

Effect of resin-tapping on the radial increment of Scots pine (*Pinus sylvestris* L.) – case study of a stand from Lidzbark Forest District

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Abstract. The study makes an attempt to evaluate the effect of resin-tapping on the radial increment of Scots pine (*Pinus sylvestris* L.). Increment cores were taken from two groups of trees: resin-tapped trees and normal trees growing in a 148-year-old pine stand in the Lidzbark Forest District. The cores were taken with the Pressler increment borer from two heights on the tree trunk: 1,30 m and 3,30 m. Using dendrochronological methods, real chronologies were built for each of the four analysed groups of cores. The value and variability of increments for each group were investigated in 20 and 40 year time periods, before and after the start of resin-tapping. In next step, the chronologies were compared and their coefficients of conformity were calculated. As a result, we can state that the radial increments were larger at 1,3 m height after resin-tapping than before resin-tapping. There was also significant effect of resin-tapping on radial growth at the height 3,3 m, above the resin-tapping face.

Key words: Scots pine, tree rings, resin-tapping, dendrochronology

1. Introduction and aim of the study

Resin is a compound of chemical substances which in natural environment is produced in resinous cells by coniferous plants. In Poland, resin is produced by native species of coniferous trees like pine, spruce, larch and fir. The main component of resin is rosin (around 70% of content) and turpentine (close to 22%). Chemical compositions of resin from natural origin were widely used material in the polish industry (Grochowski 1984, 1990; Głowacki 1990).

Rosin is a very fragile, still substance produced as a result of distilling turpentine. It is used as a material for chords lubrication, addition for paints, glues, sprays, plastic material and rubber. Turpentine is colorless or yellow-colored liquid used for paints and spray production, perfume, disinfecting and cleaning agents, and also for shoe paste production (Coppen, Hone 1995).

Due to its multiple uses, resin is an important material in many countries of minor forest utilization (Wang et al. 2006). Although in Poland from 1994, resin is not obtained, it is still used in many business branches. This material is imported to Poland from different countries, mainly China, Ukraine and Brazil. In industry usage, resin is also produced in artificial way, known commonly as polyester and / or epoxy resin. The resource base of trees suitable for resin tapping is significant in our forests. As Głowacki (1990) claims, in Poland 11 thousand tons of resin a year may be obtained, and by using ecological stimulators, like nettle juice of water yeast extract or fodder yeast, this value can be increased to 15 thousand tons.

Nowadays, attention is given to environment protection; very often natural replacements of materials produced in artificial way are searched. Therefore, the issue of resin-tapping should be looked at more broadly, since it was an important branch of Poland's forest economy in the second half of the 20th century.

Resin obtaining in modern times is associated most often with incision trees and creating resin blazes, which in turn enables this substance leakage. It can be assumed that by cutting trees, tissues in resin-tapping process are not left without influence on their further growth. Creators of ‘Instruction of pine’s resin-tapping’ (1965) were surely led by this assumption, when they advised resin-tapping to 6 years before planned cut. It turns out however, that in Poland many stands are left after resin-tapping in which planned cut was not realised. Those objects enable examining the influence of resin-tapping on condition, structure, and growth of stands.

The aim of the following study is defying the influence of resin-tapping on size and variability of Scots pine radial increments at chosen trunk’s heights.

2. Research material and methodology

Research material was collected in pine’s stand situated in the area of Lidzbark Forest Inspectorate, in which in the 60s, an intervention of resin-tapping was conducted (Detailed plan of Kostkowo Forest Inspectorate management). The age of stand at the time of research was 148 years; average DBH 40 cm, and height 32 m. The stand was located on habitat of fresh mixed hardwood forest and was characterised with 1st site index (forest management plan for Lidzbark Forest Inspectorate). For research two groups of trees were selected: resin-tapped and non resin-tapped, constituting a control group. In both the cases, the trees were characterised with high biosocial class in stand (dominant trees – II Kraft’s class). Both groups of trees also did not differ in height. The trees’ thicknesses was not compared however due to large irregularity of resin-tapped trees trunk; basic criterion of all trees selection, both resin-tapped and non resin-tapped was the same biosocial position.

