The Green Spruce Aphid – a pest of spruce in Ireland

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- **Growers may have concern at severe browning and loss of needles in their Sitka spruce crops in 2002**
- **The cause is almost certainly green spruce aphid**
- **Aphid outbreaks occur on a 3-6 year cycle**
- **The predisposing factor is the lack of sub-zero temperatures (below –7°C)**
- **Trees are not killed but there can be a loss of annual volume increment of over 7%**
- **Except in the case of Christmas trees direct control measures are not economic**
- **But preventative measures, such as the introduction of more resistant spruce genotypes, may help to reduce the severity of attack.**
- **The severity and duration of attack are also curtailed and reduced by natural predators such as ladybird larvae and lacewings.**
- **Susceptibility to aphid infestation is not a reason to stop planting Sitka spruce, as even following aphid attack it will continue to outgrow the majority of species and give an positive economic return to the grower.**

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The green spruce aphid *(Elatobium abietinum)* (Figure 1) has been recorded on spruce in Ireland since 1914, where both the host plant (spruce (*Picea*) species) and the aphid are exotic species.

Figure 1: An adult aphid and her offspring seen on the underside of a Sitka spruce needle.

Some species of spruce are more severely damaged by the pest than others (see below) but the main problem resides with Sitka spruce (*Picea sitchensis*). Although the aphid can occasionally be located on other conifer genera, it does not persist. The aphid causes major discoloration and loss of spruce foliage and a reduction in timber production during the forest rotation. It occurs almost everywhere spruce is planted and can be readily transported on nursery stock.

Identification

The aphid feeds on the underside of spruce needles causes yellow mottling/banding (Figure 2) and then browning and premature loss of needles produced in earlier years (Figure 3).

Figure 2: A spruce branch in June showing the yellowing and loss of older needles.

Figure 3: Browning foliage on the inner crown of Sitka spruce; new foliage relatively unaffected.

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The aphids are green with red eyes (Figure 4) and align on a needle facing the shoot axis. They are about 1.5 mm in length and are more readily seen on spruce needles with silvery undersides *(*Sitka*)* than against the dark green background of Norway spruce. A sharp tap on a shoot or branch will easily dislodge some of the aphids onto a sheet of white paper.

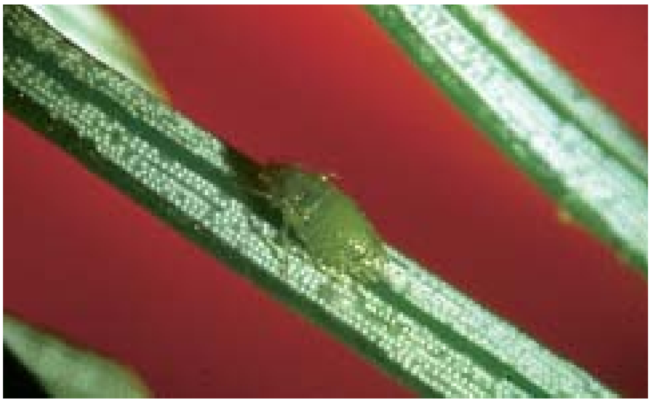

Figure 4: A single aphid illustrating a characteristic feeding position and red eyes.

The green spruce aphid produces honeydew (undigested sap sugars) which, in hot dry weather, can appear sticky on the remaining foliage. This eventually encourages the growth of sooty moulds on the older foliage. Moulds and the cast skins (exuviae) of aphids remaining on needles and shoots, provide evidence of attack even when aphid numbers have declined in mid-summer.

Other aphids which occur on spruce (for example, the spruce shoot aphid) are quite different in appearance and feed on the main axis of the shoot rather than directly on the needles. The conifer spinning mite also damages needles of spruce and causes foliage to bronze, but the culprit resembles a tiny orange-brown or grey spider (0.2-0.5 mm) and spins a covering of fine silk webbing over the needles.

Life cycle

The green spruce aphid spends its entire life cycle on the mature needle leaves of spruce where it can be found year round. An egg stage occurs in climates where freezing winter temperatures are persistent, but this is very rarely the case in Ireland or in other parts of western Europe. Instead, the aphids are all wingless females which produce a series of live young without sexual reproduction. The only change in a series of apparently identical generations is the appearance briefly in May of winged female aphids (Figure 6) in response to increasing daylength. If temperature in the middle of the day is warm and wind speed moderate, then these winged aphids can take to the air and disperse sometimes over long distances. In this way, no forest is immune from aphid immigration for long.

