



DEPARTMENT OF BIOLOGICAL AND  
ENVIRONMENTAL SCIENCES

# TESTING THE RESILIENCE OF *APIS MELLIFERA MELLIFERA* WITH OTHER SUBSPECIES IN SWEDEN:

Nectar Sources, and Mismatches in Pollination  
Timing During Adverse Weather



**AAMIR FARAAZ**

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Supervisor: Åslog Dahl (Department of Biological and Environmental Sciences)

Examiner: Anne Bjorkman (Department of Biological and Environmental Sciences)



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## 1. Abstract

The European dark honey bee (*apis mellifera mellifera*) is one of several honey producing *Apis* species and is considered to be the most economically important globally, for pollination services as well as for honey production. It plays a vital role in maintaining biodiversity by providing essential pollination services to numerous wild plants and crops. Its role as a pollinator supports the reproduction of both cultivated and wild plants, which, in turn, contributes to the stability and resilience of ecosystems. This research aims to investigate the resilience of *apis mellifera mellifera* with other subspecies such as *Buckfast*, *carnica* and *ligustica* and also what kind of nectar sources are used by these subspecies and how adverse weather affects bees foraging in honey yield. Samples were collected from various parts of Northern and central regions of Sweden such as Södertälje, Arboga, Västerås, Östervåla. Pollens were then observed from 18 different slides to see the abundance of different flora, around 33 different types of pollen were found. *mellifera* showed a little more resilience as compared to other subspecies; its foraging diversity was also higher as compared to other subspecies. The reason could be that *mellifera* is adapted to this climate as compared to *Buckfast* which is a hybrid species and *carnica* which originates from balkan region.

This study helps us to identify the different subspecies behaviour in cold climates which in turn can help us to strategize for crop pollination stability, biodiversity support and bee conservation efforts particularly in Sweden.

## 2. Brief History

*apis mellifera mellifera* is believed to have originated in northern and western Europe and adapted to the colder, wetter climates of the region. As one of the primary honeybee subspecies, it evolved distinctively from other *Apis mellifera* subspecies, such as *apis mellifera carnica* and *apis mellifera ligustica*, through natural selection favoring resilience to northern climates. (Ruttner, F. 1988). For centuries, *A. m. mellifera* was the predominant bee used in northern Europe, especially in countries like Germany, France, and Britain. Its resilience to cold winters and ability to forage under low-light conditions made it highly suited to northern European landscapes (Crane, E. (1999).

## 3. Introduction

The European honey bee (*Apis mellifera mellifera*) is one of several honey producing species and is considered to be the most economically important globally, for pollination services as well as for honey production (Hung et al. [2018](#)). It plays a vital role in maintaining biodiversity by providing essential pollination services to numerous wild plants and crops. Its role as a pollinator supports the reproduction of both cultivated and wild plants, which, in turn, contributes to the stability and resilience of ecosystems. This is especially true in colder climates, where *apis mellifera mellifera* has evolved to be active at lower temperatures and in low-light conditions, enabling it to forage in weather conditions less suitable for other bee subspecies. Studies have shown that *apis mellifera mellifera* forages efficiently in areas with fluctuating weather conditions, which is crucial for pollinating native flora in regions like Scandinavia and the British Isles. This adaptability helps maintain ecological balance, as diverse plant species rely on consistent pollination to thrive. (Ruttner, F. 1988).

Agriculturally, *apis mellifera mellifera* is an essential pollinator for a wide range of crops. Crops such as apples, pears, and berries in northern Europe benefit from the pollination services provided by *apis mellifera mellifera*, which enhances crop yield and quality. By supporting agricultural productivity, this subspecies also indirectly contributes to food security, particularly in regions with challenging weather conditions.

The European dark bee's ability to forage during cold or rainy weather—when other bees might remain inactive—ensures that crops receive consistent pollination. This trait is highly advantageous in regions prone to sudden weather changes, such as northern Europe. (Crane, E. (1999). This resilience makes it particularly well-suited to regions like Scandinavia, where harsh weather can limit the foraging days for bees. (Meixner, M. D., et al. (2010).

The adaptive traits of *apis mellifera mellifera* are of particular interest to researchers aiming to develop conservation and management strategies that bolster bee populations against climate change.

