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Resin pockets in Norway spruce wood are not caused by the bark beetle *Ips typographus*

Kvaelommer i gran skyldes ikke angrep av granbarkbillen

Erik Christiansen and Bohumil Kucera

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Front page: Spindle-shaped, crater-like scars on the bark surface (bottom) bear witness of old attacks by the spruce bark beetle Ips typographus. Lesions are found in the xylem inside these scars. Old beetle attacks can easily be distinguished from resin pockets, one of which is seen on the upper side of the stem disc.
Photo: T. Gulliksen

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Abstract

CHRISTIANSEN, E. AND KUCERA, B., 1999. Resin pockets in Norway spruce wood are not caused by the bark beetle *Ips typographus*. (Kvaelommer i gran skyldes ikke angrep av granbarkbillen). Rapport fra skogforskningen - Supplement 12:1-9.

Resin pockets occur in several coniferous genera; they cause problems for the wood processing industry and their origin is not known. Resin pockets are common in SE Norway where spruce forests are frequently attacked by *I. typographus* but not in SW Norway where this bark beetle is not found. It was therefore conceivable that resin pockets might result from attacks by this beetle. The hypothesis was tested using a material from Ås, Akershus. In spring 1987 a dozen of spruce trees fitted with pheromone dispensers were attacked but not killed by *I. typographus*. The entrance holes on the bole were marked and several years later the trees were felled and dissected. The result shows that while beetle attacks leave prominent marks in the wood of surviving trees, these traces are entirely different from resin pockets, and the latter must consequently have a different origin.

Introduction

Resin pockets occur in various genera of the family Pinaceae, e.g. in *Picea, Pinus, Larix,* and *Pseudotsuga.* Their occurrence and characteristics in Norway spruce (*Picea abies* (L.) Karst.) have been described and depicted in detail (Temnerud, 1997). In tangential longitudinal section resin pockets are oval and in radial longitudinal section or cross section they appear as narrow slits.

Resin pockets create problems for the processing and industrial use of wood. They are highly undesirable in products where the appearance is of vital importance and only materials without defects can be used (e.g. frontal parts of furniture, panel boards, window frames, and doors). When these pockets are present, resin will flow out, cover the surface, and prevent paint, varnish, etc. from penetrating into the wood. The surrounding xylem of resin pockets has the colour of sapwood, and in species with a dark heartwood, e.g. larch, a smoothly prepared surface consequently may appear mottled. In plywood production, resin pockets opening to the surface of the wooden plies create problems for gluing. A large number of resin pockets in sawlogs can create problems during processing, as resin may stick to saw and planer blades, resulting in uneven surfaces, and in some cases burn marks.

Several hypotheses have been suggested to explain the formation of resin pockets, e.g. mechanical bending, internal stress, injury by insects and pathogens, etc. (Temnerud, 1997). In the present study we investigate the hypothesis that attack by the spruce bark beetle *Ips typographus* L. may induce the formation of resin pockets. Several species of insects may attack the bole of Norway spruce trees in different states of vigour, but *I. typographus* is the only bark insect in Scandinavia that is capable of killing fully healthy, mature trees. This happens when the beetles are numerous enough to exceed the «Threshold of Successful Attack» on a tree (Thalenhorst, 1958). If resin pockets in spruce are indeed caused by insects, this beetle is a likely candidate because of its omnipresence in forest districts of South Scandinavia. Moreover, it transfers blue-stain fungi which enhance the impact of the mechanical wounding (Horntvedt et al., 1983; Solheim, 1992; Christiansen et al., 1999b; Krokene et al., 1999). Two other arguments also favour this hypothesis: (1) resin pockets are much less frequent in Scots pine (*Pinus sylvestris* L.), which does not have serious, tree-killing enemies among the Scandinavian bark beetles; (2) resin pockets are found in Scandinavian districts where both spruce and *I. typographus* are endemic, but not along Norway's west coast where *P. abies* is introduced and *I. typographus* does not occur. Against the hypothesis speaks the fact that resin pockets also occur in spruce trees that are too young to be attacked by *I. typographus*. However, young trees may be attacked, and sometimes killed, by the lesser spruce bark beetle *Pityogenes chalcographus* (L.), which has roughly the same distribution as *I. typographus*.

