

# Great gardeners

Mathematical models reconstruct the seed-dispersing role once played by now-extinct animals in the Pantanal

**Francisco Bicudo**

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Until some 10,000 years ago, giant ground sloths, mastodons and wild horses populated the South American landscape. The extinction of these mammals, known as Pleistocene megafauna, whose weight could reach several tons, may have significantly affected the vegetation of the Brazilian Pantanal wetland, according to a paper published in the journal *Oecologia* in August 2014. Although the flora that depended on Pleistocene megafauna as seed dispersers have not disappeared (there are other dispersers, including humans), they may have become less abundant and may occupy smaller areas than in the past. “Our proposal aimed to open the way for an ecological approach that could be used to observe specific relationships that had been established between animals and plants to better understand what happened when these giants left the scene,” explains Mathias Pires of the Department of Ecology at the University of São Paulo Biosciences Institute (IB-USP).

Pires was inspired by the work of the Brazilian researcher Camila Donatti during her doctoral studies at Stanford University, in collaboration with the group led by Mauro Galetti, an ecologist at São Paulo State University (Unesp) at Rio

Claro *campus*, which was published in the journal *Ecology Letters* in 2011.

Donatti studied animals in the Pantanal wetland – from fish to mammals – and characterized their seed dispersal habits. “Donatti’s approach simplifies inter-species interactions into a local dataset. Using this approach, in which we represent species by dots and their interactions by lines, we can extract data on how the organisms are interconnected,” Pires explains. “For example, we know that a certain animal consumes the fruits and disperses the seeds of plants 1, 2 and 3, but species B can only disperse plant 1, and species C scatters only 2 and 3.”

During his doctoral studies under the supervision of Paulo Guimarães, Pires took on the challenge of researching how that same network of interactions might have worked in the past. Using data on fossils found in the region, he juxtaposed the present-day animals of the Pantanal with five species of megafauna that inhabited the biome long ago. These included giant ground sloths, mastodons and a relative of present-day llamas. Pires recalled that these large animals are described in scientific literature as good plant dispersers by virtue of at least two distinctive features: because they were quite large and their diet included a variety of fruits, they ingested large



seeds that smaller animals couldn't scatter. Furthermore, they could traverse long distances, and because they digested their food slowly, the seeds germinated in places far from the mother plant.

As for the plants, Pires made a list of 10 species, specifically those whose seeds are still scattered by mammals today, such as pequi fruit, jatobá (Brazilian cherries) and some palm species. With the appropriate substitutions and adaptations, he then employed simulations, mathematical models, computers and statistics. "The idea was to observe the present-day network and investigate how it might have been in the past."

#### YESTERDAY AND TODAY

Pires highlights another finding of the study: in the networks he reconstructed, the seed-disperser roles played by megafauna were distinct and well-defined, in that large animals scattered larger seeds, and small animals dispersed the small ones. In keeping with the findings of Donatti's study, that distinction no longer exists. "Without the mastodons and giant ground sloths, the larger fruits have lost their principal dispersers. Tapirs, coatids

and howler monkeys, for example, probably played a secondary role in seed dissemination during the Pleistocene, but today, they are key agents of large-seed dispersal," he explains.

This look at the past indicates that the absence of megafauna may have had a significant impact on the vegetation of the Pantanal, as shown in a study led by Galetti. The paper, published in 2013 in the journal *Science*, suggests that in areas of the Atlantic Forest, where large birds have been extinct for more than 50 years, populations of palm trees produce only small fruit; in contrast, in better-preserved areas that have larger birds, there are still fruits of various sizes. "The same thing may have happened following the extinction of the large mammals of the past. In addition, plants that lose their seed dispersers end up confined to smaller regions, and the loss of dispersers hinders gene flow between populations. In the long term, this situation can reduce the genetic diversity of populations and lower their resistance to pests, for example," he adds.

In Galetti's opinion, this finding suggests that there is a need to responsibly consider the idea of introducing other mammals, such as horses and pigs, in-

to the Pantanal to serve as dispersers. "Perhaps some of these species can even help restore the losses," he surmises. Pires makes a further point: his work also provides an opportunity for reflection about the present-day biodiversity crisis. In his view, we need to understand ecological interactions in order to find ways to mitigate the consequences of the potential loss of large species.

The biologist, eager to add more data to this scenario, now plans to do a comparative study of other biomes so as to observe the effects of species extinction on each one. "Could the absence of tapirs in the Atlantic Forest have the same effects as in the Cerrado savannah?" he wonders. He also plans to do a quantitative comparison of the effectiveness of some animal species in the task of seed dispersal, again with an eye to the past. "We are developing mathematical models to observe how indispensable a giant ground sloth might have been in carrying seeds long distances, compared to a tapir or a peccary of today, for example," the researcher says in closing. ■



#### Projects

1. *Structure and evolutionary dynamics in mutualistic networks* (No. 2009/54422-8); **Grant mechanism** Young Investigators Awards Program; **Principal investigator** Paulo Roberto Guimarães Junior (USP); **Investment** R\$161,960.08 (FAPESP).
2. *Plant attributes in the Pantanal seed dispersal network: consequences on spatial and demographic patterns* (No. 2008/10154-7); **Grant mechanism** Regular Research Grant; **Principal investigator** Mauro Galetti Rodrigues (Unesp); **Investment** R\$117,963.58 (FAPESP).

#### Scientific article

PIRES, M. M. *et al.* Reconstructing past ecological networks: the reconfiguration of seed-dispersal interactions after megafaunal extinction. *Oecologia*. V. 175, No. 4, p. 1247-56. Aug. 2014.