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Impact of mistletoe attack (*Viscum album* ssp. *abietis*) on the radial growth of silver fir. A case study in the North of Eastern Carpathians

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Abstract. *Viscum album* ssp. *abietis* (Wiesb.) Abrom L. is one of the three subspecies of *Viscum album* L that is frequently encountered in Romanian forests. The mistletoe has notoriously negative effects on trees and forests health. The mistletoe infections not only reduce both height and diameter growth, it can also cause partial or total die-back of the trees. The present study on the incidence of mistletoe (*Viscum album* ssp. *abietis*) on silver fir (*Abies alba*) increments was carried out in natural stands of the Forest District Gura Humorului (one permanent plot Păltinoasa and one experimental plot Voroneț), because this location (400-1000 m elevation) is characteristic for pure silver fir stands that can be found on the border of Carpathians Mountains at the contact zone with Suceava plateau. Four classes describing the level of infection were distinguished: no infection, low, moderate and strong infection.
As only a few of healthy trees (class 0) were found, the comparison was made on the trees from the 1st class of attack. In parasited silver trees development were distinguished 3 phases: i) phase 1 - from 1920 till 1945 when the trees that nowadays are falling into the 2nd and 3rd class had similar growth with the ones recorded in the 1st class; ii) phase 2 - from 1946 till 1976-1977; during this period the trees had been reducing their growth. The growth of silver fir trees that fall into the 2nd and 3rd classes of parasitism represents 80% of the average growth of 1st class trees; iii) phase 3 - from 1977 till 2007 (with a couple of episodes) when trees growths from 1st, 2nd and 3rd classes of parasitism were clearly differentiated.

Keywords: *Viscum album abietis*, silver fir, radial growth, parasitism class

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Introduction

Although one of the main goals of silviculture is to produce healthy and good quality trees, some diseases may seriously affect forest trees and timber, one of them being the mistletoe, which is reducing both height and diameter growth.

The hemiparasitic white mistletoe *Viscum album* L. infects not only deciduous trees, but some coniferous species too, like European silver fir (*Abies alba* Mill.), which is affected by *Viscum album* ssp. *abietis* (Wiesb.) Abromeit, and Scots pine (*Pinus sylvestris* L.), infected by *Viscum album* ssp. *austriacum* (Wiesb.) Vollman (Tubeuf 1923). The sinkers of these parasites cause mechanical and aesthetic damages of the wood and reduce its commercial value (Tubeuf 1923).

Mistletoe is probably the most threatening pathogen affecting silver fir stands from the Eastern Carpathians border. According to Barbu (1995) and Noetzli et al. (2003), there is an age threshold around 70 years after which the trees are infested and even killed by this parasite. Other authors considered that silver fir trees become susceptible to mistletoe attack after 50 years (Zuber 1983) or after 120 years (Plagnat 1950).

For other genera of mistletoes, such as *Archeutobium*, heavy losses in vitality leading to tree dieback have been reported by several authors (Hawksworth & Wiens 1996, Hawksworth & Geils 1989, Scharpf 1964). In early studies, *Viscum album* ssp. *abietis* was considered responsible for losses in wood production (Peter-Contesse 1937, Stopp 1961) or even causing the mortality of the whole stands of *Abies alba* (Plagnat 1950, Stopp 1961). Some recent studies suggested that only single trees can be killed when infestation is very strong, as the impact of *Viscum album* ssp. *abietis* on silver fir tree growth was examined in two other studies (Nanu 1969, Uscuplic 1992). In these studies, the annual radial increment was used as a clue of the growth behavior of the host trees. In addition to that, Noetzli et al. (2003) noticed that growth reduction occurs when this hemiparasit had grown exponentially on the host. Although the consequences of mistletoe infections were previously described (Plagnat & Brossier 1969, Nanu 1969, Hawksworth & Wiens 1996), their quantitative impact on the radial growth on infection classes was never assessed.

This paper presents the results of a study aiming at comparing the radial growth of silver fir trees attacked by mistletoe, according to degrees of parasitism. The goal of the study is to analyze and quantify the reduction of growth induced by mistletoe infection on silver fir stands, by comparing the growth rate of trees according to infection levels.

Materials and methods

The study was carried out in two stands in the forest district Gura Humorului (one permanent plot - Păltinoasa and one experimental plot - Voroneț) in spring 2008 (Fig.1). Forest district Gura Humorului is representative for pure silver fir stands located on the border of Carpathians, at the contact zone with the Suceava plateau and it is located between 400 and 1000 m above the sea level (Anonymous, 2006).

