Short-Needle Disease of Scots Pine: an Abnormal Needle Length Distribution

Timo Kurkela and Heikki Nuorteva

Kurkela, T. & Nuorteva, H. 1998. Short-needle disease of Scots pine: an abnormal needle length distribution. Silva Fennica 32(1): 95–101.

Short-needle syndrome occurs commonly in southern Finland. The disease is characterized by abnormal length distribution of the needles in shoots. In most cases, affected shoots have needles of normal length as well as very short needles. The short needles are those injured during the needle elongation period; the tissues formed abnormal sclerenchymatic structures and wound periderm. One possible cause could be hemipterous insects feeding on growing needles. Salivary sheaths of such insects were often present in both deformed needle bases and undeformed mature tissues.

Keywords Scots pine, *Pinus sylvestris*, needle length, insect feeding, tissue deformation
Authors' address Finnish Forest Research Institute, P.O. Box 18, FIN-01301 Vantaa, Finland **Fax** +358 9 857 2575 **E-mail** timo.kurkela@metla.fi
Received 13 June 1997 **Accepted** 28 January 1998

1 Introduction

The short-needle disease of Scots pine (*Pinus sylvestris* L.) has been described by Gordon (1972). The disease is characterised by a stunting of one or both needles in some fascicles, whereas other needles in the same shoot develop normally. In a study in the USA, these symptoms appeared to be due to an injury to the meristematic region at the base of the needles during the needle elongation period, thus causing cessation of normal needle growth (Merrill and Zang 1982). Laitakari (1934) found that the needle length in Scots pine was often different in succeeding shoots; but he also found that part of the needles were exceptionally short in the needle set of some shoots. Apparently, the main cause for the differences in the mean needle length in the succeeding shoots is the variation in the weather factors during the growing seasons (Junttila and Heide 1981, Jalkanen et al. 1995).

Gall midges are known to cause cessation in the needle elongation and hypertrophy at the needle bases, and the affected short shoots will usually die at the end of growing season (Postner 1982, Hartmann et al. 1989). In the short-needle disease, most of the short and normal needles appear healthy; they are not curved or fused, symptoms associated with *Lygus* injuries (Holopainen 1986, Poteri et al. 1987), or with mineral deficiency or imbalance (Peace 1962). The phenomenon seems to be fairly common, varying in occurrence from season to season, and even between shoots in one tree.

This study measured the needle length variation of shoots affected by short-needle disease and of healthy shoots. In addition, some histological studies were carried out to detect possible injuries in the needle tissues.

2 Materials and Methods

Shoot samples for needle length measurements were taken from five locations in southern Finland: Ikaalinen, Ruovesi, and Leivonmäki in October and November 1978, and Hattula in the winter 1993. The samples included one to three successive annual needle sets. The sample trees were 1–2 m tall. Current year shoots collected in 1993 from the uppermost whorl of nonaffected saplings were used as control samples of natural variation in needle length. In most cases, 50 needles per shoot, beginning at the base or in some cases all needles, were measured to an accuracy of one mm. Samples were measured with a ruler or in 1993 an image analyser (Leica Quantimet 500+C) was used.

For histological studies (Jensen 1962), pieces of needles were fixed in FAA (formaldehyde-acetic acid-ethanol), embedded in paraffin and sectioned with a microtome. The sections were then stained using the safranin fast-green method, and mounted in Euparal.

Fig. 1. Short-needle disease on Scots pine.

3 Results and Discussion

The short-needle phenomenon (Fig. 1) was often restricted to only a few shoots in a given sapling. Even on one branch, succeeding needle sets were often affected differently. In some cases, the disease had become more and more serious in succeeding shoots. In some saplings, the current shoots were healthy, even though, the needle sets from the previous year were severely affected. One needle of a fascicle might have grown normally, while the growth of the other had been inhibited. The disease syndrome was found all over southern and central Finland both in young pines growing in open stands, and in solitary older trees. In the nurseries the short needle disease has not been recorded but it have some similarities with growth disturbances caused by *Lygus rugulipennis* or other *Lygus* species (see below).

The length of the needles on diseased shoots varied from 2 to 60 mm, with very high standard deviation. In healthy shoots, the range of the length of 50 needles was not greater than 4 mm in some cases. The disease was found to occur in stands growing both on mineral soil sites and on peatland. In Ruovesi (at a poor peatland site), the maximum needle length was 46 mm: the stan-

Table 1. Needle length distribution in short-needle diseased Scots pine shoots on a peatland site, Ruovesi.

