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Plant-based volatile organic compounds and their potential to deter spiders

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INTRODUCTION

Spiders are essential to ecosystems, playing a key role in regulating insect populations and maintaining biodiversity. Despite their ecological importance, human-spider interactions can often provoke **arachnophobia**, which affects **2.7% to 6.1%** of the global population. As spiders inhabit both natural and human environments, these interactions can lead to significant anxiety and fear. Therefore, finding natural spider repellents is crucial for mitigating these interactions and ensuring the safety of both humans and spiders. *Pardosa hortensis* was chosen as the model species due to their abundance and status as part of the second-largest spider genus in the world. Although they primarily reside in natural habitats, their locomotory behavior allows them to occasionally enter human environments. This study investigates the potential of 10 selected essential oils in repelling female *Pardosa hortensis* female spiders, addressing a gap in the current research on spider repellents.

CONCLUSIONS

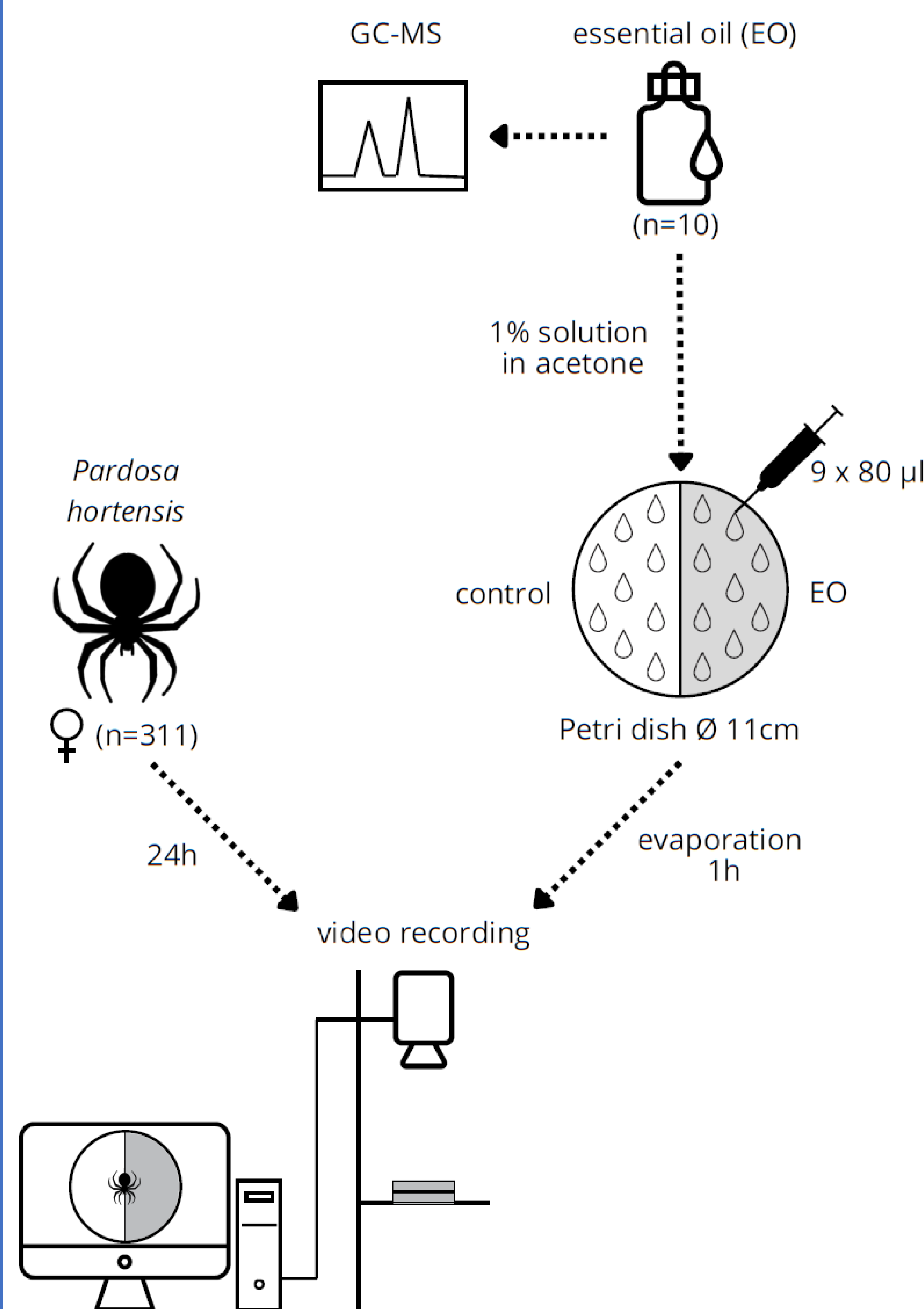
Our study demonstrates that five out of the ten examined essential oils - **catnip**, **cedarwood**, **cinnamon**, **citronella**, and **clove** - significantly influenced spider behavior, indicating their potential as **natural spider repellents**.