### 3.1 Comparison of Foraging Behavior, Temperament, and Honey Yield in Four Key Honeybee Subspecies

Subspecies	Buckfast	Mellifera	Carnica	Ligustica
<b>Colony Temperament</b>	This species is known for extremely gentle behaviour (Bienefeld, 2009)	It can be defensive and quick to sting, tends to have high swarm impulse (De la Rúa et al., 2009).	Calm and non aggressive even during inspection (Hatjina et al., 2014)	They are also generally gentle (Genersch et al., 2010).
<b>Foraging Behaviour</b>	Forages early in the day, even in cool, wet, or windy conditions (Büchler et al., 2014).	Begins foraging later in the day and avoids poor weather. (Meixner et al., 2010).	Early and intensive forager, even under cool and cloudy conditions. (Ruttner, 1988).	Prefers warm and dry conditions; less effective in cold. Forages persistently but less efficient in early spring (Ruttner, 1988).
<b>Honey Production</b>	High Honey producer under under managed conditions. (Bienefeld, 2009).	Moderate produce best in colder and harsh climate. (Meixner et al., 2010).	High producers, particularly in early spring, due to rapid colony buildup (Szabo & Lefkovitch, 1991).	Produces high honey yields, especially during long nectar flows. (Harbo & Harris, 2001).

### 3.2 Nectar Sources and Challenges faced

Diverse access to nectars both ensures colony health, stable honey production, and is thus required for *apis mellifera mellifera*. However, unlike other honeybee subspecies, *Apis mellifera mellifera* has adapted to the seasonal and often scarce floral resources available in many northern continents. As their growing season is short and winters are unpredictable, it has to adapt to find appropriate sources of nectar/pollen to survive and be productive. Climate change affects the timing and duration of flowering seasons which in turn ultimately influences the availability of these resources. Studies indicate that regions with diverse flora better support *apis mellifera mellifera* populations due to the consistent access to various flowering plants, which buffer bees against periods when specific plants may not be available (Ruttner, 1988). One important problem for the *apis mellifera mellifera* of northern European lowland is the alignment of flowering of plants and flowering of bees. Instances like an unexpected sudden cold or prolonged rainy periods for illustration, can preserve bees in tidy outside for a lengthy time. This leads to mismatches in pollination timing, where bees are active either too early or too late relative to the peak flowering times of essential plants and therefore can impact overall health and honey production. So in order to avoid this, access to food of good quality and sufficient quantity determines the development dynamics and the health of the bee populations (Nemati and Velayati, 2020, Parreño et al., 2022). *apis mellifera mellifera* represent an infrequent case of a single species naturally present across a wide range of latitudes. To successfully survive in the wide range of habitats where they naturally occur, as a result of the natural evolutionary process, honey bees have developed into many different geographical subspecies and into a wide variation of ecotypes (Ruttner, 1988; Whitfield et al., 2006). There is high variability in the diversity and quality of the available food resources ( Jachula et al., 2021), as well as in the distance from the hive that bees need to cover to collect food (Couvillon et al., 2014). When foraging time is restricted, bees may be forced to rely on less diverse or suboptimal nectar sources, which can lead to nutritional deficits. Over time, these deficits weaken colonies, reduce immunity to diseases, and lower the reproductive success of *Apis mellifera mellifera*. (Meixner et al., 2010).

Given the central importance of honeybees for ecosystem and agriculture support, interest in the resilience of *apis mellifera mellifera* to the environmental stresses in northern Europe is great. Traditionally, the European Dark Bee was adapted to cold and variable climates, thus making it an extremely important pollinator in regions where other subspecies are challenged by shorter seasons and adverse weather. In contrast, the augmented climate variability has introduced new stressors that disrupt the conservative pollination and reduce the density of high-quality nectar sources. Such changes may cause asynchrony between peak flowering times of key plants and

*apis mellifera mellifera* dependent on synchronized timing for appropriate nutrition and colony productivity.

