Old and Fresh *Gremmeniella Abietina* Damage on Scots Pine in Eastern Lapland in 1992

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Damage on Scots pine *(Pinus sylvestris* L.) caused by *Gremmeniella abietina* (Lagerb.) Morelet was assessed in the summer of 1992 in sixty-seven stands in eastern Lapland. The area and severity of damage were smaller and lighter than had earlier been estimated and occurred especially in stands in the first-thinning stage or in middle age. Significant new infection of 1991 occurred in stands previously heavily infected by *G. abietina* near the Kemihaara river, lake Naruska, the Naruska river, the Tuntsa river and lake Vilma. Fresh damage occurred mainly in the lower or middle parts of the Scots pine canopies.

1 Introduction

During the recent decades, *Gremmeniella abietina* (Lagerb.) Morelet has caused noticeable damage in Scots pine *(Pinus sylvestris* L.) forests in eastern Lapland. The area of pine forests afflicted by *G. abietina* has been estimated to be 1190.5 ha in the Ylikemi Forest District (Kaitera and Jalkanen 1991, 1992, Jalkanen and Kaitera 1992, 1993, Fig. 1). Within this area of about 900 000 ha, repeated epidemics in successive years throughout the 1980s slowed down at the end of

the decade (Salemaa et al. 1991). This led to visible recovery by living pines at Rikkilehto, one of the most seriously damaged stands in eastern Lapland (Kaitera and Jalkanen 1993a). However, the summer of 1991 was extremely rainy, and thus there was a need to estimate the extent of possible fresh damage appearing during 1992 in order to get a clear picture of the development of *G. abietina* epidemics in eastern Lapland.

The aim of this study was both to investigate the occurrence and the severity of damage caused

Fig. 1. The location of Ylikemi District (grey area) in Finland.

by *G. abietina* by 1992 and to evaluate the changes in damage by 1989–1990 and by 1992 in the Ylikemi Forest District. In addition, the extent of the fresh damage of 1992 caused by *G. abietina* in previously damaged stands was estimated.

2 Material and Methods

Sixty-seven out of 77 Scots pine stands, the only pine-dominated stands found to be damaged by *G. abietina* prior to 1989 in Ylikemi District in eastern Lapland (survey conducted by the Forest and Park Service, see Kaitera and Jalkanen 1991), were surveyed for the second time between June 17 and October 9, 1992, by walking about non-systematically, but thoroughly, in the stands and by visually estimating the damage in every sub-area of the stand. The damaged sub-areas were visually estimated as proportions of the entire stand. In most of the stands (61), pines were infected similarly throughout the stand, and only in 6 stands was the most dominating damage

estimate used as the estimate for the entire stand. The proportion of different injury levels from the total investigated area was calculated from corresponding proportions of sub-areas within the stands.

In the 1992 survey, the occurrence of old *G. abietina* damage by 1992 was assessed at the stand level in two ways: one (PATI) was that developed by the Forest and Park Service (PATI... 1990) and the other (HOP) that developed by Hopkins et al. (1979). PATI recognised the following classes:

0. Healthy
1. Slightly damaged
2. Severely damaged
3. Very severely damaged
4. Destroyed stand

Stand classification was based on the need for sanitation fellings due to *G. abietina* damage: in a slightly damaged stand, only single branches of Scots pine were infected but the infection did not give cause for any fellings; in a severely damaged stand, some trees had been killed by the pathogen and due to the high number of killed branches, thinning was needed to reduce the number of infected trees; in a very severely damaged stand, most of the trees had been killed by the pathogen and resulted in clear-cutting and reforestation; in a destroyed stand, all the pines had been killed by the pathogen and the stand had to be reforested. In HOP, the damage to the dominant storey had the highest influence. The following classes were used (Hopkins et al. 1979):

NI = Healthy
LI = Light infection
MI = Medium infection
HI = High infection
SI = Severe infection

In classes NI and LI, damage occurred only in some seedlings and suppressed trees, whereas in classes MI, HI and SI less than 10 %, 10 to 50 % and over 50 % of the dominant trees had been killed by *G. abietina*. The dominant degree of damage was given for each stand. The purpose of the PATI 92 survey was to compare its results to those of an older survey (PATI 89) conducted

by the Forest and Park Service personnel in 1989–1990 using the same PATI classification (see Kaitera and Jalkanen 1991). PATI 92 was performed by the authors, but PATI 89 was conducted by several people, and this increased the heterogeneity of the corresponding estimation. The variation in the estimate was not, however, tested.

