Molecular Plant Pathology

MOLECULAR PLANT PATHOLOGY (2013) **14**(9), 856–860 DOI: 10.1111/mpp.12084

Opinion piece

Ash dieback in the UK: a wake-up call

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The confirmation of ash dieback, caused by the fungus *Hymenoscyphus pseudoalbidus*, in English woodlands in October 2012 provided a deafening wake-up call for many people. Foresters, scientists, plant health regulators, politicians and others were jolted upright by the threat of trees dying across the UK, abruptly made aware that tree health as a discipline was itself in decline. What scientific capacity was available to study tree diseases and develop solutions? Was the UK prepared for ash dieback? Could have done better is the cruel answer. The arrival of this 'new' disease should not have been a surprise. Ash dieback was well known from a steady advance across Europe. Confirmation that it had finally reached the UK has, however, had at least one positive effect: a timely reminder to be more vigilant. A dying subject (tree health) has been resurrected, although it is still too early to say what the long-term consequences will be for research and guaranteed support.

Early pressure for change came from the British press and public. Why was UK ash being raised in nurseries in Germany and the Netherlands for planting back in the UK? Was the new arrival a failure of phytosanitary measures at UK borders? The numbers of *H. pseudoalbidus*-infected ash seedlings discovered on many planting sites around the UK earlier in 2012 suggested that the authorities should have been better prepared. The discovery at the same time of ash dieback in the 'wider environment'—established woodlands of Kent, Suffolk and East Anglia—suggested spores blown across the English Channel. This was supported by a quickly commissioned taskforce that modelled the possible spread of *H. pseudoalbidus*, led by Chris Gilligan at the University of Cambridge. Later discoveries of infections in ash woodlands in north-east Scotland, west Wales (Carmarthenshire) and in Eire indicated that introduction by aerial spread and seedlings had probably occurred at the same time. The severity of the symptoms seen on both juvenile and mature ash in the woodlands of south-east England suggested that the pathogen had been present for over 2 years. Why was it not detected earlier in a country in which woodlands and the countryside are regularly visited? The symptoms (Fig. 1) are striking, even to the casual observer. The reason why they were not seen before 2012 is probably because no-one was really looking.

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Vigilance is a function of public awareness. It is unreasonable to expect the detection of new tree diseases by dedicated professionals, even if we hired more foresters, without better information on what to look for—and where. The public is now helping to monitor ash dieback, a new role stimulated by a strong and coordinated government response to the discovery of this disease (e.g. http://www.ashtag.org/). This is one of a series of initiatives which, if the current government follows it through, will lead to major changes in how the UK manages tree health threats and other unwanted incursions.

There is a well-recognized threat posed to the health of crops and the natural environment by alien invasive pests and pathogens (e.g. Brasier, 2008). The European Union (EU) has produced rules, regulations and protocols for phytosanitary inspections; the European and Mediterranean Plant Protection Organization (EPPO), which includes countries outside the EU, monitors global pest and disease threats, as well as invasive species, and issues regular alerts (http://www.eppo.int). Yet, there is still a weak connection between official actions and public responses, a reminder of the low priority given to plant pests and diseases in comparison with animal or human problems. However, when large trees start to die, everyone notices.

The noisy clamour by the media and interest groups for action on ash dieback undoubtedly pushed the UK government to react on a wide front. Threats to tree health in the UK from introduced pests and pathogens had already risen high on the agenda for the Department for Environment, Food and Rural Affairs (DEFRA: an English government department) and equivalent departments in Scotland, Wales and Northern Ireland. The problems caused by Dothistroma needle blight and *Phytophthora ramorum* hastened official actions. Ash dieback nudged official concern a little higher, helping to sustain commitment to new funding and initiatives that might have faded in times of economic downturn.

