Wild pollinators increase crop fruit set regardless of honey bees

Summary

A recent study, published in *Science*, highlights the importance of the interaction between wild pollinators and production of animal-pollinated crops. An international research team of 50 authors led by Lucas A. Garibaldi (Universidad Nacional de Río Negro - CONICET, Argentina) analysed the consequences of the abundance of wild pollinators for crop pollination. Pollination is a fundamental step in plant reproduction, and can therefore influence harvest of crops such as fruits, seeds, nuts, or stimulants like coffee. The study includes field data from 20 countries and 41 crop systems. The research team found that the benefits of pollination by wild insects to the number of fruits or seeds produced per flower cannot be replaced by managed honey bees. Both wild insects and honey bees are needed to maximize fruit set. Therefore, the ongoing loss of wild insects in many agricultural landscapes likely has negative consequences for crop harvest. These findings prompted an urgent call to maintain and manage pollinator diversity in agricultural landscapes for long-term agricultural production.

Main text

Human survival depends on many natural processes, which do not have a direct market value, such as nutrient cycling, climate regulation, water purification, pest regulation and plant pollination. Paradoxically, changes humans have made to landscapes,such as conversion of natural habitat to human uses and agricultural intensification, can compromise these ecosystem services. Pollination of crops by wild insects is one such vulnerable ecosystem service, as wild insects are declining in many agricultural landscapes. Flowers of most crops need to receive pollen before making seeds or fruits, and pollen transfer can be enhanced by insects that visit flowers. These insects usually live in natural or semi-natural habitats, such as forest margins, hedgerows or grasslands.As these habitats are lost from cropping landscapes, pollinator abundance and diversity decline and crops receive fewer flower visits. The most important crop pollinators includes bees, beetles, flies, butterflies, birds and bats.

This paper focused on understanding whether the ongoing loss of wild insects impacts crop harvest. For this purpose, the researchers compared fields with abundant and diverse wild insects to those with degraded assemblages of wild insects across 600 fields at 41 crop systems on all continents with farmland. The study found that fruit set, the proportion of flowers setting seeds or fruits, was considerably lower in sites with less wild insects visiting the crop flowers. Therefore, losses of wild insects from agricultural landscapes will likely impact both our natural heritage and agricultural harvest.

As hives of the honey bee are frequently added for improved pollination, the researchers asked whether this application can compensate for limited abundance and diversity of wild insects and fully maximize crop harvest. They found that variation in honey bee abundance improved fruit set in only 14% of the crop systems they served. Furthermore, wild insects pollinated crops more effectively, because an increase in their visitation enhanced fruit set by twice as much as an equivalent increase in honey-bee visitation. Importantly, high abundance of managed honey bees supplemented, rather than substituted for, pollination by wild insects.These results hold even for crops stocked routinely with high densities of honey bees for pollination, such as almond, blueberry, mango or watermelon. Although honey bees are generally viewed as a substitute for wild pollinators, this study demonstrates that they neither maximize pollination, nor fully replace the contributions of diverse, wild-insect assemblages to fruit set for a broad range of crops and agricultural practices on all continents with farmland.

The results of this study reveal that new practices for integrated management of both honey bees as an agricultural input and diverse assemblages of wild insects as an ecosystem service will enhance global yields of animal-pollinated crops and ensure long-term agricultural production. These practices should include conservation or restoration of natural or semi-natural areas within croplands, promotion of a variety of land use, addition of diverse floral and nesting resources, and more prudent use of insecticides that can kill pollinators.

Quotes of the main authors of the study:

Lucas A. Garibaldi, Universidad Nacional de Río Negro - CONICET, Argentina: "Our study shows that losses of wild insects from agricultural landscapes impact not only our natural heritage but also our agricultural harvests. We found that wild insects

consistently enhanced the number of flowers setting fruits or seeds for a broad range of crops and agricultural practices on all continents with farmland. This service delivered by wild insects to agricultural systems occurred regardless of high densities of honey bees stocked routinely for crop pollination. Dependence on a single pollinator, such as the European Honey Bee, entails the risks associated with pathogen, predator and parasite development. Long term, productive agricultural systems should include habitat for both honey bees and diverse wild insects. Our study prompts for the implementation of more sustainable agricultural practices."

Luisa G. Carvalheiro (Naturalis): “This study shows that the productivity of a vast number of crops all over the world depends on wild pollinators. As the species sustaining the levels of agriculture production change from region to region and may also change through time, high levels of diversity are needed to insure future levels of crop production.”

Koos Biesmeijer (Naturalis): “De resultaten van dit onderzoek zijn ook zeer relevant voor de Nederlandse landbouw. Het ministerie van EZ ondersteund dan ook onderzoek aan de bijdrage van wilde betuivers aan de Nederlandse fruitproductie. Dit onderzoek waarbij naast Naturalis ook Alterra en EIS Nederland betrokken zijn zal zich in eerste instantie richten op appel- en blauwe besbestuiving.”

