Research Article

Seedling Community in a Patchy Tropical Vegetation Under the Influence of Bamboos

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Abstract

As a group adapted to invade disturbed sites, bamboos can dominate extensive areas and, thus, alter vegetation structure and dynamics. However, the effect of bamboo expansion associated to human activity on seedling communities in tropical forests remains poorly known. We investigated the correlation of the native bamboo *Guadua tagoara* presence for a year on the abundance, richness, diversity, dominance, evenness, emergence, mortality, and growth of the first months of the native seedlings establishment in an Atlantic forest area, São Paulo State, Brazil. Bamboo presence favored the initial establishment of the palm *Euterpe edulis* seedlings but altered seedling community structure as a whole. Species richness did not differ between bamboo and nonbamboo dominated habitats, but abundance, diversity, and evenness did. Bamboo habitats showed higher seedling abundance, emergence, and mortality than in habitats without bamboos. However, diversity was lower in these habitats. Our results shed light on the role of bamboo presence in limiting early establishment of native seedlings but favoring the first months of establishment of *E. edulis*, the dominant species in bamboo habitats (70%). Therefore, the monitoring of more specific variables could be included (i.e., bamboo culm density, soil type, decomposition of organic matter, fauna living, or foraging in bamboos) in future studies to better understand the consequences of bamboo dominance on the recruitment and dynamics of tropical forests biodiversity in the long term.

Keywords

assembly rules, ecological filters, invasive native bamboos, seedling recruitment

Introduction

Post-disturbances conditions favor many heliophyte species, such as lianas (César, Rother, & Brancalion, 2017; Schnitzer, Heijden, Mascaro, & Carson, 2014; Tabanez & Viana, 2000) and some bamboos (Burman & Filgueiras, 1993; Judziewicz, Clark, Londoño, & Stern, 1999). Lianas and bamboos are nontree life forms with high vegetative growth potential that may vigorously establish and grow in high densities after disturbances, altering forest structure on the long term (Burman & Filgueiras, 1993; Farah et al., 2014; Schnitzer, Dalling, & Carson, 2000).

Bamboo expansion is a typical example of local biological invasion caused by the interaction among the bamboo's aggressive monopolization of above- and belowground resources and disturbances created by humans or natural causes (e.g., harvesting, wind, tree fall, snow; see Yang et al., 2015). Characteristics such as morphology, high seed production, growth rate, and

clonal reproduction are important traits probably related to their ecological success and spread (Lima, Rother, Muler, Lepsch, & Rodrigues, 2012). Due to its

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dominance, some bamboo species can play a major role in forest dynamics, as they can alter population dynamic and the structure of the invaded community (Okutomi, Shinoda, & Fukuda, 1996; Veblen, 1982).

A series of studies from tropical and temperate forests have tried to understand the mechanisms behind bamboo dominance such as the disruption of ecological, functional, and structural processes, as well as other processes that shape ecosystem composition and biodiversity (Abe, Miguchi, & Nakashizuka, 2001; Giordano, Sánchez, & Austin, 2009; Muler et al., 2014; Peters, Nakashizuka, & Ohkubo, 1992; Rother, Rodrigues, & Pizo, 2009; Rother, Jordano, Rodrigues, & Pizo, 2013; Rother, Rodrigues, & Pizo, 2016; Taylor, Jinyan, & Shiqiang, 2004; Tripathi et al., 2005; Yang et al., 2015). Bamboos alter the vegetation structure by damaging both tall trees and regenerating plants and by altering the forest microclimate and largely increasing the biomass of leaf litter (Araujo, 2008). They can also influence the vegetation by altering seed rain (Grombone-Guaratini, Alves, Vinha, & Franco, 2014; Rother et al., 2009) and seed germination (Giordano et al., 2009) and by affecting the regeneration of tree species (Caccia, Chaneton, & Kitzberger, 2009; Campanello, Gatti, Ares, Montti, & Goldstein, 2007; Fantini & Guries, 2007; Oliveira-Filho, Vilela, Gavilanes, & Carvalho, 1994; Rother, Jordano, et al., 2013; Widmer, 1988), tree growth (Oliveira-Filho et al., 1994), and forest succession (Griscom & Ashton, 2003; Muler et al., 2014; Rother et al., 2016). Other studies assessed the relationship between bamboos and the vegetation by monitoring survival and recruitment of plant species in habitats covered by bamboos (Guilherme, Oliveira-Filho, Appolinário, & Bearzoti, 2004; Lima et al., 2012; Rother, Jordano, et al., 2013; Sanquetta, Dalla Corte, Salzmann, & Vulcanis, 2007).