Tree no.	Needle set[1)]	N[2)]	Mean, mm	Range, mm	S.D.
1	1	50	21.28	7–39	10.64
	2	50	28.72	17–35	4.85
	3	51	37.98	15–45	7.77
2	1	49	14.88	7–29	5.45
	2	50	27.20	23–31	1.95
	3	50	27.04	23–31	1.92
3	1	50	11.76	7–27	4.71
	2	50	22.68	17–27	2.33
	3	50	22.16	19–25	2.18
4	1	50	15.68	5–27	7.42
	2	50	22.72	19–25	1.14
	3	36	17.44	9–23	4.66
5	1	52	20.15	7–37	9.50
	2	50	28.44	25–31	1.72
	3	50	28.56	27–35	1.73
6	1	50	14.24	9–31	5.63
	2	50	26.48	25–31	1.61
	3	50	27.76	23–31	2.42
7	1	50	18.28	9–37	7.94
	2	50	33.72	31–35	1.50
	3	50	29.16	15–37	7.14
8	1	50	22.92	15–29	4.24
	2	50	23.76	9–31	6.23
	3	50	24.60	7–35	8.69

1) The needle sets of succeeding years. 1 = the needle set of the current year.
2) N = the number of needles measured.

Table 2. Needle length distribution in short-needle diseased Scots pine shoots on a mineral soil site, Ruovesi.

Tree no.	Needle set[1)]	N[2)]	Mean, mm	Range, mm	S.D.
1	1	50	31.96	9–55	17.44
	2	50	38.64	35–43	2.38
2	1	50	21.20	13–33	5.18
	2	50	34.32	17–39	3.99
3	1	48	37.38	15–53	13.15
	2	50	31.48	19–37	4.40
4	1	50	28.80	11–37	6.20
	2	48	31.04	21–39	5.63
5	1	50	14.56	5–29	7.27
	2	50	27.96	25–31	1.99
	3	50	22.76	19–25	1.65
6	1	50	32.20	13–39	7.19
	2	60	35.13	29–39	2.78

1) The needle sets of succeeding years. 1 = the needle set of the current year.
2) N = the number of needles measured.

dard deviation (S.D.) in the healthiest shoot was only 1.1, but in the most seriously diseased shoot it was 10.6 (Table 1). On the adjoining mineral soil site, the needle length varied from 5 to 55 mm: the standard deviation in the healthiest shoot was 1.7, and in the most seriously diseased shoot 17.4 (Table 2). In other locations, on a more fertile site, the corresponding figures for the standard deviation were 3.1 for healthy and 12.0 for affected shoots (Fig. 2). The skewness of the data of separate shoots was negative or positive depending on the extent to which the shoot was affected. There were clear differences in the mean lengths of the needles in the healthy control trees, but the standard deviation (S.D.) was low in each measured needle set. The highest S.D., 4.94, was in tree A58, and the lowest, 2.49 in tree A13. Actually, there were some exceptionally short needles even in these healthy shoots, e.g. in A58 (Fig. 3), which caused some negative skewness in needle length distribution.

Wood and Pennypacker (1974) showed that the development of the short-needle disease did not depend on the presence of air pollutants as Gordon (1972) previously suspected. We found that the pathologically short needles had no symptoms of fungal infection, and microscopically, no collapse of mesophyll tissue which is usually associated with the action of fungal parasites (Mitchell et al. 1978, Jewell 1993) or hyphae were observed. However, the possible presence of endophytes was not investigated. Most short needles had deformed tissue at their base often extending to the transfusion tissue or to the vascular bundle (Fig. 4), but not to the distal part of the needles. The injuries seemed to be of mechanical or physiological origin. The needles were injured in the beginning or during the active growing, otherwise elongation would not have

