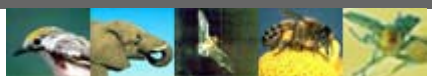
Calls of the Wild



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SCIENTIFIC AMERICAN FRONTIERS
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"Calls of the Wild"
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SONGS OF LOVE AND BETRAYAL

ALAN ALDA (NARRATION) It's one of nature's most sublime symphonies. Today, almost no one hears it. But Bruce Byers wouldn't miss it for the world.

BRUCE BYERS It's Tuesday, May 19th at 5:05 am. Recording a bird ...

ALAN ALDA (NARRATION) Bruce is listening to the dawn chorus - the wakening calls of songbirds in the Berkshire Hills of Western Massachusetts. He's here most mornings from May through July, recording the songs of one bird in particular - the chestnut-sided warbler. It's the male birds that are singing. Most of the female chestnut-sided warblers are still en route from Central America, an arduous 3000-mile migration these males have just completed. Right now, the brief twittering song the males are singing is characteristic of these last moments before dawn. But with the sunrise, the song changes. More and more males begin a new song, described in birding guides as, "Pleased, pleased, pleased to meetcha!" We wondered what it was about the songs of the chestnut-sided warbler that makes Bruce Byers get up so early. So one day in early July we arranged to meet him here in the Savoy State Forest.

ALAN ALDA Is this where you do most of the observations?

BRUCE BYERS Yup. This is where the chestnut-sided warblers live. Out here in the power line cut. They like this shrubby habitat.

ALAN ALDA (NARRATION) We'd arrived here at about 4:00 am, and spent several hours waiting out a cold drenching rain. It's now 10 o'clock - and very, very quiet.

ALAN ALDA You know, I don't hear any birds.

BRUCE BYERS Yup. It's getting to be the quiet time of day after the early morning burst of singing. This unusually cold and wet weather. They sing even less than they normally would at this time. Presumably because they have to work harder at replenishing their energy, and spend more time feeding and less time singing in this kind of weather.

ALAN ALDA Now, if they spend a day without much singing and the day goes pretty well, why do they come back the next day and sing again? What's the spur to all this singing?

BRUCE BYERS Yup, that's a good question. Only the males sing in this species and they sing only during breeding season. Presumably that means that singing is connected somehow with successfully defending a territory and successfully acquiring a mate. So, while they might able to get by for a few hours or even a day without singing, if they fail to sing at all, they would not be able to breed successfully because they wouldn't have a territory or a mate.

ALAN ALDA How big would one bird's territory be? Can you--?

BRUCE BYERS This one territory that we're on now is among the largest territories on the study site this year. It extends from just about down, almost down to that wooden power line hole there up to this one. So almost the whole distance between the two power line poles.

ALAN ALDA And from this line of trees to those trees over there.

BRUCE BYERS Yup. The birds do not go very far back into the woods. They like the open country. And so they pretty much restrict their territory to this open area.

ALAN ALDA (NARRATION) While we've been talking, Bruce's colleagues have been setting up a net to try to catch one of the birds that live here.

ALAN ALDA Is it the right bird?

BRUCE BYERS It's the chestnut-sided warbler.

ALAN ALDA Oh, let's go take a look.

ALAN ALDA (NARRATION) A net like this is designed to catch a bird without harming it - provided it's rescued before it becomes too entangled.

BRUCE BYERS So now the bird's out of the net. And we're going to weigh him and measure him and put color bands on him so that we can identify him as an individual.

ALAN ALDA Beautiful bird.

BRUCE BYERS Yeah, they are beautiful.

ALAN ALDA (NARRATION) Beautiful he may be - but also, it was to turn out, not quite what he seems.

ALAN ALDA This territory we're standing on, is that the territory of this bird? Is that why he came in here?

BRUCE BYERS Yes. In all likelihood. There is a very very high likelihood that the bird we captured here is the resident male on this territory.

ALAN ALDA (NARRATION) The male-female pair that lives here should be settling into domesticity about now, building a nest for its new family. So it's not surprising that Bruce is assuming this is the resident male.

BRUCE BYERS And he will be forever known to us as dark blue over X left, dark green--right. We'll always be able to tell who he is when we record his songs. And also when we measure his reproductive success. Now we're going to let him go. He's all banded. There he goes.

ALAN ALDA Whoa!

ALAN ALDA (NARRATION) But as the male flies off, we all hear the "pleased, pleased, pleased to meetcha" of another male, only a few feet away.

ALAN ALDA Who is that? Is that the guy who lives here or was that somebody else?

BRUCE BYERS That suggests birds pretty much only sing on their own territory. That suggests very much that the resident bird was not the bird we captured. And that we captured an intruding male that was wandering around in here.

ALAN ALDA You get a lot of stories in this little shrubby place here.

BRUCE BYERS Each territory has its own little story, that's for sure.

ALAN ALDA Who would know out here among all these power lines, life is throbbing with interest.

JIM JONES I think I found the nest over here.

ALAN ALDA (NARRATION) And it was about to become more interesting yet. Bruce's colleague Jim Jones had spotted a female flitting back and forth carrying twigs and grass to build her nest - and hanging around with the male we just released.

JIM JONES So she's still building that nest.

ALAN ALDA Would she have been the female that was interested in the male you caught?

JIM JONES Quite possibly. Because I've seen her flying around in these bushes in this area, so it was probably the same female we saw with the other male.

ALAN ALDA (NARRATION) In the hope this time of catching the resident male, Bruce's team has set up a speaker to play back the soft chirps of a female. Instead it was a female that turned up in their net.

