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HOW WASPS RECOGNIZE THEIR EGGS

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YOUNG REVIEWERS:

LUIZA
AGE: 14

OWEN
AGE: 11

Wasps are insects that many people tend to dislike. But have you heard that wasps perform really important services in nature, such as pest control and pollination, and that they can also serve as living indicators of environmental health? We can learn a lot from wasps. Most people do not know that wasps have a sophisticated communication system—they use their eyes to see, their antennas to smell, and their legs to feel vibrations. The bodies of adult and young wasps are covered by a mix of odors, which carry information about which family they belong to. We decided to do experiments to see if wasps can recognize their eggs because, to us, all wasp eggs look very similar. In this article, we will show you that wasp eggs carry odors that wasps can recognize, and this helps the entire colony to function properly.

WASPS' FASCINATING COMMUNICATION SYSTEM

Have you ever stepped up close to a wasp nest to observe what the wasps are doing? Probably not—many people are not big fans of wasps and associate them only with their stings [1]. However, wasps are cool! They have important roles in nature such as pest control and pollination, and their presence or absence can also help scientists understand whether an environment is healthy or not [2]. Similar to bees and ants, some wasp species live in well-organized societies and can communicate and recognize each other using their eyes to see, their antennas to smell, and their legs to feel vibrations. Nests of social wasps can contain anywhere from a few to hundreds of wasps.

Visual and odor information allows wasps to recognize other wasps that belong to the same nest (**nestmates**) and helps them to know which wasps are not nestmates. But how do they do that? Wasps have structures called compound eyes and ocelli that help them to see, and their antennae are their "noses" (Figure 1A). Some wasp species have specific colors on their faces that their nestmates learn to recognize, similar to humans that have specific facial features [3]. The faces of other wasp species all look the same, but they can still tell who belongs to their nest and who does not. In this case, wasps can use odors! Although we cannot smell them, wasps are covered with odors that work as chemical IDs. These chemical IDs carry information about a wasp's age, sex, which nest they belong to, their species, their health condition, and more. These odors are called **pheromones** because they are used to transmit information among individuals of the same species. Wasps' antennae contain multiple small structures capable of sensing odors and telling different odors apart [4].

NESTMATE

A word used to describe social insects that live together in the same nest.

PHEROMONES

A word to describe odors that are released and modulate behaviors among individuals from the same species.

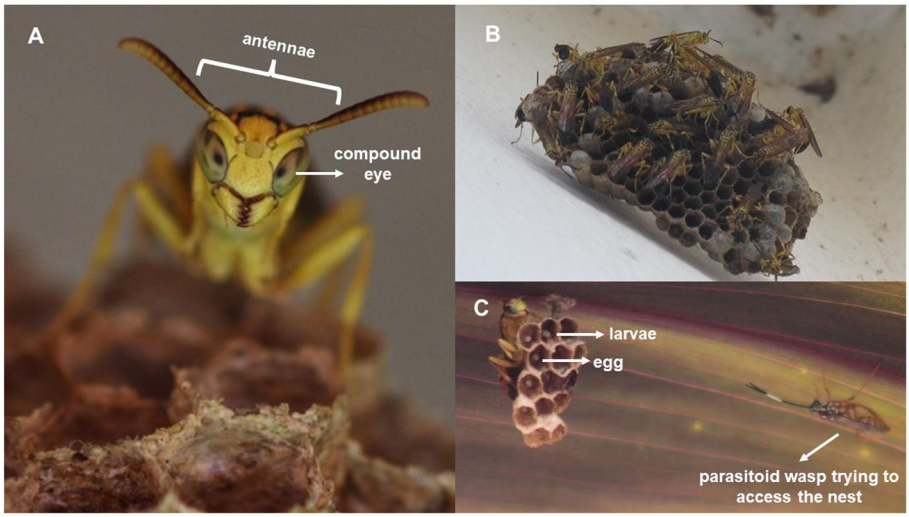

Figure 1

(A) Female wasp of the species *Mischocyttarus cerberus* showing its pair of antennae and its compound eyes. **(B)** Some wasp nests are open to the environment and easy for intruders to attack. Chemical IDs help wasps to identify intruders. **(C)** A small wasp nest under attack by a parasitoid wasp.

