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Abundance of *Viscum* in Central Poland – Results from Large-Scale Mistletoe Inventory †

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Abstract: Mistletoe (*Viscum album* L.) is a semi-parasitic plant and in moderate abundance it does not pose a lethal threat to a tree. However, recent droughts have made heavy impact on forests and mistletoe in recent years began to appear on a larger scale in regions and in places where it has never been a threat before.

The main purpose of this research was to carry out large-scale mistletoe inventory in Central Poland for assessing the number of mistletoe on individual trees and in the stands as well as to test new inventory method adapted to Polish conditions. It is based on random sample plots, each consisting of 15 trees on which impact of mistletoe is assessed.

On every sample plot the mistletoe occurrence, location in the crown, estimate of the percentage within the crown and the number of mistletoe on a tree is assessed. In addition, for further analysis, information on stand (forest habitat type, site index) as well as measured trees (age, diameter, Kraft class, crown length, loss of assimilation apparatus, crown type) levels is recorded.

Research undertaken in Kozienice Forest (100 km south from Warsaw) had taken into account 100 sample plots on which 1500 trees were assessed. Preliminary results show that 16% of trees are infected by mistletoe, more than 25% of which were infected heavily by more than 6 specimen.

Keywords: *Viscum*; assessment methods; mistletoe rating system

1. Introduction

Scots pine (*Pinus sylvestris* L.) is the most common tree species in Polish forests. Its share is currently estimated at approximately 58.2% in 9 million ha of forests. The amount of pine is significantly reduced in favor of deciduous species as a result of the reconstruction of stands. However, due to the habitat conditions, its share will be greater than that of other forest-forming species.

Until recently, the mistletoe (*Viscum*) found on deciduous species began to spread, also on coniferous species. The mistletoe found on the pine tree (*Viscum album* ssp. *austriacum* (Wiesb.) Vollm.) becomes a big problem in forest management. For example in Germany, near Brandenburg, the infestation rate is increasing. It was 1% in 2009, and in 2015 as much as 11% [1]. The dynamics of the growth of mistletoe in cooler areas is related to the recently observed climate changes [2].

Pine and mistletoe are evergreen species, which makes them compete in the spring. Pine begins to vegetate later than mistletoe, which begins its activity in late winter. The current temperature changes, related to changing climate conditions [3], are favorable for mistletoe.

Trees that become infected with mistletoe fruit and bloom less. They become an easier target for pest attacks. Sometimes the paralysis leads to the death of the host [4]. The place of the mistletoe infection can facilitate the penetration of pathogenic organisms, mainly fungi. Consequently, this causes further unfavorable factors to which the tree is exposed [5].

Currently, there is no data on the spread of mistletoe in Poland. The presence of a species in large numbers creates opportunities for increased pest risk. Mistletoe as a thermophilic species has an easier way of growing on a larger scale and at a faster pace. Strong mistletoe infections on pine, the most common forest-forming species in Poland, can potentially contribute to a large economic loss [6].

To create an effective method of fighting mistletoe, it is necessary to determine the scale and scope of the problem. This article presents the results of the large-scale mistletoe inventory: the number of trees infected, the degree of this infestation in order to determine the need for further assessment and the ways to improve the methods of assessing the presence of mistletoe.

The aim of the study was to assess the presence of mistletoe on the Scots pine in the Kozienice Forest District in central Poland (Figure 1), to analyze the results depending on the selected features of trees and stands.

2. Materials and Methods

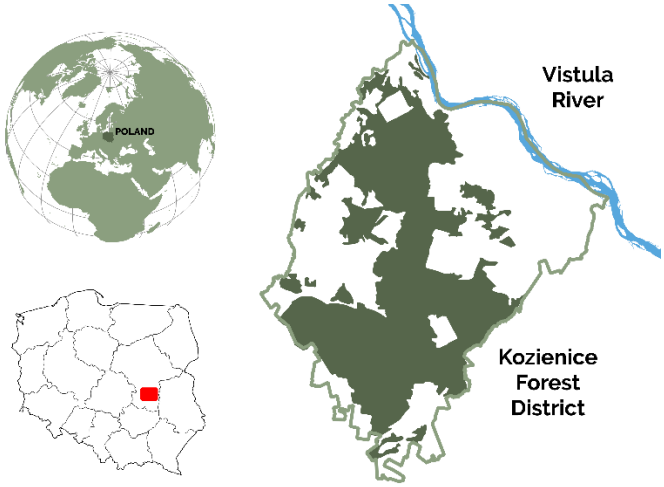

Figure 1. Kozienice Forest District forests along with its localization.