Both abiotic and biotic are important factors influencing plant dynamic, and their importance on plant community may vary in forest understory dominated by bamboos (Abe et al., 2001; Caccia et al., 2009; Lima et al., 2012). Lima et al. (2012) showed that bamboo-dominated habitats in Brazilian Atlantic forest have lower abundance of trees (>5 cm dbh), and they attribute that to physical-induced damages caused by *Guadua tagoara* loads on trees. There are evidences that bamboo effects on the early recruitment of tree species are patchy and species-specific (Rother, Jordano, et al., 2013). In a manipulating experiment, Rother, Jordano, et al. (2013) demonstrated that three tree species are especially susceptible to removal by rodents in the early establishment, and the mortality of seeds and seedlings can be more crucial than bamboo and nonbamboo differences as determinants of survival. It is interesting to note that some tree species find bamboo habitats as safe sites to survive successfully in the early establishment with potential implications for forest dynamics,

biodiversity, and succession (Caccia et al., 2009; Rother, Jordano, et al., 2013). This is also especially true to the occurrence of bamboo specialists' birds and birds that do not depend on forested habitats in bamboo areas (Rother, Alves, & Pizo, 2013).

The community seedling composition will depend on the specie-specific requirements and tolerances to various stress factors (Caccia et al., 2009). Light availability and quality are important factors to shape regeneration niches by defining seed germination, seedling emergence, and growth of understory species (Caccia et al., 2009). Authors found that canopy of bamboo-dominated habitats were more open than nonbamboo habitats. Studies also developed in Atlantic forest mention that at bamboo-dominated habitats, the vegetation has discontinuous canopy, low density of large and small trees, and low plant diversity (Fantini & Guries, 2007; Guilherme et al., 2004; Oliveira-Filho et al., 1994; Tabarelli & Mantovani, 1999).

Despite some studies carried out in the past decades, our knowledge of bamboos and their relationship with forest structure and dynamics remains incipient. In general, studies evaluating bamboo ecology highlight this group as important elements acting in positive or negative ways on the forest dynamic. Most studies, however, recognize the need for additional studies on the life cycle, evolution, and ecology of bamboos in forests (Judziewicz et al., 1999). Aiming at filling this gap, we assessed how the *G. tagoara* presence influences the structure and dynamic of the early stages of recruitment of native seedlings in an area of dense Atlantic forest. The expansion of this bamboo species in the Atlantic forest is mentioned as caused by the illegal extraction of palm heart (*Euterpe edulis*) (Fantini & Guries, 2007). Considering that the understory of *G. tagoara*-dominated forest has higher light incidence, thicker leaf litter (Rother et al., 2016), and higher mortality of native juvenile plants (Lima et al., 2012), we expected to find lower seedling abundance, richness, and growth in these areas than in bamboo-free forest.

Method

Study Area

Our study was carried out in Carlos Botelho state park at ca. 300 m a.s.l., on the Atlantic slope of the Paranapiacaba mountain range, in a 320×320 m (10.24 ha) permanent plot (24°10′S and 47°56′W), at São Paulo state, Brazil. The site is characterized by trees of 20 to 30 m height, the dominant palm *E. edulis* (jussara), scandent bamboos (*G. tagoara*), and species of the families Cyatheaceae, Rubiaceae, and Rutaceae in the understory (Custódio-Filho, 2002; Lima et al., 2011; Rizzini, 1979; Toniato et al., 2011). The bamboo *G. tagoara* covers about 3 ha of the total area of the

