Faithful gardeners

Well paid lunch: caterpillar attack and transportation of fruit benefits plants

Ants help seeds to germinate in the Atlantic Forest and cerrado regions

Maria Guimarães

When biologist Paulo Oliveira from the State University of Campinas (Unicamp) saw the pulp of an open piece of *jatobá* (Brazilian cherry) fruit being devoured by ants in a forest in the mid-1990s, he began to doubt the widely accepted notion that these social insects play an insignificant role in the ecology of seeds. Some fifteen years later, the research group immersed in the close relationship between plants and ants shows that these small animals not only drag the seeds to better locations, but also clean them, which facilitates germination. "Dispersal of seeds in the tropics is much more complex than had been thought," Oliveira notes.

Almost all the spotlights in studies on the ecology of seed dispersal are focused on birds, monkeys and other vertebrates that are attracted by the colorful fruit with tasty pulp produced by nine out of ten species of large trees and bushes. These animals carry the fruit over long distances and release the seeds into the soil. If the fruit falls by accident, it may still be almost entirely intact, but even after going through the digestive system, there is often still a little bit of pulp attached.

However, what happens on the ground had gone almost entirely unnoticed until Oliveira established one of the common threads of his research group there. One of the products comes from the PhD dissertation by Alexander Christianini, now a professor at the Sorocaba campus of the Federal University of São Carlos (UFSCar). He and Oliveira demonstrate that in the *cerrado* region of Itirapina, in São Paulo state, ants from five different genera gather seeds that fall to the ground. In an article published in 2009 in *Oecologia*, they suggest that ants play an important role after birds transport the seeds far from the mother tree: the more detailed work of gardening.

Birds and monkeys usually deposit their seeds under a tree. The rest of the pulp then attracts the ants, which take tiny bits of it into the ant colony. "The seed gets cleaned on the forest floor," says Oliveira, "which prevents the growth of fungus that kills the plant embryo." In addition, some ants carry the seeds to the ant colony, which the researcher describes as being like "an island of

2

nutrients," since it contains discarded pieces of plants and remains of dead ants and other insects.

The *jatobá* (*Hymenaea courbaril*) aroused the curiosity of this researcher. In one experiment with colleagues from São Paulo State University (Unesp) in Rio Claro and the Federal University of Mato Grosso, he showed that 70% of the seeds cleaned by the ants sprouted, which occurred in only 20% of the seeds that weren't treated by the little gardeners. From 1995 to the present, this line of research led to six doctoral degrees that showed that this relationship is fairly generalized in the Atlantic Forest and *cerrado* regions.

EASY PREY

During his time at Oliveira's laboratory in the 1990s, Marco Pizo concentrated on interactions between plants and ants in the Atlantic Forest and showed that the nutritious red aril around the seeds of the cancharana tree (*Cabralea canjerana*) attracts carnivorous ants. "For carnivorous ants, fruit rich in proteins and fats is like insects that don't fight back, don't bite and don't run away," Oliveira notes. Now at the São Paulo State University (Unesp) at Rio Claro, Pizo spread seeds with and without pulp on the forest floor, protected by small cages to keep them from being gathered by larger animals. It was clear that the ants preferred the seeds with pulp (71% of the red part is fat) and that these seeds germinate much faster after they are planted by small insects, as shown in the article highlighted on the cover of *American Journal of Botany* in 1998.

