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Mating two-spotted oak buprestid in the laboratory. Crown Copyright © 2016.

The Role of the Two Spotted Oak Buprestid in Acute Oak Decline

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Acute Oak Decline threatens both species of native English oak, keystone trees that support a wealth of biodiversity in the UK. The oak jewel beetle or two spotted oak buprestid is closely linked with Acute Oak Decline but its role in the syndrome is unclear.

As part of a wider research consortium, entomologists at Forest Research are studying the beetle in order to understand its restricted distribution in England, and to clarify its role in the syndrome. Although the causes and transmission of Acute Oak Decline are not well understood, good biosecurity practices may limit the spread of the syndrome.

Introduction

Oaks are essential to biodiversity in the UK: more insect species are associated with oaks than with any other UK tree (Kennedy & Southwood 1984), and oaks also provide food and habitats for birds, bats and other mammals. Pedunculate and sessile oaks (*Quercus robur* and *Q. petraea*) are the most abundant trees in many UK woodlands and their loss due to Acute Oak Decline would be a tragedy.

Acute Oak Decline (AOD) is a newly described syndrome that weakens and may lead to the rapid death of both oak species. Characteristic symptoms are most frequently observed on trees over 50 years old. Numerous small, vertical cracks appear between the bark plates, from which dark fluid seeps. Beneath the outer bark, lesions, or areas of decayed and dead tissue, are found, mainly in the phloem but sometimes extending into the sapwood. Although the mortality rate is high, some trees can recover; in affected woodlands, formerly diseased trees are observed with callused-over lesions (Denman *et al*. 2014; Brown *et al*. 2016).

The causes of AOD are currently being investigated. AOD is a syndrome, comprising several biotic and / or abiotic factors that work in combination. Fluctuating soil moisture levels, whether due to drought or flooding, are probably a major abiotic predisposing factor. Biotic agents include two species of bacteria new to science that are consistently found in

AOD lesions: *Gibbsiella quercinecans* and *Brenneria goodwinii* (Brady *et al*. 2010; Denman *et al*. 2012). In addition, the D-shaped exit holes of adult two spotted oak buprestid beetles *Agrilus biguttatus* and their larval galleries are frequently present. The distribution of the disease and the beetle are remarkably similar: both are largely limited to south-central England, with a northerly limit around Nottingham, and East Anglia although the first cases in Wales have recently been reported.

The role of the two spotted oak buprestid

The two spotted oak buprestid is part of the very large genus *Agrilus*, of which the vast majority of species develop on dead or dying hosts, and are therefore not considered to be economically important. The genus does, however, include several well-known pests, including the emerald ash borer *Agrilus planipennis*, an invasive species from Asia that is currently devastating US ash *Fracinus* spp. populations. As native US ash trees have little resistance to the beetle, it can attack and rapidly kill healthy trees. The two spotted oak buprestid's ecology is different from that of the emerald ash borer since it is considered to be native to the UK, and only able to develop on weakened hosts.

Trees with Acute Oak Decline bark lesions. Crown Copyright © 2016.

The two spotted oak buprestid's story is particularly interesting because it was listed as vulnerable in the Red Data Book in the UK as recently as the 1980s. It was thought to be confined to isolated patches of wood-pasture and ancient woodland where there were enough old, weakened trees to maintain small populations. AOD may have helped the beetle by increasing the number of vulnerable hosts suitable for its development. The beetle's population and range now seem to be increasing, although earlier records were not systematic. Although the association with AOD appears strong, the beetle's role is unclear; it could simply be making use of the increased availability of suitable hosts. Alternatively, the beetle could be an essential part of the syndrome, possibly by creating the necessary conditions for lesion formation or even assisting in the spread of the 'AOD bacteria', or by accelerating the mortality of the host trees (Brown *et al*. 2015).

Due to its cryptic nature, the two spotted oak buprestid beetle is difficult to study in the field, and its ecology is not well understood. The adults feed and mate in the oak canopy in early summer, and females lay eggs into bark crevices on suitable hosts. Once hatched, the larvae tunnel into the phloem tissue where they feed, and their galleries damage the host's vascular system. After completing their development, the larvae tunnel to the outer bark to prepare pupal chambers, emerging as new adults through characteristic D-shaped exit holes the next year. Temperature is the key factor influencing insect development time and success, and the two spotted oak buprestid's lifecycle is thought to vary from one to three years depending mainly on temperature.

