The association of *Eupropolella vaccinii* (Rehm) v. Höhn. and winter mortality of some ericaceous plants

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Abstract. — Ericaceous shrubs (*Vaccinium vitis-idaea* and *Arctostaphylos uva-ursi)* were killed by a snow blight during the winter. In the fall ascocarps of *Eupropolella vaccinii* were found on the leaves of shrubs which had died during the previous winter. When dead branches containing the fungus were used as inoculum, the disease was transferred to the healthy shrubs. In one more thoroughly studied case the communities of *V. vitis-idaea* died within 4—5 years.

Introduction

An extensive mycelium may often be found, especially on cut-over forest areas, in dead patches of shrubs of the cowberry *(Vaccinium vitis-idaea* L). and the bearberry *(Arctostaphylos uva-ursi* (L). Spr.) which are exposed after the snow has melted in the spring. Since the mycelium is found only on dead shrubs, the fungus porbably is *associated,* in one way or another, with their death. Ecologically, these fungi, growing on the evergreen shrubs under the snow during the winter, seem to be comparable to the causal agent *(Phacidium infestans* Karst.) of snow blight on pine (cf. Björkman 1948).

Ascocarps of the fungus *Eupropolella vaccinii* (Rehm) v. Höhn. *(Helotiales)* may be found regularly in the fall on the lower surface of leaves of the cowberry and bearberry which have died during the previous winter. *E. vaccinii* (for synonyms see Eriksson 1970) is a common fungus which also has been found earlier in Finland (Karsten 1870, Eriksson 1970). Müller (1957) resurrected the forgotten name *Eupropolella* when he elucidated the previously unclear nomenclature of *E. vaccinii.* Müller et al. (1958) described a new species of *Eupropolella (E. arctostaphyli)* on the bearberry. *E. vaccinii* and *E. arctostaphyli* are, however, morphologically very similar; and consequently, Eriksson (1970) and Morgan-Jones (1972) have regarded these fungi as one species using the former name.

Although the changes in the forest vegetation have been investigated, the reasons for the death and disappearance of various plant species have not often been determined. Kujala (1926) has made some observations on the occurrence of *Vaccinium vitis-idaea* and reports i.e. as follows: The cowberry thrives well on dry and fairly dry uplands. In groves it retreats to stones, stumps etc. Even on uplands, however, the cowberry sometimes is absent. On old uplands there are sometimes fairly large shrubless patches which may be caused partly by the detrimental effect of mycelial mats (the »soil leather» formed by species of *Calodon),* partly by severe cold on snowless places, and even by the competition of more succesful species *(Lycopodium, Phaegopteris).* Often other forest plants *(Aera flexuosa* L.) are found to thrive in such open places. Also, clear-cutting results in the rapid death of the above-ground parts of the cowberry. Obviously, this is due to the desiccation of the upper layers of the soil. Hintikka and Näykki (1967) also found that shrubs did not generally grow

