = -17.753 + 0.979 \ln DBH^2 + 0.567 \ln h$, with $R^2 = 0.98$ and $S_{xy} = 2.19\%$.

The evaluation of forest succession stage was carried out based on CONAMA Resolutions No. 2 (Brazil, 1994a) and No. 4 (Brazil, 1994b), and by comparison with other reference studies such as Klein (1980, 1984) and Vibrans et al. (2013), who also characterized Montane ARFs in southern Brazil.

3. RESULTS AND DISCUSSION

The sampling of the two compartments included 1,070 tree individuals, 15 of which included in the dead category, and four of them remaining taxonomically undetermined. The remaining individuals comprised 996 trees or saplings, 32 palm trees, and 23 fern trees. The floristic composition consisted of 46 families, 82 genera, and 143 species. The richest families were Lauraceae (29 spp.), Myrtaceae (23), Fabaceae (10), Melastomataceae (8), Rubiaceae (7), Monimiaceae (5), Aquifoliaceae, Arecaceae, and Primulaceae (4), with the first five accounting for 53.8% of the total number of species. Lauraceae exceeded Myrtaceae in only six species, with more than double the number of individuals (258 vs. 124) representing almost a quarter of the total number of living trees (24.5%) (Tables 1 and 2). The richest genera were *Ocotea* (15 spp.), *Eugenia* (11), *Miconia* (7), *Myrcia* (6), *Mollinedia* (5), *Ilex*, *Myrsine*, and *Persea* (4), and the first five genera accounting for 30.8% of the total of species. The predominant dispersion syndrome was zoochoric (123), followed by anemocoric (19) and autocoric (1).

Considering the four altitudinal zones as a whole and the two compartments of the forest (DBH ≥ 1 cm), the phytosociology computed a total density of 5,406 ind.ha^{-1} and an average dominance of 45.75 m^2.ha^{-1}. The five species with more individuals in both compartments were *Alchornea triplinervia* (Spreng.) Müll. Arg. (65), *Psychotria suterella* Müll. Arg. (58), *Ocotea catharinensis* Mez (50), *Ouratea vaccinioides* (A. St.-Hil. & Tul.) Engl. (39) and *Ocotea bicolor* Vattimo-Gil (33), totaling 23.2% of all trees and saplings. In turn, the most representative families in abundance were Lauraceae (258), Myrtaceae (124), Rubiaceae (92), Euphorbiaceae (65), and Monimiaceae (60), which summed 56.8% of the total density. However, the high value of density of Euphorbiaceae is a result of high density of only one species (*A. triplinervia*).

Table 1. Summary of phytosociological parameters of the arboreal (DBH ≥ 10 cm) and regeneration (10 > DBH ≥ 1 cm) compartments of the Montane Atlantic Rain Forest in Lauráceas State Park (10 species with the highest VI).

Arboreal component							Sapling component				
Species	Vt	RCC	RDe	RDo	RF	VI	Species	RDe	RDo	RF	VI
Ouratea vaccinioides	9.80	8.0	13.8	8.2	6.0	28.0	*Ouratea vaccinioides*	15.4	21.5	10.6	47.5
Ocotea bicolor	9.75	10.0	10.5	8.8	6.8	26.1	*Mollinedia boracensis*	13.8	5.5	8.5	27.9
Ilex microdonta	12.41	9.9	7.6	11.6	6.0	25.2	*Guatteria australis*	7.7	5.9	8.5	22.1
Ocotea porosa	4.17	8.8	7.1	6.5	5.1	18.8	*Ocotea porosa*	4.6	11.3	4.3	20.2
Ocotea vaccinioides	6.51	7.4	6.2	7.6	4.3	18.1	*Miconia pusilliflora*	6.2	5.5	8.5	20.1
Laplacea fruticosa	5.72	4.6	4.8	4.1	4.3	13.1	*Eugenia melanogyna*	6.2	4.3	6.4	16.9
Guatteria australis	2.89	4.9	3.3	3.2	6.0	12.5	*Myrsine gardneriana*	4.6	5.2	4.3	14.1
Symplocos glanduloso-marginata	6.17	7.9	3.3	6.6	2.6	12.5	*Tibouchina* cf. *pilosa*	3.1	8.2	2.1	13.4
Persea alba	4.62	2.1	3.3	3.7	3.4	10.4	*Myrcia pulchra*	3.1	4.5	4.3	11.8

Table 1. Continued...

