

The specific leaf area of forest species subjected to different degrees of shading did not differ when detached and full leaflets were compared

Folhas compostas de espécies florestais apresentam a mesma área foliar específica com folíolos destacados ou com folhas completas sob sombreamento

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Highlights:

Leaf area assessment methods produced similar results in forest species.
Total leaf area measurements in plants with compound leaves are representative.
A comparison leaf area analysis methods used to assess forest species was performed.

Abstract

Studies of forest species under different environmental conditions are essential for enhancing our understanding of plant-environment relationships. Different light conditions interfere with the production of seedlings within forests, and this interference can be verified by assessing leaf area. However, several species have leaf compound that often contain numerous leaflets, which makes the direct measurement of leaf area difficult. This leads researchers to question whether these types of leaves should be separated for analysis or measured whole. Thus, the aim of this study was to analyse specific leaf area in whole leaves and detached leaflets of six forest species subjected to different levels of shading. The forest species assessed all produced compound leaves and included *Schinus terebinthifolius* Raddi (aroeira), *Schinopsis brasiliensis* Engl. (braúna), *Dalbergia nigra* (Vell.) Fr. All. ex Benth. (jacaranda-da-bahia), *Chorisia speciosa* A. St.-Hil (paineira), *Caesalpinia peltophoroides* Benth (sibipiruna) and *Plathymenia reticulata* Benth (vinhático). Each species was subjected to six different degrees of shading: 0% (full sun); 20; 40; 60; 80 and 90%. Sombrite netting was used to shade plants. The analysis of the specific leaf area was performed using two different methods, which included the analysis of separate leaflets and whole leaves. To analyse leaflet area, 50 leaflets per plant were assessed three times, and six plants

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per treatment were assessed. To assess whole leaves, data were obtained from the whole leaves of six plants per treatment. This process was repeated for all aforementioned species. Data obtained from both analysis methods indicated that all species assessed were similarly affected by shade, and leaf area varied according to the level of shading. This similarity of data demonstrates that, for these species, it is not necessary to use complex methods to obtain specific leaf area measurements. Thus, determining specific leaf by measuring the entire leaf provides results that did not statistically differ from those obtained by measuring individual leaflets.

Key words: Atlantic forest. Compound leaf. Ecophysiology. Growth. Reforestation.

Resumo

Estudos com espécies florestais, em diferentes condições ambientais são essenciais para o entendimento da relação planta-ambiente. Diferentes condições de luminosidade podem interferir na produção de mudas florestais e o reflexo dessa interferência pode ser verificado pela análise da área foliar. No entanto, muitas espécies apresentam folhas compostas, sendo muitas vezes com inúmeros folíolos, o que dificulta as análises com mensuração direta da área foliar, proporcionando dúvidas durante a análise, se devem ser separados para análise ou mensurados com a folha inteira. Assim, o objetivo desse estudo foi analisar a área foliar específica em folhas inteiras e folíolos destacados de folhas compostas de seis espécies florestais submetidas à diferentes níveis de sombreamento. As espécies florestais utilizadas foram *Schinus terebinthifolius* Raddi (aroeira), *Schinopsis brasiliensis* Engl. (braúna), *Dalbergia nigra* (Vell.) Fr. All. ex Benth. (jacarandá-da-bahia), *Chorisia speciosa* A.St.-Hil (paineira), *Caesalpinia peltophoroides* Benth (sibipiruna) e *Plathymenia reticulata* Benth (vinhático), todas com folhas compostas. Cada espécie foi submetida a seis tratamentos de sombreamento: 0% (pleno sol); 20; 40; 60; 80 e 90%, com a utilização de “sombrites” para os tratamentos sombreados. A análise da área foliar específica foi realizada de duas maneiras: folíolos separados e folha inteira. Para a análise dos folíolos esses foram obtidos de três medidas (repetições) de 50 folíolos por planta, realizada em seis plantas por tratamento. Para a análise da folha inteira os dados foram obtidos de folhas inteiras de seis plantas por tratamento. Esse processo se repetiu em todas as espécies supramencionadas. Para todas as espécies, os dados indicaram um padrão de resposta semelhante em ambos os métodos de análise, variando de acordo com os níveis de sombreamento. Essa similaridade dos dados demonstra que, para essas espécies, não é necessário a utilização de métodos muito complexos para a obtenção da área foliar específica. Assim, a obtenção da área foliar específica utilizando a folha inteira fornece resultados estatisticamente iguais em relação àquela obtida utilizando somente folíolos.