The increasing number of newly recognized invasive pests and pathogens that have become established in the UK in recent decades has already helped to boost funding for research in the shrinking discipline of tree health. Ash dieback brought this initiative to the front pages of the newspapers, eager to raise public interest in the slow summer months, although competing well for space against the London Olympics. Despite the odd apocalyptic statement about 'no more ash trees', most press reports were

Fig. 1 Symptoms of *Hymenoscyphus pseudoalbidus* infection on *Fraxinus excelsior*. (a) Mature tree showing extensive dieback (courtesy of O. Holdenrieder, ETH Zurich, Switzerland); (b) shoot dieback on coppiced ash in Norfolk; (c) lesions on foliage of weeping ash (*F. excelsior* var. *pendula*) in October (Czech Republic); (d) lesion extending from infected axillary node on 2-year-old ash stem.

surprisingly accurate. Scientists have low expectations of the popular press. There was some confusion about the ostensibly dramatic impact of the disease in Denmark, one of the few countries to regularly quote losses. Commentators made useful comparisons with the Dutch elm disease crisis which began in the 1960s in the UK and led to the almost entire loss of an important genus of trees. Wider comparisons with devastating losses caused by chestnut blight in the USA were not made, despite the advance of this disease across Europe. The media ensured that ash dieback and, by consequence, tree health became a major public issue.

Many highly damaging introduced tree diseases have previously entered the UK without causing this same wide concern. A panoply of *Phytophthora* species includes *P. alni*, *P. quercina*, *P. ramorum*, *P. kernoviae*, *P. austrocedrae* and *P. pseudosyringae*, severely affecting woody plants in both ornamental gardens and the wider environment. *Phytophthora ramorum* has received most attention in recent years, particularly after it 'jumped hosts' and began killing Japanese larch (*Larix kaempferi*) in plantations in western Britain and Eire (Brasier and Webber, 2010). However, there was still relatively little noisy reaction from the press. Perhaps larch trees, a non-native species, are loved less than ash trees. The invasive *P. austrocedrae* is killing a native woody plant, *Juniperus communis*, an important loss that has raised too little concern.

Phytophthora austrocedrae kills the southern cedar, *Austrocedrus chilensis*, in Argentina and Chile, where large swathes of natural forest have disappeared. The pathogen is not known from any other region, yet it appeared on UK nursery stocks of *J. communis* grown for restocking our native juniper heaths. A greater commitment to tree health will help support research on a wide range of species, including those that fail to receive much public attention.

Pines in forests and plantations in the UK are being severely damaged, sometimes killed, by needle blight caused by *Dothistroma septosporum*. There was little evidence to suggest that Scots pine (*Pinus sylvestris*) was at risk until a few years ago, when it became highly susceptible to infection and damage for reasons unknown (Watt *et al*., 2009). Other invasive bacterial and fungal pathogens of trees have been recently published on UK websites, for example that of The Woodland Trust (treedisease.co.uk). Invasive insect pests are round and about, notably oak processionary moth (*Thaumetopoea processionea*) spreading westwards from London, Asian long-horned beetle (*Anoplophora planipennis*), horse chestnut leaf miner (*Cameraria ohridella*) and emerald ash borer (*Agrilus planipennis*), a devastating problem in the USA but not yet in Western Europe.

The press initially blamed plant health authorities for the failure to intercept infected ash trees at ports of entry into the UK. Once ash dieback arrived in the UK, however, it was too late. The blame for breaches of biosecurity does not rest with one person or one organization; there is a long line of responsibility for biosecurity, from the importers and exporters, through to the phytosanitary services in the source and receiving states. Not to forget customers who create the initial demand for plants. Plant health inspectors cannot look at all of the tens of millions of plants entering the UK each year; the aim is to inspect 2%. There is no evidence that they saw ash dieback when sampling consignments and ignored it. There are major difficulties arising from a lack of traceability in trade, particularly for plants that have already entered the EU. Cryptic infections on young planting material and a huge range of potential alien invasive pests and pathogens, often poorly known to science, present major challenges for plant health inspection.

Newspaper reports used Dutch elm disease, which hit the headlines in 1970, as the baseline, although that invasion probably occurred in the early to mid-1960s. Although Dutch elm disease was not the first alien invasive pathogen to hit European tree populations, it served as an anchor point for the apparent exponential increase in the numbers of invasives that have entered Europe over the last 20–25 years. Why ash dieback, in particular, has led to such an explosion in interest is unclear. Pidgeon and Barnett (2013) looked at the public response to ash dieback and pointed to parallel perceived risk events following the bovine spongiform encephalopathy and MMR vaccine scares, referring to the phenomenon of 'social amplification of risk'. These authors rightly state that the risk itself did not change: informed scientists have known for several years that ash dieback would come to the UK; it was simply a matter of when. What changed was '*the social context and institutional dynamics . . .*' of the problem (Pidgeon and Barnett, 2013). It appears that some knowledge of the disease threat, coupled with the pending death of the majority of the UK's ash and the uncertainties associated with the underlying causes and the science behind the problem, each contributed to an amplification of the perceived risk from ash dieback by the public.

