

Size, Ecology, and Seasonality Affect the Monthly Diametric Growth of Trees in a Secondary Forest

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Abstract

This work aimed to evaluate the monthly growth rate of 100 trees spread in different diametric classes and ecological groups of a secondary forest in the municipality of Igarapé-Açu, Pará, Brazil. These were selected randomly from 30 permanent plots and classified into 5 diametrical classes and separated into two ecological groups: Pioneers and Non-Pioneers. The monthly periodic increment (MPI) in diameter was measured for 11 months by means of diametric bands using digital calipers. The MPI means were evaluated by an analysis of variance (ANOVA) and Tukey's mean comparison test. Individuals from both ecological groups had similar increments in the DBH IV diameter class and different in the others. There were mean increments in the diametric classes that did not differ within the ecological groups. The trees analyzed differed in the diametric growth rate according to the diametric classes, ecological groups and the month of analysis.

Keywords: Increment, Dendrometric bands, Amazon rainforest.

1. INTRODUCTION

The secondary forests of northeast Pará in Brazil emerge after the replacement of the original forest with new vegetation which, in large part, is the result of anthropic changes in the natural environment. These have a high capacity to regenerate and occupy 4,358 km² in the Pará mesoregion (Cordeiro et al., 2017). In the Amazonian scenario, most of the secondary vegetation growth occurs due to the replacement of natural forest with fallow areas of the cutting and burning agricultural system, degraded pastures that have been abandoned or semi-perennial and perennial agricultural crops that favor the appearance of “*capoeiras*” (Pereira & Vieira, 2001). In northeastern Pará, the appearance of secondary forests is related to the historical occupation of soils that were suitable for agricultural activities, which provided a favorable environment for their regeneration (Ferreira, 2008). Before the ecological stability of a secondary forest is reached, environmental communities undergo changes in their physiological, structural, and floristic characteristics, a process called forest succession or dynamics (Odum, 1976). The forest dynamics are understood by the population balance and the increase in the size of arboreal

individuals, which is revealed by growth rates, mortality, and recruitment (Rocha, 2001). These components of forest dynamics allow the development of vegetation to be assessed and may reveal the successional stage of the forest as a function of past use history and current disturbances.

In forest dynamics, the growth of a tree can be defined as a change in the magnitude of any measurable characteristic of the individual (Encinas et al., 2005). While the primary meristem is responsible for tree height growth, the diameter growth is a consequence of secondary meristem activity or cambium (Kershaw et al., 2016). The primary and secondary growth of trees are influenced by the characteristics of the species interacting with the environment and are influenced by several limiting factors. Climatic factors such as temperature, air humidity, and luminous intensity and pedological factors such as soil fertility and structure, as well as their changes, are important elements for the growth process (Encinas et al., 2005; Kershaw et al., 2016).

Among the important measurable variables for tree growth such as height, volume, biomass, and basal area, diameter is the most accessible (Silva & Neto, 1979; Vanclay, 1994; Prodan et al., 1997). Diameter is a decisive variable for determining the

volume, therefore, to describe the natural forest dynamics, information about the increment in diameter is essential (Loetsch et al., 1973; Enright & Ogden, 1979 *apud* Filho et al., 2003). According to Scolforo (1998), growth data can be obtained by periodically collecting the diameter of the tree over a given period. The growth of an individual tree in between successive periods is called an increment (Encinas et al., 2005). Schöngart (2008) and Leoni et al. (2011) suggest that information about this variable is important to obtain the growth rate of species and to appropriately manage them.

For both planted and native forests, tree and stand growth is obtained through permanent plots measurements and remeasurements (Encinas et al., 2005). Another method of monitoring the growth of individual trees in tropical forests is through the use of dendrometric bands, both for isolated trees or forest stands (Silva et al., 2003). Some studies by Bower & Blocker (1966, *apud* Almeida, 2008) on the accuracy of diametric increment measurements using dendrometric bands have shown reliable results for measurements over short periods. The studies also indicated that the bands should be installed one year prior to the period in which the measurements are to be taken, as they tend to underestimate diametric growth in the first year of assessment. However, this underestimation applies mainly in regions with well-defined annual seasons (Keeland & Sharitz, 1993), as opposed to tropical regions such as the Amazon.