In contrast, peppermint, lavender, eucalyptus, tea tree, and lemon essential oils **did not exhibit repellent or attractant properties** for female *P. hortensis* spiders.

The strong repellent effects of these five essential oils could be attributed to their high concentrations of specific compounds such as **eugenol** (found in cinnamon and clove oils), **β-caryophyllene** (present in catnip, clove, and cinnamon oils), **geraniol** (found in catnip and citronella oils), and **cis-thujopsene** (in cedarwood oil).

These compounds have been previously shown to effectively repel other spider or insect species in various studies. Nevertheless, it is important to recognize that the effectiveness of these oils in deterring specific spider species may vary based on factors such as species diversity and the chemical composition of the substances used. Therefore, identifying a universally effective repellent for all synanthropic spider species remains challenging, underscoring the need for further research in this area.

METHODOLOGY



RESULTS

GC-MS analysis of the 10 essential oils identified a total of **113 organic compounds**. Tea tree essential oil contained the highest number of compounds - 38, while lemon essential oil had the lowest - 7. The primary constituents across most oils were **non-oxidized** and **oxidized monoterpenes**, which made up over 80% of the composition in most cases. Exceptions included cinnamon essential oil, with 51.1% monoterpenes, and cedarwood essential oil, which was predominantly composed of non-oxidized sesquiterpenes (75.1%) and oxidized sesquiterpenes (19.1%).

The results indicate that five out of ten tested substances display strong repellent properties against spiders, with no essential oil showing a significant attractant effect. Specifically, **cinnamon EO** (n = 32, p < 0.0001***), **clove EO** (n = 28, p < 0.0001***), and **catnip EO** (n = 31, p < 0.0001***) demonstrate highly effective repellent effects, achieving a Repulsion Index (RI) of 0.99, where 1 represents the maximum value. Significant repellent effects were also observed for **cedarwood EO** (n = 31, p = 0.001**) and **citronella EO** (n = 29, p = 0.001**), with corresponding RI values of 0.83 and 0.81, respectively.

Conversely, statistical analysis revealed no significant impact of the remaining five essential oils on spider behavior, as spiders exhibited a relatively even distribution between the essential oil and control sides (p > 0.178). Additionally, The presence or absence of cocoons carried by spiders had no significant effect on their behavior (p=0.019) and no interactions with EO were noticed (p= 0.092).

Repulsion Index (RI)

=

$$\frac{\text{number of pictures with spider on the control side}}{\text{number of all pictures}}$$