permanent plot, forming clumps throughout the plot that can range from 400 m^2 to 2,000 m^2 (Rother, Jordano, et al., 2013). These bamboo-dominated sites are interspersed with areas lacking bamboos forming a forest mosaic throughout the permanent plot (Rother, Jordano, et al., 2013). *Guadua* is the bamboo genus with the broadest distribution in America, comprising approximately 30 species (Londoño, 1998; Young & Judd, 1992). *G. tagoara* is a perennial bamboo with rhizomes, woody culms, 8 to 15 m height, 5 to 10 cm in diameter, erect at the base and leaning or scandent at the apex, with spinescent nodes with more developed thorns on the lower nodes, hollow internodes, deciduous stem leaves, sometimes persistent in basal nodes. *G. tagoara* stands are extremely patchy and dynamic, and its dominance is related to the anthropogenic (e.g., illegal *E. edulis* harvesting at the study site) or natural disturbances (e.g., gaps, landslides) (Lima et al., 2012). They promote a structural patchiness in the forest by altering the conditions (e.g., light availability, litter depth) for early recruitment of other plant species (Rother, Jordano, et al., 2013, 2016). Also, edges of bamboo patches are dynamic by advancing and retracting, changing consequently the forest structure. The mean temperature in the study period was 21.1°C (range, 17.4–25.2°C), and the site received 3,384 mm of rainfall. The rainiest and hottest season occurs from December to March. The soil developed over granites and colluvionar deposits and was classified as Haplic Cambisols and Fluvisols/Leptosols (Rodrigues, 2005).

Data Collection

We set up 80, 1 × 1 m plots for seedlings within the permanent plot in September 2004 being 40 in habitats with bamboos (B) and 40 in habitats without bamboos (NB). Plot location was randomized, but due to the slope of the area, some points needed reallocation, always maintaining a minimum of 20-m distance among each other. We marked all woody and herbaceous plants smaller than 30 cm in height (considered as seedlings) with plastic tags. Seedlings were numbered, and whenever possible, identified to the species level. Monthly during a year, we marked new individual plants which allowed to monitor the emergency and mortality. We did not sample individuals that showed vegetative growth or *stolon* due to the difficulty in defining their development stage (i.e., seedling or juvenile). For herbaceous plants, we considered as seedlings the individuals that did not show flowers or fruits during the study period. They were included in the abundance and diversity analysis. Due to their short life cycle compared to other life forms, they were not included in the analysis involving temporal dynamic, such as seedling emergence, mortality, and growth. We measured seedling height and diameter with a tape. Height was measured from ground level to the apical meristem, and the diameter was taken at ground level. The height and diameter measurements were taken in September 2004, January 2005, and June 2005.

We identified seedlings by comparison with specimens from the HRCB Herbarium of the State University of Rio Claro and the University of São Paulo at Piracicaba, plants cultivated in the greenhouse of the Experimental Garden of the State University of Rio Claro, and by consulting the literature and specialists. Taxonomic nomenclature follows Angiosperm Phylogeny Group III (2009).

Data Analysis

To assess the effect of bamboo presence on the early seedling establishment, we considered two components: species composition and the abundance of seedlings sampled for each species. We calculated richness (S = number of species in the sample), Shannon–Wiener diversity index (H'), dominance (1-Sympson index), and Pielou evenness (J) (Magurran, 2013). These descriptors were calculated in the program Past 2.17c (Hammer, Harper, & Ryan, 2001) and compared between habitats with *t* tests. We used species accumulation curves and the bootstrap richness estimator to test for sampling completeness in B and NB habitats (Hortal, Borges, & Gaspar, 2006). Our objective was to estimate how many species were expected in a random seedling sample in both habitats. To perform this analysis, we used the *specpool* function in the package *vegan* for R 3.4.2 (R Development Core Team, 2017), which estimates the species richness extrapolated from a species pool (e.g., all species available that could potentially colonize and inhabit a determined area), or the number of not observed species.

