11th INTERNATIONAL SCIENTIFIC CONFERENCE
RURAL DEVELOPMENT 2023
BIOECONOMY FOR THE GREEN DEAL
26-28th September, 2023, Vytautas Magnus University Agriculture Academy, Lithuania

VYTAUTAS MAGNUS UNIVERSITY AGRICULTURE ACADEMY

Proceedings of the 11th International Scientific Conference Rural Development 2023

Edited by assoc. prof. dr. Judita Černiauskienė

ISSN 1822-3230 (Print)
ISSN 2345-0916 (Online)

Article DOI: http://doi.org/10.15544/RD.2023.024

WHITE MISTLETOE *VISCUM ALBUM* L. DISTRIBUTION AND IMPACT ON HOST TREE IN EASTERN PART OF LATVIA

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White mistletoe *Viscum album* L. is not a common species in the territory of Latvia, it is mostly distributed around the cities Preiļi (Eastern population) and Liepāja (Western population). The specific of the species is that it receives water and minerals from its host tree in a parasitic way, thus gradually destroying it. One of the factors in the prevalence of *Viscum album* is climate. During recent times the climate in the territory of Latvia is getting warmer every year. This is very noticeable in the winter. As a result *Viscum album* as a warm-loving species is slowly spreading.
The main goal of the research was to evaluate the population of *Viscum album* and the response reaction of host trees in Eastern population in Latvia.
Dendrometric indicators of host trees, meteorological data and wood samples of the host trees were needed for the development of the study, for which changes in annual tree-ring width and density of wood were further analyzed. Also in order to understand the significant differences between the tree-ring widths in exact seasons and the density of wood of affected and unaffected trees wood samples were collected from trees with no *Viscum album* on them.
Conclusions show that the climate is getting warmer and the number of specimens of *Viscum album* has increased compared to previous period. Changes in the tree-rings width and wood density of the host tree are negatively directed.

Keywords: *Viscum album, host tree, air temperature, tree-ring width.*

INTRODUCTION

Loranthaceae family contains about 65 genera and about 850 parasitic species of flowering trees and shrubs. Almost all plants of this family are found in the tropics (Britannica. *Loranthaceae*, 2010). The genus *Viscum* contains about 100 species which are mainly distributed in Africa, Asia and Europe.

Viscum album L. is a perennial, evergreen, semi-parasitic shrub growing on branches and trunks of deciduous trees. It has sucker roots by which it penetrates under the bark and into the wood of the host tree. The dimensions of the shrub tend to vary from 20 to 120 cm in length, the shape is usually globular or drooping (Kahle-Zuber, 2008).

The semi-parasitic shrub white mistletoe *Viscum album* L. is rarely found in the territory of Latvia but there are certain places where it is lately not only found but population has grown significantly. Populations of *Viscum album* in territory of Latvia are located in Eastern part in Southern Latgale (Vecvārkava, Vārkava, Arendole, Kalupe) and in Western part in Southern Kurzeme (Liepāja). In this research the territory of Southern Latgale is studied.

During the data collection a survey of local residents was carried out. It is concluded that basic information about mistletoe – that it is a poisonous plant, that it could be used in medicine and the most important – it is in a list of protected species was not known to many of residents of the studied region. Destruction of each specimen of *Viscum album* is applicable a fine in the amount of two minimal monthly salaries. The residents of Vecvārkava explain that previously mistletoe was not so widely spread there, it was only found in Arendole but recently has started to spread out very rapidly. Local residents are very upset with the situation because it is not possible to get rid of the semi-parasite even though a large amount of *Viscum album* specimens on a fruit tree causes significant mechanical damage to it.

Recently the climate in Latvia has been changing and with each year the average air temperature rises. This contributes to the growth of the population of *Viscum album* as a warm-loving plant, in the same time causing a significant

impact on its host tree. Looking at the rapid distribution of the *Viscum album* it could be predicted that sometime later this shrub will no longer be in the list of protected species.

The aim of this research is to evaluate the population of *Viscum album* and response reaction of host trees on it in Eastern population in Latvia. To achieve the goal the following tasks have been set: 1) to assess the population dynamics of *Viscum album* in Eastern population over the time period from 2003 to 2021; 2) to analyze the dendrometric indicators, wood density and annual tree-ring width increment of *Viscum album* host trees; 3) to analyze meteorological data of observation station in Daugavpils and link them with changes in *Viscum album* population.