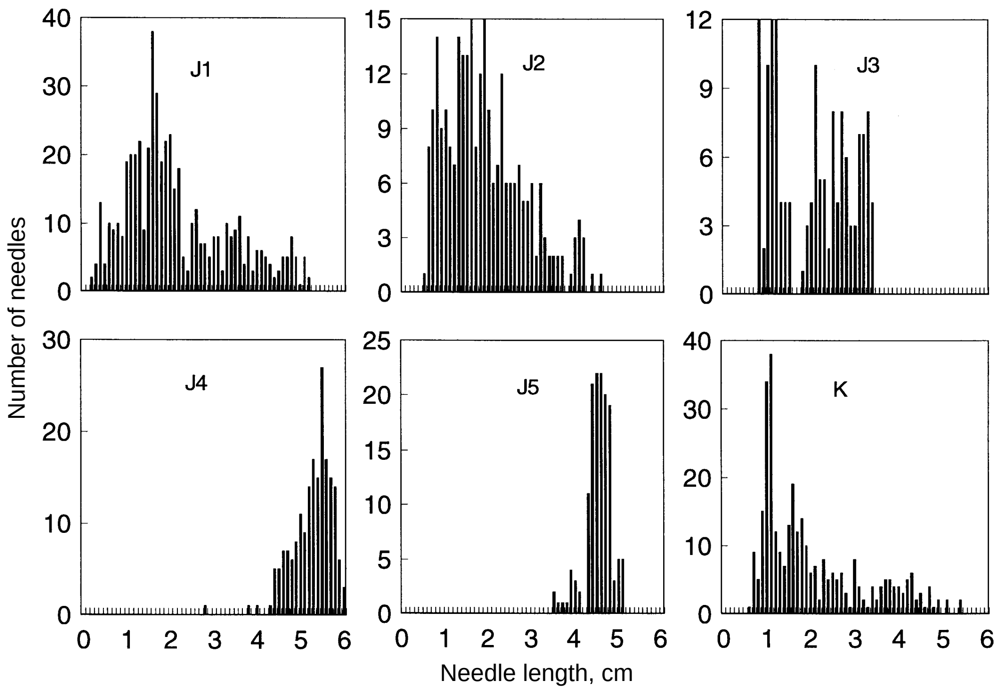


Fig. 2. Needle length variation in affected shoots from separate pine saplings. Ikaalinen and Leivonmäki.

been inhibited. The observed histological injuries were similar to those produced on pine needles in feeding experiments with *Lygus rugulipennis* (Poteri et al. 1987). Obviously, the cause of the deformation was a biological agent. According to Merrill and Zang (1982), this type of injury is most likely caused by insects. Nearly the same type of basal injury was described in pine needles by Rice et al. (1986). They stated that lesions enlarged with needle age; they posited that the phenomenon was related to sulphur depositions. In the present study, no later enlargement of lesions was observed; nor was there any evidence of the collapse of mesophyll tissue which also occurs regularly in cases of sulphur dioxide injury (Stewart et al. 1973, Smith and Davis 1978). Often in this study, the endodermis had been penetrated from the abaxial side of the needle. Salivary sheaths (Figs. 5–6), probably made by hemipterous insects (cf. Carter 1973), were found in deformed tissues in the needle bases as well as in the undeformed mature tissues of the distal parts of the needles. At the base of stunted needles, most of the tissues from the epidermis to the vascular bundle were deformed, which apparently had inhibited normal physiological functions. When the needles had not died the injuries had healed and were covered by deformed sclerencymatic hypodermal tissue or wound periderm (Fig. 4), after which the injured areas remained apparently unchanged. This kind of structural healing may be possible only in actively growing pine needles. In mature needles, defence reactions to fungal infections are restricted to the formation of chemical barriers, such as suberification or impregnation of cells with resinous or phenolic materials (e.g. Mitchell et al. 1978). The result of this study was that the abnormal needle length variation was associated with injuries at needle bases, which might be caused by insects feeding on the meristematic tissue of growing needles. However, direct evidence for this association remains still inadequate.

