Mapping the dependency of crops on pollinators in Belgium

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Abstract

Background

Because of their pollinating activity, insect pollinators provide an ecosystem service that is essential to ecosystems and our economy. A large majority of the flowering plants we consume depends on it. In turn, the decline in pollinators observed for the last decades in Belgium as in many other European countries threatens agriculture and human well-being.

New information

Here we evaluate the pollination service at a country-wide scale through the estimated value of the contribution of insect pollination to the production used for human consumption in Belgium using crop dependency ratios. We then mapped the vulnerability of crops in the face of pollinator decline at the provincial level.

We show that the part of plant production for human food that we can attribute to the action of insect pollinators represents a value of about 251.6 million euros in 2010 in Belgium. As a result, 11.1 % of total value of Belgian plant production (in terms of fruit quantity and quality) depend on pollinators.

Although the applied method to assess the pollination service estimates only a minimum value of a single aspect of the pollination service, it allows to target the areas of the country where this service is particularly at risk and where it is necessary to define pollinator conservation measures to maintain, and possibly restore current yields.

Keywords

Crop, biodiversity, pollination service, dependency ratio, vulnerability index.

Introduction

More than 80% of flowering plant species in the world depend on pollinators, especially insects (mainly from Lepidoptera, Coleoptera, Diptera and Hymenoptera genera) to ensure their reproduction (Ollerton et al. 2011).

By pollinating wild and cultivated plant species (Klein et al. 2007), insects provide an essential regulation service with benefits to humans such as crop and honey production, weed regulation and other cultural benefits (Bretagnolle and Gaba 2015).

Many countries worldwide have encountered an overall loss of their wild pollinators for the last decades (Biesmeijer et al. 2006, Kosior et al. 2007, Carvalheiro et al. 2013, Senapathi et al. 2015). In Belgium, this loss was first recorded during the 1980s (Leclercq et al. 1980, Rasmont and Mersch 1988), in response to increasing agricultural intensification and urbanization. More specifically, several factors are generally mentioned to be responsible of the decline in pollinators (Goulson et al. 2015), including: climate change (Rasmont et al. 2015), the increase in agricultural land area, the homogenization of cultured species (Benton et al. 2003), the increasing use of chemicals (Blacquière et al. 2012), the reduction of (semi-)natural habitat area (Steffan-Dewenter et al. 2006Kremen and Chaplin-Kramer 2007), the loss of genetic diversity (Winfree et al. 2009, Maebe et al. 2012, Jha and Kremen 2013), parasite and pathogen development (Cameron et al. 2011, Arbetman et al. 2013) and the reduction of floral resources availability (Kleijn and Raemakers 2008 Lonsdorf et al. 2009, Goulson et al. 2015).

As a result, the decline in pollinators threatens the pollination service they offer (Winfree et al. 2011, Potts et al. 2016) and consequently ecosystem functioning (Biesmeijer et al. 2006 , Klein et al. 2007Potts et al. 2010Ollerton et al. 2011), human well-being and crop production Klein et al. 2007, Ricketts et al. 2008, Potts et al. 2010, Garibaldi et al. 2013). Indeed, 75% of cultivated plant species worldwide rely (more or less) on insects, particularly wild bees, for fruit and seed production (Klein et al. 2007).

The objective of this study is to evaluate the contribution of pollinators to Belgian crop production for human consumption so as to figure out how threatened it is depending on the area. This also makes it possible to discuss the relevance of certain agri-environmental measures taking into account these dependency relationships between crops and pollinators.

Materials and Methods

Methods

Our evaluation of the pollination service is based on a methodology established on a global scale by Gallai et al. 2009. This method has been already tested at a national scale (e.g., Guana, Nepal, United Kingdom, France) (Gallai and Vaissière 2009, Beyou et al. 2016).

