TREE INVADERS

Over the past few years a number of pest and disease threats to trees within the UK have reached alarming levels, attracting media attention at both a local and national level. In this article Dr Glynn Percival, and Messers Jon Banks (Bartlett Tree Research and Diagnostic Laboratory) and Simon Holmes (Tree Surveys and Urban Tree Experts) summerises some of the major pests and diseases of growing concern.

Horse chestnut leaf miner

Since arriving in the 1600's, the common white flowering horse chestnut tree (*Aesculus hippocastanum* L.), now represents one of the most commonest ornamental trees found within UK towns, cities, parks and woodlands. These trees are important for structure and shade, ecological value in support of insects and animals and for production of aescin, an anti-inflammatory of pharmaceutical importance. Over the past 7-8 years however, the horse chestnut tree has suffered heavily from attack by a leaf mining insect known the horse chestnut leaf miner (HCLM; *Cameraria ohridella*). HCLM is a moth about 5 mm long that was first discovered in the UK in the London Borough of Wimbledon in 2002. Since then this pest has spread rapidly through-out the UK. Its larvae are leaf miners that cause significant aesthetic damage to foliage by tunneling into the leaves physically destroying leaf tissue and stunting future growth. Infected leaves are covered in small brown patches which spread rapidly across the entire tree, giving an autumnal appearance by July-August. Eventually the leaves die and fall prematurely. When new ones grow they are again infected. The moth is able to survive winter temperatures of -23 °C, although it thrives in warmer climates, where it can achieve as many as five generations a year. Within the temperate climate of the UK the “norm” is three life cycles a year. Adult moths appear from April onwards emerging in the early morning and fly to tree trunks where they mate. From May until August the females lay their eggs along or near the lateral veins of the leaves. A female can lay between 20-40 eggs which hatch after 2-3 weeks. Larval development takes up to 4 weeks to complete. During this time larvae feed on the inside of the leaves but leave the upper and lower epidermis intact.

The spread and establishment of HCLM is of particular concern because once established, the moth appears always to maintain exceptionally high rates of infestation without any historical

evidence of decline. The full impact of repeated HCLM infestations on long term tree vitality and growth is still an area of debate between scientists. Based on the fact that trees have re-flushed on an annual basis following heavy HCLM infestation with no significant crown die-back, many researchers consider HCLM a cosmetic pest with the suggestion that control measures are not necessarily required. Contrary to this other scientists studying the repeated effects of HCLM defoliation of horse chestnut on reproduction, concluded that reduced seed weight may severely impair future growth and survival of horse chestnut seedlings that, in turn, may endanger the long term persistence of this species throughout South-east Europe. Recent research in the UK by the author recorded a 37% reduction in tree energy caused by leaf mining activity that in turn reduced seed (conker) dry weight by 50%.

Non-chemical control of HCLM is limited. Damage can be partially reduced by removing fallen leaves during the autumn and winter and either composting or burning. However, raking and composting of leaves can be a time consuming and expensive task. Likewise HCLM populations are able to increase rapidly from un-raked remaining leaves or fly in from other areas. HCLM natural enemies are parasitic wasps, but few species exist within the UK. Consequently, natural control measures based on bio-control are unfeasible at present. Effective insecticides exist that provide longer term control of HCLM that can be applied as a foliar spray or soil drench. However, insecticides within an urban or amenity environment are reluctantly used. Recent research has concentrated on the use of an insect growth regulator (diflubenzuron) that is specific to moths and caterpillars. A single canopy spray of diflubenzuron has been shown to provide 80-100% control over a growth season. The use of diflubenzuron as a trunk or scaffold limb spray only was not as effective. As aesthetic characteristics such as flowers, bark, berry and leaf colour are an important considerations for trees planted within town and city streets, public recreation areas, parks etc., and with severe HCLM induced defoliation of horse chestnut trees observed by mid-July in the UK the aesthetic qualities of HCLM infested horse chestnut trees are now highly questionable. For these reasons use of insecticide control strategies may be warranted.

