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Notes and Comments

Recovery of a degraded area using *Platycyamus regnellii* (Fabaceae) saplings

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The degradation of nature has been one of the relevant topics in expert debates on the subject (Joly et al., 2014). The removal of vegetation cover from the soil is primarily driven by the establishment of new areas for agriculture, pastures, mining, and urbanization (Tagore et al., 2021). Over 140 million hectares in Brazil are degraded, including 50% of pasture areas that are either abandoned or suffering from advanced erosion (Terra et al., 2019). Pioneer plants are used to recover degraded areas as the exotic trees *Acacia mangium* Willd (Fabaceae) and *A. auriculiformis* A. Cunn. Ex Benth. (Fabaceae) (Mota et al., 2023; Lima et al., 2024). The restoration work is based on the premise that the development and growth of tree vegetation directly contribute to the reestablishment of an ecosystem, as the structure, biomass, and species diversity of trees are linked to environmental functions and fauna colonization (Monteiro et al., 2019). Vegetation, as a primary producer in the food chain, is fundamental for the success of restoring a degraded area, and the use of species adapted to the edaphoclimatic factors of the region should be a priority in project development (Marcuzzo et al., 2015).

The tree *Platycyamus regnellii* Benth (Fabales: Fabaceae), native to Brazil (endemic), has various uses such as pharmaceutical applications, construction, carpentry, and manufacturing due to the quality of its wood (density= 0.81). It is also suitable for landscape projects, reforestation, and the restoration of degraded areas (Ferreira et al., 2015; Moura et al., 2016). This plant forms nodules with nitrogen-fixing bacteria, enhancing the biological fixation of atmospheric nitrogen (Barberi et al., 1998). It is a climax tree (ecological group) and occurs in Cerrado and Atlantic Forest with soils of median to high fertility. Combined with its insect-attracting flowers, it becomes a good option for reestablishing vegetation cover in degraded soils (Marinho et al., 2014).

Insects are excellent bioindicators for assessing the success of the restoration process, as they are highly sensitive to structural changes in an ecosystem and environmental variations. They exhibit a great diversity and abundance of species and play a significant role in biological processes (Oliveira et al., 2014; Burgio et al., 2015). Fertilization, plant age, leaf mass, nutrition, and chemical components influence arthropod responses to the environment, directly affecting their reproduction, survival, and growth (Bowers and Stamp, 1993; Oliveira et al., 2014; Parmar et al., 2016). Disturbances in the environment are measured by analyzing changes in the abundance, diversity, and composition of insect groups at the levels of orders, families, and species, observing how these change throughout the restoration process (Oliveira et al., 2014). An tree can be an island for insects (e.g., mass ratio), and with the larger canopy has the higher the abundance and diversity of insects these animals (Burns, 2016; Demolin-Leite et al., 2017).

The objectives of this study were to evaluate, in the first and second years of planting, the numbers of leaves per branch, branches per sapling, chewing insects, sap-sucking insects, and predators, including spiders. The study also aimed to assess their abundance, richness, and diversity indices, as well as the percentage of ground cover (e.g., litter), in a degraded area. Two hypotheses were evaluated: **i)** older *P. regnellii* saplings would have larger canopies (>IBG) and greater ground cover (e.g., litter), promoting the recovery of the degraded area, and **ii)** the abundances, diversities, and species richness of herbivorous and pollinator insects, as well as predators and protocooperators, would be higher in older plants due to their larger canopies (>IBG).

The study was conducted in the *Instituto de Ciências Agrárias da Universidade Federal de Minas Gerais* (ICA-UFMG) (latitude 16° 51” 38’ S, longitude 44° 55” 00’ W, altitude 620 m). It lasted for 24 months, starting in March 2020 and ending in February 2022. The experimental design was completely randomized, with 24 repetitions (saplings) and treatments in the first and second years of *P. regnellii* sapling planting. Information on climatic conditions, soil, seedling production, spacing between plants in the field, irrigation, and fertilization in this area are available (Gomes, 2018).

