Chemical warfare

Insects are a plant's main enemy, and plants have developed many chemical defences against them. The Wild Peach (Kiggeliana africana) has leaves that, when crushed, smell like almonds – and also contain cyanide, and only one butterfly larva, the Afrikaanse Alem. The African Adonis (Agasthoma) belong to the plant family Rutaceae, or citrus family, and are virtually unknown to the majority of grass species that grow on richer soils. (Hence the tannin stained waters of the Cape mountains and the whisky making waters of Scotland.) Why is this? Some of the macromolecules that are stored in plant cells. Plants produce tannins and other long molecule compounds (many of which are insoluble and hence very stable in situ) that are packed full of carbon, hydrogen and oxygen (CHO) because they are 'cheap' molecules to make and enable the plants to dump excess CHO molecules. One of the properties of tannin is that it binds protein (and so limits protein absorption in animals), hence our conclusion that they function as anti-herbivore defences. But is this correct? Recently ecologists have found that tannins are important controllers of decomposition and nitrogen recycling in the soil, and this may well be their primary function – not defence, which is a spin-off. The only way plants can rapidly absorb molecules from the air is through their stomata – those tiny apertures that allow atmospheric gases to enter and leave the plant. It is unlikely that many macromolecules, that are insoluble, are going to be an effective means of communication.

Mechanical defences

Plants have many external structural defences that discourage herbivory. These include structural defences on stems and leaves like thorns. Some defensive compounds are produced internally but are released onto the plant's surface, for example, resins, thereby making feeding difficult. Some plants produce sticky sap that traps insects. Some are covered with sharp, barbed hairs – often containing irritants. Some have spines and thorns to reduce herbivore impact. The African acacias are well known for their thorns, but thorns and spines may not be quite what we think they are. See Prof. Moll's text box on the right.

Hypothesis

An idea or explanation that is tested through study and experimentation.

Sclerophyllous Vegetation with small, evergreen, tough, leafy-leaves with thick cuticles.

TEXT and illustrations by Eugene Moll and Caroline Vogel, with input from The Story of Life and the Environment: An African Perspective by Jo van As, Johann du Preez, Leslie Brown and Nolene Smit (Struik Nature), and PlantzAfrica (http://www.plantzfrica.com).


Science is all about testing hypotheses, and in the June 2014 issue of *Veld & Flora* there was a very interesting letter by Ralph Peckover on p. 92. Ralph had noticed that some of his aloes had grown more slowly on richer soils than on poorer soils of the same species, and he wondered if this was caused by a reaction to continuous browsing on the leaves by kudus. He writes, 'It is a well known fact that kudus browsing shrubs and trees causes the shrubs to "war" their neighbours that their leaves are being eaten so they can increase their leaf tannins to make them less palatable so the kudu move away.' But perhaps one should question this 'well known fact' because there is no conclusive scientific research that substantiates the claim that plants 'talk to each other' using tannins.

Science, like many other branches of knowledge, is an experiment-based discipline. We seem to know that plants release a chemical that other plants know about and react to in some way that benefits the food plant. This is called a chemical signal, and there are many other examples of this. How do different species communicate? Do they='speak' the same language? We don’t know, as Ralph discovered. We might have a few theories, but we do not have a full picture. Some of the macromolecules that are stored in plant cells. Plants produce tannins and other long molecule compounds (many of which are insoluble and hence very stable in situ) that are packed full of carbon, hydrogen and oxygen (CHO) because they are ‘cheap’ molecules to make and enable the plants to dump excess CHO molecules. One of the properties of tannin is that it binds protein (and so limits protein absorption in animals), hence our conclusion that they function as anti-herbivore defences. But is this correct? Recently ecologists have found that tannins are important controllers of decomposition and nitrogen recycling in the soil, and this may well be their primary function – not defence, which is a spin-off. The only way plants can rapidly absorb molecules from the air is through their stomata – those tiny apertures that allow atmospheric gases to enter and leave the plant. It is unlikely that many macromolecules, that are insoluble, are going to be an effective means of communication.

Plants fight back

They key concept of evolution is that changes in populations are inheritable, and are directed by natural selection. The process occurs within populations where individuals gradually change in form or function to adapt to or to exploit new environmental conditions or pressures. For example, this may include adaptive responses to predators, or defensive adaptations to climate change.

In ecology, predation describes a biological interaction in which a predator organism feeds on other living organisms known as prey. Animals that feed on living plants are called herbivores. So herbivory is a form of predation in which a herbivore consumes autotrophs (organisms capable of synthesizing their own food from simple organic substances) such as higher plants, algae and photosynthesizing bacteria. Following that definition, many fungi, some bacteria and protozoans and a small number of parasitic plants can also be considered herbivores along with animals. However, herbivory generally applies to animals eating plants. Fungi, bacteria and protozoans that feed on living plants are usually termed plant pathogens. Herbivores depend on plants for food and have co-evolved mechanisms to obtain this food despite the evolution of a diverse arsenal of plant defences against herbivory. Herbivores adapt to plant defences to improve their chances of feeding on the plants. Plants, on the other hand, protect themselves by limiting the ability of herbivores to eat them.

Plant defences against herbivory include a range of mechanical and chemical obstacles such as unpalatable or indigestible chemicals, toxins that kill or repel herbivores and thorns. Defences can be constantly present (constitutive) or produced by the plant following damage or stress (induced). Plants have also evolved indirect defensive features by evolving ways of attracting the natural enemies of the herbivores that feed on that specific plant. For example, the plants emit odours that attract these natural enemies, and when they arrive, the plants provide food and shelter for them, as in the case of biting ants associated with acacias. Herbivory may also be encouraged by some plants to assist in their reproduction - notably the production of nectar to attract bees and other pollinators to perform essential cross-pollination. Herbivory is not always bad for a plant and in some cases it provides a positive stimulus for plant growth. This is the case for the majority of grass species that grow much faster if they are constantly cropped by grazers such as the huge wildebeest herds of the Serengeti plains.

Insect chemical warfare

Insects are a plant’s main enemy, and plants have developed many chemical defences against them. The Wild Peach (Kiggeliana africana) has leaves that, when crushed, smell like almonds – and also contain cyanide. And indeed, its leaves contain cyanide, and only one butterfly larva, the Garden Acraea, has managed to evolve a way of safely eating it. It stores the cyanide and is consequently not itself preyed upon, except by some that have evolved ways of eating it and surviving the dose of cyanide. Likewise, the almond-scented leaves of the Wild Pear (Diosma cymosa) also smell faintly of almonds – and also contain cyanide. Buchus (Agathosma) belong to the plant family Rutaceae, or citrus family, and are virtually unknown to the majority of grass species that grow on richer soils. Some of the macromolecules that are stored in plant cells. Plants produce tannins and other long molecule compounds (many of which are insoluble and hence very stable in situ) that are packed full of carbon, hydrogen and oxygen (CHO) because they are ‘cheap’ molecules to make and enable the plants to dump excess CHO molecules. One of the properties of tannin is that it binds protein (and so limits protein absorption in animals), hence our conclusion that they function as anti-herbivore defences. But is this correct? Recently ecologists have found that tannins are important controllers of decomposition and nitrogen recycling in the soil, and this may well be their primary function – not defence, which is a spin-off. The only way plants can rapidly absorb molecules from the air is through their stomata – those tiny apertures that allow atmospheric gases to enter and leave the plant. It is unlikely that many macromolecules, that are insoluble, are going to be an effective means of communication.