Pseudomonas bleeding canker

Pseudomonas bleeding canker caused by the bacterium *Pseudomonas syringae* pv aesculi (*Pae*) has become a serious and widespread problem of horse chestnut trees with both red and white

horse chestnut varieties can suffering from infection. The common horse chestnut (*Aesculus hippocastanum* L.) and *Aesculus hippocastanum* 'Baumanii' appear to be the most susceptible although *Pae* infection has been reported on *A. indica* and *A. flava.* At present it is estimated 35,000 to 50,000 trees are affected with a few thousands probably felled as a result of infection. Horse chestnuts trees of all ages from saplings to mature trees are susceptible to attack with symptoms of infection associated with a characteristic bleeding canker where drops of black gum exudate from lesions of bark of infected trees. If bleeding is so extensive that the trunk is girdled, tree removal is generally recommended. As the bleeding cankers develop further symptoms include reduced shoot growth, small leaves, thinning crown, twig and branch dieback, bark cracking and splitting. *Pae* can also spread rapidly between and within infected trees. Information on strategies that can be employed to suppress or ideally control *Pae* are still under investigation, however a key point is that infected trees have been shown to recover from attack with no long term detrimental effects. This indicates that horse chestnut trees have the capacity to survive *Pae* infection. Although the underlying reasons for this are uncertain, it may be linked to overall tree health. As there are no chemical treatments registered to control *Pae* bleeding canker management strategies should be aimed at promoting tree vitality. This can be achieved by:

1. Inspecting for any external symptoms that could induce stress in trees i.e. new building construction and remediate if necessary.

2. Ensuring optimal tree nutrition. Sample soils for nutrient and pH levels based on a soil nutrient analysis and fertilise with the appropriate soil nutrients.

3. Apply a suitable product to control HCLM. Research by the author has shown HCLM infestation can reduce a horse chestnut tree energy budget by 30-40% that potentially can influence the energy available for the tree to defend itself from attack.

4. Apply organic matter such as an under composed wood mulch to a 5-10cm depth. Ideally mulches should be applied to 1m beyond the canopy drip line if possible.

5. Use soil moisture probes to ensure soil water status is optimal for tree growth.

6. Soil de-compact if soil compaction levels are high. Hypersonic air excavators such as the soil pick or air-spade are recommended to soil decompact and stimulate root growth.

Use of this management strategy on a vista of mature *Pae* infected horse chestnuts (18-20m high) located at the Box Moor Trust, Station Moor, Box Moor Hemel Hempstead has shown treated trees displaying signs of recovery such as drying up and reduction in canker size and larger and greener leaves.

Oak processionary moths (OPM)

OPM caterpillars are a defoliating pest of English, Sessile and Turkey oaks although the foliage of hornbeam, hazel, beech, sweet chestnut and birch are also susceptible to attack. OPM infestations were first found in London in 2006. Whilst caterpillar feeding on trees can reduce the aesthetic value of a tree, OPM, unlike the majority of other tree feeding caterpillars represents a potential human health risk. The 3rd to 6th instars caterpillars are covered in irritating hairs that contain a toxin (thaumetopoein or closely related compounds). Contact with these hairs can result in skin irritation (dermatitis) and allergic reactions (rashes, conjunctivitis). If hairs are inhaled respiratory distress such as asthma or anaphylaxis can result. Health problems can occur even if the larvae are not handled as the hairs break off readily and are dispersed in air currents. Abandoned nests contain vast numbers of detached hairs and consequently should always be treated with caution and only removed by qualified professionals. Concerns have been raised due to the fact that OPM is found on urban trees, along forest edges and in amenity woodlands where contact with the general public is highly probable.

Within the UK eggs are laid from July to early September deposited in rows in a single layer to make up a plaque covered with greyish scales that over winter on the branches. The first instar larvae hatch in April. Consequently, branch inspections for egg masses during the winter months are recommended. Any egg batches found can be marked for inspection from late March onwards and used as indicators of hatch times and appearance of the first stage larvae, which are the main targets for insecticide applications.

Oak processionary caterpillars are generally observed from April to June with six stages during their life cycle, with the larvae getting progressively bigger from one molt to the next. The larvae feed together in groups and, when not feeding, they congregate in communal nests made of white silk webbing spun under a branch or on the trunk. The larvae typically follow one another head to-tail in ‘processions’ to and from the nest and from one feeding position to another, hence the name oak processionary.

Adult moths can be observed from July until early September. They have a wingspan of around 30-32mm with grey forewings suffused with white and darker grey markings that provide excellent camouflage against the bark of oak trees. Use of pheromone traps, baited with the female sex attractant pheromone can provide an indication of population size and distribution. However, the traps only capture males and as the moths are strong fliers, it is uncertain whether the distribution of captures in the traps is an accurate reflection of the local distribution of the breeding population.

OPM Management Strategies

Surveying for the presence of OPM is a key criterion for control. However, surveying is a time consuming procedure which requires patience, experience in sighting OPM symptoms and a good pair of binoculars. Symptoms to look out for include skeletonised leaf feeding, clusters of larvae on shoots, on the underside of scaffold branches and on stems and nest formation during the later instars. Nests are found at ground level to the extremities of the tree canopy and while nest removal, is essential, it is a labour intensive, time consuming and expensive process. Results will also vary greatly and despite the most vigorous search, nests are certain to be missed resulting in ineffective control. Nest removal is performed either by MEWP or rope and harness. Such a strategy, however, exposes arborists to the health risks of OPM and the stress and fatigue of working in the summer heat in full personal protective equipment (PPE). Full PPE is essential as exposure to the OPM toxin is sensitising i.e. the more exposure the greater the effect on human health. Nests should be removed before the moth pupates and flies from July to early September. Control solely through nest removal alone however, is not an effective control option as nests are bound to be missed leading to re-infestation the following year.