Monthly data for seedling emergence and mortality between habitats were analyzed using a generalized linear mixed model, considering the habitat effect (B and NB) and a Poisson error distribution. Then, we modeled the relative growing rate (stem height recorded in Time 2 minus stem height recorded in Time 1 divided by the stem height recorded in Time 1, expressed in percentage) as a function of the habitats using a linear mixed model. The relative growth was used to eliminate the effect due to different seedling sizes. In all the mixed models, the random effect was defined as 1 × 1 plots and fixed effect as habitat (B and NB). The habitat influence over emergence and mortality was tested through the coefficient significance during generalized linear mixed model adjust assessed by a *z* test (Bates, Maechler, Bolker, & Walker, 2015). The relative growth of all seedlings was compared to *E. edulis* by an analysis of variance between mixed models, considering the likelihood ratio test proposed by Pinheiro and Bates (Bolker et al., 2009). We performed that analysis due to the dominance of *E. edulis* seedlings in the plots. We used the

packages *stats*, *lmtest*, *sandwich*, and *lme4*, for R 3.4.2 (R Development Core Team, 2017).

Results

Seedling Abundance and Diversity

We recorded a total of 982 seedlings. Of this total, 638 seedlings were recorded in B plots and 344 in NB plots. *E. edulis* was the most abundant species in both habitats. In B plots, we recorded 466 *E. edulis* seedlings, which represented 73% of the total of individuals sampled, followed by two undetermined species, and *Tetrastylidium grandifolium* (Olacaceae). In NB plots, we sampled 82 individuals of that species, which represented 23% of the individuals sampled, followed by one undetermined species, *Rudgea jasminoides* (Rubiaceae) and *Eugenia mosenii* (Myrtaceae) (see Appendix A for seedling species recorded in both habitats).

We found a total of 104 seedling species being 70 in B plots and 60 in NB plots, and seedling richness was similar between habitats ($p > .05$; Table 1). Among them, 44 species were exclusive to B plots, 34 were exclusive to NB plots, and 26 species (25%) were common to both habitats. There was lower species evenness in B plots. *E. edulis* was the most frequent and abundant species, which resulted in a lower diversity (Table 1). In NB plots, diversity was higher due to higher evenness, which differed significantly from that of B plots (Table 1).

Considering the estimation of how many species were expected in a random seedling sample in both habitats in B plots, seedling richness was estimated as 88.86 (±5.43), whereas in NB plots, it was estimated as 74.55 (±4.18; Table 1; Figure 1). Contrasting the observed and the extrapolated species richness, this result suggests that sampling of seedlings was relatively complete (Table 1; Figure 1), although the rarefaction curves did not reach an asymptote for either bamboo and nonbamboo plots (Figure 1).

Seedling Emergence, Mortality, and Growth

The emergence and mortality were affected by bamboo presence (emergence: $z = -2.756$, $p = .00584$; mortality: $z = -524$, $p = < 2e{-}16$). NB plots showed a lower seedling emergence and mortality (Figure 2). Emergence in NB was 0.66 seedlings per plot (±0.24 standard error) lower than B plots, and mortality was about 0.46 seedlings per plot (±0.001 standard error) lower than B plots. Bamboo presence did not affect the relative growth rate in seedlings height ($\chi = 0.34$, $p = .56$). Abundance of *E. edulis* seedlings in B plots was threefold higher than NB plots (Table 1); however, the relative growth rate of
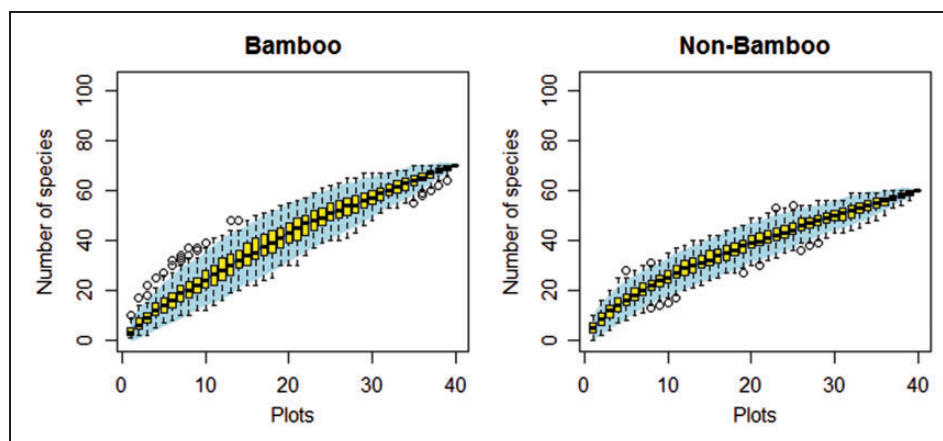
Table 1. Richness, Abundance, Dominance, Diversity Index (Shannon, H'), and Evenness (Pielou, J) for Bamboo and Nonbamboo Habitats in the Permanent Plot Located in Carlos Botelho State Park, State of São Paulo, Southeastern Brazil.

