Poetic birdsong, precisely tuned: Study finds nightingales can flexibly adjust pitch

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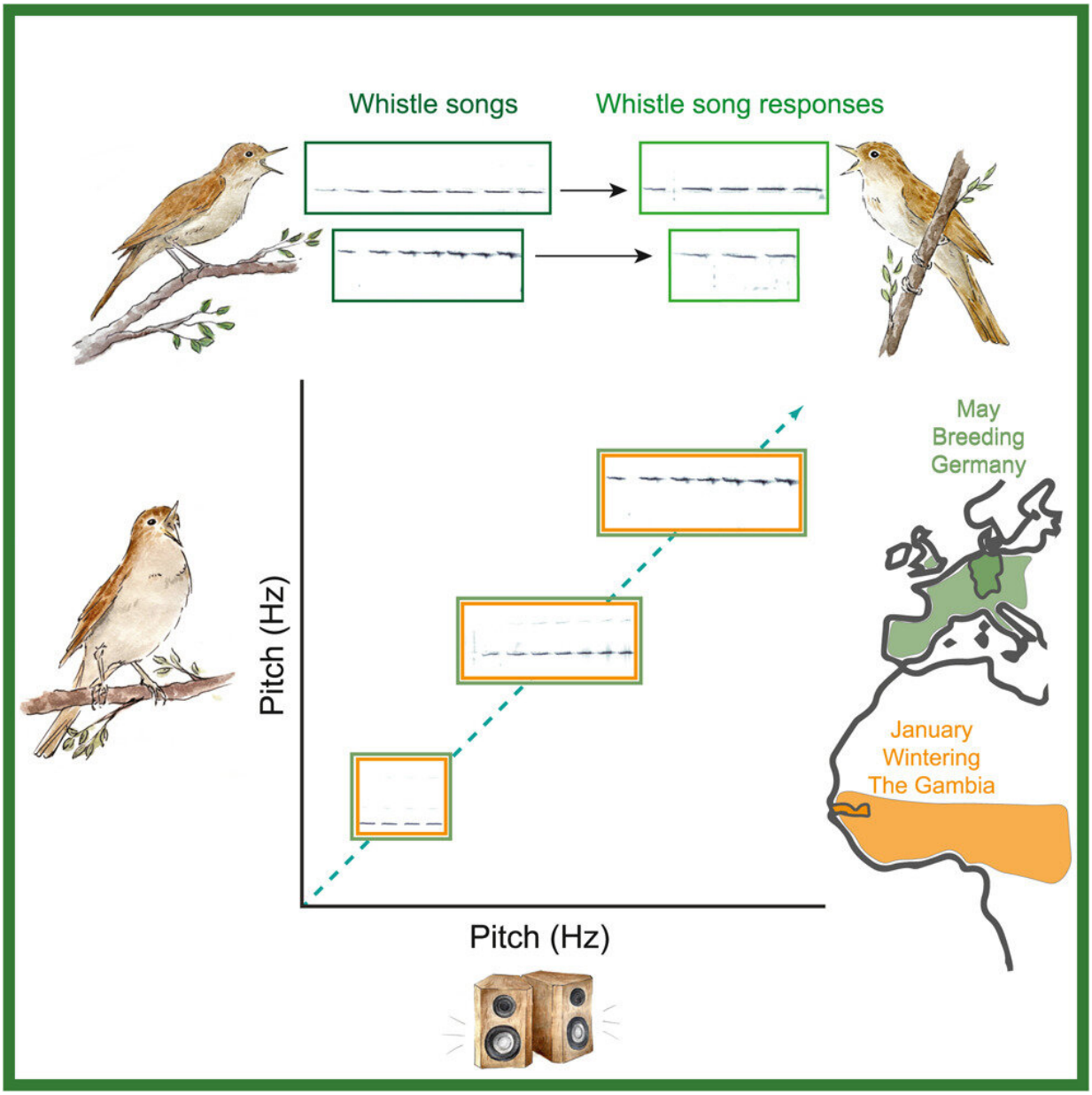
When nightingales perform their singing duels, they respond to their rivals' whistle songs by matching their pitch. Credit: Max Planck Institute for Biological Intelligence / Magdalena Warner

Nightingales are well known for their exceptional singing abilities. Researchers from the Max Planck Institute for Biological Intelligence now found that nightingales can flexibly adjust the pitch of certain song parts over a wide range of frequencies to imitate competitors.