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Despite a reluctance to use insecticidal sprays they offer the only feasible option for OPM control.

Soap provides and organic and potentially environmentally acceptable option for control, however, its use in OPM management strategies is unfeasible. Control rates with soap range from 60-80% and re-treatment would be needed following heavy rainfall. Likewise soaps are effective only when OPM come into direct contact with the wet spray. Dried residues on plant surfaces have minimal (if any) activity on OPM because soap residues degrade rapidly.

Horticultural oil is also classified as an organic option that works by suffocation rather than effects for example on the insect nervous system. However, control rates with oil would be too low. Although more rain fast than soap, re-treatment would need to occur at four weekly intervals; economically unfeasible when spraying mature oak trees.

Diflubenzuron is an insect growth regulator sold under the trade name Dimlin Flo. Diflubenzuron insecticidal mode of action is by preventing the formation of chitin through contact, a molecule necessary to the formation of an insect's cuticle or outer shell. Insects that absorb a dose of diflubenzuron cannot form their protective outer shell and die during molting. Importantly because of the selectivity of diflubenzuron it is non-toxic to honey bees, lady birds, beetles, spiders and sucking insects. The disadvantage of diflubenzon is that OPM take 7-10 days to die following spraying. However, where used diflubenzuron has been shown to provide excellent long term control of OPM.

Bacillus thuringiensis var kurstaki (BT) is a highly selective stomach acting biological insecticide which acts on larvae after ingestion. Much emphasis for the use of BT has been received from the Forestry Commission, ecologists and contractors from the continent. BT treatments however, require two or more applications at weekly intervals and are only effective on early instar larvae. While BT has the same target host range as diflubenzuron, BT is not an effective eradication control option. Eighty to ninety percent kill can be expected with rates

falling as OPM larvae reach the later instar stages. Treatment with BT maybe feasible however when trees are in close proximity to water, as BT is not toxic to aquatic organisms.

Deltamethrin is broad based synthetic pyrethroid insecticide which provides rapid and effective control of OPM i.e. 100% mortality within two hours of spraying. Based on three years of spray treatment of mature oaks within Kew Gardens deltamethrin is the only insecticide that provided total control. The main disadvantage of deltamethrin is that collateral damage i.e. death of non-target insects will be high.

A strategy suggested for OPM is to use deltamethrin in the first instance to achieve total control and in the following years replace deltamethrin with diflubenzuron to reduce collateral damage against other beneficial insects.

Massaria related branch breakage on London Plane

Massaria or *Splanchnonema platani* is a fungal disease capable of killing the bark and cambium on the branches of London Plane, (*Platanus x hispanica*) resulting in branch drop. As London Plane represents a major species planted particularly within the London Boroughs then *Massaria* branch breakage poses a potential public and traffic hazard. Full tree inspections need to be performed on average three times a year which in turn results in an increased maintenance cost. At a London Tree Officers Meeting it was estimated 23% of trees located within the Royal Parks are infected. *Massaria* is identified by a strip of dead bark starting at the base of the branch and stretching along the top of the branch. The width of the dead strip can vary but generally tapers to a distinct point. As the dead strip of bark is located on the top of the branch this makes *Massaria* difficult to observe from ground level, however, if twigs, seed clusters and sometimes dead leaves are seen then these symptoms represent potential indicators of *Massaria* infection. Larger branches, however i.e. greater than 20cm in diameter may not display any of these symptoms. On fallen limbs a white fungal mycelium may be present at the break point and a clearly zoned area of decay may be present. No fungicides or potential bio-control agents are registered to help in the management of *Massaria* although the use of selective pruning to reduce water stress within the tree has been discussed as a possible management option.

