

## Correspondences

# Honeybee buzz attenuates plant damage by caterpillars

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In recent years, it has become evident that indirect interactions between members of food webs can significantly influence ecosystem functions. For example, predators affect prey populations through either consumption (density-mediated interactions) or, equally important, by changing prey behavior or phenotype (trait-mediated interactions). Nonconsumptive effects of predators on prey may alter plant species diversity and plant performance [1,2]. Pollination and herbivory are the most important ecological and evolutionary relationships between plants and insects [3]. Honeybees are dominant as pollinators while caterpillars are very efficient plant despoilers [4]. Despite the long and intense study of honeybees, however, indirect effects of this pollinator on other food web members have hardly been assessed. Here we report on a newly discovered link that connects these two ecological functions: honeybees merely flying around vegetation significantly reduce plant destruction by caterpillars.

Wasps preying on caterpillars create airborne vibration with their wings that stimulates caterpillar sensory hairs [5,6]. To avoid the wasps, caterpillars stop moving, regurgitate gut fluid or drop off the plant [7,8]. Flying honeybees produce air disturbance that also stimulates these sensory hairs, found in most of the caterpillar species so far investigated [9]. Caterpillars eat almost continuously. The defensive behaviors elicited by airborne vibration interrupts this behavior and may be expected to lead to a reduction in destroyed foliage. To test if honeybees were able to reduce the activity of caterpillars, two cube-shaped tents (size 2 m x 2 m x 2 m; white fabric

with mesh size of 1 mm<sup>2</sup>) were set up next to each other in the botanical garden of the University of Wuerzburg. Each tent was used for three experimental series and contained either 10 plants of the bell pepper (*Capsicum annuum*) with 6–15 leaves per plant, or 10 plants of the soybean (*Glycine max*) with 11–30 leaves per plant (see Figure S1 in the Supplemental data available on-line with this issue). The bell pepper was tested with and without fruit. At the start of the experiment, 10 third-instar caterpillars of the beet armyworm (*Spodoptera exigua*) were added to each plant. This species was chosen because they feed on about fifty plant species [10], they possess sensory hairs that can detect airborne vibration and they exhibit both wasp-avoidance responses when stimulated by wing beat generated airborne vibration.

One experimental tent was connected to a bee hive such that foragers could enter the tent and fly to two feeders filled with non-scented 2.5 molar sugar solutions and mounted at half plant height above ground in the two corners of the tent furthest from

the entrance. The bees flew to the feeders at a distance of between a few centimetres and, maximally, 1 m past the caterpillars, which is close enough to stimulate them [7]. The second, control tent of the pair contained the same number and species of plants and caterpillars, but bees were not allowed access. The caterpillars in the experimental tent exhibited the same behavioural responses to flying honeybees as they do to flying wasps. Most of the larvae had completed their growth after 13–18 days and burrowed underground for pupation. At this time the experiment was stopped, all plants were removed from the tents, and all leaves were detached and scanned immediately to determine the extent of leaf destruction in terms of the missing leaf area.

In the two experimental runs using plants without fruit, the caterpillars destroyed between 69.3% and 60.6% less foliage in the tent which was visited by the honeybee foragers compared to the plants in the control tent to which the honeybees had no access (Figure 1A,B; Figure 2). A smaller difference in leaf damage resulted

