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INVESTIGATION INTO THE POSSIBILITY OF ROOT DROWNING AS A CAUSE OF *CRYPTOCOCCUS FAGI* ATTACKS AND OTHER DISEASES IN BEECH STANDS

DRUKNING AF RØDDER OG ANGREB AF *CRYPTOCOCCUS FAGI* I DANSKE BØGEBEVOKSNINGER

BY

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I. INTRODUCTION

The beech scale, or felted beech coccus, *Cryptococcus fagi,* is a common disease of beech, *Fagus sylvatica,* in Denmark. This disease has been fully described for Danish conditions by *Thomsen, Buchwald,* and *Hauberg* (1949). Extensive literature also exists describing the occurrence of this disease in other European countries, as well as the North American Continent (*Shigo,* 1964; *Spaulding,* 1948; *Spaulding, Grant* and *Ayers,* 1936; *Stone,* 1962; *Zycha,* 1951, 1955, 1959, and 1960; and *Štefančik* and *Leontovyč,* 1966).

Few studies, however, have been initiated to determine the reason for periodic outbreaks of the disease. In recent years, since the completion of the *Thomsen, Buchwald,* and *Hauberg*-study, it has been brought to the attention of the Danish Forest Experiment Station that outbreaks of *Cryptococcus fagi* and associated parasites were frequently occurring in beech stands with high ground water tables and poor drainage. The present investigation was therefore undertaken to determine if the high ground water table and resulting root drowning makes a tree more susceptible to infestation by beech scale disease.

II. REVIEW OF LITERATURE

1. Effects of high ground water level on forest trees.

General.

The detrimental effects of a high ground water table and consequent root drowning on many species of forest trees is extensively described in the literature (*Hall* and *Smith,* 1955; *Holstener-Jørgensen,* 1959a, 1959b, 1961 and 1965; *Kramer,* 1949; *Leyton* and *Rousseau,* 1958; *Walker, Green,* and *Daniels,* 1961). The results of much of this work, however, is somewhat contradictory and the actual physiological effects of flooding are still not fully explained (*Kramer,* 1949).

Kozlowski (1958) states, "In flooded soils, absorbtion of water by roots often decreases and lags behind transpiration. This causes leaves to dry out and checks photosynthesis." However, *Kramer* (1951) writes, "It is believed that injury to roots of flooded plants is complex in origin and has several causes rather than simply resulting from interference with water absorbtion."

Leyton and *Rousseau* (1958) attribute the following effects to a decreasing oxygen supply (i. e. root drowning):

(i) decreased respiratory activity
(ii) reduced nutrient uptake
(iii) reduced water uptake, and
(iv) through a series of interrelated responses, a reduction in growth.

Kramer and *Kozlowski* (1960) suggest the following:

(i) Flooding reduces soil nutrient and water absorbtion.
(ii) The killing of the roots may release toxic substances to the rest of the tree.
(iii) The leaves may suffer from the lack of some essential element produced by the roots.
(iv) The roots are made ineffective through reduced respiration.

The physiological explanation of root drowning is further complicated by the fact that various species of forest trees react differently to water-logged subsoils. For example, *Walker, Green,* and *Daniels* (1961) found that flooding of slash pine (*Pinus ellottii*) and loblolly pine (*Pinus taeda*) stands proved to be detrimental to these species. However, *Hunt* (1951) demonstrated that shortleaf pine (*Pinus echinata*), loblolly pine, and pond pine (*Pinus ridgida*) proved resistant to flooding. *Holstener-Jørgensen* (1961) states for Danish conditions, "According to the literature, beech is very sensitive to flooding, whereas oak and ash may stand up to even rather protracted flooding." Other works by *Leyton* and *Rousseau* (1958) also demonstrated the different physiological responses of various species to the presence of a high water table.

Environmental conditions, such as soil type and texture, may influence the effect of a high ground water table on various species. *Loustalot* (1945) found that flooding of pecan trees growing in sand caused photosynthesis to be reduced to 11 % of its former value. However, the flooding of trees growing in heavier soil reduced photosynthesis even more.