Dendrometric bands are easy to build low-cost instruments that are also accurate in measuring small variations in tree size and are therefore recommended for studies that require measurements over short periods. Among the advantages of using dendrometric bands are ease of installation and reading, low cost, and that they do not cause any damage to the tree stem (Keeland & Sharitz, 1993). In this context, growth monitoring is critical to understand the growth dynamics of secondary forests and the use of dendrometer bands can enable obtaining responses over short periods. This paper sought to investigate the growth rate of species in different diametric classes, ecological groups, and period of the year in a secondary forest in northeastern Pará.

2. MATERIAL AND METHODS

The study was conducted on a 44-hectare patch of secondary forest located at the Experimental Farm of Igarapé Açu (Feiga) belonging to the Federal Rural University of the Amazon (Ufra) in the municipality of Igarapé-Açu, Pará (Figure 1). The study area is located in the northeastern region of Pará, in the *Bragantina* micro-region whose landscape is characterized by second-growth forests in different degrees of vegetal succession originated by socioeconomic anthropic actions (Vieira et al., 2007).



Figure 1. Location map of the secondary forest fragment located at the Experimental Farm of Igarapé Açu of Ufra, in the municipality of Igarapé Açu, Pará, Brazil.

Average minimum and maximum temperatures in the region range from 21°C to 32°C (Pacheco et al., 2007). According to Köppen, the climate of the site is of type Am (Alvares et al., 2013). The annual rainfall varies from 1,750 mm to

2,500 mm (Andrade et al., 2017), with the highest averages from February to April and the lowest from September to November. The climate variability behaved slightly different during the period of this work as presented in the Figure 2.