Arboreal component							Sapling component				
Species	**Vt**	**RCC**	**RDe**	**RDo**	**RF**	**VI**	**Species**	**RDe**	**RDo**	**RF**	**VI**
Ocotea pulchella	8.23	3.7	1.4	6.0	2.6	10.0	*Clusia criuva*	3.1	6.0	2.1	11.2
Subtotal zone A	70.26	67.3	61.4	66.2	47.0	174.7	Subtotal zone A	67.7	78.0	59.6	205.2
Alchornea triplinervia	18.93	13.3	26.0	14.0	10.5	50.5	*Mollinedia boracensis*	8.1	11.5	5.4	25.0
Sloanea lasiocoma	34.29	4.3	1.5	18.7	2.1	22.3	*Cabralea canjerana*	8.1	5.7	7.6	21.4
Myrcia splendens	3.56	4.6	6.9	2.4	8.4	17.7	*Alchornea triplinervia*	4.8	12.0	3.3	20.1
Persea willdenovii	14.31	10.7	4.6	7.2	5.3	17.0	*Ocotea odorifera*	8.1	2.4	6.5	17.0
Ocotea odorifera	6.37	7.4	5.3	5.4	5.3	16.0	*Ocotea nectandrifolia*	5.6	3.6	6.5	15.8
Ocotea bicolor	2.95	5.5	4.6	6.0	4.2	14.8	*Guatteria australis*	6.5	1.6	5.4	13.5
Psychotria vellosiana	5.71	4.6	5.3	3.9	4.2	13.5	*Miconia pusilliflora*	4.8	4.2	4.3	13.4
Pouteria bullata	10.17	6.4	2.3	5.3	3.2	10.8	*Byrsonima ligustrifolia*	3.2	5.9	3.3	12.3
Tachigali denudata	9.88	8.9	2.3	5.3	3.2	10.7	*Pouteria bullata*	4.8	3.3	3.3	11.4
Cyathea delgadii	2.09	2.2	4.6	1.5	4.2	10.3	*Miconia sellowiana*	4.8	2.5	3.3	10.6
Subtotal zone B	108.26	67.8	63.4	69.7	50.5	183.6	Subtotal zone B	58.9	52.8	48.9	160.5
Ocotea catharinensis	119.00	31.9	12.3	29.3	7.0	48.6	*Psychotria suterella*	29.6	13.1	8.9	51.5
Cryptocarya aschersoniana	55.87	15.0	7.7	13.3	7.0	28.0	*Syagrus hoehnei*	5.3	15.6	5.9	26.9
Copaifera trapezifolia	30.44	6.7	5.4	6.9	6.0	18.3	*Mollinedia schottiana*	5.9	9.8	5.9	21.7
Pouteria bullata	5.97	1.0	6.2	1.5	6.0	13.7	*Ocotea catharinensis*	8.3	4.7	4.0	16.9
Calyptranthes lucida	4.98	3.9	5.4	1.7	6.0	13.1	*Pouteria bullata*	3.6	7.4	5.0	15.9
Cabralea canjerana	13.73	1.5	1.5	7.2	2.0	10.7	*Guatteria australis*	2.4	4.4	4.0	10.7
Guapira opposita	5.85	1.5	3.8	1.7	4.0	9.5	*Mollinedia elegans*	3.0	2.5	5.0	10.4
Alchornea triplinervia	18.29	7.6	2.3	5.2	2.0	9.5	*Eugenia neoverrucosa*	3.6	1.8	5.0	10.3
Matayba intermedia	5.13	2.0	3.1	1.7	4.0	8.8	*Cordiera concolor*	1.8	3.3	3.0	8.1
Eugenia copacabanensis	9.53	2.1	2.3	3.5	2.0	7.9	*Calyptranthes lucida*	2.4	1.7	4.0	8.0
Subtotal zone C	268.79	73.3	50.0	72.1	46.0	168.1	Subtotal zone C	65.7	64.3	50.5	180.4

Table 1. Continued...

Arboreal component							Sapling component				
Species	Vt	RCC	RDe	RDo	RF	VI	Species	RDe	RDo	RF	VI
Ocotea catharinensis	66.41	17.2	6.7	17.7	5.4	29.7	*Guatteria australis*	18.7	19.0	10.5	48.2
Alchornea triplinervia	49.82	8.1	9.7	12.8	4.5	27.0	*Euterpe edulis*	7.5	10.2	6.6	24.3
Aspidosperma australe	37.99	10.4	5.2	8.0	5.4	18.6	*Geonoma schottiana*	7.5	4.6	5.3	17.3
Protium kleinii	34.20	5.7	3.7	7.6	3.6	14.9	*Protium kleinii*	8.4	2.0	6.6	17.0
Cryptocarya aschersoniana	21.84	5.5	4.5	5.9	3.6	13.9	*Garcinia gardneriana*	1.9	8.9	2.6	13.4
Mollinedia uleana	2.28	1.8	6.0	1.0	6.3	13.3	*Cyathea atrovirens*	4.7	2.7	5.3	12.7
Eugenia copacabanensis	20.38	6.2	3.7	4.7	2.7	11.1	*Andira fraxinifolia*	4.7	4.0	3.9	12.7
Pouteria bullata	11.70	2.9	3.0	2.9	3.6	9.5	*Copaifera trapezifolia*	1.9	3.9	2.6	8.4
Psychotria vellosiana	7.77	1.9	2.2	3.2	2.7	8.1	*Pterocarpus rohrii*	2.8	2.9	2.6	8.3
Cyathea atrovirens	1.23	0.3	3.7	0.6	3.6	7.9	*Aiouea saligna*	2.8	2.8	2.6	8.2
Subtotal zone D	253.62	60.1	48.5	64.4	41.1	154.0	Subtotal zone D	60.7	61.0	48.7	170.4