	Bamboo	Nonbamboo	*p*
Richness	70	60	.914
Individuals	638	344	.000
Dominance	0.54	0.11	.001
Shannon H'	1.49	2.90	.001
Evenness J	0.35	0.71	.001

Note. *p* values represent the comparison between habitats.

Figure 1. Rarefaction curves of the seedling species recorded in plots with bamboos (left) and without bamboos (right) in the permanent plot located in Carlos Botelho State Park, state of São Paulo, southeastern Brazil. The blue area represents the confidence interval for $N = 100$ permutations. Boxplots (yellow) represent the median, and 50%, 90%, and extreme values.
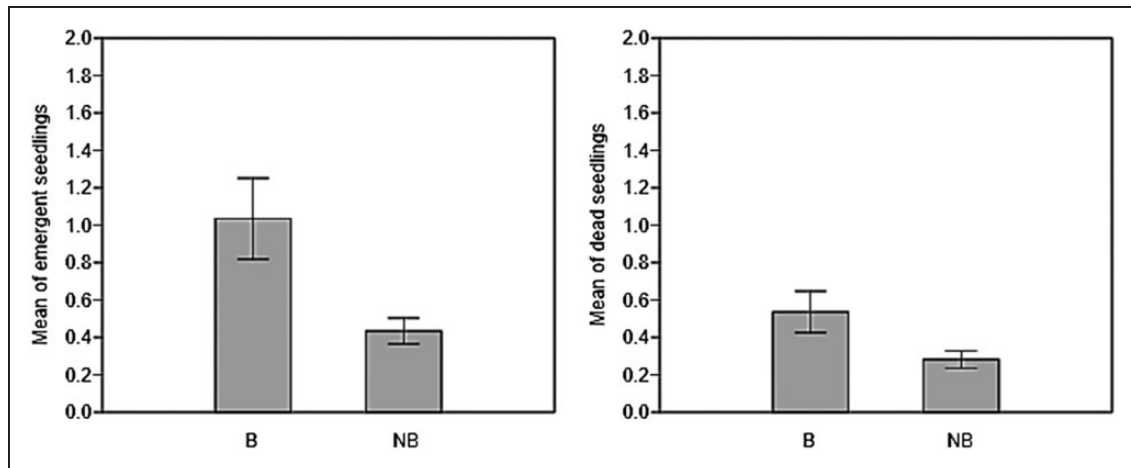
Figure 2. Boxplot comparing emergence and mortality (mean ± SE) of seedlings between habitats (B = bamboo and NB = nonbamboo) in Carlos Botelho State Park, state of São Paulo, southeastern Brazil.

