# Evolutionary arms race between smut fungi and maize plants

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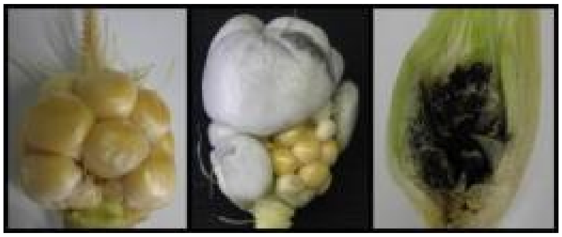

Similar and yet different: The symptoms of two closely-related smut fungi in dwarf maize cobs. Left: Healthy maize cob; Middle: Maize cob infected with *Ustilago maydis*; Right: Maize cob infected with *Sporisorium reilianum*. Credit: Jan Schirawski

Fungi are a major cause of plant diseases and are responsible for large-scale harvest failure in crops like maize and other cereals all over the world. Together with scientists from the Helmholtz Zentrum in Munich, Regine Kahmann, from the Max Planck Institute for Terrestrial Microbiology in Marburg, and Jan Schirawski, who is now based at the University of Gottingen, analysed the genetic make-up of *Sporisorium reilianum*, an important maize parasite. Based on a comparison with the genome of a related fungal species, they succeeded in identifying new genes that play an important role in maize infestation. (*Science*, December 10, 2010)

The smut fungi Ustilago maydis and Sporisorium reilianum are parasites that attack maize plants. Ustilago maydis causes a disease known as boil smut or common smut, which is characterized by large tumour-like structures on the leaves, cobs and male flowers in which the fungus proliferates and produces spores. Sporisorium reilianum also attacks maize plants; however, it infects the entire plant and its symptoms become manifested only in the male and female flowers. For this reason, it is also referred to as maize head smut.

Little has been known up to now as to how these pathogens cause disease. Four years ago, a team of scientists headed by the Marburg group succeeded in decoding the genome sequence of Ustilago maydis. They demonstrated that the genes, for a large number of completely new proteins secreted by the fungus, are arranged in groups on the chromosomes in so-called gene clusters. These proteins control the colonisation of the host plant.

## Similar and yet different

The researchers were initially only able to demonstrate the presence of these proteins in Ustilago maydis. "However, we found it hard to imagine that these proteins, which play such a crucial role in maize infestation, should only be present in the genome of a single smut fungus. For this reason, we also sequenced the genome of Sporisorium reilianum," explains Regine Kahmann from the Max Planck Institute in Marburg. Over 90 percent of the proteins secreted by Ustilago maydis also exist in Sporisorium reilianum. However, many of these proteins differ significantly between the two species and are therefore difficult to detect at the gene level. "Surprisingly, however, almost all of the genes of the two organisms are arranged in the same order. As a result, we were able to superimpose the two genomes like blueprints and display the differences in this way," says Kahmann.

The scientists discovered 43 so-called divergence regions, in which the differences in the two sets of genes are particularly significant. These included all of the gene clusters identified four years ago, whose genes play an important role in the infection of the host plant. In addition to this, four out of six randomly selected divergence regions influence the strength of Ustilago maydis infection, and surprisingly, one of these does not contain genes for secreted proteins. "This shows that additional, thus far undiscovered molecules control the relationship between the fungus and the plant," comments Jan Schirawski.

## Evolutionary struggle between maize and fungus

Therefore, the genes that differ most strongly between the two fungi are in all likelihood those that play an important role in the infestation of the maize plant. The different life styles of Ustilago maydis and Sporisorium reilianum presumably resulted in the development of species-specific gene variants in these fungi over the course of evolution, e. g. to suppress the plant's immune response. The maize plants, in turn, modified the target molecules of these fungal proteins. Maize plants apparently form at least one protein to counteract each of the proteins released by the fungi. "What we see here are the signs of an ongoing struggle between the defending plant and attacking parasite. The variety of the weapons of attack and defence used is the product of an arms race between the plant and the fungus. Each modification on one side is countered by an adaptation on the other," explains Schirawski. With the help of the molecules they discovered on the basis of the differences between the two fungi, the Marburg-based researchers have the long term hope that it will be possible to develop new strategies for disease control of these and related plant parasites.

**More information:** Pathogenicity determinants in smut fungi revealed by genome comparison Jan Schirawski, et al., *Science*, December 10, 2010

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