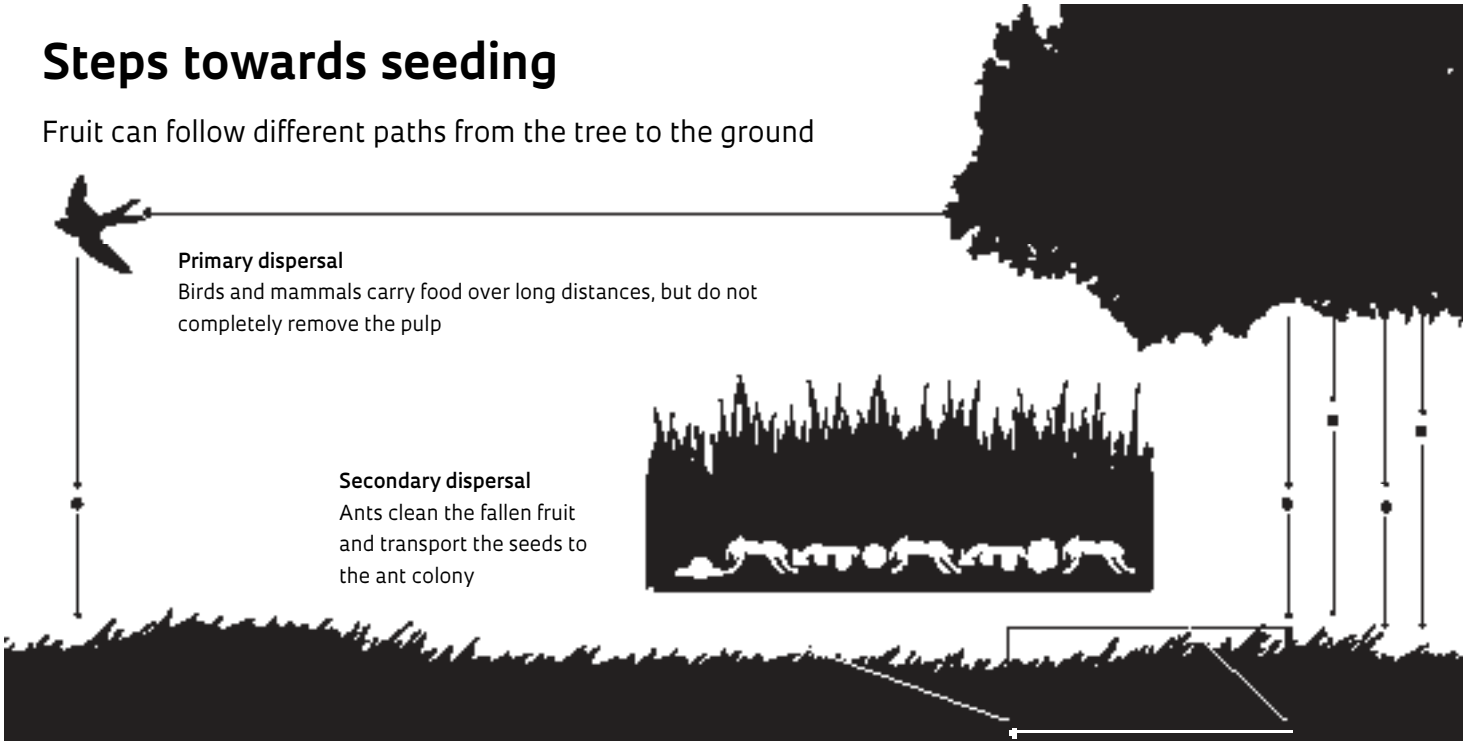
Having been proven that ants transport seeds, it remains to be seen whether this dispersal is directed or random. During the her doctoral studies with Oliveira, Luciana Passos investigated the relations between plants and ants in the barrier island forest of Cardoso Island, on the southern coast of São Paulo state. Part of the Atlantic Forest, this forest is less exuberant because it grows in poor, sandy soil. Passos spread pieces of sardines around the island to attract carnivorous ants, which took them back to their nests – 21 of them.

In an article published in 2002 in the *Journal of Ecology*, Passos explains what happens with fruit rich in the oil of the clusia tree (*Clusia criuva*), which produces about 5,800 pieces of fruit a season, or a total of 25,000 seeds. A good part of

FOTOS: 1. ANDRÉ FREITAS 2. HUMBERTO DUTRA

Steps towards seeding

Fruit can follow different paths from the tree to the ground



these seeds (83%) end up in the feces of 14 different bird species. The researcher saw that the seeds that fall to the ground are transported up to ten meters away by *Odontomachus* and *Pachycondyla,* ants, which are carnivores from the *ponerinae* subfamily and "have a bite as painful as that of hornets," says Oliveira.

But the story doesn't end there. Passos investigated closer and saw that these ants remove 98% of the seeds that reach the feces of birds without being fully digested. She then counted the young clusia shoots and found a disproportionate number near the ant colonies – double what she saw in the rest of the forest. She also kept records of the number of young plants over the course of a year and saw that they had significantly higher chances of surviving near to ant colonies. Passos sent samples of this soil for analysis to the Campinas Institute of Agronomy and saw that it is richer in nitrogen and potassium than the rest of the forest, thanks to the waste accumulated by the ants.

The same thing happens with the *maria-faceira* tree (*Guapira opposita*), whose black fruits with red stems attract birds like the *araçaripoca*, or spot-billed toucanet and the green-headed tanager and has a high protein content (28%), according to an article from 2004 in *Oecologia*. The *Odontomachus* ants carry seeds for up to four meters, and shoots are concentrated around their nests, where the ground is much softer, and richer in potassium, phosphorus and calcium.