CUTICULAR HYDROCARBONS

Chemical compounds composed by hydrogen and carbon molecules that cover the body of insects. In social insects cuticular hydrocarbons convey information that is important for the communication.

Wasp pheromones are made of specific kinds of molecules called **cuticular hydrocarbons**, which are found all over the body surfaces of insects. As the name suggests, hydrocarbons are made of molecules of hydrogen and carbon. Interestingly, each insect species has a unique combination of cuticular hydrocarbons. Because these odors do not spread easily in the air, wasps must touch each other with their antennae to "smell" each other. This behavior helps them keep intruders out of their nests (Figures 1B, C). It is not just adult wasps that have chemical IDs—young wasps (eggs, larvae, and pupae) also have their own odors.

DO WASP EGGS HAVE A SMELL?

A nest of social wasps contains a female that is responsible for laying the eggs (the queen) and other females that perform tasks such as searching for food and defending the nest (workers). Sometimes workers do not do their normal duties and instead try to be the queen. These workers stop going out to search for food and instead spend most of their time in the nest. From time to time, they lay eggs like a queen would do [5]. In big wasp colonies, eggs were discovered to have specific odors, which allows workers to recognize whether the eggs were laid by the queen or by a worker [6]. When wasps find an egg laid by another worker, they destroy the egg. This behavior is called **policing**, and it is important to make sure that only the queen has the job of laying eggs [5]. But can recognizing an egg by its odor also help wasps to protect themselves against intruders? Nests of wasps called *Mischocyttarus cerberus* can be attacked by females of different species, such as parasitoid wasps (Figure 1C). When wasps attack another nest, they often lay their eggs in the nest they invade, hoping that the wasps in the invaded nest will raise the eggs as their own. Thus, if wasp eggs have odors that are specific to their nests, maybe wasps can stand a chance against invasions.

POLICING

The behavior of egg recognition in social insects.

We investigated if *Mischocyttarus cerberus* wasps can recognize eggs and tell family apart from foes [7]. To do this, we prepared artificial wasp nest compartments (called cells) out of baking paper. The artificial cells were the same size as natural cells, and they were used to collect eggs and move them to another nest. We placed the artificial cells in other nests of *Mischocyttarus cerberus* and in nest of another species, *Mischocyttarus montei*. Eventually, wasps from both species laid eggs inside the cells (Figure 2A).

Our experiments had two goals. First, we wanted to know whether *Mischocyttarus cerberus* could tell the difference between their eggs and *Mischocyttarus cerberus* eggs from a different nest. Second, we wanted to test whether *Mischocyttarus cerberus* could tell their eggs apart from eggs of a different wasp species. Females usually check the cells from time to time, so we checked all the nests after one hour,

