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Selective bark stripping of various tree species by Polish horses in relation to bark detachability

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ABSTRACT

A test was conducted on the relation between the intensity of bark stripping by Polish primitive horses and the directly measured degree of bark detachability. A DI (damage index) was calculated for particular tree species, using those measuring 5–20 cm DBH (diameter at breast height), separately for five DBH sub-classes. Bark detachability measurements were taken using a dynamometer in ten selected tree species. The results for eight of these species showed a decreased DI the greater the DBH value and distinct differences between species (with DI varying between 0 and 2.79). The force (N) and relative force (N/g dm) used to detach a piece of bark differed between species, but this difference was not always statistically significant. The force required to detach bark generally decreased with DBH subclass, whereas this tendency did not apply to the relative force.

A regression model explained less than 20% of the DI variability, and extent of damage (DI) significantly decreased with the mean relative force. Based on these results, it can be concluded that relative force (that required to detach 1 g of bark) is one of the direct factors influencing the selection of different tree species by horses.

1. Introduction

Bark stripping by native ungulates constitutes a serious problem in forest management (Gill et al., 2000; Takeuchi et al., 2011). Bark damage can seriously affect the structure of forest stands, and the dynamics and composition of associated fauna (Gill, 1992b; Smit et al., 2015; Stewart, 2001). Depending on injury size, tree age and species, bark damage can have a significant negative impact on tree condition (Smit et al., 2015; Welch et al., 1997). Debarked trees undergo changes that may result in timber quality and growth rate reductions, breakage at a wounded place and death (Côté et al., 2004; Gill, 1992b). Intense bark damage within a forest habitat is the result of various factors such as ungulate density, season, adjacent vegetation, and topography, and differs among tree species and age (Akashi and Terazawa, 2005; Yokoyama et al., 2001).

Wild ungulates consume the bark of various tree species. Red deer, regarded as one of the main debarking agents, consume the bark of more than 20 species, mostly pine, spruce, willow, poplar, rowan and ash (Borkowski and Ukalski, 2012; Gill, 1992a). Nevertheless, certain tree species are debarked with varied intensity, depending on the site (Gill, 1992a; Vospernik, 2006). Certain tree species have always been recognised as the most susceptible to bark stripping (e.g. willow, poplar) or the least susceptible (oak, lime and birch), while many other species have been placed in varying categories of susceptibility (Gill, 1992a). Moose debark mainly pine, spruce, willow and poplar, but here too, the intensity of stripping debarking differs between sites (Metslaid et al., 2013; Miquelle and van Ballenberghe, 1989). The European bison is generally more oriented towards hardwood species, mainly hornbeam, ash, spruce, lime, hazel and even oak (Okarma et al., 2008). Some tree species, such as fir and ash, are debarked by both European bison and red deer (Klich, 2015). In contrast, roe deer feed on younger and smaller trees than red deer (Gill et al., 2000). To date, not much is known regarding the foraging by horses of woody vegetation, as they have mainly been perceived as dwellers of open habitats. Kuiters et al. (2006) observed a high degree of damage to the bark of beech and rowan (relative to their proportion in stands) by Icelandic horses in forests and tree lanes highly dominated by beech (about 80% of all trees occurring). Other studies regarding the impact of horses on woody vegetation mainly focused on browsing related to vegetation characteristics in forest and meadow habitats (Cosyns et al., 2001; Hoffmann, 2002; Klich and Grudzień, 2013).

The main factors affecting selectivity in bark stripping by ungulates within or among tree species have yet to be specified. How-

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ever, some indirect factors are bark roughness associated with tree age, branch composition and habitat characteristics. Although easily accessible trees are preferred, ungulates mainly consume the bark of younger trees with smooth bark structure (Borkowski and Ukalski, 2012; Kuiters et al., 2006). Nevertheless, distinct differences between tree species were noticed, for example pines are vulnerable for 5–16 years, a period much shorter than that of other species (Gill, 1992a; Vospernik, 2006).

Several studies have examined the chemical composition of bark as a direct factor influencing ungulate selectivity within or among tree species. Results varied significantly and showed either no specificity (Ando et al., 2003; Kuiters et al., 2006; Randveer and Heikkilä, 1996) or some differences in debarking intensity, depending on chemical composition (Faber, 1996). In view of the rapid physiological response of trees to debarking (Saint-Andrieux et al., 2009), it is unclear whether vulnerability to bark stripping depends on the chemical composition of the bark (Ando et al., 2003; Saint-Andrieux et al., 2009).