E. edulis seedlings was the same for both habitats ($\chi = 2.21$, $p = .14$).

Discussion

Bamboos affected the community structure and dynamics of the early seedling establishment in the study area. Seedling turnover (emergence and mortality) was higher in habitats with bamboos. In general, the closed canopy can increase seedling mortality by reducing light penetration in the floor (Camargo & Kapos, 1995); however, a previous study carried out in the same site demonstrated greater luminosity in the bamboo habitats (Rother et al., 2016). In contrast, studies on the influence of bamboo on forest succession in China (Taylor & Zisheng, 1988) and Japan (Tanaka, 1988) have attributed reduced seedling density to reduced levels of light under bamboos. Other studies have reported decreasing recruitment and mortality on the fall of canopy debris damaging seedlings (Benitez-Malvido, 1995; Clark & Clark, 1989, 1991; Lima et al., 2012), trampling by animals (Aizen & Feizinger, 1994), litter depth (Griscom & Ashton, 2003; Rother et al., 2016) or the attack of ants, Orthoptera (Alvarez-Buylla & Martínez-Ramos, 1990), and pathogens (Abe et al., 2001). Possibly some of these factors or their interactive effect may have resulted in higher seedling mortality in the bamboo habitats. On the other hand, the conditions for seedling emergence under bamboos seem to have been more favorable than those without bamboos. However, it is interesting to highlight that this result is closely related to the emergence of high number of *E. edulis* seedlings in bamboo habitats.

G. tagoara-dominated habitats revealed lower seedling diversity as denoted by the low evenness resulting mostly from the dominance of *E. edulis* seedlings. The decrease in seedling diversity, especially of tree species

(low abundance of seedlings excluding *E. edulis* 92 tree seedlings for NB and 56 tree seedlings for B), is the main problem in bamboo-dominated habitats, as trees correspond to the most important plant functional group for diversity, structure, and functioning of tropical forests (Denslow, 1987).

The illegal harvesting of adult *E. edulis* in the Atlantic forest results in changes in forest structure and local biotic characteristics (Rother et al., 2016). The gaps opened by the removal of palm trees are habitats with great light incidence, which favors the establishment and dominance of bamboos, but also favors the establishment of *E. edulis*, which forms a seedling bank under bamboo stands. As previously demonstrated, *E. edulis* is favored in its early life cycle stages in habitats with bamboos (Rother et al., 2016). Seedlings of this palm tree corresponded to over 70% of the seedling community in these habitats. This result seems interesting at first, as *E. edulis* is an endangered species due to the illegal exploitation of adult individuals for palm heart. However, the population structure of this palm species had higher mortality of juvenile individuals in habitats with bamboos (Rother et al., 2016). Although bamboo habitats have a positive effect on seedling recruitment of *E. edulis*, they arrest the later stages of the life cycle of this palm species probably due to physical damages on the juveniles (Rother et al., 2016). Therefore, bamboos represent a demographic bottleneck for *E. edulis*, thus changing its population structure.

Bamboo-dominated habitats have a different seedling community than that found in habitats without bamboos, the latter being composed by a smaller number of exclusive species. What we still do not know is how the seedling community maintains itself or changes in the long term. A past study pointed out that seed rain is not strongly affected by bamboos (Rother et al., 2009),

but they have a negative influence on the seedling density of some tree species (Rother, Jordano, et al., 2013). Habitats with bamboos show higher concentration of small trees (<5 cm dbh) (Lima et al., 2012), higher light incidence, and thicker leaf litter (Rother et al., 2016). Hence, evidence shows that the forest structure is strongly influenced by *G. tagoara*. The physical damage caused by the fall of culms on the plants and the physiological stress caused by high luminosity and temperature in habitats with bamboos probably make these habitats extremely dynamic (Lima et al., 2012). Although some bamboo-dominated sites may have a higher concentration of smaller trees as the studied site (Lima et al., 2012), this is not always the case. Griscom and Ashton (2003), for example, found that juveniles (5–29 cm dbh) were more severely damaged than mature trees in *Guadua*-dominated forests.

Contrary to what we expected, habitats with bamboos showed higher seedling abundance. Explanations based on niche processes depend on differences between species and the way they respond to the environment (Chesson, 2000; Tilman & Pacala, 1993). The higher light incidence in bamboo-dominated habitats (Rother et al., 2016) may have favored light-demanded species in their initial establishment, such as *E. edulis* (466 seedlings). Indeed, bamboo-dominated habitats receive higher density of *E. edulis* seeds than nonbamboo habitats (Rother et al., 2009), which could explain this great seedling density of this palm species. Authors attribute two main hypotheses to explain the seed density differences between habitats. Despite both habitats have similar densities of adults, at bamboo habitats, *E. edulis* adults are more exposed to light which may lead them to greater seed production, and also the fruits are more conspicuous to seed-eaten animals.