Koos Biesmeijer (Naturalis): “Deze studie geeft eindelijk overtuigend bewijs voor een belangrijke rol van wilde bestuivers voor onze voedselproductie.”

Koos Biesmeijer (Naturalis): “Voor productie van fruit en andere gewassen, afhankelijk van insecten, moeten we onze landschappen zo inrichten dat populaties van wilde bestuivers er goed kunnen leven”

Koos Biesmeijer (Naturalis): “Je zou het onderzoek kunnen samenvatten als: Beter tien wilde bijensoorten in het land dan één in een (bijen)kas. Honingbijen blijven belangrijk voor de landbouw, maar kunnen niet als enige oplossing gezien worden en vaak zelfs niet als de beste oplossing.”

Koos Biesmeijer (Naturalis): “De Nederlandse blauwe bessentelers weten dit al, daarom experimenteren ze naast honingbijen ook met hommels en metselbijen voor de bestuiving”

Alexandra-Maria Klein, Leuphana University of Lüneburg, Germany: “Ecosystem services can depend on biodiversity provided by wild organisms. Intensified agriculture separates crop production and biodiversity. Our study shows that this separation can have negative consequences for pollination services not buffered by honeybee management. We urgently need more research that informs but also involves the global and wider society to explore novel management designs for agricultural landscapes.”

Ingolf Steffan-Dewenter, Julius Maximilian University of Würzburg, Germany: "Our study demonstrates that pollinator diversity matters! Relying on the honeybee as a single, mainly managed, and in parts of the world introduced pollinator species seems a risky strategy, particularly as honeybees are also declining due to new pests and agricultural intensification. Long-term food security can be best achieved by maintaining and managing pollination services provided by nature. Thus, ecological improvement of crop production systems instead of conventional intensification should direct future agricultural policy."

Rachael Winfree, Rutgers University, New Jersey USA: "Our study challenges the widespread assumption that crop pollination services provided by wild insects can be replaced by a single domesticated species, the honey bee, without a loss in crop production. This will be a surprise to the agricultural establishment. Our findings also suggest that crop production is in many cases limited by lack of pollination and that production could be increased with better pollination management."

Marcelo Aizen, Universidad Nacional del Comahue - CONICET, Argentina: "Many common agricultural management practices seem to be based more on myth than sound scientific knowledge. The use of domesticated honeybee hives as the only source for crop pollination is one such a practice. It is immediate from our results that management of agricultural landscapes for increasing pollinator abundance and diversity makes not only environmental but also economic sense. Hopefully, our study will contribute to back local, national, and even supra-national regulations that ensure and promote spatial heterogeneity, particularly of intensively man-managed lands."

Saul Cunningham, CSIRO, Australia “All around the world people are looking for ways to make agricultural production more efficient. At the same time there is global concern that biodiversity loss is continuing at a dangerous rate. We need science to help solve these two challenges at the same time, and this research points in the right direction. It shows that maintaining biodiversity in agricultural landscapes supports agricultural production. For crop pollination this pattern is now clear. More generally it highlights that understanding how biodiversity underpins ecosystem services to agriculture is vital to our future.”

Claire Kremen "Beekeepers are already seriously challenged by diseases and pesticides that are causing large annual losses of honey bees. Growers that practice chemically-intensive monoculture agriculture must rely almost entirely on honeybees for crop pollination, since few native pollinators are found under such conditions. This study further reinforces the fact that honey bees on their own are a weak link in the chain from field to fork. Diversifying farm fields and landscapes to support our wild pollinators is critical to ensure food security."

Lawrence Harder, University of Calgary, Alberta, Canada "As the area of arable land is limited globally, the increasing demands for food by the growing human population require enhanced agricultural efficiency. Our study demonstrates that production of many fruit and seed crops that make diets interesting, such as tomatoes, coffee and watermelon, is limited because their flowers are not adequately pollinated. We also show that adding more honey bees often does not fix this problem, but that increased service by wild insects would help. Paradoxically, most common approaches to increase agricultural efficiency, such as cultivation of all available land and the use of pesticides, reduce the abundance and variety of wild insects that could increase production of these crops. Our study highlights the benefits of considering this paradox in designing and implementing agricultural systems."