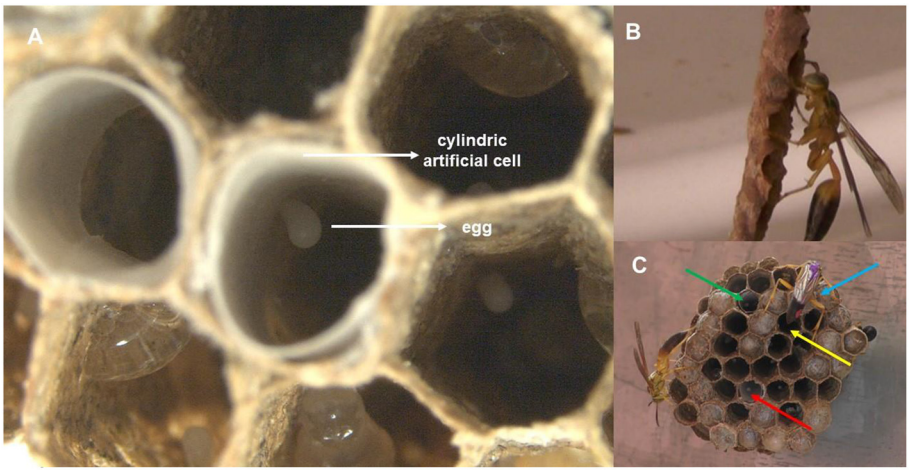

Figure 2

Figure 2

(A) An artificial cell made with baking paper, with a fresh egg inside. **(B)** *Mischocyttarus cerberus* wasp checking a cell and touching the egg with its antenna. **(C)** The yellow arrow shows an artificial cell. The red arrow shows an artificial cell with an *Mischocyttarus cerberus* egg. The green arrow shows an artificial cell with an invasive egg from *Mischocyttarus montei*. The blue arrow shows a wasp policing the cells.

one day, and one week, to see if the eggs were still there or if they had been removed by policing (Figure 2B).

We also collected some fresh eggs to study their odors, using a machine called a **gas chromatograph-mass spectrometer (GC-MS)**. Just like wasp bodies, the surfaces of wasp eggs are covered with hydrocarbons. For a wasp to detect an egg's odor, the wasp must touch the egg with its antennae [4].

GAS CHROMATOGRAPH-MASS SPECTROMETER (GC-MS)

A laboratory machine used to identify and separate chemical compounds from complex mixtures so they can be analyzed and identified individually.

WASP EGGS ARE VALUABLE RESOURCES

Our experiment showed that *Mischocyttarus cerberus* wasps can indeed recognize their own eggs and can tell the difference between familiar eggs and those of their foes (Figure 2C). Interestingly, we saw that one hour was long enough for the majority of intruder eggs to be removed (Figure 2C). Nestmate eggs had a higher chance of surviving compared to non-nestmate eggs. Our GC-MS data showed us that female wasps can tell the eggs apart because the odors covering the eggs are really different from each other, especially between species. For example, some odors are found in large amounts in eggs of *Mischocyttarus cerberus* but only in small amounts in eggs of *Mischocyttarus montei*, and vice versa.

Our experiment told us that it might be difficult for intruders to fool these wasps! Intruders may succeed in laying eggs, but this does not mean that the wasps in the invaded nest will take care of them. In fact, the opposite is likely to happen—whenever a strange egg is found, the wasps will destroy it as quickly as possible. Although tiny wasp eggs all look the same to us, they carry important information that allows wasps to identify them.

Wasps must spend a lot of energy raising their eggs to become adults, so that is why they should not waste time raising intruders' eggs. Recognizing odors to tell family apart from foes helps in this process. Wasps are amazing animals, and there is so much still to discover about how they can sense the world and learn information. We are continuing our research to find the answer to many more exciting questions. We hope that everyone who reads this article will start to like wasps for the amazing creatures they are!

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YOUNG REVIEWERS

LUIZA, AGE: 14
I am 14 years old, I really like to write. I am passionate about adventures, suspense, and magic. I like to go out with my friends and family. I am very interested in biology, as I am the daughter of biologists. Since I was a little girl, I have had contact with many animals and I love catching cockroaches and other arthropods in my hand. When I grow up I will be a comic artist, I love to draw.

OWEN, AGE: 11
I am 11 years old, and I am interested in science and chemistry. I have a pet cat and a dog. One of my favorite things to do is to read, and I also love gardening. I am interested in hydroponics and coral restoration.

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Rafael works with wasps and bees and is doing postdoctoral fellowship at Sorbonne Université, in Paris, France. He was born in Brazil and, during his Ph.D., he went to Belgium and the United States to do research internships. In Belgium, he studied various wasp species, including yellow jackets and hornets. In the United States, he

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Cintia works with wasps as a postdoctoral fellow at University College London. She was born and raised in Brazil and got her Ph.D. at the KU Leuven (Belgium). There, she studied the evolution of queen pheromones and chemical communication in several wasp species. She loves her job and loves to combine fun and work. She collects wasps in amazing places including Brazil (the Amazon), New Zealand (invasive wasps), and the heathlands in the UK. Cintia is working in UCL (London) in collaboration with the Natural History Museum in London. Cintia enjoys insects, cuddling cats and dogs, traveling, cycling, and hanging out with her friends.