

Short communication

The Relationship Between the Ash Bolete (*Boletinellus merulioides*) and an Aphid Parasitic on Ash Tree Roots

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Abstract

A new and apparently mutualistic association between the ash-tree bolete mushroom *Boletinellus merulioides* and an aphid parasitic on ash roots has been discovered. When feeding on roots, the aphid (*Meliarhizophagus frazinifolii*), a specific parasite of ash leaves and roots, is enclosed by hollow storage structures (sclerotia) of the fungus. We suggest that in exchange for housing the aphid, the fungus receives nutrients excreted by the aphid in its honeydew. This relationship could explain the specific occurrence of *Boletinellus* under ash trees. An older hypothesis, that *B. merulioides* is an ectomycorrhizal symbiont of ash trees, should now be rejected.

Keywords: *Boletinellus merulioides*, bolete, aphid, ash, mutualism, VAM, *Meliarhizophagus frazinifolii*

The ash-tree bolete, *Boletinellus merulioides* (Schweinitz) Murrill, is usually found fruiting under ash trees (*Fraxinus* spp.) in eastern North America (Singer, 1945; Snell and Dick, 1970; Cotter and Miller, 1985), resulting in the assumption that an ectomycorrhizal association occurs between these organisms (Singer, 1945; Trappe, 1962). Yet recent anatomical and physiological studies have established that *Fraxinus* is exclusively endomycorrhizal (Pope and Holt, 1981; Furlan et al., 1983; Ponder, 1984; Brundrett and Kendrick, 1988). Cotter and Bills (1985) found that *B. merulioides* produces characteristic hollow, black sclerotia, whose distribution in the soil

is highly correlated with the presence of *Fraxinus* roots and above-ground fructifications of *Boletinellus* (Cotter and Bills, 1985). These characteristic sclerotia were common in the soil near *B. meruloides* basidiomata throughout its geographical range. The ecology of this fungus has largely remained uninvestigated, although Cotter and Miller (1985) reported that it would not form either parasitic or mycorrhizal associations with ash trees under experimental conditions.

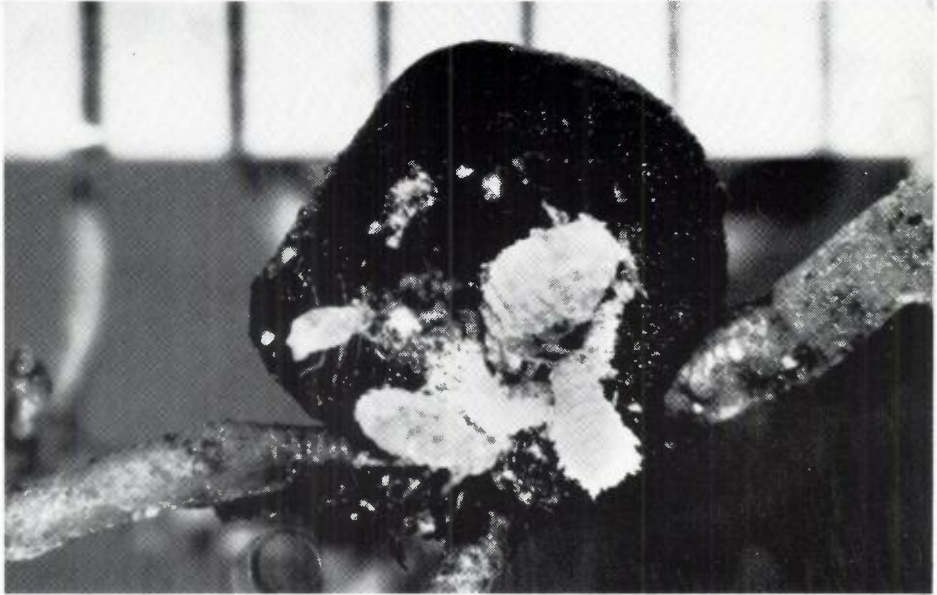


Figure 1. *Boletinellus meruloides* sclerotia attached to an ash root, sectioned to show aphids inside. Scale divisions in background are 1 mm apart.

During the course of a field study (Brundrett and Kendrick, 1988), numerous white ash (*Fraxinus americana* L.) root samples were examined in detail and all were found to contain endomycorrhizae of the vesicular-arbuscular type. However, basidiomata and characteristic sclerotia (Cotter and Miller, 1985) of *B. meruloides* were produced abundantly near ash trees at the study site. These hollow black sclerotia, 1–5 mm in diameter, were found partially enclosing ash roots, as well as in the surrounding soil. Hollow sclerotia attached to ash roots were found to contain several aphids covered in white wax (Fig. 1). The enclosed aphid was *Meliarhizophagus fraxinifolii*

(Riley) (Homoptera: = *Prociphilus frazinifolii*). This aphid occurs only on *Fraxinus*, where it causes curling of the leaves, but also migrates to the roots (Smith, 1974), although its life-cycle has not been investigated in detail. In the present study, this aphid has been found feeding on ash roots from mid-summer until late fall, typically while enclosed in *Boletinellus* sclerotia. Ash tree roots in early stages of secondary growth are most often involved. Ash root aphids were occasionally found without sclerotial protection, or surrounded by wefts of hyphae which probably represented early stages in sclerotium formation. Mycelial strands were observed attached to sclerotia in mid-summer, at which time basidiomata of the fungus formed, the first aphids were observed in the soil, and ash tree root growth began.

