

Bee Identification Using Computer Vision and Images of Induced Torpor

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Background

Pollinators support both native and agricultural plant communities, but populations are in decline worldwide

Pollinator identification is challenging and time intensive, requiring experts and meticulous attention to detail

Computer vision models have shown to be an effective method for cheap, efficient, and accessible identification

However, current models require training on large datasets containing images of pinned, deceased specimens

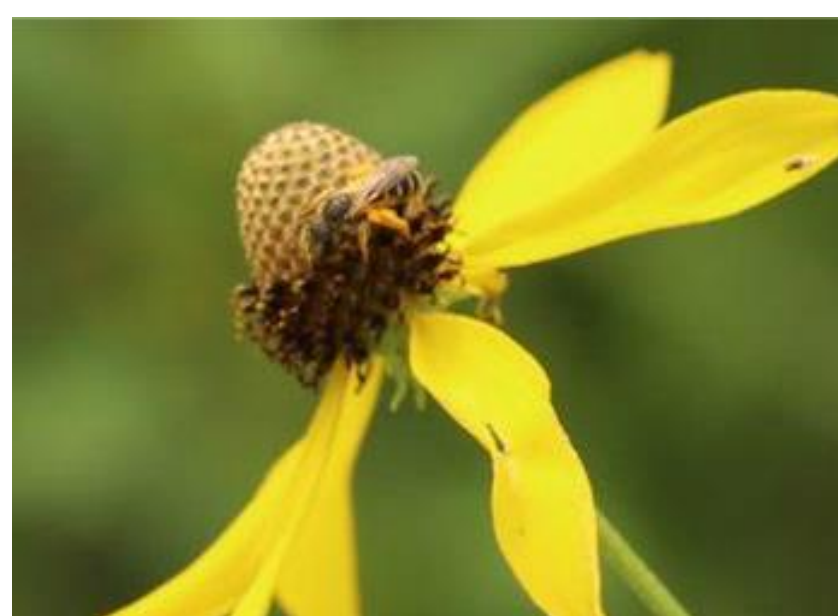
Therefore, our study assesses the potential of a model trained on images of live specimens, which are chilled to induce torpor

Objectives

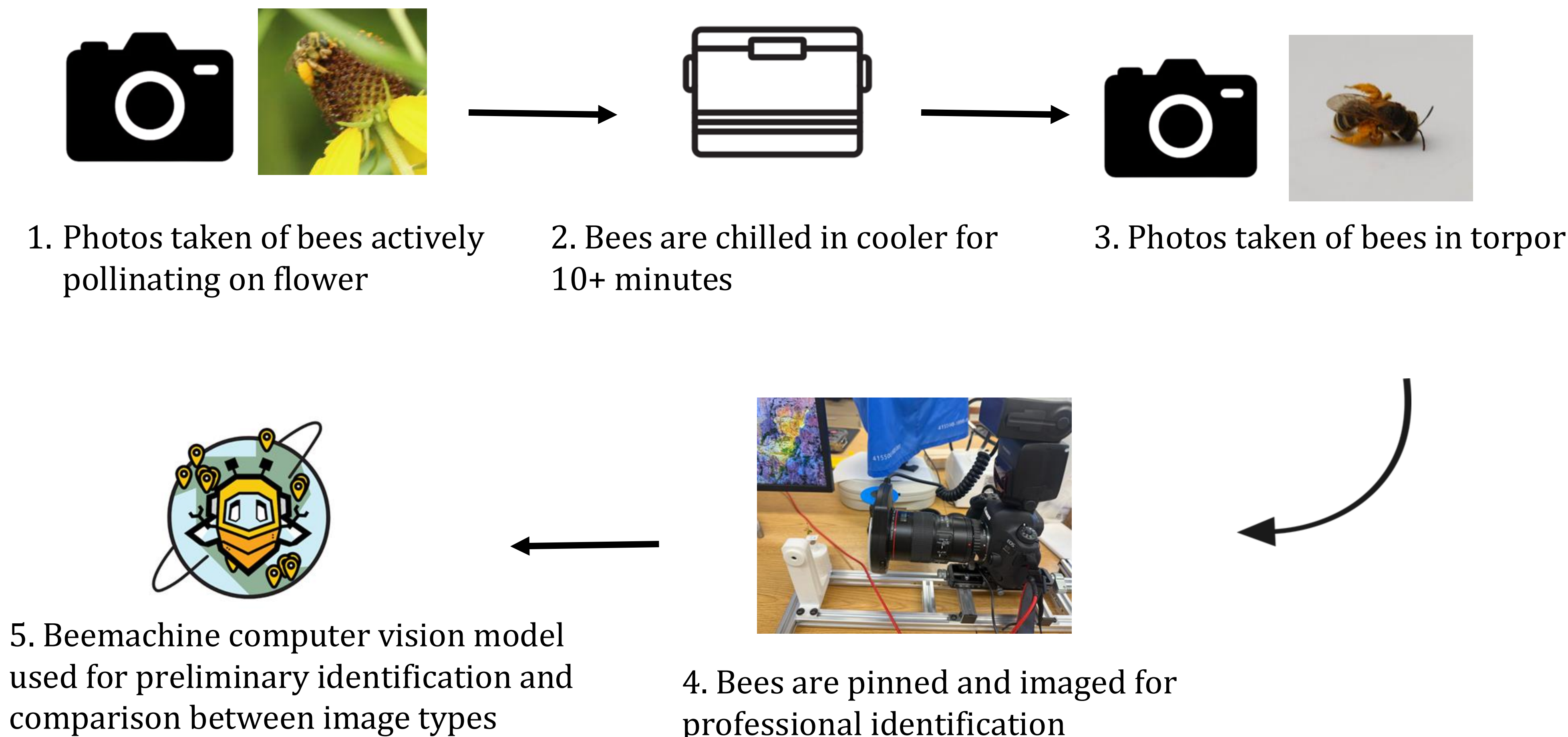
Our study investigates the success of a new method of pollinator identification using computer vision to analyze images of bees in torpor

