Spring 2020

Conservation efforts concerning native bee species of Michigan

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SIT Study Abroad

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Table of Contents

Acknowledgements

I would love to give gratitude to Dan Govoni and Alex Tyas for guidance and support for this project and for running the SIT Iceland study abroad program that led to the ideas behind this project. Thank you to Andrew Guertin, my academic advisor, for help with editing and bouncing ideas off of. Special thanks to Jason Raddatz, Whitehouse Nature Center director, for allowing me to have access to the Whitehouse Nature Center and giving me supplies for my project. I would especially want to thank all of my SIT classmates for making my time studying in Iceland truly memorable and offering support whenever I needed it.

Abstract

Bee species all over the world are declining at concerning rates. However, it is good to see the public rallying behind the "save the bees!" movement even though most efforts from this movement have been on the conservation of the European honey bees. This is because most people often associate the honey bee, which is only one of 20,000 known bee species in the world, to all other bees. Therefore, conservation efforts should be broadened and aimed towards the many native bee species that can be found locally in North America. In the state of Michigan, there are over 450 species, and conservation for these species is most effectively catalyzed by education and outreach, which can bring awareness to these native bee species. What resulted from these concerns over native bees is the creation of a pollinator garden intended for education of native bees at Albion College's Whitehouse Nature Center in Albion, Michigan.

Keywords: Native bees, conservation, education/outreach, pollinator garden

Introduction

Species of bees that are native to North America play many important roles in our environment, yet it is widely accepted today that many bee populations are declining (Burkle et al. 2013; Cameron et al. 2011; Goulson et al. 2015). This universal acceptance creates a sense of urgency and importance about bees, like the "save the bees!" movement that many people have rallied behind (Wilson et al. 2017). Even with an understood importance on bees, many people are unable to convey and express any basic knowledge about the biology of bees (Wilson et al. 2017). The purpose of this study is to find the best way within my community to help conserve native bee species of Michigan. As conservation efforts often strive for public interest and involvement (Jacobson et al. 2015), this project will look into the construction and implementation of a native bee and pollinator garden with educational components that is accessible and free to the public. This project will help teach individuals to broadly identify and differentiate species like wasps, honey bees, bumblebees, and flies, understand their behavior, and appreciate their functions within the ecosystem. This project could also be taken and applied more generally by the public, with the goal of increased learning and investment in conservation and the environment. The garden is an addition to Albion College's Whitehouse Nature Center, located in Albion, Michigan, and will help improve local education and outreach on species of bees native to Michigan.

Context and Literature Review

Bees and their significance

"Save the bees!" has become a familiar refrain within the last decade, often thrown around in an attempt to help bee populations that are struggling to make ends meet. It is nice to see a movement sprout from concern about bee declines, yet when people want to make efforts to "save the bees", they focus on what is familiar to them (Wilson et al. 2017). In this case, *Apis mellifera,* or commonly known as the European honey bee, is the familiar bee to most individuals (Wilson et al. 2017). It has become the center of attention in the "save the bees" movement and has received most of the press surrounding concerns, despite not being a native species to North America (Hanson, 2018). However, the European honey bee is but one of thousands of different bees species in the world that need saving. For a better understanding of why honey bees are the dominant figure and primary representative of bees in pop culture and research, understanding the history of the honey bee in relation with humans is important.

A major figure of English literature, Anglo-Irish author and satirist Jonathan Swift described how bees "have chosen to fill our hives with honey and wax; thus furnishing mankind with the two noblest of things, which are sweetness and light" (Swift, 1920). Here, Swift is solely describing one species of bee, the European honey bee. Honey bees have played a significant role in human history, becoming important objects and symbols in historical societies all over the world for thousands of years. They became pious figures in many religions, from embodying the tears of the Egyptian sun god Ra to forming the bow of the Hindu god Kama (Hanson, 2017). William Kirby, often considered to be the father of entomology, gave honey bees the title "heaven-instructed mathematicians" because of their ability to create perfect hexagonal combs and their highly effective eusocial behaviour (Kirby, 1837). Kirby, a natural theologian, would go on to use the honey bee as irrefutable proof of God's part in creation

because he believed the honey bee was perfect in its physiology and behavior (Kirby, 1837). Along with the symbolic and religious value of honey bees, which made them popular objects of curiosity, they have also been economically valuable in the past (Ebert, 2011). Like Swift said, they were important producers of crucial everyday commodities: honey and beeswax. Today, they maintain their economic value by performing an even more significant purpose through their pollination services.