These changes can have several important ramifications in terms of health and survival for *apis mellifera mellifera* populations, but to the ecosystems and farming systems relying on secure pollination services. In face of accelerating climate change, knowledge on the resilience of *apis mellifera mellifera*-especially in comparison to other subspecies of honey bees-is turning increasingly vital. Whereas *apis mellifera mellifera* has developed specific adaptations to forage in adverse conditions, how these compare to other subspecies with regard to environmental stressors, such as cold spells, rainfall, or seasonal mismatches in flowering, is not well understood. This paper, aims to investigate the resilience of *apis mellifera mellifera* compared to other honeybee subspecies in Sweden, in relation to the variety of nectar sources and mismatched timing of pollination under bad weather conditions. The present study investigates honey production, pollen content, and foraging behaviour of honey bees in a comparative analysis across subspecies with the aim of ascertaining whether *apis mellifera mellifera* has greater resilience under environmental stress. This thesis aims to investigate the following 1) The resilience of *apis mellifera mellifera* compared to other honeybee subspecies under environmental stressors 2) What differences exist in the variety of nectar sources utilized by *Apis mellifera mellifera* relative to other subspecies and 3) How do mismatches in pollination timing affect the foraging behavior.

#### 4. Methods

Samples of honey were collected from central and northern parts of Sweden mainly from Södertälje, Arboga, Västerås, Östervåla. The subspecies which were collected includes *mellifera*, *Buckfast*, *carnica*, *ligustica*. Pollen was extracted from honey samples using centrifugation method. For pollen extraction approximately 10 g of honey was dissolved in 40 ml of lukewarm distilled water with the addition of 1 ml safranin solution to stain and help visualize the pollen pellet. The mixture was stirred thoroughly, gently heated to aid dissolution (around 50°C), and then centrifuged for 6–8 minutes.

After the first centrifugation, the supernatant was discarded, and the pellet was resuspended in fresh water with another 1 ml of safranin. The solution was centrifuged again for 3–5 minutes. The remaining liquid was carefully removed, and the pollen-rich sediment was extracted using a Pasteur pipette. A microscope slide was labeled, and the sediment was spread evenly across the slide surface to distribute pollen grains uniformly. Excess water was allowed to evaporate if necessary. A coverslip was prepared with melted glycerin-gelatin and placed over the sediment, allowing the gelatin to flow and secure the preparation. Honey was collected from both early and late summer. Each taxon was categorized between early and late summer on the basis of when it was foraged. Early summer is defined as March to June, and late summer as mid-June to

September. This classification enabled assessment of phenological foraging range and resilience among subspecies.

#### **4.1 Calculation and Statistical Analysis**

Following pollen identification, all abundance data were converted to relative percentages per sample to account for variation in total pollen counts. For each sample, the proportion of pollen from early- and late-blooming plant taxa was calculated based on a phenological classification using Swedish flowering time data (SLU Artdatabanken). To assess phenological foraging flexibility, a Resilience Index was calculated for each sample using the following formula:  $\text{Resilience Index} = \frac{\text{Early} + \text{Late}}{\text{Early} + \text{Late}}$ . This index measures the balance of early- and late-season foraging, where values close to 0 indicate reliance on one seasonal group, and values closer to 0.5 indicate balanced foraging across flowering periods. Subspecies-level comparisons of the Resilience Index were performed using Kruskal-Wallis tests due to non-normality of the data.

A Principal Coordinates Analysis based on Bray-Curtis dissimilarity was conducted to visualize differences in pollen composition among subspecies and finally a bar plot of average nectar source diversity per subspecies was also generated to support the compositional trends observed in the PCoA.

In order to find the mismatch of pollination a bar plot illustrating the average use of Early vs. Late blooming plants by subspecies

