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Description of Damage to *Pinus Taeda L.* Trees by Wild Rodents

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Abstract

Habitat mosaics exist in exotic forest plantations. These areas, when altered, favor the emergence of several species of wildlife that cause damage to forest stands. Attacks on wild trees (*Pinus* spp.) by rodents are described in Brazil, but management of this problem is not widespread due to lack of technical knowledge. The objective of this study was to describe the damages on *Pinus* spp. trees by wild rodents. The study was conducted in two farms with *Pinus spp.* plantations in the city of Otacílio Costa, Santa Catarina, Brazil. The exotic forests present on the farms are planted in mosaic with native vegetation. The native vegetation of these areas is, basically, composed by permanent preservation areas (PPA) and legal reserves (LR), denominated wild areas. In order to describe the damage to *Pinus taeda* by wild rodents, we evaluated all plantations aged between one and eight years (n=61) on forest plantations consisting of *Pinus* spp., at South Brazil. We established plots for evaluation of plant attacks and tree lesions in 10% of attacked stands in these sites. Of the 61 plots assessed, 48 showed damage. The most frequent lesions are characterized by damages of continuous format (n=322:60%), of intermediary degree of disturbance (n=247:46%) and serious extension (n=349:65%). The intensity of the attacks ranged from 26.8% to 90.6% and increased with proximity to the native area. Conclusion demonstrate that, there are more than one species of rodent can cause the lesions to trees. The analyzed lesions were described and separated into three discrepant types. It is understood that the wild rodent attacks on *P. taeda* trees is associated with the presence of herbaceous stratum in the interior of the plantation and the successional stage of the surrounding native areas.

Keywords: Exotic pine, *Euryzygomatomys spinosus*, *Myocastor coypus*, Lesions

INTRODUCTION

The distribution patterns of species, on diversity and on the structure of the communities of small non-flying mammals related to distinct environments that integrate the Atlantic Forest biome are little known yet (PARDINI e UMETSU, 2006). Such knowledge scarcity hinders initiatives of management and conservation, as well as regional analysis of the habitat (CADEMARTORI *et al.*, 2008). According to Vital (2007), currently, forestry companies perform the management of habitats that, due to the technical knowledge accumulated, intercalate native forest rows with plantations on a mosaic form. These plantations in mosaic allow the interconnection between natural habitat and farmed forest and constitute a corridor between forest fragments, what diminishes environment impact of farmed forests, allows the transit of animals and broadens the habitat available to the local fauna (CAMPBELL *et al.*, 2005). Associated to the habitat enlargement, the animal foraging areas are also enlarged. These areas, when altered, provide the rise and dispersion of many species that have become harmful to forestry stands. As the intensification of Brazilian silviculture of homogeneous stands of *Pinus* spp. is recent, dating to the 1960 decade, all the possible plagues that may affect these newly created environments are yet to be known (ANDREIV e FIRKOWSKI, 2006).

The appearance of plagues in forests as a result of the animal-plant interaction was described by Firkowski (1993) and Sullivant *et al.* (1993). The same authors mention that the permanence of an animal in one place also depends on the shelter provided by the vegetation. Consequently, the relation between the herbaceous extract presence and the occurrence of damages caused by wild rodents to *Pinus* spp. trees are evident. The wild rodent attacks commonly occur on plantations near-native areas from 3-4 years old, on locals where there is a formation of microhabitats by the herbaceous extract. The maximum linear distance of the attacked plant in relation to the native areas does not overcome 200 m (STEINER, 2009).

Also, Andreiv e Firkowski (2006) affirm that, considering the fur morphology found on the base of the damaged trees, the dimension (width) of the incisors in recent panels and the dimension and form of debris formed in confinement, probably the

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rodent commonly named as spiny rat, *Euryzygomatomys spinosus* Fisher, is the causer of the damages. Gonçalves *et al.* (2007) also describe this species as the causer of the damages in Rio Grande do Sul. Supposedly, this animal search in the trees for some food substance not found in the natural environment (WALKER e SEUKAMP, 1977; ANDREIV e FIRKOWSKI, 2006). Nevertheless, data regarding to this behavior are inconclusive.