Other factors, such as the season of the year in which flooding occurs, may also determine the degree of influence of a high water table on forest trees. *Heinicke* (1932) observed that flooding of the soil in an apple orchard during the winter caused "considerable loss of small roots" but produced no serious injury if the soil was drained before the leaves began to appear. *Kozlowski* (1958) discusses the effects of flooding on height growth and concludes that most species of trees complete their height growth relatively early in the spring — in periods ranging from two weeks to sixty days. These results appear to indicate that spring is the most critical season in which a high ground water table can occur. *Boynton* (1941) and *Stone, Morrow,* and *Welsh* (1954) also discuss the relation of season of water-logged subsoils to root drowning.

In Denmark.

Holstener-Jørgensen (1958, 1959a, 1959b, and 1961) reports on the relationship of ground water to growth and vigour of beech forest under Danish conditions. "Danish authors have noticed that a high water table is detrimental to certain tree-species. This holds good for beech, in which the increment is reduced and the form harmed, and sometimes the stand wilts." (*Holstener-Jørgensen,* 1961).

In particular (1961) the effect of high ground water levels on root growth is described for a 116 year-old beech stand located on a poorly drained site near Valby Hegn. In the spring of 1960, the crowns of this stand were scantily leaved with small, yellowish leaves. Two trees were overturned and all roots deeper than 10 cm were dead, as well as the roots at distances greater than 50—200 cm from the base of the tree.

Holstener-Jørgensen (1961) also summarizes the reports of other Danish observers on the occurrence of root death in areas with high water tables.

Under Danish conditions, the beech stand itself is often a controlling factor in the height of the ground water table. The removal of the forest by either clear-cutting or shelterwood cutting was shown to raise the "deepest water table" by approximately two meters or one meter respectively (*Holstener-Jørgensen,* 1959a).

2. THE "BEECH SCALE DISEASE".

The "beech-scale disease" is also thoroughly discussed in the literature. *Thomsen, Buchwald,* and *Hauberg* (1949) present a detailed report on this disease with reference to Danish conditions. Therefore, only a brief discussion will be presented here.

In Danish beech stands, the trees are initially attacked by *Cryptococcus fagi,* the beech scale. When many coccids are present on the beech bark, a brown area of dead and dying cells may appear which eventually leads to the development of "brown spots". A "slime-flux" usually exudes from the brown spots. *Thomsen, Buchwald,* and *Hauberg* describe a succeeding stage in the development of the "disease" in which *Nectria* spp. infects the tree through the cracks originally produced by the coccids or through the "brown spots." However, no definite evidence of *Nectria* spp. was found on any of the trees investigated in the present study. The bark beetle, *Xyloterus domesticus,* may also be associated with the beech scale disease. Eventually, sapwood-destroying fungi (*Stereum* spp. and *Polyporous* spp.) and heartwood-destroying fungi (*Fomes* spp.) may infect diseased trees.

The preceding description of the "disease" in Danish beech stands conforms with that of other workers for various areas. *Spaulding* (1948) reports on the incidence of "beech bark disease" in New England, U.S.A., while *Zycha* (1951, 1955, 1959, and 1960) and *Štefančik* and *Leontovyč* (1966) describe the occurrence of this disease in Germany and Czechoslovakia respectively.

3. RELATIONSHIP OF A HIGH GROUND WATER LEVEL TO THE INCIDENCE OF THE BEECH BARK DISEASE.

General.

Few formal studies have been made to determine the relationship between a high ground water table in a forested area and the occurrence of various forest tree diseases.

Stone, Morrow, and *Welsh* (1954) present a thorough discussion of the relationship of poor drainage to "diseased" red pine stands (*Pinus resinosa*) in the northeastern U.S.A. The "red pine disease" as described by these authors appears not to be a true disease, but a decline in vigour and growth due to a high ground water table and water-logged soils. Stands of red pine situated on compact glacial till appeared to be "diseased" because of the existence of poor drainage conditions. Evidence was offered which indicated that red pine stands on more perfectly drained soils were not effected by the "disease". Under conditions of abnormally high spring rainfall, the imperfectly drained soils were water-logged, which resulted in insufficient supplies of oxygen for the root systems. Adequate supplies of oxygen during spring, when high rates of respiration occur, appeared to be of crucial importance.

Copeland (1949) found in a study of the incidence of "little leaf disease" affecting shortleaf pine (*Pinus echinata*) that the percentage of "little-leaf" trees increased as the internal drainage of the respective soils decreased.

Groundwater.