## 5. Results

### 5.1 Resilience Index Across Subspecies

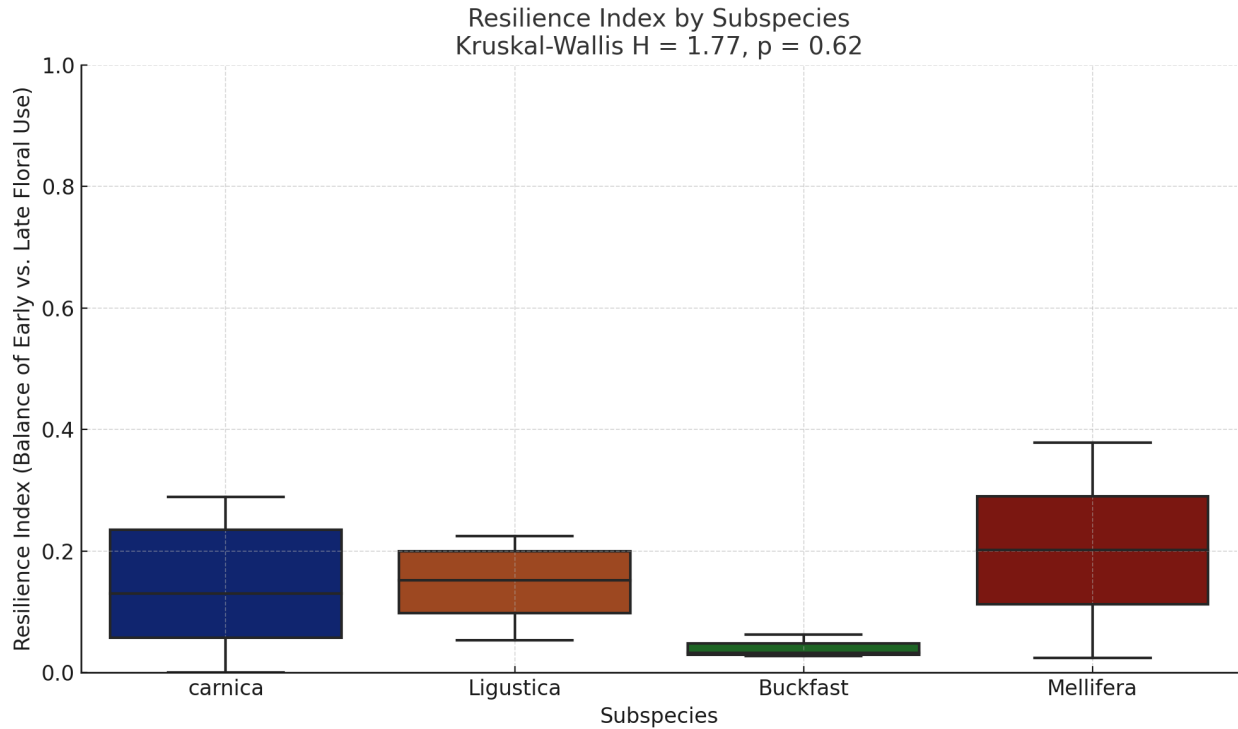


Figure 1: Boxplot of Resilience Index by Subspecies

This boxplot shows the range of the Resilience Index between subspecies, measuring the evenness with which bees foraged from early- and late-blooming flowers. Higher values suggest a more balanced foraging strategy, while lower values reflect a reliance on a single flowering phase. *Apis mellifera mellifera* exhibited highest median resilience index and consequently greater phenological foraging flexibility. However, the differences were statistically not significant according to a Kruskal-Wallis test ( $H = 1.77$ ,  $p = 0.62$ ), perhaps due to small sample size or between-group heterogeneity.