ALAN ALDA Do you think this is the female from this nest that we were looking at?

BRUCE BYERS Yup. This is almost certain this is the resident female, the one that was building the nest we were looking at a few minutes ago.

ALAN ALDA Oh, oh, so this isn't only the female who was building the nest, she was also looking to fool around with the guy you caught in the net before.

BRUCE BYERS Yes. Yup.

ALAN ALDA And then she heard what she thought was another female maybe coming in to mate--to fool around with her hubby and she got upset and came over--.

BRUCE BYERS She fell into the same trap as her lover.

ALAN ALDA Don't you think that's kind of a double standard you have there?

ALAN ALDA (NARRATION) This little love triangle we'd intruded upon turns out to be only the beginning of the soap opera that's the warblers' hectic summer. Most pairs end up raising three or four chicks. But when Bruce Byers checks the chicks' paternity with a blood test, typically half the baby warblers in a nest weren't fathered by the male that's helping rear them. So while a female chestnut-sided warbler bonds to one male as her chick's provider, she's open to others when it comes to providing her chicks with their genes.

BRUCE BYERS So is there a way that a female could look at or listen to all of the males in her area and make some kind of determination which male would have the genes that would give her offspring the greatest advantage? And so we think that songs are probably one of those things.

ALAN ALDA (NARRATION) And here's the puzzle Bruce is trying to solve. Because every male in the neighborhood is singing the same song - that same "pleased, pleased, pleased to meecha!" So how is a female to choose?

ALAN ALDA This is one call?

BRUCE BYERS Yup. This is a sonogram, a spectrographic display of an accented ending or a main attraction song. "Please please please to meet ya."

ALAN ALDA (NARRATION) By comparing these pictures of the

songs, Bruce thinks he's now discovered the key to a male's attractiveness. Because while some males sing with very slight variations, others are solidly, stolidly, predictable.

ALAN ALDA If the male can keep rendering a good version of the song - a good strong version of it - then she, and she sees another guy faltering a little bit on the second chorus, then she would go for the first one, huh?

BRUCE BYERS Right, exactly. The male that performs best and in this case we think that best means the most consistently, most rhythmically, with the least amount of variation.

ALAN ALDA (NARRATION) This show is all about listening to the calls of the wild and trying to decipher them - always with the assumption that the sounds in fact have a meaning, a purpose in the animals' lives. But before we go on…

ALAN ALDA Is it all utilitarian? I mean, is any of it, you think, just because it feels good?

BRUCE BYERS Well, if you are asking me off the scientific record I would say yes, of course. That's at least why birds sing, because they enjoy it. But, of course, we can't know, as humans, what's in a bird's mind. And those kinds of questions are kind of outside the bounds of what science can reach. It's just not part of our mandate. It's not part of what science can do. And so, ah, those kinds of conjectures have to remain speculative and not scientifically demonstrated. It doesn't mean I don't believe 'em.

ALAN ALDA Right.

ELEPHANT RUMBLES

ALAN ALDA (NARRATION) This may look like Africa. But it's all - tree included - a carefully crafted illusion. The elephant, though, is real - one of a small herd of African elephants here at Disney's Animal Kingdom in Florida - where their voices are being recorded by research biologist Anne Savage.

ANNE SAVAGE When most individuals think of elephant vocalizations, they're often times thinking of the loud vocalizations they typically hear--the trumpets and the yells and things like that. But the majority of vocalizations they give are these rumbles, these low frequency calls.

ALAN ALDA (NARRATION) The rumbles - some too low in pitch for our ears to detect - are recorded by immense microphones slung beneath the animals' throats.

ANNE SAVAGE In order to really understand what these vocalizations mean, we've got a study where we go out and have individuals filming the elephants while we're recording their vocalizations. Then what we do is take all that information back into the laboratory and match vocalizations and behavior together. After we've filmed them, it seems like it's been a very quiet day, we'll come back into the lab and we'll find out it's one of those days where they've just been chatting up a storm. It's amazing what they're saying to one another.

ALAN ALDA (NARRATION) Eavesdropping on elephants is a brand new science... still at the stage of simply trying to categorize the calls.

KIRSTEN LEONG They start at the very high frequency end of the spectrum with the trumpets that most people are more familiar with. And then the snorts, croaks and revs which are two new vocalizations that nobody's ever described before. And then going sort of down the frequency, there are chuffs, which sound a lot like an exhalation. Noisy rumbles, loud rumbles, and then rumbles. And those three, at the low end of the spectrum, are all the calls that include infrasound.

ALAN ALDA (NARRATION) We can't hear the infrasound, but the rumbles also include higher frequency harmonics that sound to our ears like a growl.

KIRSTEN LEONG So this was the noisy rumble from Infiki, followed by the rumble, loud rumble, from Tondia.

ALAN ALDA (NARRATION) Each strip on the chart is a different elephant. The infrasound bands run along the bottom of the strips.

KIRSTEN LEONG These bands are a little close together. These are more widely spaced. That's the difference between a noisy rumble and a loud rumble. But also, if you look--these are synchronized in time and the ends of them overlap a little bit. That's pretty common with elephants. They often overlap or sort of interrupt each other, which we also call chorusing.

ANNE SAVAGE There's some type of social interaction going on between these two animals. What that interaction truly is, what these calls mean in relation to that interaction is the $50,000 question. It's like studying any animal language or human language. When you go to another country and don't speak the language, you will often times have to sit and watch and watch and watch for hours and hours until all of a sudden you'll start to see relationships starting to happen.

