Tracy Peak: Hello and welcome to NC state's Audio Abstract. I'm your host Tracy Peak. The aye-aye is one of the weirdest little primates around. It's a lemur, but not cute. It has incisors that never stopped growing, bat-like ears and freaky, elongated fingers, including one that can swivel like a joystick that it uses to echolocate and spear pray, and it just got weirder, like extra finger weirder.

 We're speaking today with Adam Hartstone-Rose, an associate professor of biological sciences here at NC state and with Edwin Dickinson, a postdoctoral researcher in Adam's anatomy lab about the aye-aye's secret pseudo thumb. Welcome Adam and Edwin.

Adam H.: Thanks for having us.

Edwin D.: Thank you very much.

Tracy Peak: All right. Most people are familiar with lemurs but maybe not aye-ayes so let's start with talking about what's the difference? Why do they look the way they look?

Adam H.: So aye-ayes are one of the strangest of all mammals in the whole world and they're definitely the strangest of all of the lemurs. They branched off from other lemurs very early on. So all of the other lemurs are closer related to each other than any is to the aye-aye.

 And it has all of these really bizarre, unique traits that you are alluding to. So these bat-like ears and these weird fingers that it uses to echolocate. It's the largest nocturnal primate in the entire world, so it exists in this strange ecological zone and it's a very cryptic animal. In fact, we used to think that they were nearly extinct. And then when we started looking for their nests and their chew marks instead of actually just looking for the animals, then we realized that they actually live all over Madagascar.

 And so it's this just this really bizarre, mysterious thing. And we happened to find this piece of anatomy that makes it even more bizarre and strange.

Tracy Peak: Yeah. And that leads to the next question. How did this happen? I'm assuming people had been familiar with aye-ayes for quite some time, so how did we go and just miss this little extra digit until now?

Adam H.: Well, I've been dissecting primates for many, many years, for a couple of decades now, and I aye-ayes are very, very rare. In fact, there are, I think about 30 of them in captivity in the United States. And so I've been trying to get my hands on one for quite a while to study some of the strange anatomy.

 And a couple of years ago we finally got a really amazing specimen of one. And so we're doing really careful dissection work on it. And one of the realms of our research is looking at the anatomy of the forearms. And so all of your fingers are fired by muscles that live in your hands, but also exist in your forearms. And so we were tracing each of these muscles really carefully from the forearm into the hand. And one of the muscles we noticed was doing something strange when it passed the wrist.

 And so part of it went to the thumb, which is where it was supposed to go. And another part of it sent a little tendon very specifically to this strange structure. And as we started exploring that structure more, we realized that it was this really elaborate piece of anatomy that had a bone and a piece of cartilage and three muscles that control it and move it in different directions.

 And what we found was the pseudo thumb of the animal. And so that that sort of opened up a whole new realm of exploration. And so I did all of these detailed gross dissections with the traditional sort of scalpel dissection and I asked Edwin to join the team and he started doing this amazing digital anatomical investigation.

Tracy Peak: Can you give me a good definition of why is it called a pseudo thumb?

Edwin D.: Yes. So the reason behind the unusual name is that this digit is derived from not any structure related to the true thumb or the first digit of the hand, but rather it derives as an expansion of one of the wrist bones, a bone called the radial sesamoid.

 So rather than being related developmentally to anything that sits within the thumb itself, it's actually a growth out of the animal's wrist that functions a little bit like a thumb and exists sort of on the thumb side, part of the hand, but it's not functionally related to the thumb itself.

Adam H.: You can imagine something that's in between the thumb and the wrist, but that has some of the functional mobility of a true thumb. But because of its like different derivation, we call it the pseudo thumb.

Tracy Peak: And it's not as big as a true digit either. This thing is pretty small.

Adam H.: Yeah. So in some animals they... It's more substantial, so this is the first primate that we ever found a pseudo thumb in and it's probably been overlooked because it's really part of the fleshy part of the palm of this animal.

 And so it kind of looks like a nub, but it has all of the function... It moves in these three different directions and probably the coolest thing about it is that when you actually look really carefully at it, you can see that it has its own fingerprint. So it is like this little secret sixth digit in there that no one had ever noticed before.

Tracy Peak: So we know it exists. What do they use it for?