## 5.2 Principal Coordinate Analysis of Pollen composition

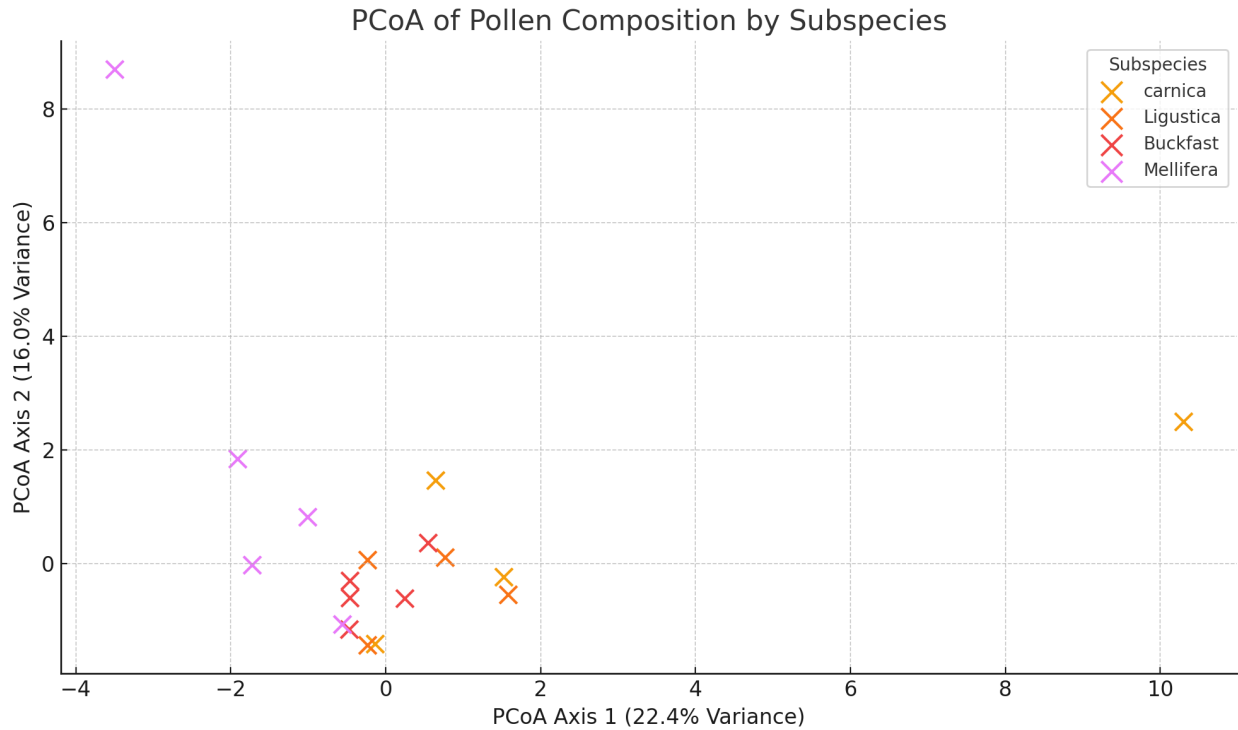


Figure 2: PCoA plot of pollen composition based on Bray-Curtis dissimilarity

The PCoA plot visualizes overall differences in pollen composition across subspecies. Points that are closer together have more similar floral foraging profiles, while those that are farther apart represent greater dissimilarity in the plant species used. Samples from *apis mellifera mellifera* are more widely spread, *mellifera* colonies collected pollen from a broader range of plant species possibly reflecting greater foraging adaptability across different landscapes or floral conditions. This suggests more diverse or opportunistic foraging behavior, which may reflect ecological resilience. In contrast, *Buckfast* and *ligustica* samples are more tightly clustered, suggesting more uniform foraging. *carnica* on the other hand indicates a little more diverse with one major outlier as compared to *Buckfast* and *ligustica* which suggest one colony may had access to unique floral conditions.