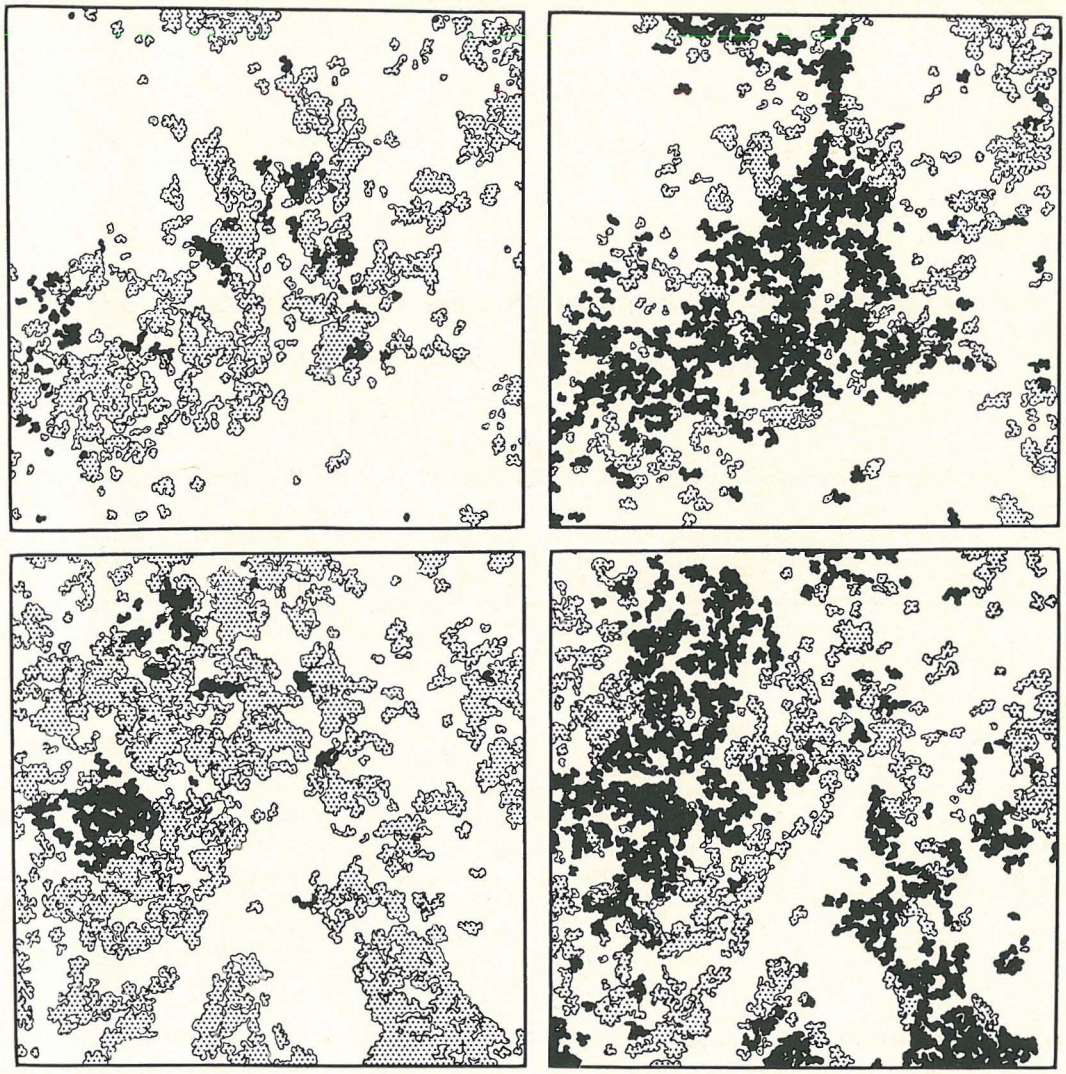

Figure 1. The coverage of cowberry *(Vaccinium vitis-idaea)* shrubs on two plots (1 m²). To left, the situation in the summer of 1967, and to the right, that of the summer of 1968. The stipled areas indicate living shrubs and the black ones indicate shrubs which died in the winter.

on places where mycelia of *Hydnellum (Calodon) ferrugineum* (Fr.) Karst. occurred. The relationship between the mycelium and the surrounding shrubs appears to be, however, some kind of an antagonistic rather than a parasitic one. KUJALA (1926) presumed that the mortality of the lingonberry shrubs after clear-cutting depended mainly on the desiccation of the upper layers of the soil. Drought may not, however, be a very common cause of mortality for the cowberry due to the xeromorphic structure of the leaves and, on the other hand, since it is known that the removal of the transpiring timber crop usually increases the soil moisture content (cf. SPURR 1964).

KUJALA (1966) found that the bearberry formed ringshaped communities when the shrubs in the center died for some reason, while the shrubs on the periphery continued to grow.

In the literature no reports have been found concerning the winter mortality of snow-covered evergreen shrubs caused by snow blight. The present paper reports some observations on such mortality among shrubs

of cow- and bearberry and on the possible role of the fungus *Eupropolella vaccinii* in such mortality. Knowledge about cowberry diseases will be required soon if the cultivation of this plant, the study of which has now been initiated, will increase in the future (cf. LEHMUSHOVI and HIIRSALMI 1973).

Materials and methods

Patches of dead shrubs were observed in the summer of 1967 in a cowberry community on a burned reforestation site in Ikaalinen, southern Finland. According to previous observations by the author, these patches seemed to be formed during the winter as a result of pathogenic fungi growing under the snow. The above-mentioned reforestation site, rather evenly covered with cowberry shrubs, was chosen for a study of this hypothesis. The entire shrub community had developed from subterranean stems which were undamaged by the slash burning. Prior to the clear-cutting, the dry site was covered with a slow-growing spruce stand which had a dense ground cover of cowberry. In the summer of 1976 the area was well covered with a regrowth of cowberry shrubs and only a few other plants, such as *Chamaenerium angustifolium* (L.) Scop. and *Senecio silvaticus* L. and here and there single shrubs of heather (*Calluna vulgaris* L.). Ten one-squaremeter experimental plots, as evenly as possible covered with cowberry plants, were chosen from the area. The plots were permanently marked and photographed, using colourpositive film, at the end of July 1967 and in May 1968. The plots also were examined during the fall of 1967, 1969 and 1970.

Maps (1:5), indicating the dead and living shrubs, were drawn from the colour slides. The difference in colour between living and dead shrubs was very distinct. Consequently, no difficulties occurred in drawing the maps. Using transparent millimeter paper, the coverage of dead and living shrubs was estimated from the maps. Results were obtained from nine experimental plots. To check the accuracy of the method the two types of shrubs were cut out from four of maps and weighed. The estimate of shrub coverage was, on an average, 2.3 % larger than the result obtained by cutting and weighing.