Palavras-chave: Crescimento. Ecofisiologia. Folha Composta. Mata Atlântica. Reflorestamento.

Introduction

The Atlantic Forest is a natural resource with value that is derived from its chemical, biological and genetic potential (Oliveira et al., 2012; Meio Ambiente - Instituto de Química - Universidade Federal do Rio de Janeiro [Meioambiente/Iq/Ufrj], 2016). Exploitation of the forest has put flora and fauna at risk (Gris & Temponi, 2017), and fragmentation and habitat loss threaten the maintenance of biodiversity (Chazdon & Uriarte, 2016). Natural regeneration or reforestation is considered an efficient tool, which can be used to

stabilize or accelerate the recovery of dismantled areas (Ottermanns et al., 2011).

Studies of forest species from the Atlantic Forest biome that assess effects of different environmental conditions are important for the verification and monitoring growth of native species, enhancing production of quality seedlings, and generating fundamental information to regulate the forestry activity, which includes the implementation of conservation and reforestation programs (Monteiro & Ramos, 1997; Dutra, Graziotti, Santana, & Massad, 2012; Roweder, Nascimento, & Silva, 2015).

To enhance the sustainability and viability of forest species is important to improve the reproductive capacity of species. In this context, studying the effects of different types of shade is useful for cultivating forest species, especially within nurseries dedicated to seedling production. Lighting requirements and the conversion efficiency of absorbed light energy can be assessed by measuring available leaf area (Câmara & Endres, 2008; Permanhani, Vasconcellos, Souza, & Martelleto, 2014).

Studies that evaluate the leaf area in plants under different environmental conditions are essential for enhancing our understanding plant-environment relationships (Moraes, Santos, Zeizer, & Krupek, 2013). Several studies implemented methods to estimate leaf area (Gao, Van der Heijden, Eveleens, & Marcelis, 2012; Liang, Kirk, & Greene, 2018; Dong et al., 2019), and others have used empirical models that facilitate monitoring species growth (Wang, Jin, Shi, & Liu, 2019).

With regard to leaf area assessments are performed in the laboratory. However, the effectiveness of the methodology used to determine leaf area has been questioned. Concerns regarding the reliability of leaf area measurements are especially relevant when forest species with compound leaves containing leaflets are assessed, because researchers have not determined if measurements should be carried out using entire leaves, or if leaflets must be separated from leaves before measurements are performed.

Thus, the reliability of data obtained using both methods must be verified, and leaf area measurements using both whole leaves and leaflets of forest species should be compared. This assessment should determine whether leaf area measurements in plants with compound leaves are reliable regardless of whether detached leaflets or the entire leaves are assessed, which will have implications regarding the feasibility leaf area assessments. Thus, the aim of this study was to compare specific leaf area (SLA) determined for

six different forest species that were subjected to different levels of shading by performing leaf area measurements of both whole and detached leaflets of compound leaves.

Material and Methods

The experiment was carried out in the experimental area “Terrace” of Embrapa Agrobiologia, Brazilian Agricultural Research Corporation, in Seropédica city (22°45'18.33"S; 43°39'58.37"W; 28 m elevation), in the State of Rio de Janeiro. Six native forest species (Atlantic Forest) including *Schinus terebinthifolius* Raddi (aroeira), *Schinopsis brasiliensis* Engl. (braúna), *Dalbergia nigra* (Vell.) Fr. All. ex Benth. (jacaranda-da-bahia), *Chorisia speciosa* A.St.-Hil (paineira), *Caesalpinia peltophoroides* Benth (sibipiruna) and *Plathymenia reticulata* Benth (vinhático) were cultivated in greenhouses and subjected to different levels of shading. The experimental design was fully randomized and six replicates were assessed.

Seed sowing was performed using a seedbed composed of washed sand substrate, and 500 seeds per species were sown. After germination, when seedlings reached a height of 10 cm, seedlings were transplanted into 25 × 20 cm plastic bags 25 × 20 cm that contained a 1:1:1 ratio of clay soil, washed sand and tanned bovine manure substrate.