### 5.3 Floral Diversity in Nectar Source

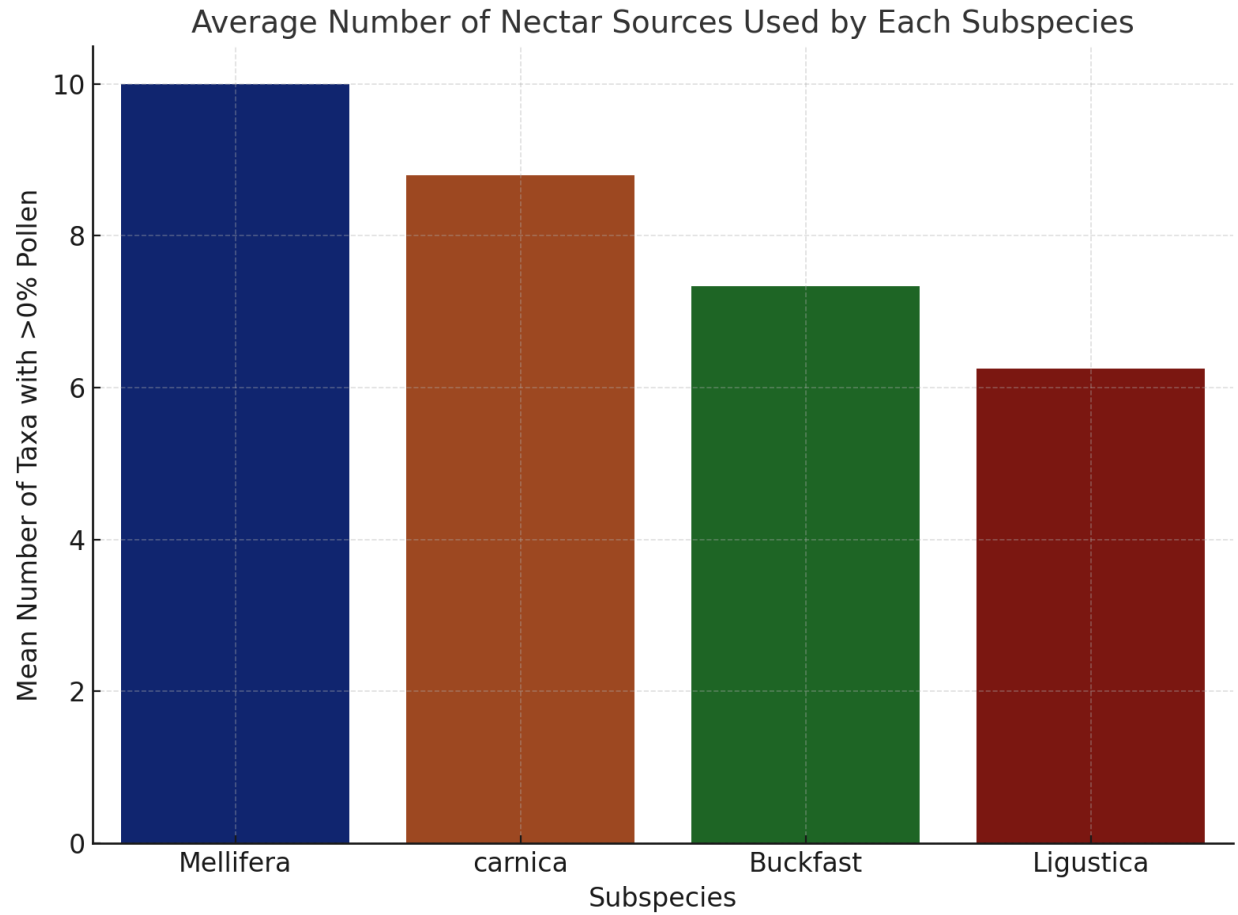


Figure 3: Floral Diversity in Nectar source

The graph shows the average number of taxa used by each subspecies for foraging based on the number of pollen types found in their honey samples (taxa with >0% abundance). *Apis mellifera mellifera* foraged on different plant species suggesting a more generalist and flexible foraging strategy. This bar plot aligns with the PCoA and supports the hypothesis that *mellifera* is more resilient to changes in floral availability.

## 5.4 Phenological Range of Foraging

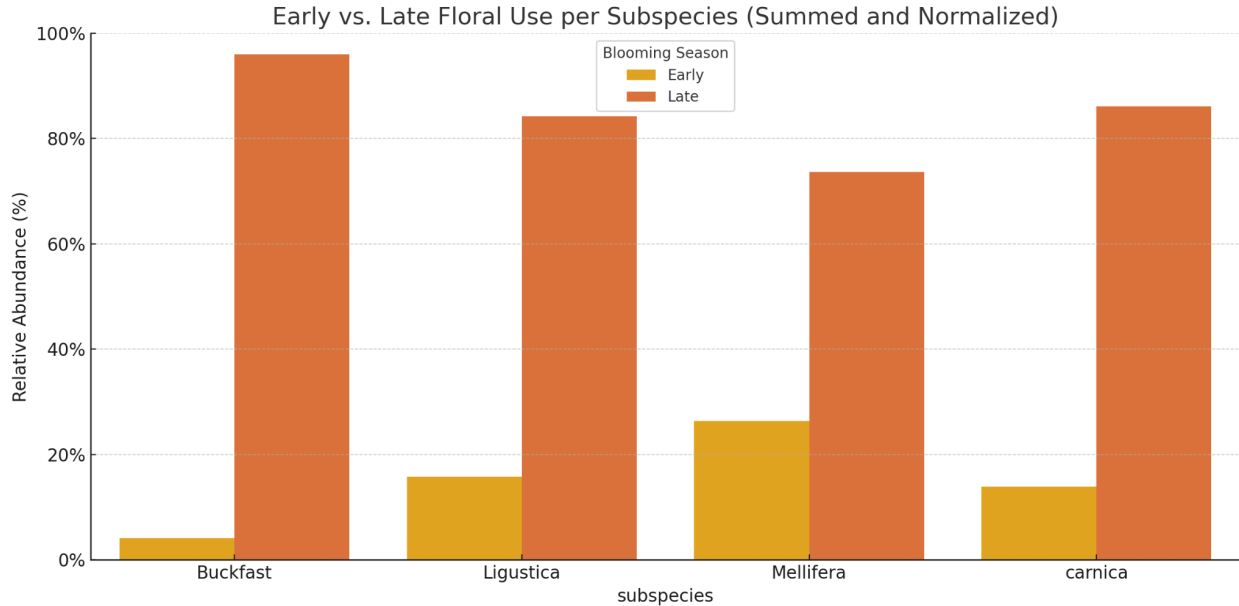


Figure 4: Bar Plot of Average Use of Early vs. Late Blooming Plants by subspecies

This bar plot compares the amount of foraging done by each bee species with respect to early and late blooming plants; it refers to the seasonal phase of the plant species they used. *Mellifera* subspecies exhibited more balanced reliance on both early and late bloomers while the other three species particularly *Buckfast* relied more on late bloomers. This supports the idea that *Mellifera* may be better suited to temporal variation in floral availability. *Mellifera* using both early and late bloomers are less likely to be dependent on one narrow floral window which also tells us that mismatches in adverse weather are unlikely to happen.