The sample plots were established in 2019 in Kozienice Forest District, one of three forest districts of Kozienice Primeval Forest. On the basis of preliminary measurements, it was assumed that for the mistletoe inventory the coefficient of variation in the mistletoe occurrence is 40%. One hundred permanent study plots were established randomly using a square grid. Each with a constant number of 15 trees in stands older than 20 years. Only pine dominated stands in their typical habitats were examined. Fifteen hundred trees were inventoried regarding mistletoe infestation. The following features were assessed on individual trees: Kraft class, type of crown, crown length, dbh, percentage of defoliation, percentage of mistletoe, location of mistletoe on the tree, number of mistletoe specimens. Only trees of Kraft class I, II and III (dominant, dominant and co-dominant) were taken into account in the study. The following types of crowns were determined: typical, spreader, one-sided, umbrella-shaped. Estimation of the proportion of the crown (crown length) was assessed in gradients of 5 percent. The measurement was made relative to the total height of the tree. For each tree, the loss of the assimilation apparatus was estimated using standard procedure [7]. Estimating the percentage of mistletoe in relation to the volume of the crown was rounded to the full 5%. The location of mistletoe within the crown was assessed divided into the top, middle and bottom of the crown. The number of mistletoe copies from 1 to 5 was also recorded. If its number was greater than 5, it was difficult to separate the mistletoe specimens and they were recorded as 6 and more (6+). Along with mistletoe inventory we have obtained information regarding the stand: forest habitat type, stand age, site index and stand crown density.

3. Results

Results from mistletoe inventory show that out of 1500 measured trees 238 (16%) were infected by that parasite. Number of mistletoe specimen on tree varied, 33% were infected by only one 27% by 6 or more, remaining 40% was distributed among classes from 2 to 5. Infection pattern differed with different stand characteristics. Trees of higher biosocial status tended to be more infected (Figure 2.).

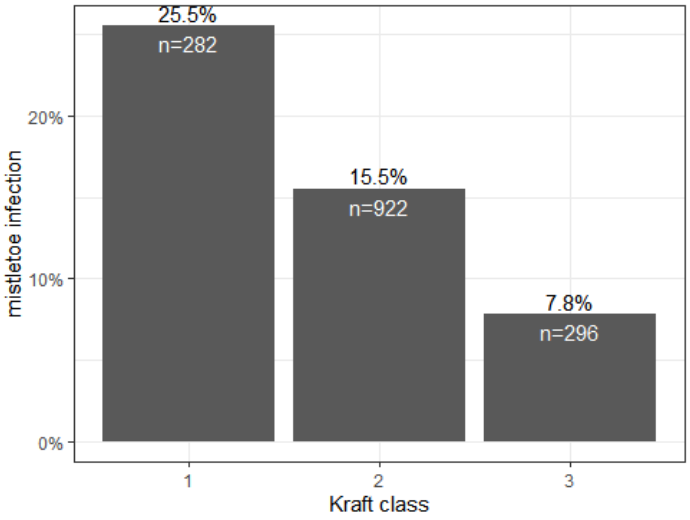

Figure 2. Impact of biosocial classes on mistletoe infection in Kozienice Forest District. Percentage shows how many trees in that class were infected, whereas *n* shows total number investigated in each group.

Results suggested that the closer the crowns in the stand grow the less mistletoe infection they obtain (Figure 3). Mistletoe tends to prefer more sunlight, infecting more than 20% of trees growing in low crown density conditions, and less than 5% in full one.

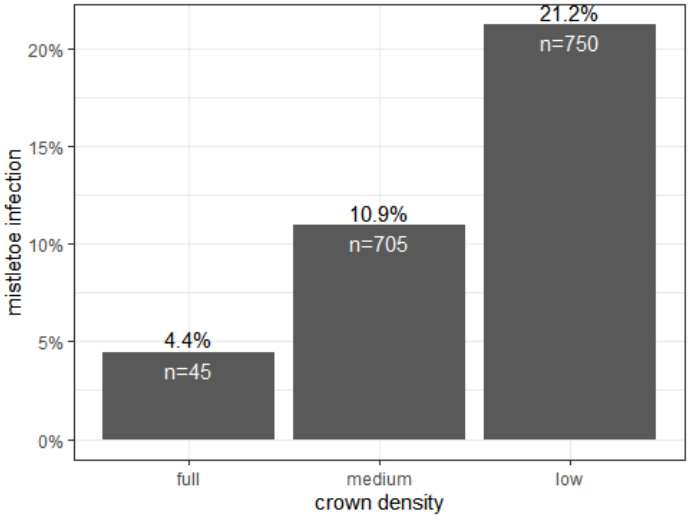

Figure 3. Impact of crown densities on mistletoe infection in Kozienice Forest District.

