Why small leaves adapt to dry soil

Key Points

- The mystery of how small plant leaves prevent drought has been solved.
- Close-together veins stop embolisms during drought conditions.
- Alternate vein highways prevent leaves suffering in drought.

By **STUART WOLPERT**

THE size of leaves can vary by a factor of 1,000 across plant species. Until now, however, the reason why has remained a mystery. A new study by an international team of scientists, led by University of California, Los Angeles life scientists, goes a long way toward solving it.

The biologists found that smaller leaves are structurally and physiologically better adapted to dry soil because of their distinct vein systems.

The research is being published in *Plant Physiology*.

LARGE LEAF: *Platanus racemosa,* or California sycamore, has a large leaf and is native to moist habitat.

PHOTOS BY CHRISTINE SCOFFONI/UCLA ECOLOGY AND EVOLUTIONARY BIOLOGY

SMALL LEAF: Toyon, or *Heteromeles arbutifolia*, is a common perennial shrub native to California down to Baja California. Toyon is a prominent component of the coastal sage scrub-plant community, and is a part of drought-adapted chaparral and mixed-oak woodland habitat. It is also known by the common names Christmas berry and California holly.

Small leaves adapt

"A hike in dry areas, such as the Santa Monica Mountains, proves that leaves can be small. But if you are in the tropical forest, many leaves are enormous," said Lawren Sack, a UCLA professor of ecology and evolutionary biology and senior author of the research.

This trend — smaller leaves in drier areas — may be the best-recognized in plant ecology, true at both the local and global scales, but it had evaded direct explanation, Sack said.

Sack and his research team found that small leaves' major veins — those you can see with the naked eye — are spaced more closely together and are of greater length, relative to the leaf's size, than those of larger leaves.

This redundancy of major veins, the researchers say, protects the leaves from the effects of embolism — bubbles that form in their "water pipes" during drought — because it provides alternate routes for water to flow around vein blockages.

"Even with strong drought that forms embolism in the veins, a small leaf maintains function in its vein system and can keep functioning for water transport," Sack said.

"Unlike people, plants don't seem to have a complex hierarchy of needs — give them sun, water and nutrients, and they will be happy," said Christine Scoffoni, a UCLA doctoral student in the department and lead author of the research. "But when one of these three fundamental resources becomes scarce, the plant will have to find a way to cope with it or die, because there is no escape. Coping with drought can be a strong selective factor on leaf form, especially on size and their venation."

"… The bulk of the water used by a plant is to make up for the water lost through transpiration, which would otherwise dry out the leaves. When the leaves open the small pores on their surface, the stomata, to capture carbon dioxide for photosynthesis, water is lost to the dry atmosphere. To stay moist inside, the plants need to replace the water lost by evaporation," she said.

Reading veins

"The less water in the soil, the more the leaves have to pull to get some out, so stronger tension starts building in the plant's pipes," Scoffoni said. "At a certain level of tension, an air bubble is pulled in from outside, blocking the flow of water. One way for a plant to withstand drought is to tolerate many of these embolisms."

Having more major vein routes by which water can flow around the air bubble provides this ability. Smaller leaves, possessing more major veins spaced closely together in a given square centimeter, have this ability, Sack said.

To test this idea, the UCLA team collaborated with France's University of Clermont-Ferrand and a member of the Institut National de Recherche Agronomique, to construct three-dimensional computer models of leaves' venation systems. They then simulated the impact of embolism on water transport for leaves of different sizes and vein architectures.

The biologists found a distinct difference in function between the major veins, which tend to show a branching pattern, and the minor veins, which form a grid embedded within the leaf and make up most of the leaf's total vein length. Blocking the major veins had a huge impact on leaf function — but one that could be remedied by having additional, redundant major veins.

Scoffoni likens the major veins to a superhighway and the minor veins to twisting city roads, where embolism is like an accident causing a major slowdown. "If an air bubble forms in the leaf's water pathway, the more alternate highways the vein system has to offer, the less the leaf will be affected by these accidents," she said.

Wolpert writes for UCLA.

DRY NATIVE: *Cercocarpus betuloides,* or mountain mahogany, has a small leaf and is native to dry habitat.