00:00 Sarah Crespi: This week's episode is brought to you in part by LifeProof backpacks. Commutes can be killers, but you'll arrive with your gear intact inside LifeProof backpacks. Made to move, LifeProof backpacks are packed with smart features to thrive in all conditions. Water-repellent Cordura fabric sheds rain, sealed tech pockets protect electronics from weather, and front tie-downs hold oversized stuff outside. Get your LifeProof backpack now at a 15% discount by going to lifeproof.com/sciencemag. LifeProof backpacks, carry on.

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00:39 SC: Welcome to the Science Podcast for July 20th, 2018. I'm Sarah Crespi. This week, science news writer, Gretchen Vogel, talks with us about suckling mammals and abstaining platypuses. Why did monotremes give up on breastfeeding? And Sandra Yuter discusses her paper on fast clearing clouds off the coast of Africa. It turns out these giant marine clouds are being moved by gravity waves.

01:09 SC: First up, we have news writer Gretchen Vogel, and she's here with a story on monotreme suckling, and we are going to say the word "suckling" a lot, so just be prepared for that. Hi, Gretchen.

01:20 Gretchen Vogel: Hi.

01:21 SC: Let's talk about suckling. Okay. Mammals suck. It's a defining characteristic. How do we, amazing mammals, make that happen?

01:30 GV: It's pretty complicated, in fact. There's a whole suite of muscles and tendons and tissues in the mouth that makes it possible, because to suck you actually have to be able to close off the back part of your mouth, between your mouth and your throat, and there's a key muscle called the tensor veli palatini that lets you do that. It stretches from your ears to the edges of the roof of your mouth, and tenses the roof of your mouth so that your tongue... When you, for example, suck on a straw, your tongue can form a tight seal with the roof of your mouth. And then when the front of your tongue drops, your mouth becomes an area of low pressure and you draw liquid in.

02:13 SC: I'm doing lots of funny things with my mouth as you speak.

02:16 GV: Exactly. I did the same thing. [chuckle] That's not exactly how babies suckle. They do some extra things with their tongue to express the milk out of the mother's teat, but in principle, that's what's happening.

02:31 SC: And this is a big deal for mammals. This is very important for mammals, to get milk from their mothers.

02:37 GV: Absolutely. It's one of the key adaptations that defines mammals, and it enabled
mammals to have pretty big brains, and it's also tightly correlated with the kind of parental care that mammals do of their fairly immature babies that are born fairly helpless but then grow pretty quickly.

02:58 SC: Well, let's turn to monotremes then. These are some outliers in the mammalian world. Why don't you talk about what makes them so different and how they are at suckling?

03:08 GV: Exactly. They're totally crazy animals. They lay eggs, for one. They don't give birth to live young, the way most other mammals do.

03:17 SC: We should mention some examples that people might be familiar with.

03:20 GV: Good point. Monotremes include today's platypus and the echidna, or a spiny anteater.

03:26 SC: And they lay eggs.

03:27 GV: They lay eggs, exactly. They still feed their young with milk, but they don't suckle. The mothers don't have teats or nipples, instead they have these patches that exude milk and the babies sort of slurp or lap the milk up. It's hard to observe, and so actually nobody knows exactly how it happens. But it's pretty clear that they don't suckle in the way other mammals do.

03:52 SC: This is a little tangential, but what makes them still mammals at this point?

03:56 GV: Well, they have hair, and they do drink their mother's milk, which is the key point. It's just they do it in a slightly different way.

04:03 SC: The story that you wrote is really about suckling science, what's going on, what have researchers recently realized about this and the history of suckling in these animals.

04:13 GV: Yeah. The story is about a research by AW "Fuzz" Crompton at Harvard University, who has, for decades, studied the anatomy and physiology and morphology of suckling. He and his colleagues have now taken a closer look at how suckling may have evolved. They've done that by taking really careful looks at both the anatomy of modern animals and taking a comparative look at some fossil skulls from mammal precursors or ancient mammal relatives that were in the same group as our precursors, as our direct ancestors.

04:50 SC: This is where that special muscle came from. This is how they figured out the importance of these various tendons and muscles involved in suckling. Right?

05:00 GV: Correct. They took a careful look at skulls of modern animals and found several muscles that play key roles, including this one called tensor veli palatini that I explained before, that helps to control the soft palate that's in the top back of the roof of mammal mouths.

