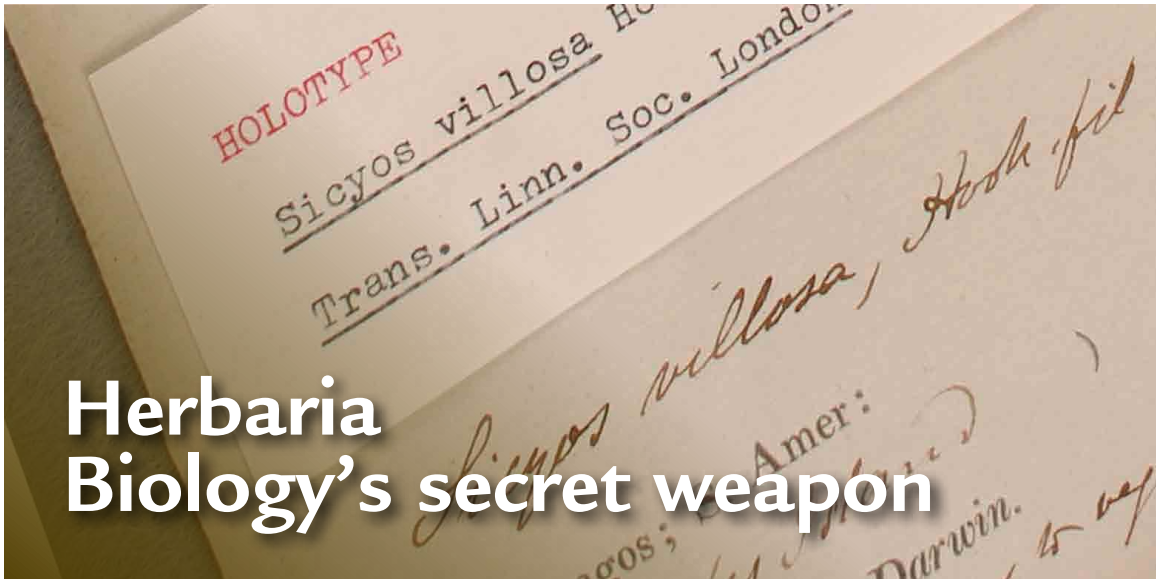
Christine Bartram



Herbaria Biology's secret weapon

The hidden halls and passageways of more than 3000 herbaria worldwide are home to millions of pressed and dried plant specimens collected over three centuries. The plants, labelled with information and stuck on to sheets of paper, preserve a 300-year biological timeline of plant-life and its global diversity. At Cambridge University Herbarium we even keep the plants collected and dried by Charles Darwin on the Beagle Voyage.

These collections are crucial to science as a physical record of the plants that scientists study, a way of permanently connecting their research with the plants they use in their experiments. Under optimum conditions a herbarium specimen should last for hundreds of years.

Imagine the scene: 1840s Ireland, the entire potato crop has perished. One million men, women and children, reliant on potatoes as their staple food, starve to death. A further million people flee the country. Researchers across Europe, eager to understand why this disaster is happening, press and dry plant material infected with the blight pathogen *Phytophthora infestans* and carefully preserve it on herbarium sheets. They cannot know that their specimens will be used 170 years later...but in 2014 scientists extracted DNA of *Phytophthora infestans* from 39 of those nineteenth-century herbarium samples. Using new developments in DNA sequencing technology, the entire genome of the destructive pathogen was reconstructed from herbarium specimens and a number of current questions about the population biology of the *Phytophthora infestans* pathogen were answered.

On the Beagle voyage (1831-36) Charles Darwin gathered from the Galápagos Islands a number of tomato plants now preserved as herbarium specimens at Cambridge. The tomatoes are tiny, unlike our modern, much-bred, larger fruits. The scientists who extracted *Phytophthora infestans* DNA from herbarium specimens have now turned their expertise to Darwin's preserved tomatoes and will compare their molecular structure with living tomato plant material growing in the same places where Darwin collected his specimens.

The Galápagos tomato, Solanum chessmanii

While on Galápagos, Darwin also collected a single specimen of *Sicyos villosa*. This member of the *Cucurbitaceae* family (which includes squashes and cucumbers) is now extinct. Known only from Darwin's specimen, which comprises just one large leaf and a few seeds, it too is preserved at Cambridge. Some of this plant's close living relatives are also dying out. *Sicyos australis*, for example now

only grows on smaller islands around New Zealand where domestic squashes and cucumbers, with the viruses that infect them, have not been introduced. In years to come we may gain more knowledge about the extinction of *Sicyos villosa* by exploring DNA from the single preserved leaf. At the moment this would mean taking a 2cm section from the leaf, a bit sad when it is the very last one of its kind.

Sicyos villosa *collected by Charles Darwin in December 1835 on Charles Island in the Galápagos. When he saw it the plants were abundant and lush. It is now extinct.*

Cambridge scientists currently studying petal spot evolution in populations of the South African Cape Daisy *Gorteria diffusa* have placed specimens of the flowers in the herbarium. Future scientists will be able to see the published results of their work but they can also check out the exact plants used in the experiments by visiting the herbarium and then accurately repeat those experiments. They can also collect even more data on the species from where the previous material was gathered.

A flower of the Cape Daisy, Gorteria diffusa

Climate change

Herbaria are now informing many climate change studies. For example, we know from looking at Cambridge herbarium specimens that some plants flower earlier than they did just 30 years ago. Also at Cambridge there are thousands of plants collected and dried before the Industrial Revolution in 18th century Europe. Study of their stomata in comparison with the stomata of the same species today reveals changes to their numbers, which may be in response to climate change and air pollution.

Herbarium specimens can be used to study the evolution of plant breeding systems and the interactions between plants and insects such as bees. A current PhD project in Prof. Beverley Glover's Cambridge laboratory aims to increase understanding of how plants evolve to improve pollinator activity by investigating the morphology (the structural features) of the anthers of *Solanum*. This large and diverse genus includes commercially important crop plants such as potatoes, aubergines and tomatoes. Anthers from hundreds of herbarium specimens and from living material are measured, DNA sampled, and coated with gold for scanning electron microscopy to see how cell structure may be evolving.

Christine Bartram is Chief Herbarium Technician at Cambridge University Herbarium, The Sainsbury Laboratory.

Look here!

Cambridge is fortunate to have a large university herbarium with over 1 000 000 specimens. But many other universities, gardens and museums, even small museums, have fascinating collections too. To find your nearest see *Index Herbariorum* at *http://sweetgum.nybg.org/science/*ih/ and type in your nearest town and country. Individual entries give addresses, plant specialisms and the name of who to contact. They are great places to visit!

Visitors to the Cambridge Herbarium study plant specimens.

See the back page of this issue of Catalyst for more about how scientists can learn about evolutionary processes by studying Gorteria.