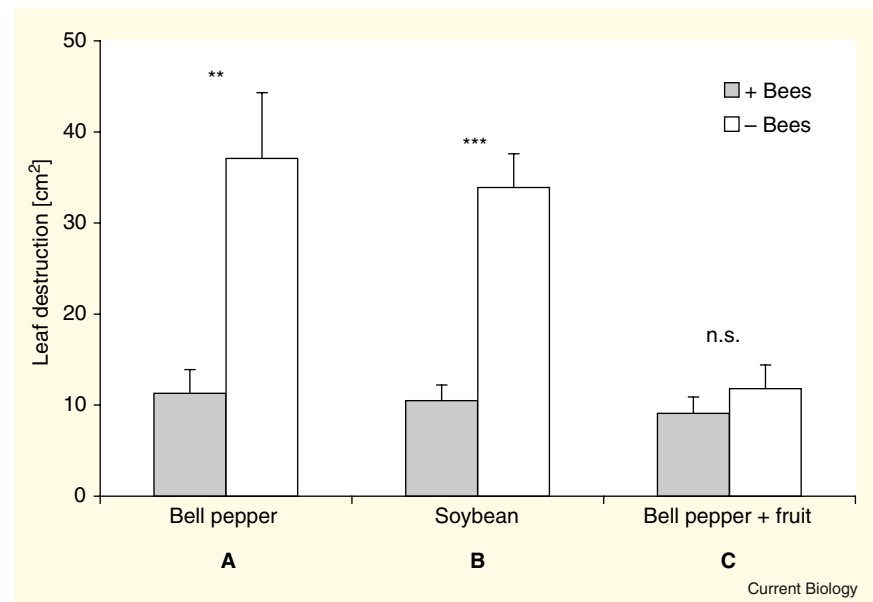


Figure 1. Area of foliage eaten by caterpillars in each of the six experiments.

Bars represent means and standard error. (A) Bell pepper plants (n = 10) after a 14-day exposure to the caterpillars (120 leaves +Bees, 172 leaves -Bees; Welch *t*-test, \*\**p* < 0.01). (B) Soybean plants (n = 10) after an 18-day exposure to the caterpillars (74 leaves +Bees, 91 leaves -Bees; Welch *t*-test, \*\*\**p* < 0.001). (C) Bell pepper plants (n = 9–10) after a 13-day exposure to the caterpillars. All of these plants were growing fruits into which most caterpillars retreated for feeding (90 leaves +Bees, 88 leaves -Bees; Welch *t*-test, n.s. = not significant).

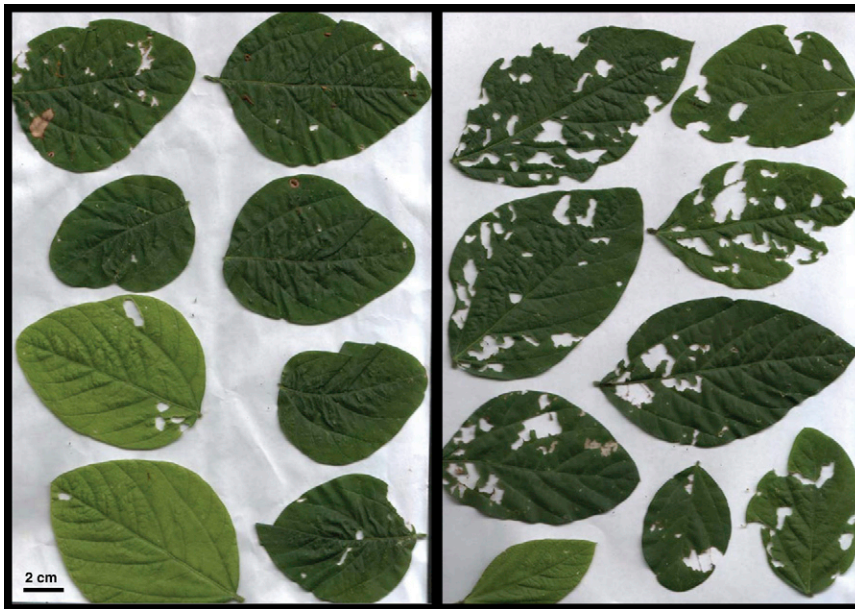


Figure 2. Soybean plants after an 18 day-exposure to caterpillars. Left: honeybees were flying past the leaves to the feeder. Right: no bees were flying inside the enclosure.

when caterpillars fed on fruit-bearing pepper plants. Here, although initially feeding on leaves, the beet armyworms soon moved into the maturing fruits (Figure 1C).

Our results indicate that visiting honeybees provide plants with a totally unexpected advantage: bees flying around plants inhibit the feeding intensity of herbivorous caterpillars, resulting in a clear reduction of leaf damage. Thus, honeybees not only transport pollen from flower to flower but in addition also reduce plant destruction by herbivores. A similar strategy has been described for extrafloral nectaries that attract ants [11]. We speculate that, apart from consumptive and nonconsumptive predator effects, pollinator–herbivore interactions may also be important factors to consider in attempting to understand community dynamics.