Vt: trunk volume with bark ($m^3.ha^{-1}$); RCC: relative canopy coverage; RDe: relative density; RDo: relative dominance; RF: relative frequency; VI: value of importance (0–300).

Table 2. Summary of phytosociological parameters of the c1 arboreal compartment (DBH ≥ 10 cm) and c2 regeneration compartment (10 > DBH ≥ 1 cm) of the Montane Rain Forest in the Lauráceas State Park.

Statistics / Zones	A	B	C	D	A	B	C	D
	c1: H (m)				c1: DBH (cm)			
Mean	7.3	9.5	18.7	17.5	17.3	19.8	25.6	25.9
Standard deviation	1.74	3.05	7.95	7.78	6.88	12.59	17.55	15.34
Coefficient of variation	23.7	32.1	42.4	44.3	39.8	63.6	68.6	59.3
Maximum	12.0	18.0	40.0	38.0	54.1	89.1	95.5	83.4
	c1: g (m^2)				c2: g (m^2)			
Mean	0.0272	0.0432	0.0754	0.0709	0.0018	0.0013	0.0012	0.0014
Standard deviation	0.0275	0.0773	0.1191	0.0875	0.0020	0.0019	0.0016	0.0015
Coefficient of variation	100.8	179.2	158.0	123.4	112.6	144.7	129.7	103.8
Maximum	0.2300	0.6239	0.7162	0.5463	0.0076	0.0121	0.0075	0.0076
Total ($m^2.ha^{-1}$)	29.43	29.99	50.14	47.87	4.70	6.59	8.21	6.05
c1 + c2 ($m^2.ha^{-1}$)					34.13	36.58	58.35	53.92

H: total height; DBH: diameter at 1.30 m; g: basal area.

The vegetation in altimetric zone A has only one vertical stratum, where *Ouratea vaccinioides*, *O. bicolor*, *Ilex microdonta* Reissek, *Ocotea porosa* (Nees & Mart.) Barroso, and *Ocotea vaccinioides* (Meisn.) Mez together accounted for more than a third of the VI. The three species with the highest relative canopy coverage were *O. bicolor*, *I. microdonta,* and *O. porosa*, totaling 28.6%. (Table 1). *Symplocos glanduloso-marginata* Hoehne, *O. bicolor,* and *Ocotea pulchella* (Nees & Mart.) Mez individuals reached 12 m and are the tallest trees sampled, while the highest absolute DBH (54.1 cm) was measured in a *S. glanduloso-marginata* individual (Table 2). The Shannon index was 3.22 nats.ind^{-1}. The climax species totaled 143.7 of the VI, while the secondary species and pioneer species summed 85.6 and 48.2, respectively.

The vegetation in zone B has two vertical strata: a lower one that reaches up to 9 m in height, composed of species such as *Cyathea delgadii* Sternb., *Mollinedia argyrogyna* Perkins, *Mollinedia boracensis* Peixoto and *Myrcia pubipetala* Miq.; and an upper one, which ranges between 9 and 18 m height, in which trees with 15 m or more in height belonged to the *Myrcia splendens* (Sw.) DC. individuals, *Ocotea odorifera* (Vell.) Rohwer, *Ocotea nunesiana* (Vattimo-Gil) Baitello, *O. pulchella*, *Persea willdenovii* Kosterm., *Pouteria bullata* (S.Moore) Beahni, *Psychotria vellosiana* Benth., *Sloanea lasiocoma* K. Schum., and *Tachigali denudata* (Vogel) Oliveira-Filho. This description shows how important the presence of Lauraceae in the canopy is. The three species with the highest coverage dominance were *A. triplinervia*, *P. willdenovii* and *T. denudata*, totaling 32.8%. The highest trees are represented by individuals that reaches up to 18 m in height and included *O. odorifera*, *S. lasiocoma* and *T. denudata* individuals, while the highest DBH (89.1 cm) was measured in a *S. lasiocoma* individual (Table 2). The Shannon index was 3.05 nats.ind^{-1}. The climax species accounted for lesser of total VI than the secondary species (106.4 and 124.1, respectively), while pioneer species summed only 27.3.