The number of leaves/branch and branches/sapling, as well as the percentage of ground coverage by litter, grasses, and herbaceous plants, were visually and monthly evaluated in 1.0 m^2 plots within the canopy projection of each of the 24 *P. regnellii* saplings. The arthropods, including

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defoliation (%), were counted biweekly through visual observation on both the abaxial and adaxial leaf surfaces during the morning period (7-11 am). Each observed repetition (sapling) was divided into the apical, middle, and basal parts of the canopy, and the leaves were analyzed in the north, south, east, and west orientations, totaling 12 leaves evaluated per sapling in the 24 *P. regnellii* plants. The captured insects were stored in 70% ethanol, separated by morphospecies, and sent for identification. The ecological indices of abundance, diversity, and species richness were calculated. The abundance and species richness indices refer to the total number of individuals and species in each sample unit, respectively. The diversity index was calculated using the Hill formula (1st order): N1 = exp (H'), where H' is the Shannon–Weaver diversity indices, calculating diversity with the current number of species (Hill, 1973).The numbers of leaves/branch, branches/sapling, chewing insects, sap-sucking insects, predators including spiders, as well as their abundance, species richness, and diversity indices, and the percentages of ground coverage and defoliation by insects were subjected to the Wilcoxon test (*P*< 0.05) (Wilcoxon, 1946). As the data collected did not present a normal distribution, we chose the non-parametric Wilcoxon test as it is the most powerful test locally among all the classification methods (see Salov, 2014). The relationships between the abundance, species richness, and diversity of arthropods and the numbers of insects from different functional groups (e.g., sap-sucking insects) with plant variables (e.g., branches/sapling) were tested using regression analyses (*P*< 0.05). Non significant data was in Supplementary Material I.

The number of branches/sapling was higher (*P*< 0.05) in the second year of *P. regnellii* cultivation, while the number of leaves/branch and the percentage of ground coverage (e.g., litter) did not differ significantly (*P*> 0.05) between the years (Table 1). These findings partially support the first hypothesis: older *P. regnellii* saplings will have larger canopies (>IBG) and greater ground coverage production (e.g., litter). The wood of *P. regnellii*, known for its high quality and use in carpentry and manufacturing (Lorenzi, 2008), has a slower growth rate compared to fast-growing trees (Rozenberg and Cahalan, 1997), which may explain the above results. Other plant species such as *A. mangium* and *A. auriculiformis* have shown better results than *P. regnellii* (Mota et al., 2023; Lima et al., 2024). However, the genus *Acacia*, being exotic (originating from Indonesia, among others), may spread its seeds and alter the biome of the area (Silva et al., 2015), which is not a concern with *P. regnellii*, as it is native to Brazil. Furthermore, *P. regnellii* has other interesting characteristics for the recovery of degraded areas as a highly attractive floral fragrance to insects, the ability to fix atmospheric nitrogen, and high photorespiratory capacity in regions with high solar radiation (Marinho et al., 2014).

The numbers of the predator Dolichopodidae (Diptera) and the tending ants *Camponotus* sp. (Hymenoptera: Formicidae) were higher (*P*< 0.05) in the second year of cultivation on the leaves of *P. regnellii* saplings. There were no significant differences (*P*> 0.05) for the other arthropods observed on the leaves of *P. regnellii* saplings and their ecological indices of abundance, species richness, and diversity, as well as the percentage of defoliation by chewing insects, between the cultivation years (Table 1). A higher number of leaves/branch increased (*P*< 0.05) the abundance and species richness of chewing insects, the abundance of sap-sucking insects, and the number of *Phenacoccus* sp. (Hemiptera: Pseudococcidae) on *P. regnellii* saplings. Additionally, a higher (*P*< 0.05) number of branches/sapling increased the number of the sap-sucking insect Pentatomidae (Hemiptera) on these saplings. These facts confirm the second hypothesis: the abundances, diversities, and species richness of herbivorous and pollinator insects, as well as predators and protocooperators, would be higher in older plants due to their larger canopies (>IBG). In the food web, plants are primary food producers and thus affect a wide range of species, especially phytophagous

Table 1. Numbers of branches/sapling, Dolichopodidae (Diptera), and *Camponotus* sp. (Hymenoptera: Formicidae) per *Platycyamus regnellii* sapling (Fabaceae) (mean ± SE) and evaluation year; and the relationships between the vegetable mass and ecological indices and number os insects.