RESEARCH METHODS

The research area is located in Eastern part of Latvia, in South Latgale. In 9 potential locations *Viscum album* L. was surveyed: Špogi, Kalupe, Nīcgale, Arendole, Vecvārkava, Vārkava, Aglona station, Vanagi and Preiļi (Figure 1).

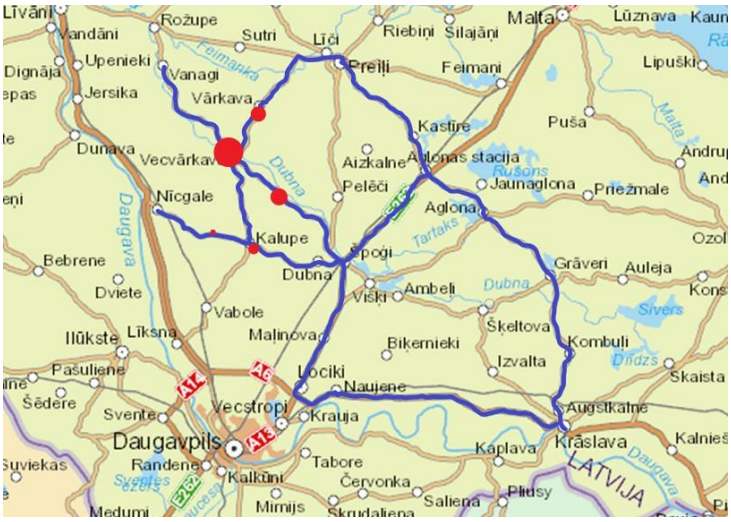

Figure 1. Territory of the research for the recording of *Viscum album* locations.

In 5 locations of all inspected *Viscum album* was detected. The biggest populations of *Viscum album* in Eastern part of Latvia are Kalupe, Arendole, Vecvārkava and Vārkava. *Viscum album* was also found in Nīcgale but the number of specimens was small. Each expedition's starting point was city Krāslava. Total distance of one trip was 164 km. The search for new locations of *Viscum album* was carried out in Preiļi city as well but mistletoe was not detected there. Studied area was visited 8 times during the summer 2021.

The examination of the territory was carried out by evaluating both sides of the road in a 500 m wide zone. Searching for specimens of *Viscum album* was done in parks, gardens of local residents, school grounds, around churches and other territories.

Climate in the Eastern part of Latvia is less influenced by Baltic Sea and the Gulf of Riga comparing to the mistletoe populations located near Liepāja. The climate in Southern Latgale is warmer in summer and colder in winter. There are cold winters with long-lasting snow cover and relatively warm summers. Looking at the overall climate statistics of the last 10 years it can be concluded that in the Southern part of Latgale the coldest month is January with an average temperature of -5.2 ºC and the warmest is July when the average air temperature is +18.4 ºC. The annual average air temperature is approximately +7.1 ºC (Vilcāne et al., 2009).

Beginning the research locations of *Viscum album* were determined, the following dendrometric parameters for each host tree after the tree species determination – height and diameter ($H_{1,3m}$) – were measured. It was also noted whether the tree has signs of decay. Using www.mfgeo.lvm.lv application the geographic location of each host tree was marked on the map. Number of *Viscum album* specimens on each host tree to understand the incidence of specimens in the study area was fixed.

To obtain host tree wood density and annual tree-ring width data 10 wood samples each with a Pressler driller from two tree species – *Acer platanoides* L.– Norway maple and *Tilia cordata* Mill. – small-leaved lime were collected. These tree species were selected because the largest number of *Viscum album* specimens were found on them.

The *Rinntech Lignostation Wood Surface Scanner* measuring system was used in the study to determine relative radial density deviations for dry wood samples using probe high-frequency scanning, at the same time tree-ring width was measured.

For data analysis host trees were divided in three groups according to the number of *Viscum album* specimens per tree: small number of specimens – 1 to 10, medium number of specimens – 11 to 20 and large number of specimens – 21 and more. Host trees were similarly grouped according to their height: low trees – 4 to 10 m in height, medium trees – 11 to 20 m, tall trees – 21 m and more.

