The Master Singer

From the tropical rainforest to the urban jungle, birds have conquered many habitats on our planet – and they sing in nearly all of them. **Henrik Brumm** at the **Max Planck Institute for Ornithology** in Seewiesen studies how they use song to communicate with each other. He has taken a particular liking to one extraordinarily talented singer.

TEXT **CLAUDIA STEINERT**

Whenever his cat lays a dead bird in front of his door, Henrik Brumm vacillates between sympathy and scientific curiosity. His inquiring mind usually wins out, and Brumm studies the bird's vocal organ, called the syrinx. At least this way the animal still makes a contribution to science. After all, Henrik Brumm is a behavioral biologist. He wants to know how animals communicate with each other – how they court each other, for instance, or how they tell each other about the best feeding areas, and how they defend their territory. That's why, since completing his doctoral thesis, Brumm has been researching what is likely the most complex form of communication in the animal kingdom: birdsong.

Of the more than 10,000 known bird species, around 4,000 are songbirds. While every bird can produce sounds, not all of them can sing. The cuckoo, for example, can manage little more than his eponymous call. Parrots imitate sounds and even human speech, but that doesn't make them songbirds. Only those whose vocal apparatus – the syrinx mentioned above – comprises particularly complex structures fall into this category.

For his doctoral thesis, Henrik Brumm studied how the urban noise in Berlin affects the communication of nightingales – how the birds get their message across over the sounds of cars honking, sirens wailing and airplanes roaring around them. Germany's capital was ideal for his project: no other major German city has such a large nightingale population. They prefer to build their nests on the ground amid herbaceous hedges that sprawl over lawn edges and curbs, and that are not always trimmed as frequently as in other cities.

ON THE PROWL AT DAWN

Brumm's decision to carry out the nightingale project wasn't entirely without ulterior motive: it suited his biorhythm. Unlike most songbirds, the nightingale sings not only at sunrise, but also at night. Brumm envisioned himself taking off before or after hitting a few

Photo: Axel Griesch

Henrik Brumm records birdsong in a forest near Starnberg. The image on this page shows a common chaffinch.

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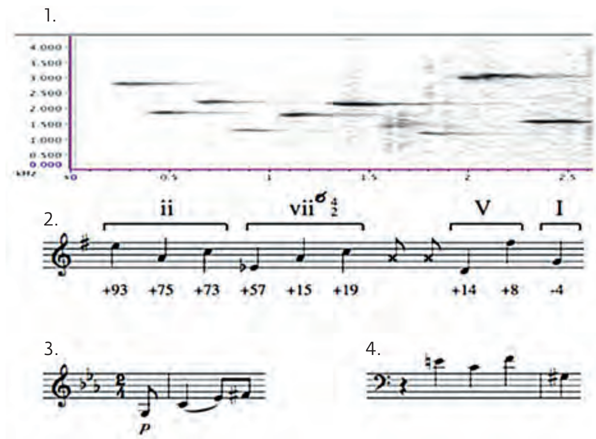


Left King of the singers: Most of the 80 species in the wren family use loud and complex songs, but no other bird can match the musician wren – his melodic singing is unique in the animal kingdom.

Right The song of the musician wren has striking similarities to human compositions: song frequency over time (1), transcription of the notes of the song (2), opening melody of the second movement of Haydn's Symphony No. 103 (3), and the opening of Bach's Fugue No. 20 in A minor, BWV 889 (4).

pubs, equipped with a night vision device, laser rangefinder and sound level meter. But that didn't pan out. "I really got cheated on that one," he says with a wink.

The university had to cut costs. Rather than a night vision device and laser rangefinder, his supervisor gave him binoculars and a tape measure. Working in the dark was thus impossible. From then on, he dragged himself out of bed at 3:30 each morning and got on his bicycle. He pedaled to the city highway, roamed through parks and stood for hours at highly frequented intersections. As soon as he saw a nightingale, he held up his sound level meter and recording device.

