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WHAT DRIVES BIRDSONG EVOLUTION?

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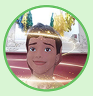

NOAH
AGE: 11

Just like how people have different languages, bird species have their own songs. These songs help birds recognize each other and find mates. Two factors may shape birdsong evolution: the habitat a bird lives in and a bird's physical features. First, habitat affects how far songs can travel. Second, body size and beak shape can limit the types of sounds a bird produces. We explored how these factors influence song evolution in a group of birds called honeyeaters. Body size is the most important factor explaining differences in song. We found that larger birds produce lower-frequency songs, just like how larger humans have deeper voices! Some findings suggest habitat influences song evolution too. However, this is likely because of differences in body size between different habitats. These results are important because birds are expected to get smaller with future climate change, and this could alter how birds communicate!

WHY IS BIRDSONG IMPORTANT?

Birdsong is one of the most well-known sounds that animals produce, and can be thought of as the "playlist" of nature. Have you ever woken up to the sound of birds and wondered why they sing? Like how humans can recognize people based on their voices, birds can recognize each other based on their songs. For example, male birds sing to attract females. Song helps birds identify members of the same **species** and choose a mate. There are over 5,000 songbird species found across the world, which means there are a lot of different bird songs! Scientists think that differences in song have contributed to the **evolution** of new songbird species. Studying evolution helps us know what factors have caused changes to species in the past. This helps us understand the species around us today, and how these species might adapt to changes in the future.

SPECIES

A group of individuals able to naturally reproduce and generate offspring that can also reproduce.

EVOLUTION

Change in characteristics of populations or species over time, often to better survive in their environments.

WHAT FACTORS COULD INFLUENCE SONG EVOLUTION?

Birdsong is a complex **trait**, and its evolution is thought to be shaped by both habitat and physical features (called **morphology**). Because males sing to attract females, it is crucial that female birds can hear males sing. The environment a bird lives in can influence song—see this Frontiers for Young Minds article on how city noise can influence birdsong. Forested or dense environments can absorb sounds and limit the distance songs can travel. In comparison, open areas such as deserts or grasslands have fewer trees and objects to absorb sounds. In these settings, songs can travel farther. Since low-**frequency** sounds travel farther than high-pitched sounds, it is predicted that over time, birds in dense environments will produce lower-frequency songs than birds in open environments so that they can be heard (Figure 1) [1].

TRAIT

A specific characteristic of an individual or species. Traits can be determined by genetics and/or environmental factors.

MORPHOLOGY

The sizes, shapes, and arrangement of parts of organisms.

FREQUENCY

The number of sound waves that occur in a second (measured in Hertz). This impacts how high or low a noise sounds.

Morphology, which means the size and shape of birds and their features, is also predicted to influence song evolution. In particular, body size and beak size and shape are expected to play key roles. How large a bird is can affect the frequency of sounds it produces. This is because body size influences the size of the **syrinx**. The syrinx is the sound-producing organ in birds, much like the voice box in humans. The size of the syrinx affects frequency [2], and larger birds are predicted to produce lower-frequency sounds (Figure 1). Beak size and shape are also expected to influence song. Similar to a musical instrument like a trumpet or flute, the size and shape of a bird's beak determines airflow and vibrations of sounds. This can impact frequency of songs. Larger instruments, or beaks, are predicted to produce lower-frequency sounds (Figure 1). In addition, beak size and shape can physically limit the movements that birds make and the sounds they produce. Larger, longer, or more curved beaks cannot

SYRINX

The sound producing organ in birds.