To test this hypothesis we utilised Norway spruce trees, which had been attacked by *I. typographus* at known times, and where single attacks had been marked out on the bole upon attack.

Materials and methods

On 19 May 1987 twelve spruce trees growing in an open stand in Ås, Akershus, were fitted with dispensers containing the aggregation pheromone of *I. typographus* (Bakke et al., 1977). Following a short flight period (22-25 May), attack density was monitored on 10 June. Beetle entrance holes were recorded on three 20-cm belts encircling the stem (upper, middle, and lower part of the attacked section), and pins were placed ca. 1 cm to the right side of each entrance hole. An additional inspection on 26 June 1987 revealed no new attacks but the next summer a few new entrance holes recorded. At this time all old and new attack sites were marked with small dots of paint.

In April 1989 all 12 trees were alive but one had been «strip-killed» by the attacks in 1987, i.e. phloem and cambium were dead in sectors covering about half the stem periphery over several meters of the trunk. Nine trees were felled at this time, including the strip-killed one in which successful breeding galleries of *I. typographus* were found in the dead sectors. The remaining 3 trees were left standing for 8 more years, i.e. till April 1997. On both felling occasions stem sections were taken to the laboratory for examination. The paint dots denoting attacks were still visible and most of the pins inserted in 1987 were also recovered. These marks were invariably found next to characteristic scars or scabs in the bark (see below).

In the laboratory the stem sections were cut in cross-sectional discs of variable thickness, cuts frequently being placed through the scars on the bark surface. The discs were cleaved in radial/longitudinal direction in places where scars occurred. Different structures in bark and wood were photographed macroscopically, slides were cut on a sliding microtome for light microscopy (LM), and small blocks of wood were planed on a microtome and prepared for scanning electron microscopy (SEM).

Results

In the strip-killed tree felled in 1989, the xylem inside stem sectors with dead bark was heavily blue-stained (Fig. 1). In sectors where the phloem and cambium were still alive a very narrow xylem ring had been laid down in 1987, in contrast to the ring of 1988 that was abnormally wide. Lesions after beetle attacks were almost entirely covered by the new xylem (Fig. 1, 2). Dead compartments of the bark had been shut off through the formation of a new periderm and the phloem also appeared to be healing (Fig. 2).

The 3 trees that were cut in 1997 had characteristic scars or scabs on the bark surface (Fig. 3). On the surface these structures looked roughly spindle-shaped and in cross-section they had a crater-like appearance. In the wood inside these scars overgrown lesions were observed (Fig. 4). Annual rings of xylem formed outside these lesions had V-shaped depressions (Fig. 5). Cleaving of a wood block through a lesion revealed a wavy structure of the wood and resin ducts extending up and down the stem (Fig. 6).

