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Original article

# Bamboo thickets alter the demographic structure of *Euterpe edulis* population: A keystone, threatened palm species of the Atlantic forest

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ABSTRACT

The rapid spread of bamboos can strongly affect forest structure by interfering plant regeneration and reducing local biodiversity. Considering that bamboos exert a negative influence on the plant community, our main goal was to investigate how this influence manifests at the population level. We compared the demographic structure of the threatened palm *Euterpe edulis* between bamboo and non-bamboo dominated patches within the Atlantic forest. In the study site, the native bamboo *Guadua tagoara* has created a marked patchiness and heterogeneity in the vegetation. Plots were set up randomly in bamboo and non-bamboo patches and the heights of all *E. edulis* individuals were measured. Data from canopy openness and litter depth were collected for both patches. Greater number of *E. edulis* was recorded in bamboo patches. However, frequency distribution of the height classes differed between patches revealing a predominance of seedling and sapling I classes in bamboo patches, in comparison to a more evenly distribution of height classes in non-bamboo patches. The canopy in bamboo patches was more open and the litter depth was thicker. Our analyses evidenced *G. tagoara* is functioning as a demographic bottleneck of natural population of *E. edulis* by arresting its later stages of regeneration and in high densities that bamboos may limit recruitment of this palm species.



## 1. Introduction

Bamboo establishment within areas of tropical forest can occur rapidly due to its naturally invasive ecology, which is facilitated by vegetative reproduction and occur even when the bamboo is native to the forest (Wong, 1991). The rapid spread of bamboos can strongly affect forest structure, either through interfering with plant regeneration and reducing local biodiversity (Lima, 2007; Lima et al., 2012; Oliveira-Filho et al., 1994; Rother, 2006; Rother et al., 2013a) or by altering the structure of vegetation (Fantini and Guries, 2007; Guilherme et al., 2004; Lima, 2007; Lima et al., 2012; Oliveira-Filho et al., 1994; Rother, 2006; Rother et al., 2013a; Tabarelli and Mantovani, 1999).

Bamboo promotes structural changes in vegetation through either direct damage to other plants or indirectly via impacts on regenerating plants through changes in the forest microclimate and increased litter deposition (Araujo, 2008). As a consequence of its establishment, bamboo may influence the vegetation in different ways: affecting the abundance of seeds entering a site via dispersal mechanisms (Rother et al., 2009), the regeneration of tree species (Carvalho, 1997; Oliveira-Filho et al., 1994; Fantini and Guries, 2007), the growth of trees (Oliveira-Filho et al., 1994) and subsequently forest succession more generally (Griscom and Ashton, 2003; Lima, 2007).

Most of the studies involving bamboo dominance of tropical forests are concentrated within a few sites in the Amazon and Atlantic Forests. Oliveira (2000) found that larger trees were the least common size class present within forests dominated by *Guadua weberbaueri* in the northern state of Acre. Also in north Brazil Silveira (2000) noted that local floristic composition was reduced to almost 40% of the initial species richness as a result of *G. weberbaueri* colonization.

In the Atlantic forest, which is threatened by habitat loss and fragmentation (Ribeiro et al., 2009), researchers and

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conservationists see *Guadua tagoara* (Nees) Kunth and other bamboo species as a major threat (Araujo, 2008). In certain protected areas, bamboo presence is considered to be one of the major factors related to the reduction of species richness (Lima et al., 2012). Despite being a native species, concerns exist because evidence that *G. tagoara* populations are expanding (Alves, 2007). At sites where *G. tagoara* naturally occurs, changes in forest dynamics have been observed when the species is able to find suitable conditions to establish and dominate (Alves, 2007; Fantini and Guries, 2007; Morokawa, 2008).

Due to the fact that it is a pioneer species and can quickly occupy disturbed areas (Judziewicz et al., 1999), some authors associate the current abundance of *G. tagoara* to anthropogenic disturbances, such as the extraction of palm heart from *Euterpe edulis*, a usually dominant tree species in non-disturbed areas (Araujo, 2008; Fantini and Guries, 2000).

Bamboo dominance and its subsequent effect on plant and bird communities is well studied in Carlos Botelho state park (Lima et al., 2012; Rother et al., 2009, 2013a, 2013b). Recent research indicates that seed rain is not greatly altered by the presence of *G. tagoara* (Rother et al., 2009), which, however, exerts a negative influence on seedling establishment, a crucial stage for plant regeneration (Rother, 2006; Rother et al., 2013a). Interestingly, this finding did not apply to seedlings of *E. edulis*, which were found to be present in greater density within bamboo dominated patches (Rother, 2006). Bamboo effects upon the early recruitment of non-bamboo species were thus demonstrated to be patchy and species-specific, with patches of bamboo dominated succession exerting a far-reaching influence over the heterogeneity of plant species composition and abundance (Rother et al., 2013a).