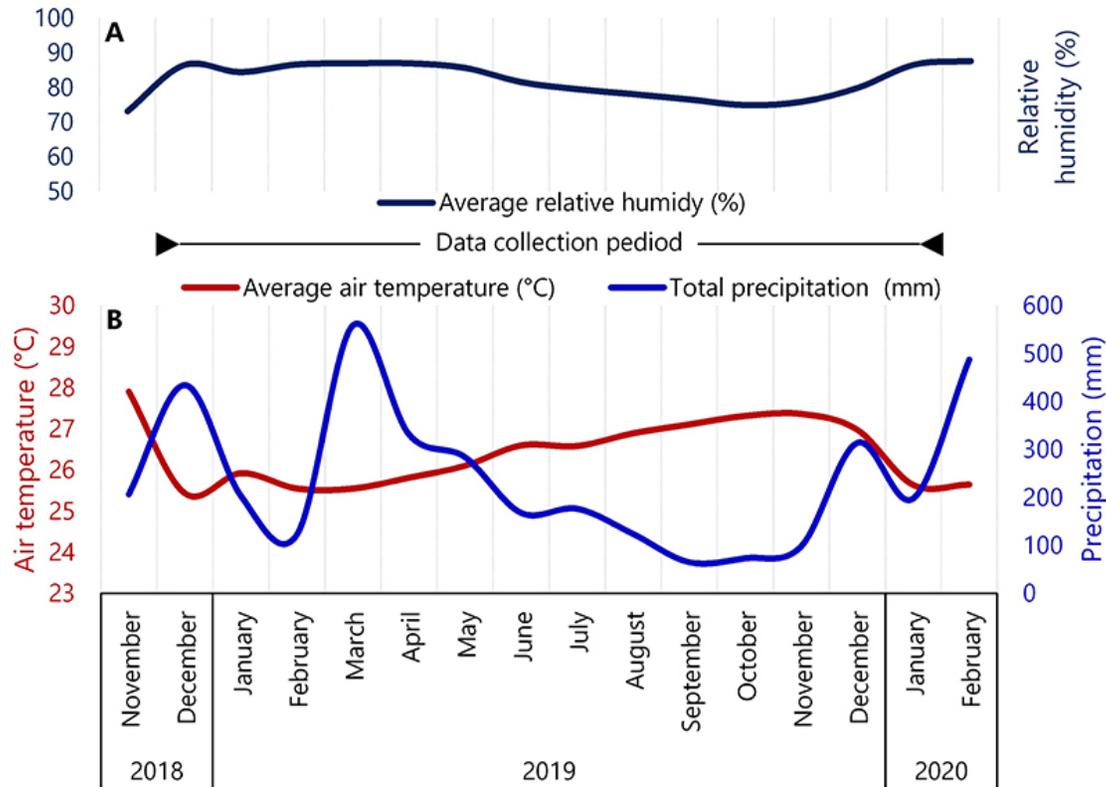


Figure 2. Study area weather variability during the data mensuration period. Monthly average for relative humidity (A). Monthly averages for air temperature and precipitation (B). The weather data are available on the website of the National Institute of Weather – INMET and were obtained by an automatic weather station located at Castanhal-PA, which is the nearest station to the study area (approx. 30 km away).

Thirty permanent plots (20 m × 50 m) were systematically distributed in the forest under analysis. In these plots, all trees with diameter to breast height (DBH) ≥ 10 cm were listed, measured, identified, and georeferenced. Subsequently, 100 trees distributed across different diametric classes were randomly selected for installation of the dendrometric bands. All species were identified by a parobotanist in the field, and by exsiccates collected and subsequent visits to the herbaria of Amazon Rural Federal University (Ufra) and the Brazilian Agricultural Research Corporation – Embrapa Eastern Amazon. The species were identified according to the APG-IV classification.

To make the diametric bands, stainless steel bands and springs were used and assembled according to the instructions by Higuchi & Higuchi (2012), in which: i) the metal band must have the size of the circumference of the target tree, with 13 cm added; ii) one hole is made at the beginning and another hole is made at a distance of 27 cm along the band;

iii) to fit the spring, a 7 cm opening is made in the band at a distance of 7 cm from the first end. After following these steps, the bands were installed on the trees preferably 10 cm above the height of the DBH, when it was not possible to install them on the portion of the tree stem that had no defect or imperfections that could affect the measurement of the diametric increment. The measurements were taken between December 2018 and January 2020, because of the necessity of the dendrometric band adaptation on tree stem there were no measurements in the months of January, February and April 2019. In the following months, the variation in growth in circumference of the individuals was measured according to the variation of the band opening in millimeters using a digital caliper with an accuracy of 0.01 mm. Thus, the DBH growth of the 100 selected trees was obtained by transforming the increment in circumference into diameter (Figure 3). The trees were separated into 5 diameter classes with a range of 10 centimeters each.



Figure 3. Procedure for collecting data on the increment in circumference (a) by measuring the opening of a dendrometric band (b) with the use of a digital calipers at the Experimental Farm of Igarapé Açu of Ufra, in the city of Igarapé Açu, Pará, Brazil.

The trees selected and measured using dendrometric bands were identified as belonging to 49 species and were distributed in 5 diametric classes with a range of 10 centimeters of DBH each, except the last one, which had no upper limit of DBH. The monthly periodic increment (MPI) was calculated using the equation 1:

$$MPI_{ij} = \left(\frac{DBH_{ij} - DBH_{ij-1}}{p_{ij}} \right) \times 30$$

Equation 1. Equation to calculate the monthly periodic increment means

Where, is the Monthly Periodic Increment of the i^{th} tree in month j (cm/month); is the DBH of the i^{th} tree at time j (cm); is the DBH of the i^{th} tree in time (cm); p is the time between the two circumference measurements (days). To transform the data into a monthly basis, the results were multiplied by 30, since there were no measurements in the months of January, February, and April of 2019, and in addition, the measurements occurred once a month with a margin of 3 days more or less between them. Their classification into ecological groups (Table 1) was based on authors who mostly followed the methodology of Swaine & Whitmore (1988), which classifies species into ecological groups of Pioneers (P) and Non-Pioneers (NP).

Table 1. Classification of the trees into ecological groups of the species and diametric distribution of all the trees selected for the installation of diametric band at the Experimental Farm of Igarapé Açu of Ufra, in the city of Igarapé Açu, Pará, Brazil.