Research material were spinal cores collected with the use of Pressler borer from a tree’s trunk at a height of 1,30 and 3,30 m. First of heights of drill collection (1,30 m) was located in the area of resin blaze of resin-tapped trees, which did not reach over 3,0 m from trunk’s base. Second of heights (3,30 m) was located above resin blaze, so in the non resin-tapped part of trunk. It’s worth adding, that resin blaze is a decorticated place on trunk’s side (up to $\frac{3}{4}$ of circuit) with cut grooves (called also slots), with which secreted resin runs down to plastic cups. Remaining, undecorticated part of trunk’s circuit contained so called life strips, which were supposed to

maintain tree’s life functions in period of resin-tapping. Depending on the tree’s thickness, the method of resin tapping allowed creating one to three blazes on tree, on which systematically, once a week, cuts were made stimulating the float of resin (Jeziński 1930, 1937; Schwarz 1921). For the purpose of research, only those trees were selected, on which two resin blazes occurred on two opposite trees sides. On all of resin-tapped trees, the location of resin blazes was the same, towards quarter’s of the globe. Therefore, the drills were collected from life strips of all trees with maintaining the same quarter’s of the globe, also at the height of 3,30 m (over blaze) and at both heights of control trees, from which the samples were collected (Fig.1). Research material included jointly 70 drills divided into 4 groups (at the height of 1,30 m and 3,30 m of resin-tapped trees and non resin-tapped trees). In the study, sample disks were also used collected at the height of DBH from the three resin-tapped trees. They were used for determining the period, in which resin-tapping took place. It was established, that this intervention began in year 1965, when this stand was 106 years old.

Spinal cores and sample disks after proper preparation underwent measurements in the Laboratory of Dendrometry and Forest Productivity in the Forestry

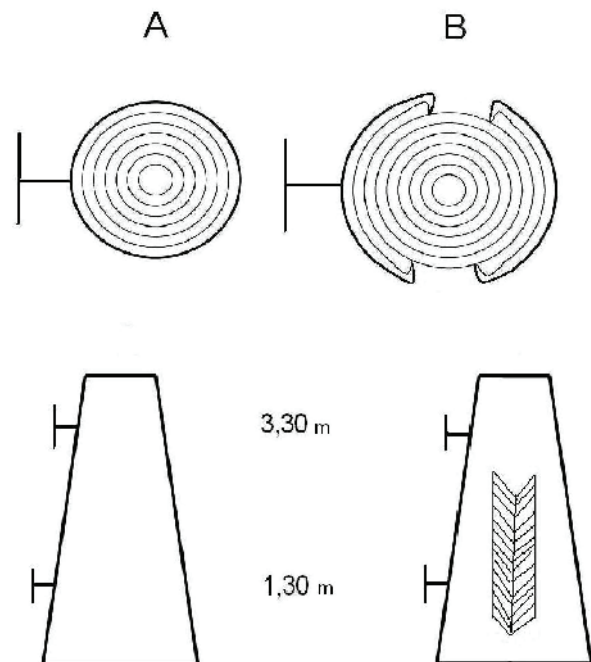


Figure 1. Scheme of collection of cores from the stem at resin-tapped (A) and non resin-tapped trees (B)

Department of Warsaw University of Life Sciences – SGGW. The first stage of work involved scanning properly the prepared drills and records the image in a graphic form. In the second stage, the width of annual rings was measured with the use of an ‘Increment’ program of BIOtronic firm, which generated a text file, used in further analysis. After the measurement of the research material with the use of CASE program, figures were transformed to the specific format required by programs from the Dendrochronology Program Library (DPL). The following stage was the selection of samples for building the chronology. The ground for rejecting increment section was representing different trees than the majority of trees in the group; increment reactions included the incremental sequence correlation factor of given samples with the averaged sequences from remaining samples. This analysis was conducted with the use of COFECHA program (Holmes 1983). Selected material was used for creating chronology, which was achieved by averaging increments of consistent increment sequences in individual groups for given calendar year.

By comparing chronologies, a division was made for two equal periods, including the year 1965, which based on the analysis of three drills collected at the

height of 1,30 m was defined as a year of resin-tapping intervention. Based on chronology, the width of rings was compared at a height of 1,30 and 3,30 m of resin-tapped trees and non resin-tapped trees. Evaluated also was the compatibility of chronology from both heights within the same group of trees (resin-tapped and non resin-tapped). Comparisons of chronology were made with the use of statistics t with student distribution calculated in accordance with Baillie’s and Pilcher’s algorithm (1973). Significance of differences was established with significance level of 0,05.