ALAN ALDA (NARRATION) In elephant society, most relationships are between females, which live together in groups. Here at Animal Kingdom some elephants grew up together, while others are relative strangers. The Disney researchers have found that rumbles are exchanged more often between the strangers than between old friends.

ANNE SAVAGE It's sort of like, you know, when I walk into a room with friends I might just kind of sit down and say, hey, how's it going, but I don't need to announce anything. But for animals that aren't as familiar, we find that often times they will announce or at least vocalize that, you know, I'm coming.

ALAN ALDA (NARRATION) Anne Savage's most notable discovery has been that female elephants - which only ovulate every four years or so - rumble more when they are nearly ready to mate.

ANNE SAVAGE Our data suggest that females will vocalize about twenty one days prior to ovulation as if, sort of, a little calling card to the males, to say, hey, in twenty one days, I'll be ready. And so the males then can figure out how they're going to enter the group;

fight amongst themselves to figure out which male will be allowed into the group. They'll then hopefully breed with the female and then she'll become pregnant.

ALAN ALDA (NARRATION) Infrasound has one very useful property that would make it the perfect calling card to males outside the group - it can travel much further than regular sound.

ANNE SAVAGE So if I'm standing here, chatting up a storm, someone could be listening to my conversation three to five miles away to try and determine if, hmm, maybe they should try to invade my territory or determine if I'm an estrus, or maybe I've found something that they really want or maybe I'm communicating about something that's going on with my group. I mean, eavesdropping is something we all do and it's not surprising that it's found in the animal world as well.

ALAN ALDA (NARRATION) Eavesdropping opportunities at Animal Kingdom are limited - with the whole of Africa reduced to a few square miles. But in the real Africa, where elephants can roam over hundreds of miles, eavesdropping may be possible far beyond the range even of infrasound. This research team, from Stanford University, is in Etosha National Park in Namibia, setting up a seismic detector of the sort usually used for earthquakes. Directed by Caitlin O'Connell, this is part of an ambitious project to see if elephants signal to each other not only through the air but also through the ground. So far, Caitlin's research has suggested that the very low frequency infrasonic rumbles do indeed set up seismic tremors nearby - and that the signals could in principle travel up to 30 or 40 miles. Here in Namibia, Caitlin's team is both recording seismic signals from elephant rumbles as well as trying something more ambitious...

CAITLIN O'CONNELL Playback starts in 15.

ALAN ALDA (NARRATION) Playing back the rumbles though the ground to see if the elephants respond.

CAITLIN O'CONNELL Five seconds. Start playback.

ALAN ALDA (NARRATION) The problem is that at this stage in her research, Caitlin's not at all sure what response to look for. Worse, she's not even proved that elephants can detect the seismic signals, let alone interpret them as something meaningful. Which is why when we caught up with her she was preparing for an experiment much closer to home, among the elephants at Oakland Zoo.

ALAN ALDA So the elephants are going crazy now over in the other pen, right?

ALAN ALDA (NARRATION) My seismic signals are about to be replaced by a device called a shaker.

CAITLIN O'CONNELL It actually creates vibrations in the ground. These were actually made to sit under the car seat to shake the car seat to the beat of the music.

ALAN ALDA What? People sell these things for that? To shake their car seats?

ALAN ALDA (NARRATION) The shakers vibrate in the same range as infrasonic elephant rumbles.

ALAN ALDA So the vibration goes down that pipe into the ground.

CAITLIN O'CONNELL Into the ground. Yes. And we've got three of them lined up.

ALAN ALDA (NARRATION) The shakers are set up about a hundred feet away from a fence…

ALAN ALDA Here you go Donna.

ALAN ALDA (NARRATION) And a friendly elephant named Donna.

ALAN ALDA That's got a lot of strength in it. It's got a really firm grasp.

GREG GILBERT Donna, no. Probably as soon as we can start, Caitlin, the better.

CAITLIN O'CONNELL Signal.

TIM Start. Rumble.

ALAN ALDA (NARRATION) Donna has already been trained to raise a foot at the sound of a rumble…

GREG GILBERT Good girl, hun.

ALAN ALDA (NARRATION) After which she gets a bite of apple.

GREG GILBERT Good girl.

CAITLIN O'CONNELL I'm going to wait for her to put her foot down.

ALAN ALDA Kind of casual there.

CAITLIN O'CONNELL Yup.

ALAN ALDA There it goes.

CAITLIN O'CONNELL Signal.

TIM Start. Rumble. End.

ALAN ALDA And… there goes the other foot.

ALAN ALDA (NARRATION) Right now, Donna is still getting the rumble through the air as well as through the ground.

CAITLIN O'CONNELL Start negative.

ALAN ALDA (NARRATION) Now comes a control.

TIM Start negative.

ALAN ALDA (NARRATION) This time there's no signal at all - through the air or through the ground.

ALAN ALDA Okay, she didn't raise her foot. Now she's getting a reward for not raising her foot when there was no rumble.

CAITLIN O'CONNELL Yes. Okay, start.

TIM Start.

CAITLIN O'CONNELL That was perfect.

ALAN ALDA (NARRATION) So far, so good. But now comes the real test.

CAITLIN O'CONNELL Okay, now unplug the speaker. So now the only thing that's coming out of the tape recorder is the shakers. So the speakers now...

ALAN ALDA So the tape recorder just goes under the ground now.

CAITLIN O'CONNELL Yes. Now we'll start positive.

ALAN ALDA You know I think I can feel this through my shoe.

CAITLIN O'CONNELL Yeah.

ALAN ALDA Yeah. I almost lifted my foot.