Comparison of groups was done for the number of *Viscum album* specimens on common linden and small-leaved lime: firstly, number of *Viscum album* specimens on Norway maple and small-leaved lime and secondly, host tree annual width changes for trees with and without *Viscum album*.

Annual tree-ring width and wood density data were processed using extreme tree growth period analysis. This method is good because it does not need a chronology created. Many of the host trees inside the stem were completely decayed with no any signs about that from outer side. The analysis of the extreme growth periods of trees is designed to determine percentage changes in both annual tree-ring width and wood density over a given period of time.

Percentage growth changes per year calculated using Black, Abrams (2004) technique, data processing period is 5 years. The percentage change for each year was calculated. Selected according to the obtained data the next ones are years with large percentage changes. Studying annual changes of tree-ring width further years with change exceeding 25% for both positive and negative years were used for selection values. The same selection took place with the wood density data but the data selection took place where positive and negative changes were greater than 10%. The next stage was to arrange the years with significant changes over 5-year period. Each period showed the total number of samples and number of samples with positive and negative values were present.

RESEARCH RESULTS AND DISCUSSION

Viscum are dioecious shrubs. That what is of high importance *Viscum* causes damage to forests, orchards, plantations and parks worldwide reducing increment, quality of the host tree's wood and predisposes the trees to attacks by insects, diseases and fungi (Reid et al., 1995).

Collecting information what is available in homepage https://dabasdati.lv/lv/ about the distribution of *Viscum* in Latvia since year 2010, a clear increase in the population of this species can be seen (Figure 2).

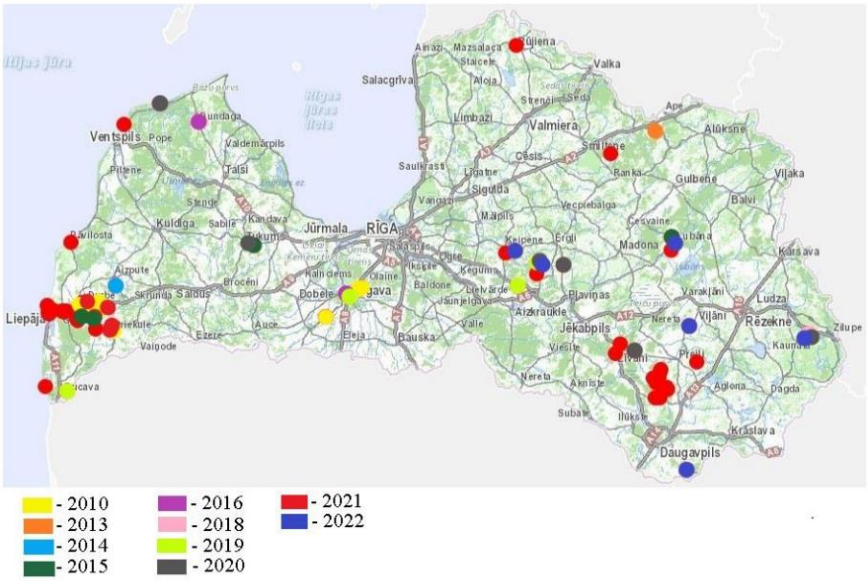

Figure 2. Distribution of *Viscum album* in the territory of Latvia starting from year 2010.

If previously 65 locations of *Viscum album* were recorded in the Atlas of Latvian woody plants (Laiviņš et al., 2009), now, considering only the data obtained from https://dabasdati.lv/lv/, the map shows 107 locations of *Viscum album.*

In the frame of the research in Eastern part of Latvia total surveyed area reaches 50075 m^2, total of 168 host trees were found and 1167 *Viscum album* L. specimens were observed during summer of year 2021, location of each host tree was fixed on the map. A summary by locations is given in Table 1.