> 70%
> of the seeds cleaned by ants germinated; without this treatment, only 20% did so

Alexander Christianini went one step further and showed that deforestation of the *cerrado* invalidated the positive effect of the ants on the ecology of plants. It is known that the centers of the forest islands are cooler and moister than the areas bordering deforested areas. He showed that large ants are also more common in the interior of the cerrado, where the soil is richer in nutrients and softer. Over the course of a year of monitoring, 92% of the ant colonies inside the forest remained, compared to 30% along the edges. Since plants also germinate better closer to ant colonies, young plants along the forest edges have about a 0.2% chance of surviving their first year of life. These results clearly demonstrate that deforestation has a harmful effect on both ants and plants, and that these effects are cumulative. But, with their talent as gardeners, the ants can help to recover an altered forest by contributing to seed germination.

This is the case when adverse conditions do not prevent them from their work. In the Atlantic Forest, fragmentation limits the benefits provided by the population of ants on the regeneration of the forest, according to a thesis defended by Gabriela Bieber at the beginning of 2012. "Large ants are more demanding and do not stay at the edges of the forests," Oliveira explains. The work also showed that insects prefer fruits that have already been handled or bitten by larger animals, of which there are much fewer in small forest sections.

The Unicamp group has been discovering a lot about the ecological functions of these miniature soldiers and workers. Some plants produce substances to attract ants, which pay it back by serving as defense troops. This is the case of the

pequi (*Caryocar brasiliense*), a typical plant of the *cerrado* region that produces a fruit highly valued by the cuisine in the central region of Brazil. These ants delight in the nectar produced by the glands in the buds of the pequi flower and attack other insects, like caterpillars. Sebastián Sendoya, a student of Oliveira and André Freitas, showed that the *Eunica bechina* butterflies, which are specialized in laying their eggs in the pequi leaves, fly over the plants and detect predator ants. This work, published in 2009 in *American Naturalist,* shows that the visual sophistication of the butterflies allows them to lay eggs on safe leaves and even recognize harmless ants.

But caterpillars and ants are not always adversaries. In an example of the rich diversity of these relations, *Parrhasius polibetes* butterflies lay their eggs on plants that are full of ants, according to a study by Lucas Kaminski, another study co-advised by Oliveira and André Freitas, and published in 2010 in *American Naturalist*. The work was conducted in an area of *cerrado* in the Campinas region, and it showed that the butterflies prefer to lay eggs on branches with ants that guard treehoppers (*Guayaquila xiphias*) that produce a sugary secretion. There, by protecting their precious herds, the ants create a zone that is protected from other enemies, like spiders or wasps, which can mean a rate of survival six times higher for the growing butterflies.

A good part of this story, in greater detail, can be found in what Oliveira considers to be the most important work of his life: the book *The ecology and evolution of ant-plant interactions*, which he wrote in partnership with his Mexican colleague Victor Rico-Gray. Published in 2007 by the Chicago University Press, this book is a broad based review of the known ecological interactions between ants and plants. "People pay more attention to vertebrates because they are the animals that they see the easiest," notes the biologist from Unicamp, "but in the Amazon region, the dry weight of invertebrates is four times greater than that of vertebrates." And ants, whose colonies can reach millions of workers, are the most numerous among the invertebrates. ■

For the predator *Pachycondyla striata*, other species like *Odontomachus chelifer* serve as food

PHOTO PAULO OLIVEIRA/UNICAMP **INFOGRAPHIC** TIAGO CARDOSO SOURCE: PAULO OLIVEIRA/UNICAMP

PROJECTS

1. *Ecology and behavior of neotropical ants* – No. 2008/54058-1 (2008-2011)
2. *Studies on neotropical ants: interactions with insect herbivores, behavioral ecology, and social organization* – No. 2011/18580-8 (2012-2013)

GRANT MECHANISM
1. and 2. Regular line of research project award

COORDINATOR
1. and 2. Paulo S. Oliveira – Institute of Biology, Unicamp

INVESTMENT
1. R$113,080.54
2. R$145,747.07

SCIENTIFIC ARTICLES

1. KAMINSKI, L. A. *et al.* Interaction between mutualisms: Ant-tended butterflies exploit enemy-free space provided by ant-treehopper associations. **The American Naturalist**. v. 176, n. 3, p. 322-34. Sept. 2010.
2. CHRISTIANINI, A. V. and OLIVEIRA, P. S. The relevance of ants as seed rescuers of a primarily bird-dispersed tree in the Neotropical cerrado savanna. **Oecologia**. v. 160, n. 4, p. 735-45. Jul. 2009.
3. SENDOYA, S. F. *et al.* Egg-laying butterflies distinguish predaceous ants by sight. **The American Naturalist**. v. 174, n. 1, p. 134-39. Jul. 2009.

FROM OUR ARCHIVES

Faithful gardeners
Issue no. 161 – July 2009