## 6. Discussion

This study investigated the foraging behavior of four *Apis mellifera* subspecies in Sweden *mellifera*, *Buckfast*, *carnica*, and *ligustica* by analyzing the floral composition of honey-derived pollen samples. The aim was to assess differences in floral resource use, particularly across early- and late-blooming plants, as a proxy for ecological resilience under seasonal shifts.

The Resilience Index, which showed the balance between pollen from early and late blooming plant species, was highest on average for *Apis mellifera mellifera*. While the Kruskal-Wallis test revealed no statistically significant difference in resilience index across subspecies ( $H = 1.77$ ,  $p = 0.62$ ) maybe due to high within-group variation or the small sample size ( $n = 18$ ) but the overall trend suggests that *mellifera* may exhibit more balanced foraging behavior. This is particularly relevant in regions like Sweden, where climatic variability can affect bloom timing and floral availability. This gives us an idea that *mellifera* subspecies have a greater temporal foraging flexibility and their genetic background could also play an important role in this (Jensen et al., 2005).

The Principal Coordinates Analysis (PCoA) further supports this trend by showing greater spread among *mellifera* samples in the Bray-Curtis space, indicating broader variability in pollen composition. This dispersion implies that *mellifera* colonies forage from a more diverse range of floral sources, potentially reflecting a flexible and adaptive foraging strategy.

A bar plot of average nectar source diversity reinforced this interpretation, as *mellifera* also showed the highest number of unique plant taxa per sample. In contrast, *Buckfast* and *carnica* samples were more clustered and relied more heavily on late-blooming plants, which may indicate a narrower phenological foraging window. While not inherently disadvantageous, such specialization could present a risk under conditions of floral mismatch due to climate change.

Phenological Range of Foraging patterns indicate that all subspecies rely on late blooming plant season but a point to be noted here is *carnica* mostly forages on early blooming plants but the result tells us the exact opposite maybe because of the small sample size. This would then most likely reflect breeding foraging specialization *Buckfast*, for instance is bred to obtain lots of honey selectively, typically timed with late-season flows. This specialization, however, may reduce fitness in environments with floral phenology shifts or spring floral gaps (De la Rúa et al., 2009).

It is important to note some limitations. Precise sampling dates for honey collection were unavailable, limiting the ability to directly measure pollination timing mismatches. Instead, floral taxa were grouped into general "early" or "late" categories based on regional phenological data.

Furthermore, the relatively small sample size ( $n = 18$ ) may reduce the statistical power to detect subtle differences between groups.

## 7. Conclusion

The results of this study suggest that *Apis mellifera mellifera* may be more foraging flexible and resilient than the other honey bee subspecies in Sweden. This is reflected in its higher average resilience index, higher floral taxon diversity of taxa used, and larger pollen composition variation range. Statistical evidence was weak, but consistent trends across different analytical approaches suggest *mellifera* to be more adapted to handle phenological variation in flower resources. As for mismatch timing, *mellifera* subspecies may be less prone to mismatch as shown in Fig. 4 due to its reliance on both early and late blooming plant species.

These findings promote the potential value of conserving or promoting native *mellifera* subspecies in climates with increasing climate uncertainty. Additional research with more samples, accurate sampling dates, and environmental metadata is recommended to determine the reproducibility of these results and improve understanding of phenological resistance in honey bees.

## 8. References:

Ruttner, F. (1988). *Biogeography and Taxonomy of Honeybees*. Springer-Verlag.

Crane, E. (1999). *The World History of Beekeeping and Honey Hunting*.

Meixner, M. D., et al. (2010). "Apiculture and honeybee conservation: Conservation strategies for native honeybee populations in Europe."

Kudo, G., & Ida, T. Y. (2013). "Early onset of spring increases the mismatch between plants and pollinators."