Ash dieback, as we now understand it, was something of an enigma for longer than usually associated with outbreaks of destructive plant diseases. A problem in determining that something unusual was happening was that ash frequently suffered bouts of dieback: for example, fluctuations in the water table as a result of climatic variations were probably responsible for a period of severe ash dieback in the UK during the 1980s. These problems are not unusual in the case of pests and pathogens affecting long-lived plants.

The impact of *H. pseudoalbidus* infection was first noticed in north-eastern Poland and Lithuania in the early 1990s (Kowalski and Holdenrieder, 2009 and references therein), and it was recognized that 'something was going wrong'. At that time, however, little was done to determine the true cause of the problem. By the late 1990s, it was clear that a raging epidemic had developed, was spreading and was something different from what we had witnessed on ash before. The problem affected trees of two of the three main European ash species, common ash (*Fraxinus excelsior*) and narrow-leaved ash (*F. angustifolia*). The third European native species, manna ash (*F. ornus*), may be infected by the pathogen, but shows little sign of damage (Kirisits *et al*., 2009); *F. ornus* is more closely related to many Asian ash species than to the two other European native *Fraxinus.*

It was obvious over 10 years ago, therefore, that the problem affecting ash in Central Europe was not caused by any diseases we already knew to affect ash on this continent. Despite this fact, the phytosanitary authorities in Europe paid it little attention, and dispersal continued. Eventually, a previously unknown asexual fungus, subsequently named *Chalara fraxinea*, was characterized and shown in inoculation tests to cause the problem (cf. Kowalski and Holdenrieder, 2009). Later, it was demonstrated that *C. fraxinea* was the anamorph of a species in the genus *Hymenoscyphus* (Kowalski and Holdenrieder, 2009); moreover, it appeared to be very similar to *Hymenoscyphus albidus*, a species known in Europe for over 150 years, which presumably had co-evolved with European ash species. The biology of the disease, however, did not make sense if the 'pathogen' had co-existed with ash in Europe for as long as ash had existed: why would the behaviour of the fungus suddenly change?

We now know, of course, that the behaviour of *H. albidus* did not change: rather soon after the announcement that *C. fraxinea* equated to *H. albidus*, more detailed molecular evidence showed *C. fraxinea* to be the anamorph of a hitherto unknown species of *Hymenoscyphus*, subsequently named *Hymenoscyphus pseudoalbidus* (Queloz *et al*., 2011). We now know that *H. pseudoalbidus* is native to Japan (possibly also to other Asian countries; Zhao *et al*., 2012). It is most likely that it was inadvertently introduced into Lithuania or thereabouts in the late 1980s. The pathway of introduction to Europe, however, is unclear.

Knowledge of the pathogen species, invaluable and fascinating though it is, does not help directly with the protection of ash trees. Arguably, the mistake in nomenclature prevented appropriate responses from the plant protection services: it would be futile to set up any regulations or protected areas to prevent the spread of a pest or pathogen which already exists in that area. In this case, however, the situation could have been better considered: there was clearly something drastic happening; it was different. Ash had not died from infection by *H. albidus* in Europe before; why should this fungus suddenly start killing trees? This problem was behaving in a similar manner to other alien invasive pathogens, such as Dutch elm disease and many *Phytophthora* species. It was obviously something 'new'.

By this point, it was too late to do anything much to prevent further spread in the UK and beyond. One Swiss colleague who had been contacted repeatedly for comment by the UK press said '*you have the problem*; *learn to live with it*' (Ottmar Holdenrieder, November 2012, ETH Zurich, personal communication).