Many gaps involving rodent attacks to *P. taeda* trees justify the continuity of evaluations of the lesions found, starting by describing the damages. Thus, the objective of this study was to describe the damages on *Pinus* spp. trees by wild rodents.

MATERIALS AND METHODS

Study area

The study was conducted in two farms with *Pinus* spp. plantations in the city of Otacílio Costa, Santa Catarina, Brazil. The areas are called Bom Retiro II e Bom Retiro III. The Bom Retiro II farm comprises an area of 1,451.8 ha and it's composed by 50 forest plantation plots handled to pulp production, while the Bom Retiro III farm has 1,603.1 ha and is composed by 47 plots with the same objective.

The adopted management on the study locals is the pulpwood, which main characteristics are the absence of pruning and thinning. The trees remain with the branches since the base of the trunk along the entire cycle of the culture, excluding the cases in which occurs natural pruning. The main planted species in both the farms is the *Pinus taeda* L., although plantations can be found with planted *Pinus elliotti* Englen, *Eucalyptus benthamii* Maiden et Cambage and *Eucalyptus dunni* Maiden.

The exotic forests present on the farms are planted in mosaic with native vegetation. The native vegetation of these areas is composed of permanent preservation areas (PPA) and legal reserves (LR), denominated wild regions.

Characterization of attack and damage

On both farms, the plots between one and eight years (n=61) were assessed to verify the damage occurred between the different ages. Damage records on other farms were performed, in order to determine the amplitude of damage occurrence and its distribution on the estate of Santa Catarina.

On five of the 48 plots, were the occurrence of damage caused by rodents was verified, it was attempted to characterize the damages. Systematically, 10 plots with 400 m² (20 m x 20 m) were allocated on each plot, totalizing 50 plots corresponding to 20,000 m², or approximately 2,600 assessed trees. The measured plots were denominated: D4A, D5B, D9B, G2C e G3C. The damages were characterized through visual analysis of the lesions, observing alterations in the region of the plants base and in general appearance of the tree, individually.

Characteristics of the plant and the damage were noted. The collected variables of each plant were the presence or absence of lesions and the phytosanitary state. The collected variables regarding the damage were: the starting height of the lesion in relation to the ground; the maximum height of the lesion on the trunk; the presence of marks from anatomic structures of rodents in the cortex or the alburnum; the presence of over attacks (attack recurrence); and the size of bark fragments removed by the rodents and left at the tree base. The presence of damages on already attacked trees were considered as evidence of over attack.

Each plant had its base inspected in search of lesions, according to the criteria utilized by STEINER (2009):

a) Damage shape: punctual – lesions disposed of randomly in the base region with no connection among lesions; continuous – symmetric lesions with homogeneous form.

b) Degree of damage disturbance: superficial – when removal of rhytidome occurred; intermediary – when it has reached a portion of the cambium; profound – when the lesions reached the alburnum.

c) Damage extension in the circumference of the base: Slight – when the damage extension is smaller or equal to 50% of the base circumference; Serious – when the damage extension is more significant than 50% of the base circumference; Girdled – when the damage extension reached the entire base circumference.

To determine the size of cortex fragments removed by the rodents, the accumulated fragments were collected on the base of 30 attacked trees. Those 30 samples were subdivided according to the similarities of the damage found, in relation to the shape, the degree of disturbance and the extension. Each sample was composed by, at least, 30 randomly selected fragments, which were measured in length and width. General data from the environment were also registered, as the presence or absence of weed competition and the existence of environmental readjustment in the permanent preservation area.