The site index, showing potential for tree growth, is also connected to mistletoe infection. Trees growing in better habitat condition and being more vigorous show lees mistletoe infection (Figure 4). Scots pine that is to achieve 32 meters of height at age of 100 years is three times less likely to be infected than the one that is going to achieve 24 meters.

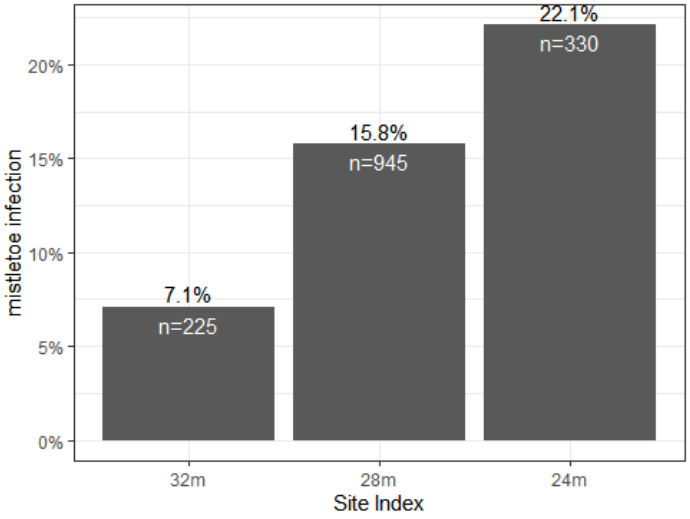

Figure 4. Impact of site index on mistletoe infection in Kozienice Forest District.

Biggest differences in mistletoe infection were observed among age classes (Figure 5). Infection severity ranged from 0% for youngest stands, showing continual growth along the way up to 67% for oldest ones.

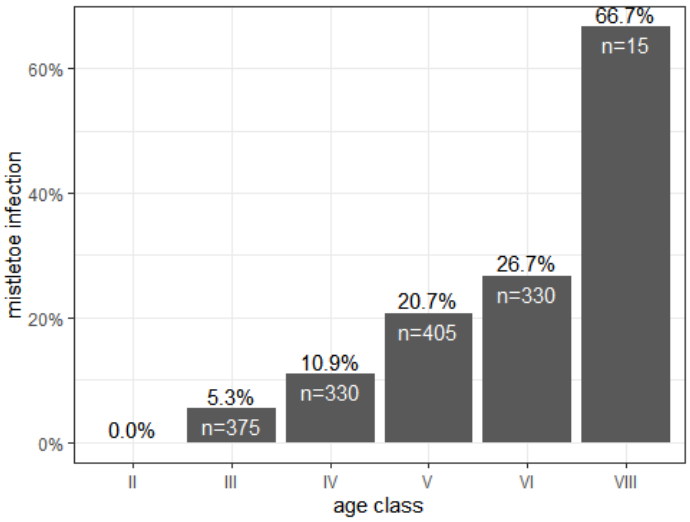

Figure 5. Impact of age class on mistletoe infection in Kozienice Forest District.

We have not seen any connection between mistletoe infection and forest habitat conditions.

4. Conclusions

1. The share of trees infested by mistletoe in the Kozienice Forest District was 16%, which should be taken into account when planning and managing forests.

2. Four main stand characteristics connected to mistletoe infection were found: Kraft class, crown density, site index and age class.

3. It was found that the most damaged were trees having best sun conditions: tallest (I Kraft class), oldest, growing in low density, and having biggest crowns.

4. We are currently investigating mistletoe on next 200 sample plots in the whole Kozienice Primeval Forest.

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W.K. and R.W.; data curation, W.K.; writing—original draft preparation, R.W.; writing—review and editing, W.K.; visualization, W.K.; supervision, R.W.

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Conflicts of Interest: The authors declare no conflict of interest.

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