The permanent square plot Păltinoasa (2500

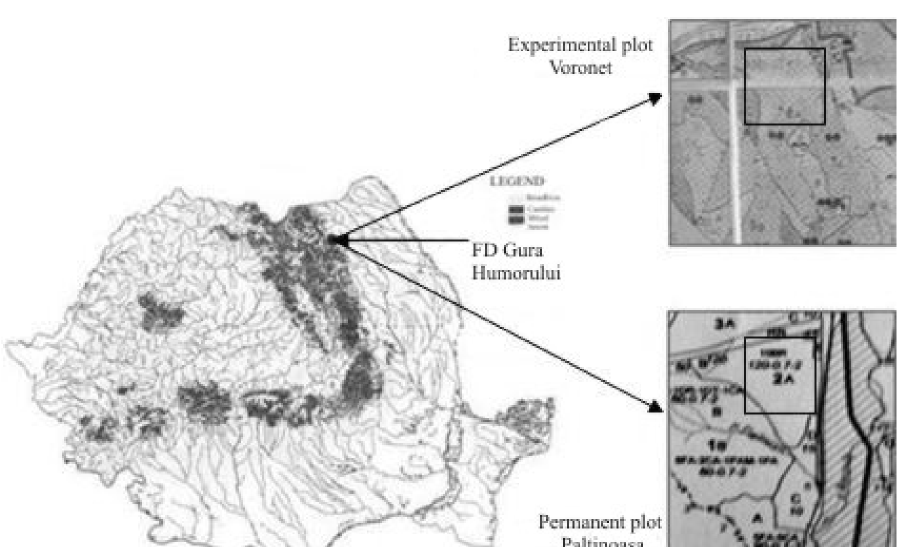

Figure 1 Location of the study

m²) was installed in a pure stand of silver fir. In this plot 27 silver fir trees were inventoried. In Voroneț plot the trees were inventoried and assigned to one of four classes of infection. Two trees per classes were selected. Plots characteristics are summed up for each plot in Table 1.

The trees were gathered into four classes of infection in order to compare their growth rates (Fig. 2, Table 2):
(i) class 0 - no infection (absence of the mistletoe) (Fig.2a),
(ii) class 1 - low infection, with high frequency of bushes on lateral branches (Fig. 2b)
(iii) class 2 - moderate infection, with very frequently bushes in the crown and drying branches (Fig. 2c)
(iv) class 3 - strong infection, with bushes growing all over the crown and stem, asymmetric crowns and trees with dying-back top (Fig. 2d).

Within all inventory plots, the diameter at breast height (dbh) as measured using a calliper and the total tree heights were measured for all trees using a Haglöf VERTEX Hypsometer III.

In both plots, the increment cores from each inventoried tree were collected. The annual increment was measured using a tree-ring analysis device (LINTAB, Rinntech).

To allow growth comparisons between trees belonging to different parasitism classes, the average growth per class was computed to form a chronology. As only a few healthy trees (class 0) had been found the comparison, we could not use the growth of the trees of that class to produce a reference chronology. Therefore, the reference chronology was made on the trees from the 1st class of parasitism.

The management plans of Forest District Gura Humorului between 1913 and 2006 were consulted in order to retrieve dates of the dif-

Table 1 Main characteristics of the two measurement inventoried plots

Plot	Stand composition (%)	Age	Slope	Coordinates		
				latitude	longitude	altitude
Permanent plot Păltinoasa (compartment 2A, V.U. V Păltinoasa, FD Gura Humorului)	100 silver fir	120	15	47⁰33‘41”	25⁰57‘08”	480-580
Experimental plot Voroneț (compartment 8A, VU II Voronet, FD Gura Humorului).	70 silver fir 20 spruce 10 beech	115	15	47⁰32‘22”	25⁰52‘40”	480-620