The main attention was paid to assessing the extent and severity of the fresh infection of 1991 (seen as fresh damage during the growing period of 1992). Fresh *G. abietina* damage was recognized visually from dead buds, loosely intact brownish needles and pycnidia in the 1991 shoots (Kurkela 1967, 1981). Fresh damage was estimated for each sub-area, and the dominant degree of fresh damage was used as an estimate for each stand. The severity of the fresh damage was classified as follows:

1. No infection (all 1991 shoots healthy)
2. Light infection (1–10 % of the 1991 shoots infected)
3. Moderate infection (11–30 %)
4. Strong infection (31–70 %)
5. Severe infection (71–99 %)
6. Complete infection (100 %)

Class intervals of fresh damage were different to make the visual estimation at tree level more easier and quicker, which led to a broader class in 'strong infection' as compared to the rest of the used classes. Occurrence of fresh damage at canopy level was estimated for the dominant storey as follows:

Significant infection occurred

1. Only in the lower canopy
2. In the lower and middle canopy, or
3. Along the whole length of the canopy

The frequencies of the stands studied applying the PATI 89 and PATI 92 surveys were tested using the chi-square (χ^2) test (SAS Institute Inc. 1989). Also, the frequencies of the forest site and development classes of the studied stands in PATI 92 and in the entire Ylikemi Forest District were χ^2-tested in classes with enough observations to find out whether the damage caused

by *G. abietina* was more frequently concentrated on a certain site or a development class than was expected according to the corresponding stand frequency in the Ylikemi District.

3 Results

Seventy-four percent of the damaged area consisted of *Empetrum-Myrtillus* (EMT) forest site type, 12 % of *Myrtillus-Calluna-Cladonia* (MC-ClT) and 12 % of *Hylocomium-Myrtillus* (HMT) (Fig. 2a)(Cajander 1926). The forest site type frequencies of the studied stands in PATI 89 and PATI 92 were the same, but differed from those of the Ylikemi Forest District; e.g. the frequencies of PATI 92 were significantly higher for EMT (χ^2 = 28.7, df = 1, p < 0.0001), lower for HMT (χ^2 = 5.7, df = 1, p = 0.017) and equal for MCClT (χ^2 = 2.8, df = 1, p = 0.095).

About 55 % of the damaged area consisted of stands in the first thinning stage, 19 % of stands of middle age, and 9 % of natural sapling stands not yet established (Fig. 2b). The stand development class frequencies of the investigated stands in PATI 89 and PATI 92 were the same, but also significantly higher in stands at the first-thinning stage (χ^2 = 36.5, df = 1, p < 0.0001) and in young stands of classes 0A, 0B, 0C, 1A and 1B (χ^2 = 5.9, df = 1, p = 0.016) in the Ylikemi Forest District. Also, the frequency of class 3 was higher in PATI 89 and PATI 92 than in the Ylikemi Forest District, but could not be tested due to inadequate observations in the other classes.

About 46 % of the total area of the damaged stands proved to be healthy, 38 % slightly damaged, 14 % severely damaged and 2 % very severely damaged or destroyed according to the PATI 92 survey (Fig. 3). According to the results of the PATI 89 survey, only a small area was estimated to be healthy (Fig. 3) due to the undamaged sub-areas of non-dominant tree classes, mainly of the overstorey. The frequency of healthy stands was higher and that of stands with light damage (χ^2 = 4.6, df = 1, p = 0.032) and severe damage (χ^2 = 4.3, df = 1, p = 0.039) was lower in PATI 92 than in PATI 89. According to HOP, twenty-four stands (36 %) belonged to the damage class healthy (NI), 38 stands (57 %) to
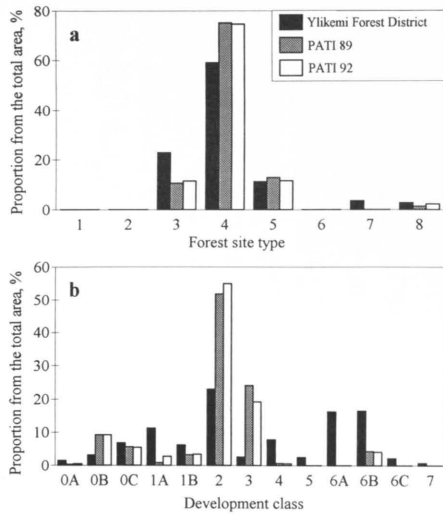
Fig. 2. Distribution of the forest stands on productive forest land in Ylikemi Forest District and the 67 stands of the PATI 89 and PATI 92 surveys in terms of forest site types (a) and development classes (b). Legend in (a): 1 = very rich, 2 = rich, 3 = moist (HMT), 4 = dryish (EMT), 5 = dry (MCCIT) and 6 = barren (CT) forest site on mineral soil, 7 = spruce mire and 8 = pine mire; legend in (b): 0A = open area, 0B = non-established natural, 0C = non-established artificial, 1A = established natural and 1B = established artificial sapling stand, 2 = stand in first thinning stage, 3 = middle aged stand, 4 = stand for final cutting, 5 = stand with seed-bearers, 6A = fully stocked, overmature and damaged stands or stands of silviculturally wrong tree species, 6B = not fully stocked underproductive stands, 6C = other underproductive stands and 7 = structurally all-sized stand.