Statistical analysis

The consequent data from this evaluation were grouped by the frequency of occurrence of different lesion typifications, allowing the discrimination of tendencies, through descriptive statistics. The analysis the analyzes were performed with R Development Core Team (2011).

RESULTS

The attack and the damage

The 61 inspected plots that had plantations between one and eight years old, attacks were registered in 48 plots. Damage were only found on *P. taeda* trees. In evaluations of plots of other species (*P. elliotti*, *Eucalyptus* spp.) and in native areas no lesions similar to those verified in *P. taeda* were found. The damages were present since the third to the seventh year of the trees. At the eighth year, no lesions were found on the trunks. Damages were found in various plantations of *P. taeda* from the city of Monte Castelo to Lages, on the state of Santa Catarina and towards the East of the State, to the city of Bom Retiro.

The most frequent lesions are characterized by damages of continuous format (n=322:60%), of intermediary degree of disturbance (n=247:46%) and serious extension (n=349:65%).

The cases of greater concern are quantified when the shape of continuous damage, deep degree of disturbance and girdled

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extension are combined.

The values of attack intensity varied from 26.8% up to 86.5% of attacked plants per plot. The D5B plantation presented the highest incidence of attacks, where of the 537 plants assessed, 86.5% (n=465) presented lesions (Figure 1). The most serious damages resulted in the death of the plants (n=17:3%). In this plantation, elevated indexes of over attack were recorded (n=472:97%).

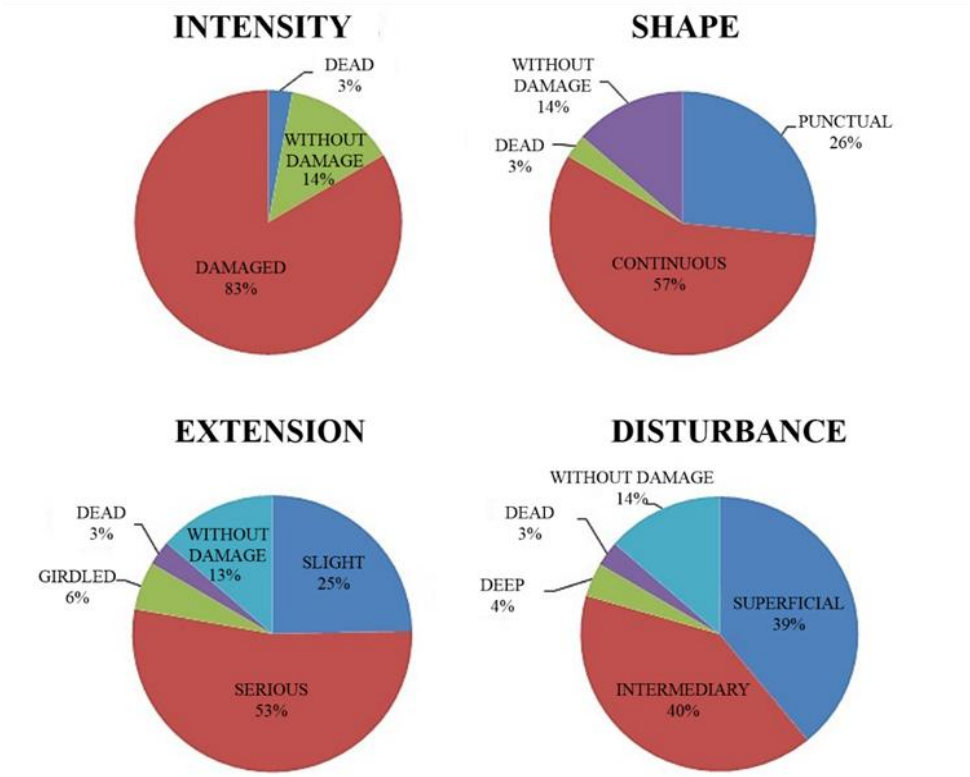

Figure 1. Qualitative and quantitative characterization of the damage caused by wild rodents in *P. taeda* trees at Farm Bom Retiro III, in the stand with the highest incidence of attacks (D5B), Otacílio Costa / SC, 2011.