There is an apocryphal belief today, perhaps because of this long-running relationship between honey bees and humans, that all bees are like honey bees in that they produce honey, live in social colonies, and die after stinging (Hanson, 2018). Yet, in a world with more than 20,000 known species of bees, only a small fraction live socially in hives, and even less produce honey (Wilson and Carril, 2016). Most bees are solitary, meaning they live alone, and lack the eusocial characteristics of honey bees. Each female solitary bee must gather pollen and nectar, build nests, and lay eggs by herself, without the help of workers (Wilson and Carril, 2016). These bees will either nest in tunnels underground or in cavities and holes in logs and stems (Wilson and Carril, 2016).

In North America there are over 4,000 species of bees, most of which are solitary (Wilson and Carril, 2016). To put that in perspective, there are 10 times as many bee species as there are mammal species in North America (Wilson and Carril, 2016). Within the state of Michigan, there are over 450 different species of bees (Pollinator Initiative, n.d.). In this paper when I mention “native” bees, I am referring to bees located and native to the state of Michigan.

The decline of bee populations

It has been widely accepted after recent analyses that many bee species are declining at alarming rates due to a wide range of factors (Burkle et al. 2013; Cameron et al. 2011; Goulson et al. 2015). The major culprits being the use of pesticides/herbicides, climate change, parasites, and especially habitat loss (Burkle et al. 2013; Cameron et al. 2011; Hanson, 2017). After "save the bees" galvanized intensive research on honey bees and colony collapse disorder, much was discovered about identifying and explaining how these factors kill honey bees, yet the same broad knowledge base for native bees species is absent (Wilson et al. 2017). However minimal it may be, the research that has been done on native bees shows clear evidence that many of these wild pollinators are declining (Burke et al., 2013). Native bee declines can result in the loss of pollination services which lead to negative ecological impacts in terms of biodiversity and the health of ecosystems, and negative economic impacts from agricultural systems without high pollination efficiencies (Potts et al., 2010). Even though honey bees are commercially used to pollinate crops, they supplement the work of natural wild bees (Garibaldi et al., 2013). In a study of more than 40 important crops grown worldwide, honey bees only increased yield in 14% of those crops, while wild pollinators were the real ones improving the pollination efficiency (Burke et al., 2013). When native bees begin to decline, this puts a strain on food systems all over the world, and therefore people. And with such a large vacancy in native bee research and data, a problem is presented concerning the conservation of these insects and relaying information to the public.

Wilson et al. (2017) carried out a survey to measure the public understanding of bee diversity. The survey revealed that nearly 100% of respondents believed bees to be critical or important, yet a mere 14% of the respondents were able to guess the number of bee species in the

US within 1000. They conclude that in order to narrow the gap between the people's interest in bee conservation and their understanding of bees, outreach and education should play a major role in all conservation efforts (2017). Therefore, because of the required public involvement in conservation efforts of native bees, understanding the state of knowledge with people invested in the "save the bees" movement is vital.

Education is the first step in conservation

Both Potts et al. (2015) and Wilson et al. (2017) describe how awareness of the significance of pollinator conservation is needed at local and global levels, and education and outreach is the means in which this can be achieved. Education relating to the environment is "one of the fundamental tools required to reverse the current trends in biodiversity loss," (Brewer, 2002) and therefore a tool to help decrease or minimize the decline of many diverse bee species. Any programs aimed at mitigating bee population decline will need to include some form of educational and outreach measures.

A 2018 study looked into pollinator conservation education by exposing students to living honey bees at a beehive, and comparing the results to students using a remote online beehive (Schönfelder and Bogner, 2018). The authors of the study claimed that education of pollinators should include reducing the perceived danger and fear of insects/bees, in order to create a stronger willingness to protect them (Schönfelder and Bogner, 2018). The issue of honey bees being the only pollinator representative in the study was addressed however, claiming that "further programs should face pollinators as a whole or other important species"(Schönfelder and Bogner, 2018).