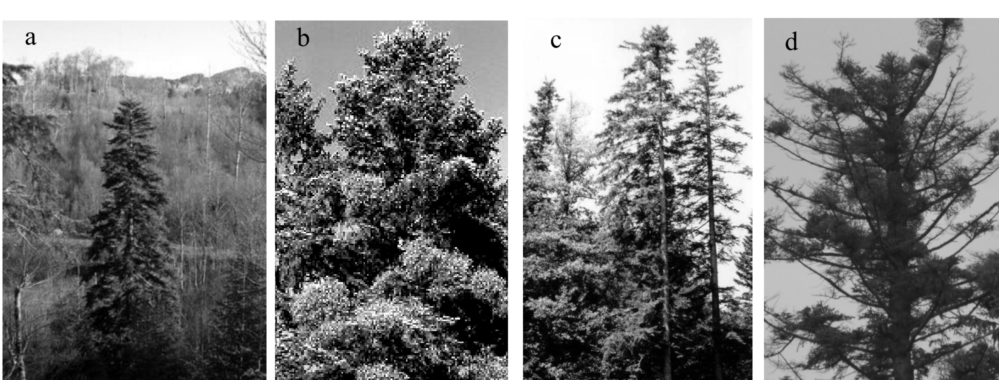

Figure 2 Example of trees from each infection classes
a) class 0 of infection; b) 1st class of infection; c) 2nd class of infection; d) 3rd class of infection

ferent silvicultural interventions.

Results

Trees from both plots were analised together because the stand condition and age of trees were similar. The 35 cored trees were groupped into parasitism classes (Table 3). The mean age, mean diameter and mean height were computed for each class. It can be observed that both mean diameter and mean high decrease from 1st to 3rd class of parasitism with 2.2 cm (3,7%), respectively 3.6 m (5,7 %).

Figure 3 presents the radial increments of all silver fir trees from 1st class (fig. 3a), 2nd class (3b) and 3rd class (3c) of parasitism. The increments dynamics of silver fir trees from each infection class are similar, so we can calculate chronology reference series.

Analysing the mean radial growths of silver fir trees from different classes of infection (Fig. 4) it can be observed an increase of ring width between 1928-1932, when the radial increments register an obvious tendency of decreasing from 4-4,5 mm at the beginning of 30's to 2-2,5 mm in 1946-1948 period because of successive periods of drought and stand density.

After 1946`s drought, a relative long period, until the 60's, all the trees had reduced increments, on average of 2,5 mm. This period probably coincides with the extinction of mistletoe attack. A thinning of 70 m^3/ha was carried out around 1962, which it resulted in a differentiation of growth rates between classes: the growth rate of trees of the 1st class increased to 3-3,5 mm/year while the trees that fall into the 2nd and 3rd class had no improvement or even a decrease of their growth rate with average ring width being below 1,5 mm.

After 1997, the tree increments from 1st and 2nd class marked an obvious improvement, while the growth of the trees falling into the 3rd class still had low values of 1,5-2 mm.

Trees from 1st class of infection (control group) and infested trees from 2nd and 3rd class of infection had very similar growth rates before 1975-1977. The growth of trees however clearly differed past 1977.

The Figure 5 revises different phases in infected silver fir trees development.

i) Phase 1, from 1920 till 1945 when the trees that nowadays are falling into the 2nd and 3rd class had similar growth with the ones recorded in the 1st class. Practically in this period all the trees were healthy.

ii) Phase 2, from 1946 till 1976-1977; during this period the trees had been reducing their growth. The growth of silver fir trees that fall into the 2nd and 3rd classes of infection represents 80% of the average growth of 1st class trees.

iii) Phase 3, from 1977 till 2007 (with a couple of episodes) when trees growths from 1st, 2nd

Table 2 Distribution of silver fir trees among infection classes

Plot	Age	Number of inventoried trees	Class of infection			
			0	1	2	3
Păltinoasa	120	27	2	8	10	7
Voroneț	115	8	2	2	2	2
Total		35	4	10	12	9

Table 3 Data colected from the studied trees

Class of parasitism	Number of trees	Mean age	Diameter (cm)	Height (m)
0	4	91	-	-
1	10	88	54.4	37.1
2	12	103	52.2	35.2
3	9	98	50.2	33.5