ALAN ALDA (NARRATION) I felt the earth move - but apparently Donna didn't.

CAITLIN O'CONNELL So close.

ALAN ALDA Almost. Almost.

CAITLIN O'CONNELL Start positive.

TIM Start positive.

ALAN ALDA She shifted her feet.

CAITLIN O'CONNELL That was definitely not...

ALAN ALDA It didn't look like she was moving toward her lift.

CAITLIN O'CONNELL No.

ALAN ALDA (NARRATION) So to see if Donna is still paying attention, Caitlin adds back the rumble sound - with unexpected consequences.

CAITLIN O'CONNELL She is lifting her trunk now. Oh she did it!

ALAN ALDA She lifted her trunk--.

CAITLIN O'CONNELL And her foot.

ALAN ALDA And then she lifted her foot.

CAITLIN O'CONNELL She said, can't we do the trunk thing now, I'm bored with the foot stuff. Come on, Donna, do it, do it. Oh, it's her trunk. The trunk and sorta leg.

ALAN ALDA See I think, you got to reward her now. The trunk, because, that's what she thinks it is.

ALAN ALDA (NARRATION) With Donna apparently now very confused, Caitlin reluctantly decides to end the trial.

CAITLIN O'CONNELL The longer we do this with her, with the trunk and the foot, the more confused it'll be next time.

GREG GILBERT You just can't let one training day bother you, because that's just the way it is.

CAITLIN O'CONNELL Yup.

ALAN ALDA (NARRATION) But just as we're all about to leave, Donna heads back to her workstation.

CAITLIN O'CONNELL Start positive.

TIM Start positive.

ALAN ALDA (NARRATION) And this time Caitlin goes for it - no rumble sound, just the shakers.

CAITLIN O'CONNELL She did it.

TIM That was good. That was good.

ALAN ALDA She's doing it, isn't she?

CAITLIN O'CONNELL Yes!

ALAN ALDA Wow! What's fascinating about this, is that she didn't start to do it until she came back on her own--.

CAITLIN O'CONNELL On her own.

ALAN ALDA And volunteered a session.

CAITLIN O'CONNELL And decided, I know what you guys want. I'll just show you that I know what's going on here.

ALAN ALDA That's really interesting about the effect that this has apparently on research of letting the animals choose--.

CAITLIN O'CONNELL Come at their own will.

ALAN ALDA Come at their own time and their own way.

CAITLIN O'CONNELL That's what's really nice about this environment here, at the Oakland Zoo, yeah. It's fantastic.

ALAN ALDA (NARRATION) But our excitement is short lived.

CAITLIN O'CONNELL Start negative.

TIM Start negative.

ALAN ALDA (NARRATION) Donna gets no signal at all - but still lifts her foot.

CAITLIN O'CONNELL Ooh. It was looking so good.

TIM Start negative.

ALAN ALDA (NARRATION) So - another control. Donna hesitates…

CAITLIN O'CONNELL That's good. She put it back down. Okay, start positive.

TIM Start positive.

ALAN ALDA Oh, wow.

CAITLIN O'CONNELL That's great.

ALAN ALDA Isn't that--? That's gorgeous. Isn't that great?

MALE SCIENTIST Good girl Donna. Good Donna. Good girl, Donna.

CAITLIN O'CONNELL Wow. I can't believe it.

ALAN ALDA (NARRATION) Of course it will take much more than one or two successes for Caitlin O'Connell to prove her hypothesis - that elephants can communicate through the ground of their native Africa for distances of up to 30 or 40 miles. Meanwhile, the elephants transplanted to their own miniature Africa at Disney's Animal Kingdom are already demonstrating that there are some calls of the wild we humans simply cannot experience.

ANNE SAVAGE I think that the idea that they are able to communicate and we can't hear it and it's sort of trying to understand the big puzzle, trying to figure out what all of this means is very very exciting. They have strategies that are so unique to their own species that makes this discovery every day a new adventure.

ECHOES IN THE NIGHT

ALAN ALDA (NARRATION) While elephant voices are too low for us to hear, the night sky over Barro Colorado Island in Panama is full of voices too high for us to hear… Unless you're lucky enough to be here with Elisabeth Kalko.

ALAN ALDA Is this good?

ALAN ALDA (NARRATION) Elisabeth calls this her bat detector -- a high-tech box that instantly lowers the pitch of the bat sound, so we can listen in.

ELISABETH KALKO Oh! And we have a bat already flying above us.

ALAN ALDA I didn't hear anything.

ELISABETH KALKO These are the bats that live under the roofs of the houses here.

ALAN ALDA Can you tell from that sound what it's doing?

ELISABETH KALKO Yeah, right now -- beautiful, beautiful -- we hear a lot of different things but it's very fast, unfortunately. What you hear now, these are search calls. They are searching for insects, and when you hear ddd... brrrrr, the brrrr is a terminal phase. This is when they home in on insects.

ALAN ALDA That brrrr?

ELISABETH KALKO Right, that was a terminal phase again. And what I find so fascinating about it is when you walk out here usually or normally you wouldn't get any of the life above us, and we wouldn't even know that bats are here, and now the forest comes alive, the acoustic world comes alive, and there's a lot of action going on!

ALAN ALDA What? What? You're hearing something great - what?

ELISABETH KALKO Well, they're just feeding like crazy right now. Hear all these weird buzzes?

ALAN ALDA Well you went into ecstasy with these sounds happening, and I can't - that's my question - how many years did it take before you could interpret these sounds so acutely? I mean, you can tell everything they're doing! How long did it take you?