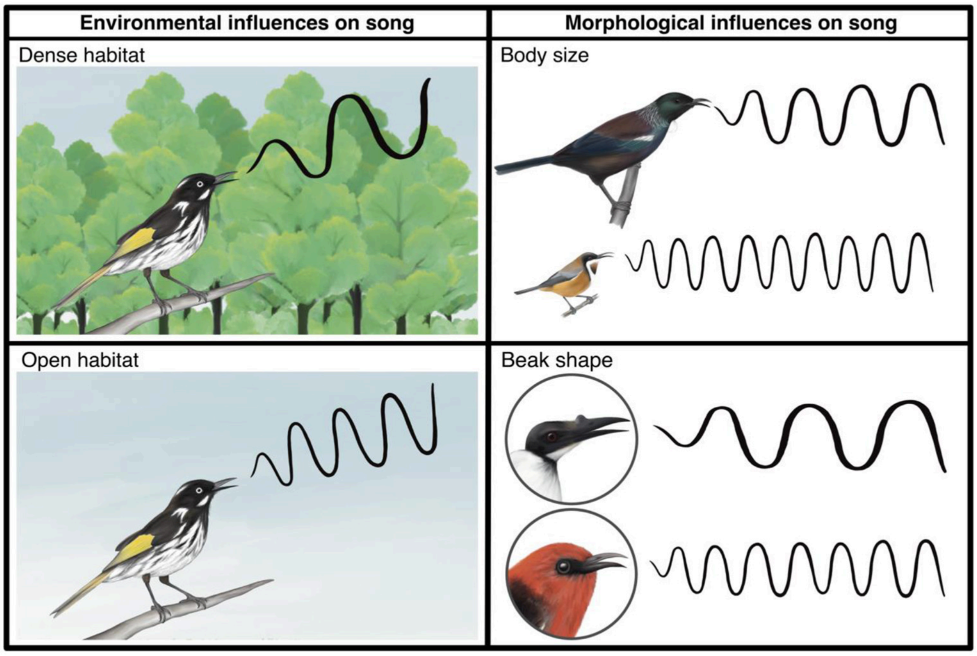

Figure 1

Figure 1

Some of the predicted effects of environment and morphology on birdsong. **(Left)** For environmental effects on song, birds living in dense habitats are expected to produce lower-frequency sounds than those in open habitats. **(Right)** For morphological effects on song, larger birds are predicted to produce lower-frequency sounds than smaller birds. Also, birds with larger beaks are thought to sing at lower frequencies than those with smaller beaks. Frequency is depicted by the sound wave. A wider wave represents a low-frequency song, and a narrow wave represents a high-frequency song (illustrations by Eleanor Hay).

open and close as fast as short, narrow, and straight beaks. This is thought to affect song pace [3].

It is clear that there are many ways habitat and morphology can influence song. To untangle these effects, it is important to consider the underlying relationships between these factors. Morphology and habitat are not independent of each other. In fact, a bird's body size and beak morphology are related to the environment. For example, birds in colder environments are often larger, to stay warm, while those in warmer climates might be smaller, to make it easier to cool off. Beak size and shape can also depend on what birds eat. Long and curved beaks are typically for feeding on nectar. In contrast, short, straight beaks can be for feeding on insects or seeds. Adding to this complexity, body size influences beak shape too. Larger birds tend to have larger beaks, simply because they are larger. Past studies have often focused on how either habitat or morphology influence song. However, because these factors are connected, we need to consider how *both* habitat and morphology influence song *together* to understand how birdsong evolves.

HONEYEATERS

We tested the joint influence of habitat and morphology on song evolution in honeyeaters. The honeyeaters are a group of birds with over 190 species. They live throughout Australia, New Guinea, New Zealand, and the South Pacific. Honeyeaters are all related to one another and have evolved from a single common ancestor. They are called honeyeaters because they largely feed on nectar from plants. Some honeyeaters, however, also eat fruits and insects. Honeyeaters are unlike nectar-feeding birds found elsewhere. Common nectar-feeding birds such as hummingbirds and sunbirds are small. In comparison, Australia's largest honeyeater, the yellow wattlebird, is over three times heavier than the largest sunbird! Honeyeaters have a lot of variation in features thought to influence song. Body sizes range from <10 g to over 350 g; beaks vary from short, for feeding on insects, to long and curved, for feeding on nectar; and species inhabit a wide variety of environments, from dry deserts to wet tropical areas (Figure 2). This makes them an ideal group for exploring song evolution.

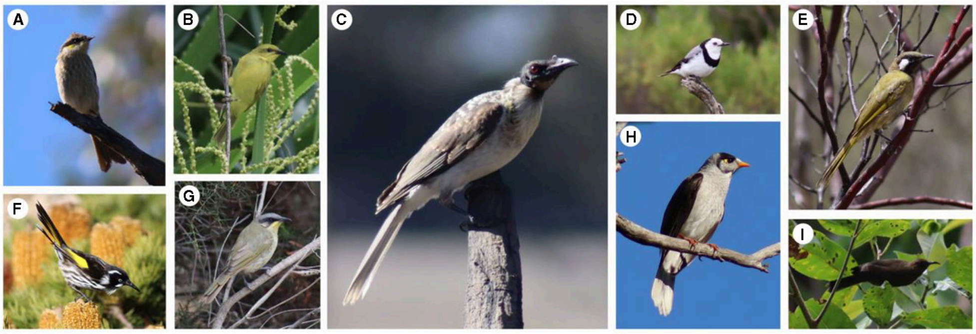

Figure 2

Figure 2

Morphological diversity of honeyeaters. Photos are of the following species: **(A)** singing honeyeater, **(B)** yellow honeyeater, **(C)** noisy friarbird, **(D)** white-fronted chat, **(E)** white-eared honeyeater, **(F)** new holland honeyeater, **(G)** purple-gaped honeyeater, **(H)** noisy miner, and **(I)** dusky myzomela (image credits: Eleanor Hay).

HOW DID WE EXPLORE THE EVOLUTION OF SONG?

To classify song in honeyeaters, we used recordings of male birdsong from online databases. We examined over 550 recordings from 163 honeyeater species. For each recording, we generated a **spectrogram**. A spectrogram displays notes according to their pitch over time, just like a sheet of music. From each song, we extracted the following traits: peak frequency, song bandwidth, and pace (Figure 3). Frequency is measured in Hertz (Hz), a unit named after the physicist Heinrich Hertz. Peak frequency is essentially the one note that sounds the loudest or strongest in the song. This is important for transmission of song because the loudest note is most likely to be heard by a potential mate. Song bandwidth is the difference between the highest and lowest notes in the entire song. Bandwidth tells us about the range of notes a species can produce. Lastly, song pace is the number of notes in the song divided by the length of the song. Pace indicates how fast or slow a bird sings (Figure 3). Together, this information captures the diversity of song across species.