05:15 SC: That's not present in, say, reptiles or monotremes but it is in other mammals.
05:21 GV: Correct. It's not present in modern reptiles. They looked at a monitor lizard. But when we look back in time, they looked at two fossil skulls, one from an animal that lived about 250 million years ago, called Thrinaxodon, and it also seemed to lack this tensor veli palatini. But when they looked at another animal that lived about 220 million years ago, called Brazil eutherian, they looked and they said, the shape of the bone and the places that you can see where muscles attach these scars that the muscles leave on the bone, they looked remarkably similar to what you see in opossums and other mammals today.

06:03 SC: That means that this was lost in monotremes.

06:05 GV: Correct. So, the fact that Brazil eutherian probably had the ability to suckle suggests that the ancestors of monotremes also had that ability, because monotremes branched off much later than when Brazil eutherian lived. So, it looks like the ancestor of monotremes, the ancestor of all modern mammals, probably could suckle. And then the monotremes did branch off fairly early. They, in the course of becoming really specialized for eating the kinds of foods that they eat, then lost this ability. It turns out that they, instead of teeth, have hard, horny pads on the back of their tongue and on their mouth, and those horny pads are fantastic for grinding up crustaceans that platypuses hunt on the bottom of rivers, but they prevent that key seal, that we talked about, at the back of the throat from forming. And so that means they can't suckle in the way other mammals do.

07:03 SC: And that's kind of a serious trade-off. Suckling has really been a very important characteristic of being able to take care of these immature young that mammals give birth to.

07:14 GV: Absolutely. And licking milk is not nearly as efficient as sucking it. You get a lot more milk a lot faster if you can suckle from your mother directly instead of lapping or licking it up. But apparently the trade-off works for platypuses and echidnas. It's a little bit surprising to researchers though to realize that they did make this trade-off. It also... Yeah, it shed some new light on the importance of this adaptation, and how it happened in the first place, and what role it's played in mammal evolution.

07:45 SC: Yeah. I guess when it comes to the platypus though, I wonder where does... [chuckle] Gretchen, is this gonna give us any clues about why platypuses lay eggs?

07:56 GV: I asked that, and it's not directly clear. It may well be tied together. They don't currently have any evidence that would tie that together.

08:06 SC: This was presented at a meeting. What were people's reactions to this revelation, that suckling is a lot older than they had thought before?

08:14 GV: Yeah. They were surprised and intrigued, and they pointed out that this was a really clever way to get some answers to these questions, because combining modern anatomy and really careful looks at modern animals, with the shape and characteristics of fossil animals, and comparing and contrasting, requires certain interdisciplinary skills that not all teams are comfortable using. But everybody really praised this approach as an important one for solving some of these really tricky questions that lie deep in the past. One person noted breasts don't fossilize, and neither do tongues,
so we have to be more creative at looking at bones and that living tissues to try and figure out what happened 200 million years ago.

09:00 SC: All right. Thank you so much, Gretchen.

09:02 GV: Thanks.

09:03 SC: Gretchen Vogel is a news writer for science. You can find a link to her story at sciencemag.org/podcasts. Stay tuned for an interview with Sandra Yuter on clearing clouds with gravity waves.

[music]

09:20 SC: Now, we have Sandra Yuter. She and her team have taken a look at some abrupt cloud clearing. This is clouds moving very quickly, clearing in really big bands, and they suspect gravity waves are behind this change in the cloud's appearance. So, Sandra is here to talk to us about clouds. Welcome.

09:40 Sandra Yuter: Hey, thank you, Sarah, and a pleasure to be here.

09:43 SC: I'm so excited to talk about clouds. Let's start with these special clouds off the coast of Africa. They're marine clouds. What does that mean?

09:50 SY: Marine is just meaning that it's over the ocean. They're marine low clouds. If you think about a thunderstorm, those clouds are very tall, often about 10 miles higher, so these clouds, the top of the clouds is only about a mile or so. They are very long-lasting, very extensive cloud decks are normal for this region in the subtropics off the coast of Africa. And what we're seeing is this phenomenon that can rapidly remove large areas of cloud, and essentially you have a line that moves off the coast, about local midnight, and as it moves, it's essentially removing the cloud along a very organized line, about the length of California. And when I talk about removing, I'm basically talking about evaporating away the cloud.

10:32 SC: Yeah. And when you look at the video of this, it's like an invisible forearm is just sweeping a table and it's clearing off a big chunk of this cloud. It's really quite impressive.

10:42 SY: The clouds, they're bright and they reflect a lot of sunlight, and so when you take them away, that energy actually ends up going into the ocean. So, these clouds are important for cooling. You can think of the cloud as like a sun shade, so it's very rapidly just moving that sun shade away. And so anything that removes them very quickly like this is something that we're very interested in.

11:05 SC: We saw videos of this, there's photographs, is that the kind of material they are using to measure and try to understand what was happening here?