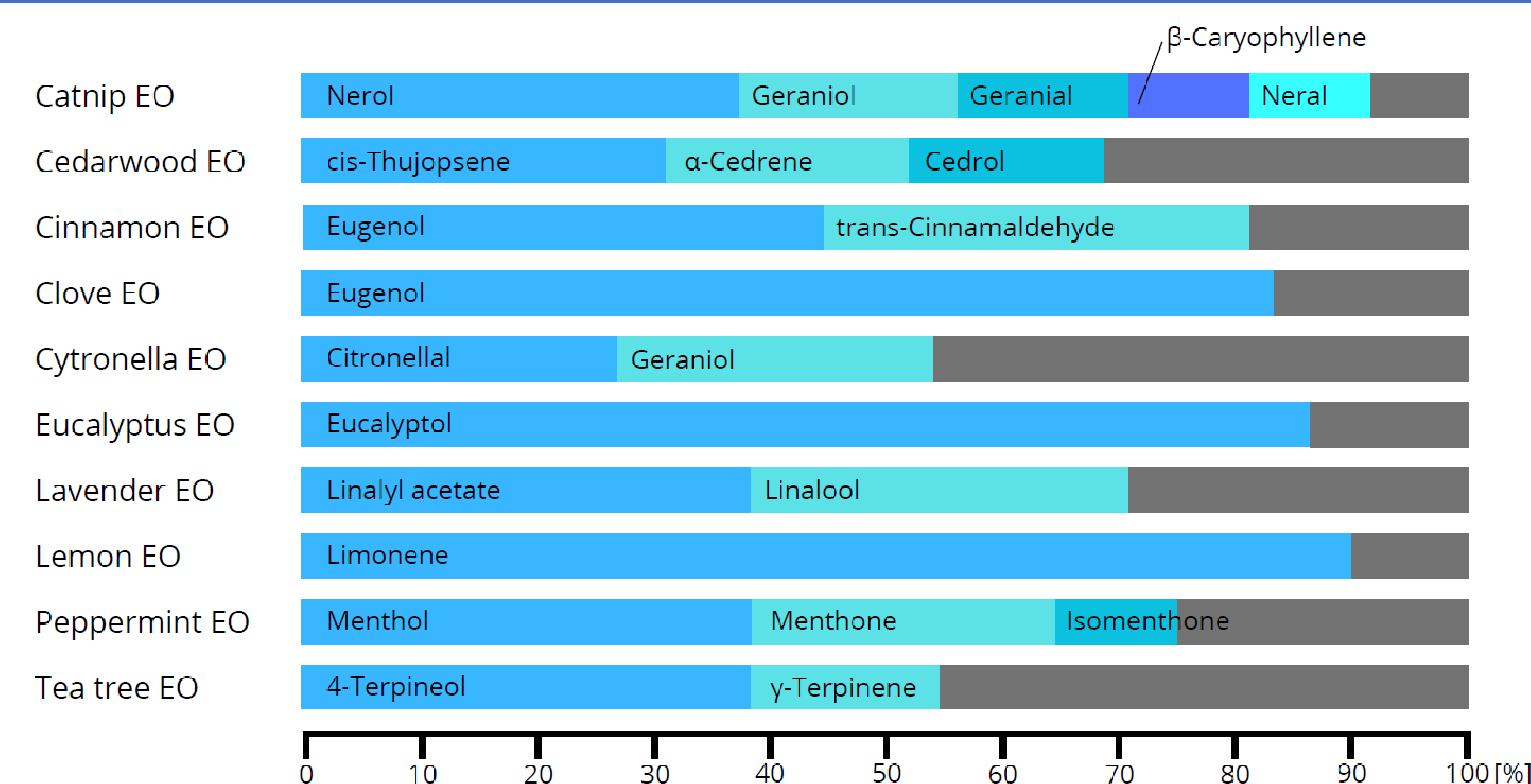


Figure 1. Diagram depicting the GC-MS analysis results, emphasizing compounds that make up more than 10% of the mixture. Compounds not individually specified are represented by gray shading.