*E. edulis* is the dominant species of palm in the understory of the Atlantic forest. It is also threatened by illegal overexploitation (Galetti and Fernandez, 1998). Within Carlos Botelho State Park, *E. edulis* populations are reducing rapidly as a result of this intense exploitation (Muler et al., 2014; Rother et al., 2009). Bamboo expansion has also been linked to this exploitation (Araujo, 2008, Fantini and Guries, 2000).

*E. edulis* has characteristics that amplify its ecological importance in the forest ecosystem. Its historic abundance lends the species a central place in the vegetation structure and dynamics of the Atlantic Forest, rendering it a priority species within forest management plans and conservation efforts. It also plays a key role concerning the attraction and retention of seed dispersers by annually producing large quantities of fruit, most crucially within the food shortage period (Castro et al., 2007; Fadini et al., 2009).

As the only species in the local plant community which did not suffer any limitation by bamboo in the early stages of the regeneration cycle, the study of *E. edulis* population structure in bamboo dominated forest has the potential to function as a model for evaluating the consequences of bamboo thickets on forest dynamics (Rother et al., 2013a).

In the literature, there are plenty of studies that investigate the effects of a plant species population on other plant species population (Wang and Augspurger, 2004, 2006). Nonetheless, remain scarce studies focusing on the influence of bamboo species on plant populations. Considering that bamboos exert a negative influence on the plant community, our main goal was to investigate how this influence manifests at the population level. We compared the demographic structure of *E. edulis* between bamboo and non-bamboo dominated patches within the Brazilian Atlantic forest where *G. tagoara* has created a marked patchiness and heterogeneity in the vegetation (Muler et al., 2014; Rother et al., 2013a).

The demography of natural populations of *E. edulis* has been well studied (Melito et al., 2014; Meyer and Dornelles, 2009; Raupp et al., 2009; Reis et al., 2000; Silva, 1991; Silva et al., 2009). We are interested here, however, in evaluating whether different habitats characterized by the extent of bamboo dominance can lead to different demographic structures of *E. edulis*. Also, we are interested in characterize both patches regarding canopy openness and litter depth. After considering the pre-existing literature, we hypothesized that bamboo dominated patches would show an arrested recruitment of *E. edulis* in the later stages due to a possible physical barrier to the growth of this palm. Finally, we discuss the influence of bamboo dominance and microhabitat characteristics on the future of *E. edulis* populations in the Atlantic forest.

## 2. Materials and methods

### 2.1. Study site

The study took place in a 10-ha permanent research plot located within Carlos Botelho state park (Fig. 1), a reserve of over 37,000 ha of well-preserved Atlantic rain forest (*sensu* Morellato and Haddad, 2000) located in the state of São Paulo, SE Brazil. The study site (24° 10′ S, 47° 56′ W; 350–450 m a.s.l.) is covered by tall (20–30 m) lowland old-growth forest with an opened understory. During the study period, the mean temperature was 21.1° C (range 17.4–25.2° C), and the site received 3384 mm of rainfall. Rains are well distributed throughout the year, but the rainiest and hottest season occurs from December to March.

Approximately 3 ha of the study area is covered by *G. tagoara* which form scattered patches throughout the plot. *G. tagoara* is a perennial plant with woody stems 8–15 (–20) m high, 5–10 cm diameter, erect at the base but scandent at the apex. Stems have spines on nodes, more developed in the lower nodes, hollow internodes, and deciduous leaves sometimes persistent in the basal nodes. The genus *Guadua* is widely distributed throughout the Neotropics and contains around 30 species (Londoño, 1998; Young and Judd, 1992). *G. tagoara* occurs within the Brazilian Atlantic forest in areas of secondary growth (Fantini and Guries, 2007). The reproductive behavior of this species needs further studies, but there are indications that the populations die after fruiting period (Alves, 2007).

In non-bamboo dominated patches vegetation is characterized by the presence of trees, woody lianas and epiphytes in an abundance that differentiate them from other vegetation formations (Dias, 2005; Veloso and Oliveira Filho, 1992). It is similarly covered by a tall (20–30 m) lowland old-growth forest with an opened understory where the palms *E. edulis* (269.8 individuals.ha-1; unpubl. data) and *Geonoma* spp., and arborescent ferns (Cyatheaceae) are common. Myrtaceae, Lauraceae, Rubiaceae, Fabaceae and Sapotaceae are the richest plant families (Dias, 2005).

### 2.2. Species

*E. edulis* (hereafter *Euterpe*) is one of the most abundant understory tree species in the Atlantic Forest, occurring at an approximate density of 224 individuals.ha$^{-1}$ when counting trees with diameter at breast height (DBH) > 4.8 cm (Rodrigues, 2006). Individual palms produce 1–5 infructescences annually bearing on average over 3000 fruits each (Mantovani and Morellato, 2000). *Euterpe* fruits are globose drupes containing a single rounded seed which averages 12 mm in diameter (Pizo and Vieira, 2004). Fruits are eaten by a variety of animals, including birds and mammals, which disperse the seeds (Galetti et al., 1999).

### 2.3. Data collection

#### 2.3.1. Euterpe demography

Twenty 10 × 10 square plots were set up randomly in bamboo