Weird and wonderful fungi

Elio Schaechter

Fungal spores are produced in prodigious numbers. Elio Schaechter describes some unusual mechanisms for their dispersal.

I happen to believe that all fungi are surprising and intriguing, and that many have stories to tell. From this extensive repertoire I have chosen a few examples to illustrate a particular point, how fungi appropriate or modify the structures and functions of their hosts to enhance spore dispersal.

If there is a theme that pervades the world of the fungi, it is an intense preoccupation with the widespread distribution of their spores. Fungi make prodigious numbers of spores and scatter them over large areas. A middle-sized mushroom, say one with a cap 10 cm across, may make as many as 100 million spores per hour. Giant puffballs may produce 20 trillion spores (a figure so large that laymen may grasp it only by comparison to the national debt of industrialized countries). Making so many spores is an example of conspicuous production. In this realm, lavishness is necessary: rare is the spore that germinates into successful fungal growth and helps the species spread in the environment. Such wastefulness, however, is not unlike the production of millions of unsuccessful sperm cells by the human male.

Not only are spores made prolifically, they are also dispersed in the environment by an impressive array of strategies. Frequently, spores are scattered about by mechanically intricate mechanisms. Thus, in the mushrooms, spores are forcefully discharged from the hymenial surface of a fruiting body. Being light, such spores are readily wafted aloft by breezes to be deposited at distant sites. This, however, is not good enough for certain fungi. For even more efficient dissemination, some species have developed cunning ways that involve modifying the behaviour or structure of their plant or animal hosts. As is often the case in biology, some of the most intriguing phenomena in this field involve the interaction between hosts and parasites.

Fooling the pollinators

For tweaking the host into making a new and elaborate structure, the prize goes to a rust fungus, *Puccinia monoica*. This species infects wild plants of the mustard family (*Arabis* and others) and induces them to develop dense clusters of leaves at the tips of stems. These rosettes of leaves look like the petals of a real flower, all the more so because they become covered with fungal growth. The surface becomes sticky and sweet smelling. These pseudoflowers, as they are called, are of a beautiful yellow colour, different from that of the normal flowers of this plant but similar to those of other plants that grow in the same area. Insects arrive, with pollen on their agenda, and poke around the pseudoflower, collecting fungal spores instead of the desired pollen. And off they go, spreading spores to other plants. As seen in the photograph (Fig. 1), the impersonation is nearly faultless. The discoverer, Dr Barbara Roy of the Swiss Federal Institute of Technology, writes,

'*The floral mimicry fools humans as well as insects: botany students at the Rocky Mountain Biological Laboratory have frequently collected pseudoflowers thinking they were flowers and, at a distance, many professional botanists have mistaken them for true flowers*'.

The urge to climb

Many ants that normally live on the forest floor drastically change their behaviour when infected by fungi. The kinds of fungi involved (often ascomycetes of the genus *Cordyceps*) do not develop rapidly, at least for some time. Because of this moderation, the infected ants stay alive and remain active, but alter their deportment: they acquire an urge to climb up the stalks of vegetation and trees. When reaching a certain height, they impale themselves with their mandibles and remain perched aloft for the rest of their life and thereafter. Such behaviour is seen in a number of other insect groups as well: infected grasshoppers, locusts, aphids and flies also exhibit this 'summit disease'. The fungi then grow and develop fruiting bodies replete with spores which can now be dispersed from on high, possibly to be carried over great distances (Fig. 2).

When the reason for the ants' urge to climb is sought, the answer depends on one's tolerance for teleology. '*Because it's there*' won't do, but claiming that the fungus makes the insect climb for its own benefit is also seen with suspicion by some researchers. Clearly, remaining on the forest duff decreases the chances for aerial spore dispersal. However, getting off the forest floor means that infected insects are exposed to sunlight, therefore warming up to temperatures deleterious to the fungi. In the words of the entomologist R.A. Humber,

'*this is a behavior quite analogous to your heading for a warm bed and constant supply of chicken soup when feeling sick*'.