Sudden Oak Death (SOD)

SOD is caused by *Phytophthora ramorum*; a fungal-like pathogen causing substantial damage to trees and ornamental plants in California and Oregon, USA and many European countries such as Belgium, Denmark, France, Germany, the Netherlands. The first discovery of SOD in the UK was in 2002 on container-grown viburnum plants in a nursery. SOD on rhododendron and several other shrub species have since been recorded. The first tree infection was on an American southern red oak in October, 2003 in the South of England. SOD has since been found causing trunk cankers on beech, horse chestnut and Turkey oak. It has also caused a foliar and shoot-blight on evergreen oak, Turkey oak and sweet chestnut. Interestingly, however, while SOD in for example California has reached epidemic proportions causing the death of a substantial number of trees such a response did not readily occur in the UK until 2009 when *P. ramorum* was discovered infecting and killing large numbers of Japanese larch in South West England. To date SOD has now been recorded on Japanese larches in Wales, Northern Ireland and the Republic of Ireland. This sudden change in SOD behaviour is a major cause for concern. This was one of the first ever recording of *P. ramorum* infecting and reproducing on large numbers of conifer trees. SOD infection of larch has now been confirmed at sites in Lancashire and Cumbria in North West England, the Peak District of Derbyshire in central England, and on the island of Mull in western Scotland.

In addition to infecting Japanese larch needles, SOD can also infect and kill mature Japanese larch bark, leading to branch dieback and crown death. Entire trees can be killed in a single growing season primarily by girdling as SOD invades and destroys the cambium layer located just under the bark. The two main forms of symptoms of SOD infection on Japanese larch include i) wilted, withered shoot tips with blackened needles, with infected shoots shedding their needles prematurely and ii) bleeding cankers exuding resin on the upper trunk and branches.

No chemical treatments have been registered for SOD control although research in the United States as found application of potassium phosphite useful in managing SOD. Potassium phosphite works by switching on tree defence systems following spray or soil application, a concept known as systemic induced resistance. The use of potassium phosphite as a treatment for SOD in the UK although research appears warranted. At present, current control approaches rely

on preventing or minimising spread of SOD. This is achieved by removing and killing infected larch after SOD detection.

Acute Oak Decline

The concept of poor health in oak trees is not new. English and on occasion sessile oak suffer from a slow and steady decline termed chronic oak decline that is characterized by a thinning of the canopy as twigs and fine branches are lost. In severe cases large branch dieback can occur providing trees with a 'stag-headed' appearance. In this case, however, decline is a slow steady process lasting over many years. Chronic oak decline is believed to be caused by a combination of factors such as pest and disease attack and/or in combination with impoverished soils (compaction, nutrient deficiency) and drought. Acute oak decline is a different condition whereby symptoms develop rapidly and result in high levels of tree death within 4-5 years of infection; especially in mature trees older than 50 years. Symptoms of AOD include bleeding or oozing of a dark, sticky exudate from small lesions or cracks in the bark. Initially bleeding patches are first seen on the tree trunk around 1–2 m above ground level but with time they can be observed in the tree canopy. As infection becomes more severe trees can start to display the canopy symptoms associated with oak decline. At present AOD is primarily occurring on oaks located in the Midlands, England although an increasing number of AOD reports on oaks located in the south and south-east regions and Wales now exist. Presently it is estimated several thousand oak trees are infected. Some of the trees affected with AOD have also been infested by the wood-boring larvae of the beetle (*Agrilus biguttatus*) known to cause bleeding on oaks. However, these beetles are now considered to be opportunistic taking advantage of the oaks weakened state rather than the actual causal organism of acute oak decline. The main cause of AOD is now believed to be a bacterium or bacterial complex. Recent scientific evidence points to a novel bacteria for which the name *Gibbsiella quercinecans* gen. nov., sp. Nov has been proposed. Confirming AOD is difficult based on visual symptoms alone as other factors such as *Phytophthora* attack can cause similar symptoms to AOD. Bark samples removed from the tree and sent for laboratory testing are required for an accurate diagnosis.

Control measures are limited at present. Advice is to leave infected trees in place and monitor tree health unless it is believed the tree has declined to such an extent that there is immediate

concern about public safety. Cordoning the trees to prevent access is also recommended as well as minimizing any contact with bleeds to reduce the possibility of AOD transfer from tree to tree. If only a limited number of trees appear to be infected a rigorous sanitation policy against infected individuals is suggested. No chemical treatments have been registered for AOD control however; similar to SOD the use of potassium phosphite may have potential.

Conclusion

Management of trees especially those planted in urban and amenity environments in relation to pest and diseases is becoming more demanding. With increased global trade of timber and ornamental woody plants combined with international travel the chances of importing alien pests and diseases will increase. With limited fungicides and insecticides registered for amenity purposes and even then a reluctance to use them tree management should rely on promoting tree vitality and alleviating all forms of stress. Many of these strategies will be new to professionals involved in management of trees within our towns, cities and parks. They require changes to our existing management programs and this perhaps is the key. If we don't adapt our current management systems to embrace new technologies to counter these emerging pests and diseases and other potential threats not yet in the UK such as emerald ash borer or Asian long horned beetle then many of our dominant UK landscape trees may follow the way of the elm and disappear over the next 40-60 years.