After recording the song, he rolled out his tape measure and measured the distance between himself and the bird. From the distance and the sound level, he then calculated the absolute volume of the song. His conclusion: the more noise surrounding the nightingales, the louder they sing. They display what is known as the Lombard effect.

Lombard was a French physician who noticed, some 100 years ago, that we involuntarily adjust our volume according to the noise level of the environment, so that those we are talking to can better understand us. And it is precisely this trick that birds, too, use to make themselves heard in the city. "Nightingales sing more loudly during the week than on the weekend, because the streets are louder on weekdays," explains Brumm.

Birdsong is so characteristic that ornithologists can recognize a species by it. But that takes practice – except in the case of one of their representatives: "Even amateurs can identify the musician wren," says Brumm. This bird, which lives in the Amazon and measures just 12 centimeters, is smaller than a sparrow and has similarly inconspicuous coloring. But while it's not much to look at, when it opens its beak and begins to sing, it sounds as if music were floating through the jungle.

A VIRTUOSO IN THE RAINFOREST

The musician wren has gained quite some renown in its native habitat. Due to its remarkable song, it is as significant in the culture of indigenous peoples as the nightingale is in ours. The locals revere the small bird, which they call "Uirapuru," and numerous legends have been woven around it. Anyone who hears it sing will enjoy good fortune in hunting, in love, or even in all aspects of life. Some restaurateurs or shop owners even bury a dead Uirapuru in front of their door in the hope that it will improve business. When the Uirapuru sings, so the stories go, all other animals in the forest fall silent and gather around it to listen to its songs.

Yet the song of the Uirapuru serves a very practical purpose: like all songbirds, it uses its melodies to attract female birds during mating season. The female birds can tell from the song how viable a male bird is, and consider it a sign that the singer evidently managed to conquer a food-rich territory – how else would he have so much time for singing! In the Amazon, communication by song is also important for another reason. In the undergrowth of the tropical rainforest, with visibility often below three meters, it is very difficult for animals to see their potential partners. Calls and songs, however, penetrate the dense vegetation.

In 2003, Brumm himself stood in the jungle of the Amazon rainforest for the first time. Around him, everything was green, with trees and bushes blocking his view. Suddenly he heard this song and he immediately knew: it's him – the musical bird that he had previously known only from audio recordings. Henrik Brumm wanted to know why the musician wren sings like that. Why do its songs sound to humans like a concert musician's performance, while

Photo: Michel Clément; graphic: MPI for Ornithology other birds sound like children leaning to play the recorder? No one knew.

At the University of St Andrews in Scotland, he met musicologist Emily Doolittle. Doolittle was looking for biologists who research animal sounds. Brumm was looking for someone who understood more about music than he did. Together, the two began to develop an experiment to answer the questions that had long occupied Brumm: why does the song of the musician wren sound like music? The findings needed to be quantifiable. They wanted facts and figures, not subjective opinions.