ELISABETH KALKO Well, I'm working with this system here, with echolocation I think, well, let's see - it was almost ten years.

ALAN ALDA (NARRATION) We brought a special night vision system out to the island, to help us see what Elisabeth already sees in her mind. The night sky in the forest is filled with action. The bats are hunting. All those clicks and squeaks are different kinds of echolocating sounds, used to bounce off, and find, the prey. It's mainly insect eaters that are out right now.

ELISABETH KALKO Wha!

ALAN ALDA (NARRATION) The zipping noise is the final burst of sound as the bat swoops in for the kill.

ELISABETH KALKO That must have been an excellent sound recording.

ALAN ALDA (NARRATION) Elizabeth's latest work is figuring out exactly how bats use all these different sounds.

ELISABETH KALKO The white-lined bats, they're called Saccopteryx bilineata, catching the insect about three meters above the ground.

ALAN ALDA (NARRATION) So her nights are spent out in the forest,

making recordings for analysis later.

ELISABETH KALKO Searching for the insect...

ALAN ALDA (NARRATION) Here's a typical hunting sequence.

ELISABETH KALKO Now... Speeding up the calls... Right...

ALAN ALDA (NARRATION) And then in for the kill.

ELISABETH KALKO A gorgeous terminal phase.

ALAN ALDA (NARRATION) For Elisabeth, it's like some kind of air show up there.

ELISABETH KALKO I hear the naked-backed bat, then I hear Saccopteryx bilineata, the white-lined bat, in the background I hear a free-tailed bat. So it's a whole symphony of bat calls that surrounds us right now.

ALAN ALDA (NARRATION) The edge of the lake is a favorite hunting ground for bats. Every night, insect eaters and the big fish eaters swoop out of the forest in a spectacular aerial display.

ALAN ALDA Are the bigger ones one species, and the smaller ones another?

ELISABETH KALKO Yes, yes. The big one is the fishing bat, Noctilio leporinus, and that's a bat that is specialized in catching small fish and occasionally also insects from the water surface, and the smaller one is Noctilio albiventris and that's a purely insect eating bat and taking prey from the water surface too. We are now connecting the synchronization unit with my sound recording equipment, so that we can actually later on release this whole system.

ALAN ALDA (NARRATION) To understand exactly how different bats hunt, Elisabeth invented this multi-flash picture system.

ELISABETH KALKO So let's see whether the flashes are working. Uh huh. Ready, go.

ALAN ALDA (NARRATION) The bats' echolocation sounds are recorded at the same time. Watch this bat delicately plucking fish from the water surface.

ALAN ALDA Are they zeroing in on the water and the prey at the same time, and each other, all those things?

ELISABETH KALKO Actually what they do is since they echolocate individual targets, they know exactly which spot they want to go to. For example, for the fishing bat when a little fish breaks the water surface, the echolocation call to the bat gives an echo back that indicate very clearly there's a fish breaking the water surface, so the bat goes specifically for this spot. There were almost 300 nights that I was out there, listening to bats, making multi-flash recordings, and trying to decipher a little bit of their mysterious lives.

ALAN ALDA (NARRATION) Elisabeth keeps an exhausting schedule -- nights in the forest, then days in her lab.

ELISABETH KALKO Yes, I have a print here from one of the pictures that we took last night, and it shows the bat approaching a little fish that broke the water surface, and the bat approaches this water disturbance and hits the water with its claws, tries to get the fish out of the water, takes the fish out, and then carries it away.

ALAN ALDA When the bat senses the fish coming out of the water, by the time the bat gets there the fish is back in the water.

ELISABETH KALKO Exactly.

ALAN ALDA So the bat has to know where it would be at the right time.

ELISABETH KALKO Right, and this is visible here, because we see the disturbance here in the water, but when the bat hits the water surface it's different.

ALAN ALDA (NARRATION) In the split second the fish breaks the surface, the bat measures its speed and direction, using a rapid burst of calls. Here they're slowed down fifty times.

ALAN ALDA So how many of these little beeps is the bat making in a second?

ELISABETH KALKO In the terminal phase, and this is when they make the most calls, they may make about 150 to 170 calls per second. So that's a lot.

ALAN ALDA It is! What kind of a mechanism does the bat have to make such rapid sounds? How does it do it?

ELISABETH KALKO It does it, like we talk. Bats produce their calls, with their vocal cords, and so it's like talking. But of course they have special muscles that allow them to get the tension up and to produce these calls at such a fast rate.

ALAN ALDA (NARRATION) Now look at insect eaters. First they use a special call which actually tells them what kind of insect is out there. Then they track the insect -- it's the lower set of dots in the picture -- with a different call, until the moment they snatch it out of the air. So here's the first call, used to identify the prey. It's a series of steady notes that bounce off the insect's wings, and come back wobbly.

ELISABETH KALKO It gets modulations back that tell the bat there is an insect. And not only that, it can also determine the wing beat rate. It knows, this a beetle, this a moth--it knows the direction the insect is flying.

ALAN ALDA It's a real sound picture of these wings beating.

ELISABETH KALKO That's a real sound picture. But the bat has great difficulties with its call type to determine how far away is the insect.

ALAN ALDA (NARRATION) Now the bat changes to rapid calls, like the fish eater. Elisabeth discovered that each of these is a falling call, like a series of piano notes. They're a super-accurate way to measure the distance.

ALAN ALDA It's going "ddddddddd", and from the other end of the room it's coming back, "ddddddd", but it's measuring the time of each of those notes as it comes back.