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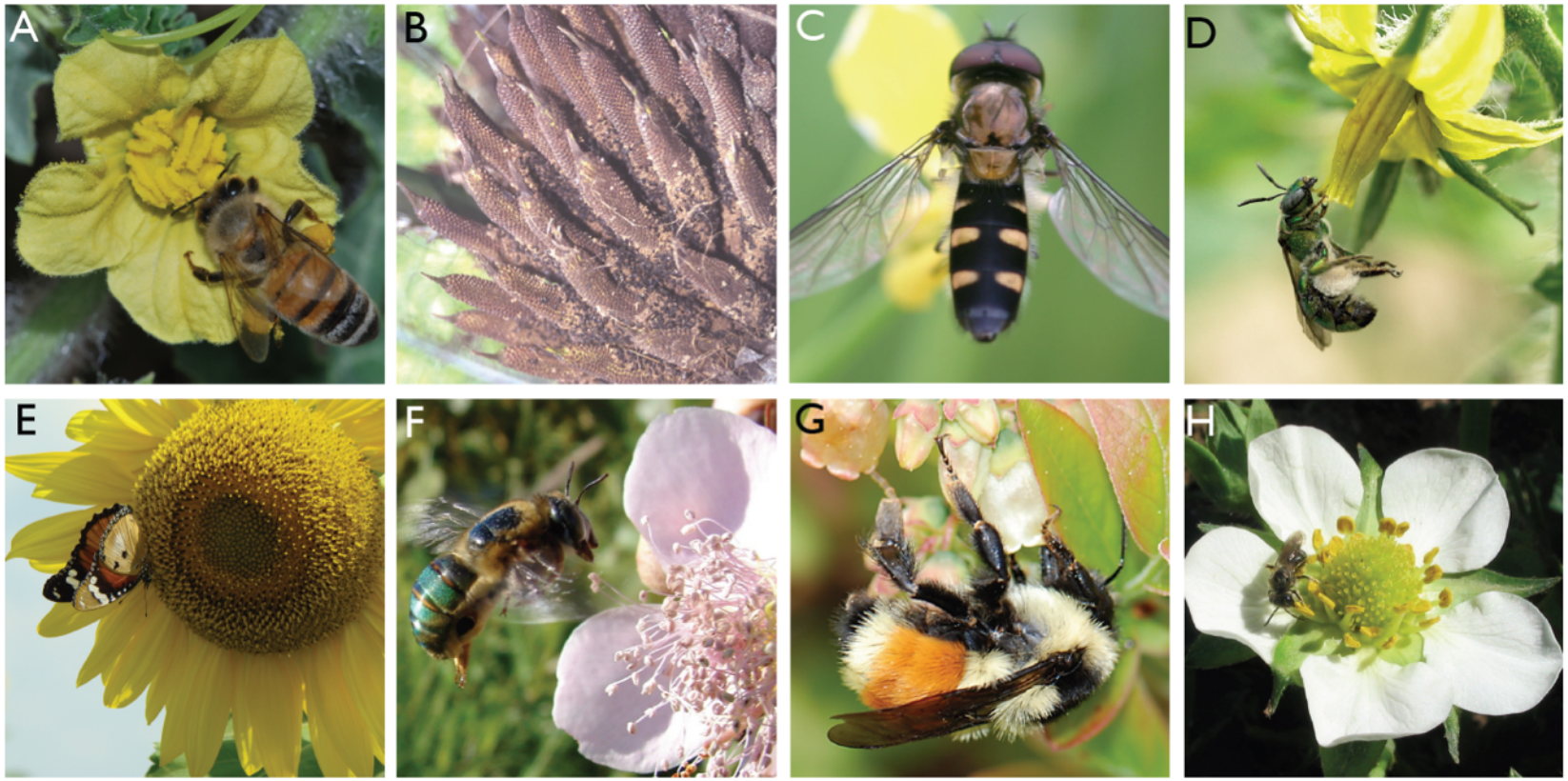
Ricketts T.H., Rundlöf M., Seymour C.L., Schüepp C., Szentgyörgyi H., Taki H., Tscharntke T., Vergara C.H., Viana B.F., Wanger T.C., Westphal C., Williams N., Klein A.M. Wild pollinators enhance fruit set of crops regardless of honey-bee abundance. Science

Multimedia

Examples of crops that depend on pollinators for higher yield. (**A**) Turnip rape field in New Zealand. (**B**) Coffee grown under native forest shade in India. (**C**) Highbush blueberry field with two cultivars that differ in their bloom phenology in USA. (**D**) Cherry orchard (after bloom; in the lower half of the picture) in a heterogeneous landscape in Germany. (**E**) Grapefruit plantation in Argentina. (**F**) Almond orchard with managed honey bees in USA. (**G**) Commercial lowbush blueberry field in Canada. (**H**) Watermelon field in Israel.



Examples of crop pollinators. (**A**) Honey bee (*Apis mellifera*) visiting watermelon, Israel. (**B**) Oil palm weevils (*Elaeidobiuskamerunicus*) visiting male oil palm flowers, Costa Rica. (**C**) New Zealand black hoverfly (*Melangynanovaezelandiae*) visiting Turnip rape, New Zealand. (**D**) Augochlorine bee visiting tomato, USA. (**E**) Diadem butterfly (*Hypolimnasmisippus*) visiting sunflower, South Africa. (**F**) *Oxaea* sp. hovering in front an annato flower, Brazil. (**G**) Orange-belted bumblebee (*Bombusternarius*) visiting lowbush blueberry, Canada. (**H**) Mining bee (*Andrenasubopaca*) visiting strawberry, Germany.