Many education and outreach initiatives are focused around early and direct experiences with the environment for the youth. Engaging youth interest in the environment is important, but especially the local wildlife and ecosystems (Genovart et al. 2013). Today, natural attractiveness of children towards nature and wildlife is heavily focused on a small rage of iconic species (Ballouard et al., 2011). Engaging youth in environmental practices that are directed toward local organisms and wildlife will lead to a development of conservation consciousness locally (Ballouard et al., 2011). This will make conservation education a more practical and relatable experience.

Native bees make an ideal model for raising awareness about local conservation and ecology based on the overall positive attitude toward bees (Breuer et al. 2015). Along with their local positionings, native bees have the potential to teach about many environmental topics from plant-animal relations, biodiversity, human impact on the environment, etc. Wilson et al. (2017) brings up a great point about how the lack of public knowledge on bees lays forth a unique opportunity: a community of people already invested in the "save the bees" movement but have not been able to learn about conserving bee species. With native bees having such an important and relevant role in our society, they can become the perfect tool for their own conservation and environmental conservation as a whole. Their diversity and aesthetically pleasing appearances make them not only an ideal model for conservation, but also easily approachable.

Pollinator gardens as conservation techniques

If approaching education with native bees is the most appropriate path to their conservation, then a pollinator garden focusing on education would allow for science instructions

and knowledge transmission to be more effective because they would be conducted outdoors compared with a classroom setting (Cronin-Jones, 2000). Along with improved educational benefits, a pollinator garden would help native bees at the local scale after filtering due to urbanization and loss of habitat (Levé et al., 2019).

Methods

Literature Review

In order to be properly informed for this project I needed to conduct literature reviews for three focus areas. The first literature review is on the most effective forms of education and outreach for conservation, especially with native bees. This research concentrated on youth education in particular and effective ways for implementing and presenting valuable and approachable education initiatives. Jacobson et al. presented a wide range of knowledge and insight on conservation education in their book *Conservation Education and Outreach Techniques* (2006). Jacobson et al. lays out steps for designing successful educational programs, how to incorporate arts into conservation, a variety of methods for teaching and learning, and more components that need consideration when creating education and outreach programs for conservation.

The second literature review was on the development of an efficient and productive pollinator garden and the creation of nests/nesting habitats for native Michigan bees. In the book *Managing Alternative Pollinators*, Lee-Mäder et al. (2010) primarily discusses the best approaches to maintaining bees for pollination services, which is not the main purpose of the garden I am creating, but they also discuss ways to construct gardens that give native bees and other pollinators easier access to healthy and beneficial food and nesting resources. Along with

Managing Alternative Pollinators, the Michigan State University Pollinator Initiative website provides a large range of knowledge and expertise for creating pollinator gardens/habitats at all scales (Pollinator Initiative, n.d.). Useful information from these sources were related to site selection and preparation, garden design, weed control, etc. These sources also give step by step instructions for the construction and installation of a variety of nests like "bee hotels" for certain solitary bee species. For bumble bees, which are eusocial, I read a study by Johnson et al. (2019) on the placement and preferences of bumble bees for their nests.

The final literature review I conducted was on researching the native bees species of Michigan and the flowers that attract and support them. I did not research specific bee species, as there are over 450 different species within Michigan, but rather conducted research that was more general, studying the characteristics of families of bees (e.g. andrenidae, apide, colletidae, halictidae, megachilidae, and melittidae). I utilized the book, *The Bees In Your Backyard*, by Joseph S. Wilson and Olivia Messinger Carril (2016), as well as the Michigan State University Pollinator Initiative website and the Ohio State University Bee Lab. By researching the taxonomy, anatomy, physiology, and biology of native bee species, I therefore simultaneously researched the flowers that different species of bees utilize for different times of the year.

The Whitehouse Nature Center

Having access and being able to work with the Albion College Whitehouse Nature Center is crucial to this project by allowing the implementation of a pollinator garden, making it a part of the facilities and services that are offered and open to public schools and the community. The garden will be given public exposure and a strong platform for educational programs, as the

nature center already has many established. It is important to have an audience when education is the goal of the project, and the Whitehouse Nature Center provides that audience.