3. Research results

Statistic analysis of real chronologies of radial increments at the DBH height – 1,30 m and over resin blaze – 3,30 m of resin-tapped trees and non resin-tapped trees was conducted by dividing into two periods: twenty years (Table 1) and forty years period (Table 2). After establishing the period of the beginning of resin-tapping for year 1965, the width of annual rings in the years 1945–1964 (twenty years period), 1925–1964 (forty years period), before beginning of resin-tapping, and subsequent periods 1965–1984

Table 1. Descriptive statistics of the tree-ring width with raw chronologies at heights of 1,30 and 3,30 m above the ground in a twenty-year period (nz – non resin-tapping trees, z – resin-tapping trees).

Descriptive statistics		Height 1,30 m				Height 3,30 m			
		before resin-tapping (1945–1964)		after resin-tapping (1965–1984)		before resin-tapping (1945–1964)		after resin-tapping (1965–1984)	
		nz	z	nz	z	nz	z	nz	z
Average	mm	1,06	0,99	0,98	1,53	0,68	0,92	0,63	0,69
Median	mm	1,04	1,00	1,02	1,55	0,64	0,93	0,62	0,67
Standard deviation	mm	0,15	0,21	0,25	0,58	0,15	0,13	0,20	0,16
Minimum	mm	0,78	0,72	0,47	0,63	0,45	0,66	0,29	0,44
Maximum	mm	1,35	1,43	1,32	2,70	0,99	1,16	1,00	0,97
Range	mm	0,57	0,71	0,86	2,08	0,53	0,50	0,71	0,52
Coefficient of variation	%	14,0	21,3	25,1	37,6	21,4	14,4	31,8	23,8
Kurtosis		-0,52	-1,06	-0,48	-0,76	-0,49	-0,80	-0,75	-1,18
Skewness		0,40	-0,19	-0,52	-0,08	0,83	-0,08	0,05	0,28

Table 2. Descriptive statistics of the tree-ring width raw chronologies at a height of 1,30 and 3,30 m above the ground in a forty-year period (nz – non resin-tapping trees, z – resin-tapping trees).

Descriptive statistics		Height 1,30 m				Height 3,30 m			
		before resin-tapping (1925–1964)		after resin-tapping (1965–2004)		before resin-tapping (1925–1964)		after resin-tapping (1965–2004)	
		nz	z	nz	z	nz	z	nz	z
Average	mm	1,08	1,09	1,06	1,71	0,84	1,08	0,64	0,63
Median	mm	1,06	1,12	1,04	1,71	0,86	1,04	0,62	0,60
Standard deviation	mm	0,17	0,21	0,28	0,48	0,21	0,24	0,18	0,16
Minimum	mm	0,78	0,72	0,47	0,63	0,45	0,66	0,29	0,40
Maximum	mm	1,53	1,43	1,53	2,70	1,21	0,00	1,00	0,97
Range	mm	0,75	0,71	1,07	2,08	0,76	-0,66	0,71	0,57
Coefficient of variation	%	15,2	19,3	26,1	28,4	25,4	21,9	28,2	25,2
Kurtosis		0,39	-0,95	-0,56	-0,13	-1,22	-0,11	-0,61	-0,96
Skewness		0,42	-0,52	0,21	-0,00	-0,26	0,50	0,35	0,59

and 1965–2004 after beginning of resin tapping were analyzed.

By comparing individual statistic measurements of thickness increment at a height of 1,30 m of resin-tapped and non resin-tapped trees, significant differences in annual rings increment may be seen in set periods before and after performing the intervention. Before resin-tapping period, the average width of trees annual rings in both groups was similar; arithmetic mean of resin-tapped trees was 1,53 mm, while one with non resin-tapped trees persist on unchanged level – 0,98 (Table 1). Similar regularity may be observed with the analysis of annual rings in forty year periods before and after beginning of resin-tapping (Table 2).

By analysing the thickness increment over resin blaze of resin-tapped and on corresponding height at 3,3 m of non resin-tapped trees (Table 1, 2), it can be observed that before the year 1965 non resin-tapped trees were characterised with much lower increments than trees, on which the intervention was performed. It therefore proves that selecting trees for resin-tapping was influenced by their thickness. From resin-tapping experience on Scots pine indicate, that trees of bigger annual ring's width are characterised with bigger resin-tapping efficiency (Antkowiak 1992). Arithmetic mean

of non resin-tapped trees' increments in period 1945–1964 equaled 0,68 mm, whereas resin-tapped trees – 0,92 mm, and in period 1925–1964 subsequently 0,84 and 1,08 mm. After intervention, radial increments over resin blaze of resin-tapped trees lowered, and so did the variability of rings widths.