The thick, highly melanized walls of *Boletinellus* sclerotia clearly provide some protection to feeding aphids. The complete enclosure of honeydew secreting aphids suggests that the fungus in turn receives nutrition from honeydew. Aphid honeydew contains simple sugars as well as smaller amounts of other nutrients including amino acids and minerals (Way, 1963), possibly in sufficient quantities to satisfy the nutritional requirements of the fungus. This unusual form of nutrition may explain why *B. meruloides* has the energy to fruit more abundantly than most other agarics of deciduous forests.

A similar relationship involving the aphid, *Mimeuria ulmiphila* Del Guercio, feeding on the roots of a European elm tree (*Ulmus carpinifolia* Gleditsch) has been reported (Krzywiec, 1962). In this latter association, identification of the fungus was difficult and it is probable that hyphae from several common saprophytic fungi combine to enclose the aphids and exploit their honeydew (Krzywiec, 1962). Other similar mutualistic fungus-insect interactions include scale insects that are enclosed by members of the Septobasidiales (Couch, 1938), and insect galls of *Solidago* which are comprised partly of fungi that have been found to confer increased protection from parasites (Weiss, 1982). These interactions are functionally similar to the more common association of ants with aphids, in that food is being provided by the aphid in exchange for other services (Cutright, 1925; Way, 1963).

The specific occurrence of *Boletinellus meruloides* under ash trees may be explained by its apparent dependence on *M. frazinifolii*, which occurs only on ash. This proposed mutualistic association provides an explanation for the success of *B. meruloides*. However, the possibility that either partner can exist separately has not been ruled out. We do not yet know how widespread this association is, although the fungal partner has been reported wherever

ash trees occur in mixed deciduous and deciduous-coniferous forests in eastern North America (Singer, 1945; Snell and Dick, 1970). The range of both the aphid, *Meliarhizophagus frazinifolii*, (Smith, 1974) and its host trees, *Frazinus* spp., (Brockman, 1986) is larger than the range of *B. merulioides*. If the *Boletinellus*-aphid association is common in eastern North America the energy drain they jointly impose on *Frazinus* may be a significant factor limiting the production of these important tree species. Field observations from other parts of North America are required to determine the extent of this association. *Boletinellus merulioides* should be removed from lists of ectomycorrhizal symbionts since we know that *Frazinus* does not form this type of association.

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REFERENCES

- Brockman, C.F. 1968. *Trees of North America*. Golden Press, New York.
- Brundrett, M.C. and Kendrick, B. 1988. The mycorrhizal status, root anatomy and phenology of plants in a sugar maple forest. *Can. J. Bot.* **66**: (in press).
- Cotter, H.V.T. and Bills, G.F. 1985. Comparison of spatial patterns of sexual and vegetative states of *Boletinellus merulioides*. *Trans. Br. Mycol. Soc.* **85**: 520-524.
- Cotter, H.V.T. and Miller, O.K. 1985. Sclerotia of *Boletinellus merulioides* in nature. *Mycologia* **77**: 927-931.
- Couch, J.N. 1938. *The Genus Septobasidium*. University of North Carolina Press, Chapel Hill.
- Cutright, C.B. 1925. Subterranean aphids of Ohio. *Bull. Ohio Agric. Expt. Stn.* **387**: 173-240.
- Furlan, V., Fortin, J.A., and Plenchette, C. 1983. Effects of different vesicular-arbuscular mycorrhizal fungi on growth of *Frazinus americana*. *Can. J. For. Res.* **13**: 589-593.

- Krzywiec, D. 1962. Morphology and biology of *Mimeuria ulmiphila* (Del Guercio) (Homoptera, Aphidae), part II, *Bull. Soc. Amis. Sci. Lettr. Poznan (D)* **3**: 63-97.
- Ponder, F. Jr. 1984. Growth and mycorrhizal development of potted white ash and black walnut fertilized by two methods. *Can. J. Bot.* **62**: 509-512.
- Pope, P.E. and Holt, H.A. 1981. Paraquat influences development and efficiency of the mycorrhizal fungus *Glomus fasciculatus*. *Can. J. Bot.* **59**: 518-521.
- Singer, R. 1954. The Boletaceae of Florida with notes on extralimital species. II. The Boletaceae (Gyroporoideae). *Fartlowia* **2**: 223-303.
- Smith, C.F. 1974. Keys to and descriptions of the genera of Pemphigini in North America (Homoptera: Aphidae: Pemphiginae). *Tech. Bull. N.C. Agric. Expt. Stn.* No. 226.
- Snell, W.H. and Dick, E.A. 1970. *The Boleti of Northeastern North America*. Cramer, Lehre.
- Trappe, J.M. 1962. The fungus associates of ectotrophic mycorrhizae. *Bot. Rev.* **28**: 538-606.
- Way, M.H. 1963. Mutualism between ants and honeydew-producing homoptera. *Ann. Rev. Ent.* **8**: 307-344.
- Weis, A.E. 1982. Use of a symbiotic fungus by the gall maker *Asteromyia carbonifera* to inhibit attack by the parasitoid *Torymus capite*. *Ecology* **63**: 1602-1605.