The greenhouses were 2.5 × 6 × 10 m wooden structures that were covered using black mesh screens to generate the following levels of shading: 20, 40, 60, 80 and 90%. Growth under full sunlight (control) was also assessed. Air temperature, photosynthetically active radiation (PAR) and relative humidity data were obtained via automatic WatchDog 2550 weather stations (Spectrum Weather), which were installed in each environment. Each shade level was measured with using a Model LP PAR 80 ceptomètre (AccuPAR). All six species were grown together in greenhouses, and were subjected to specific levels of shading or full sunlight.

Three hundred five days post-sowing, six plants of each species were harvested per treatment. Leaves of sampled plants of each species were measured using two different methods (whole compound leaves and detached leaflets). Direct measurements were performed using a LI-3100C Area Meter instrument (LICOR, Inc). In addition, leaf dry matter mass was obtained after leaves were dried in an oven until a constant mass was determined (~72 hrs at $65^{\circ}\text{C} \pm 5$) using a precision analytical balance.

To determine detached leaflet area, three measurements (repetitions) of 50 leaflets per plant (collected randomly from each plant) were performed on six plants per treatment. The total leaf area measurements determined for 50 leaflets was divided by 50 to generate mean leaflet area, which was divided by average leaflet dry matter mass. Entire leaf area was determined by measuring the leaf area of six plants per treatment.

SLA was obtained by dividing the leaf area by the leaf dry matter mass. The data were submitted to analysis of variance (5% significance), and adjusted via regression analysis (5%) of shading levels for all species. Differences in SLA were assessed using the Tukey test (5%) and Assistat software (7.6 beta).

Results and Discussion

SLAs of whole and detached leaflets were the same for all forest species analyzed, and leaf size varied only according to shading level. We recommended using entire compound leaves to perform measurements without detaching leaflets, since no statistical difference between the two forms were observed when measurements were performed direct measurement reading mode. Throughout the experiment, photosynthetically active radiation decreased as shading levels increased. Further, relative humidity, air temperature, dew point temperature and precipitation levels did not vary in greenhouses providing different levels of shade, and species were cultivated under appropriate conditions (data not shown).

The results of the analysis of *Schinus terebinthifolius* (aroeira) are shown in Figure 1A. Data revealed that even when plants were subjected to 60% shade, leaves grew normally and specific area remained unaffected. The shading levels of 80 and 90% resulted in increased SLA, and new and expanded leaflets were produced. These findings indicated that very high levels of shading affected the growth of the species. According to Scalon, Sacalon and Masetto (2012), luminosity can greatly influence the leaf area and leaf development. In the study, researchers determined that leaf growth of aroeira seedlings was greatest when subjected to 0% of shading (full sunlight). In accordance with results of this study, Leite (2002) reported that aroeira seedlings are sensitive to high levels of light and recommended that the species should be planted under shady conditions.

The SLA of whole leaves increased $78.37 \text{ cm}^2\text{g}^{-1}$ when plants were subjected to increased levels of shading (60% to 90% shade). However, when analyzing increases in SLA in plants exposed to 0% and 60% shade, just a $70.29 \text{ cm}^2\text{g}^{-1}$ increase observed. When new leaflets, expanded leaflets and whole leaves were assessed separately, the SLAs of leaves subjected 90% shading relative to full sunlight increased 222.13; 263.18 and 248.66 cm^2g^{-1} , respectively, which corresponded to 41, 30 and 32% increases, respectively. When values determined using whole leaves and leaflets were compared, no statistical differences were observed for any level of shading (data not shown).

Since no difference between whole leaves and leaflets of aroeira were observed, an analysis SLA differences observed when plants were subjected to different levels of shading was performed. This analysis revealed that shading influenced SLA, and findings are included in Table 1. For aroeira, results showed that levels of shading between 20 and 40% did not affect SLA. Aroeira are pioneer species, therefore, they are expected to tolerate full sunlight treatment (Azevedo, Quirino, & Bruno, 2015). Accordingly, plants subjected to 90% shade

produced leaves with the greatest SLA values. According to Klich (2000), in areas exposed to increased levels of light, species tend to have

small leaves to reduce potential negative effects of elevated transpiration rates and high ambient temperatures.

