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Peak performer

While all around it cower from the cold and wind, one plant thrives high in the Himalayas. Henry Nicholls reveals its extraordinary secret

THE foothills of the Himalayas are lush and verdant. But the higher you go, the shorter the plants get. Above the treeline, at around 4000 metres above sea level, conditions are extreme. It's cold and windy, the steep slopes consist mostly of shattered rocks rather than soil, and from above comes an invisible barrage of ultraviolet light. The plants here are tiny and cling closely to the mountainsides, barely peeking above the scree-clad slopes. Every now and then, though, a towering pale form looms, ghostlike, out of the mist.

When the botanist Joseph Hooker caught his first glimpse of this peculiar plant in the 1840s, he was "quite at a loss to conceive what it could be". From a base of normal green leaves rises a hollow column made of overlapping pale-yellow leaves. The columns can grow nearly 2 metres high, dwarfing the other vegetation around them.

So how does this plant manage to grow so much larger than others at this altitude? The translucence of the column suggests an amazing answer: it grows its own greenhouse.

When Hooker examined the plant closely, he identified it as a member of the rhubarb family. He named it *Rheum nobile*, the noble rhubarb. Like the species widely grown for food, the stems of the green leaves are edible. Hooker noted that they taste pleasant and are much eaten – perhaps too pleasant, for the plant is now endangered in the wild.

A few botanical gardens and plant enthusiasts grow *Rheum nobile*, but it rarely flowers away from its natural habitat, and the flowers are the extraordinary part. The hollow columns are actually flower spikes. The pale yellow leaves – or bracts, as botanists call these modified leaves – grow from each spike, surrounding and hiding the flowers inside. "On a scale of 1 to 10 for botanical novelty, it's probably getting towards 8," says David Simpson, head of the herbarium at Kew Gardens in London, where the specimen collected by Hooker is still stored.

The bracts keep the flowers enclosed throughout their development and pollination, and while fruit and seeds form. Only after that do they turn brown and fall off, exposing the now-dead seed-bearing stem within. "In the winter these naked black stems, projecting from the beetling cliffs or towering above the snow, are in dismal keeping with the surrounding desolation of that season," Hooker wrote.

But why enclose the flowers in the first place? *Rheum nobile* is often referred to as a "glasshouse plant", but it is unclear who first suspected it might act as one. The earliest such reference *New Scientist* could find was by the Japanese botanist Sasuke Nakao in 1964. "The flowers open in the self-made warm room," he wrote. This boosts pollination, Nakao proposed, by providing favourable conditions for insects.

Flowers hidden inside the column are revealed in this illustration from 1855

Another Japanese botanist, Hideaki Ohba, later suggested the warmth boosts the growth of the plant itself as well. "The inflorescence is sheltered by papery and translucent leafy bracts that can be compared to the glass of a hothouse," he wrote in a 1988 book.

In the 1990s, a study confirmed that the hollow columns do have a "greenhouse effect". The bracts allow visible and infrared light to pass through and they trap the resulting heat, just like the glass or plastic of a greenhouse.

A few other plants also appear to exploit this effect. Most are inconspicuous affairs, but *Rheum alexandrae*, another rhubarb, looks like a smaller version of *R. nobile*. It seems to be a case of parallel evolution, though. The genetic evidence suggests that their hollow columns evolved independently, says Jianquan Liu, a molecular ecologist at Lanzhou University in China.

But what exactly did they evolve for? Although the pale bracts lack chlorophyll, they are packed with substances that absorb ultraviolet light. It could be, for example, that they evolved to be, and are needed as, UV filters, and that the greenhouse effect is entirely incidental.

So Hang Sun, a botanist at the Kunming Institute of Botany in China, sent two students to investigate what, if any, benefits the bracts provide. Using the remote Tibetan village of Wengshui as a base, they drove a hired car up into the mountains each morning to monitor *Rheum nobile* plants growing in the wild. They removed the bracts from some plants before they flowered, from others after they flowered, and left a third group intact.

Their work confirmed Nakao's suggestion about insects. The main pollinator of *Rheum nobile*, a fungus gnat, showed a strong preference for visiting plants that still had all their bracts – presumably attracted to the warm shelter within. Intact plants are also easier to find, Sun thinks. "These bracts act as a flag to help pollinators to locate their host."

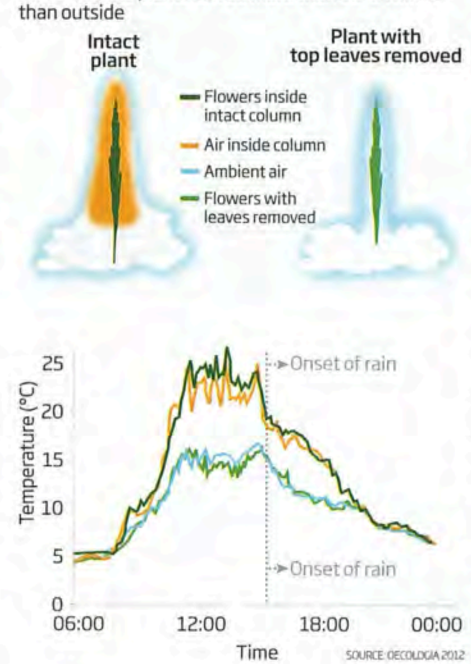
The team also confirmed the importance of the UV filtering. When pollen-bearing flowers were exposed to high UV levels in the lab without the protection of the bracts, far fewer pollen grains germinated. However, the normal, chlorophyll-containing leaves at the base of the plant provide more UV protection than the bracts, so the translucence of the bracts must have evolved for another reason.

The bracts also protect the flowers from rain and hail, Sun's team found. *Rheum nobile* flowers during the rainy season and, in plants whose bracts were removed, most of the pollen grains were washed away. Again, though, this does not explain the bracts' translucence.

It is, however, necessary for the greenhouse effect. On a sunny day, the air was around 10 °C warmer inside the columns than outside (see right), a finding in keeping with observations by other researchers. But Sun and his team went further, collecting pollen from several flowers and showing that grains kept at higher temperatures were much more likely to germinate. So the extra warmth really does matter for pollination.

Keeping cosy

The temperature inside the flower columns of *Rheum nobile* plants can be more than 10°C warmer than outside



The warmth and shelter boosts seed development, too. Plants with intact bracts produced larger seeds that were more likely to germinate than those whose bracts were removed after flowering, the team found (*Oecologia*, vol 172, p 359). "The bracts act as a greenhouse to increase the temperature, and thus promote pollen germination and seed development," Sun concludes. They are an ingenious solution to the hostile environment, he says.

There is one downside. The gnats that pollinate the plants lay their eggs in the flowers, and the larvae feed on the seeds. More seeds were eaten in plants with intact bracts. But the losses are outweighed by the bracts' other benefits. What's more, the gnats are needed to pollinate the next generation.

So it seems *Rheum nobile* evolved its extraordinary structure for much the same reasons that gardeners and farmers use greenhouses – to provide shelter and boost growth – and that it has the same problems, allowing pests to thrive as well. We can add the greenhouse to the long list of things that evolution invented first. ■

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