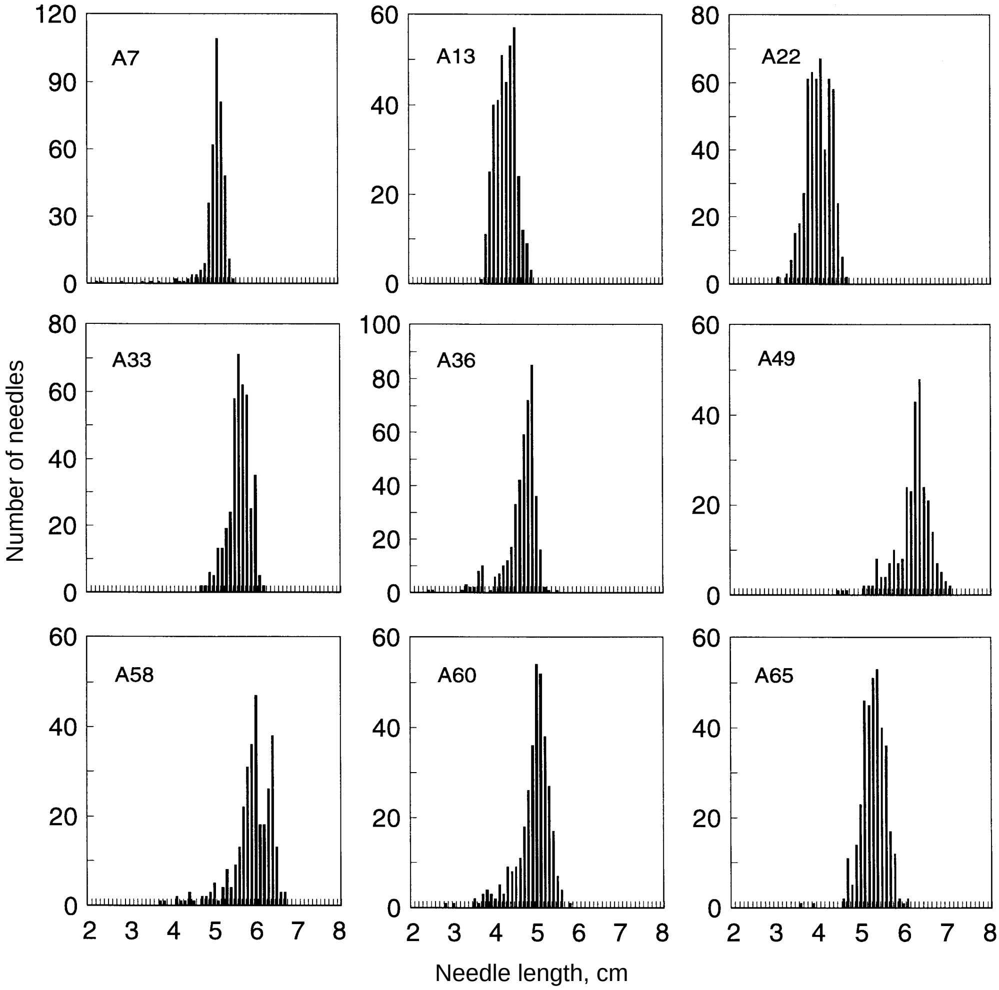
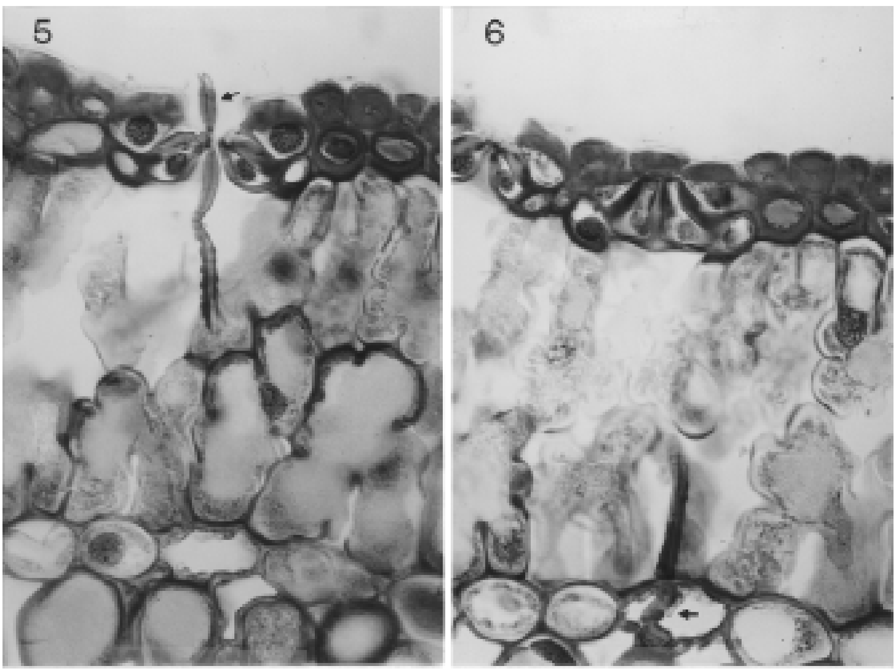


Fig. 3. Needle length distribution in the shoots of nine control trees.

