Attack of the Sap Suckers

Theft of body fluids is a way of life for countless animals but as many as 3000 species of flowering plants also depend on the sap of other plants. These parasites obtain water and nutrients from their hosts by producing haustoria or "bridges" which connect the transport systems of the hosts to their own vascular tissues. When the host is an important crop plant, the damage caused by the parasite takes on grave significance.

Parasitic plants grow all over the world. In Britain, perhaps the best known is the Christmas mistletoe which parasitises the trunks and branches of trees. Mistletoes are responsible for considerable losses of timber. Parasitism is less obvious in the root parasites, for example the plants of the figwort family, and where the haustoria are below ground, as in the eyebrights and louseworts. All these are hemiparasites in that they are not wholly dependent on their hosts; they take up water and minerals from other plants but can photosynthesise their own foods. Not so the fully parasitic holoparasites, which lack chlorophyll completely.

Perhaps the most important parasite, economically, is the witchweed which often devastates crops of sorghum, millet and maize in Africa. It is not, however, only farmers in the developing world that suffer. In Europe, a member of the figwort family, yellow rattle, is an inhabitant of grain fields. It was once called the "stealer of bread from the ovens". In the USA, the dodder is still an important parasitic weed where it is known as "the Devil's thread".

The haustoria were once thought to serve merely as collecting devices for parasites, but now they have been shown to be metabolically active structures. There is evidence of the "digestion" of nutrients from the host in which haustorial cells convert sugars and amino acids into forms more suited to the parasite. It is believed that haustoria have evolved from modified roots; the roots of two plants which are closely intertwined may sometimes fuse naturally. All that was then needed was the development of mechanical or enzymatic action to enable haustoria to penetrate the host's vascular tissue.

Central to the survival of parasitic plants is the need to locate a suitable host. Mistletoe plants are found growing out from the branches or trunks of trees. Their seeds are surrounded by the sticky flesh of the fruit which birds readily eat. The sight of birds with mistletoe seeds stuck to their beaks is common in the mistletoe-infested orchards of France. The dwarf mistletoes of trees in North America hold the record for being the fastest plants on earth – at least their seeds are! They explode from the fruits at more than 100 kilometres per hour and shoot as far as 15 metres from the parent plant. An alternative strategy is to produce many small seeds. Individual witchweed plants regularly produce 100 000 tiny seeds each with a diameter of only 0.3 mm.

Witchweed also uses its host's defence system as a way of recognising a good place to germinate. Sorghum roots produce chemicals called sorgoleones. These normally inhibit the growth of plants which compete with sorghum. Witchweed seeds must germinate very close to a potential host and they have evolved the ability to recognise sorgoleones that leak from the sorghum roots. The sorgoleones *stimulate* haustorium development in the parasite and the haustoria invade the sorghum root tissues, "hunting" for nutrients. In another parasite, dodder, the haustoria have intrusive finger-like structures which penetrate the vascular bundles of the host.

Once the parasite has attached itself to the host, it can divert sap away for its own consumption. Mistletoes, figworts and witchweed achieve this by maintaining a high rate of transpiration from their leaves, losing water more than 10 times as fast as their hosts. The rapid loss of water from the parasite's leaves drains water and dissolved nutrients from the host, and the solutes become concentrated in the parasite's tissues.

The special characteristics of these plant parasites offer scientists a chance of controlling the species that damage valuable crops. The broomrape, for example, which is found in the Mediterranean area, parasitises legumes such as broad beans. It resembles asparagus tips and has long, pointed shoots with reduced leaves which are completely white. It is now the subject of experiments testing the effect of the herbicide, glyphosate. This herbicide will kill any plant but some crops can survive small doses of it. Recent studies have shown that low concentrations of glyphosate sprayed onto broomrape-infested broad beans can successfully exterminate the parasite without killing the host. In this case, the mechanisms that the parasite has evolved for acquiring nutrients are responsible for its downfall.

Witchweed has been successfully controlled in northern Africa by the use of antitranspirants which block the stomata on the surface of the leaves. After spraying infected sorghum with antitranspirant, the witchweed withered and died within an hour or so of treatment. The speed of response astonished scientists who could not believe that the parasite was dying so quickly merely from a reduced supply of sap from its host. Tests have confirmed that the dying witchweed is not significantly short of water and nutrients. The cause of death must lie elsewhere. Further developments in our understanding of how these parasites function will surely provide us with more clues to effective methods of limiting the damage that they can cause.

Using the information in the passage and your own knowledge of biology, answer the following questions. Short, concise answers are required.

1 (a) Suggest how the yellow rattle gained its name as the "stealer of bread from the ovens" (line *15*). **1**

(b) Which part of the host does the yellow rattle parasitise? **1**

2 Give **two** functions of haustoria. **2**

3 (a) Give a feature of witchweed seeds which makes it essential that they "germinate very close to a potential host" (line *33*). **1**

(b) How does the presence of the host affect the early development of the witchweed parasite? **1**

4 Suggest how the fruits of the Christmas mistletoe are adapted to utilise birds as the agent of their dispersal to a new host. **1**

5 Suggest how the dispersal mechanism used by the dwarf mistletoes would enable new hosts to be infected. **1**

6 (a) Name **one** plant that can be identified as a holoparasite, *by using information in the passage*. **1**

(b) Explain your choice. **2**

7 Identify the vascular tissues that would be invaded in (i) hemiparasites and (ii) holoparasites. **1**

8 **Outline** how radioactive ^{14}C might be used to confirm whether a plant growing on a host is a hemiparasite or a holoparasite (lines *8–11*). (Details of experimental procedures are **not** required.)

Give the results that you would expect. **3**

9 Suggest **two** structural ways in which high rates of transpiration might be achieved in parasites such as witchweed (lines *39–40*). **2**

10 Explain how the herbicide glyphosate can control the broomrape without damaging the broad bean host plants (lines *46–48*). **2**

11 Suggest why the antitranspirant spray caused such a rapid death of witchweed growing on infected sorghum plants (lines *51–52*). **1**

20