Basically, canopy species might function as diversity filters as they strongly influence the environment located under their crown (Souza, Gandolfi, & Rodrigues, 2014). Therefore, the canopy of trees or bamboos might affect light incidence in the understory and soil (Souza et al., 2014; Vázquez-Yánes & Orosco-Segovia, 1990; Vázquez-Yánes et al., 1990), soil surface temperature (Molofsky & Augspurger, 1992), seed germination, seedling recruitment, and the deposition and decomposition of leaf litter (Metcalfe & Turner, 1998; Ponge et al., 1998; Rother, Jordano, et al., 2013, 2016). Consequently, these variables have a different influence on species composition in different habitats, as they select seedlings of species that are better adapted to different microhabitat conditions. The outcomes of understory tree seedlings regarding the environment will depend on the species' requirements and tolerances to various abiotic and biotic factors (Abe et al., 2001). To demonstrate such differences in species performance, Rother, Jordano, et al. (2013) showed that the most favorable habitat for

seeds and seedlings of *E. edulis* and *Virola bicuhyba* were bamboo-dominated habitats, while they were the least favorable for *Sloanea guianensis*.

Species classification according to forest dynamics strategies is controversial in the literature, as plants are subjected to a complex set of variables (Oliveira-Filho et al., 1994). Under natural conditions, bamboos create different regeneration niches. However, the increase and superdominance of this group can have negative consequences on plant life cycles, as bamboos can limit seedling emergence and mortality. We observed that habitats with and without bamboos showed a tendency to select some species by limiting the establishment differently. Excluding *E. edulis* seedlings of the both habitats, we notice that the species composition and abundance are very different (Appendix A). Considering that the life cycle (average 7.4 years between flowering seasons, see Alves, 2007) and the structure of the *G. tagoara* environment are extremely dynamic, long-term studies are crucial to understand the effects of its dominance on late stages of plant recruitment, as well as on biodiversity dynamic, in tropical forests.

Implications for Conservation

Disturbances of tropical forest alters structure and ecological processes of the vegetation (César et al., 2017; Lima et al., 2012). Illegal harvests of palm heart create gaps that favor bamboo proliferation (Fantini & Guries, 2007). In the studied site, this activity benefits proliferation of *G. tagoara* that when overabundant, they may negatively affect important processes to forest regeneration. Factors appeared to be limited especially to physical damage, physiological stress by not only high light incidence and litter depth but also seed removal by rodents and mammal trampling on seedlings (Rother, Jordano, et al., 2013). We tested the prediction that *G. tagoara* presence influences the structure and dynamic of the community of the first months of establishment of the seedlings, a fundamental ecological process to forest dynamic. We found that in bamboo habitats, the initial establishment of the palm *E. edulis* seedlings was favored, but the seedling community structure was altered as a whole. Also, we found that habitats with bamboos showed higher seedling abundance, emergence, and mortality than in habitats without bamboos. In a short term, we conclude that bamboo presence may limit the early establishment of native seedlings but favor *E. edulis* establishment. However, there is evidence that bamboos are functioning as a demographic bottleneck for later stages of *E. edulis* populations (Rother et al., 2016). Over time, the dominance of bamboos may have negative consequences in the future tree community, but this issue needs more investigation for long-term monitoring. Despite these evidences of negative influence of bamboos

on the forest regeneration, this bamboo species is an important element to the forest providing sources of food, perches, and shelter for bamboo specialist birds and birds not dependent on forested habitat (Rother, Alves, et al., 2013). Attempts to control this bamboo species remain premature (Lima et al., 2012) and need parsimony. Therefore, it is essential to test different experimental methods to manage *G. tagoara* and to monitor variables such as fauna populations, cover, litter, and ecological processes after management.

