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Resistance of Young Conifers to Feeding Damage by Pine Weevil

INFORMATION NOTE

BY DAVID WAINHOUSE AND SARA BROUGH OF FOREST RESEARCH AUGUST 2007

SUMMARY

Pine weevils can damage or kill young conifers planted on clearfell sites by feeding on the bark of the main stem. Insecticides are commonly used to minimise damage. The ability of young trees to survive or resist attack can make a significant contribution to the management of this important pest. The degree of resistance depends on the size of resin ducts in the bark and the amount of resin that flows from them when they are damaged by weevil attack. On resistant trees, feeding is largely confined to the outer bark, which contains few resin ducts, so that damage to the cambium and the risk of the stem being girdled is reduced. Pine is generally more resistant than spruce, but in both, recognising the expression of resistance in young trees on restock sites can ensure that post-planting applications of insecticides are only made when and where necessary.

INTRODUCTION

The pine weevil *Hylobius abietis* is the principal pest of young conifers throughout the UK. Weevils injure young trees by feeding on the bark of the main stem. This occurs after they emerge as adults from the stump and associated root system (root–stump) of conifers left on sites after clearfelling (Wainhouse *et al*., 2007). This damage can result in a significant number of unprotected trees being killed on sites where weevil population densities are high. Insecticides are applied as a pre- or post-planting treatment to protect young trees, but it is important that their use is minimised by, for example, only treating the trees most at risk. The main risk factor is exposure to weevils emerging from root–stumps in autumn or in spring when they re-emerge from overwintering sites. The degree to which young trees need protecting with insecticides during these high risk periods, or alternatively, the duration of the fallow period needed to allow weevils to emerge and disperse from the site, is influenced by how resistant they are to weevil feeding. The main resistance trait in young pine and spruce that affects feeding has now been identified and is described in this Information Note. Examples of weevil damage are illustrated as a guide to the recognition of resistant and susceptible trees in the field.

Research on the resistance of young conifers has been carried out within the *Hylobius abietis* Integrated Pest Management (IPM) programme. The programme has the overall objective of reducing the amount of insecticide used to manage weevils in line with current best practice in sustainable forest management (Forestry Commission, 2004).

WHY WEEVILS ATTACK TREES

When adult weevils first emerge from root–stumps, they are reproductively immature and, in addition, many also lack fully developed wing muscles and so are unable to fly. Reproductive development and the formation of wing muscles is dependent on a period of 'maturation feeding'. Significant amounts of this feeding occur on young conifers if they are present on emergence sites, but feeding is also common on the bark of twigs in the crowns of mature trees that often surround clearfelled areas. Weevils may also feed on brash and the inner bark of logs, and signs of feeding have been seen on the fine roots of living trees. The nutritional quality of the bark on which weevils feed is determined by its nitrogen content and the concentration of defensive secondary chemicals, which affect not only the rate of reproductive development of the weevil, but also the size and number of eggs laid (Wainhouse *et al*., 2001; Wainhouse *et al*., 2004).

For young conifers, the amount of bark removed during weevil feeding and its distribution on individual stems has a significant effect on plant survival, with extensive feeding (Figure 1) often resulting in girdling and death of the tree. Feeding behaviour is influenced by a number of factors. For example, the amount eaten tends to increase with both weevil size and stem diameter. However, the main factor influencing feeding behaviour is the degree of resistance expressed by the trees. The survival of attacked trees in the field (Figure 2) is often good evidence for the existence of naturally occurring resistance.

Figure 1

(a) Extensive damage to a young spruce tree: deep feeding has penetrated to the xylem and the stem has been girdled. (b) Deep feeding damage to a young pine.

Figure 2

(a) Spruce and (b) pine trees that have been attacked by pine weevil. In each case, one tree has shown some resistance to weevil feeding while the other has been killed.

RESISTANCE MECHANISM

Resistance in young pine and spruce depends principally on the flow of resin from resin ducts within the bark that are damaged during weevil feeding. This is an active defence mechanism that is most fully effective in the living tree. When stem sections are removed from the tree, little or no resin flows from feeding wounds (Figure 3).

