British Naturalists' Association
The National Body For Naturalists
Founded 1905

Plant Pathogens – a naturalist's perspective

Professor David Skydmore PhD, FLS, FRGS, FRSB, FBNA

This year is the International Year of Plant Health (2020), called by the United Nations. We know a lot more this year about our health and R numbers and hygiene than we did before. Well, the same applies to plant health as it does to human health. Plant diseases can become epidemics and insect pests can become major outbreaks. This year there have been huge swarms of locusts in East Africa putting local food supplies at risk. In the United Kingdom we have seen, close at hand, plant disease causing changes on a landscape scale. Ash die-back, caused by the Ascomycete fungus *Hymenoscyphus fraxineus*, has arrived from Asia, via Europe and the loss of leaves on our ash trees is obvious almost everywhere. The Oomycete water-mould *Phytophthora ramorum,* probably more related to seaweeds than fungi, causes dieback of larch and other species. We do not know its origin, but it has spread through Wales only recently, leaving, in its wake, areas of cleared, bare ground that used to be forests. We will also all have seen the browning of horse chestnut leaves early in the season because of the horse chestnut leaf miner moth (Figure 1) which was only confirmed as a new species in 1984 and was first recorded in the UK in 2014. In that short time it has become very widespread. So, the International Year of Plant Health has been given the strapline "Protecting Plants, Protecting Life" and declares that controlling pests and diseases can help reduce worldwide poverty and hunger, help protect the environment, and assist economic development.

Pests and disease are studied by entomologists and plant pathologists who have, of course, developed their own terminology. It may be helpful to explain some of this language. A pest is usually considered to be an animal that causes damage to plants e.g., insect, nematode. In contrast, pathogens are organisms that cause disease in plants e.g., fungi, watermoulds, bacteria, viruses, mycoplasmas. The disease itself is the collection of symptoms that is caused by a single pathogen, or a combination of them acting in the same plant. If you hear of a plant disorder, this describes a physiological problem e.g., frost damage, nutrient deficiency, water stress.

The disease is usually given a common descriptive name based on its symptoms and you can quickly become familiar with recognising the main groups of diseases when you are out in the field. For instance, rusts look like patches or pustules or orange or brown rust on leaves or stems. Powdery mildews coat the upper and lower surfaces of leaves with white and, if looked at under the microscope have delicate and intricate reproductive structures, cleistothecia. Anthracnoses are brown spots on leaves.

The pathogens feed on the plants in different ways. Biotrophs feed on living tissue e.g., *Puccinia lagenophorae,* a rust fungus that can be seen as bright, orange spore masses on the stems of Common Groundsel (*Senecio vulgaris).* They have specialised, nutrient absorbing structures, haustoria, that grow inside the plant cells and these pathogens are usually quite specific as to which host they can invade. Necrotrophs kill off the plant cells and then feed off the contents. They generally have a wider host range e.g., *Botrytis cinerea* with which we are familiar as the grey mould that covers and softens soft fruit such as strawberries. Saprotrophs, e.g., the oak polypore *Piptoporus quercinus*, only feed off tissue that is already dead and so are not strictly plant pathogens but rather decomposers, although some necrotrophs can also live as saprotrophs. Diseases are spread between plants via several mechanisms. Wind disperses the spores of the ash die-back pathogen over long distances. The swimming zoospores of the water moulds (yes, they do have flagella and can swim) move in rain splashes or in airborne water droplets, or through soil and irrigation water. Animal vectors, such as aphids and other sap-sucking insects, inadvertently take viruses from one plant and inject them into another whilst feeding.

Both pests and pathogens are originally part of natural ecosystems and have had long relationships with their host species. Viruses, possibly, evolved along with the first single cells. The relationships between hosts and diseases may be of complex, interlinked life cycles. We are seeing an example of this through the fascinating work on Acute Oak Decline being carried out with the involvement of Dr Sandra Denman, Forest Research and Bangor University, amongst others. This is showing that disease to be caused by the interaction of bacterial species, mediated by a beetle.

However, it is the epidemic level of pest and disease of which we are most aware (unless it is the loss of tomatoes in our back-garden!). Often, we see pests and pathogens as detrimental. These epidemics and outbreaks occur when the delicate

balance in the natural ecosystem is disrupted. Then the pests or pathogens multiply so quickly that they become a problem to crops and ecosystems, and need to be managed. This disruption can occur for several reasons. When there are monocultures of plants, which are uniform in their susceptibility, as in agriculture, the pests and pathogens have a huge food supply and can multiply dramatically. Or, if pests and pathogens arrive from other regions into an ecosystem that has not previously had to combat it, resistance may be low or absent in that population of hosts. We are seeing this type of invasion with ash dieback disease, or in the threat from the emerald ash borer (the beetle *Agrilus planipennis*) which could arrive on imported plant products. The same lack of resistance is a factor when climatic conditions change, making the environment more favourable to pest and disease spread. Climate change is expanding or shifting the geographical ranges in which many pests and pathogens can live and thrive. Global heating, with its alterations in temperature and rainfall, can increase the susceptibility of plants as they become stressed and physiologically unhealthy.