Thomsen, Buchwald, and *Hauberg* (1949) do not implicitly state any relationship between high ground water table and the occurrence of the beech scale disease. To the contrary, they report that, "Practical foresters have thought that lowering of the groundwater table due to the increased demand of Copenhagen and various towns might have been the origin of the trouble" (i. e. the beech scale disease). However, after obtaining ground water level records from the Danish Geological Survey for the various areas under study, it was found that the correlation between areas with ground water table lowering and the occurrence of the beech scale disease was not sufficiently close to prove the hypothesis.

These authors also state, "... a sudden change to a more drastic thinning was thought by several foresters to have furthered an outbreak" (of the beech scale disease). *Holstener-Jørgensen* (1959a) has shown that root death may be caused by thinning, since under Danish conditions, thinning may result in a rise in the ground water level due to reduced transpiration of the forest stand. Therefore, these two independent studies seem to imply a causal relationship between thinning, root drowning, and the beech scale disease.

Bejer-Petersen (1964) essentially agrees with *Thomsen, Buchwald,* and *Hauberg* in suggesting that the lowering of the ground water table, either through pumping or drought, may be responsible for the occurrence of the beech scale disease in certain areas of Denmark.

Climate Change.

In addition to the above hypotheses, *Thomsen, Buchwald,* and *Hauberg* suggest the relationship of abnormal weather conditions to the occurrence of outbreaks of the beech scale disease. They propose that hot, dry summers may be partially responsible for the occurrence of this disease. *Štefančik* and *Leontovyč* (1966) support a similar hypothesis for Czechoslovakian conditions.

Bejer-Petersen (1964) and *Bejer-Petersen* and *Koch* (1964) further discuss the possible causes of outbreaks of beech scale disease in Denmark. Essentially, these authors agree with, and elaborate upon the original hypothesis made by *Thomsen, Buchwald,* and *Hauberg* concerning abnormal climatic conditions. *Bejer-Petersen* (1964) states that healthy beeches in normal stands may be made more susceptible to the beech scale disease by unusual climatic conditions (drought, etc.) when (1) shelterwood cutting, (2) soil compaction by logging, and/or (3) thinning have taken place. This author also suggests that codominant trees are usually more susceptible to the disease than are dominant trees.

III. DESCRIPTION OF THE STUDY

1. STUDY AREA.

Diseased and healthy trees were selected for study purposes in 11 different forests on Lolland and Falster and one forest on Seeland: (1) Raunstrup Skov (Orup Gd.), (2) Systofte Skov (Orup Gd.), (3) Christianssæde, (4) Kærstrup, (5) Corselitze, (6) Bødkerskov (Halsted Kloster), (7) Torrig Skov (Halsted Kloster), (8) Ludvigshave (Halsted Kloster), (9) Rykkerup Skov (Krenkerup), (10) Fruemose Skov (Krenkerup), (11) Rudbjerg Gd. and (12) Karise Hestehave (Bregentved).

These forests are located on clay soils, which in turn overlay a substratum of morainic material from the Pleistocene and Cretaceous chalk. The topography of all the study areas is very level and the soils are heavy clays with poor drainage due to the deficient slope and compact subsoils. With the sole exception of the study site at Fruemose Skov, all the study sites had very shallow spring (April-May) water tables from 20—70 cm depth.

2. METHOD OF STUDY.

1. During late March and April, 1966, the 12 forests were initially visited. Isolated trees infected with *Cryptococcus fagi,* brown spots, bark throw, bark beetles (*Xyloterus domesticus*) (diseased trees), and/or showing signs of vigour reduction were selected for study trees. In each forest, only isolated diseased trees could be found and no large "pockets" of diseased trees were located. However, several relatively large pockets of beech with reduced vigour probably due to root drowning were located and selected as study sites. Observation wells were bored near each selected tree to a depth of 120—130 cm and the drainage conditions of each selected site noted.

2. The study trees were again visited in early May during the leafing-out period. At this time, it was possible to ascertain the vigour of each tree and to note the level of the ground water in each of the previously dug observation wells.

3. During June, 1966, a detailed inspection of the root system of each study tree was made. In order to investigate the root systems, a soil pit was dug at a distance of one meter from each tree to a depth of 1.2 m. In some cases, the tree was pulled over by a tractor in order to investigate the root system.

A tree of comparable age and size to the study tree, but showing no signs of disease, was selected near each diseased tree for purposes of comparison (control tree). If obvious heavy root drowning had occurred in the root system of the diseased tree, then a soil pit was also dug near the control tree and the condition of its root system was observed.