ELISABETH KALKO Right.

ALAN ALDA (NARRATION) Thanks to Elisabeth Kalko's bat detector - and more importantly her boundless enthusiasm -- bat squeaks are now among the best understood of all the calls of the wild.

BEE LINES

ALAN ALDA Now these are stingless bees, huh?

DAVID ROUBIK Yeah these are the user friendly bees.

ALAN ALDA (NARRATION) Like Elisabeth Kalko, David Roubik works at the Smithsonian Tropical Research Institute in Panama.

DAVID ROUBIK They have all the same problems that any other bee that makes honey and has a big luscious nest to eat would have, but they're very selective about where they build a nest. It's usually only in a standing tree, and they do have defenses. Some of them bite very well.

ALAN ALDA Oh, oh, oh.

DAVID ROUBIK So it's a combination. They're not fools, you understand.

ALAN ALDA But we're surrounded by them here, so we don't have to worry?

DAVID ROUBIK Yeah, well they're just coming and going here. It's an active colony.

ALAN ALDA (NARRATION) Actually inside his lab, David keeps an entire colony of one of the many stingless bee species.

ALAN ALDA They make honey, so what do they make it out of?

DAVID ROUBIK Well, out in this forest there are about a thousand species of different flowering plants they can go to, they might use two or three hundred kinds during the course of a year. So constantly, every day of the year, all during the daylight hours they're foraging . Bees are going out, maybe as far as two or three kilometers and bringing back food.

ALAN ALDA (NARRATION) The bees have to make hundreds of trips each day, back and forth between forest and hive. What the researchers have found is that the bees can tell each other exactly where to go in the forest.

ALAN ALDA How accurately can the bee communicate to the others

where this good source of food is?

DAVID ROUBIK Finding how well they could communicate was really what shocked us, because they're not just kind of giving a general cue of "there's some good food out here, fly around and maybe you'll find it". They're saying how far away, how high up and in what direction, so three dimensions.

ALAN ALDA (NARRATION) The story of this remarkable discovery begins with David's specially arranged bee colony.

ALAN ALDA Where are they, here?

ALAN ALDA (NARRATION) A pipe running through the wall channels the bees into an observation hive, where you can watch and listen to the bees in action.

ALAN ALDA So this is what it looks like inside a normal hive.

ALAN ALDA (NARRATION) These are foragers entering and leaving the hive. Here on the left is where other workers store honey. This is the queen, mother of all worker bees, who lays her eggs in rows of cells. There's also one other thing about these bees.

ALAN ALDA They have little numbers on them.

DAVID ROUBIK This is a sign we've been here before.

ALAN ALDA Just let me make a guess -- you put them there, right?

DAVID ROUBIK You're exactly right.

ALAN ALDA (NARRATION) How on earth do you put a number on a bee?

JAMES NIEH How we do it is we just grab a bee. They're quite docile when they're feeding, and also they're stingless so that helps. Here I'll let you try and label it....

ALAN ALDA (NARRATION) Biologist James Nieh works with David on bee communication research.

ALAN ALDA Now what do we do?

JAMES NIEH And then you smear a little bit on to her thorax.

ALAN ALDA Her thorax is right after her head, right?

JAMES NIEH Right. Exactly, that little furry spot.

ALAN ALDA (NARRATION) Being able to tell one bee from another is crucial for doing communication experiments.

ALAN ALDA Seventy-eight. Now we've numbered a bee! Number seventy-eight is my bee! When this bee makes a great scientific discovery, and we all go to Sweden to get the prize, number seventy-eight is mine!

ALAN ALDA (NARRATION) After the bees are numbered, they're trained. Sugar water is injected into the hive to excite the bees interest. Next, a feeder with the same sugar water is placed at the hive entrance. In just a few seconds the bees discover the feeder, and there's no doubt they like what's there. Once a few bees have had a good drink, the feeder is moved away from the hive. As long as it stays within smelling distance of where it was before, the bees can easily find it again after making deliveries to the hive. James steadily leads the bees into the forest, advancing twenty feet at a time -- about the maximum distance the bees can smell. So they can train bees to forage anywhere in the forest... Even at the top of a hundred-and-twenty-foot tower, which simulates a tall flowering tree. You really have to love bees to make this climb. The question they're asking here is whether bees can communicate the height of a food source to their fellow workers back in the hive. Of course some bees already know where the food is, because they've been trained. That's why you have to know their numbers, so they can be discounted. Here's 3... 34... 5... 26. They're all trained bees. Wait a minute -- here's one without a number. Well, that's a complication. New workers are born every day, so there are always a few like this. They have to be marked as they show up. Now as the bees fly between the tower and the hive, James looks for new recruits -- ones he hasn't trained to come here. Meanwhile, down at the base of the tower David watches a second, identical feeder. Maybe new recruits will find this one.

DAVID ROUBIK OK James, there you have it set up here now.

JAMES NIEH Let me know if you get any new recruits, over.

DAVID ROUBIK No recruits here yet, James, haven't seen a bee.

ALAN ALDA (NARRATION) If the bees can communicate how high the food is, then no new recruits should show up at the ground level feeder. They should all head out of the hive, straight to the top of the tower. And that, in fact, is what happens. These are all new recruits.

JAMES NIEH Looks like I just got my ninth recruit, and that means about nine to zero, is that correct? Do you have any new recruits down there? Over.

DAVID ROUBIK They're making a bee line to you it seems to me. It's been pretty dull down here.

