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NEEDLE-CAST OF PINE

(Lophodermium pinastri)

By R. G. Pawsey, B.Sc., M.Sc., Ph.D.

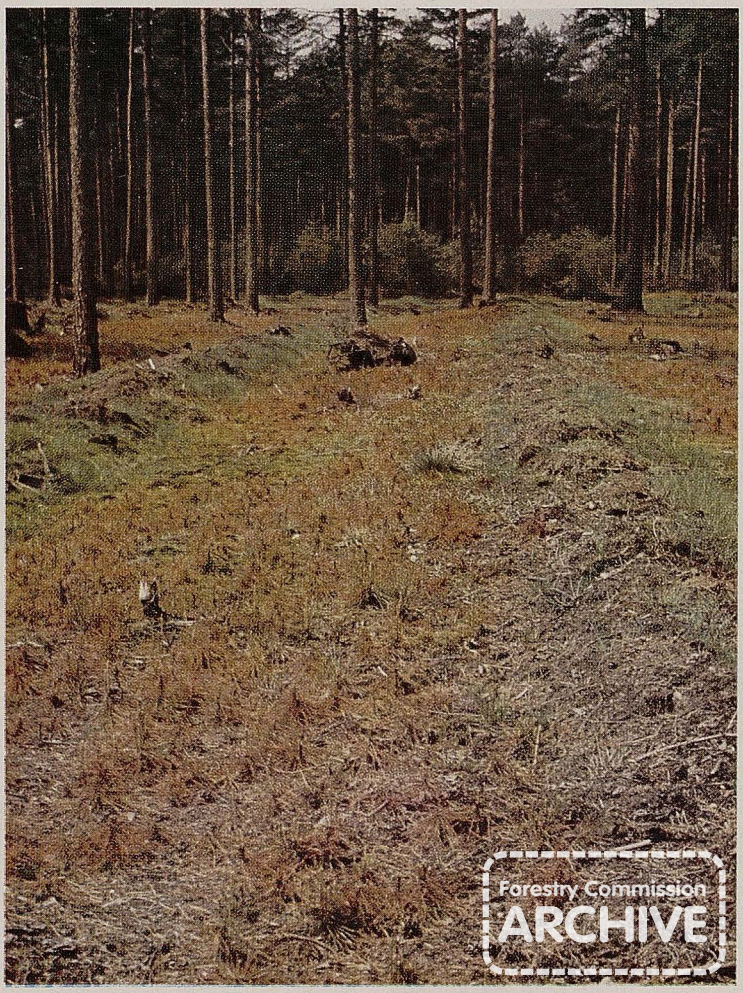

Figure 1. Severe infection by *Lophodermium pinastri* of Scots pine seedlings. Note the plantation, immediately adjacent to the seedling area, from which infection originated.

NEEDLE-CAST OF PINE

(Lophodermium pinastri)

Lophodermium pinastri (Schrad.) Chev. is the fungus most commonly associated with needlecast of pines. This fungus has a widespread distribution in Europe and North America, and has also been recorded as causing severe damage to the Monterey pine, *Pinus radiata*, in New Zealand. Many species of pine are attacked, but in Britain, where *Lophodermium pinastri* is by far the most common fungus on pine needles, infection is most frequent on Scots pine, although Corsican pine is also commonly affected. So far, Lodgepole pine, *Pinus contorta*, appears to have considerable resistance to infection. The severity of damage caused by *Lophodermium* varies very greatly in different parts of the world. In continental Europe, it is regarded as an important pathogen in both forest and in nurseries, while in Britain serious damage is usually confined to nurseries. In North America, the fungus is generally considered to be of minor importance. This variation in the behaviour of the fungus is attributable to many factors such as climatic conditions, the species of pine grown, methods of forest management and genetical variation of the fungus itself.

GENERAL CONDITIONS CAUSING BROWNING AND CAST OF PINE FOLIAGE

Browning of pine and premature needle fall or cast can be caused by a great many agents, both physical and biological. Accurate diagnosis of the cause of the damage is often extremely difficult, particularly as a combination of several factors may be involved. Infection by *Lophodermium* is much influenced by climatic conditions which affect the dispersal of the fungus and its initial colonisation of needle tissue, and also by climatic and other conditions which either cause physical damage to the needles or have a marked effect on the general vigour of the trees. The same relationship also exists between the environment of the tree and other fungi (and to a lesser extent, insects) which cause similar symptoms to those produced by *Lophodermium*.

The object of this account is to clarify the conditions and symptoms most usually associated with infection by *Lophodermium*, particularly as an aid to the decision whether or not control of the damage should be attempted.

The most important physical factors causing pine needle browning are extreme cold and exposure, and needles thus damaged are usually colonised by *Lophodermium*, or by a wide range of less important fungi. Under these conditions, *Lophodermium* is of little direct importance because most of the damage is caused by the initial adverse climatic factors, and unless these are followed by a prolonged period of other climatic conditions which favour development of the fungus, the damage due primarily to *Lophodermium* is likely to be limited.