Table 1. The total number of host trees and *Viscum album* specimens in each identified location

Location	**Number of host trees**	**Number of *Viscum album* specimens**
Arendole	41	311
Kalupe	11	30
Kalupe – Nīcgale (road)	2	4
Vārkava	26	165
Vecvārkava	76	574
Arendole – Vārkava (road)	9	74
Kalupe – Vārkava (road)	3	9
Total	168	1167

The table shows data of the total number of host trees and the total number of *Viscum album* specimens in each location explored. According to the obtained data it can be seen that the largest number of *Viscum album* specimens was found in Vecvārkava and the least in Kalupe. According to local residents, even before the Second World War, *Viscum album* was widespread in the Southern Latgale but after the war the number of *Viscum album* specimens decreased rapidly and the last specimens remained only in Arendole. As a proof of it is Āmuļu elementary school in Arendole ("āmuļi" means *Viscum* in Latvian), founded after the war, can be considered. The name of the school may have been directly related to the name of a special plant that remained in this place. Also, when talking about changes in a short period of time (10 years), the local residents of Vecvārkava claim that *Viscum album* used to be mostly found only in Arendole. It is interesting that now there are more specimens of *Viscum album* found in Vecvārkava comparing to Arendole.

In general, analysing the situation in the research area, significant statistical changes can be observed when comparing both the total amount of host trees and the total number of *Viscum album* specimens. According to these data, a rapid increase of *Viscum album* specimens is visible. In that case, the data obtained prove the hypothesized fact that the number of *Viscum album* specimens increased in recent years but the fact that Vecvārkava has the largest number of *Viscum album* specimens and Kalupe has the smallest number of *Viscum album* specimens remains unchanged.

In any case the spread of *Viscum album* is ensured by various biotic and abiotic factors. The biotic factors include birds which are the main distributors of *Viscum album* (Babenko, 2020). Another important role is played by the mistletoe's ability to compete with other parasites. The most important biotic factor is certainly to some extent determined by chance and it is the probability that the seed will be brought to a host tree of a species suitable for germination so that *Viscum album* can initially grow in it and then absorb water and minerals from it (Skrypnik et al., 2020).

Results of the research shows that *Viscum album* mostly grows in built-up areas, rarely found along the road from one city to another. This could be due to the fact that there were only meadows or coniferous forests around along the road.

In the studied area *Viscum album* is mostly found on three tree species – *Acer platanoides* L., *Tilia cordata* Mill. and *Malus domestica* Borkh. (Figure 3.).

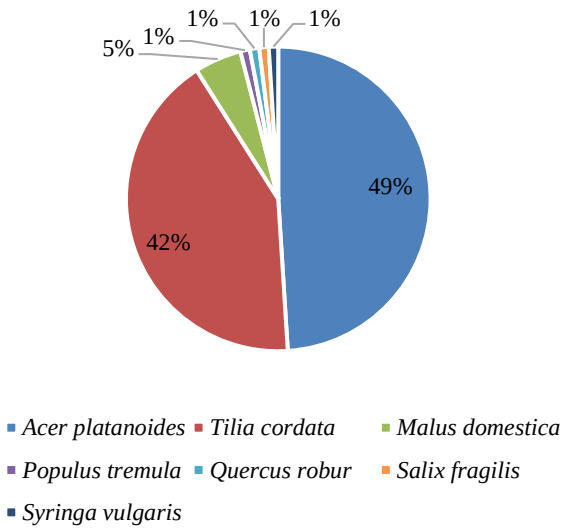

Figure 3. *Viscum album* host tree species in Eastern Latvia in year 2021.

Initially it was intended to study in depth all the three tree species on which specimens of *Viscum album* were often found. While collecting wood samples from *Malus domestica* rot damage was found in many cases. Therefore it was not possible to obtain high-quality wood samples from apple trees, and only two tree species remained for further research – Norway maple and small-leaved lime. During data collection not only apple trees were found to have rot and cancer *Neonectria ditissima* (Tul.&C.Tul.) Samuels&Rossman but many other trees also showed signs of these diseases. In total from 168 trees signs of cancer were found in 79 specimens. In many cases, it was easy to tell that the tree had cancer damage, trees had peeling bark, a cavity had formed or the trunk was covered with wounds. Looking at the data collected, 79 host trees were damaged by cancer, 22 trees had *Viscum album* with specimen number equal to or greater than 10 units. This means that the presence of *Viscum album* in the tree may have contributed to the development of cancer in those host trees.

When *Viscum album* colonizes host tissues, it can produce two types of endophytic systems. The first type is called haustoria, which overgrow the host tree's tissue, eventually penetrating the host tree's cambium which allows the mistletoe to absorb water and minerals. A second type of endophytic system is the cortical bands produced by mistletoe, which enter the tree through the parenchyma tissue and phloem where they spread laterally or longitudinally. The cortical bands contain chlorophyll and are 4 to 6 cm long in average. Although these bands contain phloem and xylem, it remains to be confirmed whether these bands form a physical connection that allows water and nutrients to be absorbed from the host tree (Szmidla et al., 2019).

