The dandelion uses latex to protect its roots against insect feeding

January 5 2016

The larva of a cockchafer *Melolontha melolontha* attacks the roots of a dandelion. Credit: Meret Huber / Max Planck Institute for Chemical Ecology, PLOS Biology

Dandelions are troublesome weeds that are detested by most gardeners. Yet dandelions also have many insect enemies in nature. However, they are able to protect themselves with their latex, a milky, bitter-tasting sap. Scientists at the Max Planck Institute for Chemical Ecology in Jena, Germany, and the University of Bern, Switzerland, have now demonstrated that a single compound in the latex protects dandelion roots against voracious cockchafer larvae. Thus, latex plays a crucial role in dandelion defense against root feeders. (*PLOS Biology*, January 2016, Open Access)

Dandelions are survival experts

Dandelions (*Taraxacum officinale agg.*) are well-known plants of European and Asian origin that have spread around most of the temperate world. Children love their yellow flowers and even more the fluffy seed heads with their parachute-like seeds that can travel long distances by wind. Young plants grow with such force that they can penetrate even asphalt. Therefore dandelions have become a symbol for survival in modern cities.

In fields and meadows, the plant must fend off many herbivores, among them cockchafer larvae. The common cockchafer (*Melolontha melolontha*) spends the first three years of its life cycle underground as a grub feeding on the roots of different plants. One of its favorite foods is dandelion roots. Like many other plants, dandelions produce secondary metabolites to protect themselves against herbivores. Some of these defenses, such as terpenes and phenols, are of pharmaceutical interest and are considered promising anti-cancer agents. The most important dandelion metabolites are bitter substances which are especially found in a milky sap called latex, a substance found in almost ten percent of all flowering plants.

Meret Huber studies latex metabolites in dandelion and their role in root herbivore defense. Credit: Anna Schroll

Why dandelion latex is bitter

Scientists from the Department of Biochemistry and their colleagues from the University of Bern have now taken a closer look at dandelion latex. The scientists found the highest concentrations of the bitter latex in the roots of dandelions. Dandelions need to protect their roots very fiercely because these are the main storage organs for nutrients which fuel growth early in the spring.

One single defensive chemical protects the plant

The scientists tested first whether latex compounds produced by dandelion roots were negatively associated with the development of cockchafer larvae. They also wanted to know whether these compounds had a positive effect on the fitness and reproductive success of dandelions under *Melolontha melolontha* attack. An analysis of the components of dandelion latex revealed that one single substance negatively influenced the growth of cockchafer larvae. This substance was identified as the sesquiterpene lactone, taraxinic acid β-D-glucopyranosyl ester (TA-G). When the purified substance was added to an artificial larval diet in ecologically relevant amounts, the grubs fed considerably less.

The researchers succeeded in identifying the enzyme and gene responsible for the formation of a precursor of TA-G biosynthesis, and so were able to engineer plants with lower TA-G. Roots of engineered plants with less TA-G were considerably more attacked by cockchafer larvae. The chemical composition of latex varies between different natural dandelion lines. A common garden experiment with different lines revealed that plants which produce higher amounts of TA-G maintained a higher vegetative and reproductive fitness when they were attached by cockchafer larvae. "For me, the biggest surprise was to learn that a single compound is really responsible for a defensive function," says Jonathan Gershenzon, the head of the Department of Biochemistry at the Max Planck Institute in Jena. "The latex of dandelions and other plants consists of such a mixture of substances that it didn't seem necessarily true that one chemical by itself had such a protective role against our study insect."

The combination of approaches as a key to success

"It was clearly the combination of techniques that was crucial for the success of our studies," explains Matthias Erb from the University of Bern who led the study. "Each approach has its weaknesses that were

balanced by the strengths of the others. We think that this type of interdisciplinary research can be very powerful to understand biological systems."

The scientists are now planning further experiments study the co-evolution of dandelions and their root herbivores in order of find out whether the presence of root-feeding insects has shaped the plant defensive chemistry in the course of evolution and whether the insects show adaptations to dandelion defenses. [AO]

More information: Huber, M., Epping, J., Schulze Gronover, C., Fricke, J., Aziz, Z., Brillatz, T., Swyers, M., Köllner, T. G., Vogel, H., Hammerbacher, A., Triebwasser-Freese, D., Robert, C. A. M., Verhoeven, K., Preite, V. Gershenzon, J., Erb, M. (2016). A latex metabolite benefits plant fitness under root herbivore attack. *PLOS Biology*, DOI: 10.1371/journal.pbio.1002332. Open Access

Provided by Max Planck Society