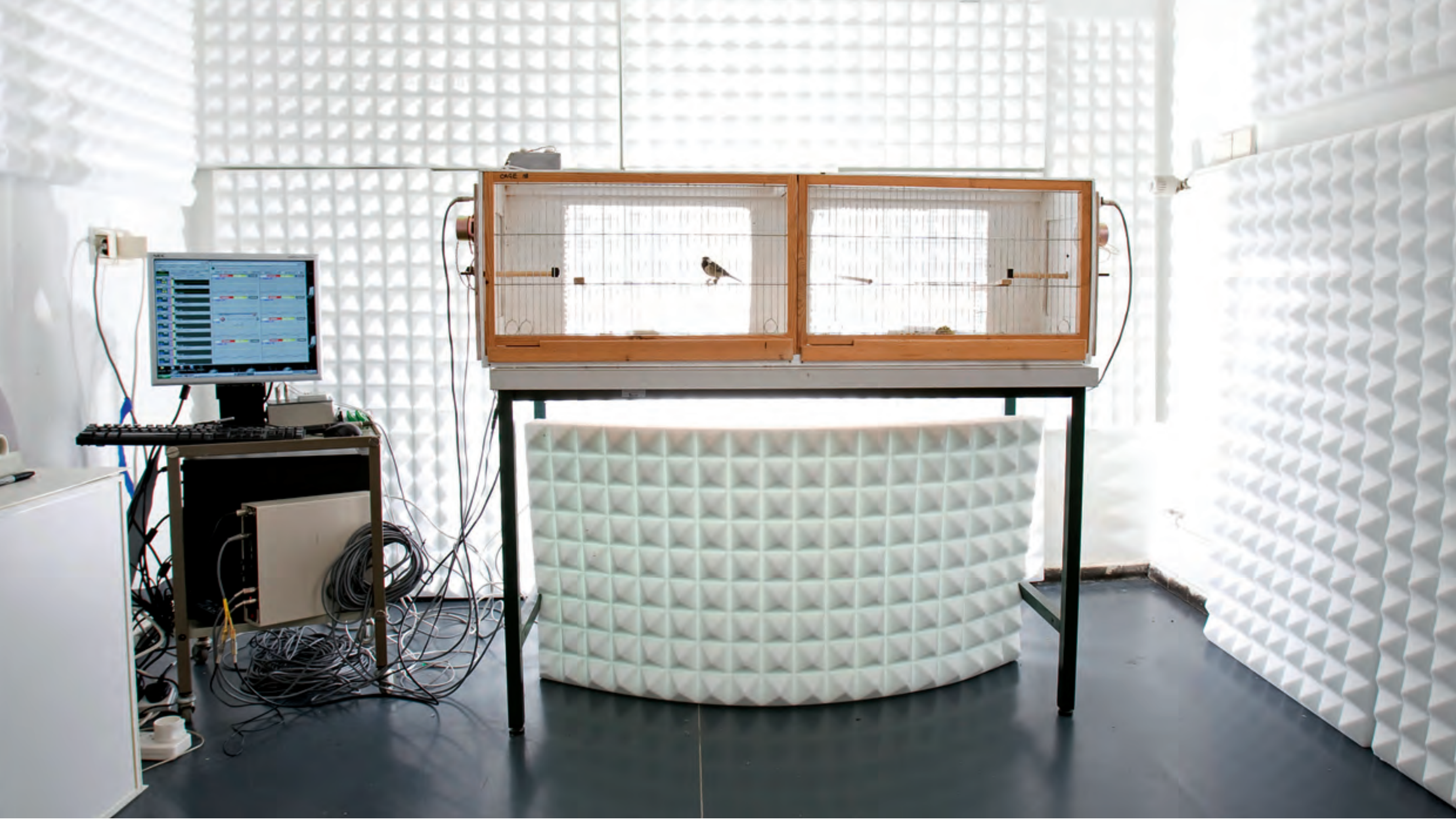
Of course Brumm would have preferred to travel through the Amazon himself and collect bird sounds, but no one would have paid him to do that. So Brumm and Doolittle used the xeno-canto database, where anyone – scientists and amateurs alike – can upload recordings of bird songs. This put an incredible variety of bird sounds from around the world at researchers' fingertips.

First they reproduced the songs of many different musician wrens using a synthesizer, as listeners in the experiment were not to know that the melodies were birdsong. Next, they jumbled up the individual notes of each song. They didn't change the pitch or duration of the notes – only the order. They played both the original and the jumbled version for study participants: concert pianists, garage band founders, and people with no musical inclinations. They were asked to decide which of the two variants sounds more musical. The original melody was the clear winner. "Even those who knew nothing about music agreed," says Brumm.