Hung et al., 2018 . "The worldwide importance of honey bees as pollinators in natural habitats"

Nemati and Velayati, 2020. "Environmental determinants and bee health".

Parreño et al., 2022 "Temporal and spatial distribution of flowering plants and their impact on honeybee health"

Jachula et al., 2021 "Impact of floral diversity on bee foraging behavior and honey quality".

Couvillon et al., 2014 "Assessing honey bee foraging and colony health by analyzing waggle dance."

Bienefeld, K. (2009). *Reproductive traits of honey bee queens and drones*. In *Beekeeping and Bee Conservation* (pp. 56–68)

De la Rúa, P., Jaffé, R., Dall'Olio, R., Muñoz, I., & Serrano, J. (2009). *Biodiversity, conservation and current threats to European honeybees*. *Apidologie*, 40(3), 263–284

Hatjina, F., Costa, C., Bontempo, L., et al. (2014). *Population structure and genetic variability of honey bee colonies from Greece*. *Journal of Apicultural Research*, 53(1), 157–165.

Genersch, E., Von der Ohe, W., Kaatz, H., et al. (2010). *The German bee monitoring project: a long term study to understand periodically high winter losses of honey bee colonies*.

Büchler, R., Costa, C., Hatjina, F., et al. (2014). *The influence of genotype and environment on the development of European honey bee colonies*. *Journal of Apicultural Research*, 53(2), 205–214.

Harbo, J. R., & Harris, J. W. (2001). *Resistance to varroa destructor (mesostigmata: Varroidae) when honey bees are bred from colonies that have survived infestation*. *Journal of Economic Entomology*,

Szabo, T. I., & Lefkovitch, L. P. (1991). *Effect of weather conditions and food supply on honeybee colony development and honey production*. *Canadian Journal of Animal Science*, 71(3), 617–627.

## **What Can a Spoon of Swedish Honey Tell Us About Bees Resilience in this adverse climate?**

### **Did you know that honey also tells us that how bees cope with changing seasons**

This became the focus of my research.

I collected honey from different parts of central and Northern regions of Sweden, I examined the pollen inside to compare the resilience of *Apis mellifera mellifera* which is native to the Northern region of Europe with other subspecies like *Buckfast*, *carnica* and *ligustica*. The honey tells us various aspects of bee such as the flower it visited, the season it thrived and how it adapted to challenges like harsh whether my goal was to examine that if *apis mellifera mellifera* has better resilience as compared to subspecies other or not.

### **Sweden Bees: A test of Nature's Timing**

In cold countries like Sweden, nature is strictly on a schedule. Flowers are briefly out of season, and the bees have to time their action with these flowering windows. If the timing is off let's say there is a sudden cold snap that delays flowering bees will miss a chance to forage or pollinate crops. Both flowers and bees can be harmed by this. In order to find out which bees manage this timing best, I compared various subspecies' foraging activity. I noticed what kind of flowers they tasted, whether they gathered pollen in the beginning or end of the season, and the diversity of diet.

### **Key Insights: *Mellifera* subspecies unique adaptability**

Among all subspecies, *apis mellifera mellifera* European dark honey bee stood out. It foraged from a wider range of plants and balanced its foraging activity between early and late blooming flowers. By this we can conclude that it is more resilient and can handle harsh whether condition as compared to other subspecies. Although the sample size was small but still the result showed that *mellifera* subspecies was more adaptable. If I talk about other subspecies they were more selective and focused more on late season. That could be risky in a warming world where seasons shift unexpectedly.

## **Why this Research Matters**

Apart from producing honey which has its own health benefits bees are silent architect of pollination about 75% of crops worldwide are pollinated through bees so if bees struggle so do we. Understanding which bees can thrive in challenging weather helps us protect biodiversity.

*apis mellifera mellifera* may hold the key to building climate resilience into our farming systems. Through this study we also get insights to how nature responds to a changing world.

## **Concluding thoughts: Let Natures Pollinators guide us**

Honey isn't just a food it's living evidence of biodiversity in bloom an evidence that how our ecosystem is changing. Specially mellifera subspecies which has shown high resilience in these climatic conditions. In order to protect the ecosystem we must protect the bees and we can do so by listening to their message, so we can learn how to take better care of nature and ourselves. Monitoring bees specially *apis mellifera mellifera* calls for greater investment in ecological research and the creation of biodiversity camps places where we can preserve them.