CellPress

Quick guide

Ambrosia beetles

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What are ambrosia beetles? Ambrosia beetles (Figure 1) are members of two weevil subfamilies — Scolytinae and Platypodinae — which share a common ecological strategy: fungus farming. The term 'ambrosia beetle' does not refer to a taxonomic grouping but an ecological one. In fact, this ecology evolved independently around a dozen times within different bark beetle lineages. Unlike the ancestral bark beetles, ambrosia beetles carry around spores of symbiotic fungi in special invaginations of their exoskeletons. Once the beetle finds a suitable host — usually a freshly dead tree — it bores a tunnel into the wood. The fungi colonize the ambient wood and concentrate nutrients in enlarged conidia which serve as the only source of food for both the adult beetles and the developing larvae. Both partners benefit from the ambrosia symbiosis: the beetles get nutrition from the fungi and the fungi are transmitted by the beetles to suitable habitats.

Is there an advantage to feeding on fungi instead of plant tissues? As ambrosia beetles do not feed directly on host tissues, they can circumvent the plant's chemical defenses and colonize a wide variety of tree species. This considerably broadens their host range. Although they only consume their respective fungal symbionts, they are, in effect, polyphagous. A few species of ambrosia beetles are even known to steal from their neighbors — they acquire fungal spores from fungal gardens of different beetle species.

What do they look like? Ambrosia beetles are among the smallest weevils, with most species below 5 mm. Their cylindrical bodies are adapted for boring into wood and navigating inside tunnels. Given the small size, uniform body shape and drab coloration they can be difficult to detect and identify by eye, but a microscope unveils the fantastic morphology of the front end, rear end and microsculpturing of different species.

If these beetles are so tiny and inconspicuous, what's all the fuss about? The great majority of ambrosia beetles are important members of the wood-associated ecosystem, often being the most abundant insect on dead trees. Unfortunately, several invasive species became pests in forests, tree nurseries, plantations, orchards and timber storage throughout the world. In recent years, the number

Figure 1. Ambrosia beetles.
Left: Lateral and dorsal views of several ambrosia beetle species of the genus *Xylosandrus*. From top: *Xylosandrus amputatus*, *X. compactus*, *X. crassiusculus*, *X. curtulus* and *X. germanus*. Scale bar: 1.0 mm. (Photo from Gomez *et al.* (2018); CC BY 4.0.) Top right: Various species of ambrosia beetles captured in an ethanol-baited trap and prepared for identification (photo: Marek Dzurenko). Bottom right: Tunnels in wood with larvae of the black stem borer (*Xylosandrus germanus*) (photo: Juraj Galko, used with permission).

of newly reported invasive ambrosia beetle species has grown considerably. One case — the redbay ambrosia beetle *Xyleborus glabratus* — vectors a fungal symbiont that is lethal to the tree hosts: the New World members of the laurel family. Their invasion resulted in the death of hundreds of millions of bay trees (*Persea* spp.) and economic losses for Florida's avocado industry and continued spread poses a grave danger to Central and South American Lauraceae.

The redbay ambrosia beetle seems like a serious invasive pest. Are there more like it? No other ambrosia fungus acts as a systemic tree pathogen. But many invasive ambrosia beetles attack stressed trees. Their damage is becoming prominent in contemporary nurseries, orchards and ecosystems, where tree stress is a common condition. The most successful invasive ambrosia beetles belong to the tribe Xyleborini. For instance, two closely related species, also from East Asia, the black stem borer (*Xylosandrus germanus*) and the granulate ambrosia beetle (*Xylosandrus crassiusculus*), are major pests in US orchards and tree nurseries.

What is the secret of the success of Xyleborini? Hypotheses range from their small size, cryptic lifestyle, and symbiosis with fungi, but those are features of all ambrosia beetles, most of which are not invasive. What distinguishes members of Xyleborini is a combination of the fungus farming, which provides them with wide host range, and their unusual reproductive biology. The males are smaller, flightless and only possess one set of chromosomes (they are haploid), unlike the females, which are diploid. Males leave the tunnels infrequently, and only after they have mated with their sisters. Inbreeding (sibling-mating) is the norm.

Wait, sibling-mating — is that what I think it is? Indeed, all Xyleborini males normally mate with their brood sisters. In most animals, the mating of closely related partners generally causes inbreeding depression, resulting in reduced offspring fitness. But the combination of inbreeding with haploidy in males purges harmful mutations right away, so the larger population does not suffer. As a result, a single female can establish an entire population all by herself without any negative effects on her progeny's fitness. This is one of the main reasons why Xyleborini are so efficient at invading novel areas.

What can be done about this problem? Biological invasions are one of the greatest threats to biodiversity worldwide. Our global civilization with its vast international trade and travel provides more and more pathways for invasive species. Thanks to their small size and cryptic habits, ambrosia beetles are often accidentally transported and introduced to non-native regions through shipments of wood products and packaging materials. It is therefore extremely important to abide by the international phytosanitary regulations. Prevention is key, because a newly established non-native ambrosia beetle is virtually impossible to eradicate. After a sizeable population is established within a larger area, usually the only course of action left is monitoring and damage control. When it comes to mitigating ecological and economic damage, numerous strategies involving tree stress prevention, disposal of infested trees or timber, chemical and biological control, and resistance breeding have been, and are still being, developed. As for monitoring, volatiles such as ethanol or quercivorol are attractive to multiple ambrosia beetle species.

Are you saying these beetles like alcohol? Yes. Ethanol is emitted by stressed, dying and dead trees which serve as hosts for ambrosia beetles. Thus, for some species that are specialized on stressed trees, ethanol represents the primary olfactory cue indicating the presence of suitable host trees. This makes the scent of ethanol irresistible for the beetles. Many have experienced ambrosia beetles landing on their hand while they were holding a drink. But ethanol is not a universal attractant: some ambrosia beetles do not respond to it or are even repelled.

What can we do to prevent damage? Keep your trees healthy. If you're growing trees, make sure that they are not weakened by drought, flooding (including overzealous irrigation) or frost damage in young age, all of which trigger ethanol emission. Finding out whether your trees or timber have already been colonized is relatively straightforward. Look for tiny holes on the trees' surface. These are circular shaped entry holes about 1 to 2 millimeters wide through which the beetles bore into their hosts. While boring into the wood, the beetles extrude long and thin 'noodles' of fine sawdust, which are clearly visible. Baited traps, bolts, logs and trees treated with ethanol can be used to monitor and capture large numbers of beetles. Attractant and repellent chemicals can be combined to create push-pull strategies, with repellents driving beetles away from the hosts toward traps baited with attractants. Insecticide-treated protective netting has also proven to be an effective way to protect trees and timber, although admittedly it has a major negative effect on local fauna. The most important recommendation is to manage the trees for good health, rather than focusing too much on the beetles.

Where can I find out more?

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