The vegetation of altimetric zone C has four vertical strata: the lower one reaches up to 9 m height, gathering several sciophilous species that compete with sapling trees of the upper stratum, especially *Cyathea atrovirens* (Langsd. & Fisch.) Domin, *Guatteria australis* A. St.-Hil., *Mollinedia schottiana* (Spreng.) Perkins, *Mollinedia elegans* Tul., *P. suterella,* and *Syagrus hoehnei* Burret; the second stratum ranges between 9 to 18 m height and are mainly composed of *Aniba viridis* Mez, *Calyptranthes lucida* DC., *Guapira opposita* (Vell.) Reitz, *Inga sessilis* (Vell.) Mart. and *P. bullata* individuals; the third stratum ranging from 18 to 28 m height is composed of large *A. triplinervia*, *Aspidosperma australe* Müll. Arg., *Cabralea canjerana* (Vell.) Mart., *Copaifera trapezifolia* Hayne, *Cryptocarya aschersoniana* Mez, *Eugenia copacabanensis* Kiaersk., *Matayba intermedia* Radlk., *Nectandra oppositifolia* Nees, *O. catharinensis*, *Ocotea nectandrifolia* Mez, *O. odorifera*, *Schefflera angustissima* (Marchal) Frodin and *Posoqueria latifolia* (Rudge) Schult. individuals; the fourth and highest stratum (28 to 40 m height) is formed of emergent trees, such as *A. triplinervia*, *C. aschersoniana*, *C. trapezifolia*, *Marlierea reitzii* D. Legrand, *Myrcia undulata* O. Berg, *O. catharinensis,* and *O. nectandrifolia*. Three species showed the highest coverage dominance (*O. catharinensis*, *C. aschersoniana,* and *A. triplinervia*), totaling 54.6% of this parameter. The highest DBH (95.5 cm) was measured on a 40 m-height specimen of *O. catharinensis* (Table 2). When only canopy species were considered, *O. catharinensis* was also the most abundant in the sapling compartment with 560 ind.ha^{-1}. The Shannon index was 3.45 nats.ind^{-1}. The climax species accounted for 126.6 of the VI, while the secondary species and the pioneer species, summed 108.2 and 18.0 of VI, respectively.

In the altimetric zone D, vegetation has also four vertical strata: the first reaches up to 9 m in height and are mainly composed of species such as *C. atrovirens*, *C. delgadii*, *Endlicheria paniculata* (Spreng.) J.F. Macbr., *Euterpe edulis* Mart., and *Garcinia gardneriana* (Planch. & Triana) Zappi; the second stratum varies from 9 to 18 m height, and the major species are *Amaioua intermedia* Schult. & Schult.f., *G. opposita*, *Hirtella hebeclada* DC., *Mollinedia uleana* Perkins, and *P. vellosiana*; the third stratum ranging from 18 to 28 m height is similar to forest in zone C in species composition. *A. triplinervia*, *C. aschersoniana*, *E. copacabanensis*, *Heisteria silvianii* Schwacke, *M. intermedia*, *M. reitzii*, *N. oppositifolia*, *O. nectandrifolia*, *Protium kleinii* Cuatrec., *P. bullata,* and *Vitex polygama* Cham. are

the major species of this stratum; the last and higher stratum varies between 28 to 38 m in height and is formed of emergent trees such as *A. triplinervia*, *A. australe*, *C. aschersoniana*, *C. trapezifolia*, *O. catharinensis*, *P. kleinii,* and *Pterocarpus rohrii* Vahl. The three species with the highest coverage dominance were *O. catharinensis*, *A. triplinervia,* and *A. australe*, totaling 35.8% of this parameter. Two *O. catharinensis* trees must be distinguished, one with the highest DBH (83.4 cm) and other with the highest absolute height (38 m; Table 2). This species was also the most abundant canopy tree among the sapling species, totaling 320 ind.ha^{-1}. The Shannon index was 3.64 nats.ind^{-1}. Unlike the other areas, here human intervention was detected by the clandestine extraction of peach-palm *E. edulis*, which may explain the massive presence of individuals in the regeneration strata, and the absence of adults in the arboreal compartment. The climax species totaled 77.0 of the VI, while the secondary and the pioneer species 134.6 and 25.5, respectively.

It is worth mentioning that the average height of the trees tends to increase while the altitude decreases. In this altimetric zone, the mean height was 30% higher in zone B than in zone A, and 97% higher in zone C than in zone B. The same trend was observed for the mean DBH, which was 14% higher in zone B than in zone A, and 29% higher in zone C than in zone B. Finally, the basal area recorded for zone A (34.13 m².ha-1) represents a decrease of 71% in the same parameter when compared with zone C (58.35 m².ha-1) (Table 2).