Edwin D.: That's, that's a really good question, it’s something that we hope to be able to explore more with experimental studies into the future. Our current hypothesis is that because the aye-aye's hand is become so specialized for its tap foraging strategy, so it has these really long slender fingers that it uses for finding grubs underneath bark, the aye-aye's hands have become very poor at actually arboreal grasping.

 And we think that the pseudo thumb is important for generating a more distal grip or like a wrist positioned grip so that this animal can actually support itself as it's walking through the trees, being unable to use its fingers as other lemurs do to like wrap around digits as it's walking.

Tracy Peak: Okay, so-

Adam H.: Basically the fingers became really good at doing something amazing. So they do this crazy behavior with these long spindly fingers, but they're not really good at fingery stuff. They're not really good for grasping. And so we think that this wrist bone that it's kind of became this own structure helps compensate for the loss of the type of grabbing that most animals would do with their fingers.

 So I always joke that lemurs... that aye-ayes look like lemurs walking on spiders cause they've got these long fingers and the longer and more spindly your finger is the worse it is for picking little things up or holding onto trees. And so we think that the palm of the aye-aye kind of added this amazing adaptation to help it maybe even grab small items and also for gripping while it's walking around on branches.

Tracy Peak: Well these animals are certainly super interesting. So we'll move away some from the specifics of this research because that's pretty cool. And into sort of a more general realm of lemurs versus aye-ayes. Why are you drawn to these animals, lemurs and aye-ayes? What do you like about them and what do you like about aye-ayes specifically? Because I've seen pictures and they're just, wow.

Adam H.: Yeah, aye-ayes are crazy looking. I mean, so I think they're horrible looking.

Tracy Peak: Okay.

Adam H.: A lot of people think that they're so ugly, they're cute. So a real litmus test to show people a picture of a baby aye-aye, which is a ridiculous scary. It looks like something out of the gremlins, like you would have thought that it was a Muppet and not a real animal.

Tracy Peak: Don't feed it after midnight.

Adam H.: Yeah, exactly. But they're amazing. And so they're probably the smartest of all of the lemurs. They have the largest brain for a lemur. Lemurs are unfortunately kind of famous for not being very brainy. So lemurs are more primitive than monkeys and apes. And so they're more olfactory, so they use their nose more than their vision. They're not really as cognitively adapted as monkeys are, but aye-ayes are really probably exceptional among them.

 And they do all of this amazing stuff so they can hear... When they're doing this tap foraging behavior, they flick on the wood with that crazy middle finger and what they're actually hearing for are voids in the wood. So they're hearing for essentially the carved out troughs and trails that these grubs are chewing in the wood and they can make a mental picture of those trails underneath the wood, the subsurface trails.

 And they've actually been shown to be, to gnaw holes, not randomly in those trails, but they find intersections of those trails so that they can access the best routes by sticking that creepy finger into them. And so this requires just amazing cognitive abilities. I mean, these are things that humans can't do. They can echolocate like bats, which is something that no primate, no other primate can do. These ever-growing teeth that are very useful for this type of behavior. No other primate has that.

 And then this amazingly dexterous finger. There's only one other animal that I know of, this bizarre marsupial in Papua New Guinea that has a crazy skinny finger like this that it uses for fishing out stuff.

 And so it's got this amalgamation of all of this bizarre anatomy. And I think that because everybody's been so interested in that amazing finger and the amazing head adaptations that nobody ever noticed, this little wrist thing that we think is pretty nifty as well.

Tracy Peak: It's a little nub, but it's more than just a nub.

Adam H.: The little nub. It's more than just a nub.

Tracy Peak: How about you, Edwin, what's your favorite thing about the aye-aye?

Edwin D.: So what I find really interesting about lemurs in general to begin with is how from a relatively basic body plan, I mean lemurs are considered like the most basal level of primates and they have relatively simple and conservative anatomy. They're able to branch out into all of these different ecological niches and eat different things and live in different places.

 But what makes the aye-aye so special is that amongst all lemurs, it really just decided to do totally its own thing. It is truly like a trailblazer among lemurs in that it's anatomically derived beyond any kind of constraint of other lemurs. It has a totally unique diet. It's nocturnal, it's basically a lemur that's decided the last thing in the world it wants to be is a lemur and it's changed everything about its anatomy and its behavior in order to try and stand out from the pack.

