BIOMEDICAL SCIENCE JOURNAL FOR TEENS

AUGUST 2022

What happens to mother bees' brains as they age?

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Associate Editor:
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Abstract

You're probably familiar with honeybees and bumblebees. But did you know that there are over 20,000 species of bees, and most of them are solitary? In worker honeybees, certain brain areas grow larger as the insects get older and have more experiences. We wanted to know if this was also the case for solitary bees. We studied a particular type of solitary carpenter bee named *Ceratina calcarata*. We collected female bees of three different ages. Then we measured their brains and other body parts under a microscope. As expected, older female bees had smaller ovaries and more worn wings. But surprisingly, older bees had smaller brains than younger bees. We think that female *C. calcarata* bees invest their energy and resources into reproduction, rather than growing bigger brains.

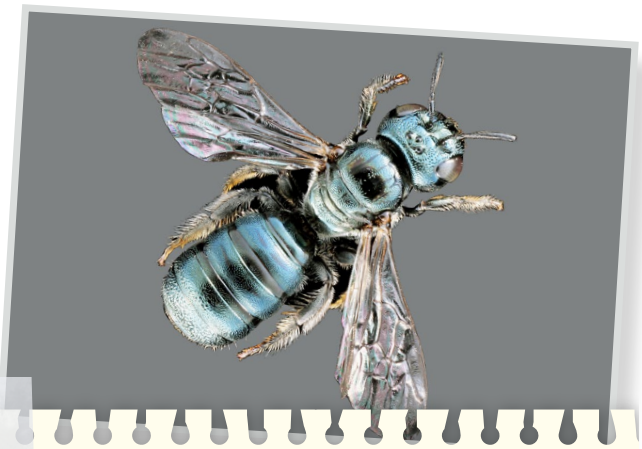
Introduction

Your brain will reach its biggest size by the time you're a teenager. But the brains of many insects keep growing well after they become adults. This is the case for honeybees. Their brains get bigger as they age. It's the result of two kinds of experience: **foraging** for food and social interactions with others. These activities appear to demand more brain power.

Most people think of bees as social insects. Honeybees, for example, live in close-knit colonies. But there are thousands of bee **species**. Many of them are **solitary**, meaning they live mostly alone. We know a lot more about social bees than solitary bees. That includes how their brains change over time.

We wanted to find out how adult experiences affect brain size in an unusual kind of carpenter bee named *Ceratina calcarata*. In the spring, females of this species forage for pollen and nectar to feed their babies, like other types of solitary bees. However, unlike most other bees, these single mothers also provide food late in the summer when their babies are grown up. This extra food helps their then-adult kids survive the winter.

We thought that this extra foraging, plus the extra social interactions with their adult **offspring**, would result in bigger brains in the older mothers.



A female carpenter bee, *Ceratina calcarata*.
Photo credit: Sandra Rehan

Methods

We collected female *C. calcarata* carpenter bees from their nests around Durham, New Hampshire. We looked at three different ages of bee:

1. new mothers in spring who forage for food for their babies,
2. older mothers in late summer who are done **reproducing** but still feed their adult offspring, and
3. adult offspring of the mothers in late summer.

We removed their brains and measured different parts of them under a microscope. These parts included areas called the **mushroom bodies**, which are important in learning and memory.

Besides the brain areas, we measured the size of the bees' **ovaries**. These are the parts of the female reproductive system that make eggs. Large ovaries mean that the bee is about to lay an egg. We also evaluated the wear on their wings. This was a measure of their flying and foraging experience. The more they fly, the more nicks and tears accumulate on the edges of their wings.

Results

We thought that the extra foraging and social interactions with their offspring would result in larger brains in older mothers in the late summer. But we were wrong!

Older mothers in the late summer actually had *smaller* mushroom bodies than younger moms and adult offspring (Fig. 1).

Older mothers also had more worn wings than younger mothers and adult offspring. Younger mothers, meanwhile, had the largest ovaries of the three groups. Among the older mothers, but not the other groups of bees, wing wear increased as the size of the brain and the ovaries decreased.

Box-and-whisker plot reminder: the box represents the middle 50% of the group, and the lines above and below mark the 75th and 25th percentile, respectively.