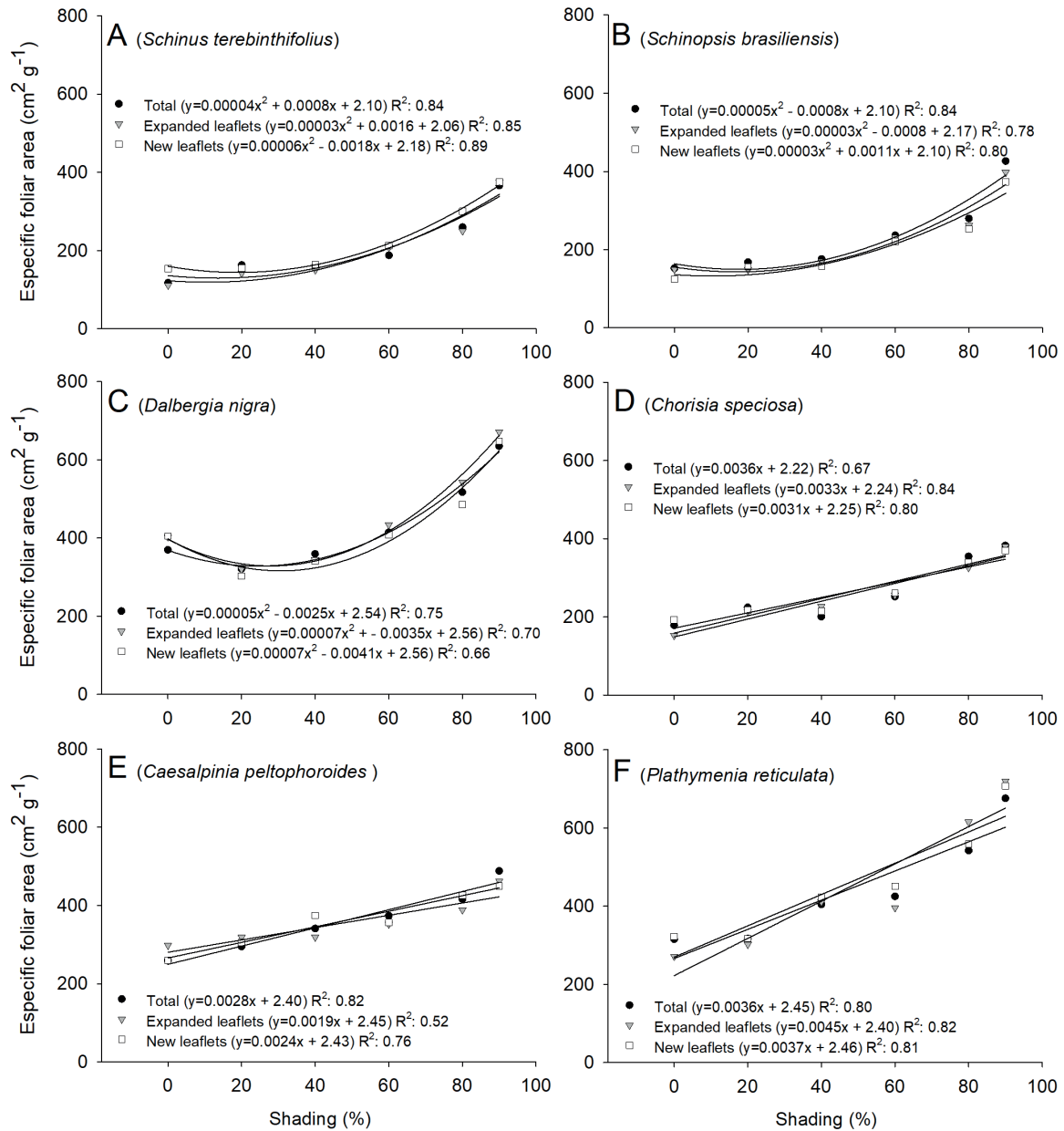


Figure 1. Specific Leaf Area of six forest species subjected to different shading levels (0; 20; 40; 60; 80 and 90%). Aroeira: *Schinus terebinthifolius* Raddi (A); braúna: *Schinopsis brasiliensis* Engl. (B); jacaranda-da-bahia: *Dalbergia nigra* (Vell.) Fr. All. ex Benth. (C); paineira: *Chorisia speciosa* A.St.-Hil (D); sibipiruna: *Caesalpinia peltophoroides* Benth (E); wine: *Plathymenia reticulata* Benth (F). The data (symbols) represents the mean adjusted via regression analysis (5%) of shading levels for all species.