Based on this method, the economic value of the pollination service is estimated by the contribution of pollinators to the market value of Belgian crop production intended for human consumption (Klein et al. 2007, Gallai et al. 2009). This calculation involves data on production price (P_{ij}, €/ton from FAOSTAT, 2010), quantity (Q_{ij}), tons from Belgian Federal Public Service of Economy (2010) (Function 1) and dependency on pollinator insects (D_i, % from Klein et al. 2007) (Function 2) of a crop $i \in [1, I]$ in a region $j \in [1, J]$ (Suppl. material 1). The dependency ratio D_i reflects the contribution of pollination to food production and corresponds to the quantitative relative loss of agricultural production that would be induced by the disappearance of pollinators. For example, cereal production dependency on entomophilous pollination is null (D = 0%) but it is essential to ensure the production of cucurbits (very high dependency, D = 90-100%) (Klein et al. 2007). The ratio between these two values quantifies the rate of vulnerability of crops to the disappearance of pollinator insects (Function 3).

$$PEV = \sum_{i=1}^{I}\sum_{j=1}^{J} P_{ij} \times Q_{ij}$$

Function 1. Total production economic value (€).

$$IPEV = \sum_{i=1}^{I}\sum_{j=1}^{J} P_{ij} \times Q_{ij} \times D_i$$

Function 2. Insect pollination economic value (€).

$$RV = \frac{IPEV}{PEV}$$

Function 3. Rate of vulnerability of crops (%) to pollinator insect disappearance.

Results and discussion

The results obtained by crop category at the national scale for the reference year 2010 are listed in Table 1. The computation of these indices at the provincial scale allowed their mapping (Fig. 1).

The rate of vulnerability of crops used for human food is about 11.1% at the national scale and ranges from 0.0% (Brussels Capital) to 41.1% (Limburg) at the provincial one. Even if these values of the pollination service depends heavily on our knowledge of pollination requirements which may vary between varieties and area (Gallai and Vaissière 2009), they have the advantage of giving an overview of the spatial heterogeneity of pollination demand in agriculture. This huge spatial variability is mostly due to the concentration of fruit crops in the northern provinces of Belgium (e.g., Limburg and Flemish Brabant where the RV > 20%). Some provinces are highly productive but are less dependent on pollinators (e.g., Hainaut, West Flanders) because they are dominated by cereal crops. Unfortunately, the lack of historical price data prevents us from comparing the 2010 results with the past situation. At this stage, it does not allow us to establish a trend at the national level.

It should be noted that products of some large Belgian crops (e.g., cereals, sugar beets) are not entirely used for human consumption (Delcour et al. 2014). However, it is very difficult to isolate the part of the production that is used as food, feed, fuel or fiber. This distinction could not be made in this study, leading to an underestimation of the proportion of food production that depends on pollinators.

Estimates of potential production loss would also be more realistic if taking into account the rate of decline of pollinators and their substitutability, but also changes in other factors than only pollinator decline. Currently this caveat cannot be taken into account in the production function proposed by Gallai et al. (2009).

The hypothesis of total disappearance of the pollinators which is behind these calculations is binding or even unrealistic. Although local extinction is feasible, it is unlikely to occur on a larger scale. Nevertheless, the mapping of these indices highlights the geographical distribution of the preservation issues of pollinators and show the importance of preserving pollinating activity to ensure the sustainability of Belgian agricultural production. In this sense, it could constitute a tool to aid decision to prioritize conservation measures of pollinators on Belgian territory, including the implementation of agri-environmental schemes (e.g., sown wildflower strips, high biological value meadows). They generally enhance species richness and abundance of major pollinator groups but not rare and/or declining species. Thus, they preserve the crop pollination service but their role in the conservation of threatened pollinator species is limited (Albrecht et al. 2007, Haaland et al. 2011, Scheper et al. 2013).

Conclusions

Although many of the largest production areas are independent on pollinators (cereals) and are wind-pollinated, a large portion of fruit crops (e.g., apple, pears, cherries) are potentially vulnerable to pollinator decline. Because insect pollination is the most effective natural pollination method, if it becomes insufficient, it can be replaced only by an action of man to maintain yields (Garibaldi et al. 2009). It is thus an essential agricultural input.

To better assess pollination service, more information is needed to understand how the dependency of crop production on pollinators varies, including in relation to crop variety, production area, and pollinator diversity and abundance (Hoehn et al. 2008, Winfree and Kremen 2009).

