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Using nutritional ecology as driver of pollen preferences in the ApisRam honey bee model

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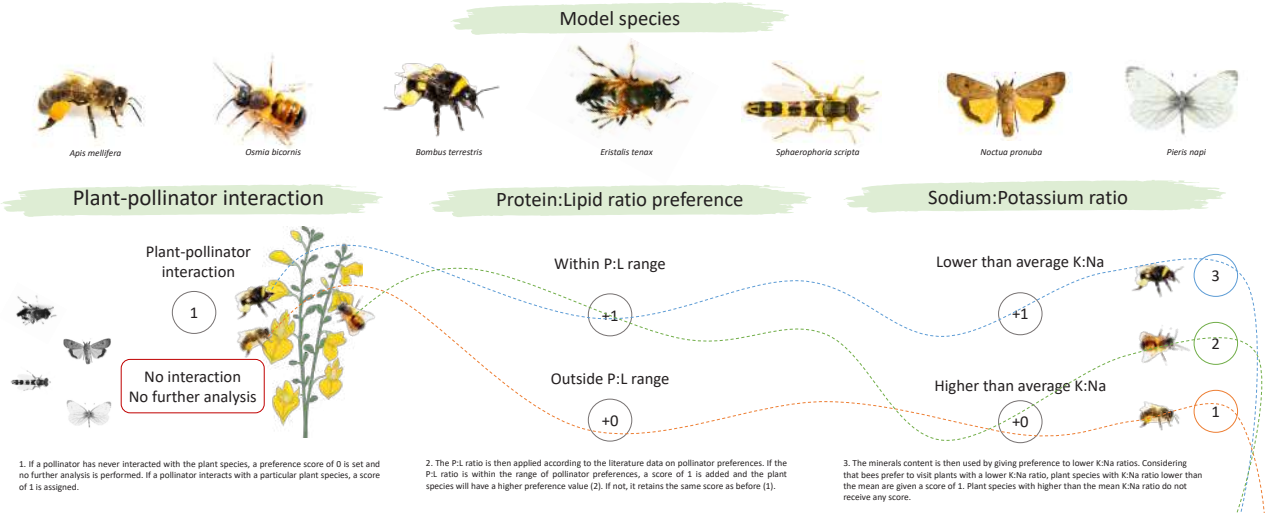
INTRODUCTION

The European Food Safety Authority (EFSA) aims to increase the complexity and realism of the Environmental Risk Assessment (ERA) of bees, to better protect these pollinators and their services. To achieve this goal, there is a need to develop models that capture our landscapes spatial and temporal heterogeneity. The ALMaSS is a system of spatially explicit agent-based/subpopulation-based models with a landscape simulation model for use in predicting the effects of human landscape management on a range of key animal species, including pollinators. In the system, several landscape layers are created based on ecological data. For pollinators, one of the most relevant layers is the food availability over time. At this moment, the system already integrates data on the amount of pollen, nectar and sugars produced by a single flower/inflorescence of a given plant species with information on flower/inflorescence abundance (i.e., density of flowers/inflorescences per unit area), flowering phenology, plant composition of the flora/habitat and flora/habitat composition and configuration within the ecosystem/landscape. This approach enables the spatio-temporal availability of floral resources to be predicted within different flora/habitat types and across different ecosystems/landscapes. Nevertheless, to predict landscape-specific pollinator carrying capacities, the pollinators' (agent) behavior and interaction with the virtual landscape also needs to be considered. In here we present a framework to drive these interactions based on the pollen quality for some model species and discuss its implementation within the ApisRam honey bee colony model, which is under development to be implemented by EFSA to increase the ERA realism.

METHODS & RESULTS

A **semi-qualitative scale from 0 to 3** was created to infer the pollinator pollen preference for each plant species that is currently in ALMaSS (total of 408 plant species). The scale follows a stepwise approach based on their possible interaction, and on their nutritional needs and preferences. Each plant species can have a score from 0 to 3, which determines the level of preference of the pollinator: 0 = no interaction, 1 = poorly preferred, 2 = moderately preferred and 3 = Strongly preferred.



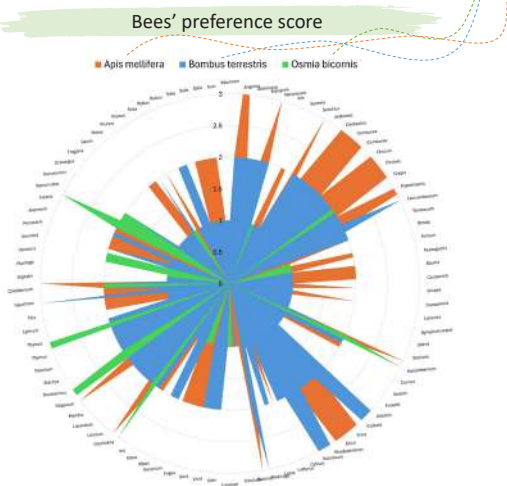
KEY MESSAGES

It is not possible to use the pollen quality strategy to set preferences for syrphids, butterflies and moths. Only for bee species, which collect pollen to feed their larva.

There are plenty of data on plant-pollinator interactions for most of the model species. The exception is *Noctua pronuba*. The organism's nocturnal behaviour makes it harder for researches and citizen scientists to register their interactions.

When considering only bees, 37% of the coded plant species are not visited by any of these pollinators, while 19% of them are visited by only one species. **Thus, possible competition** events between bee species can occur on the remaining **44% .**

Of the 230 species visited by *Apis mellifera*, a preference score of 3 was attributed to 32 species, a score of 2 to 118 species, and a score of 1 to the remaining 80. The implementation of these metrics in the ApisRam honey bee colony model can help to stir the bees (agents) interaction with the landscape.



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The most recent version of the guidance document on the risk assessment of plant protection products and bees (Apis mellifera, Bombus spp. and solitary bees), published by EFSA in 2024, has shown that measures are being taken to increase pollinators protection to the potential negative effects of PPPs. Nevertheless, there are still several drawbacks on the proposed scheme that increase its uncertainty. Adding pollinators' behaviour on top of the toxicity endpoints can reduce the risk assessment uncertainty. In other words, there is a need to add more Ecology into the (Eco)toxicology assessment, which can be achieved by the implementation of a system-based ERA in which the multiple interactions between the pollinators and the surrounding landscape are considered in a single system. To develop such a system, agent-based models of several pollinator species have been developed. These virtual pollinators interact with the virtual landscape and collect resources. For the collection of pollen, we have developed a methodology to classify pollen preferences according to the nutritional content of pollen. Important nutrients as proteins, lipids, potassium, and sodium are included in the strategy to classify pollen nutritional content. This strategy, based on nutritional ecology, was applied to set pollen preferences for Apis mellifera, Bombus terrestris and Osmia bicornis. In here, we show how in the honey bee model, ApisRam, forager bees change their behaviour on pollen collection, with and without, considering the pollen quality strategy. These preliminary simulations show how the nutritional content of pollen can be used to reduce the uncertainty of risk assessment by performing a better prediction of bee behaviour and its interaction with the landscape.