In addition, the infected insect may climb for altruistic reasons, namely to avoid infecting other members of its

TOP:
Fig. 1. Pseudoflower caused by a rust fungus, *Puccinia monoica*, being visited by a *Polygonia* butterfly.
PHOTO B. A. ROY, REPRINTED WITH PERMISSION FROM *NATURE* 362, 56–58

FAR RIGHT:
Fig. 2. *Cordyceps curculionum* fruiting bodies arising from a weevil.
PHOTO JAMES BEACH

colony. This is suggested by the different behaviour of certain other insects when infected by fungi. Infected larvae of butterflies and moths do the opposite from the ants: they crawl into inaccessible spaces such as crevices or beneath tree bark, as if to get away from their kin. The fungus involved must develop a long stalk to make its fruiting body effective. Whatever the reason, the interplay of signals between the fungus and the insects seems extraordinary. Is there a mechanism that keeps the fungus from growing until the insect reaches a certain distance above the ground? What makes the insects develop the urge to climb up a tree? Who gains and who loses?

People, voles and truffles

Human beings and other vertebrates are not immune to the commands of fungi either. Not only do people cultivate mushrooms, thus enhancing the fungi's reproductive potential, but they also hunt them in their natural state. If you need to be shown how human behaviour can be influenced by fungi, let me quote from Worthington Smith, who, in *Gardener's Chronicle*, reported on the first organized mushroom hunts held by the Woolhope Naturalists' Field Club, founded in 1851. He writes about Mordecai Cubitt Cooke, a leading light of that club and one of the fathers of British amateur mycology.

> '*Dr Cooke, furnished with a large leathery travelling trunk (in place of a hand basket or tin collecting case) was one of the first to arrive in the Forest. By 4 o'clock the Doctor's phenomenal portmanteau was full of funguses. Where one generally looks for a tooth-brush might be found a Phallus, in place of a sponge was a bloated Boletus, in lieu of writing paper, sheets of dry-rot. Shirts were shirked, and fungi both fresh and frouzy were in all the compartments of the valise. No one but an advanced fungologist could so treat a portmanteau.*'

Whether such activities lead to enhanced spore dispersal is debatable, although nice specimens of ceps or chanterelle continue to shed spores in the collector's basket. Because such baskets are usually made from wicker or wooden slats, there is considerable opportunity for spores to escape. But it does not seem likely that this is an effective mechanism. More to the point is the fact that the spores of many fungi pass through the digestive tracts of vertebrates intact and are thus deposited wherever the animals go. Truffles, perhaps the most prized and certainly the most expensive fungi of all, grow underground. Humans, pigs and dogs are not the only animals that are attracted to truffles – so are small mammals and invertebrates, which play an essential role in the dispersal of the truffles. An example is a field vole that consumes the truffle from the Northwestern United States, *Tuber gibbosum*. These truffles do not compete with the famed ones of the Perigord or Piedmont, at least not on the open market, but they constitute the main diet for the voles. People, of course, tend to cook the mushrooms they eat, something the fungi didn't count on in their evolution. A few mushrooms are eaten raw, as in a spinach and sliced *Agaricus* salad and I have wondered about the viability of such spores after passage through the human digestive tract! Granted, this may not be a burning problem for investigation. Attention should rather be paid to the other bewildering and engaging phenomena relating to fungi. There is no dearth of important questions left to be studied regarding their effects on animal and plant behaviour.

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Further reading

Cooke, M.C. (1892). *Vegetable Wasps And Plant Worms*. London: Society for Promoting Christian Knowledge. (A highly readable book on insects and fungi.)

Ingold, C.T. (1971). *Fungal Spores. Their Liberation and Dispersal*. Oxford: Clarendon Press. (Written by an erstwhile president of the British Mycological Society, this book not only systematizes the subject but also provides many cogent examples and illustrations.)

Schaechter, E. (1997). *In the Company of Mushrooms*. Harvard, MA: Harvard University Press. (For a broader view of the fungi).