WHY EVOLUTION IS TRUE

Fantastic and plastic mimicry in a tropical vine

Well if this doesn't beat all! There are flowers that mimic insects, and insects that mimic flowers, and even plants that mimic stones (*Lithops*) to hide them from predators, but this is the first time I've heard of a plant mimicking another plant. Not only that, but the mimic, a vine, can modify its leaves to resemble those of at least eight other trees on which it climbs.

The article describing this, in press in *Current Biology* (full reference and link to abstract below; the paper is behind a paywall though judicious inquiry might yield a copy), shows that the neotropical vine, *Boquila trifoliata* from South America, can not only mimic at least eight different species of tree, but—and this is truly amazing—a single plant can mimic the leaves of several different trees if it happens to entwine around more than one of them. In other words, each plant has the genetic ability to somehow sense which tree it's on, and modify its leaf shape to resemble the leaves of its "host." Now *that's* what I call plasticity!

Below is a screenshot of figure 1 from the paper showing the vine's leaves (arrows) next to the plant on which it climbs or is near. I've added the caption for those with more serious botanical interests. Note how closely the vine leaves resemble the tree leaves. The plasticity involves changes in shape, size, and color.

The other amazing thing is that the vine doesn't actually have to touch or climb the tree whose leaves it mimics; it only has to be *near* it. That means that the vine has to somehow sense what tree is nearby. That rules out explanations for the mimicry involving physical contact. But more on that below.

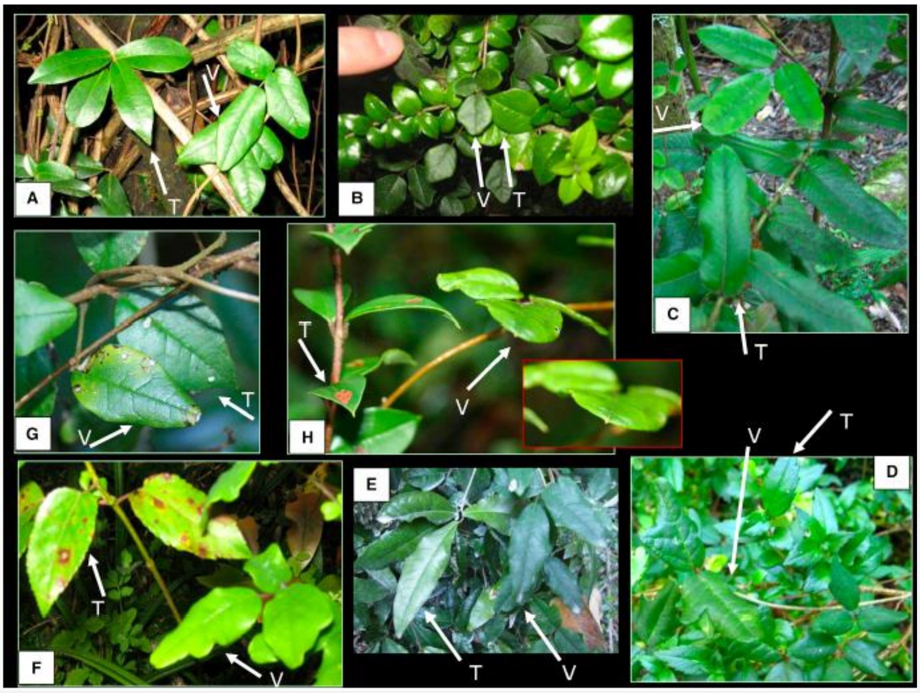

Figure 1. Leaf Mimicry in the Climbing Plant Boquila trifoliolata Pictures of the twining vine B. trifoliolata co-occurring with woody species in the temperate rainforest of southern Chile, where leaf mimicry in terms of size, color, and/or shape is evident. White arrows point to the vine (V) and to the host tree (T). Leaf length of the tree species is shown in parentheses [13]; this may help to estimate leaf size variation in the vine. (A) Myrceugenia planipes (3.5–8 cm). (B) Rhaphithamnus spinosus (1–2 cm). (C) Eucryphia cordifolia (5–7 cm). Notably smaller leaves of B. trifoliolata appear to the left of the focus leaf. (D) Mitraria coccinea (a woody vine; 1.5–3.5 cm). Both here and in (F), the serrated leaf margin of the model cannot be mimicked, but the vine shows one or two indents. (E) Aextoxicon punctatum (5–9 cm). (F) Aristotelia chilensis (3–8 cm). (G) Rhaphithamnus spinosus (1–2 cm). (H) Luma apiculata (1–2.5 cm). The inset shows more clearly how B. trifoliolata has a spiny tip, like the supporting treelet and unlike all the other pictures (and the botanical description) of this vine. See also Figure S1 for pictures showing different leaves of the same individual of B. trifoliolata mimicking different host trees.

