

Free-living populations of various subspecies of honey bees, *Apis mellifera* L., are vital pollinators, yet their abundance and conservation status remain poorly understood. There is a widespread belief that the introduction of the parasitic bee mite, *Varroa destructor*, from its native East Asian habitat to Europe led to the decline of free-living bee colonies, as bees are unable to withstand the parasite's invasion without human intervention. However, free-living bee colonies have been observed in various European countries, including Ireland, Poland, Germany, and Spain, primarily inhabiting tree cavities. These colonies can potentially be crucial in preserving local bee subspecies and populations, although information regarding their occurrence and density is scarce in Europe. The project aims to investigate the demography and genetic diversity of free-living bee colonies across Europe to gain insights into their dynamics and conservation requirements. Additionally, it seeks to assess the impact of managed bee colonies (bees from apiaries) on gene pools and the adaptation of free-living colonies.

Managed bee colonies are regularly treated with chemicals to combat parasites and diseases, leading to the assumption that free-living colonies cannot survive in the wild without similar treatment. Major honey bee diseases and pathogens, including *Varroa destructor*, American foulbrood, and *Nosema*, also raise concerns regarding the role of free-living colonies in their spread. Although the microbiomes and parasite burden of free-living colonies are not adequately documented, preliminary data suggest differences from managed colonies. Understanding these differences is crucial for understanding resistance to pathogens and implementing effective disease treatments. Therefore, insights gained from studying free-living bee colonies are essential for developing strategies to protect the well-being of honey bees, their environment, and potentially benefiting the beekeeping industry. The research project aims to investigate bees' adaptation to natural environments to promote more sustainable beekeeping practices.

The project brings together partners with expertise in ecology, evolution, honey bee morphology, genetics, microbiology, beekeeping, and nature conservation. Its objective is to understand where honey bees are found in the wild in Europe and the mechanisms enabling their survival in natural nesting places, such as tree cavities. We anticipate that honey bees capable of surviving without human intervention possess the genetic makeup suited for such environments. Local bees likely exhibit an increased ability to adapt to life in the wild without human intervention. Our research will examine the impact of climate, availability of nesting sites, and beekeeping intensity on the distribution and survival of free-living colonies. By employing a citizen science approach and locating bee nests based on field activity of forager workers ('bee hunting'), the project will assess the distribution of free-living bees across partner countries, focusing on forested areas along a latitudinal gradient from Iberia to Scandinavia. The study will explore family density, survival rates, correlations with climate, and variability in free-living population demography and their viability across Europe.

The genetic integrity of free-living honey bee populations is threatened by the introgression of genes from commercial breeds, especially the C evolutionary lineage. The frequency and impact of these interbreedings are unclear, making it challenging to assess the threat that beekeeping poses to free-living populations. Beekeepers typically select specific breeds of bees for breeding based on characteristics that may not favor survival in the wild, potentially limiting the adaptability of wild cohorts. The project aims to address these issues by examining genetic introgression in free-living colonies, potential adaptation to natural environments, and signs of adaptation to climate. We will analyze selection signatures in the genome, phenotypic variation, and patterns of infestation by parasites and pathogens in free-living and managed bees to understand the diversity of traits influencing survival in the wild. We will focus on ensuring that the acquired knowledge also benefits beekeeping. Additionally, we aim to improve stakeholders' perception of free-living bees, promote sustainable beekeeping practices, and protect endangered local honey bee biodiversity.