The results determined from the assessment of *Schinopsis brasiliensis* Engl. (braúna) leaf growth are represented in Figure 1B. Data revealed that exposure to 0-40% shading resulted in similar SLA values, and increased SLA was observed in plants subjected 60, 80 and 90% shade. In plants subjected to 90% shading, leaf area reached 373.66 cm² g⁻¹ for new leaflets, 397.81 cm² g⁻¹ for expanded leaflets and 426.51 cm² g⁻¹ for whole leaves. In plants subjected to full sunlight, the leaf area was

determined to be 124.71, 149.86 and 152.35 cm² g⁻¹ for new leaflets, expanded leaflets, and whole leaves, respectively. Thus, an SLA increase of 33, 38 and 36%, respectively, was observed. Plants exposed to 90% shading were determined to have the greatest SLA regardless of whether whole leaves, or new or expanded leaflets were measured. Further, differences between areas of expanded and new leaflets relative to that of whole leaves were not significant (data not shown).

Table 1
Averages of the specific leaf area (SLA) of six forest species subjected to different levels of shading

SLA species	Shading levels					
	0%	20%	40%	60%	80%	90%
<i>Schinus terebinthifolius</i>	127.40 d	153.43 d	158.49 d	202.87 c	270.08 b	372.06 a
<i>Schinopsis brasiliensis</i>	142.30 c	153.84 c	168.39 c	229.72 b	264.99 b	399.32 a
<i>Dalbergia nigra</i>	392.54 cd	314.87 e	348.50 de	418.88 c	515.47 b	651.43 a
<i>Chorisia speciosa</i>	185.15 e	217.94 d	213.86 d	256.03 c	340.17 b	377.39 a
<i>Caesalpinia peltophoroides</i>	272.13 b	306.16 a	344.61 b	360.67 b	410.40 c	466.83 c
<i>Plathymenia reticulata</i>	303.04 d	312.03 d	412.45 c	423.87 c	572.06 b	700.97 a

* The means followed by the same letter on the line do not differ statistically from each other by the Tukey test at the 5% probability level. CV%: (*S. terebinthifolius*: 15.83; *S. brasiliensis*: 17.84; *D. nigra*: 13.63; *C. speciosa*: 10.79; *C. peltophoroides*: 11.17; *P. reticulata*: 11.76).

The SLA of aroeira and braúna exposed to different levels of shading were compared. Data revealed that SLA values determined for both aroeira and braúna, which are both members of the Anacardiaceae family, were very similar (Table 1), and indicated that both plants similarly responded to light. *Dalbergia nigra* (Vell.) Fr. All. ex Benth. (jacarandá-da-bahia) leaf growth is shown in Figure 1C. SLAs determined using whole leaves of plants subjected to shading levels of 0% (full sunlight), 20, 40, 60, 80 and 90%, were 369.78, 321.18, 359.39, 414.10, 517.25 and 635.10 cm² g⁻¹, respectively. Similar trends in which values increased linearly from 20 to 90% shading in were also observed when the SLAs of new and expanded leaflets were determined.

The SLA of the jacaranda-da-bahia increased concomitantly as shading levels increased, which indicated that the plant is very well adapted to high levels of shading. This is a typical characteristic of late secondary species (Pacheco, Pereira, Silva, & Alvarenga, 2013). This finding, which was not observed in either aroeira or braúna species, should be taken into account when jacaranda-da-bahia is used for reforestation. When observed the initial shading, these were not as representative for the jacaranda-da-bahia, as they remained with an area inferior to the treatment in full sunlight. The SLA determined for whole leaves of plants exposed to 20% shade was 321.18 cm² g⁻¹, while that of plants exposed to 90% shade was 635.10 cm² g⁻¹. Thus, an SLA increase of approximately 51% was observed

in leaves exposed to 90 vs. 20% shade. These results confirm that jacarandá-da-bahia species should not be one of the first introduced to regenerate forests. The species is classified as late secondary, since it tolerates little to medium levels of shade (Carvalho, 1994).