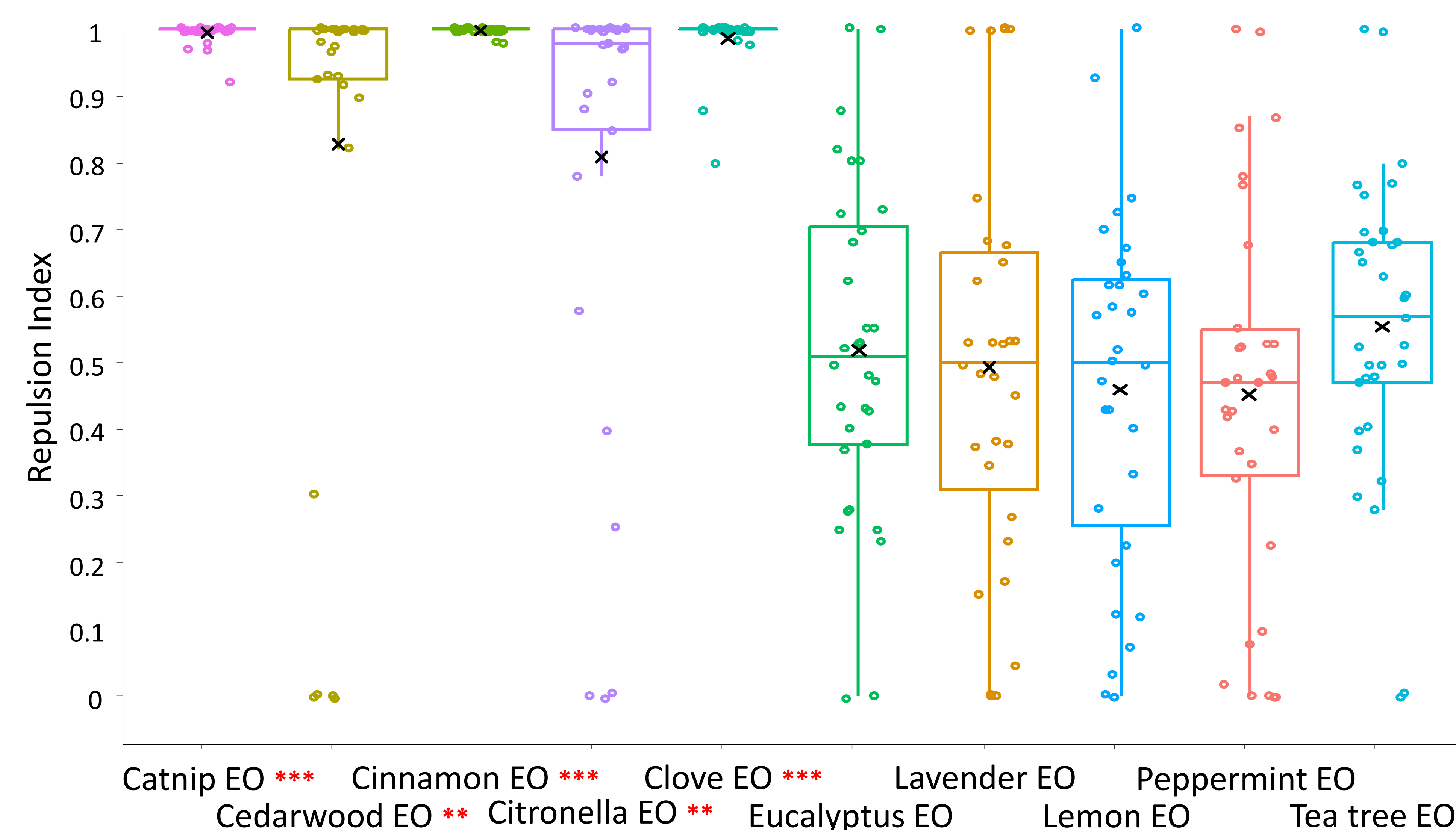


Figure 2. The repellent effect of 1% essential oil solutions (10 essential oils) on *P. hortensis* females (n=28-32). A higher Repulsion Index indicates a more effective deterrent activity against spider. Box plot shows the median, upper and lower quartiles, range, outliers (dots out of range), and means (crosses). Data were analyzed using a generalized linear mixed model (quasibinomial distribution) with the explanatory variables oil type. Factors such as presence/absence of cocoons, tested side, day of the test, temperature and humidity were found not significant and thus discarded from the final model.