Figure 1. Browning of horse chestnut leaves early in the season by horse chestnut leaf miner moth
Photo: D. Skydmore

Figure 2. *Melamopsora* on Black Poplar *Populus nigra*
Photo: D. Skydmore

The International Year of Plant Health is promoting awareness, amongst farmers and consumers, about the ways in which the spread of pests and pathogens can be minimised. This is through the planting of resistant crops and varieties, and by being biosecurity conscious and not importing, or planting, infected material. The '*UK Plant Health Risk Register*' (DEFRA on line), lists more than a thousand pests and pathogens which are currently threats to crops and ecosystems in Great Britain and Northern Ireland.

We need to make sure that the environment is healthy enough to keep plants in good condition and able to resist infection. This will be done by maintaining soil health (which is so important for the well-being of the plant), improving pollinator health, protecting biodiversity and taking action to reduce climate change. As naturalists we have a major contribution to make in promoting and educating about the protection of the environment and the recognition of biodiversity.

Within natural ecosystems, where host and pest or pathogen co-evolve, their inter-relationships tend to be more balanced. The host can evolve to become resistant but then the pathogen changes to become virulent again. A step-for-step process. In these ecosystems, pathogens are an important control in the growth of plant populations. There is limited research on pathogens in natural ecosystems and we need to encourage more of it. Professor J.L.Harper (1977), was one of the first to call for this as he said that the dynamics of ecosystems could not be understood without appreciating the role of pathogens and animal predation on plants. For instance, the Janzen-Connell effect (which was first proposed for tropical forests) gives a theoretical account of the lower survival of seedlings when they grow near their parent tree (Gilbert GS. 2002). This theory suggests that, when seedlings are at a high density, growing around the plant from which the seeds have fallen, the pathogens and host-specific herbivores are able to spread readily between these hosts. So, infection rates are dependent on the host's population density. The infections then reduce the density of the host species. The hypothesis has been supported by much experimental evidence (Comita, LS *et al.* 2014). The conclusion of this is that herbivores and pathogens, by thinning dense populations, stabilise complex ecosystems allowing many species to grow, rather than single species being dominant. This, of course, depends on other environmental factors which in some circumstances will allow dominance of a few species. Another way in which pathogens can regulate the composition of plant populations is when resistant hosts are selected because the pathogen infects only the susceptible plants. The resistant phenotypes then dominate.

So, plant pathogens and 'pests' are an integral and valuable part of ecosystems. Indeed, some of them need our help through conservation. The wonderful Welsh Rust Fungi project, giving us the '*Rust Fungi Red Data List and Census Catalogue for Wales*' (Woods *et al.* 2015), shows the rarity of some native, rust pathogen species. It notes that, of the 225 taxa of rust fungi recorded in Wales, 3 are probably extinct and 39 are threatened with extinction. For example, the rust fungus *Puccinia bistorta* is critically endangered on the Common Bistort *Persicaria bistorta.* The pathogens may also be on rare plants e.g., *Melamopsora* on Black Poplar *Populus nigra* (Figure 2) Natural England has listed a range of fungi which are '*Species of Conservation Concern*' as part of its Biodiversity Action Plans (Ainsworth M. 2004).

If you already have an interest in fungi, have a go at adding plant pathogens to your list of species. Or, whilst you are identifying plants, see if you can also find some of those pathogens that are so important to our ecosystems.

References

Ainsworth M. 2004. BAP Fungi Handbook. English Nature Research Reports no. 600

Comita LS, Queenborough SA, Murphy SJ, Eck JL, Xu K, Krishnadas M, Beckman N & Zhu Y. 2014. Testing predictions of the Janzen– Connell hypothesis: a meta-analysis of experimental evidence for distance- and density dependent seed and seedling survival. Journal of Ecology 102: 845-856

Gilbert GS. 2002. Evolutionary ecology of plant diseases in natural ecosystems. *Annua. Review of Phytopathology.* 40:13–43

Harper JL. 1977. *Population Biology of Plants. London: Academic Press.* 892pp

Woods RG, Stringer RN, Evans DA & Chater AO. 2015. *Rust Fungus Red Data List and Census Catalogue for Wales.* Aberystwyth: A. O. Chater 84pp

UK Plant Health Risk Register.
https://secure.fera.defra.gov.uk/phiw/riskRegister

David Skydmore took his first degree in biology at the University of Manchester. He went on to take his PhD on *Phytophthora* in Bangor, North Wales. From there, he moved to the University of Cambridge to work on the fungal taxonomy of pathogens as a postdoctoral assistant to Professor D. S. Ingram in the School of Botany. He was then appointed to a lecturing position and a fellowship at Girton College. After a spell working in IT, he moved back to teaching botany and horticulture at the Welsh College of Horticulture, which later became Glydnwr University where he led the Department of Natural and Built Environment.
David is now an Emeritus Professor and a Director of the Lovell Quinta Arboretum in Cheshire.

This article has been adapted as a web article, from the original article published in Country-*Side* Winter 2020 issue.