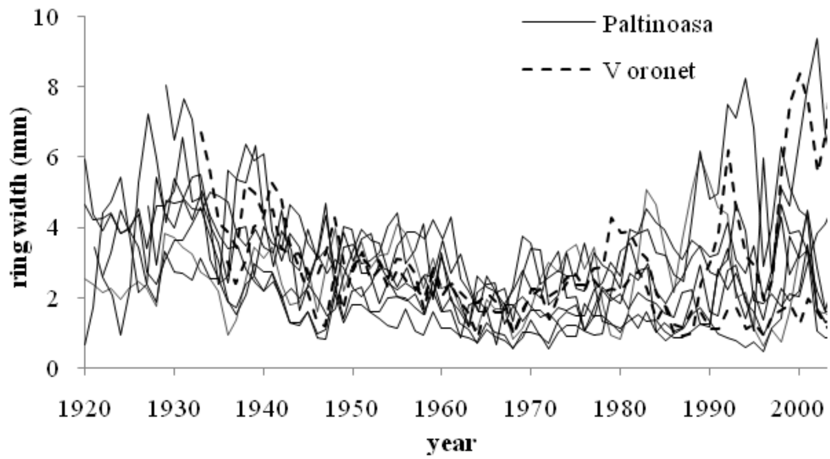

Figure 3a Radial increment of silver fir trees from 1st class of parasitism

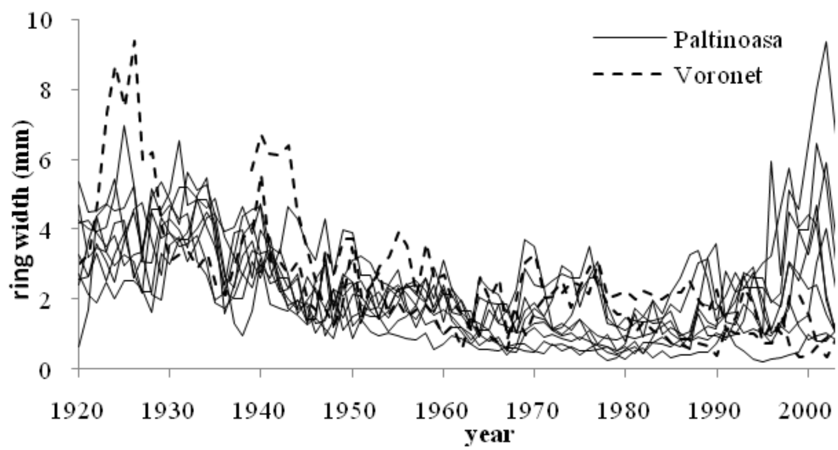

Figure 3b Radial increments of silver fir trees from 2nd class of parasitism

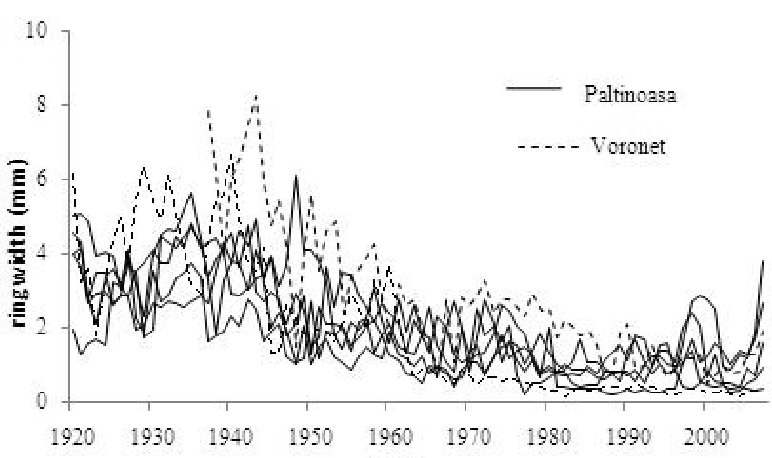

Figure 3c Radial increments of silver fir trees from 3rd class of parasitism

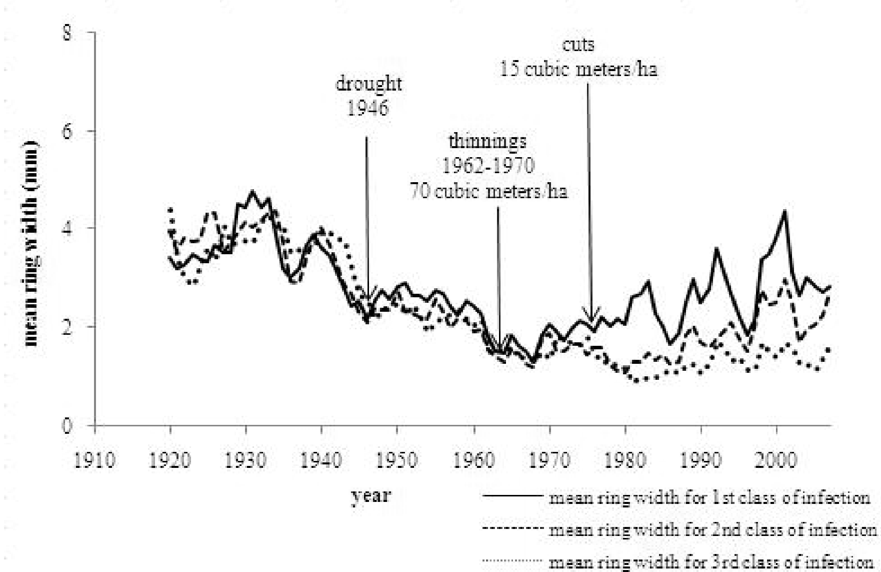

Figure 4 The mean radial increments of silver fir trees from 1st, 2nd and 3rd classes of infection