Viscum album is most abundant on maple despite the fact that lime has a greater average height comparing to maple. In general, it can be observed that lime trees are larger than maple trees according to dendrometric parameters.

For example, *Viscum album* was found on lime with the largest diameter of 94 cm while the largest diameter of maple was 55 cm, and also if look at the minimal diameter then again, the minimal diameter of 31 cm for lime is greater than the one of 20 cm for maple, a similar situation is also according to height. On the one hand it is concluded that *Viscum album* is more likely to choose higher trees with easy access to the sun than lower trees but on the other hand it can be seen that *Viscum album* is more common on medium-high trees. Stress caused by water use from the host tree causes a water deficit in the host tree which reduces nutrient resources for the leaves because the photosynthetic capacity of the host tree is reduced, especially during summer drought. In addition, due to the water load, the increasingly closing flaps reduce the assimilation of carbon in the tree. Such conditions encourage co-infection, the contamination of tree tissue with disease-causing agents which further weakens the host tree. The poor health of parasitized trees affects their growth, reproduction and wood quality (Szmidla et al., 2019).

Nutrients taken in by trees – macroelements (N, K, Ca, P, S) and microelements (Mg, Fe, Cu, Zn, Mo, B, Na, N) – accumulate in *Viscum album*, making them unavailable to the host, especially needles, increasing the impact of adverse drought. In infected pine needles, the decrease in chlorophyll content resulted in reduced photosynthetic efficiency and chloroplast damage as a result of Fe+ deficiency. As a result, partial defoliation was observed in trees infected by *Viscum album* (Mutlu et al., 2016).

Abiotic factors that can affect the spread of *Viscum album* are high soil moisture, high air humidity, air pollution and one of the most important abiotic factors is air temperature. *Viscum album* is a warm-loving woody plant. The optimal temperature for propagation is between 15 and 20 °C. Germination can also occur at lower temperatures but will take longer – from 10 to 31 days while at 18 – 32 °C it will take a total of 2 to 8 days (Golabek, Slawinski, 2017).

The average air temperature in the temperate zone is between 0 and 20 °C. The maximum air temperature is + 40 °C while the minimum can be up to - 40 °C, precipitation reaches 1000 to 2000 mm per year (Meteoblue: Climate zones, 2022). So, for the easy propagation of *Viscum album* climate with warm air temperature and normal rainfall is necessary. Climate change makes Latvia more and more appropriate place for *Viscum album* to expand the population. In the frame of this study when analyzing the data of the closest meteorological observation station data (Daugavpils) the selected time period is 50 years (from year 1970 to 2020). When studying climate change, such parameters as maximal, minimal and average air temperature as well as total amount of precipitation are analyzed.

Analyzing the changes in the maximum air temperature, it can be observed that it changes slightly during the studied period. It can be noticed that, in general, from year 1970 to 2009, the maximal temperature is mostly between 25 ºC and 35 ºC but during the last 10 years it was always equal to or higher than 30 ºC. The minimal air temperature is not as stable as the maximal. However, it can be noted that earlier in the winter period, the minimal air temperature more often reached the -30 ºC. On the other hand, during the last 10 years, the minimal air temperature did not reach this level. Since 1996, the average air temperature has never fallen below +5 ºC. During the last eight years the average air temperature has remained stable above +6 ºC. In year 2021 it was +6.6 ºC which means that the average air temperature continues to increase.

As for the amount of precipitation, it has decreased since year 1998, many times not reaching the limit of 600 mm.

In the interval of 1-10 mistletoe specimens per host tree since year 1985 the change in the tree-ring width of is stable in the interval from 2 to 3 mm, but beginning from year 2017, a slight decrease in the increment in is noticeable (Figure 4).