Averaged sizes of selected samples were presented on Figure 2 (real chronologies of trees radial increment at the height of 1,30 m) and on Figure 3, (the real chronologies of trees' radial increments at a height of 3,30 m). In the earlier phases of life, thickness increment of resin-tapped and non resin-tapped trees at a height of DBH was forming similarly. Such course of incremental curves is observed till 1971, after which substantial increase of annual rings width of resin-tapped trees followed. The explanation of increment increase may be trees' release from stress factor, influencing trees for 6 years, which was active resin obtaining. After this period, a tree retrieved vitality and increased its thickness increments on left life strips, which can be observed on examining the end of a tree's life period (Fig. 2).

On Figure 3 the course of real thickness increment chronologies at a height over resin-blaze of resin-tapped trees are presented along with increments at a height

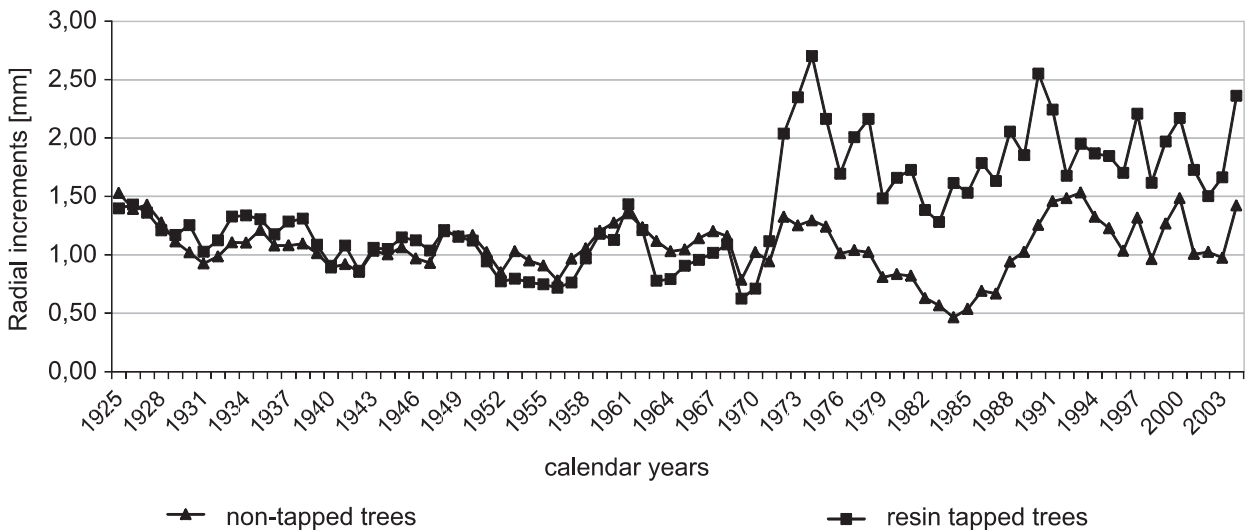


Figure 2. The tree-ring width raw chronologies at the height 1,30 m above the ground for resin tapped and non-tapped trees.