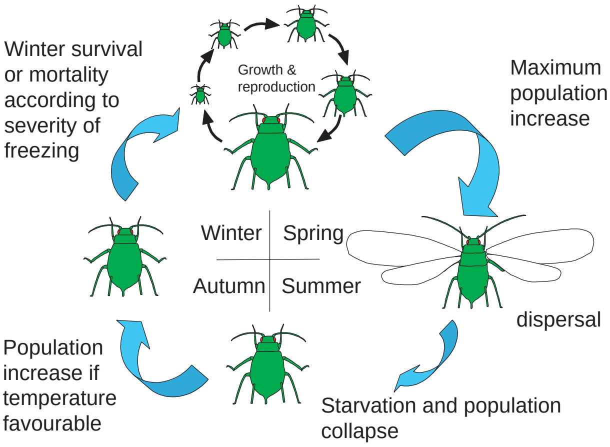

Figure 5: Life cycle of the green spruce aphid.

Figure 6: A winged female aphid in May.

Damage caused

The aphid feeds on spruce needle sap obtained through narrow stylet mouthparts. Each aphid consequently

Figure 7: Terminal shoots of spruce with no old needles remaining.

remains apparently motionless for long periods but, while feeding, minute quantities of a toxic saliva pass into the plant tissue and are thought to have a rather profound effect on tree physiology. Locally, an aphid feeding event will cause discolouration of the needle (a chlorotic band) and each such event contributes to the likelihood that a needle will eventually be lost. High population densities occurring around the time of budburst are likely to cause the browning and subsequent loss of most of the older foliage (Figure 7) and to cause occasional lightening of the new shoots (Figure 8). Aphids can be found on the new needles but they rarely feed there for long.

Figure 8: Damage caused to older foliage and blanched new foliage.

The result of an early summer infestation is that much of the old foliage can be lost but new shoots and needles are retained to partly refoliate the canopy. However, the thinning of canopies in this way (Figure 9) can seriously affect tree growth over time. Foliage can normally be retained by spruce for six years, so the cumulative loss of canopy leaf area has an impact on wood increment.

Figure 9: Plantation trees with thinned crowns due to aphid damage.

However, there appears also to be another effect of aphids on wood increment, independent of immediate needle loss, and this may be the result of their influence on the developing needle primordia within spruce buds.
The first effect of green spruce aphid infestation is a reduction in leader length, and this is followed by delayed effects on diameter and volume increment. The growth effects on young and more mature trees are probably different because of the relative balance within crowns of new and older foliage. Overall, the complexity of the interaction makes for difficulties in evaluating the impact on growth in the longer term, but recent estimates suggest that the moderate incidence of aphids results in more than 7% reduction in annual timber volume. More frequent bouts of defoliation may result in financial returns reduced by 17%.

For Christmas tree (Norway spruce) growers, almost any discolouration and loss of foliage is unacceptable and would render trees unsaleable.

Population fluctuations

The two main causes of population changes are the aphid's response to its host plant and to weather in the form of temperature. The aphid depends for growth on nutrients derived from sap and a high enough temperature (more than 5˚C) to benefit. Sap nutrients are at their highest levels while spruce buds are dormant and while temperature is generally favourable between March and October. Aphids are killed in increasing numbers at sub-zero temperatures and mortality is severe below –7˚C. This means that in Ireland, aphid population levels are usually highest in early June and possibly with a minor peak again in October, but population is very low in mid-summer and in winter. A combination of the level of population in June and the severity of weather during the following winter, determine the population to be expected in the following year. The overall result is an irregular appearance of severe defoliation at a frequency of 3-6 years.

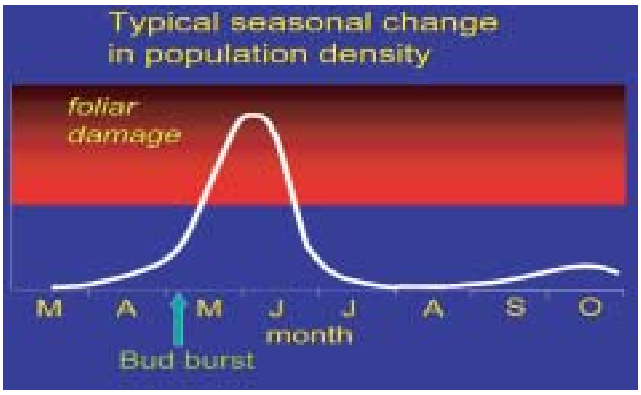

Figure 10: Seasonal population change of the green spruce aphid in Ireland.