Garden and nest design and construction

I was given the opportunity to create the garden in many different sites around the nature center. I was looking for a site that had a large amount of sun exposure, was well-drained, minimal existing weeds, and a large amount of public exposure. After the spot was chosen, I cleared old foliage and wood chip piles that covered the garden spot, exposing just the soil. I used what I found from researching native bees and flowers to narrow down the most appropriate and applicable flowers for the garden.

For a bumble bee nesting box, I created a nest that was large enough to hold a bumble bee colony because of their eusociality. I cut boards of wood (not pretreated) to create a box about 9 inches deep, 6 inches wide, and 6 inches tall. On both sides of the box, I drilled ventilation holes and covered them with a fine mesh to keep ants and other insects from entering the nest. Within the nest, I made two connecting chambers divided by a wooden wall: a vestibule, about 3 inches long, and the main nesting compartment, about 6 inches long. The purpose of the vestibule is to provide a space for the bees to carry out their necessary defecation or self cleaning before entering their nest (Wilson and Carril, 2016). I drilled a half inch hole for entryways in the dividing wall and the wall to the outside. I placed a pipe into the nest entrance to minimize water flooding the vestibule. I placed the nest behind the garden plot slightly under shrubs. The nest is south-facing (towards the sun) and in a dry location, but shaded from direct sunlight. Most man-made nest boxes for bumble bees take a long time for a queen to choose to

colonize there and many are unsuccessful in attracting bees (Johnson et al., 2019). For solitary bees nesting in logs and stems, I drilled around 4-5 centimeter deep holes into logs of wood at varying sizes and stacked them together for the "bee hotel" aesthetic. I also placed a premade reed "bee hotel" in the garden. All nesting entrances (the holes) are facing south towards the sun.

Sign design

The garden will contain permanent educational components through signage and displays for students and the public to learn about bees when they are unable to join or there are no established programs by the nature center. I used canva.com to create custom designs for the displays. I strived for a simplistic design and information that was easy to follow.

Ethics

While conducting the literature reviews, there were often concerns by the public when it comes to bee stings (Breuer et al., 2015; Gerdes, Uhl, and Alpers, 2009; Schönfelder and Bogner, 2018; Wilson et al., 2017). Native bees (in fact, all bees but honey bees) will only sting if they are being squished (Wilson and Carril, 2016), yet bees will often get the blame when people are stung by wasps (which are much more aggressive) and are unable to distinguish a wasp from a bee (Schönfelder and Bogner, 2018). Although these insects are often considered as fear-inducing and frightening (Breuer et al. 2015; Gerdes, Uhl, and Alpers 2009) the perceived danger can be reduced through education on what are and are not bees while the willingness to protect them can be increased (Schönfelder and Bogner, 2018). Therefore, because "children are afraid of insects and invertebrates that can potentially cause pain or are thought to do so" (Breuer

et al. 2015), I put in measures to mitigate, or at least minimize, this fear. The pollinator garden and educational programs based around it will include information on the special breed and behavior of native bees and how to differentiate bees from insects with a similar appearance (e.g. wasps and flies) to reduce the perceived danger of bees for humans. Once people are able to identify species and know the difference between wasps, bees, and flies, they are closer to understanding their behavior and appreciating their functions within the ecosystem (Breuer et al. 2015).

I attempted to minimize the bias of working on a solo project like this, however, the signs contained information that I personally found interesting and what originally caught my attention while learning about native bees. I did this with the intention of gaining a broader audience but I was very intentful on making everything on display for the public driven by facts and reviewed science and research.

Results

Outcome of garden

I decided to have the garden at the front of the nature center, giving it plenty of sunlight and exposure to the public. The garden is divided into three sections, each section holding different species of flowers. Section 1 contains flowers that have a blooming period in the spring (March through June). Section 2 contains flowers with blooming periods in the summer (July-October). Section 3 has flowers with blooming periods that overlap the two seasons, ranging somewhere from May to August.