When weevils are feeding, the total area of bark that is damaged is often similar on resistant and susceptible trees. On resistant trees, however, the flow of resin from larger or more numerous resin ducts ensures that most feeding is superficial and restricted to the outer bark, often in discrete areas which may be covered with resin (Figures 4 and 5). In contrast, on susceptible trees feeding is typically 'deep', penetrating to the xylem and creating wounds that are less readily healed by wound repair mechanisms such as callus formation or the development of secondary periderm (Figure 6). As well as limiting the damaging effects of weevil feeding by protecting the inner cambium, resistance also benefits the tree by reducing the probability that stems will be girdled by deep feeding which invariably proves fatal. In addition to these beneficial effects for young trees, resistance has negative effects on weevils because the nitrogen content of the outer bark that is consumed during superficial feeding is lower than that of the protected inner bark, and this results in a reduced rate of reproductive development (Wainhouse *et al.*, 2005).

Figure 3

Mass of resin extracted from weevil feeding areas in relation to the cross-section area of resin ducts on intact stems (closed symbols) and on stem sections cut from a living tree (open symbols).

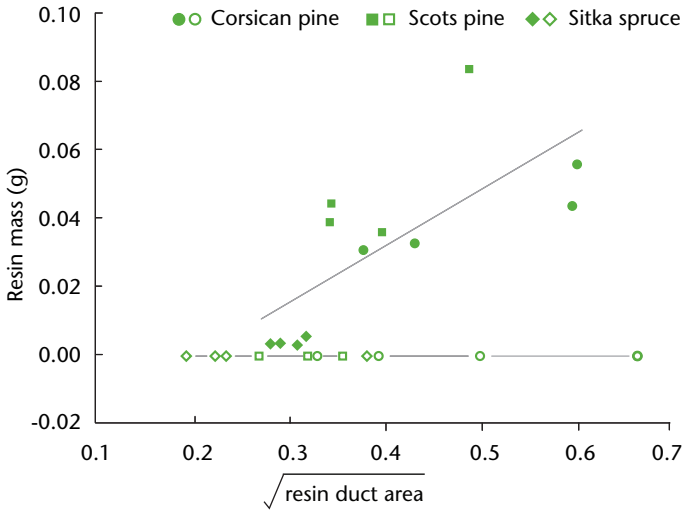


Figure 4

Cross-sections of Corsican pine stems (a) resistant and (b) susceptible to weevil feeding. On the resistant tree, resin flows from severed resin ducts and weevil feeding is superficial. On the susceptible plant, resin ducts are small and resin flow limited.

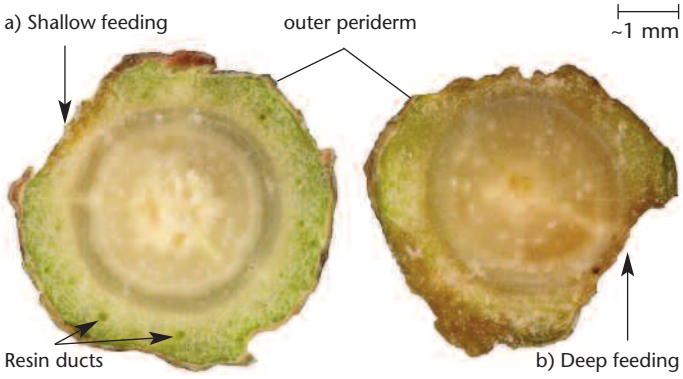


Figure 5

Pine showing resistance to feeding by pine weevils. Superficial feeding (a) with resin flow and (b) where resin ducts have remained intact and resin does not flow from the wound. Extensive weevil feeding (c, d) which is largely superficial and in places covered by resin.

