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EXAMINATION OF THE RELATIONSHIP BETWEEN DIFFERENT DENDROMETRIC QUANTITIES OF HOSTS AND MISTLETOE BUSH NUMBER

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The monitoring of presence of European mistletoe (*Viscum album*) was carried out between the years 2011 to 2013 in winter period in castle park in Lednice. The most common host taxa belong to genera *Acer*, *Tilia*, *Crataegus*, *Juglans* and *Robinia*. For statistical evaluation of collected data we used linear and exponential regression models. Our results confirmed that the mistletoe bush number was higher with increased tree height, diameter at breast height, crown volume and crown projection. In some cases (e.g. *Tilia cordata* or *Tilia platyphyllos*) the regression analysis showed higher relationship (ca. 25–35 %) between the mistletoe number per tree and diameter at breast height and crown volume. There is big difference among the hosts within similar dendrometric quantities, consequently, some host taxa are more sensitive for infection. The strongest relationship was observed in case of *Juglans nigra* (max. 45 %), which probably will be the most endangered host in the whole park.

Keywords: *Viscum album*, host woody species, mistletoe infection, regression analysis

Introduction

European or white berry mistletoe (*Viscum album* L.) from the family *Viscaceae* (Santalaceae sensu lato; Nickrent et al., 2010) is a globular evergreen, perennial, epiphytic and hemiparasitic shrub with persistent haustoria in the host (Zuber, 2004). It is able to infect 452 (mostly deciduous) woody species, subspecies, varieties and hybrids belonging to 96 genera of 44 families. Spontaneous infections of the hardwood mistletoe in Europe were reported on 384 taxa, including 190 alien, introduced trees and shrubs (Barney et al., 1998).

The distribution of *Viscum album* is quite uneven in Europe but it is one of the most common branch parasites in the Old World. Its vertical and horizontal distribution depends primarily on temperature which is needed for its optimal growth (Dobbertin et al., 2005; Zuber, 2004). Within this area its distribution depends primarily on the hosts, birds and man (Wangerin, 1937). Other factors (e.g. individual differences among host trees) are less obvious, but also may play an important role in explaining local abundance and distribution of mistletoe plants (Kartoolinejad et al., 2007). Our previous studies (Baltazár et al., 2013a) confirmed that the likelihood of infection increases with the age of trees or lowering vitality of tree. In case of *Parrotia persica* (DC.) C. A. Mey., the infection intensity has positive significant relationship with diameter at breast height (DBH), distance to conspecificity and locating in the stand edge, but no correlation was found between tree height and infection intensity. In other cases (Baltazár et al., 2013b) it was proved that the infected trees are bigger and have a greater crown volume than uninfected trees. There is also different intensity of infection in each host (Baltazár et al., 2013a; Kartoolinejad et al., 2007).

The main aim of this study was to find relationship between some dendrometric quantities and number of mistletoe bushes on tree and to confirm the hypothesis that number of mistletoe bushes will be higher with increased e.g. tree height or crown volume.

Materials and methods

The research locality Lednice is situated in southern Moravia at an altitude of 165 m above the sea level and its average annual temperature is about 9 °C and approximately 500–650 mm of rainfall per year. The field investigation was focused on the spread of European mistletoe (*Viscum album* L.) in the castle park and it was usually carried out in winter periods (from December to March) of the years 2011 to 2013. All trees were individually evaluated and the pre-eminently following data were recorded:

- Identification of individuals, which included: serial section number, serial department number, serial number of the element in a department, element type, taxon (for this purpose we used the nomenclature according to Erhardt et al., 2008).

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- Basic dendrometric quantities: tree height, crown width, diameter at breast height (DBH). Measured in practice by common methods (Machovec, 1982).
- Crown projection: was calculated as the area of ellipse: $A = \pi \times a \times b$, the possible damage of crown was deducted (percentage estimate).
- Crown volume: was calculated as the volume of ellipsoid: $V = 4/3 \times (\pi \times a \times b \times c)$, the possible damage of crown was deducted (percentage estimate).
- Exact number of mistletoe bushes.