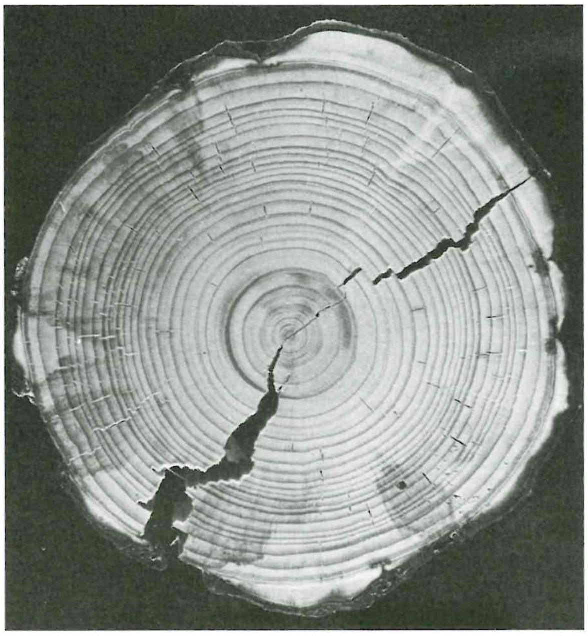
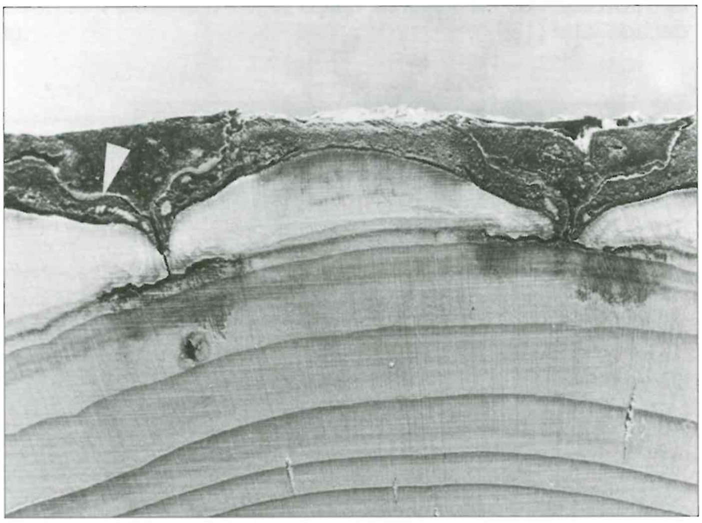


Figure 1.
Cross-sectional view of a *P. abies* stem attacked by *I. typographus* in 1987 and cut in 1989. In large sectors (left side) the phloem and cambium are killed and the xylem blue-stained. Here, viable broods were produced in bark beetle galleries. On the opposite side several beetle attacks have failed. Very little wood staining is seen, and the surviving cambium has laid down an abnormally wide xylem layer in 1988, apparently to compensate for the loss of conductive wood. The radially oriented cracks that are visible in this and other figures are due to quick drying of wood discs.

Figure 2.
Close-up of the marks after two of the abortive beetle attacks seen in Figure 1, one from 1987 and the other from 1988. Sectors of the cambium, 10-12 mm wide, have been killed. Adjacent cambial cells have produced new xylem, now covering most of the lesions. The wood inside the lesion is locally impregnated with resinous material. In the bark outside the wound dead, resin-impregnated bodies are seen, lined by a new periderm separating it from the live phloem inside arrow.



Adjacent to overgrown, beetle-caused lesions one or two layers of traumatic resin ducts were seen within the xylem rings (Fig 7), both in the year of attack and in the following one or two years. Such aggregations of ducts were not observed in connection with resin pockets, which also occurred in the examined stem sections (Fig. 8).

Figure 3.
Stem surface of a *P. abies* with spindle-shaped, crater-like scars after *I. typographus* attacks that occurred in 1987/88. The photo was taken a decade later (1997).

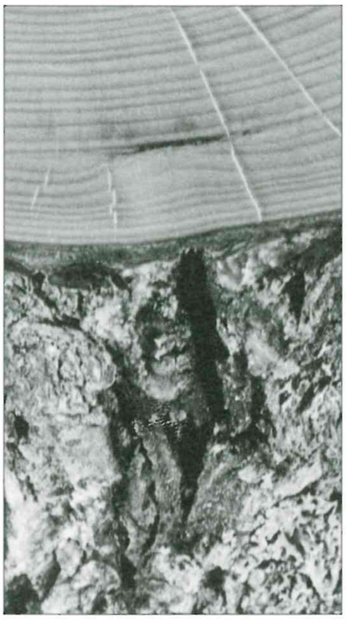


Figure 4.
Inside one of the scars on the bark surface (cf. Figure 3) damage is seen in the xylem ring of 1987.

