Bridgewater Review

Volume 4 | Issue 1

Article 15

Apr-1986

# Research Note: Do Mushrooms Have a Sex Life?

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# Do Mushrooms Have A Sex Life?

*Figure 1.* **Cluster of *Armillaria mellea***

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When people learn of our research on mushrooms, they usually assume that we cook our subjects after we have dissected them. In fact, the honey mushroom, the particular variety we study, is highly edible, and each fall, during the brief period when the familiar mushrooms appear, collectors harvest baskets of the prized fungi from stumps or from the bases of old trees. Nevertheless, the only mushrooms we have eaten have been supplied by grocery stores or restaurants. Having studied the honey mushroom for over twelve years, we feel that it would be a little like eating an old friend.

Species of the honey mushroom (*Armillaria mellea* spp.) live throughout temperate regions of the world. Their name reflects the fact that many are honey colored. However, the group as a whole ranges in color from bright yellow to dull brown, usually having minute scaly outgrowths on the cap and when young, a collar around the stalk.

Reportedly good to eat, the honey mushrooms are also "eaters" themselves and do a great deal of damage in the process. In fact, horticulturists and forest pathologists on six continents are very much interested in this mushroom because of its devastating effects on crops and both commercially managed and natural forests. Clumps of these mushrooms are often seen in the eastern United States at the bases of dead or dying trees and tree stumps. Severe infestations occur west of the Rocky Mountains, especially in California, where they cause root rot of fruit and nut crops, ornamental trees and shrubs. To date, over 600 species of plants have been reported to be susceptible to attack by this fungus. In addition to parasitic attacks on living plants and saprophytic growth on dead or dying trees, the honey mushroom is sometimes involved in mutually beneficial relationships with several species of trees and with at least two species of orchids. Honey mushrooms, therefore, show a diversity not only in appearance but also in their nutritional relationships with plants.

*Figure 2. Armillaria mellea*

When studying the life cycles of mushrooms, it becomes apparent that, in general, the mushroom's reproductive cycle is surprisingly similar to our own. Like human beings, mushrooms reproduce sexually: they form sex cells which, like the human sperm and egg cells, have half the number of chromosomes found in other body cells and are therefore referred to as "haploid." These sex cells eventually fuse to produce somatic cells (cells other than reproductive cells) with double the number of chromosomes and are called "diploid." The idea that such simple organisms as mushrooms have the same kind of reproductive process as human beings seems quite remarkable.

Although mushrooms definitely do have a sex life, not all of the details of that sex life are understood in all species. (Mushrooms are notably secretive about these matters.) We were interested in studying the honey mushroom in particular to learn exactly how and when certain cells become haploid and others become diploid (*fig. 3*). We know that the honey mushroom produces four kinds of spores (sex cells) which appear under its cap in fall. These spores drop to the ground and germinate; compatible pairs of germinated spores mate and form cells containing the diploid number of chromosomes (cell type A). This part of the sexual cycle has been duplicated in the laboratory. Since compatible matings generally result in the formation of a mushroom, we then wanted to find the exact location within the mushroom of diploid cells and the specific manner in which the diploid cells give rise to haploid cells, such as those found in cell type B (*fig. 3*).