Fig. 3. Distribution (%) of the area of the investigated stands into *G. abietina* damage classes in the PATI 89 and PATI 92 surveys. Legend to damage classes: 0 = healthy stand; 1 = light damage, 2 = severe damage, or 3 = very severe damage; 4 = stand destroyed, and 5 = data missing.

light (LI) and four stands (7 %) to the class of medium infection (MI). Not a single stand belonged to the class of high (HI) or severe (SI) infection. Small sub-areas of MI class occurred in sixteen stands, HI in two stands and SI in one stand. The damaged stands were concentrated on three main areas, namely southern Salla (Vilmajärvi), northern Salla (Naruska), and northern
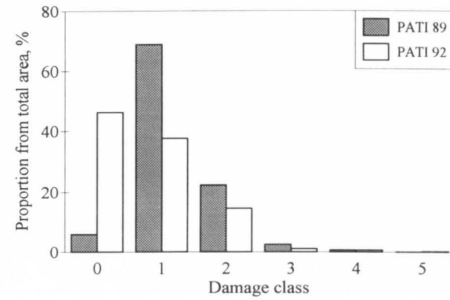
Savukoski (Kemihaara) (Fig. 4a, b). Most of the damaged stands were situated in river valleys (Fig. 4a).

Fresh infection of the year 1991 was not evident in twenty-six stands (39 %). In thirty-six stands (54 %), the infection was light, in three (4 %) moderate and in two (3 %) high (Fig. 4b). No stand was severely or completely infected. No fresh infection was observed in the Kivitunturi area (Fig. 4a, b). In the forty-one stands infected in 1991, fresh damage was concentrated only in the lower part of the pine canopies in twenty stands (49 %), in both the lower and middle part in seventeen stands (41 %), and along the whole length of the living Scots pine canopy in four stands (10 %).

According to the results of both PATI 92 (Fig. 5a) and HOP (Fig. 5b), the highest number of injured stands belonged to development classes 2 and 3, on which the fresh damage was also concentrated (Fig. 5c). Stands with old damage were situated on forest sites EMT and MCCIT (Figs. 5d, e); this was also the case with fresh damage (Fig. 5f).
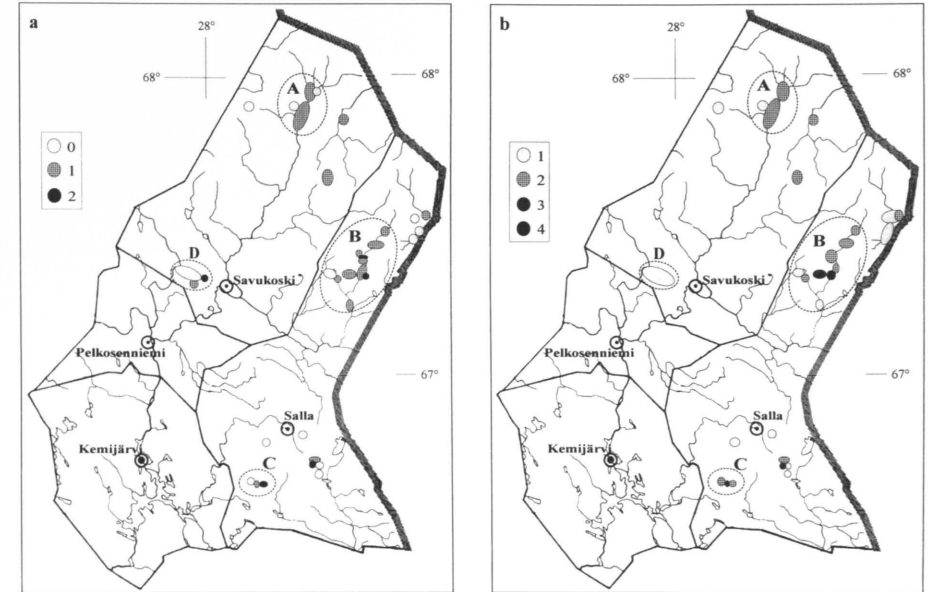
Fig. 4. a. Location of *G. abietina*-afflicted areas of Scots pine according to the PATI 92 survey in eastern Lapland. 0 = healthy stand, 1 = slight damage, and 2 = severe damage. b. Severity of *G. abietina* infection based on assessment of the fresh 1992 damage on Scots pine in the PATI 89 stands in eastern Lapland. 1 = no infection (all 1991 shoots healthy), 2 = light infection (1–10 % of the 1991 shoots infected), 3 = moderate infection (11–30 %) and 4 = medium infection (31–70 %). Screened areas contain several stands each. A = Kemihaara, B = Naruska, C = Vilmajärvi, D = Kivitunturi.