Since the disease was thought to spread during the winter under the snow from dead shrubs to surrounding live ones, an inoculation experiment was carried out in order to elucidate the problem. Leaves collected from dead shrubs were used as inoculum. In the autumn shortly before the first snowfall, the leaves were spread densely on the living shrubs. On the lower surface of the dead leaves used for inoculation there were abundant ascocarps (apothecia) of the fungus *Eupropolella vaccinii*. The following were examined in the experiments: i) The susceptibility of shrubs of both cow- and bearberry and ii) the inoculum potential of dead leaves of both hosts bearing the fungus *Eupropolella vaccinii*. The inoculation spots were examined in the spring after the snow had melted.

Results and discussion

The development and mortality of cowberry shrubs during the periods between photographing are presented in Table 1. At the time of the first picture the coverage of the shrubs was 50 %, and mortality was 20 %. Apparently, some more shrubs had developed after the pictures were taken at the end of July. The photographs taken the next spring showed that the coverage of the shrubs had increased in seven of nine plots while it had clearly decreased on the two remaining ones. These changes in coverage were not statistically significant. The examinations conducted in the fall of 1967 showed that the num-

Table 1. Coverage of cowberry shrubs and percentage of dead shrubs on the experimantal plots in 1967 and. 1968.

	1967		1968	
Plot no.	Coverage of the shrubs	Dead shrubs	Coverage of the shrubs	Dead shrubs
1	38.5[a]	20.3b)	43.7	59.5
2	40.7	9.9	42.2	54.3
3	53.1	22.8	59.4	80.5
4	60.7	16.2	62.0	69.2
5	29.4	13.9	20.1	61.3
6	43.4	27.8	48.7	80.5
7	48.8	7.5	64.7	66.4
8	67.7	43.8	44.2	69.7
9	60.8	18.9	71.3	91.0
$\bar{x}$	49.2	20.4	50.6	70.3

a) Percentage of plot surface area
b) Percentage of shrubs

ber of dead shrubs had not increased after the photographing in July. In the spring of 1968 the mortality of the shrubs was about 70 %. Consequently, the mortality of the shrubs occurred during the winter. On the plots exposed from beneath the snow in the springtime there was dense gray-green mycelium between and on all parts of the dead shrubs. The mycelium disappeared rapidly after the first rains. Figure 1 shows shrubs of cowberry and their mortality on two plots at the times when the first and second picture were taken. During the following winters, i.e. 1969 and 1970, the shrub mortality continued. In the spring of 1970 the shrubs were almost completely destroyed on all plots. Until the fall the subterranean shoots had not been able to develop more than a few shoots which, during the following winter, had no possibilites to resist the disease.

The results of the inoculation tests are presented in Table 2. The leaves of dead shrubs, which contained apothecia of *E. vaccinii,* always caused the formation of a patch of dead shrubs among the living ones during the winter in those cases where the inoculation material had been collected from the same species. Leaves of *V. vitis-idaea* containing *E. vaccinii* always infected shrubs of the cowberry and only poorly those of *A. uva-ursi.* Similarly, the material collected from the bearberry always infected that species but only in a few cases, the other species. If the causal agent of this snow blight is *E. vaccinii,* which seems to be most likely, then this fungus obviously has two pathogenic races adapted to these two host species.

Table 2. An inoculation experiment on shrubs of *Vaccinium vitis-idaea.* L. and *Arctostaphylos uva-ursi* (L.) Spr. The dead leaves used as inoculum contained abundant mature apothecia of *Eupropolella vaccinii* (Rehm) v. Höhn.

Inoculated plants	Origin of the inoculum	Positive result from the total of 12
Vaccinium vitis-idaea	*V. vitis-idaea*	12
V. vitis-idaea	*A. uva-ursi*	4
Arctostaphylos uva-ursi	*V. vitis-idaea*	2
A. uca-ursi	*A. uva-ursi*	12

Regardless of which pathogen causes the mortality of the cowberry, the disease seems to be rather devastating on areas from which the shading effects of trees have been removed. On open areas in the forests the shrubs of cowberry seem to remain alive only on the highest spots of the ground microtopography, on stumps and their roots, hummocks and stones from which the snow first melts in the spring and on which the infective time of the fungus is shortest during the period of thaw in the spring.

The cowberry often produces a large crop of berries for a couple of years after a clear-cut, but soon, however, the production of berries is reduced. The crop reduction is probably associated with the mortality of the shrubs caused by the snow blight. A considerable increase in the berry crop could be possible by controlling the spread of the snow blight by some means, e.g. by using fungicides. PCNB-products have been found useful for control of pine snow blight both in nurseries (JAMALAINEN 1961) and in field conditions (RUMMUKAINEN 1971). The economy of snow blight control could possibly be improved if the same treatment would increase the yield of cowberries. On the other hand, some snow molds living on ericaceous shrubs seem to protect small pine seedlings against snow blight with an antagonistic effect (KURKELA 1969).

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