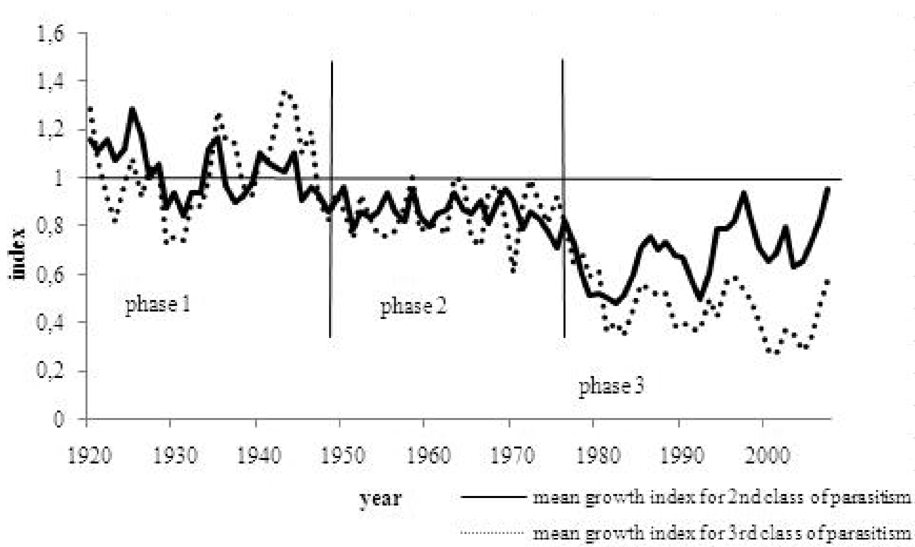

Figure 5 The mean growth index of silver fir trees from 2nd and 3rd class of parasitism

and 3rd classes of parasitism were clearly differentiated. During this stage the growth trends were differentiated as follows.

Between 1977 and 1983, the growth has been lower and lower; the increment of trees falling into the 2nd class represented 50% of the 1st class trees growth, while the same parameter for the 3rd class was about 40% of 1st class trees growth.

After 1983, the growth of the trees falling into the 2nd class recouped to 75% of the 1st class tree growth, while the growth of the 3rd class trees didn't act in the same manner - their growth was kept to 40% or even 30% of the 1st class benchmark growth and they didn't manage to overcome.

Considering an average diameter of 48 cm when the trees started to differentiate their growth, by the end of the 30 years observation period (1977-2007) we came up to the following results: the trees from 1st class had reached a dbh of 54 cm, the trees from 2nd class 52 cm and the trees from 3rd class 50 cm (Table 3) so that result significant differences on basal area and volume increments estimated at 75 % of 1st class increments for trees from 2nd parasitism class and 50 % for the trees from 3rd parasitism class.

Discussion and conclusions

Our results show substantial differentiations in trees growth, according to infection classes. Recently, the increments of silver fir trees from 2nd and 3rd infection classes are lower than 1st class increments.

Having not enough trees with any parasite, the trees less affected were used instead to build up our reference growth chronology. Having such not-infected benchmark trees, the growth trends likely would have been only magnified but not altered. The ratios would probably have been lower which, in turn, it means that the reduction of growth caused by mistletoe infection can be larger than 80%, if comparing strongly infested versus healthy trees.

The thinnings and drought triggered the differentiation. In the absence of light, the mistletoe can be instaled only on higher trees (predominant and dominant trees), not doing to much damage. When the trees from canopy are put into light (after thinnings), the mistletoe begins a more and more active life, developing abundatly and increasing its infections (Plagnat 1950).

After the 1946`s drought (Topor 1963) and the 1962-1970`s thinnings episode, the increments of silver fir trees showed a decrease trend, peculiarly after the 70's, when trees of the 3rd class did not recover from a severe increment losses.