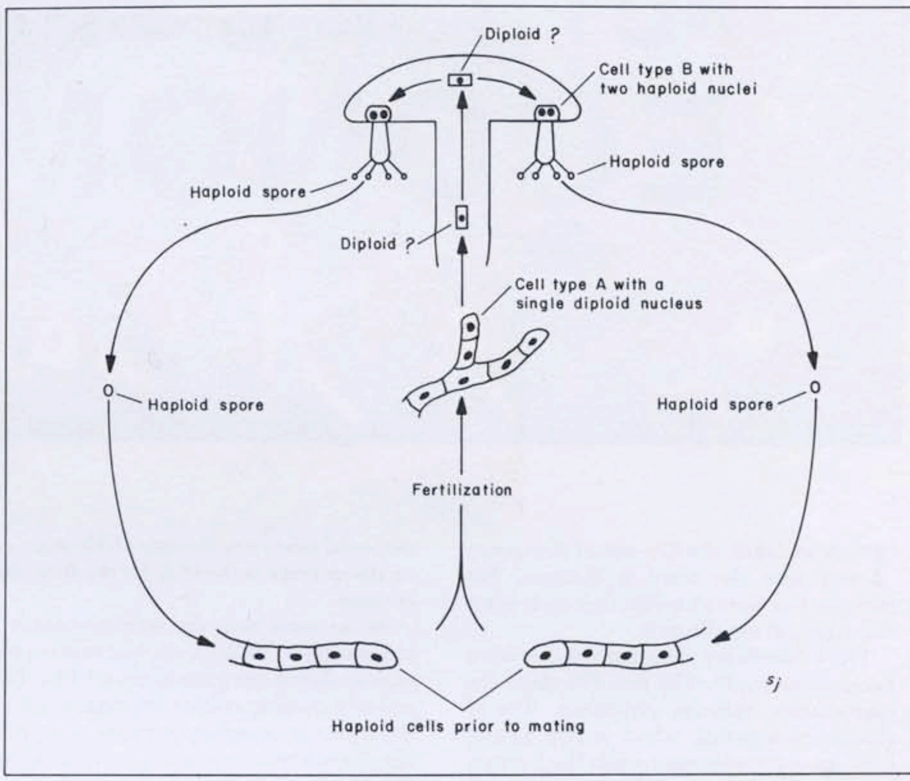


**Figure 3. Life cycle of *Armillaria mellea***

In order to do this, we carefully removed tissues from specific parts of freshly collected honey mushrooms. We used a DNA-specific stain to find out whether the cells were haploid or diploid. (DNA is the hereditary material of which genes are primarily composed.) The DNA-specific stain attaches only to the DNA and causes DNA to fluoresce when it is illuminated through a microscope with particular wavelengths of light. The amount of light emitted by the fluorescing DNA is proportional to the amount of DNA present and can be quantified by a photometer attached to a microscope. A haploid cell, for example, emits only half the light that a diploid cell emits when subjected to excitation wavelengths of light.

Material for study was readily available in the fall, as we have at that time a cluster of honey mushrooms in our backyard in Bridgewater. This is very convenient, as it made the collection of fresh samples at just the right stage of development a simple matter. As we began to quantify the DNA content of cells in close proximity to cell type B, we were surprised to find that every cell was haploid. Thinking that the source of diploid cells must be farther from cell type B than we had thought at first, we sampled cells from the cap and stalk of individual mushrooms. To our surprise, we were still unable to find diploid cells. Our current thinking is that diploid cells of "type A" must occur in one of the earlier stages of the life cycle which is completed below ground prior to formation of the familiar "mushroom" stage above ground. We have collected samples of various subterranean tissues of honey mushrooms and are continuing to look for the diploid "type A" cells.

The haploid condition of cells in the honey mushrooms was unexpected based on previous mycologists' (scientists who study fungi) reports. In order to determine whether our Bridgewater honey mushroom was an aberrant form or whether honey mushrooms are composed of haploid cells in general, we wrote to mycologists in the northeastern United States and requested samples for study. We even enlisted the help of family members living in Worcester. Thirteen mycologists responded, including seven from New York, Pennsylvania, and Massachusetts whose samples were fresh enough to study using our technique. Again we found that all samples have mushrooms composed primarily of haploid cells. It now appears that what looked like an unusual condition in our isolated form of the honey mushroom is the general rule in this group of fungi rather than the exception.

Although our finding is of interest primarily to a rather restricted group of biologists, the classical mycologists, it has an implication which is of interest to a much broader group. Based on what is known about the process of haploidization (diploid cells becoming haploid) in other organisms, the presence of haploid cells in the stalk and cap of a mushroom suggests that a genetic mosaic may exist in these organisms. That is to say that cells with different combinations of somatic chromosomes and genes may exist, side by side, within the body of individual mushrooms. This varies considerably from the situation in humans and most other diploid organisms where somatic cells have the same chromosomes. We are attempting to test the genetic mosaic hypothesis by recovering individual cells from the stalk region of individual mushrooms and testing them for among-cell genetic variation. If it turns out that honey mushrooms are genetic mosaics of several different cell types, this information may be useful in understanding their broad range of colors and host nutritional relationships. This, in turn, may provide insight into determining a control for this devastating plant pathogen.

Although the fact that honey mushrooms do have a sex life has long been known, many details of that sex life still remain mysterious.

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