Section 1 will contain some or all of the native flowering plants: penstemon (*Penstemon hirsutus*), tickseed (*Coreopsis*), evening primrose (*Oenothera* and *Camissonia*), American elder (*Sambucus canadensis*), and golden Alexanders (*Zizia aurea*).

Section 2 will contain: Late figwort (*scrophularia marilandica*), swamp milkweed (*Asclepias incarnata*), culver's root (*Veronicastrum virginicum*), nodding wild onion (*Allium cernuum*), yellow giant hyssop (*Agastache nepetoides*), blue lobelia (*Lobelia siphilitica*), smooth aster (*Aster laevis*), Riddell's goldenrod (*Solidago riddellii*), and New England aster (*Aster novae-angliae*).

Section 3 will contain: Beardtongue (*Penstemon hirsutus*), swamp milkweed (*Asclepias incarnata*), Culver's root (*Veronicastrum virginicum*), yellow coneflower (*Ratibida pinnata*), Missouri ironweed (*Vernonia missurica*), and horsemint/spotted beebalm (*Monarda punctata*).

Signs

See appendix A.

Nests

The bumble bee nest will be placed behind the garden facing south. This nest will be next to section 3 because bumble bees are active through both the spring and summer (Wilsom and Carril, 2016). The premade "bee hotel" and the logs drilled with holes will be placed by section 1 as they are specifically designed for mason bees (*Osmia*) which are active in the spring (See appendix B). Each garden plot will have a patch of bare dirt/mud, allowing solitary bees to nest underground that do so rather than in stems or logs.

Discussion

The relationship between the blooming period of flowers and the phonology of different native bee species was important in determining how to present the many different species of bees without it becoming overwhelming and therefore uninteresting to the public. I matched the family of bee species with the different blooming periods of the flowers. Bee families active in the spring matched with spring bloom periods, and the same for summer active bees with summer bloom periods. I incorporated that logic into the structure of the garden, separating different bloom periods to simultaneously show when and where to find different bee species. For bees that are active for all of spring and summer, I correlated them with flowers that bloom in both the spring and summer (section 3 of the garden).

This pollinator garden, which focuses on the education and conservation of the native bee species of Michigan, has the unique opportunity to truly become a source of education due to the Whitehouse Nature Center's platform and history. With the pollinator garden becoming a part of the nature center, educational programs and many nature camps that are already established with the center and have a public audience, native bee conservation and education can easily and effectively be added to the current curriculum. For example, there is already a beekeeping school that occurs there over the summer (Whitehouse Nature Center, n.d.), adding a component on native bee species and their pollination benefits could be easy to plan and initiate .

As Jacobson et al. (2015) describes, education programs that are successful and efficient often include a combining different learning theories to increase understanding, such teaching with experiential learning or activities and then using what was learned to apply that to new and relatable situations. This garden has the strong potential to do this. For example, teaching students about antive bees and their role in pollinating our foods. An activity about how bees pollinate and its importance and then giving fruits or ice cream or another food relyant on pollinators, which will give students a physical representation of their connection and relation to bees.

For educational sign displays, I thought a welcome sign with an overview of what bees are and how they are important was needed. I also wanted to include information on how individuals can help native bees in their own yards and gardens. Another display that I thought was necessary was about identifying bees vs wasps and flies. I chose to include this due to the results of the survey done by Wilon et al. (2017) finding that very few participants correctly identified images of the bees other than honey bees or bumble bees in the survey, which such an outcome could lead to poor or misguided efforts to help protect jeopardized native bee and other pollinator populations.

Conclusions

Native bees present a unique opportunity for conservational efforts because of public awareness of their importance while often being overlooked in their ecological functions and services. Spreading awareness of these species can reduce the perceived danger of bees and create a closer and more relatable connection between these insects and people. With the

importance of native bees to the Whitehouse Nature Center garden, it also applies generally to conservation and can increase learning and investment in different conservation efforts and other environmental issues. This project will support not only educational gains locally, but also potential ecological health and biodiversity benefits. This garden and educational components provide a model for future education and outreach programs, either involving the conservation of pollinators or any other conservation initiatives. With education comes understanding, and with understanding comes appreciation; finding a larger audience to appreciate native bees is what could really “save the bees”.

