An ant visits the inflorescence of the *para-tudo-do-campo* or *perpétua* (*Gomphrena macrocephala*)

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[ECOLOGY]

Chemistry in the air

Volatile compounds control the interaction between vegetables and insects

CARLOS FIORAVANTI, FROM PRATÂNIA

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The abacaxizeiro-do-cerrado [the Cerrado savanna pineapple plant] is one of the few red spots in the midst of the dried-out grayness of the trees on a savanna reservation surrounded by sugar cane and eucalyptus plantations on an estate in Pratânia, in central São Paulo State. The pale-blue flowers and the leaves of this pineapple plant (*Ananas ananassoides*) release volatile compounds that attract hummingbirds, bees and butterflies in their quest for nectar or pollen. "The pineapple maintains a closer relationship with the hummingbirds, but this doesn't mean that other animals don't visit it," says biologist Juliana Stahl, who is heading a study under the guidance of Sílvia Rodrigues Machado and Elza Guimarães, both of them professors from Paulista State University (Unesp) at Botucatu. The aromas that permeate the air in woods, plantations or gardens express ongoing battles for survival and show that plants are definitely not passive. After millions of years of natural selection, the only ones to grow are those that can interact with animals and other plants, releasing natural compounds that enable defense, or establish agreements that often involve mutual advantage.

"Plants 'manipulate' their visitors," explains Sílvia. Her group's research is detailing why certain plants attract specific groups of pollinators. They are also explaining the formation of chemical compounds that are of interest to humans. Tatiane Rodrigues, one of the biologists in Sílvia's team, found that the elongated and rounded secreting structures of the stalk and the root of the *copaíba* tree produce an oil that people use to treat inflammation, wounds and mycoses, and to treat plants against insects. "Even plants that have just germinated have oil-secreting cells that protect them from predators," she says. Her colleague Shelley Favorito has identified five types of glands on the surface of the leaves of

A bee reaches *Diplopterys pubipetala* in search of oil

CLÍVIA POSSOBOM/ELZA GUIMARÃES/UNESP

Lippia stachyoides; they produce a strong smelling oil that waterproofs the leaves and repels predators.

Learning more about this interaction helps to define the species of plants and animals that are more important for the continuity of natural environments. The *Croton glandulosus*, a one-meter bush that grows in abandoned pieces of land, is one of them. Lucia Maria Paleari, a researcher from Unesp in Botucatu does not cease to be amazed at the diversity of millimetric bees, aphids, flies, butterflies, beetles and ants that satiate themselves with the secretions of secreting structures in roots, stalks, leaves and flowers. One of the visitors is the jataí bee (*Teragonisca angustula*), which feeds on the nectar of the croton flowers, producing honey that can cost as much as R$ 120 a liter. For Lucia, this bush, which does not compete for light and nutrients with farmable plants, should be kept in agricultural areas rather than being eliminated as a negligible weed, its usual fate. "The croton feeds insects that could work as natural enemies of agricultural pests," she says.

Opportunity – Brazil's wealth of plants and animals is driving researchers from Brazil and the USA to interact. One of the centers to house international collaborations is the National Institute of Science and Technology - Center of Energy, Environment and Biodiversity, coordinated by José Rodrigues and Tetsuo Yamane, headquartered at the University of the State of Amazonas (UEA), in Manaus. At the institute's inauguration, in April, Jerrold Meinwald, one of the pioneers in this area, stressed Brazil's potential in this field in a talk. "The Amazon Region, with its broad diversity that has been studied very little, offers a unique research opportunity," he notes. "If Brazil were to consistently invest in this area it might be able to produce world-class research and an institute capable of attracting and training scientific leaders."

One of the members in this group, which is beginning to take shape, is Brazilian biologist Consuelo de Moraes, a researcher from Pennsylvania State University, who showed that messages from plants may have specific addressees. "Many researchers did not believe in the specificity of the interactions of plants with other species," she says. As explained in detail in her article published in 1998 in *Nature*, the *Cardiochiles nigriceps* wasp distinguished between the composition of compounds released by tobacco, cotton and corn attacked by caterpillars of the species *Heliothis virescens* and *Helicoverpa subflexa* – and only looks for plants with caterpillars of the first species.