The data analysis was carried out only with these infected host taxa which occurred in the park most frequently. For characterization of the relationship between the dendrometric quantities and the mistletoe bush number, linear and exponential regression analysis was performed, where mistletoe number was used as the dependent variable and dendrometric quantities as the explanatory variables. The best-fitting curve was obtained by the method of ordinary least squares (OLS). Coefficient of determination (R^2) was used for measurement of how close the data are to the fitted regression line. The data processing and evaluating was carried out in Microsoft Office Excel 2010 and statistical analyses were performed using the statistical program R version 3.0.2. (R Core Team, 2013), for editing R scripts the Tinn-R code editor was used (Faria, 2013).

Results

Due to our results we can conclude that there is no or small relationship between the selected dendrometric quantities and mistletoe bush number. However, the mistletoe bush number is higher with increased e.g. tree height, DBH etc., as predicted. The average percentage value of this correlation was between 10 and 20.

Table 1 Relationship between the mistletoe bush number and dendrometric quantities with different host taxa

Type of relationship	Taxon	Linear regression model	R^2	Exponential regression model	R^2
Tree height (x) and mistletoe number (y)	*Acer campestre*	$y = -3.23 + 1.52x$	0.07	$y = 2.28e^{0.09x}$	0.08
	Acer platanoides	$y = -20.14 + 3.05x$	0.17	$y = 1.51e^{0.12x}$	0.14
	Acer pseudoplatanus	$y = 5.64 + 1.61x$	0.05	$y = 5.50e^{0.06x}$	0.04
	Crataegus monogyna	$y = -14.46 + 4.29x$	0.16	$y = 2.56e^{0.17x}$	0.08
	Crataegus pedicellata	$y = 0.58 + 1.05x$	0.01	$y = 1.87e^{0.12x}$	0.01
	Juglans nigra	$y = -20.47 + 4.55x$	0.36	$y = 5.65e^{0.11x}$	0.33
	Robinia pseudacacia	$y = -2.15 + 0.83x$	0.18	$y = 1.47e^{0.09x}$	0.20
	Tilia cordata	$y = -23.30 + 4.38x$	0.22	$y = 4.40e^{1.48x}$	0.21
	Tilia platyphyllos	$y = -6.20 + 1.97x$	0.08	$y = 3.34e^{0.06x}$	0.06
Diameter at breast height (x) and mistletoe number (y)	*Acer campestre*	$y = 0.19 + 0.44x$	0.14	$y = 3.21e^{0.02x}$	0.13
	Acer platanoides	$y = -4.40 + 0.73x$	0.19	$y = 3.14e^{0.03x}$	0.14
	Acer pseudoplatanus	$y = 2.45 + 0.72x$	0.17	$y = 5.75e^{0.03x}$	0.10
	Crataegus monogyna	$y = -13.28 + 1.55x$	0.31	$y = 2.31e^{0.07x}$	0.19
	Crataegus pedicellata	$y = -0.97 + 0.72x$	0.15	$y = 1.52e^{0.09x}$	0.15
	Juglans nigra	$y = -3.23 + 1.49x$	0.44	$y = 8.52e^{0.04x}$	0.40
	Robinia pseudacacia	$y = 3.16 + 0.19x$	0.21	$y = 2.51e^{0.02x}$	0.24
	Tilia cordata	$y = -3.35 + 1.17x$	0.30	$y = 7.39e^{0.03x}$	0.27
	Tilia platyphyllos	$y = -19.86 + 0.94x$	0.40	$y = 1.96e^{0.03x}$	0.36
Crown projection (x) and mistletoe number (y)	*Acer campestre*	$y = 6.94 + 0.18x$	0.13	$y = 4.58e^{0.01x}$	0.12
	Acer platanoides	$y = -4.40 + 0.73x$	0.19	$y = 3.14e^{0.03x}$	0.14
	Acer pseudoplatanus	$y = 2.45 + 0.72x$	0.17	$y = 5.75e^{0.03x}$	0.10
	Crataegus monogyna	$y = -13.28 + 1.55x$	0.42	$y = 2.31e^{0.07x}$	0.19
	Crataegus pedicellata	$y = -0.97 + 0.72x$	0.15	$y = 1.52e^{0.09x}$	0.15
	Juglans nigra	$y = 24.66 + 0.39x$	0.44	$y = 19.08e^{0.008x}$	0.40
	Robinia pseudacacia	$y = 3.16 + 0.19x$	0.21	$y = 2.51e^{0.02x}$	0.24
	Tilia cordata	$y = -3.35 + 1.17x$	0.30	$y = 7.39e^{0.03x}$	0.27
	Tilia platyphyllos	$y = -19.86 + 0.94x$	0.40	$y = 1.96e^{0.03x}$	0.36