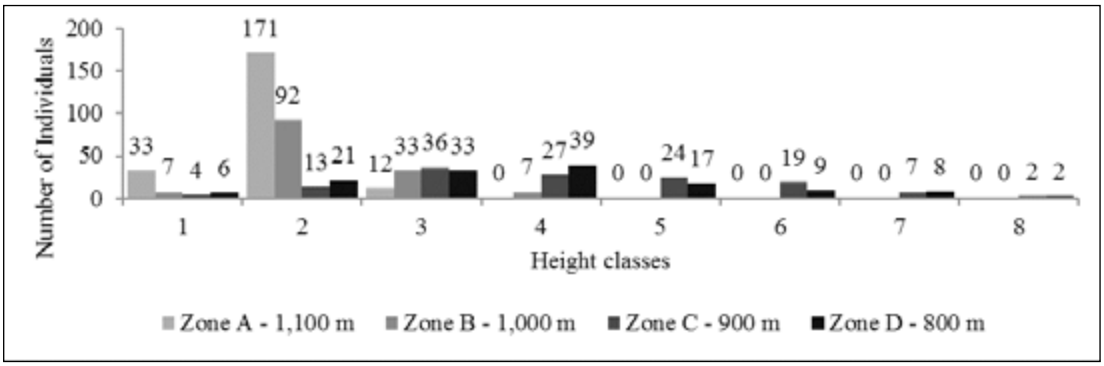

Figure 1. Distribution of the number of individuals per height class in the Montane Atlantic Rain Forest in the Lauráceas State Park, Paraná, in which 1: 1.5-5 m; 2: 5.1-10 m; 3: 10.1-15 m; 4: 15.1-20 m; 5: 20.1-25 m; 6: 25.1-30 m; 7: 30.1-35 m; and 8: 35.1-40 m.

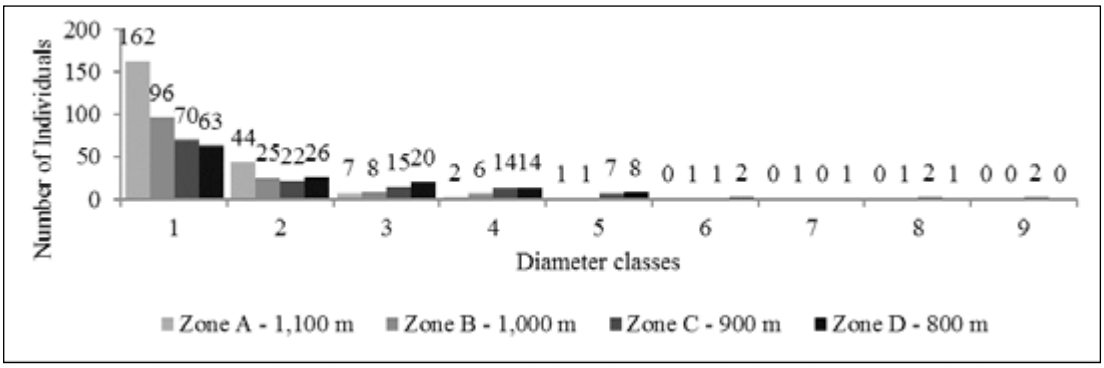

Figure 2. Distribution of the number of individuals per diameter class in the Montane Atlantic Rain Forest in the Lauráceas State Park, Paraná, in which 1: 10-20 cm; 2: 20.1-30 cm; 3: 30.1-40 cm; 4: 40.1-50 cm; 5: 50.1-60 cm; 6: 60.1-70 cm; 7: 70.1-80 cm; 8: 80.1-90 cm; and 9: 90.1-100 cm.

Table 3. Phytosociological parameters of the arboreal component (DBH ≥ 10 cm) of the Montane Atlantic Rain Forest of the Lauráceas State Park - summary of the families emphasizing the Lauraceae family species.