11:12 SY: Yes. Satellite data was one of the primary data sources that we use. This is actually an area of the world where there's not a lot of surface-based observations, but we did find some
balloon soundings from an island called Saint Helena, and then we also looked at data from numerical models to try to help constrain the conditions.

11:32 SC: What were you able to figure out about the cause of this rapid clearing from the satellite and other kinds of data that you looked at?

11:39 SY: One of the things is that we looked at how often this occurs, and it occurs about half the days in May, and so it's very frequently in April, May, June time period. And what we've essentially been able to do so far is rule out a couple of things. We've ruled out that this is caused by the air just being pushed out of the way. We've also ruled out that this is related to the amount of dust or aerosol in the air because they occur in both high and low aerosol conditions. And what we're trying to do right now is constrain what are the types of environments that are conducive to this occurring. And we're looking at a potential hypothesis for how this could occur, and that involves the interaction of the stable air over the ocean with an offshore flow coming off Africa, and the idea there is that that would trigger these atmospheric gravity waves. And then that, in addition to some kind of mechanism, that would promote mixing and cloud of operation maybe what is causing this big change in cloudiness.

12:42 SC: We should right here just say, for our audience, gravitational waves versus gravity waves, what's the difference, and which one are we talking about?

12:50 SY: Okay. We're talking about gravity waves, which is a term that meteorologists use when we refer to actually something that's also called buoyancy waves. This is more like an upward and downward motion in the air. A rough analogy is if you're out of the beach, floating and bouncing up and down in the waves, if you're past where the breakers are, that kind of wave motion where you're just moving up and down, that's more like this kind of buoyancy or gravity wave. What we're talking about is that kind of motion in the atmosphere.

13:22 SC: Gravitational waves are ripples in space time, totally different thing. Einstein stuff. Right?

13:28 SY: Right. So, that's different, yeah.

13:30 SC: What do you suppose causes these gravity waves, and why would they be moving off the clouds like this?

13:35 SY: It's well known that this kind of gravity waves can cause long lines of clouds. What's different about what we've found is that it's removing cloud.

13:45 SC: Twenty miles an hour, 25 miles an hour. Is that fast for a cloud?

13:47 SY: It's the combination of how fast it happens and also the fact that it's organized along this very long line. So, if you look up in the sky, you see clouds growing, you see clouds dissipating, but it's all random. What's really interesting about this is that it's organized along this very long line that moves westward.
14:08 SC: What could possibly make this cyclical? How might that work?

14:12 SY: Well, related to this idea that the initial waves are triggered by the interaction of offshore flow coming off Africa and the air over the marine layer, the offshore flow coming off Africa is actually related in part to nighttime cooling, so that area has its very dry desert area, at night it gets quite cold, and basically air will get heavier and slide down the high lands toward the ocean. And so that, we think, is why it's very regularly where the wave is essentially starting at about local midnight from the African Coast.

14:50 SC: I think we should circle back to how important these clouds are. These cloud decks, there's three of them that are just gargantuan, they cover a large percentage of the planet, and I think we should acknowledge that we don't know enough about how clouds work right now. Can you talk a little bit about that?

15:08 SY: Right. These subtropical marine clouds are occurring in the Southeast Atlantic, the Southeast Pacific, and the Northeast Pacific, and they're very extensive, very persistent cloud decks. They're important because there's a big difference in how bright a cloud is versus the underlying ocean. So, when you have these clouds in place, that leads to cooling. And there's been some calculations that show, if you change the area of this kind of marine low clouds by about 4% or so, that would potentially offset cooling associated with a doubling of CO2.

15:43 SC: How might this interact with the way the planet is warming?

15:48 SY: We're also, one, trying to understand this phenomenon as it exists today, but we're also interested in how it might change in changing climate, whether it's sensitive at all, and that's also something that we're in the process of looking at.

16:02 SC: All right, Sandra, thank you so much for talking with me.

16:05 SY: Okay. Thank you. It was a pleasure.

16:07 SC: Sandra Yuter is a distinguished professor in the Department of Marine, Earth and Atmospheric Sciences at North Carolina State University. You can find a link to her research at sciencemag.org/podcasts.

16:18 SC: And that concludes this edition of the Science Podcast. If you have any questions or comments for the show, write to us at Science Podcast at aaas.org. You can subscribe to the show on iTunes, Stitcher, many other places, or you can listen on the Science site. On the site, you can also find links to the research and new stories discussed in the episode. That's sciencemag.org/podcasts. The show is produced by Sarah Crespi and edited by Podigy. Jeffrey Cook composed the music. On behalf of Science Magazine and its publisher, AAAS, thanks for joining us.
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