We developed methods to study the beetle's lifecycle in the laboratory by mimicking the conditions in the field. We collected adults by felling colonised trees and keeping slabs of outer bark and sapwood in large emergence cages. We

found that the adult beetles could live for a couple of months, and that sexually mature females are capable of laying many batches of eggs over their lifespan. We measured egg development time and formulated a procedure to insert eggs into cut oak logs so that we could study the development time of the larvae and pupae at various temperatures. These new data on the two spotted oak buprestid's lifecycle have allowed us to construct a model that predicts the beetle's development under the fluctuating temperatures experienced in the field. It also will allow us to predict the likely geographical range.

While our work on the two spotted oak buprestid's lifecycle is ongoing, our data support the initial hypothesis that the beetle is temperature-limited in the UK, and can only survive in south-central England where warm summers make its development viable. If the beetle is shown to be an essential component of AOD, the distribution of the syndrome may then be limited by the distribution of the beetle. However, it is important to consider the potential for climate change to increase the beetle's UK distribution. Indeed, the recent warmer average temperatures in England may be in part responsible for the beetle's reported population increase.

In order to better understand the beetle's role in AOD, two field studies are underway using trees at sites that have been monitored for symptoms and beetle exit holes. In the first, a dendrochronological study, we removed cores from a range of trees with and without AOD symptoms. By examining the annual growth of these trees, we should be able to determine whether symptomatic trees were already under stress (and perhaps predisposed to disease), as evidenced by reduced growth, before developing characteristic AOD bark lesions and being colonised by the beetle. The results from this work are very preliminary, but there seem to be clear differences between the growth patterns of asymptomatic and symptomatic trees. Using the same set of trees, we are also examining their susceptibility to colonisation by two spotted oak buprestid. We have wounded the trees, and are measuring their callusing response as a proxy for tree defensive ability. As two spotted oak buprestid larvae are thought to be unable to develop on healthy trees, by looking at the defensive ability of a range of asymptomatic (uncolonised) and symptomatic (colonised) trees, we should be able to quantify the stage of decline necessary for the beetles to establish on the trees and complete their development.

An Acute Oak Decline lesion (outer bark removed), with two-spotted oak buprestid larval galleries and dead larvae. Crown Copyright © 2016.

Management recommendations

The causes and transmission of Acute Oak Decline are not yet fully understood but the Forestry Commission leaflet *Managing Acute Oak Decline* (Denman *et al*. 2010) describes current management recommendations and protocols to limit its spread. Information is also available on the Acute Oak Decline page of the Forestry Commission website (http://www.forestry.gov.uk/acuteoakdecline).

If AOD is suspected, woodland managers should contact Forest Research via its advisory service, Tree Alert (http://www.forestry.gov.uk/treealert), so that the

Two-spotted oak buprestid. Crown Copyright © 2016.

syndrome can be accurately diagnosed. Note that other agents, such as *Phytophthora* spp., can produce similar symptoms. Woodland managers are advised to survey and monitor affected woodlands after a diagnosis is confirmed. As trees often recover, felling is usually not recommended, but may be prudent if only a small number of trees are affected, or if affected trees represent a safety hazard.

On sites where AOD is present, biosecurity measures should be taken to limit the spread of the bacteria and beetle. Wherever possible, cordon off affected trees to prevent access, do not touch affected trees and do not take any affected material such as leaves and sticks out of affected woodlands. The beetle can persist in its larval form in the outer bark before emerging the following summer, therefore it is recommended that the timber from an AOD-affected tree be debarked before transporting it off site. The bark should ideally then be burnt on site. Boots should be sterilised when leaving affected woodlands, as should any tools and equipment used on affected trees.

Conclusion

Many thousands of pedunculate and sessile oaks, two of England's most iconic and biodiversity-rich trees, have been damaged or killed by Acute Oak Decline since the 1980s. Initial studies suggest that the UK range of the two spotted oak buprestid beetle associated with the syndrome is restricted by temperature. Warmer summers resulting from climate change may allow the beetle to expand its range, and, if the beetle proves to be an essential component of AOD, may also influence the distribution of the syndrome. Further research aims to clarify the beetle's role in AOD. Meanwhile, implementing biosecurity measures recommended by the Forestry Commission may help to reduce the likelihood of between-tree and between-site spread of Acute Oak Decline.

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