Figure 6

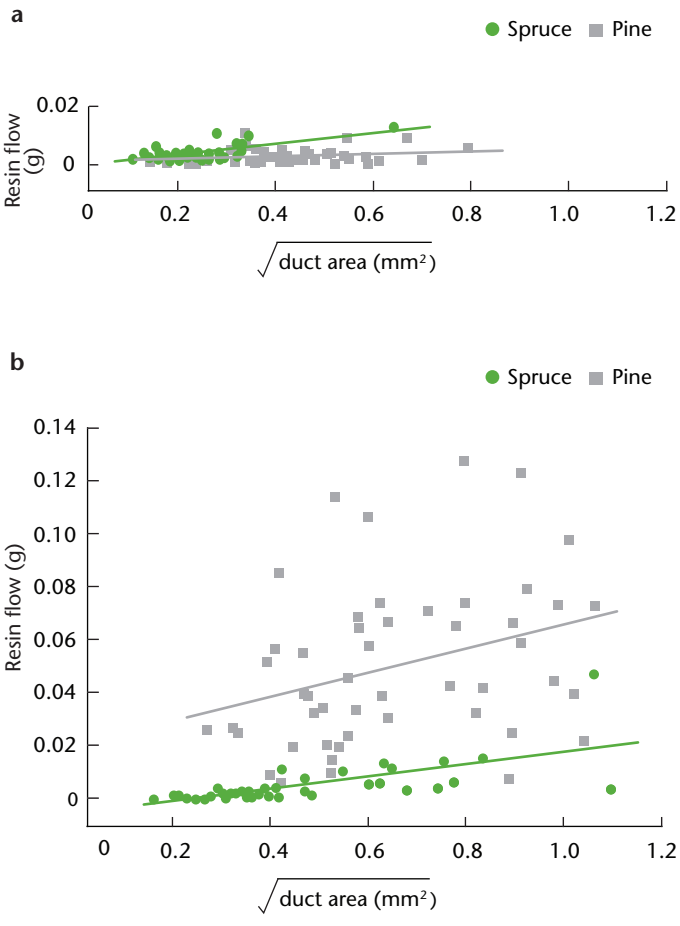
Pine weevil feeding wound on spruce that has begun to heal through the formation of callus around the edge of the wound.

Differences between pine and spruce in the size and arrangement of resin ducts within bark and in the amount of resin flow have a genetic basis and help to explain the relative resistance of these species. In Sitka spruce, resin ducts tend to be relatively short, vary widely in diameter along their length and tend to be more branched. As a result, resin flow is less than that from pine for a given duct size. On average, resin flow decreases in the order Corsican pine, Scots pine, and Sitka spruce.

Genetic variation in resistance within particular species has not been investigated but the influence of the environment on resistance expression, principally the growing conditions of the young trees, is currently being studied. Preliminary results indicate that, in both spruce and pine, resin flow is much less in one-year-old (Figure 7a) than in two-year-old trees (Figure 7b) and is also influenced by nursery treatment such as the level of fertiliser application, whether trees are containerised or bare-rooted, or whether trees are derived from seedlings or by vegetative propagation.

Figure 7

Resin flow in relation to the area of resin ducts in bark measured on stem cross-sections of potted trees: a) One-year-old trees. b) The oldest internode of two-year-old trees.



The twigs of mature trees, on which weevils also feed, exhibit resistance that appears similar to that of young conifers – with the depth of feeding influenced by the amount of resin flowing from ducts (Figure 8). Feeding on twigs can be seen in autumn and spring on trees around sites where weevils are emerging.

Figure 8

Feeding damage to twigs in the crown of a pine tree on the edge of a clearfell area. One prominent wound was made earlier in the year and has begun to heal.

MONITORING DAMAGE TO TREES

One obvious way of reducing attack on young conifers is to time planting so that it avoids the major peaks in weevil emergence. On spruce clearfells, where there are typically several 'waves' of emergence, a fallow period of up to five years may be needed (Heritage and Moore, 2000). On lowland pine, where weevil development on root–stumps occurs much more quickly, a delay of 1–2 years is usually effective in minimising the risk of damage. For sites that have been replanted before weevils have emerged or dispersed from the site, it is often necessary to use top-up sprays of insecticide. However, the tree species used and the level of resistance expressed should be taken into consideration when assessing the need for and extent of insecticide treatment. A method for monitoring feeding damage and resistance expression in newly replanted areas to provide decision support for top-up spraying in lowland pine is described in Wainhouse *et al.*, 2007. In general, pine, and Corsican pine in particular, is more resistant than Sitka spruce to weevil damage. Recognising the expression of resistance in young trees on restock areas described in this Note can help to ensure that insecticides are only be applied where and when tree mortality is anticipated.

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