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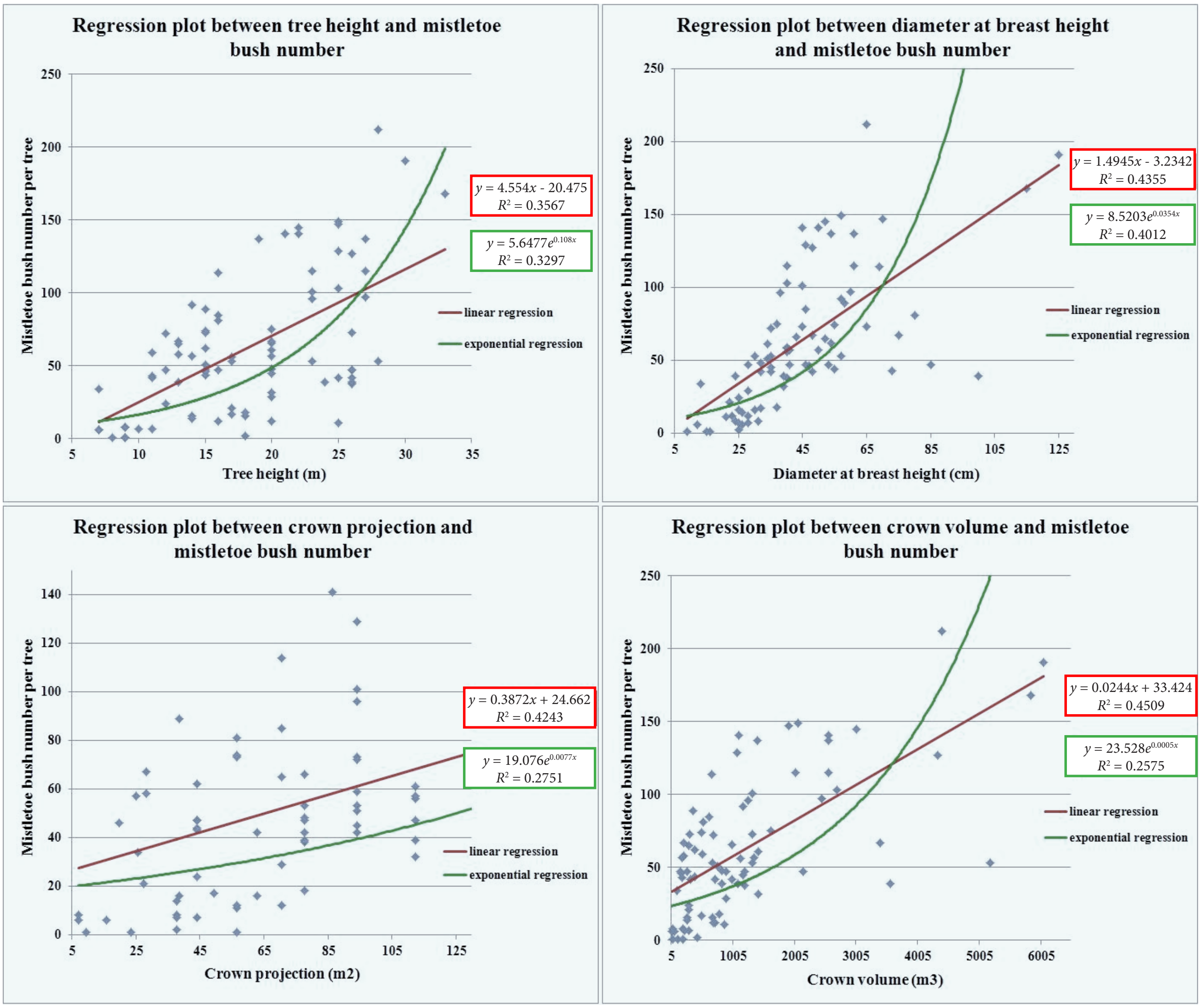