Two increment cores were taken at breast-height from all the diseased and low vigour trees, as well as from each of the corresponding control trees.

Two transects were established in "pockets" of low vigour trees. It was suspected that the non-vigorous condition of beeches in these "pockets" was the result of water-logged subsoils and high ground water table. One six-tree transect was established in Raunstrup Skov at Orup Gd. and another four-tree transect at Karise Hestehave at Bregentved. Soil pits were dug and root systems of each of these trees were investigated in the same manner as were the diseased trees.

In all, 42 diseased and/or nonvigorous trees were selected along with 33 control trees. (Only two control trees were selected in the transects). Of this total of 75 trees, the root systems of 63 were investigated.

4. An analysis of year-ring width from the increment cores was made. The results of this analysis aided in determining if root drowning had occurred at a particular site.

Throughout this series of visits, detailed notes on the tree's vigour, the extent of disease, the condition of the root system, and the condition of the surrounding site were made. A summary of the observations made on the crown vigour, root system vigour, severity of disease, etc. at each site is presented in the succeeding section.

IV. RESULTS AND DISCUSSIONS

1. General.

Table 1 briefly summarizes the results of the observations made during the study. Further descriptions of the study findings are presented in the succeeding sections.

2. Summary of observations of trees with the beech scale disease.

Orup Gd. — Raunstrup Skov

Two trees (Nos. 1 and 2) with severe *Cryptococcus* and a few brown spots were located in compartment 15 and their root systems were investigated. Root drowning had occurred in the root system of one of the trees.

Four trees (3, 4, 5, and 5-B), each with either serious *Cryptococcus,* serious beetle infestation, serious bark throw, and/or brown spots were located in a non-vigorous one-hectare stand, located on a very wet site. Some root drowning was apparent in the root system of each tree; however, the vigour of the root system of each tree was relatively superior to that of the crown. Therefore, it appeared that the decline in vigour of the root system resulted partially from the incidence of the disease as well as from the presence of a high water table within the compartment.

T a b l e 1. Results of observations.

T a b e l 1. Oversigt over undersøgelsesresultater.

Location	Study trees					Control trees			Remarks
	No.	Beech scale disease	Only vigour decline	Root drowning	Growth decline	No.	Root drowning	Growth decline	
	Forsøgstræer					*Kontroltræer*			
Lokalitet	*Nr.*	*Luseangreb*	*Kun utrivelig*	*Døde rødder*	*Tilvækstnedgang*	*Nr.*	*Døde rødder*	*Tilvækstnedgang*	*Bemærkninger*
Orupgård, Raunstrup	1	+		0	0	1A		+	
„ „	2	+		+	+	2A		0	
„ „	3	+		+	+	3A		+	
„ „	4	+		+	+	4A		0	
„ „	5	+		+	+	5A	+	+	
„ „	5B	+		+	+				
Orupgård, Systofte	6	+		0	0	6A		0	
Kærstrup	7		+	+	0	7A	+	0	
„	8		+	+	+	8A	+	0	
„	9		+	+	0	9A	0	0	
Christianssæde	10	+		+	0	10A	+	0	
„	11	+		0	+	11A		+	
„	12	Frost cracking *frost revner*		+	+	12A	+	0	
„	13	+		0	+	13A	0	0	
„	14	+		+	+	14A	+	0	
„	15	+		+	+	15A	0	+	
„	16	+		+	+	16A		+	
„	17	+		+	+	17A	0	+	
Corselitze	18	+		0	0	18A		0	
„	19	+		+	+	19A	0	0	
„	20	+		0	0	20A		0	
„	21	+		+	+	21A	+	+	
Halsted Kloster, Bødkerskov	22	+		+	+	22A	+	0	22A in reality vigour decline
„	23		+	+	+	23A	+	+	23A in reality vigour decline
Halsted Kloster, Ludvigshave	24		+	+	+	24A	+	+	
„ „	25	+		+	+	25A	0	0	

Table 1 (continued).
Tabel 1 (fortsat).