Despite its imperfections, this method used here has the advantage of being simple (to use and compare), robust, easily transposable to different scales and low cost. It shows the necessity to define policy recommendations in favor of the protection of pollinator insects (e.g., planting wild melliferous plant species) due to the high value of pollination service, particularly in the case of fruit crops. Yet, this value relates only to one aspect of the pollination service and therefore gives only a minimal value of it. It does not take into account for example its contribution to crop production not used for human consumption (forage and industrial crops, ornamentals), human health (essential micronutrients), pollinator patrimonial value (education, recreation, inspiration,…) or to wild plant species and landscapes conservation (IPBES 2016). It must also be borne in mind that our national economy also depends on the pollinating activity abroad on which certain imported commodities depend.

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Conflicts of interest

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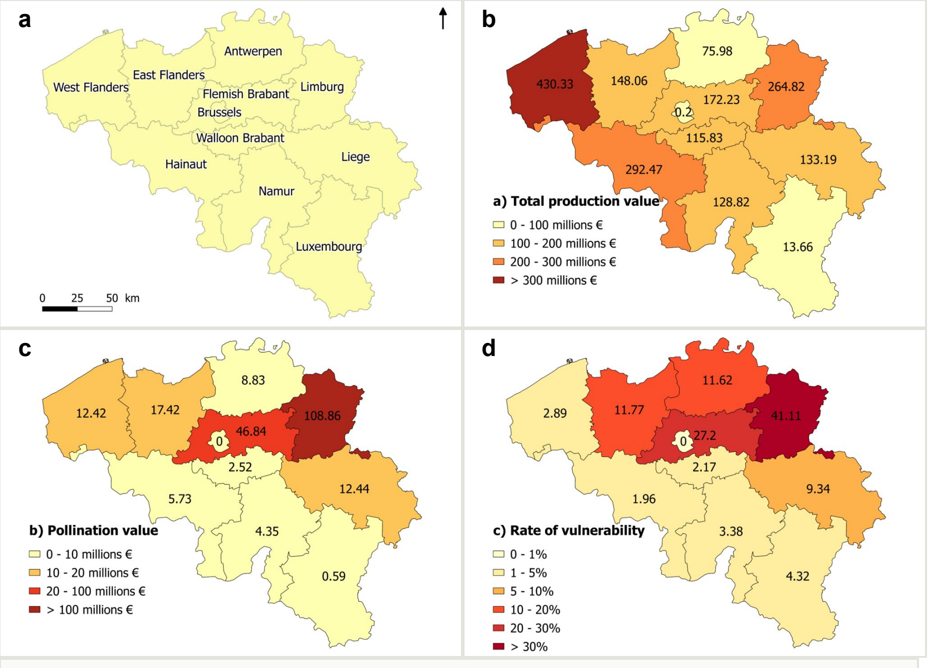

Figure 1.

Major crops whose products are used directly for human food per Belgian province (in 2010).

a: Belgian provinces

b: Total production value

c: Total value of insect pollination

d: Rate of vulnerability to the decline in pollinators

Table 1.

Total value of crop production (PEV, €), pollination service (IPEV, €) and vulnerability (RV, %) of crop categories used as human food in Belgium in 2010.

Crop category	Total value of crop production (PEV, million €)	Total value of pollination service (IPEV, million €)	Vulnerability index (RV, %)
Cereals	476.88	0.00	0.00
Fruits	320.41	205.27	64.06
Oilcrops	6.06	1.82	30.00
Pulse	1.57	0.17	10.97
Roots and Tubers	409.12	0.00	0.00
Stimulant crops	0.26	0.00	0.00
Sugar crops	119.21	0.00	0.00
Vegetables	992.50	44.37	4.47
Total	**2264.70**	**251.62**	**11.11**

Supplementary material

Suppl. material 1: Agricultural data and dependency ratio of crops on insect pollination used at Belgium scale in 2010

Authors: Floriane Jacquemin
Data type: agricultural data and dependency ratio of crops on insect pollination
Filename: appendix.pdf - Download file (150.37 kb)