If successful, this technology will be useful to researchers, land managers, and bee enthusiasts, making bee identification more accessible, while requiring less bees to be killed for research purposes.

This project will provide preliminary results for potential future, larger scale projects in the Spiesman lab



Methods



Results

Images were analyzed using the existing Beemachine model, and were compared with the model's **confidence**, which measures the estimated probability of the model's prediction being correct. Analyzing confidence allows us to assess differences in model performance among image types. Future analyses will be performed following expert identification of the specimens to determine overall precision.

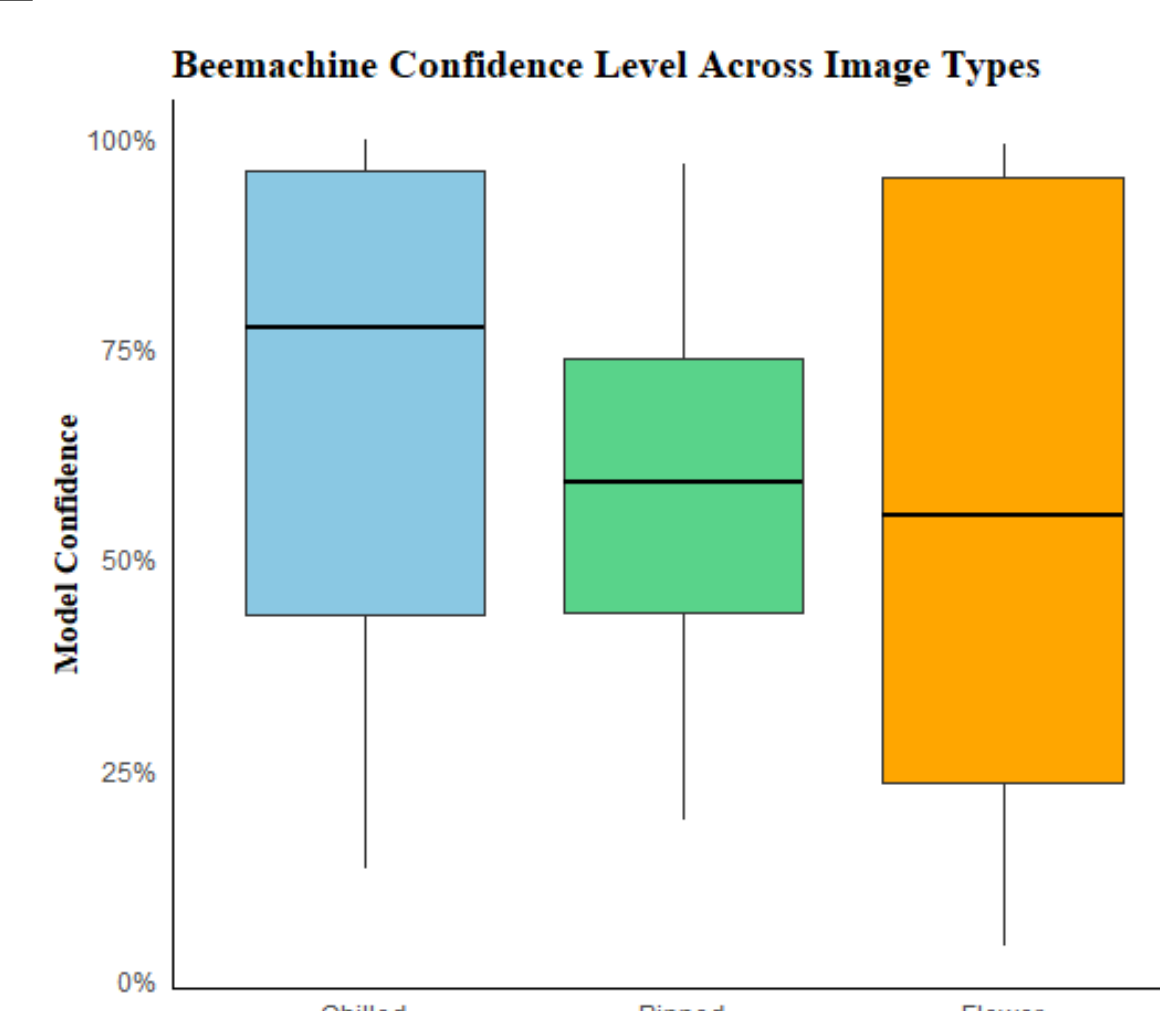


Figure 1: Mean confidence was analyzed for each image type. Linear mixed effects model found a significant difference between chilled and pinned image confidence ($p=0.0168$), as well as between chilled and flower images confidence ($p=0.0036$), while no significant difference was found between pinned and flower image confidence.