Average SLA values determined for jacaranda-da-bahia did not statistically vary when entire leaves and leaflets were used to generate data (data not shown). However, statistical differences were observed when mean SLAs of plants exposed to varied levels of shading were compared (Table 1). Rêgo and Possamai (2003) observed that jacaranda-da-bahia seedlings exposed to a moderate degree shading (44% and 64%) had larger leaves. These findings were not observed in this study, since the largest mean leaf area occurred in plants subjected to 90% shade. The authors also emphasized that planting in the field should be carried out in slightly shaded areas, in order to maintain seedling stem quality and maximize growth.

SLA of *Chorisia speciosa* A.St.-Hil (paineira) species are shown in Figure 1D. Findings indicated that SLA increased as level of shading increased. The only exception to this trend was observed in plants exposed to 40% shade. These plants had slightly lower leaflet and whole leaf SLA values than those which were determined for plants exposed to 20% shade. Leaf areas of whole leaves, expanded leaflets and emerging leaflets of plants exposed increasing levels of shading increased 203.77, 288.47 and 176.83 cm² g⁻¹, which represented 46, 40 and 52% increases, respectively.

Like findings previously described, the leaf areas of paineira species did not statistically differ when values determined using whole leaves and leaflets were compared. However, leaf area did differ when levels of shading were compared (data not shown). In Table 1, the relationship between average SLA and shading level is shown. SLA values determined for plants exposed to 60 and 80% did not differ, and neither did values determined for plants exposed to 20 and 40% shade. However, exposure

to 90% shade increased leaf area in the species in a manner similar to that which was observed for other species described. According to Campos and Uchida (2002), low light intensity is associated with increased SLA. This allows plants to maximize the collection of minimally available light and, thus, to enhance physiological functioning and survival.

Assessment of the SLA of *Caesalpinia peltophoroides* Benth (sibipiruna) revealed trends that were similar to those observed for paineira species. However, for plants were exposed to 40% shade, an increase in the SLA of new leaflets relative to those exposed to 60% shade was observed (Figure 1E). The increase of SLA for whole leaves, expanded leaflets and new leaflets that occurred in plants exposed to 90% shade relative to full sunlight was 229.29, 163.99 and 190.82 cm² g⁻¹, respectively, which corresponded to increases of 53, 64 and 58%, respectively. As shown in Table 1, SLA values determined for plant leaves exposed to different levels of shade statistically differed, and differences were most distinct when leaves exposed to 90% shade were compared to those exposed to unobstructed sunlight.

Results determined from the assessment of the leaf area of *Plathymenia reticulata* Benth (vinhático), are shown in Figure 1F. Relative to leaflets exposed to unobstructed sunlight, those exposed to 20% shade displayed slightly reduced SLA. Similarly, expanded leaflets exposed to 60% shade, relative to 40% shade, displayed a slight reduction in mean SLA. Trends observed for the species were similar to those of other species assessed.

The SLAs of whole leaves, expanded leaflets and new leaflets of vinhático exposed to 90% shading differed from those exposed to unobstructed sunlight by 360.04, 448.33 and 384.89 cm².g⁻¹, respectively. This represented a 47, 38 and 45% change in area, respectively. A comparison of SLA values determined for whole leaves and leaflets exposed to the same levels of shade revealed that values did not significantly differ (data not shown). However, when analyzing differences between the SLAs of

leaves exposed to different levels of shade, values were statistically distinct (Table 1). SLA values determined for plants exposed to 40 and 60% shade did not differ. SLA values determined for vinhático exposed to unobstructed sunlight and 20% shading also did not differ, which indicated that these differences in sun exposure do not influence SLA.

The data presented in Table 2 describe findings determined for all species exposed to each level of shading. The assessment was performed since there was no difference observed between measurements of the whole leaf and leaflets of species. In this analysis, the pioneer species aroeira and braúna,

which belong to the same family, stood out. Findings of each species were similar, and no statistical differences among species were observed. When jacarandá-da-bahia, sibipiruna and vinhático were exposed to 20% shade, similar SLA values were produced. However, when the species were exposed to different degrees of shading, SLA values did differ. In fact, only jacarandá and sibipiruna had the same SLA values when plants were exposed to 40% shade, and only vinhático and jacarandá had the same SLA values when plants were exposed to 60% shade. When plants were exposed to 90% shade, the SLA of paineira was similar to those of braúna and aroeira.

