Food security not (yet) threatened by declining pollination

Peer-reviewed letter

Concern for food security has several roots, of which pollination deficiency resulting from supposed pollinator declines has received considerable publicity (Allen-Wardell *et al.* 1998; Kremen *et al.* 2002; Klein *et al.* 2007). Reports of widespread pollinator losses have raised public awareness of the importance of maintaining essential ecosystem services, such as pollination, which is often portrayed as being necessary for every third mouthful we eat (McGregor 1976; and widely repeated since). As an issue of food security this is, at the very least, alarming. Although we question the "third mouthful" concept, our purpose is not to evaluate its accuracy, but rather its implications: is food security threatened by declining pollinators, arising from land-use changes, specifically land-use intensification?

Arguably, land-use intensification is associated with declining pollinator services (Kremen *et al.* 2002). On this basis, we posit that increasingly intensive land use will cause pollinator-dependent crop production to increase at a slower rate than non-pollinator-dependent crops. We evaluate this hypothesis using UN Food and Agriculture Organisation (FAO) statistics spanning 15 years (1990–2005; WebTable 1). Several measures of land-use intensification relevant to declines in pollinator services have been suggested by previous researchers (Kearns *et al.* 1998; Kremen *et al.* 2002; Steffan-Dewenter *et al.* 2005; Dale and Polasky 2007; Klein *et al.* 2007). These include forest cover, crop diversity, and fertilizer use, which we adopt in our analyses. We also select rural population growth rates, tractor densities, and pollution as additional indicators of rural land-use intensification. The full dataset is available online (WebTable 1). We use national-level data to highlight the relevance of pollinator declines for regional and global food security. We recognize that a more disaggregated analysis will undoubtedly reveal much local variation that could be attributed in large part to pollinator responses, but our approach seeks to determine whether such responses scale up to issues of global or regional concern.

Our analysis of crop yield and land

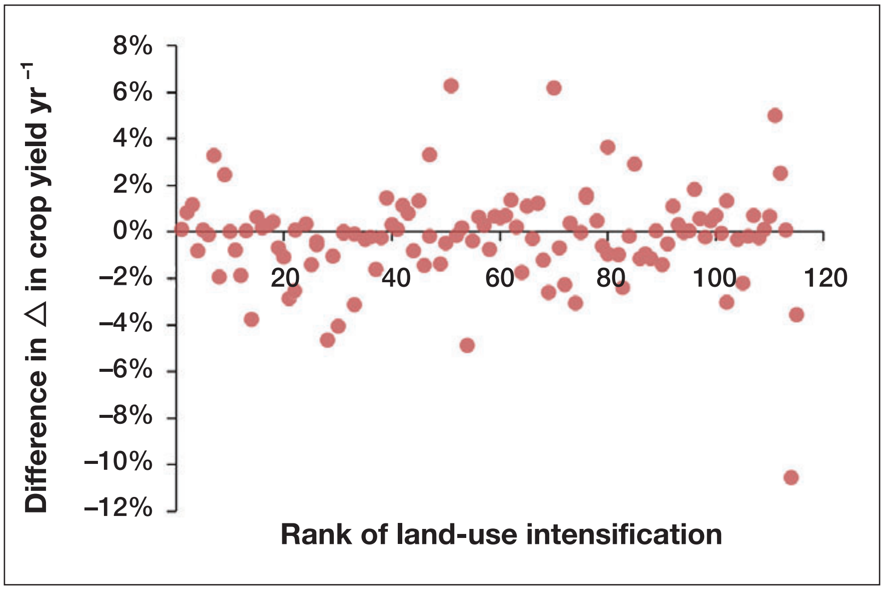

Figure 1. *Difference in annual change in yield between pollinator-dependent and non-dependent crops for 115 countries (non-dependent minus dependent), and their average rank orders for land-use intensification based on forest cover, crop diversity, rural population, tractor density, fertilizer use, and pollution between 1990 and 2005. Data for all variables were obtained from the UN FAO and the World Resources Institute (see WebTable 1 for further details).*

Table 1. List of 10 countries most vulnerable to catastrophic losses in agricultural productivity due to pollinator declines

	Land-use intensification (average annual % change)						*Exposure (%)*	
Country	*Forest cover*	*Crop diversity*	*Rural population*	*Tractor density*	*Fertilizer use*	*Pollution*	*Pollinator-dependent crops*	*Remaining forest*
Guinea-Bissau	–0.44	–11.23	1.85	–0.81	67.38	15.00	57.86	33.7
Benin	–1.95	1.28	1.95	na	9.35	10.26	11.68	3.5
Guinea	–0.62	0.17	1.68	0.03	40.41	18.21	15.68	5
Côte d'Ivoire	0.12	0.99	1.71	4.03	16.47	23.84	57.24	9.9
Ghana	–1.73	–1.88	1.25	–2.83	10.96	15.21	52.29	8.6
Honduras	–2.47	4.33	1.89	3.30	6.04	6.17	13.13	51.6
Malaysia	–0.44	–13.65	–0.08	na	2.43	7.43	78.94	63.8
Liberia	–1.49	7.33	2.15	0.04	na	14.89	17.90	44.2
Panama	–0.12	0.89	1.35	3.32	–2.32	34.30	10.16	62
Mauritius	–0.34	–0.13	0.71	3.38	–0.61	8.00	47.85	na