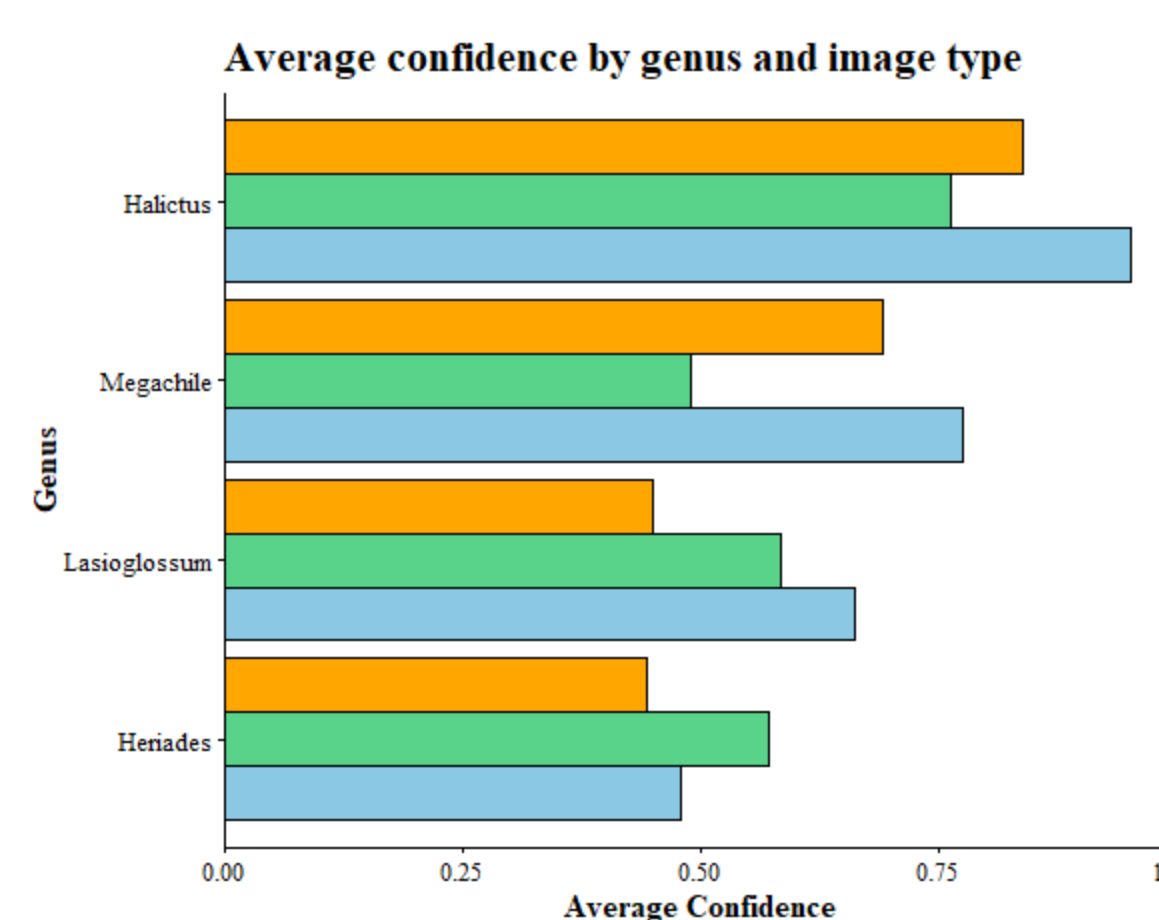


Figure 2: Confidence was averaged for each genus for which >3 individuals were collected ($n=4$). *Halictus* specimen showed the highest confidence levels, while *Heriades* showed the lowest.

Images were then analyzed based on **agreement**, a metric which for each bee specimen ($n = 88$), measures the number of total images of each type which matched the most common species