Table 2
Averages of the specific leaf area (SLA) of the six forest species in relation to the different levels of shading

SLA species	Shading levels					
	0%	20%	40%	60%	80%	90%
<i>Schinus terebinthifolius</i>	127.40 d	153.43 c	158.49 d	202.87 d	270.08 e	372.06 d
<i>Schinopsis brasiliensis</i>	142.30 cd	157.76 c	168.39 d	229.72 cd	264.99 e	399.32 d
<i>Dalbergia nigra</i>	392.54 a	314.84 a	348.50 b	418.88 a	515.47 b	651.43 b
<i>Chorisia speciosa</i>	185.15 c	217.94 b	213.86 c	256.03 c	340.17 d	377.34 d
<i>Caesalpinia peltophoroides</i>	272.13 e	306.16 de	344.61 cd	360.67 c	410.40 b	466.83 a
<i>Plathymenia reticulata</i>	303.04 b	312.03 a	412.45 a	423.87 a	572.06 a	700.97 a
CV%	23.79	12.12	15.16	12.04	12.75	8.73

* The means followed by the same letter in the column do not differ statistically from each other by the Tukey test at the level of 5% probability.

Data within Table 3 revealed that as degree of shading increased, SLA tended to increase, as expected. However, despite the fact that they are heliophilous, some species such as aroeira and braúna, did not have SLA values that significantly increased as degree of shading increased, relative to other species (Table 4). This may have been a result of insufficient light resources. Greenhouse conditions at each level of shading were, however, the same for all species, as shown in Table 4. This finding is in accordance with work performed by Ortega, Almeida, Maia and Angelo (2006). The authors reported *Psidium cattleianum*, which is also

a heliophile, did not display significantly increased leaf area as a result of increased degree of shading.

The data shown in Table 3 demonstrate that in unobscured sunlight and when plants were subjected to 20% shade, no differences between species were observed. Additionally, data revealed that SLA values determined for jacarandá-da-bahia and vinhático did not differ; and neither did SLA values of aroeira and braúna. Data presented in Table 4 showed that leaf area was significantly affected by increasing the degree of shading, and that exposure to 90% shade, for most forest species, resulted in the greatest SLA values.

Table 3
Comparison of the specific leaf area (SLA) of all forest species in each shading treatment

	Shading levels					
	0%	20%	40%	60%	80%	90%
SLA	237.09 e	243.70 e	274.38 d	315.34 c	395.53 b	494.66 a

* The means followed by the same letter on the line do not differ statistically from each other by the Tukey test at the 5% probability level. CV%-a = 11.59.

Table 4
Comparison of the specific leaf area (SLA) of all shading in each forest species

	Forest species					
	aroeira	braúna	jacarandá	paineira	sibipiruna	vinhático
SLA	214.05 d	227.08 d	440.28 a	265.08 c	360.14 b	454.07 a

* The means followed by the same letter on the line do not differ statistically from each other by the Tukey test at the level of 5% probability. CV%-b = 13.82.

It is worth mentioning that light is not the only environmental factor capable of influencing leaf characteristics, since temperature, soil characteristics and water availability have also been shown to affect leaf area (Boeger et al., 2006). SLA relates is a measure of the leaf surface relative to its own weight, meaning that it represents area per gram of leaf tissue, and indicates the way in which leaf biomass per unit leaf area is allocated (Grisi et al., 2011). Analyses presented here demonstrated that there was no difference between values produced using either whole leaves or isolated leaflets. Studies with other species with and without compound leaves, should be carried to ensure the reliability of each type of SLA measurement method.

Conclusion

Leaves of *Schinus terebinthifolius* Raddi (aroeira), *Schinopsis brasiliensis* Engl. (braúna), *Dalbergia nigra* (Vell.) Fr. All. ex Benth. (jacarandá-bahia), *Chorisia speciosa* A. St.-Hil (paineira), *Caesalpinia peltophoroides* Benth (sibipiruna) and *Plathymenia reticulata* Benth (vinhático) that were measured using both whole leaf and individual

leaflets produced nearly identical SLA values. Further, SLA varied according to shading level. These results indicate that for these forest species the entire leaf may be used to generate leaf area measurements, and it is not necessary to measure SLA using detached leaflets, which enhances the speed and practicality of performing analyses.

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