So what can be done? What can science do? What message can we give to the public who love ash? Or to foresters who planted ash in the hope of generating income from it in the long term? This, sadly, is where things become even more difficult. Our track record in dealing with alien invasive pests and pathogens affecting our trees is poor. What happened with elm? Almost all trees died (or are dying). Yes, there are now a number of cultivars of elms available that show good levels of tolerance to *Ophiostoma novo-ulmi* in tests and have even stood up to disease in the field in the short term. In North America, there are hopes that, in time, replacement hybrids for the majestic American chestnut (*Castanea dentata*) will be seen again in the eastern USA, following successful breeding with Chinese chestnut species to reduce susceptibility to the chestnut blight pathogen, *Cryphonectria parasitica*, that wiped out the native *C. dentata* between 1904 and 1940 (Thompson, 2012).

Compared with Europe, Australia and New Zealand have much stronger biosecurity measures in place at ports of entry, including more detailed checks of both people and goods coming into their territories. Quarantine is used for plants: they are kept in strictly controlled facilities for up to 3 months (more for some species), until any possible pests or pathogens should have manifested themselves. Any plants showing symptoms or problems are destroyed. This system is a bottleneck in the import/export trade, but it certainly means that the buyers and sellers are careful about what is ordered and what is despatched. Biosecurity breaches still occur, however, despite these stringent measures. The USA has strengthened phytosanitary inspections at borders too, with further regulations in place between individual states.

Although biosecurity must improve in the EU, the enormous volume of trade in plants and plant products, coupled with the rules of trade, mean that incursions of alien invasive pests and pathogens will continue in the foreseeable future. Rules of trade protect traders, customers, profits: although the World Trade Organization includes biosecurity checks in its protocols, the frequent incursions of alien invasive pests and pathogens we are witnessing strongly suggest that the regulations do not work effectively; they should be overhauled with real inputs from the evidence base. The EU is already reviewing the plant health regulations to improve some of the many biosecurity issues.

In the immediate aftermath of the confirmation of ash dieback in British woodlands, the UK government set up The Tree Health Task Force, to '*advise on the current threats from pests and pathogens and to make recommendations about how those threats to trees and plants could be addressed*'. The report, published in May 2013 (Gilligan *et al*., 2013), gave eight recommendations for action, including the development of a UK plant health risk register, the appointment of a chief plant health officer, improved preparedness for alien invasive pest and pathogen incursions, strengthening of legislation, further international collaborative efforts on plant biosecurity and strengthening of phytosanitary protocols at borders. It was recognized that the public should have rapid and simple access to accurate information on these problems, and that numbers of plant pathologists with field expertise, and tree pathologists, in particular, needed to be increased considerably, to reverse the long-term decline in the personnel qualified in these subject areas.

Over and above the improvements in biosecurity protocols recommended by the Task Force, we need properly funded tree selection and breeding programmes for a number of native species, so that we can incorporate greater tolerance to pests and diseases inherent in some exotic trees into species grown in Europe. Responsibility for this initiative should be divided amongst all European states, shared with near-neighbour countries. Modern state-of-the-art molecular techniques will enable us to speed up the discovery of the genetic basis for broad-based tolerance to pests and pathogens in both European and Asian ash species, for example, which can then be transferred into European ash species using whichever methods prove expedient.

This work was initiated in part with the funding given to the Nornex consortium, coordinated by the John Innes Centre in Norwich, UK, which, amongst other things, is examining the genetic basis for reduced susceptibility to *H. pseudoalbidus* in European *F. excelsior*. Moreover, large plantings of UK provenance ash are underway to screen for less susceptible genotypes. There are, however, other problems not yet found in the UK which cause serious damage on ash and these must be given serious consideration in any attempts to find ash genotypes with greater resistance to *H. pseudoalbidus*. Ash trees resistant to dieback will be suitable food sources for the destructive emerald ash borer (*Agrilus planipennis*), a buprestid (jewel) beetle native to China. Within 20 years of its discovery in North America, it had killed tens of millions of ash trees. The insect is already in Europe (at least 250 km west of Moscow); in the absence of strict vigilance, it will arrive in the UK within a few years. Less well known is ash yellows, caused by an insect-vectored phytoplasma, which occurs in North America but is most severe in planted exotic ash in urban areas of Colombia. Although we are highly unlikely to import ash trees from North America or Colombia, trade in plant materials could introduce insect vectors carrying the pathogen.