ALAN ALDA (NARRATION) When the experiment is reversed, and the bees are trained to the base of the tower, all new recruits show up there. So the bees do somehow communicate height. Next, bees are trained to a feeder north of the hive, and the new recruits show up there -- not at a feeder to the south. So the bees can also communicate direction. And it's the same for distance. Even when two feeders are set up only about thirty feet apart, new recruits always went to the feeder where their hive mates were trained. So how do the bees do it? Maybe the new recruits simply follow the trained bees. So James repeated the experiments, this time capturing all bees leaving the hive, and keeping those which had been to the feeder. But new recruits still found the correct place, so simple following can't be the explanation. Is it possible the recruits follow some kind of scent trail in the forest? After all, biologists know that bees often deposit a mysterious liquid on leaves. To rule

out this possibility, feeders were taken across a lagoon where no scent trail could be left -- and the recruits still went to the right feeder. So looking for some form of communication, James began videotaping bees as they returned from feeders... And he found the secret world of bee talk. This red marked bee has just returned from a feeder. As it hands over food to other workers, it makes a series of pulsing buzzes. Then it does a brief dance, accompanied by another series of buzzes. By comparing bees that came in from different feeders, James managed to decipher the buzzing code.

JAMES NIEH This is a bee that's foraging at the base of the canopy tower. We also have another group of bees that's foraging at the top of the canopy. And what you should notice here, is that...

ALAN ALDA The pulses are shorter.

JAMES NIEH Exactly. Right. So from here to here the bee's unloading food, and if you compare the pulses, they're definitely shorter.

ALAN ALDA (NARRATION) Short buzzes made while unloading food mean that the food comes from near the ground. And the longer the pulses, the higher the food source. For sound made during the dance, the longer the buzz, the farther away the food.

ALAN ALDA It's like the bee book! It's like if they weren't at home you could leave this around, they could walk across it and read it and see how far to go.

JAMES NIEH Exactly. It's a bee sentence.

ALAN ALDA It's a bee sentence.

ALAN ALDA (NARRATION) As for how the bees communicate direction, that's still a mystery. Maybe number seventy eight will show them how it's done.

A NEW WAY TO HEAR

ALAN ALDA (NARRATION) In the desert mountains of Arizona, Damian Elias is out hunting creatures whose calls no-one has heard before - not because, like elephants, they're too low, nor because, like bats, they're too high, but simply because no-one ever thought to listen. Jumping spiders have spectacular looks - and the eyes to appreciate their species' finery - which, as is usual in nature, is critical to the successful courting of a mate. What even ardent arachnophiles had never appreciated until Damian began his work is that some jumping spiders also murmur sweet nothings during courtship… Sweet nothings that are actually sweet somethings - if we listen right.

ALAN ALDA You have this set up so you can hear him easily with this thing? How does this work.

DAMIAN ELIAS So how it works is, we have a phonograph needle placed right underneath the female, so as the animal is vibrating it will be vibrating the surface and we can hear it, as sound.

ALAN ALDA So you're really hearing what she's hearing as she

hears through her legs?

DAMIAN ELIAS Exactly.

ALAN ALDA (NARRATION) Most of the sounds I can hear through earphones are a cacophony of pattering footsteps and paintbrush dabs as Damian tries to wrangle the male spider into position.

DAMIAN ELIAS He has to basically face her in the right position and then he'll go, oh. It's a female, and then he'll start going.

ALAN ALDA Oh, I see.

DAMIAN ELIAS But when you dump him on this it's, oh, look at this, I'm going to run away, oh, there's a big paintbrush coming at me, I'd better run away. So you basically have to wrangle him until he sees the female and then it works great.

ALAN ALDA (NARRATION) The male makes its sounds by rattling its abdomen... conducting his song with his expressive front legs. This species even adds in a lovesick moan. Damian Elias' discovery that his Arizona jumping spiders sing while they dance while they court was made in a laboratory at Cornell University that is dedicated to understanding the sounds of bugs, and how they use those sounds to communicate. But spiders are newcomers here. The lab's workhorse is an insect whose love songs we all can share on a soft summer's night. A male cricket's chirps have evolved to attract female crickets. But potential mates aren't the only females listening. This is a female fly, of the species Ormia ochracea. And when she hears a cricket in the dark, she'll land nearby and lay hundreds of minute larvae, each less than a millimeter long. Now, this next part gets a little gruesome - but stick with it. You'll be rewarded not only by a tale of the impossible - there's no way a fly should even be able to hear a cricket, let alone locate it from its chirps - but also by an unexpected pay-off for people like me who find it hard to converse in a noisy room. By now, ormia larvae have crawled all over the unfortunate cricket looking for a soft spot to burrow through. Just ten days later, having eaten the cricket from the inside out, they're ready - like creatures from a science fiction movie - to emerge, leaving the cricket behind, a dying shell. Who cares that a fly can hear a cricket? Well, Ron Hoy, for one.

RON HOY So these are the host crickets. And they're quite easy to capture.

ALAN ALDA (NARRATION) I've joined Ron Hoy in his lab at Cornell University, where he rears crickets by the hundreds, so he can raise flies to find out how they hear.

ALAN ALDA You're interested in the flies because how they hear, but what was your interest in crickets?

RON HOY My interest in crickets was to understand their communication system. I've always been interested in their communication. Now, my father, who came from China, was very concerned about this, because in China, crickets are used for fighting. And when he heard that I was studying crickets, he was concerned that this was going to be a euphemism for gambling.

ALAN ALDA Oh, he thought you were getting into gambling. Oh,

that's funny. But interestingly, you've got led from communication in crickets to hearing in flies.