4 Discussion

In the 1992 *G. abietina* damage survey (PATI 92), damage observed proved to be lighter than was earlier reported (Kaitera and Jalkanen 1991). This was mainly due to certain incorrect diagnoses of damage in the Kivitunturi area and overestimation of damage in some stands with only a minor sub-area damaged by *G. abietina* and the rest of the stand being healthy. Moreover, the first survey (PATI 89) was performed just after a serious outbreak (Kaitera and Jalkanen 1992) and may thus led to overestimation of the damage.

The old damage was concentrated in stands of first-thinning stage or middle age. The concentration of damage in young plantations of sapling size was documented after the serious outbreak in 1982 in northern Finland (Uotila and Jalkanen 1982) and in the 1970s and 1980s in southern Finland (Aalto-Kallonen and Kurkela 1985, Sairanen 1990). In the Ylikemi Forest District, there was a little damage on peatland sites, moist mineral soils and on sandy sites as opposed to observations made during previous epidemics in southern Finland (Nevalainen and Uotila 1984, Sairanen 1990). Nor did Kaitera and Jalkanen (1993b) find any correlation between forest site characteristics and the damage degree in a badly damaged Scots pine stand in eastern Lapland.

The present study also revealed that the pathogen had killed 1–10 % of the dominant trees (MI class in HOP) in only a few stands. However, the
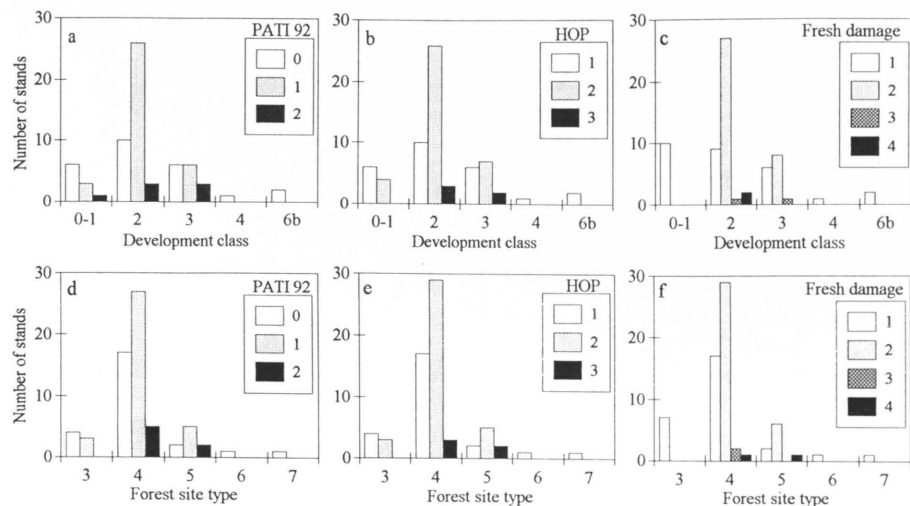
Fig. 5. Frequency of studied stands in eastern Lapland in 1992 by development classes according to a. PATI 92, b. HOP and c. fresh damage, and by forest site types according to d. PATI 92, e. HOP and f. fresh damage. For figure legends to PATI 92 and fresh damage, see Figs. 2 and 3. Development class '0–1' includes classes 0A, 0B, 0C, 1A and 1B. Legends to HOP: 1 = No infection, 2 = Light infection and 3 = Medium infection.

number of stands with small sub-areas severely infected was rather high, reflecting local concentration of serious *G. abietina* damage.

The location of stands with fresh damage along waterways indicated that areas such as Kemihaara (= a river), Naruskajärvi (a lake), Naruskajoki (a river), Tuntsajoki (a river) and Vilmajärvi (a lake) act as infection centres (Fig. 4a, b). In over half of the investigated stands, there were fresh infections indicating that *G. abietina* had not disappeared from eastern Lapland. In the areas previously heavily afflicted by *G. abietina*, there were also moderate or strong fresh infections in 1991. This can only be explained by repeated fresh infections by conidia unable to spread very far (Skilling 1969, Uotila 1985). Although fresh infection targeted mainly at the lower or middle canopy diminishes the significance of new infection, the maturation and spread of the conidia must be monitored very closely in order to get a clear picture of the development of the epidemic in the near future as well.

Acknowledgements

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