Beretning nr. 194

B. BEIER PETERSEN AND B. SØEGAARD:

STUDIES ON RESISTANCE TO ATTACKS OF CHERMES COOLEYI (GILL.) ON PSEUDOTSUGA TAXIFOLIA (POIR.) BRITT.

(UNDERSØGELSER OVER RESISTENS MOD ANGREB AF CHERMES COOLEYI (GILL.) HOS PSEUDOTSUGA TAXIFOLIA (POIR.) BRITT.)

(Særtryk af Det forstlige Forsøgsvæsen i Danmark, XXV, 1958)

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STUDIES ON RESISTANCE TO ATTACKS OF CHERMES COOLEYI (GILL.) ON PSEUDOTSUGA TAXIFOLIA (POIR.) BRITT.

UNDERSØGELSER OVER RESISTENS MOD ANGREB AF CHERMES COOLEYI (GILL.) HOS PSEUDOTSUGA TAXIFOLIA (POIR.) BRITT.

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*)The present investigations were planned to demonstrate the resistance of Douglas fir to attacks of needle-cast caused by the fungus, Phäocryptopus Gäumanii. However, before the investigations were well begun, a very severe attack of Chermes cooleyi set in, so severe that the material was judged only suitable as a basis for investigating the resistance of Douglas fir to attacks of that aphid species.

Attacks on Sitka spruce are not included in the investigations.

The material used was collected in the form of scions from selected trees in various Danish Douglas fir stands, including also a few Douglas firs grown from material brought to Denmark from British Columbia, Canada. Scions were cut and graftings made, in part at the Danish State Forestry Tree Improvement Station, Humlebæk, and in part at the Arboretum, Hørsholm. The grafting took place in the spring of 1951. Table 1 gives a survey of the plant material.

In the spring of 1953 the 33 clones, 140 plants in all, were placed in a glasshouse, built that same spring for such purposes. (The glasshouse has a ground surface area of 8×12 m; its height is between 3 and 6 m). A glasshouse of this type provides uniform environmental conditions for the plant material being studied. The plants in the experiment were set out in 7 rows 50 cm apart with a distance of 50 cm between the plants in each row.

During the experimental period the two specimens from clone no. 129 died, and are therefore not included in the final statement of results.

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Fig. 1. Glasshouse with grafts of Douglas fir, January, 1957. (Phot. Noll Sørensen).

Fig. 1. Væksthus med douglaspodninger, januar 1957.

The aphid attacks were assessed twice each year throughout duration of the experiment. As it was impossible to undertake an exact count of the aphids on the entire plant, only the most severely attacked shoot was used as a gauge. However, there was complete agreement between the severity of the attack on this shoot and on the plant as a whole. When examined in May shoots were short, 2—8 cm on all the plants. In August the length varied from 10—60 cm. The variation in number of needles was less than the variation in length of shoot, and the number of aphids found depends rather on the number of needles than on length of shoot. The scale of measurement used in describing the attack is given in table 2. However, an exceptionally severe attack (large numbers) of the aphids is indicated by "4*". In the late summer assessment (about August 1.) the basis for grading is by counts of the numbers of wooly wax deposits secreted by the four aphid generations which produce wax on Douglas fir in summer (Migrantes, Sistentes and Progredientes). In May the

Table 1.

Description of the Plant Material.

Beskrivelse af plantematerialet.