Location	Study trees					Control trees			Remarks
	No.	Beech scale disease	Only vigour decline	Root drowning	Growth decline	No.	Root drowning	Growth decline	
	Forsøgstræer					*Kontroltræer*			
Lokalitet	*Nr.*	*Luse-angreb*	*Kun utrivelig*	*Døde rødder*	*Tilvækst-nedgang*	*Nr.*	*Døde rødder*	*Tilvækst-nedgang*	*Bemærk-ninger*
Halsted Kloster, Torrig	26	+		0	0	26A	0	0	
Krenkerup, Rykkerup	27	+		0	0	27A		0	
„ „	28	+		0	+	28A		0	
Rudbjerg-gaard	29	+		0	0	29A		0	
„ „	30	Frost cracking *frost revner*		+	0	30A	+	+	
„ „	31	+		+	+	31A	+	0	
Bregentved, Karise Hestehave	32		+	+	+	35	0	0	
„ „	33		+	+	+				
„ „	34		+	+	+				
Orupgård, Raunstrup	37		+	+	+	36	0	0	
„ „	38		+	+	+				
„ „	39		+	+	+				
„ „	40		+	+	+				
„ „	41		+	+	+				
Krenkerup, Fruemose	85	+		0	+				
„ „	91	+		0	0				
Sum	+	27	13	30	30		12	11	
„	0			12	12		9	22	
„	Frost crack 2								

Orup Gd. — Systofte Skov.

One tree (no. 6) was located in this forest with severe *Cryptococcus* and a few brown spots. No indication of root drowning was found.

Christianssæde.

Observations made in this forest did not conclusively indicate a relationship between root drowning and the occurrence of the beech scale disease. Seven trees with the beech scale disease (nos. 10, 11, 13, 14, 15, 16, and 17) were located and investigated. Trees 11 and 13 had serious infestations of the beech scale disease — but no root drowning was in evidence.

Trees 10 and 17 had both serious root drowning and beech scale disease, thereby indicating a relationship. Some root drowning also appeared to have occurred in the root systems of trees 14, 15, and 16. However, it was difficult to say if the dead roots were actually the result of root drowning or had been caused by the substantial decline in vigour of the crown as a result of the beech scale disease.

Corselitze.

Four trees with evidence of the beech scale disease were investigated here (nos. 18, 19, 20, and 21). Trees 18 and 20 exhibited mild and severe attacks of *Cryptococcus* respectively, but no root drowning was apparent. However, trees 19 and 21 had both the beech scale disease and evidence of root drowning.

Halsted Kloster — Bødkerskov.

Two trees (nos. 22 and 23) were studied in a non-vigorous stand of approximately one to two hectares in size. Both of these trees had non vigorous root systems with 60—90 % of the root system being dead. No. 22 was the only beech with *Cryptococcus* found in this stand.

This diseased tree had bark throw, a severe attack of *Fomes fomentarius,* a severe bark beetle infestation, and a moderate to severe *Cryptococcus* attack. However, the root system of this tree was the more vigorous of the two. The two control trees selected for comparison purposes (nos. 22-A and 23-A) also had severe root drowning, and they were not fully vigorous.

Halsted Kloster — Ludvigshave.

One tree with the beech scale disease was located in this forest (no. 25). This tree showed some signs that root drowning had occurred.

Halsted Kloster — Torrig Skov.

The single tree located in this forest with the beech scale disease (no. 26) did not show any signs of root drowning.

In summary, the information gained from the investigations at Halsted Kloster did not either prove or disprove any causative relationship between the beech scale disease and root drowning.

Krenkerup — Rykkerup Skov.

Two trees, both with moderate to severe *Cryptococcus,* were located in this stand and their root systems investigated. No indications of root drowning were observed.

Krenkerup — Fruemose Skov.

Two trees (nos. 85 and 91) were pulled over with a tractor to expose their root systems. One tree was infected with severe *Cryptococcus* and mild brown spots while the other exhibited severe bark throw and bark beetles. However, the root systems of both trees were completely healthy.

Rudbjerg Gd.

Observations made in this forest once again did not indicate a definite relationship between root drowning and the beech scale disease. Two trees with the disease (nos. 29 and 31) were investigated. Tree 29 showed no indication of root drowning, while definite root drowning had occurred at the site of tree 31.

Summary.

From the preceding it appears that in some cases root drowning may have made a tree more susceptible to the beech scale disease.

It seems reasonable to assume, however, that if root drowning does make beech more susceptible to infection by the disease then more than one or two trees with the disease would have been found in areas where a high ground water table existed. For example, at Raunstrup Skov, Bødkerskov, Ludvigshave, and Rudbj. Gd., root drowning occurred over areas of up to one hectare, yet only one to four trees were found at each site with the beech scale disease.