Adam H.: I mean it's even strange and I mean it's definitely the strangest primate and it was so strange that most anatomists up until relatively recently, the middle of the 20th century, they thought it was a rodent. That's how strange it really was.

Tracy Peak: Well, and it's little teeth. I thought it was a squirrel, or a rat, or a-

Adam H.: It's teeth, yeah, it has a bushy tail, like a squirrel. It has these ears that are not primate like at all. It has inguinal mammaries, so it lactates between its legs basically, which is unique for primates.

Tracy Peak: What?

Adam H.: Yeah. It's just really strange, and so you can't really blame people in the 19th century for classifying it as a squirrel for most of the known existence of the aye-aye, it was classified as a squirrel.

Tracy Peak: A really freaky squirrel too. Yeah.

Adam H.: A really freaking big squirrel.

Tracy Peak: It is definitely its own thing. Good grief.

Adam H.: But lemurs are amazing animals in general. The largest one is a lemur called the indri, which is... It's really an amazing animal and it doesn't exist anywhere outside of Madagascar. They don't survive in captivity. They stop eating. They like go into a depression and... Yeah, but they're so they're these beautiful, amazing animals and they make this really loud call like morning wailing sounds that's just fantastic. If you ever go on YouTube and listen to the sound of the indri, it's really mystical.

 And then there are all these really cool quadrupedal lemurs. So like when you think of like the classic lemurs, the ringtail, so it moves around kind of like a cat. And in fact the ring-tail lemur is named lemur catta and that was one of the first species that Linnaeus named and he named it catta because it makes a sound that sounds like meowing of a cat, but then there are little itty bitty nocturnal lemurs. So the smallest primates in the world are mouse lemurs. There are all sorts of lemurs. There... Now we think there are about a hundred species and they only live in the Island of Madagascar.

Tracy Peak: That's amazing. They just decided to branch out, the lemurs. The lemurs just decided that lemuring could be an amazing diverse thing.

Adam H.: One of the things that I love about lemurs is that they are on that arc on their own. So Madagascar is in a lot of ways like a biological experiment, very much like Australia, except whereas in Australia, all of the diversity is this amazing marsupial diversity. For those of us like Edwin and I who are really interested in primates, Madagascar is the special place cause that's got this amazing Island biogeography with this really cool lineage of primates that diversified there.

Tracy Peak: And that leads me to my final question for both of you. What's the coolest thing about your research?

Adam H.: The coolest thing about our research. So what I enjoy the most, so you mentioned that we're at NC state and what I enjoy the most is incorporating students into our research. And so what I think is really fun is that we have all of these different questions that we can ask about the anatomy of hands and the anatomy of forearms and adaptations. And these types of studies are really fun for students.

 So we have a lot of students who are interested in going into research but also students who are pre-med and pre-veterinary. And we have pre-dental students who do art and do research on teeth and skulls with us.

 And so it's really amazing to be able to use this fascinating research to open up sort of worlds of opportunities for students to get involved and get dissection experience and an understanding of functional morphology. And so we publish a lot of these papers with students as coauthors. And in fact, one of the authors on this aye-aye research was an undergraduate who worked with me in my lab years ago and continued working with me. She became my lab manager and she's a fantastic anatomist and now she's in medical school trying to become a surgeon. And so I really love using this research to inspire future generations of students and scientists.

Edwin D.: And one thing I really enjoy is just being able to build our research around questions that interest us. So everyone who we work with has their own personal interests relating to research or animals that they particularly like or find fascinating. And it's just such an enjoyable experience to be able to ask questions relating to something that truly interests you and go out into the field and observe these animals or work with them in captive settings and try and understand from a functional perspective how it is that all of these animals are capable of doing the behaviors that they practice on a day to day basis. And then for us to try and sort of back out some of the evolutionary pressures that could have led to this sort of incredible diversity and that characterizes the lemurs.

Tracy Peak: Adam and Edwin, thank you so much for being here today.

Adam H.: Thanks for having us.

Edwin D.: Yeah, thank you for inviting us.

Adam H.: Yeah, we're excited to be able to talk about this really exciting research about this bizarre animal.

Tracy Peak: We have been speaking today with Adam Hartstone-Rose, an associate professor of biological sciences here at NC state and Edwin Dickinson, a postdoctoral researcher in Adam's anatomy lab. This has been NC state's Audio Abstract. Thank you so much for listening.