The damage caused by wild rodents in *P. taeda* involved the removal of the cortex, exposing the phloem cells, which are extracted by the scraping of the incisor teeth of the rodent, also removing the meristematic cells (cambium). There were no pieces of evidence of the use of claws or other anatomical structure to the bark removal, remaining on all attacked trees the marks of the rodent teeth. The removed cortex fragments accumulated at the base of the trunk, while the phloem and cambium cells not visualized. The results obtained with the measurement of cortex fragments removed by the rodents, gathered to the evaluations of damages formed groups of lesion characteristics in three different types:

Type 1 – punctual lesion or continuous, sometimes girdling the base of the trunk, with the height of no more than 30 cm, starting from the ground. The bark fragments do not exceed 1.8 cm in length and 0.7 cm in width (Figure 2 A).

Type 2 – Continuous lesion, but not girdled, not exceeding 70% of the trunk diameter. The lesion begins at approximately 20 cm from the ground and reaches up to 68 cm in height. The bark fragments found can reach 4.5 cm in length and 2.3 cm in width (Figure 02 B).

Type 3 – Non-girdled punctual lesion, located from the base of the tree up to 50 cm high, approximately in the second layer of existing branches. It is noticed that the causer of this lesion scales the branches and uses them as support to reach locals farther from the ground. In those locals, the lesion was found only around the semicircular shaped branches (Figure 02 C).

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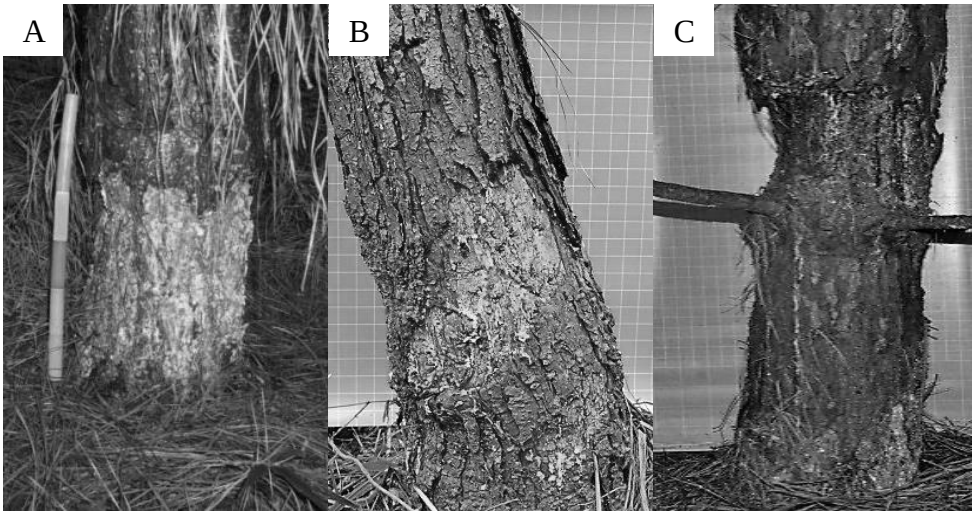

Figure 2. The general appearance of different lesions types found in *P. taeda* trees, caused by wild rodents. (A) Lesion type 1. (B) Lesion type 2. (C) Lesion type 3.

The areas adjacent to the type 2 damages were formed by flooded regions, were six individuals of *Myocastor coypus* Molina (Coypu) were registered.

In all the plots with the presence of attack, the vigorous expression of weed competition was perceptible. In plots were the PPA was at a later stage of succession the damage was not recorded. The intensity of attacks was bigger in regions of the plot close to the native areas, being able to reach 100% of the trees assessed in the plot.