This strategy is thought to increase their mating chances during the breeding season. Interestingly, the researchers could also observe this behavior in the birds' wintering grounds in Africa, where they usually do not produce sophisticated song. These findings suggest that a robust neural circuitry allows nightingales to precisely adjust the pitch of their whistle songs to auditory stimuli in real time.

"It was the nightingale and not the lark," exclaims Juliet in a pivotal scene of Shakespeare's drama when she speaks to Romeo for the last time. The elaborate singing behavior of nightingales has inspired humans for centuries and has been referenced in literary works such as Homer's 'Odyssey' and John Keats' 'Ode to a Nightingale', to name a few.

Nightingales' large vocal repertoire and their singing capabilities do not only inspire artists but are a fascinating field for researchers studying vocal communication, too. During the breeding season, nightingales perform singing duels to attract partners and defend their territory. They use a strategy known as song matching, by which male nightingales imitate the songs of their rivals to increase their chances of attracting a female.



Credit: *Current Biology* (2023). DOI: 10.1016/j.cub.2023.06.044

"Song matching requires the nightingale to adjust its song in real time to what it hears," explains Daniela Vallentin, group leader at the Max Planck Institute for Biological Intelligence. "Humans adjust many features of their voice during a conversation, like volume or pitch,

depending on the listener. This process helps us to have meaningful conversations. We wanted to find out if nightingales are capable of doing something similar and flexibly modify their singing behavior depending on their rivals' songs."

To find out how accurately nightingales can adjust their songs to match auditory stimuli, the researchers recorded the vocal interactions of nightingales during the mating season in their German breeding grounds. Nightingales sing whistle songs that are composed of whistles with pitches covering a broad range of frequencies.

The recordings revealed that the birds exchanged whistle songs with their rival neighbors, flexibly adjusting their pitch to imitate the whistle pitch of their opponents. They did so across a wide range of sound frequencies, even when the scientists presented artificial whistle songs.

Interestingly, nightingales adjusted their song frequencies most precisely when they replied promptly. The replies were less precise after longer delays. "This finding suggests that the frequency relay happens through a special neural circuit that connects sensory input to the motor areas generating singing behavior," says Giacomo Costalunga, a doctoral student in Daniela Vallentin's group.

To explore this idea further, the team studied a group of nightingales at their wintering grounds in The Gambia, West Africa. Like many migratory songbirds, nightingales show seasonal changes in their physiology that also affect their song production. In winter, the birds usually do not produce elaborate song. However, when the scientists presented whistle songs to the birds, they replied just as they would during mating season in Germany—with pitch-matched whistle songs.

"This was a big surprise to us," recalls Giacomo Costalunga. "It suggests that the neural circuit that controls the pitch of whistle songs is not

subject to the seasonal changes in physiology that affect other aspects of singing." The findings could indicate that the imitation of song frequencies is not only useful during the breeding season, but may have a broader function throughout the year, for example in territorial defense.

Next, the team aims to identify the neural mechanisms underlying pitch frequency matching. "We are interested in how acoustic information is relayed to the motor commands that control singing," says Daniela Vallentin. "How are different pitches encoded? Are the neural mechanisms the same during breeding and non-breeding season?"

The song of nightingales has always fascinated and inspired humans, and answering these questions could add further to this fascination. The research of Daniela Vallentin and her group will help to better understand the strategies and neuronal underpinnings of nightingale song , and perhaps that of other songbirds as well.

The findings are published in the journal *Current Biology*.

More information: Giacomo Costalunga et al, Wild nightingales flexibly match whistle pitch in real time, *Current Biology* (2023). DOI: 10.1016/j.cub.2023.06.044

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