That wide-spread root drowning had occurred at these sites was readily apparent in the field because of the poor vigour of the beeches. These field observations of poor vigour were later confirmed in the laboratory by measuring the increment cores taken from the diseased and control trees. The trees located in areas suspected of root drowning exhibited poor growth (i. e. very narrow annual rings) for a number of previous years.

In some instances foresters reported that diseased trees had been removed from the study areas in recent thinnings. This factor has undoubtedly biased the study observations. However, it still appears reasonable to assume that if root drowning makes beech more susceptible to the beech scale disease; then more infested beeches — rather than only one to four — should have been found in areas where wide-spread root drowning has occurred for some time.

3. Summary of the observations of trees with frost cracking and sap flood.

Only two trees were investigated which exhibited signs of frost cracking and sap flood (Nos. 12 and 30). The root systems of both of these trees showed indications of definite root drowning along with the root systems of the nearby control trees.

However, since only two trees with these symptoms were investigated, it is difficult to state that root drowning was definitely responsible for the frost cracking and resulting sap flood.

4. Summary of the observations of trees with vigour decline only.

Six trees at Kærstrup (7, 8, 9, 7-A, 8-A, and 9-A), a six-tree transect at Orup Gd. (trees 36—41), a four-tree transect at Bregentved (trees 32—35) and single trees located in other forests (Nos. 23 and 24) were investigated. The purpose of investigating these trees which showed a definite vigour decline as a symptom of root drowning — but no beech scale disease — was to gain a better indication of the effect of the root drowning on increment and vigour. The observations made on these trees allowed more intelligent decisions to be made concerning the occurrence of root drowning in trees with the beech scale disease.

5. Statistical analysis.

Several Chi-Square statistics were calculated from the data in Table 1.

As previously stated, the basic objective of this study was to determine if a high ground water table and the resulting root drowning made trees more susceptible to the beech scale disease. Two indicators of adverse effects of a high ground water table were used: (1) *observable dead roots* and (2) a *decline in growth in the last 20 years* as determined from the increment core analysis.

A total of 27 trees infected with beech scale disease have been examined (Table 1). Of these, 15 have dead roots, whereas no dead roots were found on 12. The ratio is 15:12.

In 12 of the control trees pertaining to the beech scale diseased trees the root systems have been examined. In 6 of these trees dead roots were found. Here the ratio is 6:6.

The 15:12 ratio does not differ significantly from the latter.

$\chi^2 = 0.33$ with 1 degree of freedom is considerably less than the value 3.84, which corresponds to the 5 % level.

Hence it must be presumed that there is no basis for inferring a connexion between root drowning and *Cryptococcus* attacks. If there were such connexion, the attacked trees should be expected to show a considerably higher frequency of trees with dead roots.

In the group of study-trees, root death has been found in 30 trees, 26 of which show a fall in increment. This group further contains 12 trees on which no dead roots have been found. 4 of the latter show a fall in increment.

In the group of control-trees, root death has been found in 12 trees (including 22A and 23A), 5 of which have a fall in increment. Besides, there are 9 control-trees without dead roots. 2 of the latter show a fall in increment.

Taken as a whole, this material contains a group of —

42 trees *with* root death, of which
31 show a fall in increment, whereas
11 show no fall in increment,

and another group of —

21 trees *without* root death, of which
6 show a fall in increment, whereas
15 show no fall in increment.

The former ratio 31:11 may be compared with the latter 6:15. The ratios are clearly significantly different ($\chi^2 = 42.1$ with 1 degree of freedom).

Obviously there is a close connexion between root death and fall in increment.

V. CONCLUSIONS

From the observations and data discussed in the preceding section, it seems possible to conclude the following:

1. Few observations, and little statistical evidence were found to suggest that high ground water tables and the resulting root drowning necessarily makes beech more susceptible to attack by the beech scale disease.

2. There appears to be a close correlation between root drowning and increment falling off.

3. Since only two trees with frost-cracking and sap flood were examined, it is difficult to state if root drowning makes beech more susceptible to this malady.

VI. DANSK SAMMENFATNING

I de seneste år har der været betydelige angreb i bøgebevoksninger af *Cryptococcus fagi,* ofte fulgt af de velkendte svampe- og billeangreb, slimflod med mere. Hidtil har man ikke med sikkerhed kunnet udpege bestemte faktorer som årsager til angrebene. Der har dog været enighed om, at bøgene skulle være svækkede for at blive disponeret for angreb af lus og følgesygdomme.