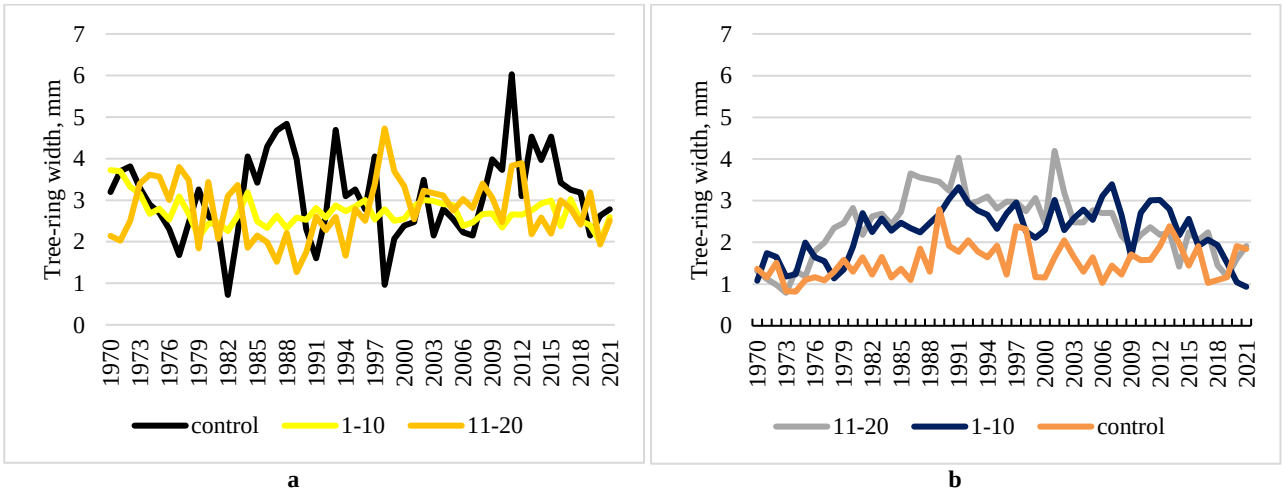

Figure 4. Changes in annual tree-ring width depending on the number of *Viscum album* specimens on the host trees: (**a**) of *Tilia cordata*; (**b**) *Acer platanoides*.

Changes in *Tilia cordata* tree-ring width more clearly follow changes in the minimal air temperature especially when there is a high number of mistletoe specimens per host tree. For *Acer platanoides* this relationship is significantly less pronounced. All the most noticeable changes in air temperature started about 10 – 15 years ago, it can be observed that the negative changes in tree-ring width started at about the same time. Comparing *Viscum album* specimens data in year 2003, 2004 and 2021 it can be seen that number has increased rapidly during last 15 years.

Wood density for *Tilia cordata* starting with year 1995, it can be observed that there are changes in the wood density, the result of the first two five-year period fluctuates more towards the positive side but starting with year 2005, the percentage of negative changes remains higher than the positive. A similar picture is revealed when studying samples of *Acer platanoides*.

It can be seen that all significant changes in host tree annual tree-ring width occurred at the same time in all studied situations. The host trees could have been affected by both climate change and the rapid spread of *Viscum album*, which also occurred due to an increase in actual air temperature. The obtained results confirm the fact that negative changes occur in the wood of the host trees.

In order for the data to be more accurate, it would be desirable to obtain more accurate data on changes in wood density from those host trees on which *Viscum album* specimens were found in year 2003 and 2004. It is necessary to fix the age of each shrub in order to be able to investigate from which year the first specimens of *Viscum album* appeared on the host tree and whether any significant changes in the vitality of the host tree can be detected during this time.

CONCLUSIONS

Evaluating the distribution dynamics of white mistletoe *Viscum album* L. in Southern part of Latgale during last decade there were four main locations found: Vecvārkava (574 specimens), Arendole, Vārkava and Kalupe (30 specimens). Most common species of host trees were *Acer platanoides* L. – Norway maple and *Tilia cordata* Mill. – small-leaved lime and *Malus domestica* Borkh. – apple. *Viscum album* was mostly found on tall trees (H > 21 m) but for most host trees the total number of *Viscum album* individuals varied mostly within the interval from 1 to 10.

Comparing the annual tree-ring width of the host trees with the minimal and maximal air temperature it should be concluded that changes often coincide with minimal temperature fluctuations.

For trees without semi-parasitic *Viscum album* specimens the increase of annual tree-ring width is significantly higher comparing to the trees on which *Viscum album* was detected. Evaluating percentage changes in the tree-ring width and wood density there is connection that the latest significant changes in wood quality of the host trees are noticeable, what is a consequence of the increase of the number of *Viscum album* specimens.

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