BF	SCIENTIFIC NAME	EG	RA	DIAMETRIC CLASSES				
				I	II	III	IV	V
Anacardiaceae	<i>Tapirira guianensis</i> Aubl.	P	vi	3	6	1	1	-
Annonaceae	<i>Duguetia marcgraviana</i> Mart.	NP	ii	4	-	-	-	-
	<i>Guatteria poeppigiana</i> Mart.	P	ii	2	-	-	-	-
Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	P	ii	-	2	-	-	1
Bignoniaceae	<i>Jacaranda copaia</i> (Aubl.) D. Don.	P	x	-	1	-	-	-
Boraginaceae	<i>Cordia bicolor</i> A. DC.	NP	xi	1	-	-	-	-
Calophyllaceae	<i>Caraipa densifolia</i> Mart.	NP	ii	-	1	-	-	-
Clusiaceae	<i>Symphonia globulifera</i> L.f.	NP	x	1	-	2	-	-
Elaeocarpaceae	<i>Sloanea grandiflora</i> Sm.	NP	ii	1	-	-	-	-
Euphorbiaceae	<i>Hevea brasiliensis</i> (Willd. ex A.Juss.) Müll.Arg.	NP	x	2	2	1	-	-
	<i>Margaritaria nobilis</i> L. F.	P	iii	1	1	-	-	-

Continues...

Table 1. Continued...

BF	SCIENTIFIC NAME	EG	RA	DIAMETRIC CLASSES				
				I	II	III	IV	V
Fabaceae	<i>Abarema jupunba</i> (Willd.) Britton & Killip	NP	ii	1	-	-	-	1
	<i>Amphidon effusus</i> Huber	NP	x	1	-	-	-	-
	<i>Bowdichia virgilioides</i> Kunth	P	iii	1	1	-	-	-
	<i>Enterolobium timbouva</i> Mart.	NP	xii	2	-	-	-	-
	<i>Inga cinnamomea</i> Spruce ex Benth.	P	ii	1	-	-	-	-
	<i>Inga edulis</i> Mart.	NP	ii	1	-	-	-	-
	<i>Inga rubiginosa</i> (Rich.) DC.	NP	ii	1	1	-	-	-
	<i>Inga velutina</i> Willd.	NP	v	1	-	-	-	-
	<i>Macrobium angustifolium</i> (Benth.) R.S.Cowan	NP	v	2	-	-	-	-
	<i>Parkia nitida</i> Miq.	NP	ii	1	-	-	-	-
	<i>Pithecellobium acacioides</i> Ducke	P	ix	-	-	1	-	1
<i>Swartzia panacoco</i> (Aubl.) R.S.Cowan	NP	vii	1	-	-	-	-	
Lauraceae	<i>Nectandra cuspidata</i> Nees & Mart.	NP	x	1	-	-	-	-
	<i>Ocotea guianensis</i> Aubl.	NP	ii	4	1	-	-	1
Lecythidaceae	<i>Eschweilera coriacea</i> (DC.) S.A.Mori	NP	v	-	-	1	-	-
	<i>Eschweilera grandiflora</i> (Aubl.) Sandwith	NP	x	1	-	-	-	-
	<i>Lecythis lurida</i> (Miers) S.A.Mori	NP	iii	-	1	-	1	-
Malvaceae	<i>Apeiba echinata</i> Gaertn.	NP	x	-	-	-	-	1
Moraceae	<i>Clarisia racemosa</i> Ruiz & Pav.	NP	iv	1	-	-	-	-
	<i>Maquira sclerophylla</i> (Ducke) C.C.Berg	P	x	1	-	-	-	-
Myristicaceae	<i>Iryanthera juruensis</i> Warb.	NP	ii	-	-	-	-	1
	<i>Virola</i> Aubl.	Ni	ni	2	-	-	-	-
	<i>Virola michelii</i> Heckel	NP	xi	-	1	-	-	-
	<i>Virola surinamensis</i> (Rol. ex Rottb.) Warb.	NP	x	1	2	-	1	-
Myrtaceae	<i>Eugenia</i> L.	NP	x	1	-	-	-	-
Nyctaginaceae	<i>Neea floribunda</i> Poepp. & Endl.	NP	ii	3	-	-	-	-
Ochnaceae	<i>Ouratea castaneifolia</i> (DC.) Engl.	NP	iii	1	-	-	-	-
Rubiaceae	<i>Alibertia stipularis</i> (Ducke) W.Schultze-Motel	Ni	ni	1	-	-	-	-
	<i>Palicourea marcgravii</i> A.St.-Hil.	NP	iii	1	-	-	-	-
Salicaceae	<i>Banara arguta</i> Briq.	P	i	1	-	-	-	-
	<i>Casearia arborea</i> (Rich.) Urb.	NP	viii	1	-	-	-	-
	<i>Casearia sylvestris</i> Sw.	P	i	1	-	-	-	-
Sapindaceae	<i>Sapindus saponaria</i> L.	NP	iii	1	-	-	-	-
Sapotaceae	<i>Pouteria caimito</i> (Ruiz & Pav.) Radlk.	NP	x	1	-	-	-	-
Simaroubaceae	<i>Simarouba amara</i> Aubl.	NP	x	4	-	-	-	-
Urticaceae	<i>Cecropia distachya</i> Huber	P	ii	2	-	-	-	-
	<i>Pourouma guianensis</i> Aubl.	P	x	3	-	1	-	-
Vochysiaceae	<i>Vochysia maxima</i> Ducke	NP	x	-	-	-	-	1