På lerjord med højtstående grundvand sker der ofte roddrukninger af større eller mindre omfang i bøgebevoksninger. Når rodsystemet reduceres indskrænkes træernes rodrum og dermed deres mulighed for at optage vand. Træerne svækkes, og det er nærliggende at forestille sig, at denne svækkelse kan føre til luseangreb. Hypotesen støttes af den kendsgerning, at luseangrebene har været temmelig kraftige i de seneste år for eksempel i Maribo amt, hvor roddrukningsbetingelserne er til stede (lerjord, højtstående grundvand).

I foråret og sommeren 1966 gennemførtes en undersøgelse af problemet i forskellige skove i Maribo amt. En enkelt undersøgelse blev samtidig gennemført på Bregentved.

Undersøgelserne gik i to retninger:

1) Der udvalgtes par bestående af et luseangrebet træ og et tilsyneladende sundt træ.

2) Der udvalgtes træer, som viste kendte tegn på roddrukning og — så vidt muligt — sundt udseende sammenligningstræer. De symptomer på roddrukning, som benyttedes ved udvælgelsen, var et alment utriveligt udseende af træernes kroner: små blade, døde grene og kviste i kronens øvre del, i ekstreme tilfælde topdød.

Samtlige træer blev nummererede. I det tidlige forår boredes et 125 cm dybt hul (12 cm diameter) ved hvert, og der måltes afstand til grundvandspejlet et par gange, for at man kunne være sikker på, at der var højtstående grundvand.

Ved hvert af studietræerne gravedes et jordbundshul så tæt ved stammebasis som muligt. I hullet undersøgtes træets rodsystem. Hvis man fandt døde rødder, blev der som regel også gravet et hul ved sammenligningstræet.

På alle træer blev der udtaget borespån, og årringsbredderne i de sidste 10 år blev målt. Årringsbredderne blev lagt op på millimeterpapir. For mange træer viste det sig, at der gennem de sidste år havde været faldende årringsbredder. For andre træer var det ikke tilfældet. De grafiske afbildninger lod sig let sortere i to grupper:

a) træer med tilvækstnedgang
b) træer uden klar tilvækstnedgang.

Samtlige undersøgelsesresultater er samlet i tabel 1.

Der blev ialt undersøgt 27 træer med luseangreb m. m. Af disse havde 15 døde rødder, mens der ikke blev iagttaget døde rødder på 12.

På 12 af kontroltræerne blev rodsystemerne undersøgt. På 6 af disse træer blev der fundet døde rødder.

Et χ^2-test viser, at 15:12-fordelingen ikke er signifikant forskellig fra 6:6-fordelingen. Man må følgelig antage, *at der ikke er holdepunkter for hypotesen om, at der skulle være en forbindelse mellem roddrukning og luseangreb.* Hvis en sådan sammenhæng eksisterede, måtte der blandt de angrebne træer være en væsentlig større hyppighed af træer med roddød.

Blandt samtlige undersøgte luseangrebne og utrivelige træer var der 30 træer med konstateret roddød. 26 af disse havde en tilvækstnedgang. I denne gruppe var der endvidere 12 træer uden døde rødder. 4 af disse havde en tilvækstnedgang.

Blandt kontroltræerne var der 12 træer med roddød (træerne 22-A og 23-A er medregnet her trods bemærkningerne i tabel 1). Der var 5 af disse, som viste tilvækstnedgang. 9 kontroltræer var uden døde rødder, og 2 af disse viste tilvækstnedgang.

Slår man hele dette materiale sammen, får man grupper på

42 træer *med* roddød, hvoraf
31 viser tilvækstnedgang, mens
11 ingen tilvækstnedgang viser.

21 træer *uden* roddød, hvoraf
6 viser tilvækstnedgang, mens
15 ingen tilvækstnedgang viser.

Fordelingerne 31:11 og 6:15 er med stor statistisk sikkerhed forskellige og viser, at der er en sammenhæng mellem roddød (-drukning) og tilvækstnedgang.

Undersøgelserne har kunnet gennemføres, fordi Statens teknisk-videnskabelige Fond har bevilget penge til dem. Vi er fondet megen tak skyldig for støtten. Vi har endvidere fået hjælp og støtte fra de skovdistrikter, som er nævnt i tabel 1, og vi vil gerne benytte denne lejlighed til at takke dem varmt.

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