Now working on her doctorate, Clívia Possobom lent strength to the hypothesis of specific messages when she found that a creeper from the Cerrado savanna, the *Diplopterys pubipetala*, maintains quite a close relationship with bees from the Centridini tribe. Glands at the base of the flower produce an oil that only seems to be of use to the bees: they use it to line their nests and as food for their larvae. "I know of no other function of this oil, which only appears when the bee scrapes the gland," says Clívia. According to her, this oil "may be a kind of reward for the pollinators that the *Diplopterys* depend on, because the plant is auto-incompatible" (the grains of pollen of a given plant, even if produced by a hermaphroditic flower, can only germinate if they reach the feminine structure of the flower of a different plant from the same species). "There is an exchange at play, a co-evolution," comments Sílvia. "The *Dyplopteris* and the bees depend on each other."

Substances released by the plants may guide other plants, though the latter may not always be welcome. In an issue of *Science* from 2006, Justin Runyon, Mark Mescher and Consuelo showed that the *cipó-chumbo* (five-angled dodder) or *Cuscuta pentagona*, through volatile compounds, selects hosts, growing in their direction. It is a parasite of tomato, alfalfa, potato, soy and onion plants, but not of wheat, which releases compounds that repel it. "After germinating, *Cuscuta* has 10 days in which to find a host plant," says Consuelo. "Because it lacks roots and leaves, if it doesn't find one, it dies." Another type of parasitic plant, the *Cuscuta racemosa*, lives in the Mata Atlântica forest and should have similar behavior. We are not dealing with an

THE PROJECT

The role of the glandular structure of the Croton glandulosus in tritrophic interactions

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isolated example here, because at least 4,500 species of plants with flowers, or 1% of the total, are parasites that live off the water and nutrients extracted from other plants.

"Chemical signaling is nature's dominant means of communication," says Meinwald. The number of types of interactions is practically unlimited. To complicate matters further, flowers and leaves may produce different types of compounds as they grow. In 2006, Sílvia, Elza and Elisa Gregório, from Unesp in Botucatu, showed that the flowers of a Cerrado savanna bush, the *Zeyheria montana*, produced alkaloids, which repel visitors, during their early development, and terpenes, which attracts them, when the grains of pollen are ready to fertilize other flowers.

Message for other leaves - At least 1,000 species of plants resort to chemical language, according to a study by Christopher Frost, from Consuelo's team, in *Plant Physiology*. The plants release at least three types of compounds that give woods their typical smell. Identified by the abbreviations z3HAL, z3HOL and z3HAC, they trigger a response to parasites, inducing the release of substances with a nasty taste. In 2008, in *New Phytologist*, Consuelo and her group described the biochemical reactions through which one of these substances, z3HAC, released by leaves that are being devoured by insects, activates the production of compounds that strengthen the defense of leaves that are still intact in a type of poplar, a cold-weather tree. "If a leaf is being attacked, the neighboring leaf prepares to defend itself when it perceives the volatile compounds," says Consuelo. "The leaves that are not connected amongst themselves communicate through these compounds."

Lucia Paleari decided to present these interactions in a more exciting manner and proposed an exhibition about the *croton* to a group of students from Unesp in Botucatu, last November. According to her, two thousand children, youths and teachers from an elementary school and high school in Botucatu became acquainted with the plant and were amazed at the immense models and expanded photos of insects and their heads on show at the school's sports gym. "They asked how insects could have so many structures on their head and how could a plant that they referred to as a weed be so interesting and capable of attracting so many different little animals," she recalls. "We are learning to look at such things more slowly." ■

Scientific articles

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2. RODRIGUES, T. M.; Machado, S. R. "Developmental and structural features of secretory canals in root and shoot wood of Copaifera langsdorffii Desf. (*Leguminosae Caesalpinioideae*)." **Trees.** v. 23 (5). p. 1013-18. 2009.

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Insects copulate under the fluff of the *paineirinha-do-cerrado* (*Eriotheca gracilipes*)