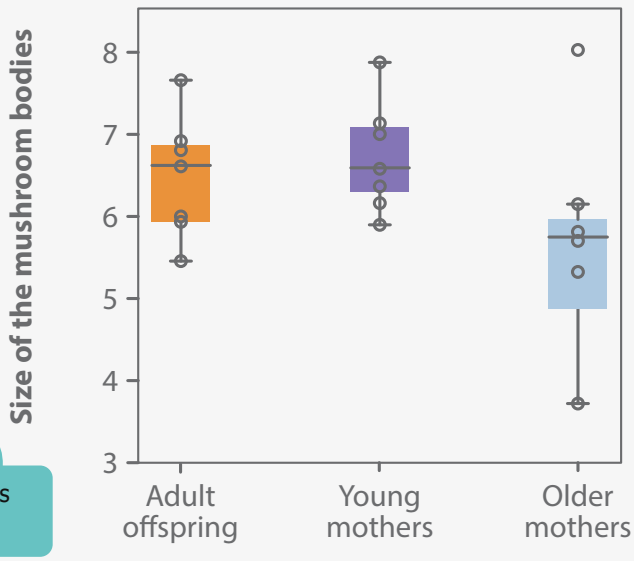


Figure 1:
Comparing the size of the mushroom bodies (parts of the insect brain that deal with learning and memory) in adult offspring, young mothers, and older mothers.

How does the size of the mushroom bodies change as *C. calcarata* females get older?

Discussion

We found that the older mother bees from the late summer had smaller ovaries than the younger mothers. This makes sense, since by late summer the bees are done reproducing, but the young mothers are laying eggs. We also found that older mother bees had more worn wings than younger bees. We expected this result, too, since older mothers have been foraging for a longer period of time.

We did not expect that the mushroom bodies of older mothers would be smaller than those of younger mothers. In previous studies of social insects like honeybees and ants, this part of the brain got larger with increasing age and experience. Our results suggest that after female carpenter bees are finished reproducing, their mushroom bodies shrink.

Why are these carpenter bees different from social insects, whose brains do not decline with age? Previous studies looked at **worker bees** and ants. These insects never reproduce. Instead, they invest in helping the **queen** reproduce and raise offspring. The solitary bees that we studied *do* reproduce. This takes energy and resources, which are then not available for growing a bigger brain. We think these carpenter bee mothers invest more energy in reproduction and raising their babies. By late summer, there is no more energy to invest in growing or maintaining bigger brains.

Conclusion

Most people think of female bees as either queens or workers. But most bees are solitary single mothers. Like honeybees, solitary bees have an important role in our ecosystem. They **pollinate** plants, which helps the plants reproduce and helps produce a lot of our food.

Here are some ways to help the solitary bees in your neighborhood:

- Fill your garden with diverse, native flowering plants.
- Don't use chemical fertilizers or pesticides. These can be toxic to bees.
- Provide shelter and nesting materials, such as brush piles, compost heaps, and bare spots of soil for bees that nest in the ground. You can even build a bee hotel!

Glossary of Key Terms

Forage – search for food. Bees forage for pollen and nectar from flowers.

Mushroom bodies – an area in the insect brain involved in learning and memory. These are parts of the brain, not actual mushrooms growing inside!

Offspring – a person or animal's young. This carpenter bee continues to feed its offspring even after they are adults.

Ovaries – female reproductive organs that produce eggs. Older mother bees have smaller ovaries because they are done having babies.

Pollinate – to carry pollen to the parts of a plant that need it to reproduce. This allows fertilization, so the plant can make seeds.

Queen – the only female in an insect colony that can produce offspring. The queen bee's primary job is to have lots of babies.

Reproduction – the process by which animals or plants produce offspring (babies). In solitary bee species, all the females reproduce.

Solitary – living mostly alone. Most species of bee are solitary and do not live in large colonies.

Species – a group of animals or plants that share lots of characteristics in common. They can reproduce with one another and produce offspring. There are thousands of bee species and most of them are solitary.

Worker bee – a female bee that cannot produce offspring but collects food for the other bees in its colony. The worker bee goes out foraging and brings back food for the colony's young.

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Check your understanding

1 How are *C. calcarata* females different from female honeybees?

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2 Why would you expect older mother bees to have smaller ovaries and more worn wings?

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3 In social insects, certain brain regions grow larger as the insects use them more. Can you think of another example where using something more causes it to grow?

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4 In some bees, the more foraging experience they gain, the larger certain areas of their brain grow. Why might foraging require more brainpower? What is challenging about this activity?

Acknowledgment: This article's adaptation was supported by the National Science Foundation