Notes: These countries were identified by first shortlisting 34 countries where at least 10% of total agricultural area was under pollinator-dependent crops. Within this subset, we considered the top 10 countries that have undergone the most intense land-use changes, as those most vulnerable to pollinator declines. Many of these countries also retain less than 50% of their original forests (far right column). Numerical values in the six left-most columns represent average annual percentage changes. Data for all variables were obtained from the UN FAO and the World Resources Institute (see WebTable 1). Complete and detailed raw data for all variables are available from the authors upon request. na = indicates datum not available.

use across 129 countries reveals no trend between various measures of land-use intensification and pollinator-dependent crop yields (WebFigure 1). Neither are there differences between pollinator-dependent and non-dependent crops in terms of yield responses to land-use intensification over time (Figure 1). In other words, this global analysis provides no evidence for differential susceptibility of crop production based on pollinator dependency. Taken at face value, this study suggests little cause for concern on issues of food security from a pollination perspective. However, there are reasons to be cautious in drawing such a conclusion, particularly given the coarse scale and the recognized limitations of FAO statistics; yet, until new and more reliable data become available, we feel that our conclusions warrant attention, since they are based on the best global dataset that is readily accessible.

These results are open to several possible interpretations, the most parsimonious of which is that land-use intensification does not cause pollinator declines. Unfortunately, we cannot test this directly, because data on pollinator population dynamics for most regions are limited or non-existent, and often equivocal when available (Biesmeijer *et al.* 2006). An alternative interpretation is that some pollinator groups are indeed declining (eg honeybees and bumblebees in North America and Europe), but that this does not impact crop production at national scales. This may be because other pollinator groups (including introduced pollinators, such as non-native honeybees) maintain a pollination function sufficient to maintain crop production trends (eg Ghazoul 2007). Perhaps declines are patchy and spatially coincident with intensively farmed non-pollinator-dependent crops, whereas areas dominated by pollinator-dependent crops retain habitat structure sufficient to maintain pollinator populations. Perhaps pollinators do not limit crop productivity, even after pollinator decline (Ghazoul 2005).

The absence of any negative impact of land-use intensification on crop productivity as mediated by pollinator availability (at national and global scales) is good news for food security, even if it undermines arguments for conservation. Such a conclusion may, however, be premature. It is possible that pollinator populations have not yet declined to the critical numbers at which crop productivity is impacted, but are following a trajectory, such that impacts will be realized soon. Although we do not necessarily believe this to be the case, our analysis does suggest that several countries are particularly vulnerable to such outcomes (Table 1). These are the "canaries in a coal mine" whose crop production systems have changed most radically toward intensification over the past two decades and that rely most heavily on pollinator-dependent crops. Such countries include Guinea-Bissau, Benin, Guinea, Côte d'Ivoire, and Ghana, where pollinator-dependent crops make up a large proportion of agricultural area (12–58%), intensification has been rapid, and more than two-thirds of the original forest coverage has been lost. If global food security is threatened by pollinator declines, then these countries might provide advance warning of impending problems elsewhere. For now, we take comfort that our analysis – despite its coarse scale – indicates no imminent decline in pollinator-associated crop productivity trends at global scales.

Jaboury Ghazoul* and Lian Pin Koh
Institute of Terrestrial Ecosystems, ETH Zürich, Zürich, Switzerland
**(jaboury.ghazoul@env.ethz.ch)*

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doi:10.1890/10.WB.001

Biodiversity effects in real ecosystems – a response to Duffy

Duffy (*Front Ecol Environ* 2009; **7[8]**: 437–44) attempts to justify the use of biodiversity–ecosystem function (BEF) experiments (ie in which organism diversity is experimentally varied and ecosystem response variables then measured) to look at how real ecosystems may respond to the loss of species. We do not agree with several aspects of the article, and believe it contains important omissions.

First, Duffy claims that recent meta-analyses show "surprisingly consistent" (positive) effects of diversity on functioning "across taxa, trophic level, and habitats". However, those analyses involved grouping together studies that are highly dissimilar in terms of duration, experimental approach, and range of species richness, so they may lack the statistical power needed to distinguish differences in diversity effects among organism types or habitats. Further, Duffy makes no mention of studies that have directly investigated diversity effects across contrasting environmental conditions