On attacked plots, the adjacent wild areas was passing through environmental adequacy assessment (changes in the size of permanent preservation areas and legal reserve), according to the current legislation. The vegetation was in the initial stage of regeneration, being composed mainly by trees/shrubs of pioneer species and grasses.

DISCUSSION

Andreiv and Firkowski (2006) warned of damage in the cities of Ponte Alta do Norte, São Cristóvão do Sul, Santa Cecília, Curitibanos, Brunópolis and Lages, corroborating with the sites described in this study. The damages by wild rodentss are widely distributed in assessed farms, in other words, in 48 of the 61 plots assessed (n=78.6%), which is confirmed by the same authors in the evaluated areas in the city of Ponte Alta do Norte.

Furthermore, Schonherr *et al.* (1973), evaluating plagues in the southern region of the country, mentioned that adult plantations are also subject to rodent attack, as well as the *P. elliotti* species. Such fact is not consistent with the observed in this study since damage was only verified in young trees of *P. taeda* species. Unlike this, Steiner (2009) reinforces this statement, mentioning that in the plots evaluated by him only *P. taeda* trees presented damages.

It was verified through damage assessment that injuries are caused exclusively by rodent incisor teeth. According to the variables collected in the evaluation of the damage of wild rodents to *P. taeda* trees, it is reinforced the hypothesis that more than one species utilizes this resource, unlike the hypothesis of Andreiv and Firkownki (2006), which suggest that the marks are caused only by the spiny rat (*E. spinosus).* These characteristics were also observed by Walker and Seukamp (1977) in the United States, where rodents are classified as the main predators of saplings and more than one species utilizes this resource source. Schonherr *et al.* (1973) also identified the damage to trees and related the removal of bark from conifers to *Cuniculus paca* Linnaeus (Paca), *Cavia fulgida* Wagler (Shiny guinea pig), *Dasyprocta azarae* Lichtenstein (Agouti) and *Hydrochoerus. hydrochaeris* (Capybara).

Biometrically, type 2 lesions are closely related to *M. coypus*. The coypu (*M. coypus*) is a medium sized mammal, 70-100 cm in length, weighing up to 7 kg. The incisors of this animal have a width of 0.8 cm ± 0.2 (BONVICINO *et al.*, 2008). This rodent, due to its characteristics, is the mains suspect of causing lesions in regenerating *P. taeda* trees in regions close to flooded areas.

The type 2 lesions, described above, are not related to *E. spinosus*, as reported by Andreiv e Firkowski (2006), since they present dimensions up to 26 cm height, from the base of the tree (mean height of 13.5 cm). This type of lesion was also found in the studied areas and was defined as type 1. *E. spinosus* is related, therefore, as responsible for type 1 lesions, the most abundant found in this study. This species has incisors with width ranging from 1.95 to 2.05 cm, dimensions of 20.8 to 27.0 cm and weight ranging from 170 to 100 g (BONVICINO *et al.*, 2008).

The type 3 lesions are not related to the species described in the literature, which requires the continuity of monitoring of the areas with the presence of this type of lesion, including animal inventory techniques. Although the determination of the species causing the lesions takes into account indirect observations, it is possible to discriminate different types of lesions and to indicate the causers, with reliability. Teipner *et al.* (1983), consider that indirect data of the lesions allow concluding which species is the causer of the damages.

Besides the determination of the causal agent of the damages, the study of lesions found in *P. taeda* trees contributes to the definition of forest planning strategies, based on the level of damages. By detailing different lesions, specific results for each field are provided, allowing more precise decision-making.

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Walker e Seukamp (1977), in studies in the Northern Hemisphere, place of the natural occurrence of the *Pinus* genus, mention that the attack of rodents can reach 100% in homogeneous plantations and result in 64% of mortality. Nevertheless, unlike what is verified in recent descriptions, the attacks to trees in the United States commonly occur when plants are in early stages of growth up to one year old.

