The hidden life of *Cerrena unicolor*

By Sue Lancelle

Cerrena unicolor is a rather unassuming polypore that you can easily pass by, but there is a lot more to it than initially meets the eye. The common name of *C. unicolor* is "mossy maze polypore" because the caps often turn greenish with age (Fig. 1). However, the green comes from an algae and not a moss. It looks "mossy" because the caps are densely velvety to downright furry looking (figure above). Caps are 2-10 cm wide, with concentric hairy zones of various shades of brown when not overtaken by algae (Fig. 2).

Figure 1. *Cerrena unicolor*, the "mossy maze polypore," often looks green with age because of algae that grown on the cap.

The pores on the underside of the cap form a maze-like structure on younger caps (Figs. 2,3) and can elongate into tooth-like structures on older caps. It is widely distributed throughout Europe, Asia and the Americas.

C. unicolor is a white rot fungus that grows on various species of hardwood trees and can initially be a parasite on living trees, later becoming a saprophyte as the trees die. White rot fungi are able to digest all

Figure 2. Caps of *C. unicolor*, showing the maze-like structure of the spore forming tissue on the lower surface and the concentric rings in shades of brown on the upper surface of the caps.

of the cell wall components of wood, leaving behind whitish-looking rotting wood (as opposed to brown rotters, which cannot digest lignin) (Blanchette 2019). The ability to digest all of these components in various

Figure 3. The maze-like structure of the spore forming tissue on the underside of the cap of *C. unicolor.*

species of wood requires many different enzymes and metabolic pathways, and indeed, *C. unicolor* is being investigated as a possible source of economically important industrial enzymes (reviewed in Pawlik *et al.* 2019). In addition, in studies with cultured mammalian cells, various compounds produced by *C. unicolor* show promise as antiviral, anticancer and immune system modification drugs (Mizerska-Dudka *et al*. 2015, Matuszewska *et al*. 2016).

The story of *C. unicolor* becomes even more interesting when you consider its involvement in a fascinating mutualistic association with an insect in the family Siricidae, or "wood wasps." Wood wasps are large, nonstinging wood boring insects. Members of several genera of wood wasps in the subfamily Siricinae attack conifer wood, while species in the subfamily Tremicinae almost exclusively attack hardwoods (Gilbertson 1984). The eggs of wood wasps are coated with specialized fungal spores (arthrospores) so that as the female deposits the eggs in the wood, she also introduces the fungus. The fungus benefits from this relationship because the wood wasp disperses it to new sites that it would otherwise have difficulty colonizing, while the developing insect larvae have a ready-made food source in the form of proliferating fungal hyphae and perhaps partially digested wood.

Buchner (1928, in Francke-Grosmann 1939) first described specialized organs containing hyphal fragments (the arthrospores) in adult female wood wasps. These organs are now called "mycangia" and they occur in most species of wood wasps. Francke-Grosmann (1939) showed that wood wasp eggs deposited in wood have fungal arthrospores stuck to them. Once deposited in the wood, the fungi immediately start proliferating and breaking down wood components, providing a food source for the developing larvae once the eggs have hatched. Francke-Grossman (1939) showed that extracts from wood wasp intestines readily digest fungal hyphae. But it is not clear that this is the only source of larval nutrition. The larvae bore through the rotting wood, leaving behind undigested fragments. Martin and coworkers (reviewed in Martin 1992) have shown that ingested fungal enzymes can remain active in the gut of wood boring insects and these may contribute to the digestion of wood components, since insects do not produce the necessary enzymes on their own. Thus it is likely that wood wasp larvae are able to digest fungal hyphae as well as at least some components of the wood, especially cellulose, utilizing enzymes from the ingested fungus.

The wood wasp larvae are completely dependent on the presence of the fungus for development; in the absence of the fungus, the wood wasp eggs hatch, but the larvae do not complete development (Stillwell 1967). During normal development in the presence of the fungus, female wood wasp mycangia become reinoculated with the fungal hyphae (references in Gilbertson 1984).

The polypore *C. unicolor* attacks hardwoods, and thus its wood wasp symbiont is in the Tremicinae. In our geographical area, the species is *Tremex columba*, the "pigeon tremex" or "pigeon horntail" (Fig. 4). Stillwell (1964) first established that the fungus carried

Figure 4. *Tremex columba*, the "pigeon tremex" or "pigeon horntail," the symbiont of *C. unicolor*. Note the impressive ovipositor and shorter "horn" emerging from the abdomen.

by *Tremex columba* is *C. unicolor*, but other species of *Tremex* in other parts of the world also associate with the same fungus (Kuramitsu *et al*. 2019, Pažoutova and Šrůtka 2007, Tabata and Abe 1995).

The pigeon horntail is fierce looking but harmless to us (Fig. 4). They are rather large, up to several cm long, and the females have two distinctive abdominal appendages; a "horn" at the tip of the abdomen and a longer ovipositor for drilling into wood and laying eggs. In their native range, wood wasps generally attack wood that has already been weakened by other forces (Gilbertson 1984), but when introduced into exotic areas, they can become destructive pests (Schiff *et al*. 2006). Native wood wasps have natural enemies that keep them under control, and this is where our *C. unicolor* story takes another turn: it appears that the fungus itself may attract the natural predators of the wood wasps!