Two questions arise immediately:

1. What's the advantage to the vine of being able to modify its leaves to match those of its host tree? The first thing that comes to mind is protection from leaf-eating insects. This could occur in either of two ways, though the authors don't mention these alternatives.

The first advantage comes if the leaves of its host are somehow toxic to herbivores, who then learn to avoid them. In this case the mimicking vine would be a *Batesian mimic*, an edible species that takes advantage of a learned avoidance response by the herbivore. (The herbivore could use visual cues, which must be the case here because of the visual resemblance of leaves, as well as other olfactory or other chemical cues, which weren't investigated in this case. Could the vines show "chemical mimicry" as well?

The other hypothesis is simply that by mingling your leaves with those of an edible, and resembling them, the chance of you being nommed by a herbivore is lessened: most likely the herbivore will go first for the more numerous leaves of the tree, so the vine gets protection by being outnumbered.

The authors, as I said, don't distinguish between these theories, but they did preliminary experiments to show that the mimicry does seem to confer protection against herbivores. They did this by looking at how often the vine's leaves were munched it was attached to a tree whose leaves it mimicked, compared to vines that were either naked on the ground or entwined around a tree that was leafless. After showing that the rate of herbivory on vines climbing leafy trees was similar to that of the trees themselves, they also showed that the rate of herbivory of vines on the ground or naked trees was significantly higher.

Now that doesn't show that the *mimicy* itself confers protection—only that being on a leafy tree confers protection. The authors still need to show that *making your leaves resemble those of the specific tree* confers greater protection than if your leaves are mismatched. That could be done fairly easily, I think, through transplant studies.

2. How the hell does the vine know how to grow its leaves to mimic the nearest tree? This is the real stunner, for each vine apparently "knows" how to change into the best of at least 8 possible leaf shapes; that is, the vine carries genetic information to sense the leave morphology of the nearest tree, and also the genetic information to transform its leaves into that particular shape. The evolutionary scenario for how this could happen boggles the mind, for it involves cues and switches between at least eight discrete morphologies. And the mechanistic basis is unknown. How do the vines sense what tree is near?

The authors offer two hypotheses, one much better than the other.

a. Volatile compounds emitted by the tree are sensed by the vine, which uses that signal to change the shape of its leaves appropriately. This is feasible becasue such volatiles are known in some plants, and are used to deter herbivores or affect the grown of nearby plants of the same species.

b. The second hypothesis is far more speculative (and to my mind, unlikely). Here it is in the authors' words:

"An alternative hypothesis, but perhaps less plausible, would consider horizontal gene transfer between plants, a phenomenon that is increasingly being reported. These cases include both single and multiple transfer events per species, which are hypothesized to be mediated by a vector or result from plant-plant parasitism or natural grafts. The plasticity in leaf mimicry in *B. trifoliolata* could involve horizontal gene transfer on an ecological timescale and might be mediated by airborne microorganisms. The latter speculation is based on the fact that mimicry is observed with respect to the foliage to which the vine is nearest, irrespective of whether this foliage belongs to the host tree that the vine has climbed. Further research on leaf mimicry by *B. trifoliolata* might lead to the identification of the host tree volatiles or vector-mediated gene transfers that trigger differential gene expression in this singular climbing plant."

I think this *far* less likely, because I find it implausible that the very genes carried by some kind of vector microorganism would include those involved in leaf shape, and would insert in the appropriate place in the vine genome and be expressed properly. Were I the investigators, I'd concentrate on the first hypothesis.

Clearly there's a lot more work to be done on this system. But it's really a fantastic one. Who would have thought that a vine could act like a chameleon, able to change its leaf shape to match the surroundings, to match at least eight different model hosts, and to match more than one host on a single vine? This is the kind of stuff that gave rise to the adage in my field, "Evolution is cleverer than you are."

Gianoli, E. and F. Carrasco-Urra. 2014. Leaf mimicry in a climbing plant protects against herbivory. Current Biology, in press. http://dx.doi.org/10.1016/j.cub.2014.03.010