Legend: BF = Botanical Family; EG = Ecological Group; P = Pioneers; NP = Non Pioneers; RA = Reference Author; i = Abreu (2013); ii = Amaral (2009); iii = EMBRAPA (2020); iv = Ferraz (2004); v = Gama (2002); vi = Araújo (2010); vii = Nascimento (2016); ni = Unidentified; viii = Silva (2003); ix = Silva (2018); x = Trindade (2016); xi = Prata (2007) e; xii: Bezerra (2010).

After classifying the species into ecological groups and into diameter classes, the means of the increments were compared using an analysis of variance (ANOVA) with a double factor model in random blocks performed, in the R Core Team 2020 program with the Rstudio compilation interface. The analysis factors were the months (MON), the diametric classes (CLA) and the ecological groups (EG), in a random block scheme with the months as blocks and the diametric classes and ecological groups as factors. For those factors for which there

was a significant difference, a Tukey's test was applied to test the contrast between the means.

3. RESULTS AND DISCUSSION

In ANOVA results presented in the Table 2, the effect of months, diametric classes, and ecological groups on growth were verified, as well as the existence of interaction between them in the analysis of the diametric increments of the Feiga species.

Table 2. Analysis of variance (ANOVA) results of the monthly periodic increment (MPI) in centimeters of the diameter according to the factors: Ecological group - EG; Diameter class - CLA; Month of collection - MON and its interactions at the Experimental Farm of Igarapé Açu of Ufra, in the city of Igarapé Açu - PA

SOURCE OF VARIATION	DF	SQ	MQ	F	P Value
EG	1	0,0326	0,0326	6,1478	0,0133
CLA	4	0,0709	0,0177	3,3381	0,0100
MON	9	0,2944	0,0327	6,1625	0,0183
EG : CLA	4	0,1363	0,0340	6,4188	0,0427
EG : MON	9	0,0328	0,0036	0,6864	0,7217
CLA : MON	36	0,1842	0,0051	0,9642	0,5304
EG : CLA : MON	36	0,1045	0,0029	0,5468	0,9867
Residuals	923	4,8986	0,0053		

Legend: DF = degrees of freedom, SQ = sum of squares, MQ = Mean squares, F value = F statistic, P value = P value for F value. p values in bold indicate significance at 5% probability.