Steiner (2009), at Lageadinho farm, located in the city of Monte Castelo, verified worrying data with mortality higher than 6% after the fourth year. For Monte Castelo, the pattern is distinct, being of a continuous format (70%), of deep degree of disturbance (60%) and serious extension (51%) (STEINER, 2009). Andreiv e Firkowski (2006), evaluating a stand with 415 damaged trees, accounted 197 trees (47.5%) presenting more than 50% of the circumference of the base damaged and 10.6% with complete girdling, which could, therefore, have caused the death of these trees.

In the present study, 6% of girdled plants were found, which possibly reflects the mortality (3%) at an age higher than 4 years. The death process could be visually identified by the chlorosis of the canopy. Besides promoting the death, such damages, when partial, cause injuries, exposing intern tissues to diseases and plagues that may affect the resistance of trees (SULLIVANT *et al.*, 1993; FIRKOWSKI, 1993).

The damages intensity may vary according to the causing species, the population density, the attack duration, the developing stage and the attacked vegetable structure (SANTANA *et al.*, 2005). The rodent attacks to the *P. taeda* trees were located mainly on places close to native areas, which were submitted to environmental adequacy, in other words, to removal of the exotic trees of the permanent preservation area, according to the current environmental legislation. These areas were submitted to a recovery process and forest regeneration.

According to Chazdon (2007), regeneration is a process of secondary succession at a community and ecosystem level over a deforested area that previously contained a forest. The successional process proceeds in stage progressions during which forests present a progressive enrichment of species and an increase of functional and structural complexity. Former fields that initially replace abandoned clearings become regenerating young forests, dominated by pioneer tree species of fast growth and high dispersion rate. With time, plant and animal species that are characteristic of initial stage forests slowly replace the successional pioneer species. According to Pinotti (2010), these structural changes, floristic and functional that occur during regeneration should result in habitat characteristics changing that are important to the fauna.

It is known that the wild rodent attacks to *P. taeda* trees are related to the successional condition of the native areas. The high population of rodents, related to the initial stages of forest succession of the native areas, forces these animals to explore different feed and habitats, compelled by adverse environment conditions. (SULLIVANT *et al.*, 1993). The gradual evolution of the forest succession of native areas can be related to the wild rodent attacks to *P. taeda* trees.

In homogeneous forests, where the natural balance was heavily altered, the density of an animal species can considerably increase due to the lack of natural enemies and to a specific occupation capacity (Andreiv e Firkowski, 2006). This comparison based on the increase of the population size can also be related to environmental factors such as the large supply of biomass (seeds), widely used by rodents, and with high energy power, from the grasses that colonize the area on the first stages , associated to the absence of predators in this phase and also to the ecologic strategies of the rodent species registered, recognized the "R" strategists. (PAGLIA et al., 1995; STRATZULAS, 2013).

The use of *P taeda* by wild rodents as energetic source is connected to the existence of the herbaceous stratum associated to the planting, which offers favorable conditions to the presence of these animals. The attacks are no longer recorded when, firstly, the PPA is at a later regeneration stage (but still initial) and, finally, when the microhabitat formed by the herbaceous stratum inside the plantation, ceases to exist, due to the needle leaves accumulation on the soil and reduction of the transmittance by the canopies closure. In the eight years, old plots assessed, no lesions were found, for at this time, the treetops had already closed the canopy and the needle leaves had already accumulated under the trees, ceasing the weed competition.

CONCLUSIONS

- More than one species of rodent can cause the lesions to trees. The analyzed lesions were described and separated into three discrepant types.
- It is understood that the wild rodent attacks on *P taeda* trees is associated with the presence of herbaceous stratum in the interior of the plantation and the successional stage of the surrounding native areas. These animals utilize the plantation of *P. taeda* as foraging areas, due to the availability of food resources found in the sap of the trees, when there is a favorable condition to the displacement/permanence resulting from the presence of the herbaceous stratum associated to the plantation.

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