Clone no. *Klon nr.*	Criterion for Selection *Kriterium for udvalget*	Locality *Lokalitet*	Origin *Oprindelse*	
K. 126	Growth-energy and health. *Vækstkraft og sundhed*	Bjerge Skov comp. 27, Buderupholm.	unknown.	3
K. 127	„ „ „	Kompedal comp. 393, Viborg.	Lauterbach, Hessen, Germany.	2
K. 128	„ „ „	„ „ 393, „	„ „ „ „	3
K. 129	„ „ „	„ „ 420, „	unknown.	2
K. 130	Shape, „ „ „ *Form,*	„ „ 420, „	„	3
K. 131	„ „ „	Hoverdal comp. 668, Ulborg.	„	3
K. 132	„ „ „ „ „	Klosterheden comp. 524.	Shuswap Lake, east of Kamloops, British Columbia, Canada.	3
K. 133	„ „ „	Gødding Skov comp. 2, Randbøl.	unknown	3
K. 134	„ „ „	„ „ „ 18, „	Santiam, California, U.S.A.	3
K. 135	„ „ „	„ „ „ „ „	„ „ „ „	3
K. 136	„ „ „	„ „ „ „ „	„ „ „ „	2
K. 137	„ „ „	„ „ „ „ „	„ „ „ „	3
K. 140	„ „ „	Brahetrolleborg comp. 150.	unknown.	3
K. 152	„ „ „	Baldersbæk (1), Vejle amt.	Louella, Washington, U.S.A.	3
K. 153	„ „ „	„ (2), „ „	„ „ „ „	3
K. 154	„ „ „	„ (3), „ „	„ „ „ „	3
K. 155	„ „ „	„ (4), „ „	„ „ „ „	3
K. 156	„ „ „	„ (5), „ „	„ „ „ „	3
K. 157	„ „ „	„ (6), „ „	„ „ „ „	3
K. 158	„ „ „	„ (7), „ „	„ „ „ „	3
K. 159	„ „ „	„ (8), „ „	„ „ „ „	3
V. 1091 J	Import of a new type. *Indførelse af ny type*	The Arboretum.	Copper Creek, near Vancouver, B.C., Can.	10
V. 1091 K	„	„	„ „ „ „ „ „	4
V. 1091 H	„	„	„ „ „ „ „ „	5
V. 1090 G	„	„	„ „ „ „ „ „	6
V. 1090 A	„	„	6 miles east of „ „ „	6
V. 1090 B	„	„	„ „ „ „ „ „ „	9
V. 1090 C	„	„	„ „ „ „ „ „ „	6
V. 1090 H	„	„	„ „ „ „ „ „ „	6
V. 1090 E	„	„	„ „ „ „ „ „ „	6
V. 1090 D	„	„	„ „ „ „ „ „ „	6
V. 1090 G	„	„	„ „ „ „ „ „ „	6
V. 661	Growth-energy and health. *Vækstkraft og sundhed*	Linaa Vesterskov comp. 36 A.	Second Danish generation. Import via France.	10
33 clones.				140

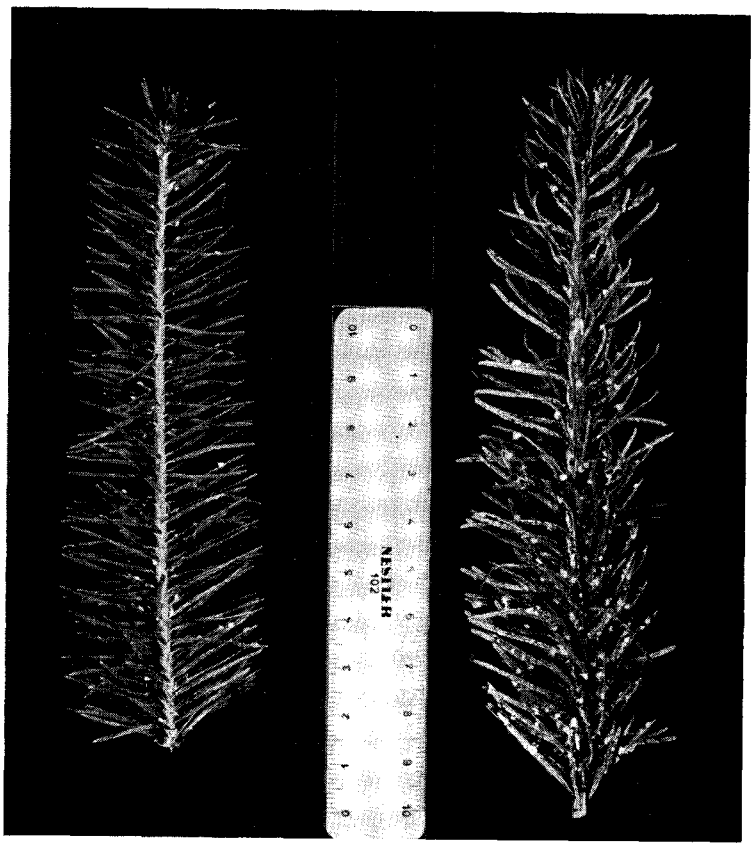
Table 2.
Scale showing degree of attack (on the most severely affected shoot).
Skala for angrebets styrke (på den stærkest angrebne gren).

Score *Grad*	Discription *Karakteristik*
1.	unattacked *uangrebet*
2.	1—10 wax deposits or nymphs *1—10 voksklumper eller larver*
3.	11—50 wax deposits or nymphs *11—50 voksklumper eller larver*
4.	more than 50 wax deposits or nymphs *over 50 voksklumper eller larver*

basis for grading is nymphs derived from eggs of the generation (Sistentes) hibernating on Douglas fir. For the biology of Chermes cooleyi, and the occurrence of the species in Denmark, see *Math. Thomsen* (1940).

The assessments from the two seasons of the year are not absolutely comparable. The wax deposits are easily seen and counted; degrees 1—3 indicate light attacks (fig. 2 a), degree 4, a severe attack (fig. 2 b.), in which the number of wax deposits, usually more than 300, on the most severely attacked shoots, greatly exceeds the boundary, 50. It is difficult to see the nymphs when they are few in number. They may be present, even though not observed. Generally they were found in much greater numbers than the wax deposits. Degrees 1—3 consequently indicate a relatively slight attack, whereas degree 4 included thousands on a single shoot, an average of perhaps 1—3,000. The number of hibernating nymphs was sometimes also immense, on a single needle more than 40 were counted, on a shoot nearly 10,000.

