Adaptation to a changing world :

How do wild bees cope with climate change

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Introduction

Wild bees are the main pollinators of many angiosperm plants [1]. Their decline [2] is thus worrying and its causes [3.4] need to be well understood to adapt mitigation strategies. Numerous scientific programs addressing these conservation issues are carried on all around the world. This is the case of the BELBEES project, dealing with apoids of Belgium. Among the potential decline factors, climate change might be one of the most important. Indeed, climate change may affect bees by inducing changes in their phenology (fig. 1). These changes could induce mismatches with the pollinated plants [5.6]. Very little is known about phenological shifts in bees whilst they are well understood for other pollinators such as butterflies [7] or hoverflies [8].This lack of knowledge is a consequence of the absence of long term phenological studies for wild bees around the world. However, new methods using museum data that are validated by scientists [9.10] now allow us to study bees phenology within substantial time series.

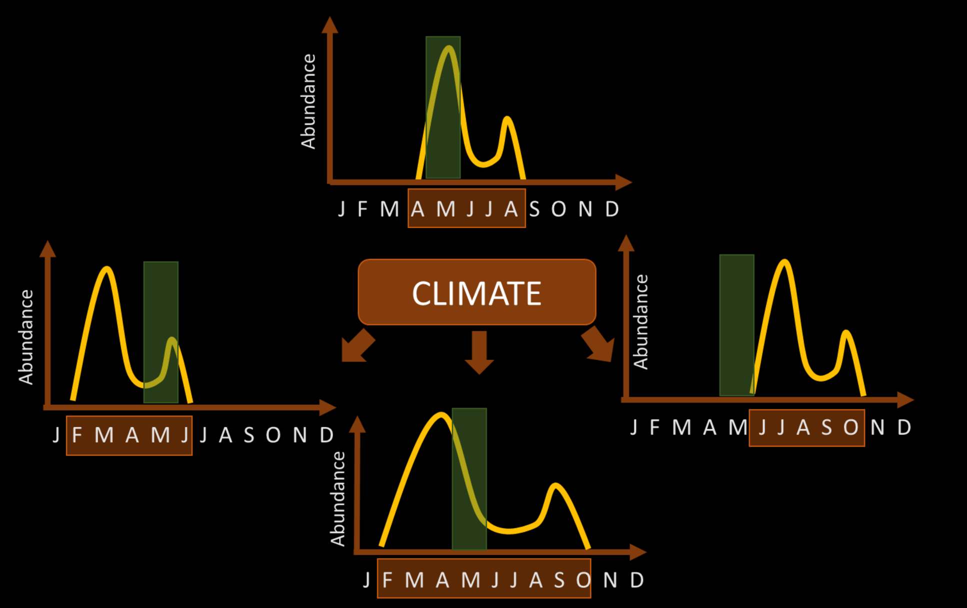

Fig. 1: This schema shows how climate may influence bees' phenology. It represents current and potential phenological diagrams of a virtual bee species. On present day (top diagram), the species phenology ranges from April to August. Climate change may induce an advance in phenology (right diagram), a delay in phenology (left diagram), or both (bottom diagram). These changes can have consequences on plant-pollinators interactions. Indeed, mismatches can occur between the bee and a pollinated plant (green squares) if the plants' phenology is not influenced in the same extend as the bees'.

The BELBEES project

BELBEES is a multidisciplinary assessment of Belgian wild bees' decline to adapt mitigation management financed by federal scientific policy BELSPO (Belgian Science Policy Office) over 4 years. This project gathers 5 Belgian laboratories and institutions (UNamur, UGent, UMons, IRSNB, Gembloux AgroBioTech) that investigate together hypothesis of wild bees decline in Belgium. Climate change is one of the examined theory, making bees' phenological shifts one of BELBEES research axis. In the end, the BELBEES project aim is to assess the respective role of all different factors in wild bees decline.

Fig.2 : BELBEES is a multidisciplinary assessment of BELgian wild BEES decline to adapt mitigation management.

Fig. 3: Visit the BELBEES website for more information on this project.

Fig. 5 : Female of *Colletes daviesanus* foraging on *Tanacetum vulgare*.

Aim of the study

Fig. 4 : Male of a wild bee of the genus *Eucera*, foraging on *Vicia sepium*. It is important to know the extend of bees' phenological shifts in order to study possible mismatches with pollinated plants. Indeed, mistiming would affect plant-pollinator networks and pollination services.

We intend to do a <u>**first assessment of the wild bees' phenological shifts that might have occurred since 1900 in some European regions, including Belgium**</u>. This is an important first step that will help us understand the extent of bees phenological shifts and its consistency among species and regions. This will also bring new information for the study of mismatches between bees and pollinated plants.

Once this assessment will be achieved, we will investigate the possible correlation with climate parameters, that might support the hypothesis of climate change influence on wild bees' phenological shifts.

We will also examine the link between phenological shifts and bees' traits such as sociality level, hibernation state, nesting type… The aim is to highlight patterns among bee species' phenological shifts. Indeed, generalization of the results would be very helpful to adapt conservation strategies to entire groups of species rather that to a few well known species.