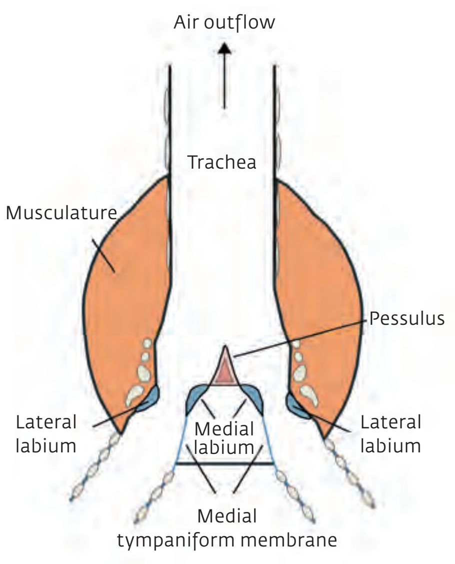
Since the researchers had not altered either the notes themselves or their duration, only one factor remained. It had to be the note intervals – the spans between successive notes. "Of course we don't know whether the bird has any perception of intervals or tonality," says Brumm. But that wasn't his concern. Brumm's aim wasn't to discover whether the musician wren is musical. He also didn't want to know whether the bird perhaps even carries within it what some invoke as the primeval music that

Henrik Brumm analyzes the songs of his feathered study subjects on the computer – using the latest software to fathom every last detail.

Photo: Axel Griesch



Below Unlike mammals, who produce sounds with their larynx, birds vocalize using a unique organ called the syrinx, which is located at the base of the trachea where it branches into the primary bronchi. Songbirds have a two-part syrinx that houses a separate sound source in each bronchus, each of which is controlled by a separate set of muscles These muscles adjust the tension and position of the labia, known as the medial and lateral labia, and the medial tympaniform membrane and in this way, in conjunction with additional factors, regulate the pitch of the song. Since different neurons in the bird brain control the muscles, the two sides of the syrinx function independently of one another. Songbirds can therefore sing two different notes at the same time, or alternate between the right and left sides in rapid succession.



is supposed to have inspired all man-made music. He only wanted to know why the song of this little bird sounds so pleasing and beautiful.

Upon analyzing the melodies more closely, it turned out that the musician wren does, in fact, sing particularly often in what are known as perfect consonances. He warbles in fourths, fifths or octaves – that's what music theorists call an interval of four, five or eight tonal steps. To our ears, these intervals sound particularly harmonic; they are also used in many folk and children's songs. Imperfect consonances are much rarer in the song of the musician wren, and they avoid dissonances, which occur frequently in jazz music and create disharmony.

EVOLUTION AS A COMPOSER

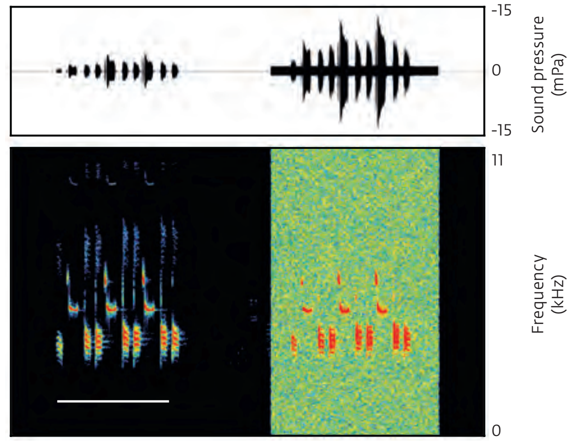
Our perception of perfect consonances as harmonic and beautiful isn't merely a construct of Western culture. It also has something to do with our order-loving brains and the physics of soundwaves. For every note, soundwaves vibrate at a certain frequency: the faster they vibrate, the higher the frequency. When the frequencies of two notes are in a simple mathematical ratio – for instance, one frequency is twice as high as the other – we perceive the interval as calm and harmonic. An octave has the frequency ratio 2:1, a fifth, 2:3, and a fourth 3:4.