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Appendix A: Sign displays

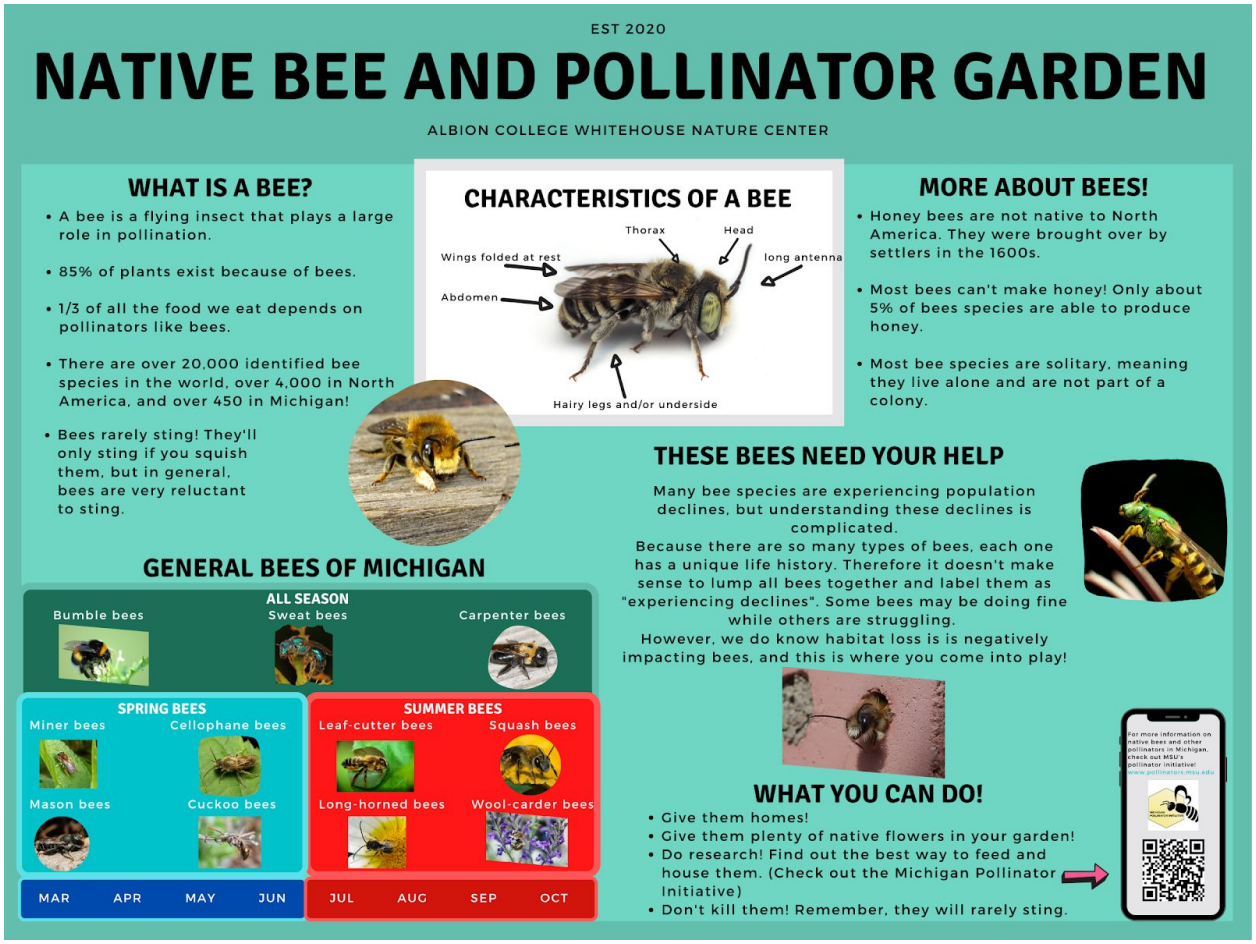

Figure 1: First draft of the main and largest sign for the garden (As garden is developed signage may change).