Selection and breeding for lower susceptibility remains a long-term venture, undoubtedly considerably longer than some of the optimistic predictions arising from reports of apparently resistant ash trees in Denmark, Sweden or Lithuania would suggest. The polygenic, durable resistance, taking into consideration destructive organisms, both exotic and native, other than *H. pseudoalbidus* that can attack ash, will be complex and difficult to manipulate. Given the time required for breeding, ash populations will collapse in the wild before we can start repopulating our woodlands, parks and hedgerows with genetically improved genotypes. Moreover, environmental purists will argue rightly that these are not true European ash, but hybrids; they will contain genes from Asiatic ash—there are up to 23 Asian *Fraxinus* species to choose from; they may not fulfil all of the same roles provided by the native ash. However, surely it is better to have ash in the environment, enabling the survival of at least a proportion of the other organisms dependent on ash, than to further deplete our tree stocks based on an ecological prejudice?

Apart from ash, selection and breeding programmes are urgently needed for other threatened European native tree species. Pines face a range of pests and pathogens currently not present in the UK, notably pine processionary moth (*Thaumetopoea pityocampa*) and *Fusarium circinatum* pitch canker (present in Spain and Portugal). Oak is threatened by two wilt pathogens: one, *Ceratocystis fagacearum*, long known in North America, the other, *Raphaelea quercivora,* killing native oaks in Japan, China and Korea. *Platanus* species, so abundant and important in towns and cities of the southern UK, are already being damaged by the emergent massaria decay (*Splanchnonema platani*); elsewhere in Europe, *Ceratocystis platani* is killing planted planes and has spread into the native range of *Platanus orientalis* in Greece, destroying whole ecosystems. Modern molecular techniques can be used to shorten the times required for resistance breeding: we should not now have to wait as long as 50–100 years, as with elm and sweet chestnut.

REFERENCES

Brasier, C.M. (2008) The biosecurity threat to the UK and global environment from international trade in plants. *Plant Pathol*. **57**, 792–808.

Brasier, C.M. and Webber, J. (2010) Sudden larch death. *Nature*, **466**, 824–825.

Gilligan, C.A., Fraser, R., Godfray, C., Hanley, N., Leather, S., Meagher, T., Mumford, J., Petts, J., Pigeon, N., Potter, C., Shaw, M.W., Unger, J.-G. and Woodward, S. (2013) *Final Report. Tree Health and Plant Biosecurity Expert Taskforce*. London: Department for the Environment, Food and Rural Affairs.

Kirisits, T., Matlakova, M., Mottinger-Kroupa, S., Cech, T.L. and Halmschlager, E. (2009) The current situation of ash dieback caused by *Chalara fraxinea* in Austria. In: *Proceedings of the Conference of IUFRO Working Party 7.02.02, Eğirdir, Turkey, 11–16 May 2009* (Doğmus-Lehtijärvi, T., ed.). *SDU Faculty of Forestry J., Ser. A*, Special Issue: 97–119.

Kowalski, T. and Holdenrieder, O. (2009) The teleomorph of *Chalara fraxinea*, the causal agent of ash dieback. *For. Pathol*. **39**, 304–308.

Pidgeon, N. and Barnett, J. (2013) *Chalara and the Social Amplification of Risk*. London: Department for Environment, Food and Rural Affairs.

Queloz, V., Grünig, C., Berndt, R., Kowalski, T., Sieber, T.N. and Holdenrieder, O. (2011) Cryptic speciation in *Hymenoscyphus pseudoalbidus*. *For. Pathol*. **41**, 133–142.

Thompson, H. (2012) The chestnut resurrection. *Nature*, **490**, 22–23.

Watt, M.S., Kriticos, D.J., Alcaraz, S., Brown, A.V. and Leriche, A. (2009) The hosts and potential geographic range of Dothistroma needle blight. *For. Ecol. Manage*. **257**, 1505–1519.

Zhao, Y., Hosoya, T., Baral, H., Hosaka, K. and Kakishima, M. (2012) *Hymenoscyphus pseudoalbidus*, the correct name for *Lambertella albida* reported from Japan. *Mycotaxon*, **122**, 25–41.