

Darwin's mystery explained

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The appearance of many species of flowering plants on Earth, and especially their relatively rapid dissemination during the Cretaceous (approximately 100 million years ago) can be attributed to their capacity to transform the world to their own needs. In an article in *Ecology Letters*, Wageningen (The Netherlands) ecologists Frank Berendse and Marten Scheffer postulate that flowering plants changed the conditions during the Cretaceous period to suit themselves. The researchers have consequently provided an entirely new explanation for what Charles Darwin considered to be one of the greatest mysteries with which he was confronted.

During the Cretaceous, the Earth's surface underwent one of its greatest changes in vegetation composition, a change which also took place with unprecedented speed. Frank Berendse (Professor of Nature Conservation and Plant Ecology), and Marten Scheffer, (Professor of Aquatic Ecology), both at Wageningen University, wanted to understand how this happened. They looked for the explanation in a totally unconventional direction.

Before the early Cretaceous, the vegetation consisted primarily of gymnosperms and ferns. These plants were largely replaced by an entirely new group of plants: the angiosperms ([flowering plants](#)). During the early Cretaceous - approximately 125 million years ago - the first flowering plants evolved. Soon thereafter, the gymnosperms in the tropics were replaced almost entirely by the angiosperms. And by the end of the Cretaceous (65 million years ago), the empire of the flowering plants had become definitively established in much of the rest

of the world. The gymnosperms continued to exist only in the far north - which is the case even today.

The rapid increase in the fantastic diversity of flowering plants - linked to their rapid conquest of the Earth - was one of the greatest puzzles faced by Charles Darwin. In a letter to Joseph Hooker dated 22 July 1879, he referred to an "abominable mystery". The great diversity of fossil flowering plants from the late Cretaceous, while there were virtually no fossils known from the early Cretaceous, appeared to be completely in conflict with his vision that the emergence of new species could only take place very gradually.

The big question was how this massive change could have taken place with such unprecedented speed. Was it because - just before the Cretaceous - that the big Sauropods were forced out by the much smaller Ornithischian dinosaurs, which then systematically ate all the seedlings of the gymnosperms? Or was it because the flowering plants could evolve simultaneously with many insect species that could pollinate their flowers?

According to Berendse and Scheffer, we must think in a totally different direction. They postulate that the flowering plants were able to change the world to suit their own needs. They grew more rapidly and therefore required more nutrients. In a world that was poor in nutrients and was entirely dominated by the gymnosperms, that kept the soil poor - with their poorly degradable litter - flowering plants had great difficulties to establish. But at some locations where the gymnosperms had temporarily disappeared, for example due to floods, fires or storms, the angiosperms could increase so that they were capable of improving their own conditions with their easily degradable litter.

According to the theory of Berendse and Scheffer, this led to positive feedback; as a result, the flowering plants could increase even more

rapidly and were capable of replacing the angiosperms in much of the world. Ultimately, the improved edibility of the leaves and fruits of the flowering plants led to a tremendous increase in the number of plant eaters on the Earth, which opened the way to the rapid evolution of mammals, and finally to the appearance of humans.

Provided by Wageningen University

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