The Chermes attack increased in severity during the experiment (table 3.). Only on 3 clones out of 32 was there no increase in severity. The increase may be due to a greater possibility of infection since, as the plants grew, there was increased contact from plant to plant. Furthermore, there was unhindered opportunity for migratory aphids to pass back and forth from the glasshouse to a hedge of Sitka spruce only 10 meters distant through an open door. Numerous galls of Chermes cooleyi were observed in the hedge.



a b

Fig. 2 a. Branchlet of Douglas fir with between 11 and 50 deposits of Chermes wax (degree 3), January, 1957. (Phot. Noll Sørensen).
Fig. 2. a. Douglaskvist med mellem 11 og 50 Chermes-voksklumper (grad 3), januar 1957.

Fig. 2 b. Branchlet of Douglas fir with more than 50 deposits of Chermes wax (degree 4), January, 1957. (Phot. Noll Sørensen).
Fig. 2 b. Douglaskvist med over 50 Chermes-voksklumper (grad 4), januar 1957.

On studying the extent of wax production as a measure for the severity of attack — free nymphs without wax may be considered as temporary visitors — the separate clones are found to react differently to Chermes. This fact is emphasized by the grouping in table 3. Groups 1, 2, 3, 4 and 7 are of special interest.

Table 3.

Development of the Attack.
Angrebets udvikling.

Group No.	Clone No.	Variation in Severity of Attack within each Clone*) *Angrebets variation i styrke, angivet i grader, inden for klonen* July 22, 1954 (wax) *(voks)*	May 18, 1955 (nymphs) *(larver)*	July 28, 1955 (wax) *(voks)*	May 14, 1956 (nymphs) *(larver)*	Aug. 1, 1956 (wax) *(voks)*	Remarks on the Attack (wax formation) *Bemærkning (voksdannelsen)*
1	133	1—1	1—1	1—1	1—3	1—1	Not attacked during observation period. *Vedvarende uangrebet.*
2	132	1—1	1—3	1—1	1—1	3—3	Not attacked at first; later slightly attacked. *Uangrebet, senere svagt angrebet.*
	134	1—1	1—2	2—2	2—2	2—2	
	135	1—1	1—2	2—3	1—3	2—2	
	136	1—1	3—4	2—3	2—4*	3—3	
3	130	1—1	1—2	2—3	1—2	3—4	Not attacked at first; later some severely attacked. *Uangrebet, senere nogle stærkt angrebet.*
	137	1—1	1—1	2—3	2—2	4—4	
	140	1—1	1—2	2—3	2—4*	2—4	
	158	1—1	2—3	2—3	3—4*	4—4	
	1091K	1—1	2—2	2—3	3—4*	3—4	
4	127	2—3	4—4	2—2	4*—4*	2—2	Slightly attacked throughout observation period. *Vedvar. svagt angrebet.*
5	128	2—3	3—4	3—4	3—4	3—3	Slightly attacked at first; later some severely attacked. *Svagt angrebet, senere nogle stærkt angrebet.*
	152	1—3	2—4*	2—3	4—4*	4—4	
	153	1—3	1—4*	2—4*	2—4*	3—4	
	155	1—2	2—4*	3—3	2—4*	3—4	
	156	2—3	4—4*	3—4	2—4*	3—4	
	157	1—2	2—4	2—4	3—4*	4—4	
	159	1—3	2—4*	2—3	2—4	3—4	
	1090A	1—2	1—4*	2—4	3—4*	2—4	
	1090B	1—2	3—4	2—4	4—4*	3—4	
	1090C	1—2	3—4*	3—4	4—4*	3—4	
	1090D	1—3	3—4*	3—4	4*—4*	4—4	
	1090E	2—3	4—4*	2—4	4—4*	3—4	
	1090G	1—3	1—4	2—3	3—4	4—4	
	1090H	1—3	2—4*	3—4	3—4*	3—4	
	1091g	2—3	4*—4*	2—4	3—4*	2—4	
	1091h	1—3	4—4*	3—4	4*—4*	3—4	
	1091j	1—3	2—4	2—4	3—4*	3—4	
6	126	1—4	1—4*	3—3	3—4*	2—4	Some severely attacked throughout observation period. *Vedvarende nogle stærkt angrebet.*
	131	3—4	4*—4*	3—4	3—4	3—4	
	661	3—4	4*—4*	3—4	4—4*	3—4	
7	154	1—4	2—4*	2—3	4—4*	2—3	At first some severely attacked; later slightly attacked. *Først nogle stærkt, senere svagere angrebet*

*) The scores were allotted according to the definitions given in Table 2.