THE FUNGUS AND DISEASE SYMPTOMS

Lophodermium pinastri is a member of the Ascomycetes, belonging to the family Hypodermataceae in which the sexually-produced fructifications are elongated and embedded in the host tissue and from which the spores are liberated through a longitudinal split in the tissue above the fructification.

As is generally the case with ascomycete fungi, there is more than one type of fructification in the life cycle. With this fungus two fructifications occur: (a) the sexually produced (perfect) fructification referred to above, and (b) the asexually produced (imperfect) fructification, known as the *Leptostroma* stage. *Leptostroma* was the generic name given to the imperfect fructification before it was discovered that two fructification types occurred at different stages in the development of the same fungus.

The imperfect *Leptostroma* fructification is a typical black pycnidium (a minute flask-shaped structure) of pin-head size, embedded

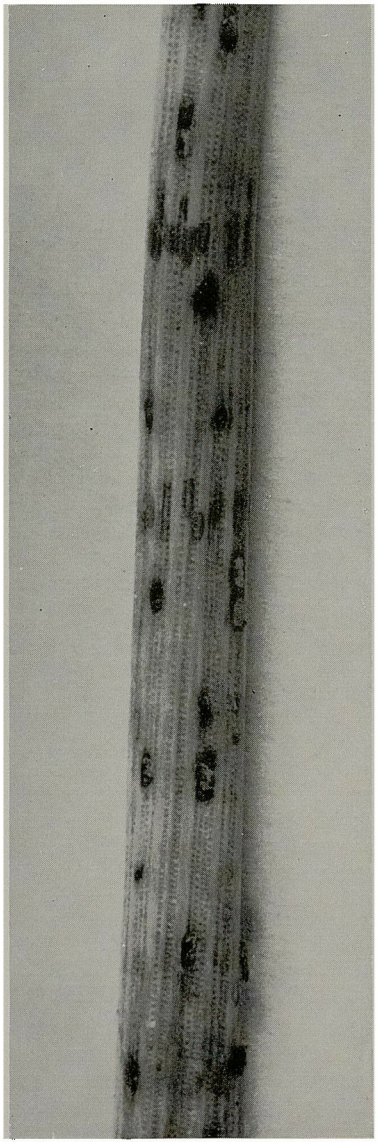

Figure 2. Pycnidia *of Lophodermium pinastri* at various stages of development on a Corsican pine needle.

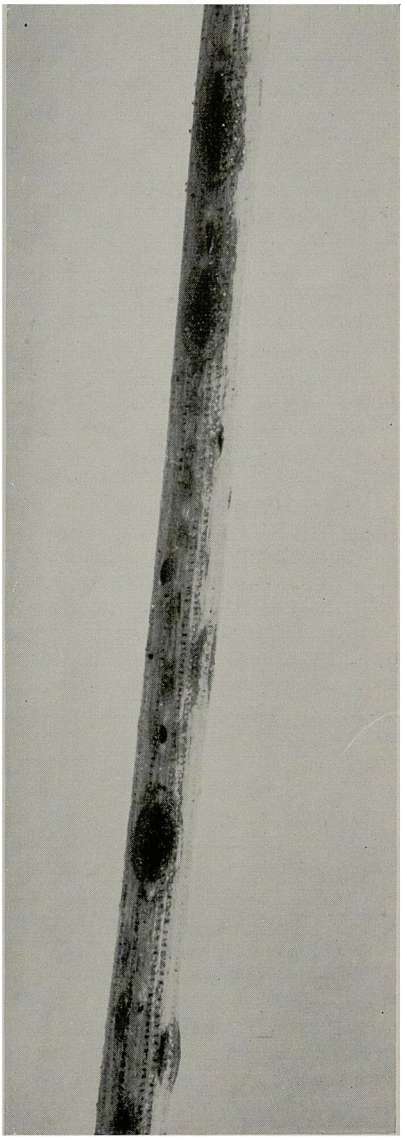

Figure 3. Mature apothecia of *Lophodermium pinastri* showing the longitudinal split of the epidermis above the fructification through which the spores are discharged.

in the epidermis of the needle (Figure 2). Within the pycnidium are produced numerous microscopic spores (conidia), which are released through the minute pore at the apex of the pycnidium. Unlike those of many ascomycete fungi, these conidia play no part in the dispersal of the fungus and at the present time their biological function, if any, is not known. The black *Leptostroma* pycnidia are produced early in the development of the fungus in the needle and are the fructifications most commonly seen before needle-cast from the tree occurs.

After the needles have fallen (and also, infrequently, before this occurs) the development of the perfect fructification, or apothecium, commences. Usually apothecia formation begins in the late autumn and continues slowly through the winter, finally maturing in the spring or early summer of the following year. However, the life cycle of *Lophodermium* is influenced by so many factors that fructification production is often irregular, a fact which increases the difficulties of applying control measures at the most effective time. The apothecia of *Lophodermium* are only clearly recognisable when they are approaching maturity or when they have discharged their spores. The mature apothecia are dark brown or almost black in colour, elliptical or more elongated in shape, and usually partially covered by the needle epidermis which has split longitudinally (Figure 3). Under moist conditions the minute ascospores (which are extremely narrow or filiform in shape) are actively discharged a short distance into the air from the surface of the fructification. The spores are carried by the slightest air movement away from the fructification and then passively dispersed by the wind.