RON HOY It's really interesting, because flies are not at all related to crickets. So how flies essentially got to play the game of cricket by hearing is a deep and compelling question because most flies don't have ears that can hear crickets. In fact, 99.999 percent of flies cannot hear crickets. So this is a very unusual phenomenon.

ALAN ALDA What's that high-pitched noise I hear?

ANDREW MASON That is a simulated cricket chirp, so, this is a small speaker sitting in front of this fly.

ALAN ALDA What's that ball you have there?

ANDREW MASON That's actually a ping pong ball.

ALAN ALDA And you drew little dots on it?

ANDREW MASON Yes, with a magic marker. And we built this from a computer track ball. Just like this one. So this is what we--. This is the same type of device.

ALAN ALDA This has little dots on it.

ALAN ALDA (NARRATION) This ingenious little fly treadmill clearly shows the fly responding to the cricket call, darting forward - or trying to - at every chirp. But the Cornell researchers also used the trackball to explore the flies' extraordinary ability to locate the exact source of the sound. Every time Andrew Mason moves the speaker, the fly changes direction. In fact, the fly is able to detect and respond to changes in the direction of the speaker as small as 2 degrees - about the same accuracy you or I have in locating a sound.

ANDREW MASON There are two ways to do this: One is to detect a time difference of when the sound arrives at each ear. So this obviously depends on how far apart your ears are. The other is to detect a difference in the loudness of the sound at the two ears. And this generally depends on having some relatively large body structure such as a head, in between your ears. So that sound coming from one side is blocked a little bit. So the flies are too small to block any of the sound in between their two ears so there's no difference in loudness. And they're so small that they're ears are so close together that the time difference of when it arrives is--.

ALAN ALDA So it must be that they can't hear it. He's just got really good eyes. How does he know? How does he hear it? If the both of those ways of hearing are prevented.

ANDREW MASON Loudness difference is prevented. There is no loudness difference. The time difference is there but it's infinitesimally small.

ALAN ALDA (NARRATION) Amazingly, ormia can detect a difference of only a few billionths of a second in the time a sound arrives its two ears - which it wears on its chest under its head.

FEMALE SCIENTIST So after popping up the head, you can see the ear. That's this large structure here.

ALAN ALDA It's interesting that we need ears that are separated to get a sense of directionality. These ears are jammed right up next to one another.

FEMALE SCIENTIST That's one of those fantastic things of this fly, one of the great mysteries which--.

ALAN ALDA How does it work?

RON MILES It's pretty amazing that you can get directionality out of something that small. But basically, the way it works is, these ears, rather than being isolated like most ears on big animals like us, these ears are connected together.

ALAN ALDA (NARRATION) Connected together like a teetertotter able not only to pivot about the center... the whole thing can also flap like a bird. When a sound arrives, say, from the left, the pitching and the flapping combine to exaggerate the motion on the left and suppress it on the right, giving a signal big enough for the fly's brain to pick up. A simple mechanical trick...

ALAN ALDA It's like that thing we used to do as kids, going up and down. But somehow the fly knows that there's a cricket over there. That's pretty smart.

RON HOY Yeah, yeah. It's a lot smarter than we are.

ALAN ALDA (NARRATION) Ron Hoy the biologist and Ron Miles the engineer have now teamed up to in effect construct a mechanical replica of ormia's ear. The idea is to make a new kind of hearing aid for people like me.

RON MILES A lot of folks who are hearing impaired have a lot of trouble understanding speech when they're in a noisy place. And, ah--.

ALAN ALDA Yeah. That's certainly my experience. In a room where people are standing around chattering before dinner, if there's a lot of people, I can't hear those sounds like "f" and "s" and "sh". I can't distinguish those sounds. Now, how will hearing like this fly? How will a hearing aid made like this fly's ear help me hear better?

RON MILES Well, what we're working on is a way to make an actual microphone that operates in a similar way to the way the fly's ear works. And what that'll accomplish is, inside a hearing aid, we can have the hearing aid respond more to sound, say, from the front of the person that's wearing it than from the back. So that the microphone itself in the hearing aid will be directional. And it will filter out those unwanted sounds for you.

RON MILES It's kind of hard to see but we've fabricated some prototypes--.

ALAN ALDA (NARRATION) On this tiny chip of silicon, only a millimeter long, Ron Miles has already constructed a microphone that responds to sound just as do ormia's ears - by both pitching...

and flapping - and so should allow its wearer not only to locate crickets, but also hear the person in front of them.

ALAN ALDA So that will go right inside this thing.

RON MILES Yeah.

ALAN ALDA So you literally borrowed from the fly.

RON MILES Yeah.

ALAN ALDA We'll be hearing with ears the same size as a fly's ear. So how long do you think I have to wait for this?

RON MILES Well, it depends on money, basically.

ALAN ALDA I'll give you fifty dollars right now.

RON MILES Fifty dollars?!

ALAN ALDA On the spot.

RON MILES Thank you.

ALAN ALDA (NARRATION) There can be few research projects that so beautifully illuminate the value of a curious scientist simply asking the question, how? In this case, how does a fly find its victim. In answering it, Ron Hoy and his colleagues discovered a whole new way of hearing - and will maybe one day help my dinner conversations make sense.

RON HOY It's always a humbling experience to realize, hey, this is a bug. But it can do all these really cool things. And given that we only understand, that we only know about a quarter of all the insects that are out there, there are really a lot more. I think there are a lot more ears to be discovered, there are more eyes to be discovered, more noses. And I hope that I'll be around long enough to keep after them. 'Cause it really is fun.

return to show page