Figure 1 Regression plot between different dendrometric quantities and mistletoe bush number in case of *Juglans nigra*

Conversely, there is bigger difference among the hosts, because in some cases (e.g. *Juglans nigra*) we found stronger correlation (max. 45 %). There is also no big difference between the fitting of linear and exponential regression model. The following table (Tab. 1) represents the equation of linear and exponential regression line with coefficient of determination, where *y* is the dependent variable (always mistletoe bush number) and *x* is the explanatory variable (dendrometric quantities). Fig. 1 also shows these relationships in case of *Juglans nigra*.

Discussion and conclusion

From our results it is obvious that we observed none or small relationship when we individually analysed the influence of local factors. However, when we analysed these factors together, the multiple regression analysis showed higher (but not very strong) relationship between these dendrometric quantities and mistletoe number. Probably, these or other local factors (e.g. vitality of tree, tree age) together may influence the rate of infection in the park and therefore they cannot be studied separately.

There is big difference among hosts with similar dendrometric quantities which proves that hosts react to the infection in different ways and some hosts are more sensitive than others. Similar results were obtained by Baltazár et al. (2013a), in case of *Tilia cordata* the average number of mistletoe bushes on a tree was five times higher than in case of *Acer campestre* with similar quantities. The analyses proved the strongest relationship in case of diameter at breast height and tree volume used as an explanatory variable. *Juglans nigra* will be the most endangered host in the whole park and *Tilia cordata* and *Tilia platyphyllos* will be more sensitive to infection than other tree species.

Several other studies were obtained in case of other taxa of the family Viscaceae. Aukema and Martínez del Río (2002) on *Phoradendron californicum* Nutt., Donohue (1995) on *Plicosephalus curviflorus* (Benth. ex Oliv.), Overton (1994) on *Phrygilanthus sonorae* (S. Watson)

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Standl. and Reid and Smith (2000) on *Amyema preissii* (Miq.) Tiegh. found a weak relationship between host size and infection intensity. This pattern appears to be typical for bird-dispersed taxa (Roxburgh and Nicolson 2007), because Nowak and McBride (1992) found more *Arceuthobium campylopodum* Engelm. on smaller host trees. This plant is not dispersed by birds and has explosively dispersed seeds that are likely to land on smaller trees close to a host tree (Roxburgh and Nicolson, 2007).

Overton (1994) suggested that size-prevalence relationship would occur simply because larger trees are older and have had more time to be infected. Roxburgh and Nicolson (2007) claimed that unequivocally separating the effects of tree age and tree size is difficult as they are tightly correlated. However, their result proves that taller trees in the same age are more frequently parasitized. Overton (1994) also affirmed that the mistletoe infection intensity of a tree can be considered as an indicator of the attractiveness of a tree to a disperser.

Our results did not answer the question which dendrometric quantities have the most important role to mistletoe distribution in model area. In the near future we are going to study the influence of other factors (e.g. vitality, development stage, exact location of host in park) and difference among hosts for better understanding the mistletoe occurrence and its distribution.

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