Pollination merely one production factor

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Bees of the Apis cerana (eastern honeybee) species pollinate coffee flowers. Farmers can increase the services of pollinating insects with particular cultivation methods. Credit: J. Ghazoul / ETH Zurich

(Phys.org) —No food for the human race without bees? It is not quite as straightforward as that. A case study by ecologists from ETH Zurich in a coffee-growing area in India reveals that pollinating insects are just one production factor among many. Farmers have several possibilities to

increase their harvest.

All over the world, bees are dying and insect diversity is dwindling. Only recently, both the media and scientists expressed fears that insect pollination is in decline, which jeopardises food security. The (lack of) pollination has thus become a sound argument for the protection of species and natural habitats, and organic farming.

ETH-Zurich researchers from the group headed by Jaboury Ghazoul, professor of ecosystem management, set about investigating this argument by studying the influence of pollinator insects on coffee harvests in an agroforestry system at coffee plantations in the province of Kodagu in southern India. They also included soil and forest management, environmental factors such as water and soil fertility, and tree cover for the cultures in their study.

The research group thus obtained a different picture of the role of pollinators to the popular perception of this cultivation system of "no bees, no harvest". According to their findings, pollinator bees are merely one production factor among many and to some extent coffee farmers can increase the productivity of their plantations independently of the insects. The results of the study have just been published in the journal *PNAS*.

Important but not the only factor

"Pollinators are important for coffee farmers," stresses Ghazoul; "as far as effective coffee growing and increasing harvests are concerned, however, they are much less important than irrigation or liming, for instance." This encapsulates one of the central findings from coffee farming in the Kodagu province.

Coffee is grown in a traditional agroforestry system in the region. As

coffee plants must not be grown in direct sunlight, they are planted in the forest's undergrowth or the shade of large, isolated trees. The coffee plants all bloom at the same time after heavy rains between February and March and three species of bee pollinate the flowers: the giant honeybee Apis dorsata, Apis cerana and the solitary wild bee Tetragonula iridipennis. The giant honeybee is the largest and most important pollinator, forming large colonies and needing the thick branches of tall trees to bear the weight of their nest.

The giant honeybee (Apis dorsata) is the principle coffee pollinator. Credit: S. Krishnan / ETH Zurich

Greater yield through irrigation and limestone

In order to harvest more coffee, however, the farmers have got other options than merely banking on the work of bees, as Ghazoul discovered. They can increase the yield through liming, irrespective of bee density. And instead of relying on rainfall, it is worth the farmers' while to induce flowering with artificial irrigation. "It is particularly in a farmer's interests to irrigate his plantations at a different time to other farmers in the vicinity," says Ghazoul. After all, this will turn his plantations into bee magnets. This concentrated pollination increases the yield from the plantation enormously, the ETH-Zurich researchers reveal in their publication. It is a different story if the rain makes all the coffee plants in the region flower at the same time, however: the bees spread out over a wide area, the pollination is less effective and the harvest is poorer.

Trend towards deforestation

In an agroforestry system, the farmer also has another trick up his sleeve: felling trees or the forest to shed more light onto his coffee plants, which also increases the harvest. In doing so, however, he destroys the habitat of the giant honeybee (Apis dorsata).

A farmer who combines both courses of action is especially successful, initially unaffected by the disappearance of the large bees on his own plantation. Only when all farmers opt for this course of action do things take a turn for the worse. "From a plantation perspective, it makes sense to remove trees and increase yields," says the ETH Zurich professor. "But if every farmer goes for the same option, they will all suffer the consequences of poor pollination because the giant honeybee will disappear."

Sure enough, the researchers observed gradual deforestation in the Kodagu experiment area. Ghazoul is convinced that the farmers will lose Apis dorsata in the long run and thus – unless they take countermeasures – their valuable contribution towards coffee pollination. "It remains

unclear whether the other two species of bee could compensate for this loss." However, the farmers' predicament is not hopeless, he says. They could domesticate Apis cerana, a very close relative of the European honeybee, and place beehives on the plantations, which would guarantee the pollination service without becoming dependent on Apis dorsata. The drawback: this absolves the farmers from their responsibility for the forest and trees. "The farmers are thus free to decide whether they want to have trees on their land or not," stresses the ecologist, which spells bad news for nature conservation. "But good news for farmers. They have got possibilities to increase their harvest and sustain or even improve their existence."

Unexpected threat from exotic tree species

The traditional forest trees face another danger. Farmers often replace felled local trees with the exotic Australian silver oak (Grevillea robusta), which provides the coffee plants with the shade they need. Moreover, it grows quickly and has a straight trunk, which farmers can use to grow pepper as the spice can be harvested more easily on the trunks. The sale of pepper and wood from the silver oaks is a way for the farmers to supplement their income.

However, the farmers are increasingly beginning to realise that the exotic tree also has its drawbacks. For one, its leaves barely decompose, covering the ground and coffee plants and thus becoming a breeding ground for harmful fungi and bacteria. It might also influence the nutrient cycle, which one of Ghazoul's doctoral students is currently looking into. The silver oak leaves probably slows the nutrient cycle, preventing the coffee plants from receiving enough nitrogen in the long run, which eventually affects the harvest.

The example case of coffee growing in the province of Kodagu is interesting from a research perspective as it brings home how bees,

farmers, their farming methods and natural occurrences influence and depend on each other. In this respect, the insects are not the sole influential factor in this agricultural system.

Ten principles for the reconciliation of nature and humankind

Teaming up with other scientists, ETH-Zurich professor Jaboury Ghazoul has defined ten principles that should help reconcile the conflicting interests of agriculture, nature conservation and other stakeholders with regard to a sustainable agricultural land use. The principles, which were published in the journal *PNAS*, include training farmers in cultivation methods that can be adapted to changing conditions. Another principle advocates taking different levels into consideration for a landscape approach, namely the landscape level itself and the individual farm level. In the example case in India, another principle is significant: the clarification of rights and responsibilities. For instance, the cultivated land belongs to the local farmers but not the trees, which belong to the state. This can cause conflicts. The principles should help to use an approach geared towards the landscape.

More information: Boreux, V. et al. Interactive effects among ecosystem services and management practices on crop production: Pollination in coffee agroforestry systems. *PNAS*. 2013 May 21;110(21):8387-92. doi: 10.1073/pnas.1210590110. Epub 2013 May 13.

Sayer, J. et al. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *PNAS* 2013 110 (21) 8349-8356; published ahead of print May 21, 2013, doi:10.1073/pnas.1210595110.

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