Groups 1—4 show that in spite of the presence of nymphs, at times in very large numbers (clone 127, May 14, 1956) some plants show no wax masses at all (clone 133) or only a few wax masses. Possibilities for infection in the glasshouse must be great, as larvae have been found on all the clones. It seems reasonable therefore to assume that significant differences exist in the susceptibility of individual Douglas firs to attacks of Chermes cooleyi.

Too much emphasis should not be placed on the fact that a single clone (133) was totally exempt from attack; it may perhaps have the same fate as clone 132 (group 2)*). On the contrary it should be realized that the appearance of individuals (clones) immune to attacks of Chermes in a Chermes infected stand, does not necessarily imply infallible "resistance".

Syrach Larsen (1953) and *Heitmüller* (1954), have reported the probability of single cases of complete resistance to Chermes attacks. Clone 133 in this experiment may be such a case.

Table 4.

Variation in Chermes wax deposits within the single clones.
Variation i mængden af Chermes-voksbelægning inden for de enkelte kloner.

Year	Number of clones and the variation in degree of attack			
	0	1	2	3
1954	11	11	8	2
1955	7	20	5	0
1956	12	15	5	0

Table 3 shows the variation latitude in degrees within the single clones; in table 4, these data, as applied to wax deposits are summarized. A very considerable uniformity is observed among the plants of the individual clones. During the 3 year experimental period, 69—84 % of the clones showed either no difference or of only a single degree. In no more than 6 % of the clones, and that only 1954, were all 4 degrees represented. This uniformity within the clones supports the conclusions made above and indicates genetically determined differences in susceptibility to attacks of Chermes cooleyi.

*) Clone 133 is still not attacked August 15th. 1957.

Whether these genetic differences manifest themselves in, for instance, varying thicknesses of wax coating on needles, or in the chemical properties of the cell sap cannot be stated. However, it seems as though a pronounced ability to strong cork formation in the young shoots which were covered profusely with free Chermes nymphs, might be the reason why only a few nymphs were able to establish themselves.

The colour of the needles of the clones varied from pure green to bluish. It should be noted that "colour" in this application does not refer to the colour characteristics of the Douglas fir varieties, viridis, caesia and glauca, but only expresses individual variation. All the clones are derived from the variety, viridis. For resistance of the three varieties named, see *Heitmüller* (1954) and *G. Teucher* (1956). It was impossible to see any relationship between these colour-features and susceptibility to attack. However, during the experimental period it was noted that there was an increase of specimens with bluish colour among the severely attacked clones, presumably because of honey-dew formation.

The effect of a severe attack of Chermes cooleyi on plant increment cannot be determined in this experiment, as presumably the different clones possess varying degrees of growth energy. Perhaps, in addition to being genetically determined, growth energy is also dependent on the age of the parent tree and on the part of the tree from which the material for propagation is cut (*Schaffalitzky de Muckadell*, 1956). We can only state that the Chermes attack, even where very severe, did not cause even an approximately proportional reduction in height growth. Many of the severely attacked trees had top shoots of very considerable length. A slight growth reduction, which might reasonably be expected, can only be shown by using material from the one clone and excluding all possibility of Chermes attacks from some of the plants.

There were considerable differences in flushing time of the plants, but it was not possible to prove any connection between this and the severity of the Chermes attack.

Summary:

On all 32 clones of Douglas fir grown under uniform conditions in a special glasshouse with great possibilities for infection of Chermes cooleyi, the nymphs of that species were found. The clones varied greatly in susceptibility, judged by the wax deposits. One single clone, alone, remained unattacked throughout the 3 year experimental period.

SAMMENDRAG.

Undersøgelser over resistens mod angreb af Chermes cooleyi (Gill.) hos Douglasgran (Pseudotsuga taxifolia (Poir) Britt.).

På 32 kloner af douglasgran (tabel 1), der dyrkedes under ensartede kår i et væksthus (fig. 1) med stor mulighed for infektion af Chermes cooleyi, blev der på alle kloner konstateret forekomst af larver.

I tabel 2 anføres den benyttede gradskala ved beskrivelsen af angrebsstyrken og i tabel 3 vises udviklingen i løbet af forsøgsperioden. Inden for denne periode var angrebsstyrken i almindelighed stigende. Der var stor variation mellem klonerne i modtagelighed (voksdannelsen) (sml. fig. 2 a & b), men inden for den enkelte klon var variationen ringe (tabel 4), hvilket tyder på tilstedeværelsen af en genetisk betinget resistens. Kun en af de undersøgte kloner var i hele den treårige forsøgsperiode uden voksdannelser (klon 133).

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