Risk factors

Years following a severe winter (air temperature below –7˚C for a significant period) are unlikely to experience an aphid outbreak. Conversely, some mild winters are followed by aphid problems with 2002 being a noticeable example. Two consecutive years with severe aphid problems are not very likely.

Coastal areas with mild oceanic climates are more likely to experience spring/summer attacks than more continental areas or those at altitude. However, relative drought conditions in uplands may dispose trees to attack by stimulating bud dormancy early and improving nutrient conditions for the aphid while temperatures are still warm. In these conditions, autumn or even winter attacks can occur.

Sitka spruce grown in gardens or in rows along roadsides are particularly susceptible either because soil conditions and drainage improve the favourability of foliage or because natural enemies of aphids are absent or less abundant than in forest conditions. Soil fertilisation can certainly result in higher aphid numbers.

Carter and Winter (1998) distinguish between six categories of spruce (*Picea)* species according to their susceptibility. Most susceptible (6) is *sitchensis* (Sitka), then (5) *aperata, x hurstii, abies* (Norway) and *glauca,* (4) *engelmanii, pungens pungens glauca* and *mexicana,* (3) *mariana,* (2) *orientalis, schrenkiana, brachytyla likiangensis* and *wilsonii*, and least suceptible (1) *breweriana, omorika, jezoensis, polita, glehnii, koyamai, smithiana* and *rubens.*

Control

1) Pesticides

On small ornamental spruce and Christmas trees, there is little alternative than to spray a contact insecticide at the first signs of aphid presence. Checks should be made particularly in March and September. A spray any time after June will render trees free from immigration until the following May and a prophylactic spray using pirimicarb is recommended for Christmas trees in September (Strouts and Winter 1994). The green spruce aphid is not difficult to control in this way or with fumigants applied under appropriate conditions.

2) Resistance

A more promising, but longer term, solution for plantation forests is the use of improved and more resistant Sitka spruce stock. Recent research shows decisively the existence of genetic variation in resistance among spruce clones, that this is spatially and temporally consistent, and that it has substantial heritability. Markers linked to resistance genes have been identified, so there is a longer term prospect of improving breeding stock with aphid resistance in mind.

3) Biocontrols

A range of natural enemies of the green spruce aphid can reduce population growth, to the extent that peak populations with natural enemies present are substantially less than when they are absent. There is no doubt that natural enemies contribute to reducing the loss of foliage and the loss of incremental growth of spruce. Some of the most important natural consumers of aphids are brown lacewings (larva Figure 11, adult Figure 12), ladybird beetles (larva Figure 13, adult Figure 14), predatory bugs (egg Figure 15, adult Figure 16), hoverflies (larva Figure 17), soldier beetles (adult Figure 18), parasitoid wasps (mummified aphid Figure 19), and pathogenic fungi (Entomophthorales Figure 20).

These organisms are especially effective in plantation forest conditions and ladybird beetles, brown lacewings and soldier beetles are always present in Sitka spruce forests. In future, we may have a better idea of how the abundance of natural enemies can be manipulated through silvicultural practice.

Figure 11: A brown lacewing larva (Hemerobius sp.).

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Figure 12: A brown lacewing adult (Hemerobius sp.).

Figure 13: A ladybird larva (Aphidecta obliterata) consuming an aphid.

Figure 14: A ladybird adult beetle (Aphidecta obliterata).

Figure 15: The egg of the bug Anthocoris nemorum waiting to hatch by an aphid developing wings.

Figure 16: The adult of the bug Anthocoris nemorum.

Figure 17: The larva of a predatory hoverfly consuming an aphid.

Figure 18: The adult of the predatory soldier beetle Rhagonycha lignosa.

Figure 19: The mummified body of an aphid containing a parasitoid wasp.

Figure 20: The mummified corpse of an aphid infected with an Entomophthorales fungus.

Additional sources of information:

Carter, C. and Winter, T. 1998. Christmas tree pests. Forestry Commission Field Book 17, H.M.S.O., Norwich.

Strouts, R.G. and Winter, T.G. 1994. Diagnosis of ill-health in trees. H.M.S.O.