identification. Agreement allows us to assess the consistency of model predictions among image types.

Agreement between flower, chilled, and pinned identifications

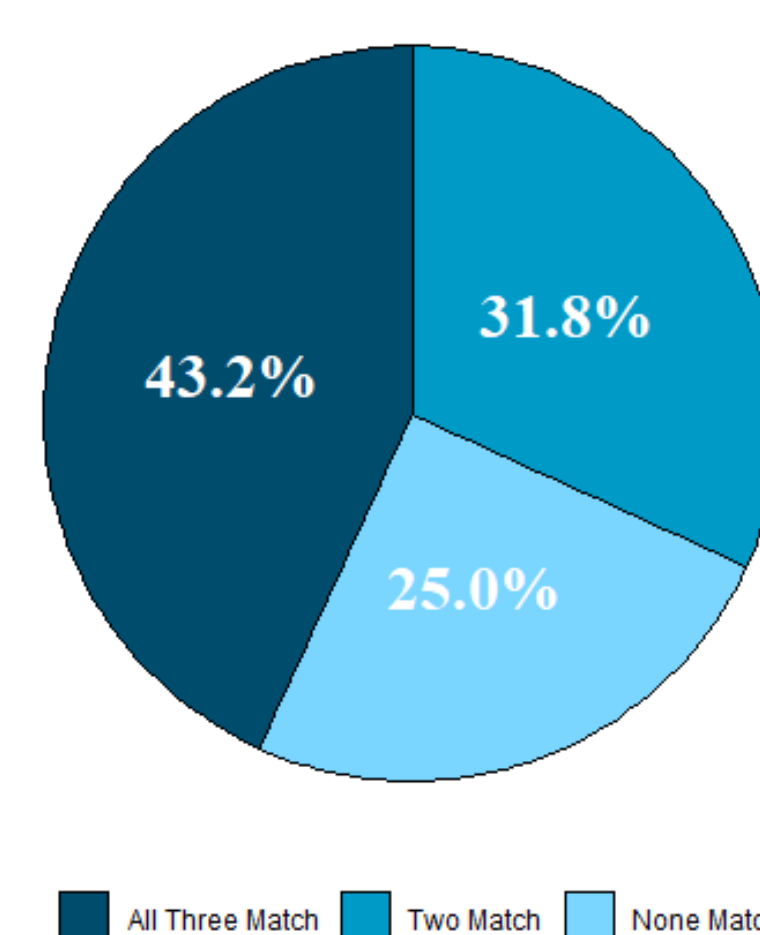


Figure 3: Percent agreement between image types, or proportion of flower, pinned, and chilled images for each specimen in which all three, or two, or none of the image types resulted in the same specimen ID.