"The intriguing question is why this one bird species specialized in consonant intervals," says Brumm. This type of song probably gives the birds an evolutionary advantage. The female birds could be the driving force behind this: if they prefer harmonic songs and mate more frequently with male birds who sing them, this trait would become dominant. Each generation would then be somewhat more musical than the one that preceded it. What remains unclear is why this preference for consonances developed specifically in musician wrens and not in any other birds. To date, no other species has been found to prefer perfect consonances. To our ears, many bird species sing downright unmusically.

Songbirds learn singing the way humans learn speaking: the chicks imitate what the adults sing to them. To produce sound, however, birds don't use the larynx, but rather the syrinx, which is located at the base of the trachea where it branches into the primary bronchi. This allows birds to produce two notes simultaneously and sing a duet with themselves.

Brumm and his colleagues discovered that birds and humans, despite

Photo: Axel Griesch; graphic: Sue Anne Zollinger/MPI for Ornithology



Left page In the soundproof lab, the researcher tests what female birds most enjoy listening to. The animals can play songs themselves by pressing a button. Female birds just can't get enough of the song of male birds of their own species: they listen to it several hundred times a day.

Top right Birds sing twice as loud (right) in a noisy environment as they do in a quiet one (left).

Bottom right Frequency spectrum of the song under the same conditions as above.

their different anatomies, use the same mechanism to produce sound. It is a system that is particularly forgiving of errors. When humans speak, the elastic vocal cords open and close. The combination of air pressure and muscle tension in the vocal cords produces a certain tone. Children who are just learning to speak must experiment for a very long time to learn which combination produces which sound.

If there were just one correct vocal cord position for each sound, it would be incredibly difficult to imitate sounds accurately. However, because the elastic vocal cords don't just open and close, but in the process also undulate like a wave, there are multiple correct positions that all produce the same tone. The syrinx of birds works on the same principle. It is thus much easier for children and chicks to learn how to speak and sing, respectively. Not only did Brumm and his colleagues discover this principle in birds, they also showed that all birds – from the sparrow to the ostrich – possess this mechanism. "The principle seems to have proven successful."

In big cities, however, it is rapidly becoming more difficult for birds to communicate, due to the noise that engulfs every metropolis like a cheese dome. The World Health Organization estimates that 200,000 people in the European Union die each year from cardiovascular diseases caused by constant noise. Brumm is now investigating whether noise leads to sleep disturbances in birds, too, or triggers chronic stress in them, causes their cells to age faster or disrupts their immune system functioning. "The birds could be a model for better understanding these processes in humans."

For some time now, Brumm has been studying bird populations at Berlin's Tegel Airport. He originally wanted to test how they behave when the terminals eventually close and peace and quiet descends on the nesting sites in the northern part of the capital city, but that hasn't happened yet: "The operators of Berlin's new airport thwarted that." So the field studies there will have to wait another couple of years. In the meantime, Brumm plays Munich's traffic noise to the birds at the Max Planck Institute in Seewiesen. ◀

TO THE POINT

- **Loud environments make it more difficult for birds to communicate, so they adapt their song and likewise sing louder – a phenomenon referred to as the Lombard effect.**
- **To human ears, the song of the musician wren sounds like music because the bird sings in perfect consonances. The melody is made up of fourths, fifths or octaves. It is not known how the birds themselves perceive their song or whether they have any concept of consonance, tonality or theme.**
- **Birds and humans produce sounds in the same way: the vocal cords of mammals and the labia of the syrinx in birds oscillate in the same patterns of overlapping waves.**

GLOSSARY

Musician wren: A member of the wren family, this bird lives in the Amazon, where it has a large range. Due to its unusual song, the species plays a prominent role in South American mythology and folklore, and even the English name points to the bird's distinctive musicality. The nearest relatives of the musician wren (the chestnut-breasted wren and the song wren) have much simpler songs. Only the musician wren favors perfect consonances in its song.

Lombard effect: This phenomenon, named after French physician Étienne Lombard, causes people (and also some animals) to adjust their voice to the volume of their environment. If the surrounding noise level increases, people involuntarily speak more loudly. If, for example, several people are speaking in a small room, the volume in the room may gradually grow louder and louder.