Detachability may be another direct factor contributing to differences in debarking intensity within and among tree species. A theoretical background of the physical aspects of bark removal was given by De Crombrugghe (1965). Seasonal differences in bark stripped from beech were related to changes in bark tissue structure, such as easier removal during rainy days in summer. This was explained by reduced elasticity of parenchyma cells and more rapid lignification of their walls during periods of drought. This was confirmed indirectly by Saint-Andrieux et al. (2009) through measurements of the length of the detached bark, showing seasonal differences in beech bark detachment. The water content of the bark was also positively related to stripping frequency by red deer, and indicated that during spring and summer, greater amounts of beach bark were removed than in autumn and winter. Various tree species may present different degrees of bark water storage, and this may be a result of differences in bark structure (Levia and Herwitz, 2005). Consequently, differences in bark adhesion may be observed between tree species (Duchesne and Nylinder, 1996; Fiscus et al., 1983). Although other authors indicated the role of the physical characteristics of bark removal in explaining ungulates' selectivity (Ando et al., 2003; Gill, 1992a; Kuiters et al., 2006), so far no direct measurements have been taken. In this study, I hypothesise that the force required to detach bark significantly influences selection between tree species. To test this hypothesis, I compared the bark stripping activities of Polish horses to the measured force required for bark detachment. The study was performed on an enclosure of 7 ha with considerable tree species diversity.

2. Methods

2.1. Study site

The study was carried out within the acclimatisation enclosure of the former Radziejowa Village (49°17′38″N, 22°20′8″E) and forest habitats in the Głogów Forest District (near Rzeszów, Poland). The approximately 7 ha area was enclosed by means of wooden poles and the addition of a wire mesh fence in order to block access by other animals. The area was covered mainly by fresh meadows (70%), and woodlots dominated by willow *Salix caprea*, ash *Fraxinus excelsior*, birch *Betula pendula* and hazel *Corylus avellana*. During the spring of 2008 (between February 26th and May 12th), 36 horses were free to use this area for grazing, browsing and debarking, with access to hay *ad libitum*. Following an acclimatisation period, 32 horses were released to the wild on May 12th, and the remaining horses were kept in the enclosure until the end of the project on free ranging Polish horses in the Carpathians in 2009 (Skiwski and Klich, 2012). The Głogów Forest District lies in the Rzeszów foothills mesoregion and is characterised by climatic features and soil composition similar to those of the Baligród Forest District (Zielony and Kliczkowska, 2012). Forest habitats mainly constitute mixed coniferous and broad-leaf forests with soils of medium fertility. In such habitats small patches with high tree diversity also occur.

2.2. Field and laboratory measurements

Data on trees with evidence of bark stripped was gathered within the acclimatisation enclosure shortly after releasing 32 horses in May 2008. Within the enclosure, all trees and selected bushes reaching 5 cm DBH (diameter at breast height) were analysed. DBH was measured with accuracy to 1 cm. Bark damage was also measured with accuracy to 1 cm and recorded for each tree species along with DBH measurements. All bark damage that: (a) was less than 1 cm, (b) in which the bark was only partially torn from the tree or (c) in which only the outer part of the bark was damaged, were treated as failed attempts by horses. Data on bark damage caused by horses was compared with direct detachability measurements.

Detachability measurements were carried out in May 2014 and 2015 in the Głogów Forest District, due to the cutting of most trees within the enclosure following completion of the project. For these measurements, I selected similar types of habitat: fresh (i.e. with moderate water content in the soil) with mixed tree species (habitats with a large variety of species), close to the forest edge and on a smooth slope. Individual trees were selected randomly (measurements during one day covered various species with varied DBH measurements). Measurements were performed on sunny days at least five days after the most recent rain. I selected ten native tree species, which were represented by at least ten individuals each. The individuals selected had DBH values between 5 and 20 cm and were located within the enclosure (see Table 1). No individuals within the enclosure with DBH values over 20 cm were debarked.

Bark detachability was assessed by direct measurement of the force required to detach a piece of bark from a tree trunk. A simple rectangular steel woodworking clamp was used after sharpening and hardening the fixed jaw opposite the clamping screw. This fixed jaw was 1.8 cm wide and simulated a horse's tooth stripping the bark. The fixed jaw was hammered into the bark (between the bark and xylem) to a depth of 3 cm at breast height and clamped with the screw perpendicularly to the tree trunk. To avoid damage of the outer bark, a piece of wood measuring 5 × 5 cm was placed between the screw and the bark. A dynamometer with an axis sen-

Table 1
Total numbers of assessed tree species of DBH size ranging from 5 to 20 cm, the rate of damage intensity (DI - for description, see text) and remarks about force measurements.

Tree species	N	DI	Remarks
Willow	354	2.79	Force measurement
Apple-tree	10	1.1	Excluded (domestic species)
Spruce	12	0.33	Force measurement
Maple	109	0.3	Force measurement
Poplar	62	0.45	Force measurement
Alder	65	0.69	Force measurement
Fir	15	0.6	Force measurement
Beech	71	0.12	Excluded after 10 trials
Plum-tree	32	0.19	Excluded (domestic species)
Pine	15	0.0	Force measurement
Ash	299	0.0	Force measurement
Birch	735	0.0	Excluded after 10 trials
Hazel	149	0.0	Excluded (only lower DBH)
Others	123	0.0	Excluded (low numbers or domestic species)
Total	2051		