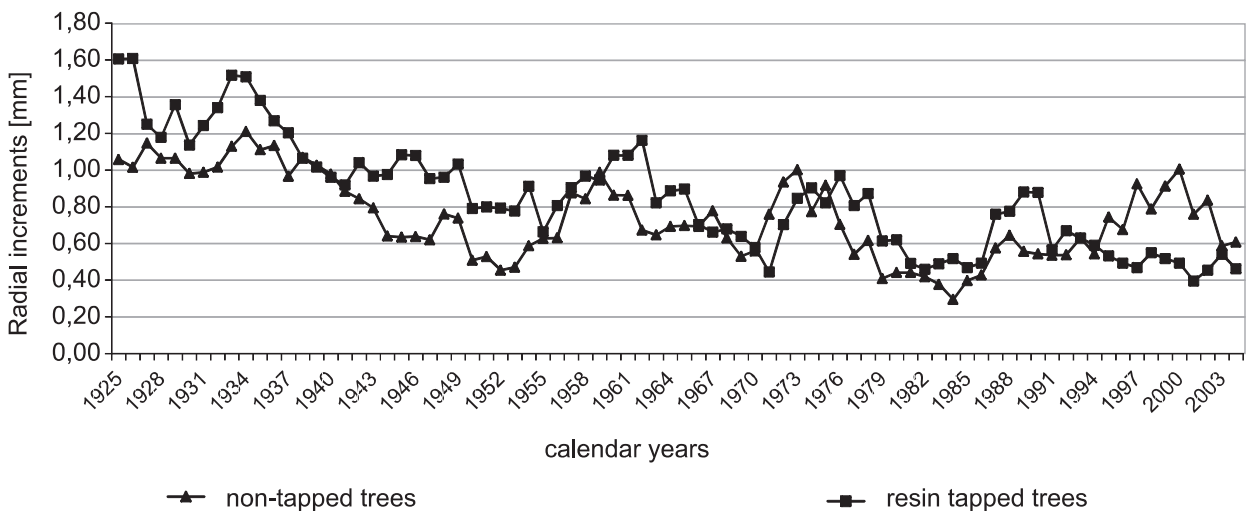


Figure 3. The tree-ring width raw chronologies at a height 3,30 m above the ground for resin tapped and non-tapped trees.

of 3,3 m of non resin-tapped trees. The value of trees' increments at this height persists on similar level in both the compared groups of trees.

Compatibility of chronologies was examined for twenty and forty years periods before and after the beginning of resin-tapping process (Table 3). For examining compatibility of chronologies used was *t* test, with significance level 0,05 where for 40-element sample test's critical value was 2,02 and for 10-element

– 2,09 (Zieliński 1987). Before resin-tapping, all groups of compared chronologies were consistent. The highest values of *t* test adopt chronology couples at the DBH height of resin-tapped and non resin-tapped trees. After conducted intervention stated was compatibility between chronologies of resin-tapped and non resin-tapped trees at the DBH height and between chronologies at the height of 1,3 m and 3,3 m of non resin-tapped trees.

Table 3. Comparison of coincidence of chronologies thick growth of trees

Comparison groups		Twenty-year comparison periods		Forty-year comparison periods	
		before resin-tapping (1925–1964)	after resin-tapping (1965–1984)	before resin-tapping (1925–1964)	after resin-tapping (1965–2004)
Comparison of chronologies at the height of 1,30 and 3,30 m above the ground	resin-tapped trees	3,05	1,88*	2,96	1,17*
	non resin-tapped trees	2,81	5,73	3,23	5,04
Comparison of chronologies of resin-tapped and non resin-tapped trees	height 1,30 m	5,25	5,66	7,44	8,86
	height 3,30 m	2,59	–0,25*	2,3	0,08*

* lack of coincidence of chronologies at 0,05 significance level

4. Discussion

In Poland resin obtaining for large scale began in interwar period of 20th century with assumption, that it will bring large financial benefit for State Forests. In post-war period occurs further increase of obtained resin quantity. From those periods come also the majority of studies described over influence of resin-tapping intervention on trees. When analyzing the literature available, can be found many theoretical deliberations unsupported by empirical research. Particularly little research concerns the increment of resin-tapped trees, including thickness increment.

The following study is an attempt of filling this gap. Thanks to the fact that in the area of Lidzbark Forest Inspectorate remained a stand, in which both resin-tapped and non resin-tapped trees occur, it was possible to make an attempt to compare both groups, to show possible influence of resin-tapping on trees thickness increment. By using dendrochronological methods, it was possible to analyse the annual increments in trees within the pre resin-tapping, during intervention and after its termination periods.

Already in 1930, by comparing sizes of DBH radial increments of resin-tapped and non resin-tapped trees,

observed was, that resin-tapping is not neutral for radial increment of Scots pine (Jeziński 1930). It was possible to observe after several years on resin-tapped trees, without the necessity of conducting any other research that the blaze height life strips increased in the form of semicircular thickenings, whereas at the location of resin blaze such increment was not present.

Research conducted in the following study indicate, that on life strips up to the height of resin blaze i.e. around 3 m. along trunk, the thickness increment after beginning of resin-tapping significantly increased. About increment increasing in butt end part after beginning of resin-tapping wrote Jeziński (1932), justifying it with a statement that ‘tree by not increasing in places damaged by blaze, try in different parts of circuit to compensate this fact by increasing more energetically’. He explained the process of stronger increase by trial of wound healing, which for trees are resin blazes. Legitimacy may be Kaludin’s theory (Grochowski 1984), who regarded, that tree left standing after a period of resin-tapping can catch up, what it lost during resin-tapping. However, what deserves consideration is whether what increases on trunk after finishing of resin-tapping has an economic meaning, because the butt end part of the trunk does not constitute good quality assortment. Even if the tree

would heal the wound created, inbarks, wood defects would still remain, which in turn makes it impossible to use the assortment. Of course in polish forests, there is no production cycle long enough for leaving such trees to heal the damaged part of trunk. It is known, that Scots pine can live to over 250 years. As claimed Bohmerli (after Jezierski 1930), the fact whether a given tree falls out of stand after resin-tapping period, or remains in it, depends not only on 'vital ownership of tree' but also on external factors, inter alia on fall quantity.