The predator of the pigeon horntail is an even larger, fiercer looking wasp, the giant ichneumonid wasp, actually several species of the genus *Megarhyssa*

Figure 5. The giant ichneumonid wasp, *Megarhyssa atrata*. Note the very long ovipositor stuck into the wood.

(Fig. 5). The most striking thing about these wasps is their very long ovipositor, up to several inches long. And while the ovipositor looks like a "stinger," these wasps do not sting and are harmless to humans.

Giant ichneumonids are parasitoids, that is, their larvae feed on the larvae or pupae of other insects. In our area there are at least three species of *Megarhyssa*, and they all parasitize only the pigeon horntail, drilling into the wood with their long ovipositors and depositing eggs into or near the larvae of their prey. How do they find these larvae, deeply embedded in the wood? The mechanism hasn't been clearly established for *Megarrhysa*, but in a study of another parasitic wasp in the genus *Ibalia* (Kuramitsu *et al*. 2019), researchers found that the parasitoid is attracted to volatile compounds produced by *Cerrena unicolor*. Other studies suggest that *Megarrhysa* can detect subtle vibrations or sounds emanating from the movement of the larvae in the wood (Heatwole *et al*. 1964). Perhaps the giant ichneumonids are initially attracted to volatiles produced by the fungus *C. unicolor*, and then can more precisely pinpoint the location of their prey larvae using sound or vibration detection. In any case, this natural enemy of the pigeon horntail keeps the population of this native wood borer in check.

While you are out hunting for fungi, keep your eyes open not only for the "mossy maze polypore," *C. unicolor,* but also for the impressive wasps that are associated with it. You can find the wasps most easily while they have their ovipositors drilled into wood. They are a wonderful reminder that when it comes to fungi, there is almost always a fascinating story going on "behind the scenes!"

References

Blanchette RA. 2019. Wood decay: the action behind the polypores. Fungi 11(4):10-19.

Buchner P. 1928. *Holznahrung und Symbiose*. Springer Verlag, Berlin.

Francke-Grosmann H. 1939 On the symbiosis of woodwasps (Siricinae) with fungi. (Translated from the original German by David Rutland, January 2008). Originally published in 1939 in *Zeitschrift für Angewandte Entomologie* 25: 647-679.

Gilbertson, RL. 1984. Symbiosis of wood wasps and wood-rotting fungi. In: Fungus-insect relationships, Wheeler Q and Blackwell M, eds. Columbia University Press, New York. pp. 130-165.

Heatwole H, Davis DM, Wenner AM. 1964. Detection of mates and hosts by parasitic insects of the genus *Megarhyssa* (Hymenoptera: Ichneumonidae). Am. Mid. Nat. 71: 374-381.

Kuramitsu K, Ishihara T, Sugita A, Yooboon T, Lustig B, Matsumori Y, Yamada H, Kinoshita N. 2019. The attraction of *Tremex apicalis* (Hymenoptera, Siricidae, Tremecinae) and its parasitoid *Ibalia japonica* (Hymenoptera, Ibaliidae) to the fungus *Cerrena unicolor*. J. Hymenoptera Res. 68:37-48.

Martin MM, 1992. The evolution of insect-fungus associations: from contact to stable symbiosis. Amer. Zool. 32:593-605.

Matuszewska A, Karp M, Jaszek M, Janusz G, Osińska-Jaroszuk M, Sulej J, *et al*. 2016. Laccase purified from *Cerrena unicolor* exerts antitumor activity against leukemic cells. Oncol Lett. 11: 2009–2018.

Mizerska-Dudka M, Jaszek M, Blachowicz A, Rejczak TP, Matuszewska A, Osinska-Jaroszuk M, *et al*. 2015. Fungus *Cerrena unicolor* as an effective source of new antiviral, immunomodulatory, and anticancer compounds. Int J Biol Macromol. 79: 459-468.

Pawlik A, Ruminowicz-Stefaniuk M, Frąc M, Mazur A, Wielbo J, Janusz G. 2019. The wood decay fungus *Cerrena unicolor* adjusts its metabolism to grow on various types of wood and light conditions. PLOS ONE 14(2): e0211744. https://doi.org/10.1371/journal.pone.0211744

Pažoutová S, Šrůtka P. 2007. Symbiotic relationship between *Cerrena unicolor* and the horntail *Tremex fuscicornis* recorded in the Czech Republic. Czech Mycol. 59: 83–90.

Schiff NM, Valley SA, LaBonte JR, Smith DR. 2006. Guide to siricid woodwasps of North America. USDA Forest Service.

Stillwell, MA. 1964. The fungus associated with woodwasps occurring in beech in New Brunswick. Can. J. Bot. 42:495-496.

Stillwell M. 1967. The pigeon tremex, *Tremex columba* (Hymenoptera: Siricidae), in New Brunswick. Can. Entom. 99: 685-689. doi:10.4039/Ent99685-7

Tabata M and Abe Y. 1995. *Cerrena unicolor* isolated from the mycangia of a horntail, *Tremex longicollis*, in Kochi Prefecture, Japan. Mycoscience 36: 447-450.