Abstract

Have you ever been somewhere noisy and had to shout to be heard? Imagine having to speak at that volume all day. Would you feel more tired if you shouted all the time or spoke at a normal volume?

Bats are very unusual animals because they can use sound to see at night. Bats use very loud echolocation to hear tiny insects that are far away, but their calls are at a frequency that we cannot hear. In fact, bats are some of the loudest animals on earth. Being louder means they can find insects more easily in the dark, but most bats don't "shout" louder than a certain level.

We wanted to find out if this is because bats use more energy when echolocating louder. To do this, we recorded and analyzed the calls of bats while they were flying. We then studied how much energy they were using.

Introduction

Nathusius’ pipistrelle (Pipistrellus nathusii) is a common bat found throughout most of Europe. Every night it leaves its roost to search for food. Despite the darkness, it can "see" using echolocation. To do this, bats produce a high-pitched call that echoes off objects and returns to their ears. The bats then use this information to build a picture of what's around them.

Bats produce their calls at frequencies that are too high for humans to hear. If we could hear it, a bat’s normal call would be as loud as a chainsaw – but they can shout to volumes as loud as a jet engine! In nature, bats sometimes shout over the calls of other bats.

Echolocating and flying rely on the same group of muscles. Scientists think that bats save energy by coordinating their calls with their wingbeats. Because of this, scientists assumed that echolocating while flying did not use much more energy than flying on its own. However, nobody has ever tested this theory for bats calling at different volumes.

We designed an experiment to test if:

1. Echolocating requires extra energy from flying bats.
2. Louder calls use more energy than quieter calls.
Methods

We caught nine wild bats from roost boxes and trained them to fly in a wind tunnel within our laboratory (Fig. 1). The wind speed was always kept constant to make it easier for the bats to fly.

We exposed the bats to two sound conditions within the wind tunnel. The control sound condition was the noise that the wind tunnel made. In the experimental sound condition, we played background noise at a set volume through speakers in the wind tunnel. We used the background noise as a way to get the bats to call louder in the wind tunnel. This is because when bats are in closed spaces (like a room, or the wind tunnel), they call more quietly than when they are in the open, like in nature.

We recorded and analyzed the bats’ calls under both sound conditions. We focused on the volume of their calls, and we also looked at how often they called and how long each call was.

We compared the amount of carbon dioxide in their breath before and after each flight. From this, we worked out the metabolic rate (how much energy the bat was using) while echolocating and flying.

Results

Under the experimental sound condition, the bats’ calls were significantly louder. The bats also had a higher metabolic rate in this sound condition. We found a significant relationship between the call volume and the metabolic rate (Fig. 2).

We found that echolocating while flying requires extra energy. At lower call volumes, bats use less than 3% extra energy as compared with flying alone. But when bats shout, they use almost 22% extra energy.

We call this type of increase "linear growth." Can you come up with some other examples of linear growth from your own life? What other types of increases could there be?
Discussion

Our results showed that echolocating while flying requires extra energy. We also found that increasing the volume of the call increases the amount of energy the bats used. At low call volumes, the extra energy requirement (on top of the metabolic cost of flying) is low. But the extra energy requirement increases as the bat’s calls become louder. This increase in metabolic rate is probably because the bats’ abdominal muscles have to work harder to help them produce a louder sound.

Previous studies have shown that Nathusius’ pipistrelles can search for food for seven hours per night. If bats had to shout the whole time, they would need to forage for another hour to replace the extra energy they used up. This means in the extra hour they fly, they’d have to try and catch almost one-tenth of their whole body weight in insects! (For humans, one-tenth of an average adult’s body weight is the same as 40 apples!)

Cities are both noisy and have lower insect populations. So, bats living near cities may struggle to find enough food to make up for the extra energy they use to shout over the city noise.

Conclusion

There are many ways that you can help bats. The best way to help them is by increasing the number of insects available for them to eat. If you have a garden or a balcony at home, you could build an “insect hotel,” or even encourage your school to make one! Wild meadows, ponds, and flowering plants also increase insect activity. Bats aren’t the only animals that feast on insects. By boosting insect populations, you can help birds and hedgehogs, too!

Glossary of Key Terms

- **Echolocation** – the ability to locate objects using soundwaves.
- **Frequency (sound)** – the number of soundwaves that pass a point every second. High sound frequencies have more waves per second than low sound frequencies.
- **Metabolic rate** – the speed that energy is used up within the body.
- **Population** – the number of people or animals living in a certain place.
- **Roost** – the place where bats rest during the day.

REFERENCES


https://www.nature.com/articles/s41559-020-1249-8

Bat Conservation Trust: Flight, food, and echolocation
https://www.bats.org.uk/about-bats/flight-food-and-echolocation

National Geographic: Echolocation in animals
https://www.nationalgeographic.com/animals/echolocation-is-natures-built-in-sonar
Check your understanding

1. Can humans hear a bat echolocating?

2. Why do scientists think calling louder might use more energy than calling quietly?

3. Why would bats need to forage an extra hour if they spend the whole night calling loudly?

4. How much extra food would a bat need to eat if they spend the whole night calling loudly?

5. Insect populations around the world are getting smaller. Can you think of reasons why they are declining?

Acknowledgment: This article’s adaptation was supported by the Goggio Family Foundation.