Material and Methods

This study is based on long term data sets extracted from the BDFGM (*Banque de Données Faunique de Gembloux-Mons*) database. This database brings together 2,5 million data from 1750 to present day, spread through whole Europe. It includes now all European data from the FP7-STEP project (Status and Trends of European Pollinators). From preliminary analysis of these data, 19 bee species in 4 European regions (Belgium, England, Nederland, South of France) seem to have suitable time series for this analysis. Phenological changes will be studied for these model species through two different statistical methods. First, by working with generalized linear model with presence/absence data, a method that minimizes the collecting data biases [5]. Secondly, by working with non-parametric statistical tests such as Mann-Kendall test [11], a method that takes into account the variation in abundance of individuals during time periods. In a second time, climate parameters will be added to models. These climate parameters come from open source climate data (WorldClim), collaboration with other laboratories (UAntwerpen) and meteorological institutes (IRM, MeteoFrance...). The aim is to study various climate parameters that are biologically relevant for bees and that are accurate regarding the collecting sites. Eventually, we will introduce species' traits (sociality, hibernation stage, nesting type, phenology type) in our models and test if they have significant effect.

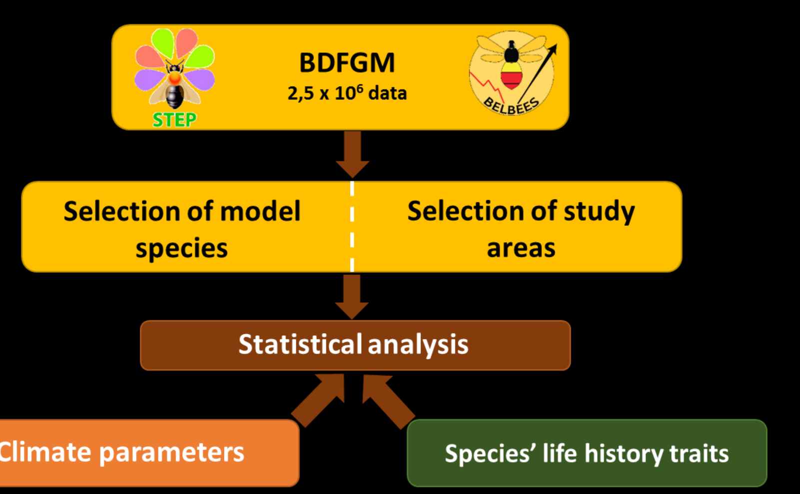

Fig. 6 : This diagram presents the different steps of our analysis. First, bee species and locations for which datasets and time series are consistent are to be chosen. Then statistical analysis will be performed in order to detect changes in bees' phenology across time series. Afterwards, climate parameters and species' traits will be included in models to determine if these show correlations with the bees' phenological shifts.

Perspective

There actually is a great difference in the phenology of social and solitary bees (fig. 6) that has to be considered. Wild bees (Apoidea) are historically little studied compared to others insects. This is why, amongst the 360 bee species in Belgium and the > 900 bee species in France, we only have subsequent datasets to study phenological changes for the most studied and common species. This represents about 20 species, that is to say 5% of the bee fauna of Belgium and less than 2% of the bee fauna of France. This underlines the importance of a generalization of our results to life traits which is the only chance to propose conservation strategies adapted to the whole wild bees' community.

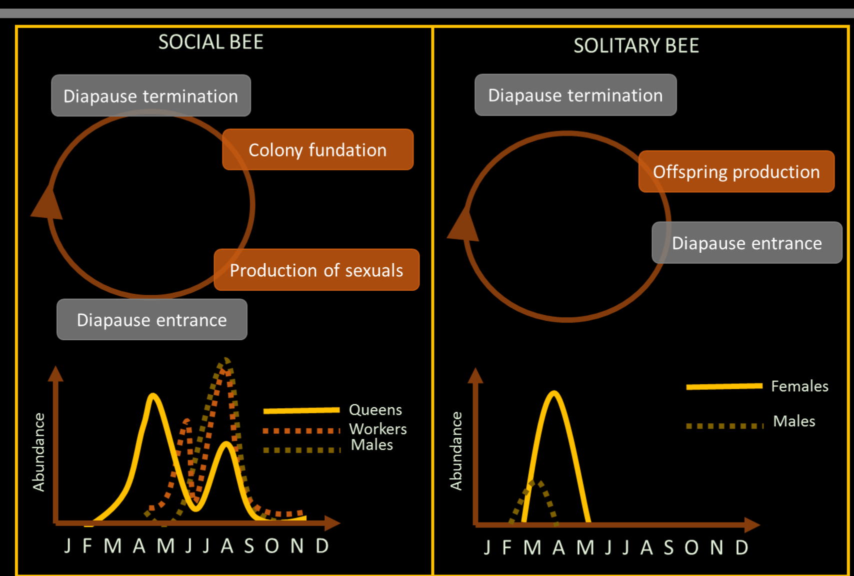

Figure 7: Comparison of the life cycles and phenologies of a social bee (*Bombus terrestris*) and solitary bee (*Andrena cineraria*).

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