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Appendix A

Seedling Species Recorded at Bamboo and Nonbamboo Habitats in the Permanent Plot Located in Carlos Botelho State Park, State of São Paulo, Southeastern Brazil.

Seedling species	Bamboo	Nonbamboo
Abuta selloana	0	3
Araliaceae 1	1	0
Ardisia martiana	0	1
Bauhinia guianensis	0	1
Byrsonima sp.	1	0
Casearia decandra	1	3
Casearia sp.	0	1
Casearia sp. 1	1	0
Casearia sp. 2	2	7
Casearia sylvestris	1	1
Cecropia glaziovii	4	0
Chrysophyllum viride	0	11
Coccosypselum lanceolatum	1	0
Copaifera trapezifolia	1	0
Cordia sp.	3	0
Cryptocarya moschata	1	1
Cupania sp.	1	0
Dorstenia hirta	0	1
Eugenia cuprea	2	0
Eugenia melanogyna	4	1
Eugenia mosenii	0	23
Eugenia oblongata	1	0
Eugenia sp. 1	1	1
Eugenia sp. 2	0	2
Euphorbiaceae 1	1	0
Euterpe edulis	466	82
Geonoma sp.	5	10
Gomidesia sp.	1	1
Gomidesia spectabilis	1	2

(continued)

Continued.

Seedling species	Bamboo	Nonbamboo
Guapira opposita	3	0
Hymenaea courbaril	1	0
Inga edulis	1	0
Inga marginata	2	2
Inga sessilis	0	1
Inga sp.	1	1
Inga sp. 3	1	0
Inga sp. 4	1	0
Ixora sp.	0	1
Leandra mosenii	1	0
Mikania sp.	3	0
Mollinedia schottiana	1	0
Mollinedia sp.	1	0
Monstera adansonii	1	0
Myrsine hermogenesii	3	7
Myrtaceae 1	1	3
Myrtaceae 10	0	1
Myrtaceae 2	0	1
Myrtaceae 4	1	0
Myrtaceae 5	1	0
Myrtaceae 6	1	0
Myrtaceae 7	1	0
Myrtaceae 8	0	1
Myrtaceae 9	1	0
Nectandra sp.	2	0
Neomitrantes glomerata	0	6
Parinari excelsa	1	0
Paullinia trigonia	0	3
Philodendron sp.	1	0
Piperaceae 1	1	3
Piperaceae 2	0	2
Posoqueria acutifolia	0	2
Pouteria sp.	0	1
Protium widgrenii	1	0
Psychotria cf. *leiocarpa*	0	1
Psychotria sp.	2	3
Psychotria sp. 2	1	0
Psychotria umbellata	0	1
Rubiaceae 1	0	1

(continued)

Continued.

Seedling species	Bamboo	Nonbamboo
Rubiaceae 2	2	3
Rubiaceae 5	0	1
Rubiaceae 6	1	0
Rudgea jasminoides	3	23
Sapindaceae 1	2	1
Sapium glandulatum	1	0
Sloanea sp.	0	2
Strychnos brasiliensis	1	0
Tetrastylidium grandifolium	6	20
Undetermined 1	5	6
Undetermined 10	1	0
Undetermined 11	0	1
Undetermined 12	0	1
Undetermined 13	0	1
Undetermined 14	1	0
Undetermined 15	1	0
Undetermined 18	0	1
Undetermined 2	1	1
Undetermined 20	0	1
Undetermined 21	0	1
Undetermined 22	1	0
Undetermined 23	1	0
Undetermined 24	0	1
Undetermined 25	3	1
Undetermined 26	3	13
Undetermined 27	52	67
Undetermined 28	0	1
Undetermined 29	1	0
Undetermined 30	0	1
Undetermined 31	9	0
Undetermined 5	1	0
Undetermined 6	1	0
Undetermined 7	0	2
Undetermined 9	1	0
Virola bicuhyba	5	1
Zanthoxylum rhoifolium	0	1