Variables	Year		Wilcoxon test	
	First	Second	*Test Valour*	*P*
Branches/sapling	1.57±0.24	2.98±0.32	3.29	0.00
Dolichopodidae	0.00±0.00	0.24±0.15	1.77	0.04
Camponotus sp.	0.00±0.00	0.24±0.09	2.35	0.00

Simple regression analysis	R^2	ANOVA	
		F	*P*
Abundance of chewing insects= -0.34 + 0.19 x Leaves	0.14	6.59	0.01
Species richness of chewing insects= -0.26 + 0.16 x Leaves	0.15	7.04	0.01
Abundance of sap-sucking insects= -2.54 + 0.64 x Leaves	0.12	5.20	0.02
Number of *Phenacoccus* sp.= -2.77 + 0.69 x Leaves	0.11	4.99	0.03
Number of Pentatomidae= 0.09 + 0.10 x Branches	0.14	6.28	0.01

n= 24 per treatment. Leaves=number of leaves/branch, and Branches= number of branches/sapling.

insects, providing them shelter and serving as a food source (Souza et al., 2021; Sousa et al., 2024), which directly implies their ecological significance (França et al., 2014), explaining the improvement in ecological indices of abundance, species richness, and insect diversity, mainly sap-sucking insects observed with the increase in leaves/branches (e.g., *Phenacoccus* sp.) and branches/ saplings (e.g., Pentatomidae) on the studied plants, in other words, an increase in biomass (> BGI). The higher BGI in *A. mangium*, *Sapindus saponaria* L. (Sapindacea), and *Terminalia argentea* Mart. & Zuc (Combretaceae) resulted in increased diversity of tending ants, diversity of natural enemies, and abundance and species richness of sap-sucking insects (Costa et al., 2021; Souza et al., 2021; Silva et al., 2023; Lima et al., 2024). The numerical increase of *Camponotus* sp. ants is associated with the numerical increase of *Phenacoccus* sp. sap-sucking individuals through the tritrophic interaction among plants, sap-sucking insects, and tending ants (Stadler and Dixon, 2005; Araujo et al., 2016). This interaction occurs because ants feed on the honeydew produced by hemipterans and the nectar from extrafloral nectaries (Bluthgen et al., 2000; Peeters et al., 2017), which quantitatively improve with tree size (Campos et al., 2006), and defend the sap-sucking insects from their natural enemies (Zhou et al., 2015). Moreover, tending ants are most abundantly reported in association with tropical tree canopies (Floren and Linsenmair, 1997), and among other microhabitats, they can nest under tree bark (McArthur, 2007, 2009; Klimes et al., 2012). Adult Dolichopodidae flies are important predators that feed on soft-bodied invertebrates such as mites, thrips, aphids, and others, and their larvae are found in habitats like tree trunk holes and under tree bark, where they can be predators or scavengers (Bickel, 2009), thus their improvement in the numerical index of individuals can also be associated with the sap-sucking *Phenacoccus* sp..

The higher production of leaf mass and certain arthropods in the second year of cultivation indicates that *P. regnellii* is a promising choice for the restoration of degraded areas. It can be concluded that the increased plant mass in *P. regnellii* saplings had a positive impact on certain insects, confirming the theory of the biogeographical island.

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Supplementary Material

Supplementary material accompanies this paper.
Supplementary material I.
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