#### Supplemental Data

Supplemental data are available at [http://www.current-biology.com/supplemental/S0960-9822\(08\)01407-3](http://www.current-biology.com/supplemental/S0960-9822(08)01407-3)

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## Shade coffee farms promote genetic diversity of native trees

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Coffee is cultivated across 11 million hectares (ha) of land within the world's richest centers of terrestrial biodiversity [1]. In tropical America, coffee is traditionally grown under a diverse canopy of overstory shade trees, which enhances the quality of the coffee farm as a conservation matrix and supports a broad spectrum of pollinators that increase fruit set per bush [2–4]. Unlike sun coffee monocultures, shade coffee also sustains a diverse array of vertebrates, including bats and migratory birds, which provide farmers with many ecological services, such as insect predation [5], and may also conserve seed dispersal processes necessary for native tree re-establishment [6]. However, little is known about the capacity of shade coffee farms to maintain gene flow and genetic diversity of remnant tree populations across this common tropical landscape. In this study, we conducted genetic analyses that reveal recent colonization and extensive gene flow of a native tree species in shade coffee farms in Chiapas, Mexico. The high genetic diversity and overlapping deme structure of the colonizing trees also show that traditional coffee farms maintain genetic connectivity with adjacent habitats and can serve as foci of forest regeneration.

Previous genetic studies of forest regeneration in degraded tropical landscapes have focused on canopy trees and have found pronounced fine-scale spatial genetic structure within colonizing tree populations (e.g., [7,8]) as a result of limited seed dispersal from scattered maternal trees. Such population bottlenecks can lead to inbreeding depression and demographic declines for plants in fragmented landscapes. Alternatively, agricultural matrices that facilitate the movement of seed and pollen dispersers among habitats can increase the breeding size and genetic diversity of native plant populations.

#### References

1. Bernays, E.A. (1997). Feeding by lepidopteran larvae is dangerous. *Ecol. Entomol.* 22, 121–123.
2. Schmitz, O.J. (2008). Effects of predator hunting mode on grassland ecosystem function. *Science* 319, 952–954.
3. Harder, L.D., and Barrett, S.C.H. (2007). *Ecology and Evolution of Flowers* (Oxford: Oxford University Press).
4. Schoonhoven, L.M., van Loon, J.J.A., and Dicke, M. (2005). *Insect-Plant Biology* (Oxford: Oxford University Press).
5. Tautz, J. (1977). Reception of medium vibration by thoracic hairs of caterpillars of *Barathra brassicae* L. (Lepidoptera, Noctuidae). I. Mechanical properties of the receptor hairs. *J. Comp. Physiol.* 118, 13–31.
6. Tautz, J. (1978). Reception of medium vibration by thoracic hairs of caterpillars of *Barathra brassicae* L. (Lepidoptera, Noctuidae). II. Response characteristics of the sensory cell. *J. Comp. Physiol.* 125, 67–77.
7. Tautz, J., and Markl, H. (1978). Caterpillars detect flying wasps by hairs sensitive to airborne vibration. *Behav. Ecol. Sociobiol.* 4, 101–110.
8. Rostás, M., and Blassmann, K. (2008). Insects had it first: surfactants as a defence against predators. *Proc. R. Soc. Lond. B. e-Pub* ahead of print.
9. Markl, H., and Tautz, J. (1975). The sensitivity of hair receptors in caterpillars of *Barathra brassicae* L. (Lepidoptera, Noctuidae) to particle movement in a sound field. *J. Comp. Physiol.* 99, 79–87.
10. Berdegue, M., Reitz, S.R., and Trumble, J.T. (1998). Host plant selection and development in *Spodoptera exigua*: do mother and offspring know best? *Entomol. Exp. Appl.* 89, 57–64.
11. Heil, M., Rattke, J., and Boland, W. (2005). Postsecretory hydrolysis of nectar sucrose and specialization in ant/plant mutualism. *Science* 308, 560–563.

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