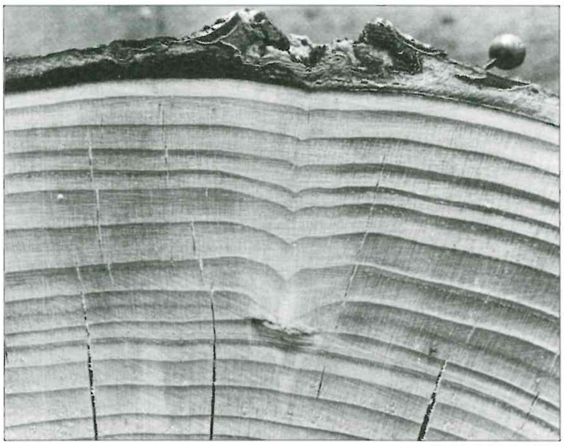


Figure 5.
A cross-section *of P. abies* shows an old lesion covered by new xylem layers. Outside the site of damage, the annual xylem rings show a v-shaped depression. In the year of attack (1987), a pin was inserted next to a beetle entrance hole in the bark. Ten years later a "crater" is seen at the site of attack.

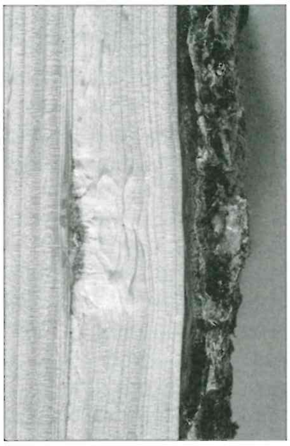


Figure 6.
When cleaved in radial-longitudinal direction a bolt from an attacked tree reveals lesions in the bark and wood. The xylem that is laid down later has a wavy appearance.Traumatic resin ducts extend in longitudinal directions from the lesion.

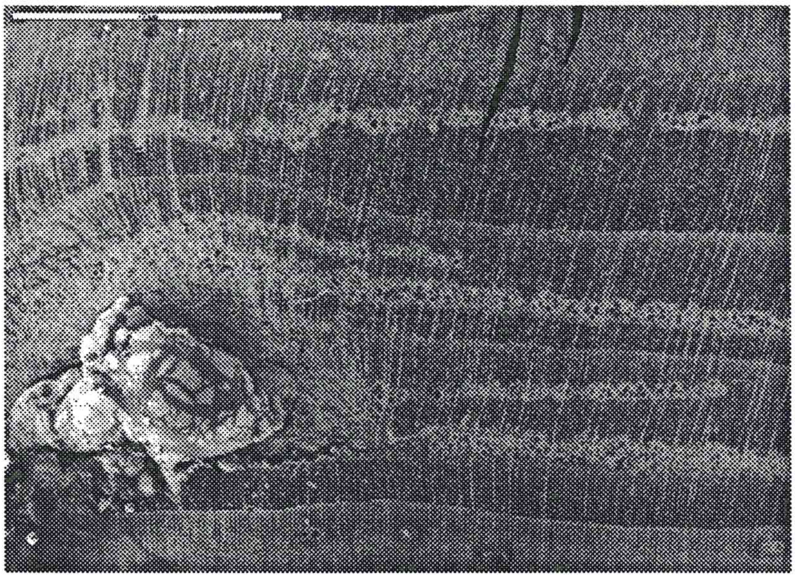


Figure 7. Abnormalities in the xylem of *P. abies* xylem after an *I. typographus* attack. During preparation for SEM, vacuum has pulled out a resin droplet from the corner of an old lesion caused by the beetle's boring activity. Whereas only a few scattered resin ducts are seen in the latewood prior to attack (1986 annual ring at bottom), the xylem of the years 1987-1989 exhibits multiple layers of traumatic resin ducts. The white bar is 2 mm long.