During the epidemic, the average increment of the infested trees from 2nd and 3rd classes decreased. This result matches older studies of the same parasite-host combination (Nanu 1969, Vallauri 1998). The increments of 2nd class trees represented 50% of the 1st class trees growth, while the same parameter for the 3rd class was about 40% of 1st class trees growth. Noetzli (2003) showed that the growth increment of parasite trees started to decrease with a delay of 1 to 5 years after the beginning of the infestation.

Our study pointed out an improvement of 2nd and 3rd class trees growth in the last years. Usually, the last stage of the attack, in which die-back occurs, it is characterized by the absence of any green exterior part of the mistletoe, but the presence of mistletoe is indicated by the fall of 60-75 % of the type I branches in the middle third of the crown, abnormal swelling of the tree and often by the die-back of the top of the tree. Often, the trees whose crowns are dying form on the trunk epicormic branches (compensation crown). The length of this compensation crowns is greater than the length of the effective crown. These compensation crowns have been formed in the last 15-20 years (Barbu 1995). Thus, someone can explain that the trees from the final stage of attack (3rd class) had increased radial growth in the last few years.

It should not be neglected that the wood increment is only one of many possible parameters to measure tree health and growth. Other parameters, such as leafmass, wood density, early and laterwood-width could be measured as well to improve the estimation of growth or health state (Noetzli et al. 2003). The silvicultural treatment in the investigated stand, as changes in the light regime, can cause short term changes in increment of a forest trees (Schweingruber 1996).

To avoid economical losses due to mistletoe on silver fir, it was suggested to reduce the ratio of this species in favor of Norway spruce (Stopp 1961). Eliminating infested trees may not to be suitable to control the disease as well, as in thinned stands, light condition may improve the growth of mistletoe (Noetzli 2003). The living conditions in a thinned stand may be better for *Turdus viscivorus*. This bird species plays an important role in the population dynamics of white mistletoe (Plagnat 1950, Tubeuf 1923).

References

Anonymous. Forest District Gura Humorului management plans between 1913 and 2006

Barbu I., 1995. Cercetări privind reconstrucția ecologică a ecosistemelor forestiere din zonele cu uscare intensă din raza filialei teritoriale Suceava prin revenirea la fostele arbotere naturale. Referat științific final, 80 p.

Hawksworth F. G., Geils B. W., 1989. How long do mistletoe -infected ponderosa pine live? Wst. J. Appl. For. 5: 47-48.

Hawksworth F. G., Wiens D., 1996. Dwarf mistletoe: biology, pathology and systematics. Agricultural handbook 709. Washington, DC: USDA, Forest service, 410 p.

Nanu N., 1969. Vâscul (*Viscum album*) un parazit al bradului din arboretele platoului calac aros Anina - Oravița. Revista Pădurilor 84,.4: 177-178.

Noetzli K, P., muller B., sieber T.N., 2003. Impact of population dynamics of white mistletoe (*Viscum album* ssp. *abietis*) on European silver fir (*Abies alba*), Ann. For. Sci: 60: 773-779

Peter-Contesse J., 1937. Influence du gui sur la production du bois de service, J. For. Suisse 88: 145-153.

Plagnat F., 1950. Le gui du sapin. Ann. Ec. Natl. Eaux For. 12: 157-231.

Plagnat F., Brossier J., 1969. Les sapinieres au gui. Revue Forestiere Francaise 6: 553-557.

Scharpf R. F., 1968. Dwarf mistletoe on True Firs in California, Forest Pest Leaflet 89.

Schweingruber F. H., 1996. Tree Rings and Environment in Dendroecology, Haupt, Bern, 276 p.

Stopp, F., 1961. Unsere Misteln, A. Ziemsen, Wittenberg

Topor, N., 1963. Ani ploioşi, ani secetoşi. Editura Insitutului Meteorologic. Bucureşti, 302 p.

Tubeuf, K., 1923. Monographie der Mistel, R. Oldenburg, München and Berlin. 832 p.

Uscuplic M., 1992. Influence of forest management on the occurence of silver fir mistletoe (*Viscum album* L.). Glasnik Sumarskog Fakulteta, Univerzitet u Beogradu 74: 7-18

Vallauri D., 1998. Dynamique parasitaire de *Viscum album* L. sur pin noir dans le bassin versant du Saignon (Préalps françaises du sud). Ann. Sci. For 55: 823-835.

Zuber R., 1983. Forstschutz, Bünderwald Beih. 12: 115-119.