All families							
Zone A – 1,100 m	**VI**	**Zone B – 1000 m**	**VI**	**Zone C – 900 m**	**VI**	**Zone D – 800 m**	**VI**
Lauraceae	91.1	Lauraceae	81.4	Lauraceae	114.5	Lauraceae	71.2
Aquifoliaceae	42.5	Euphorbiaceae	50.5	Myrtaceae	40.0	Euphorbiaceae	27.0
Ochnaceae	28.0	Myrtaceae	26.6	Fabaceae	28.8	Myrtaceae	24.5
Symplocaceae	20.8	Fabaceae	23.5	Sapotaceae	13.7	Rubiaceae	19.3
Myrtaceae	18.4	Elaeocarpaceae	22.3	Rubiaceae	12.2	Apocynaceae	18.6
Theaceae	13.1	Rubiaceae	13.5	Meliaceae	10.7	Burseraceae	14.9
Annonaceae	12.5	Sapotaceae	10.8	Nyctaginaceae	9.5	Cyatheaceae	14.2
Euphorbiaceae	9.2	Cyatheaceae	10.3	Euphorbiaceae	9.5	Fabaceae	13.3
Cunoniaceae	8.6	Theaceae	10.1	Sapindaceae	8.8	Monimiaceae	13.3
Nyctaginaceae	7.2	Monimiaceae	6.7	Apocynaceae	6.7	Sapotaceae	9.5
14 other families	41.2	10 other families	39.1	10 other families	34.0	16 other families	61.0
Dead	7.5	Dead	5.2	Dead	11.5	Dead and undet.	13.2
Total	**300.0**	**Total**	**300.0**	**Total**	**300.0**	**Total**	**300.0**
Lauraceae family							
Zone A – 1,100 m	**VI**	**Zone B – 1000 m**	**VI**	**Zone C – 900 m**	**VI**	**Zone D – 800 m**	**VI**
Ocotea bicolor	26.1	*Persea willdenovii*	17.0	*Ocotea catharinensis*	48.6	*Ocotea catharinensis*	29.7
Ocotea porosa	18.8	*Ocotea odorifera*	16.0	*Cryptocarya aschersoniana*	28.0	*Cryptocarya aschersoniana*	13.9
Ocotea vaccinioides	18.1	*Ocotea bicolor*	14.8	*Ocotea nectandrifolia*	7.3	*Ocotea nectandrifolia*	4.3
Persea alba	10.4	*Ocotea nunesiana*	9.5	*Nectandra oppositifolia*	6.2	*Nectandra oppositifolia*	4.0
Ocotea pulchella	10.0	*Ocotea pulchella*	6.6	*Aniba viridis*	5.8	*Ocotea pulchella*	3.8
Aiouea acarodomatifera	4.7	*Cryptocarya aschersoniana*	4.7	*Ocotea odorifera*	5.1	*Ocotea bragai*	3.7
Nectandra puberula	1.5	*Ocotea silvestris*	4.0	*Rhodostemonodaphne macrocalyx*	3.9	*Beilschmiedia emarginata*	3.6
Persea major	1.5	*Ocotea nectandrifolia*	2.3	*Ocotea bicolor*	3.7	*Ocotea odorifera*	2.5
		Ocotea paranaensis	2.3	*Ocotea pulchella*	2.2	*Aniba viridis*	1.9
		Ocotea vaccinioides	2.1	*Ocotea indecora*	1.9	*Rhodostemonodaphne macrocalyx*	1.9
		Aiouea glaziovii	2.1	*Aiouea glaziovii*	1.9	*Ocotea indecora*	1.8
Total	**91.1**	**Total**	**81.4**	**Total**	**114.5**	**Total**	**71.2**

VI: value of importance (0-300).

The graphs of the hypsometric distribution (Figure 1) and of the diametric distribution (Figure 2) of the arboreal compartment also show a significant difference between the altimetric zones. The number of individuals sampled was greatest in altimetric zone A, and individuals are concentrated in classes of smaller diameter and height, while in zones C and D there are more individuals in the classes with greater diameter and height, but with a lower number of individuals. Contrarily, altimetric zone B seems to represent a transition zone between the first and the last area. Zones C and D have 130 trees per hectare with DBH > 40 cm, and almost half of them are Lauraceae.

The calculation of stem with bark volume in zones C and D showed *O. catharinensis* summed 92.70 $m^3.ha^{-1}$, which represents 25.5% of the total volume, followed by *C. aschersoniana* with 38.85 $m^3.ha^{-1}$ (10.7%), *A. triplinervia* with 34.06 $m^3.ha^{-1}$ (9.4%), *A. australe* with 20.21 $m^3.ha^{-1}$ (5.6%), and *C. trapezifolia* with 17.91 $m^3.ha^{-1}$ (4.9%). However, the two major Lauraceae species were more expressive in zone C, accounting for nearly half of the commercial volume (49.3%). In zone C, *O. catharinensis* accounts for 119.00 $m^3.ha^{-1}$ (33.5%) and *C. aschersoniana* for 55.87 $m^3.ha^{-1}$ (15.7%) (Table 1). The total volume values in zones A and B were significantly lower than in C and D, respectively, totaling 106.83 $m^3.ha^{-1}$ and 143.58 $m^3.ha^{-1}$ versus 354.93 $m^3.ha^{-1}$ and 373.28 $m^3.ha^{-1}$.

An alternation was observed in the main families' VI order according to altitude in the sapling compartment. In zone A, Myrtaceae (55.2), Lauraceae (47.6), and Ochnaceae (47.5) are the main families ordered according to VI values; in zone B, Lauraceae (76.8), Myrtaceae (39.8), and Melastomataceae (29.8); in zone C, Rubiaceae (63.3), Lauraceae (50.4), and Myrtaceae (47.6); and, finally, in zone D, Lauraceae (56.7), Arecaceae (51.2), and Myrtaceae (46.7).