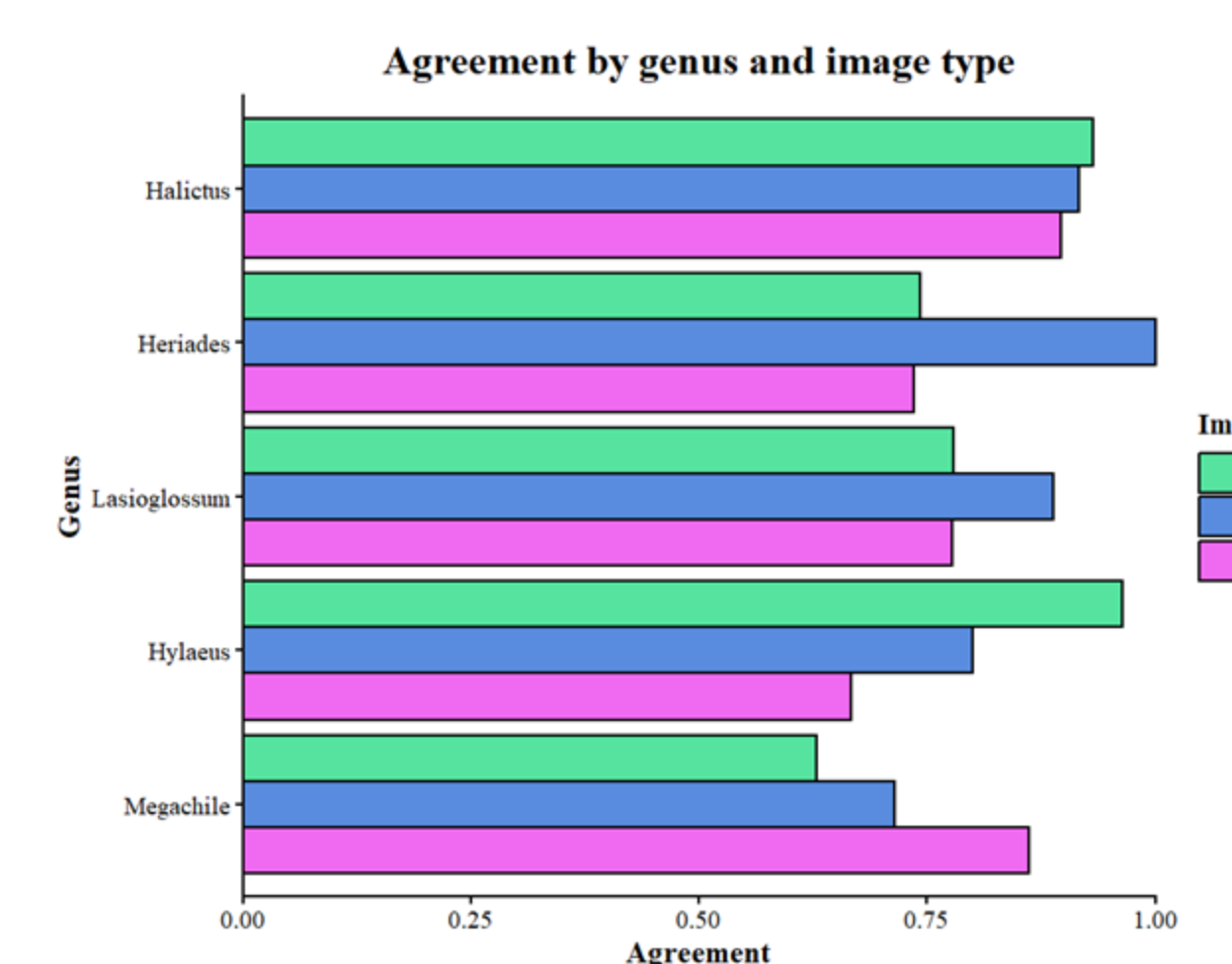


Figure 4: Agreement was measured for bee genera for which over 8 photos were collected ($n=5$). Generalized linear mixed effects model found significant difference between chilled and pinned image types ($p < 0.0001$), as well as between flower and pinned image types ($p=0.0174$), while no significant difference between chilled and flower image types.

Conclusions

“Chilled” images of bees in torpor may be a viable method of bee identification, evidenced by the BeeMachine model displaying the highest confidence on these images.

Among genera, confidence and agreement seem to coincide with the ease of each genus to recognize from photographs; chilled and flower images struggled more on images of smaller bees

Agreement metrics show that chilled and flower image recognition is less consistent than that of pinned images. Probably due to these image types containing more low-quality images.

Results point to a need for consistent photographing methods when imaging chilled specimens for greater model consistency in identification.

Future Directions

The favorable results of our study encourage future, larger scale projects in the Spiesman lab focusing on torpor imaging.

Future work will seek to train a computer vision model using images of torpor to improve model efficacy in identifying these images, allowing researchers to confidently use the images as an identification method.

Future work will also seek to train a model using primarily pinned specimens which can effectively identify bees actively pollinating on flowers.

Acknowledgments

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