ANOVA results indicated that there was an interaction between the MPI averages of the ecological groups and diametric classes, but the variable months was the only one that did not show interaction with the others. To model the data analysis of the experiment more accurately, the MON variable was changed to an additive variable instead of an interaction variable. Thus, Table 3 shows the modified ANOVA for this experiment, with MON as the block — because there was certainty that there was a difference between them — and EG and CLA as the factors. With the removal of the interaction of the MON factor, it was observed that there was a significant difference between the means of MPI of the factors EG, CLA, MON (isolated) and when EG interacted with CLA. The difference was highly significant in the MON variable when isolated, and in the interaction of the EG variable, it interacted with CLA. In EG, the difference was significant to 1% and in CLA the difference was significant to less than 1%.

Table 3. Analysis of variance (ANOVA) of the monthly periodic increment (MPI) in centimeters of the diameter as a function of two factors: Ecological group - EG; Diameter class - CLA and its interactions with the MON (month of collection) factor as an additive variable in this analysis.

SOURCE OF VARIATION	DF	SQ	MQ	F	P Value
EG	1	0,0326	0,0326	6,2754	0,0124
CLA	4	0,0709	0,0177	3,4074	0,0088
MON	9	0,2944	0,0327	6,2904	0,0108
EG:CLA	4	0,1363	0,0340	6,5520	0,0331
Residuals	1004	5,2201	0,0051		

Legend: DF = degrees of freedom, SQ = sum of squares, MQ = Mean square, F value = F statistic, P value = P value for F value. p value in bold is significant at 5% probability.

When carrying out this second stage of the analysis, a test of normality of Shapiro Wilk was also performed, which

detected that at the level of 5%, the residuals generated by ANOVA were not normally distributed. This was explained by the form of increment distribution, which did not resemble the normal distribution, and was not distributed in a “balanced” way within the sample for this experiment. This aspect does not generate negative effects that the results of analysis need to be discarded, since the other assumptions of variance analysis were met for the analyzed data. Table 4 shows the MPI averages of the ecological groups within each diametric class.

Table 4. Analysis of the means of monthly periodic increment (MPI) in centimeters of the ecological groups of Pioneer and Non-Pioneer species within classes I, II, III, IV, and V in diameter.

DIAMETRIC CLASSES	GROUP	AVERAGES (cm)
Class I	A	0,0384
	B	0,0224
Class II	A	0,0557
	B	0,0352
Class III	A	0,0654
	B	0,0205
Class IV	A	0,0480
	A	0,0036
Class V	A	0,0689
	b	0,0240

Legend: Groupings with the same letters refer to statistically identical averages at the 5% probability level.

Since there were differences between the MPI means among ecological groups and among diametric classes, Table 4 demonstrates the analysis results which indicate the groups and classes that represent these differences (or parities) among the MPI means. The monthly increment averages per ecological group were compared within the diameter class factor levels. The mean comparison test revealed that there were differences between the means of MPI within the classes I, II, III, and V of diameter. In class IV, the test showed that the MPI means of the ecological groups were statistically equal. It is possible to affirm that the means of MPI in this class were different (0.0480 cm and 0.0036 cm), however, they were statistically equal, since a greater variability within the groups suggests a greater uncertainty about their true mean. Therefore, at the resulting probability level, it was not possible to state that the means were different precisely because of the degree of uncertainty of the means. Thus, this test worked with the variance of the data around the means of each ecological group and diameter class and suggested that, in class IV, the means were equal. ANOVA indicated that the means of MPI of the MON variable interacted with each other. Figure 4 shows that the averages of the two ecological groups distributed in the five diametric classes were different for each month analyzed. As shown in table 4, class IV had statistically equal MPI means of the ecological groups.

Figure 4. Curves of the monthly periodic increment (MPI) averages in centimeters for the Pioneer and Non-Pioneer species groups for each diameter class.