The Montane ARF located between 800 and 1,100 m of altitude in the *PEL* have the following five families of major sociological importance: Lauraceae (VI = 89.6), Myrtaceae (27.4), Euphorbiaceae (24.0), Fabaceae (16.8), and Rubiaceae (12.6) in the arboreal compartment (Table 3); and Lauraceae (52.0), Myrtaceae (46.6), Monimiaceae (29.0), Rubiaceae (23.7), and Melastomataceae (22.4) in the regeneration compartment.

The richness of the forest community studied is close to the numbers already known for the Montane ARF in Paraná, which are 52 families, 101 genera, and 210 species (Scheer & Blum, 2011). The richness order of the first five families perfectly coincides with those cited by these authors. The families Fabaceae, Lauraceae, Myrtaceae, Melastomataceae, and Rubiaceae are recognized as the richest in the ARF of southern and southeastern Brazil, while the genera *Eugenia*, *Miconia, Myrcia,* and *Ocotea* are always cited as species-rich families (Oliveira-Filho & Fontes, 2000; Scheer & Blum, 2011; Vibrans et al., 2013).

An unusual fact is that Lauraceae surpassed the number of taxa of Myrtaceae. This was recorded only once among four sites surveyed in the Montane ARF in Paraná, in Serra da Baitaca (7 spp./5 spp.) (Roderjan, 1994). The others pointed to a greater species richness of Myrtaceae over Lauraceae, at Serra da Prata (40 spp./12 spp.) (Blum, 2006), at Mananciais da Serra (22/11) (Reginato & Goldenberg, 2007), and at Serra da Melança (19/8) (Lacerda, 1999). The same pattern occurs in South and Southeastern region of Brazil, where Myrtaceae richness is slightly less than twice the species number of Lauraceae in Montane ARF, such as in the municipalities of Alfredo Wagner, SC, (23/16) (Silva et al., 2013), Morro Grande, SC, (11/7) (Bosa et al., 2015), Cotia, SP, (56/32) (Catharino et al., 2006) and São Luiz do Paraitinga, SP, (57/33) (Padgurschi et al., 2011); or in a lower montane ARF such as in the municipalities of Blumenau, SC, (21/18) (Caglioni et al., 2015), Brusque, SC, (34/19) (Maçaneiro et al., 2015), Siderópolis, SC, (14/9) (Colonetti et al., 2009), Pariquera-Açu, SP, (40/19) (Ivanauskas, 1997) and Cachoeiras de Macacu, RJ (27/14) (Kurtz & Araújo, 2000). However, this pattern changes in most Submontane ARF areas in southeastern Brazil or in ecotone zones with Seasonal Forests, in which Fabaceae and Rubiaceae families increase their specific richness, surpassing Myrtaceae and/or Lauraceae (Borém & Oliveira-Filho, 2002; Carvalho et al., 2007; Leite & Rodrigues, 2008; Pinto Sobrinho et al., 2010; Campos et al., 2011; Gomes et al., 2011).

The predominance of Lauraceae and Myrtaceae is corroborated by studies in Montane ARF in Paraná, with a remarkably small VI sum amplitude (111–117.5) (Lacerda, 1999; Blum, 2006; Reginato & Goldenberg, 2007), except in the study by Roderjan (1994), who obtained a VI sum of 71.6 for the two families. This can be the result of a sampling range that covers areas with altitudinal range above that of the other studies, which results in addition of taxa typical of high altitude.

The forest structure in zone A resembles that of two other sites sampled in Serra do Mar in Paraná State. In Serra Gigante (1,000 m a.s.l.), less than a half of both communities' richness is shared, accumulating a VI of 216 (Scheer et al., 2011) versus 179 in the *PEL*. In turn, in Serra da Baitaca (1,135-1,250 m a.s.l.) the shared species represents only one-third of total species assembly, accumulating a VI of 106 (Roderjan, 1994) versus 103 in the *PEL*. Although the Serra Gigante site was considered a cloud forest (upper montane ARF), the authors observed the flora included species frequently found in montane forests, which could be related to the lower altitude of the site when compared with other cloud forest sites. The same trend was observed in zone A.

The forest in zone B resembled the sampled site at 1,000 m altitude in Serra da Prata (Blum, 2006), but the shared species assembly accumulate different importance values (VI = 68 in Serra da Prata, versus 148 in the *PEL*). Although the basal area of 55.53 $m^2.ha^{-1}$ at Serra da Prata has been higher, the canopy height (from 16 to 17 m), mean height (10.3 m) and average DBH (20.7 cm) reached values quite similar to those found in zone B.