In examined stand on trees, which were resin-tapped, two resin blazes on two opposite sides of trees were located with maintaining life strips, as the resin-tapping instruction required it (Instruction of pine's resin-tapping 1956). Wherever possible, as many as possible blazes were set up. It can therefore be concluded, that trees with one blaze heal only from one side, so the real increase may be smaller.

Another part of research indicated, that over resin blaze at the height of 3,30 m after resin-tapping period, the increment between two groups of trees is shaped in similar way. However, increment over resin blaze of resin-tapped trees (3,30 m) was lowered. Similar results received Kutuzow, indicating, that increment over resin blaze after resin-tapping is lowered significantly (Kutuzow 1953). In the following research, high volatility of trees' thickness increment at a height of 3,30 m occur between groups of resin-tapped and non resin-tapped trees before resin-tapping period, and after the resin-tapping period, the increment is equalized. It may be thus confirmed that resin-tapped trees had faster increment in youth and were crop trees. An evaluation of the compatibility of chronology allows for explanation of resin-tapping influence on the trees' radial increment. Lack of compatibility was observed between chronologies at a height of 1,3 m and 3,3 m after conducting the resin-tapping intervention ($t = 1,17$), which can be a proof for significant impact of intervention on the width formation of annual rings.

Due to the fact that post the resin-tapping period, chronologies of radial increments at a height of 3,3 m has stopped being compatible (change of value t from 2,50 for $-0,25$ and from 2,30 for $0,08$ depending on period length), it may be stated, that resin-tapping period significantly influences the formation of thickness increment along the shaft. There is an increase of lower shaft section tapering; it is hard to answer however how high on trunk the influence of resin-tapping reach without performing trunk analysis of resin-tapped trees. It was also observed that during a 6 year cycle,

resin-tapping did not give rise to any increase of DBH. Increment increased after ending of intervention, wherein increments can be accumulated only on life strips.

It is hard in any manner to express the loss of a total tree's mass in the result of resin-tapping in percent or in cubic meter, as confirmed by de Larnage, Pallas, Karol Bohmerle and Suchecki (Jezierski 1930). During resin-tapping, as showed earlier, average increment of annual rings at DBH height increases, and thickness increment decreases. The increase of radial increments does not take place on a whole tree's circuit; with time, disproportion is expanding between life strips and resin blaze, which as a matter of fact is much wider than life strip. It is hard to say therefore about a diameter increment, because a tree after resin-tapping intervention has an irregular shape and its diameter may be interpreted in various ways.

5. Conclusion

Size and variability of annual increment at a height of 1,3 m of resin-tapped trees and non resin-tapped before resin-tapping were on similar level; after 1965, increments of resin-tapped trees increased significantly, reaching an average value in period of 1,71 mm. It allows stating that resin-tapping has significant influence on size of Scots pine radial increments at the height of DBH, wherein this increment happens only on a part of trunk's circuit, which is life strip.

A significant influence of resin-tapping intervention on size of Scots pine's annual increment was stated over resin blaze.

The most significant year in terms of increment analysis at a height of 1,30 m in group of resin-tapped trees is 1971; this is the first year in which interventions with 6 year resin-tapping circulation were not run, in which trees were released from stress caused by frequent slot incision and therefore reacted with strong increment.

Before resin-tapping all groups of compared trees, thickness increment of chronologies are consistent. The highest degree of compatibility characterises chronology couples at a height of DBH of resin-tapped and non resin-tapped trees. After execution, the intervention stated was compatibility only between chronologies of resin-tapped and non resin-tapped trees at a height of DBH and between chronologies at a height of 1,3 and 3,3 m of non resin-tapped trees. With

different increment patterns, after executed intervention characterised were sequences at the height of 1,30 and 3,30 m of resin-tapped trees and at a height of 3,30 m of both group of trees.

Scots pine can live long after resin-tapping intervention. In examined stand, over 40 years after the beginning of resin-tapping intervention, considerable part of trees were still alive. Their general state was however worse than non resin-tapped trees.

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