Fig. 4. Transverse section of a deformed needle base with wound periderm (arrows) surrounded with deformed sclerenchymatic tissue (s), vascular bundle also deformed but one of the xylems (x) still recognizable. Sheath scales (sc) are covering the needle base.



Figs. 5–6. A salivary sheath (arrow) going through a stomata into the needle (Fig. 5) with its end penetrating an endodermal cell (Fig. 6).

References

Carter, W. 1973. Insects in relation to plant disease. John Wiley & Sons, New York. 759 p. ISBN 0-471-13849-5.

Gordon, C. C. 1972. Plantations vs. power plants. American Christmas Tree Journal 16: 5–10.

Hartmann, G., Nienhaus, F. & Butin, H. 1989. Skador och sjukdomar på träd. Göteborgs Universitet, Institutionen för miljövård. 256 p. ISBN 91-7776-0506.

Holopainen, J. K. 1986. Damage caused by Lygus rugulipennis Popp. (Heteroptera, Miridae), to Pinus sylvestris. Scandinavian Journal of Forest Research 1: 343–349.

Jalkanen, R., Aalto, T., Derome, K., Niska, K. & Ritari, A. 1995. Männyn neulaskatoon 1987 johtaneet tekijät Pohjois-Suomessa. Loppuraportti (summary in English). Metsäntutkimuslaitoksen tiedonantoja 544. 75 p. ISBN 951-40-1417-0.

Jensen, W. A. 1962. Botanical histochemistry. W. H. Freeman & Co., San Fancisco. 408 p.

Jewell, F. F. Sr. 1993. Histopathology of loblolly pine needles infected by Mycosphaerella dearnessii, the brown-spot needle disease pathogen. European Journal of Forest Pathology 23: 110–119.

Junttila, O. & Heide, O. M. 1981. Shoot and needle growth in Pinus sylvestris as related to temperature in northern Fennoscandia. Forest Science 27: 423–430.

Laitakari, E. 1934. Männyn kääpiöversojen ja kasvainten välisistä suhteista. (Zusammenfassung: Über die gegenseitigen Verhältnisse zwischen den Kurz- und Langtrieben der Kiefer). Acta Forestalia Fennica 40: 853–901.

Merrill, W. & Zang, L. 1982. Experimental control of the short-needle disease of Scots pine. American Christmas Tree Journal 26: 19–20.

Mitchell, C. P., Millar, C. S. & Williamson, B. 1978. The biology of Lophodermella conjuncta Darker on Corsican pine needles. European Journal of Forest Pathology 8: 108–118.

Peace, T. R. 1962. Pathology of trees and shrubs. Oxford University Press, Oxford. 753 p.

Postner, M. 1982. Cecidomyiidae (= Itonididae), Gallmücken. In: Schwenke, W. (ed.). Die Forstschädlinge Europas, IV Bd. Paul Parey, Hamburg & Berlin. p. 291–357. ISBN 3-490-11016-1.

Poteri, M., Heikkilä, R. & Liu, Y.-I. 1987. Peltoluteen aiheuttaman kasvuhäiriön kehittyminen yksivuotiailla männyntaimilla. Summary: Development of the growth disturbance caused by Lygus rugulipennis in one-year-old pine seedlings. Folia Forestalia 695. 14 p.

Rice, P. M., Carlson, C. E., Bromenshenk, J. J., Gordon, C. C. & Tourangeau, P. C. 1986. Basal injury syndrome of Pinus needles. Canadian Journal of Botany 64: 632–642.

Smith, H. J. & Davis, D. D. 1978. Histological changes induced in Scots pine needles by sulphur dioxide. Phytopathology 68: 1711–1716.

Stewart, D. M., Treshow, M. & Harner, F. M. 1973. Pathological anatomy of conifer needle necrosis. Canadian Journal of Botany 51: 983–988.

Wood, F. A. & Pennypacker, S. P. 1974. Development of long and short needle disease of pines in charcoal-filtered atmospheres. Proceedings of the American Phytopathological Society 1: 1210.

Total of 18 references