In turn, zone C and D were similar to sites with the same altitude in Serra da Prata (Blum, 2006) with quite similar values of maximum DBH (96.5 cm) and basal area (54.75 $m^2.ha^{-1}$), while the maximum height (23 m), mean height (12.3 m), and average DBH (22.5 cm) values were lower than those determined for zones C and D.

In general, the results of *PEL* gradient was compatible with studies conducted in the same altimetric range in the state of Paraná.

Once comparing these results with the gradient studied by Blum (2006), and based on terms he suggested, one can define the vegetation located between 800 and 900 m in the *PEL* as a typical Montane ARF and that between 1,000–1,100 m as a short-stature Montane ARF; thus indicating that this structural tendency seems to be repeated in different areas of Serra do Mar mountain range in Paraná.

When the structural parameters are compared with those established by Brasil (1994a, 1994b), they firstly indicate that the vegetation in altimetric zones A and B could be a forest in middle stage of regeneration. In these zones, the number of strata, the canopy height, and the basal area agreed with the reference values, while the mean height showed lower value, and the mean diameter and the diametric distribution showed higher values. Diversely, evaluating the representation of species ecological groups using VI results, climax species remarkably prevail at 1,100 m of altitude (although the forest has only one stratum). Secondary species prevail at 1,000 m, with little difference for climax species.

The structural parameters suggests the forest succession stage in the zones C and D can be considered in advanced stage of succession, since some parameters such as the number of strata, the canopy height, the basal area, and the mean diameter fits quite well in those established in Brasil (1994a, 1994b). However, the mean height value was slightly lower, and the diametric distribution was slightly higher than the values proposed in Brasil (1994a, 1994b). In the Forest Floristic Inventory of Santa Catarina (*Inventário Florístico Florestal de Santa Catarina - IFFSC*), four sample units (of numbers 386, 421, 578 and 1,025) at an altitude similar to that of this study site were considered primary forests, therefore being in an advanced stage of succession with basal area ranging from 31.36 to 54.26 $m^2.ha^{-1}$ (Vibrans et al., 2013), values quite similar to those found for zones C and D.

According to Roderjan (1994), the structural and floristic changes in the forest varies in direct proportion to the thickness of the soils, which may explain the variation along the gradient studied, similar to that observed by Blum (2006). Moreover, considering that no register of human intervention in zones A and B is found, the best designation for these communities is an advanced successional stage conditioned by limiting environmental factors, which results in a smaller forest compared with zones C and D.

The forest community of the *PEL*, specifically between 800 and 900 m a.s.l., in several aspects, resembles those of ARF in the lower and middle parts of the Itajaí valley in Santa Catarina (Klein, 1980). The structural importance of Lauraceae is among the main similarities, given their great abundance and frequency, as well as the dominance of their canopies, representing 27% of all trees and 44% of the total canopy cover in the *PEL*. The major species in the upper stratum in both regions are *O. catharinensis*, *C. aschersoniana*, *A. triplinervia*,

A. australe, and *C. trapezifolia*, emphasizing that the first two species aggregated a VI of 60.1 in this study.

Another striking comparison concerns the description of forest slopes with deeper soil and soft undulating relief in the lower and middle parts of the Itajaí valley (Klein, 1980), a topographic description identical to that of forest in zone C. For Klein (1980), this topographic situation allows *O. catharinensis* to express its greatest vitality, often representing between one-third and one-half of wood volume per hectare, while canopy coverage often reaches 40% to 50%. The author also mentions that this species shows a very balanced vitality in almost all of the vast Itajaí valley, with young and adult individuals capable of maintaining high sociological values. Compared with another species in zone C, *O. catharinensis* had the highest values of density, dominance and frequency, which result in a VI of 48.6, nearly one-sixth of the total. It was also the most abundant canopy tree among the saplings. Its relative crown dominance was the highest (31.9%), and, although somewhat lower than that reported by Klein (1980), it was still relevant considering that it divided the total with 43 other species. Finally, its stem volume represented 33.5% among all species.

4. CONCLUSIONS

At lower altitudes, the community was classified as typical Montane Atlantic Rain Forest, where *Ocotea catharinensis* is the dominant species followed by *Cryptocarya aschersoniana*, which very well characterizes a typical Southern Brazilian *Ocotietum*. At higher altitudes, the community was classified as a short-stature Montane Atlantic Rain Forest, where *O. porosa* and *O. vaccinioides* have high importance.

Lauraceae is the main family in structural expression and species richness in the Montane Atlantic Rain Forest composition within the "Lauráceas" State Park, in both compartments adults and regeneration. A remarkable aspect is that the lauracean species richness surpassed those of Myrtaceae, somewhat rarely found in southern and southeastern Brazilian forests.

The Lauráceas State Park has remnants of Montane Atlantic Rain Forest in an advanced stage of succession. Its structure indicates that it probably has not undergone logging.

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