SPECTROGRAM

A visual representation of audio signals, showing how frequency changes over time, just like a sheet of music.

PHYLOGENETIC (OR PHYLOGENY)

Phylogenetics is the study of the evolutionary history between groups of organisms. A phylogenetic tree, or phylogeny, is a diagram illustrating these relationships, similar to a family tree.

To explore honeyeater song evolution, we had to consider the **phylogenetic** relationships between species. A phylogeny is like a family tree. It tells us how species are related to one another and when these relationships formed over time. Fortunately, we knew these

Figure 3

A spectrogram displaying a song of the New Zealand bellbird as frequency (kHz) over time (seconds). The three song variables used in our study are labeled on the spectrogram.

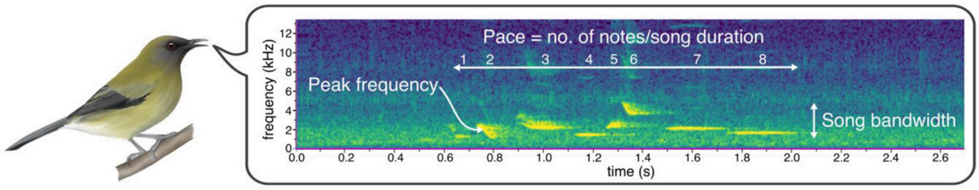

Figure 3

relationships for honeyeaters from an earlier study [4]. It is important to consider phylogenetic relationships between species because closely related species often have more similar traits than distantly related species. For example, bird species are expected to have similar songs if they are closely related. This can occur regardless of whether they share similar habitats and morphologies. This phylogenetic effect is like how kids often look more similar to their parents than to other people.

LARGER BIRDS PRODUCE LOWER-FREQUENCY SONGS

We found the main driver of song evolution in honeyeaters was body size. Larger birds produce lower-frequency sounds and sing at slower paces. This is because body size influences the size of the syrinx. Smaller birds tend to have smaller syrinxes, which can vibrate more rapidly and produce higher-pitched songs. In comparison, larger birds have larger syrinxes that usually vibrate at lower frequencies, producing lower-pitched sounds. This is a common trend across many animals: body size influences communication in mammals, insects, fish, reptiles, and amphibians [5]. In fact, larger humans tend to have deeper voices too! Despite our predictions, we found no evidence that beak morphology impacts honeyeater song evolution. Beak morphology is associated with body size, but in honeyeaters we found that body size has stronger associations with song evolution and no influence of beak shape was found.

WHAT ABOUT THE ENVIRONMENT?

We did find some evidence that the environment influenced honeyeater song. Songs with slower paces, low frequencies, and wider bandwidths were preferred in dense habitats. Initially, this suggested that habitat plays a role in song evolution. However, we also found that honeyeaters are larger in dense habitats than in open habitats. Ultimately, influences of habitat type on song are more likely caused by body-size differences in the different habitats. This further supports body size to be the main driver of birdsong. Past studies have only found weak evidence that the environment can influence song in other groups of birds, however, it is thought that environmental influences on communication could be more widespread in other animals, such as frogs and mammals [1]. So, overall, we believe that habitat influences song evolution by altering species traits such as body size.

HOW MIGHT BIRDSONG CHANGE IN THE FUTURE?

Now that we understand how song has changed in the past, we can predict how it could change in the future. One of the biggest threats to species is climate change. Other studies have shown that changing climates are causing birds to shrink in body size, to help them cool down more effectively [6]. Since we found that body size determines song frequency, smaller body sizes in the future will probably cause higher-pitched songs. Changing climates will also cause habitat loss and habitat transformation. We showed that habitat influences traits such as body size, which can jointly influence song. Thus, climate change and habitat loss will have consequences for song evolution, transforming how animals communicate and altering nature's playlist.

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ORIGINAL SOURCE ARTICLE

Hay, E. M., McGee, M. D., White, C. R., and Chown, S. L. 2024. Body size shapes song in honeyeaters. *Proc. R. Soc. B.* 291:20240339. doi: 10.1098/rspb.2024.0339

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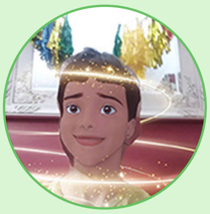
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ISABEL, AGE: 14

I love languages and biology. I play the drums and love going for bike rides. I love the seaside and the cinema. If I could I would eat Asian food everyday. But I cannot cause I am terrible at cooking.



NOAH, AGE: 11

I am 11 years old and live on the coast in the UK. In my free time I enjoy reading, drawing, helping in the kitchen, watching Dr Who and coding on my Raspberry Pi.

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Chris is an associate professor at University of Miami. He studies conservation ecology, gathering information about organisms' habitat requirements and life histories in order to better protect them. As part of his interest in preserving biodiversity, Chris enjoys exploring how diverse groups of organisms evolve to allow coexistence in the same community. He has two daughters, who he takes hiking whenever possible.

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