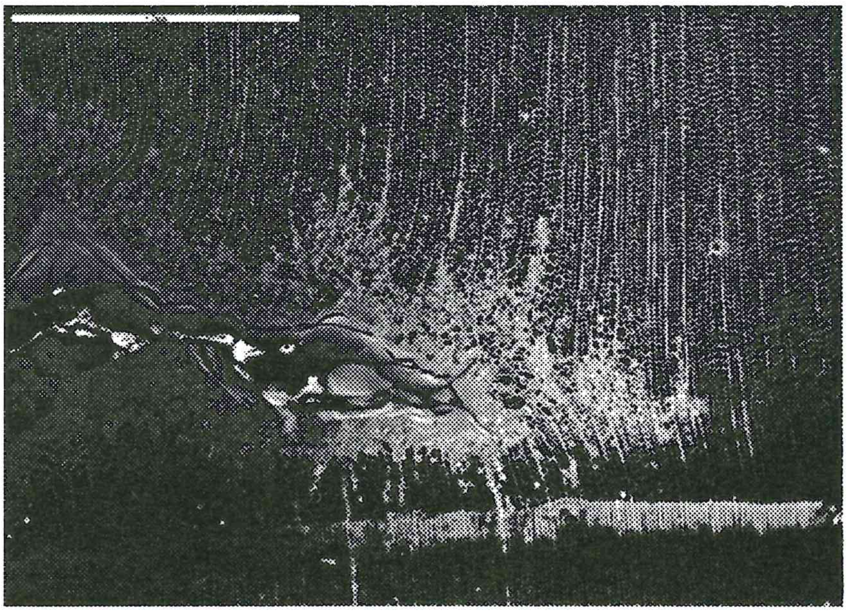


Figure 8. SEM picture of xylem abnormalities in *P. abies* at the corner of a resin pocket. Resin fills the crack and surrounding tracheids. No traumatic resin ducts have been formed in the xylem adjacent to the pocket.

Discussion and Conclusion

Marks in the xylem caused by attacks of *I. typographus* and its symbiotic blue-stain fungi can be distinguished from resin pockets. Beetle entrance holes penetrating to the wood surface produce a local lesion where the cambium is killed. In following years adjacent cambial cells produce new xylem that grows over the edges of the lesion, eventually enveloping it. Cambial continuity across the old wound is hence re-established, however, in cross-section a V-shaped depression is seen in the post-attack xylem rings. In radial, longitudinal section the wood of these rings exhibits a wavy structure. The above characteristics are absent in case of resin pockets, the formation of which does not imply cambial killing.

I. typographus attacks also cause the formation of abundant traumatic resin ducts in the xylem. Beetle-transmitted fungi enhance the formation of these longitudinal canals: masses of ducts are formed after artificial fungal inoculation, as well as after abundant but unsuccessful beetle attacks (Christiansen et al., 1999a; Nagy et al., 2000). *I. typographus* attacks or other fungus-infected wounds that only penetrate to the outer layers of the living bark are efficiently arrested and rendered harmless by the polyphenolic parenchyma cells of the phloem (Franceschi et al., 2000). Such shallow wounds may also induce a local formation of traumatic resin ducts.

The study does not support the hypothesis that resin pockets in the wood of Norway spruce are caused by *I. typographus* attack. The factor or factors inducing resin pocket formation remain unknown, and we do not intend to speculate further on this here.

Acknowledgements

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Sammendrag – Kvaelommer i gran skyldes ikke angrep av granbarkbillen

Kvaelommer fins i mange bartreslekter; de skaper problemer for treforedlingsindustrien, og man vet ikke hvordan de oppstår. De er vanlige i Sørøst-Norge hvor skogen ofte angripes av granbarkbillen, men ikke på Vestlandet hvor billen ikke finnes. Det kunne derfor tenkes at de oppstår som følge av billeangrep. Dette ble undersøkt i et materiale fra Ås i Akershus. Våren 1987 ble et dusin grantrær angrepet av granbarkbillen etter at det var satt feromondispensere på dem, men billene var for få til å erobre trærne. Angrepspunktene på stammen ble merket av, og flere år senere ble trærne felt og undersøkt. Resultatet viste at billeangrepet etterlater tydelige spor i veden hos trær som overlever, men disse er helt forskjellige fra kvaelommene, som derfor må ha en annen årsak.

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