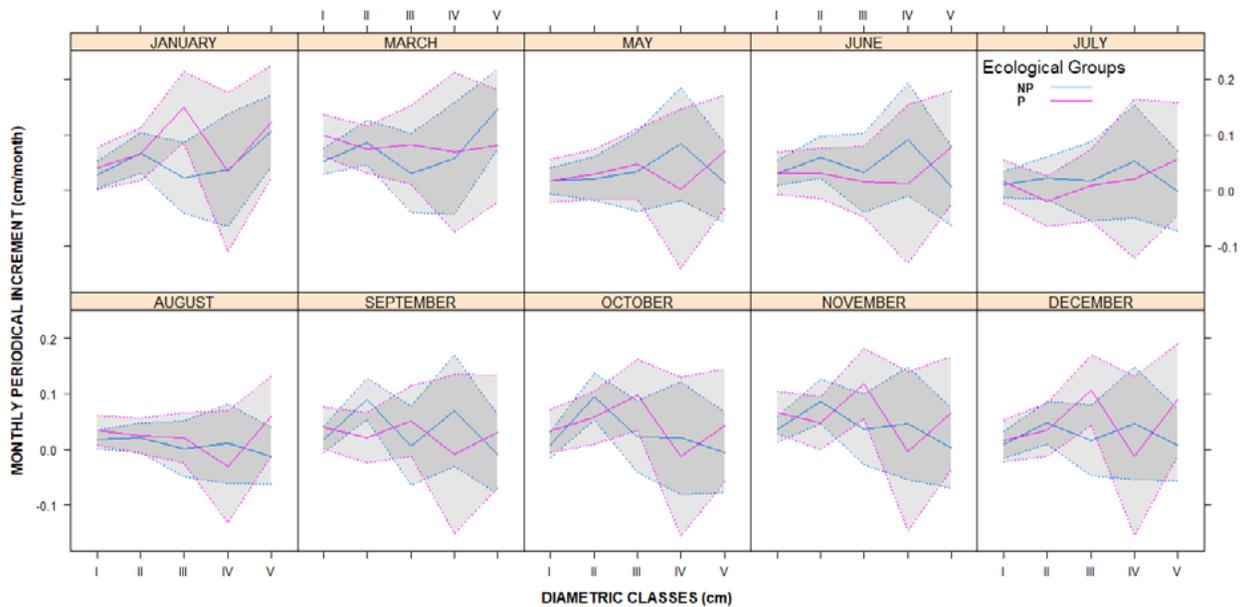


Figure 4 indicates that the means of the Pioneer and Non-Pioneer species were equal in this class when compared to each other for each month. However, each month had a different MPI average. Class I showed equal ecological group averages in every month except August. Class II had averages of the same ecological groups in October and December and different averages in the other months. Class III showed a difference between the means of the two groups in all months and the same result was identified in Class V.

Some characteristics influence the difference between the MPI averages of the Pioneer and Non-Pioneer species group. According to the study by Kanieski et al. (2017) in a mixed ombrophilous forest in southern Brazil, the difference in increment between trees is related to the sociological position (canopy or undergrowth). In their research, the rates of increment of trees in the understory were lower than those in the canopy, with a significant difference. This may explain the differences found in this study. According to Brienen et al. (2006), juvenile trees tend to present significant growth autocorrelations, as they are temporally linked to the variation in light availability due to canopy dynamics, while larger trees are influenced by environmental factors, such as vine infestations, which can cause growth differences among trees. The growth inequalities in some groups reveal the need to consider a differentiated growth pattern in the production estimates of a forest, since the forest does not have a single growth pattern, thus avoiding information that is highly discrepant from reality (Vatraz, 2018).

As in Igarapé-Açu, the study by Moraes (1970) indicated that the diametric growth of species from the Mocambo reserve

in an urban forest of Belém had one of its peaks in the month of March and was influenced by rain, but for some species, light could be the limiting factor of this growth. According to the same author, in tropical forests, some characteristics such as altitude, location, disturbance, and topography can influence the availability of water and soil nutrients. In addition, climatic and ecological aspects, such as shade availability, may explain the levels of development of species (Kariuki et al., 2006). These and other factors, together with species-specific characteristics can help in understanding the growth patterns of these populations. We then analyzed the MPI averages of each diameter class within the Pioneer and Non-Pioneer species group represented in table 5.

Table 5. Analysis of MPI averages of classes I, II, III, IV, and V in diameter within the group of Non-Pioneers and Pioneers.