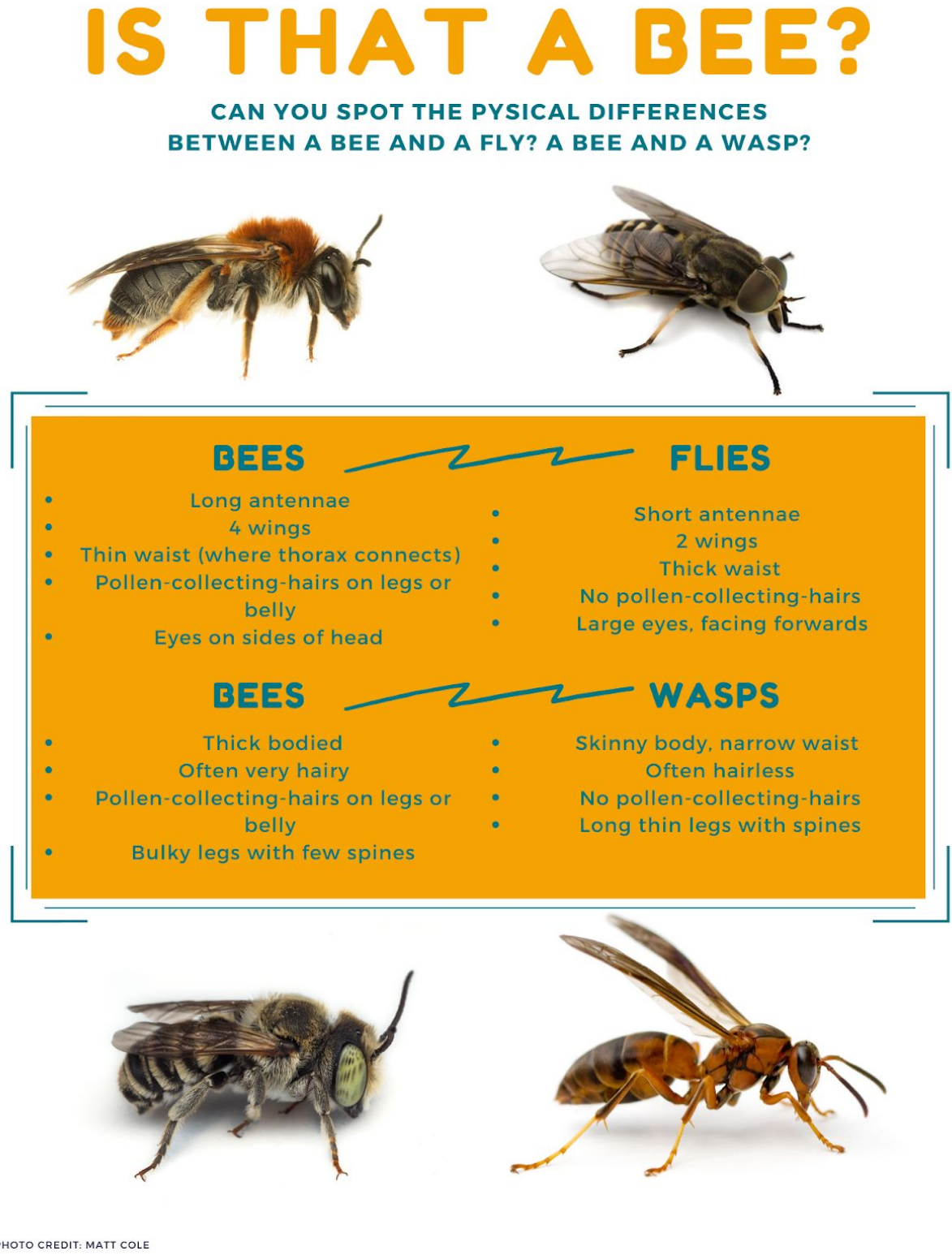

Figure 2: Sign showing differences between bees and flies; bees and wasps.

Appendix B: Nests

Figure 1: The bumble bee nest

Figure 2: Inside the bumble bee nest. The pipe leading to the vestibule and then an opening to the main nesting compartment. Leaves placed for installation.

Figure 3: Premade bamboo nest for solitary bees

Figure 4: Holes drilled in logs for solitary bee nests.