Infected needles which bear either the imperfect (*Leptostroma*) pycnidia or apothecia (or both) are usually completely brown in colour and narrow black bands (or diaphragms) generally occur at intervals along the length of the needle (Figure 4). These black diaphragms must be used with caution in the identification of *Lophodermium* as they are also produced by other fungi in pine needles. However, they are most commonly produced by *Lophodermium* and are a useful additional recognition feature.

The ascospores ejected from the apothecia are extremely fragile structures and remain viable for only a short while after discharge. The effective dispersal range of these spores is therefore very short and careful observations in British forest nurseries indicate that the disease is not usually transmitted more than 50 to 100 yards by these spores.

Fresh infection is caused if the spores are deposited on to pine foliage and experience conditions which are suitable for their germination and the penetration of the germ tube into the leaf. Within the needle the fungus grows by the production of minute branched filaments, or hyphae, which eventually cause the death of the tissue, which results in needle browning. Generally, the first browning symptoms of *Lophodermium* infection are seen during the late summer or early autumn. After vegetative development of the hyphae within the needle tissue, fructifications are then produced on the needle surface.

Infection takes place most frequently on first-year needles, but may also occur in two-year or even older needles. Infected needles are usually shed in the autumn or during the winter. Heavy infection may result in complete loss of the previous year's needles, but usually defoliation is only partial; but if this occurs over a period of two or three consecutive years, particularly on nursery or newly planted stock, it may have a serious effect on the growth of the trees.

FACTORS AFFECTING THE SEVERITY OF INFECTION

As mentioned above, any adverse conditions which cause actual damage or a weakening of needle growth may lead to infection by *Lophodermium*. Of much more importance, however, are the climatic factors which directly encourage the growth and development of the fungus. In Britain, severe infection is usually associated with cool wet summers, but mild autumn and winter conditions may also be important. As is

Figure 4. Needle-pair of Scots pine infected by *Lophodermium pinastri*, showing apothecia, pycnidia, and characteristic black diaphragms.

frequently the case with diseases of this nature, it is extremely difficult to disentangle the influence of climatic conditions on the fungus from that on the host, and this is particularly so with *Lophodermium* which may develop as a saprophyte on needle tissue killed by a wide range of agencies.

In Britain, pines in plantation are seldom seriously attacked, except at a very early stage after planting. Nevertheless, needle infection by *Lophodermium* may often be a factor contributing to the eventual death of a tree suffering from other diseases, insect infestations, adverse soil conditions, etc. Serious losses are almost entirely confined to pine in nurseries, particularly where conditions favouring disease development occur in two or more consecutive seasons. The most severe attacks have usually occurred in small pine woodland nurseries, i.e. nurseries established in strips or in small areas of open ground within large blocks of pine plantations (Figure 1). In such sheltered nurseries, the high humidities in pine seedbeds and transplant sections probably enhance infection, but undoubtedly the close vicinity of trees carrying ubiquitous slight needle infection, and the abundant source of spores from infected pine litter beneath the trees are of prime importance. In Forestry Commission forests, the raising of pines in pine woodland nurseries, and as far as possible, in nurseries with pine shelter-belts at the perimeter, has been discontinued. Because of the short effective dispersal range of *Lophodermium* ascospores, pine stock should only be raised in small nurseries with no older pine in the immediate vicinity, or in sections of larger nurseries as far as possible from any older pines outside.

CONTROL

Because of the relatively slight, and often secondary damage to older trees caused by *Lophodermium*, it has never been considered necessary or practicable to apply control measures against this disease in plantation crops in Britain. On the Continent, however, where the severity of infection is much greater, large areas of pine forest are sprayed against attack by *Lophodermium*.

In nurseries in this country, prevention is undoubtedly the best method of control, and under normal circumstances the raising of pine can be confined to nurseries not immediately adjacent to older pine, and in this way avoiding, or greatly minimising, the chances of serious infection.

Providing that the materials can be applied at the right time, effective chemicals are available for the control of the disease in nurseries, but as mentioned before, the irregular occurrence of infection by *Lophodermium* presents difficulties in the correct timing of fungicidal treatments. The copper-containing Bordeaux mixture has long been the traditional material in the control of *Lophodermium*, but this has now largely been supplanted by zineb fungicides, which are both easier to handle and more effective. Wettable powders containing 65—75% zineb should be applied at about 4 lbs. powder per 100 gallons water per acre. The addition of a wetting agent is advisable and should be ordered with the proprietary material concerned. The rate of application will naturally vary with the size of the nursery stock concerned and the aim should be complete coverage of the needles with a fine spray. In small nurseries which are adjacent to older pine, three spray applications are recommended, at the end of July, August and September respectively. In cases of earlier infection spraying should commence as soon as *Lophodermium* infection is recognised, and be continued at monthly intervals until the end of September.

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