NON-PIONEERS			PIONEERS		
GROUP	CLASS	MEANS (cm)	GROUP	CLASS	MEANS (cm)
a	II	0,0557	A	V	0,0689
a	IV	0,0480	A	III	0,0654
b	V	0,0240	B	I	0,0386
b	I	0,0224	B	II	0,0352
b	III	0,0205	C	IV	0,0036

In the Non-Pioneer species group, the averages were organized in a decreasing order and received two groupings: “a” and “b”. In this case, the diameter classes II and IV were part of group “a”, that is, their MPI averages were statistically equal. In addition, these were the classes with the highest MPI averages within the group of Non-Pioneer trees. Classes

V, I, and III correspond to group “b” and were statistically equal, presenting the lowest MPI averages of this analysis.

The averages of the Pioneers’ group were also organized in a decreasing order, but three groups were grouped: “a”, “b”, and “c”. The treatment “a” grouped the classes V and III which had statistically equal MPI means. This suggests that the MPI averages were equal among trees with DBH between 30 cm and 40 cm and among trees with DBH equal or greater than 50 cm. Classes I and II were grouped into “b” with statistically equal means, that is, equal means among trees with DBH between 10 cm and 20 cm and among trees with DBH between 20 cm and 30 cm. The grouping “c” corresponded only to class IV, in which the MPI was statistically different from the others and presented the lowest average of the five diameter classes.

In this experiment, the Non-Pioneer species had an average growth of 0.169 cm and the Pioneer species, 0.209 cm; the latter had the highest average. This difference can be explained by the inverse relation between wood density and tree increment. This aspect, according to Chave et al. (2006), indicates that when the increment of the tree is faster it suggests that the species invests lesser in conductive tissues and more in survival strategies. This results in a low wood density of some individuals, which is characteristic of Pioneer species.

The highest rainfall rates in the municipality of Igarapé-Açu occur between the months of February and April (Figure 1) with a peak in March (Pacheco & Bastos, 2005) and Figure 4 indicates that in that same month there was the highest diametric growth of this experiment. This indicates that there is a direct relationship between rainfall and diametric increment. Since excess rainfall influences the increase in diameter of species, the volumes of trees with low wood densities, such as those of Pioneer species, can be overestimated since there is an intense inflow of water into the tracheids. This fact does not significantly influence the volume of trees with higher wood densities (Almeida, 2008). Higuchi et al., (2011) identified a strong relationship between precipitation and diametric increment measured over 5 years through diametric bands in Central Amazonia. The same authors concluded that diametric growth is dependent on both the amount of rain and the way it is distributed throughout the year in the region.

Worbes (1999) working on tree ring analyses and dendrometer measurements of 26 tree species in a semi deciduous forest of the Reserva Forestal de Caparo Venezuela found that cambial growth was generally high during the rainy season and decreased to zero towards the end of the rainy season or soon after the beginning of the dry season. The study carried out by Silva et. al. (2003) in an experimental station of INPA,

proved that the relationship between precipitation and increment is direct. There was a tendency for higher increments to be associated with higher precipitation or, for lower increments to be associated with lower precipitation. The growth pattern in diameter is characterized by a decrease in the increment in the driest months of the year, from May to September. In addition, one of the two diametric growth peaks occurred in March, in view of the high rainfall detected, which was also found in the present study. Also in the same study, the authors showed that the largest increases were related to the largest diameters. Thus, the DBH \geq 50 cm class had the highest value compared to the others, a result similar to that obtained in the MPI averages of Pioneer species in the Igarapé Açu experiment.

4. CONCLUSIONS

- The species class with DBH between 40 cm and 49.99 had similar MPI averages among both ecological equivalent groups, Pioneers and Non-pioneers;
- The Feiga forest shows the highest growth during the rainy season, as it had the highest MPI averages in this period of the year;
- The size classes and the characteristics of the ecological groups determined the average MPI values of the species present in the studied forest;
- There was a difference in the rate of growth of trees in the secondary forest of Feiga because there was a difference between the averages of monthly periodic increment of ecological groups and the diameter classes of species.

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