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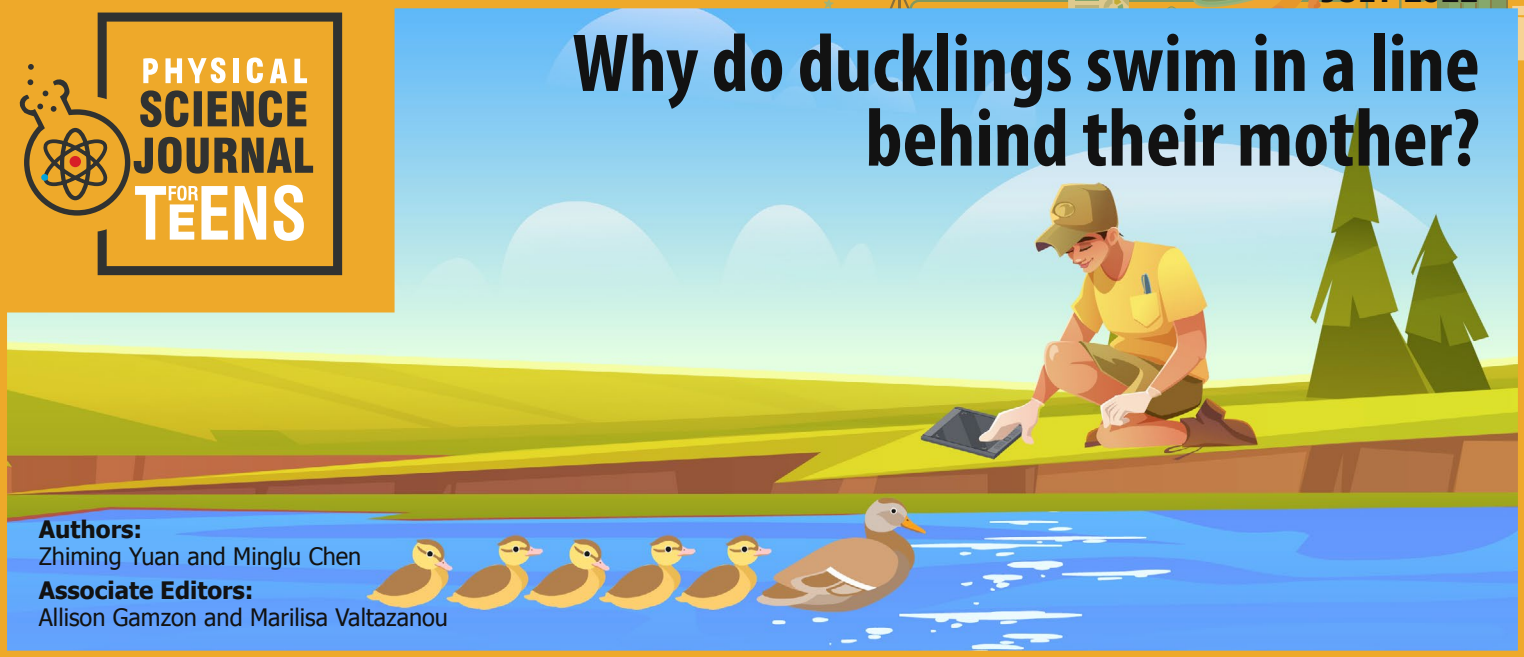
Why do ducklings swim in a line behind their mother?



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Abstract

UPPER READING LEVEL

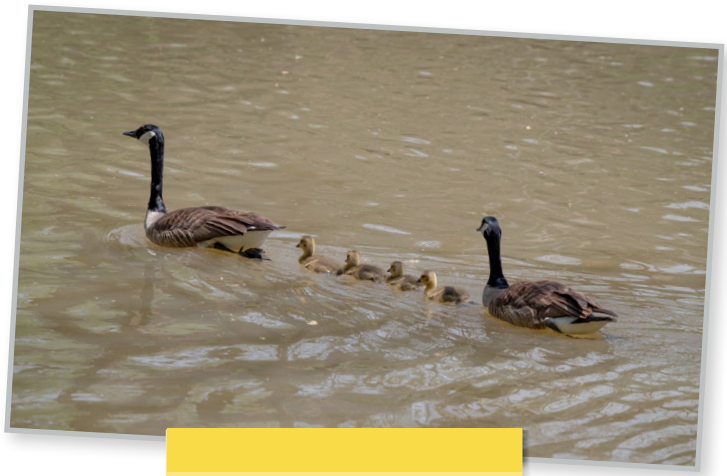
Have you ever seen baby ducks or geese swimming in line behind their mother? They're so cute! But why do they do that? Is it to keep everyone organized and safe? Or is it to make swimming easier for the babies? We wanted to figure out how swimming in a line benefits the ducklings. We hypothesized that this formation saves the ducklings energy. We created a mathematical model to test our hypothesis. We realized that the most energy-efficient place for them to swim is behind their mother. And if they swim at specific positions, the waves created by their mother or passed along by the other ducklings propel them forward. This saves lots of energy!

Introduction

Moving in a line is not just a human practice. It is common for water birds like ducks and geese. And while we often do it to keep things organized, animals may have different reasons. For years, scientists have hypothesized that animals move in formation to save energy. But most studies have looked at birds in one **medium**, such as air. Birds swimming across ponds and lakes are at the boundary between two media: air and water. We wanted to figure out how swimming in a line benefits birds as they move across the water's surface.

We hypothesized that swimming behind their mothers at specific positions reduces wave **drag**. Drag is a force that an object experiences when moving through a **fluid**. Drag pushes against the object's motion. If you have ever gone swimming with friends, you have probably experienced wave drag. As people move in the pool, they create waves. As you try to swim through these waves, they exert a force against you. This force changes how easy or hard it is to swim.

To test this hypothesis, we created a mathematical model. Our model calculated the wave drag on ducks swimming in formation. We analyzed each position to see what happens to the amount of wave drag. We also investigated how changes in wave drag relate to the mother duck or goose swimming in front.



A family of geese swimming with the baby geese in a line behind the mother goose.
Photo: Chris F

Methods

Our mathematical model calculated a number called the C_{DR}. This number described what happened to the amount of wave drag.

- When the C_{DR} was more than 0, the wave drag decreased.
- When the C_{DR} was less than 0, the wave drag increased.
- When the C_{DR} was exactly 0, the wave drag was the same as if the baby swam by itself.
- When the C_{DR} was 100% or more, the wave drag transformed into a force that propelled the duckling forward.

For our mathematical model to work, we made a few assumptions.

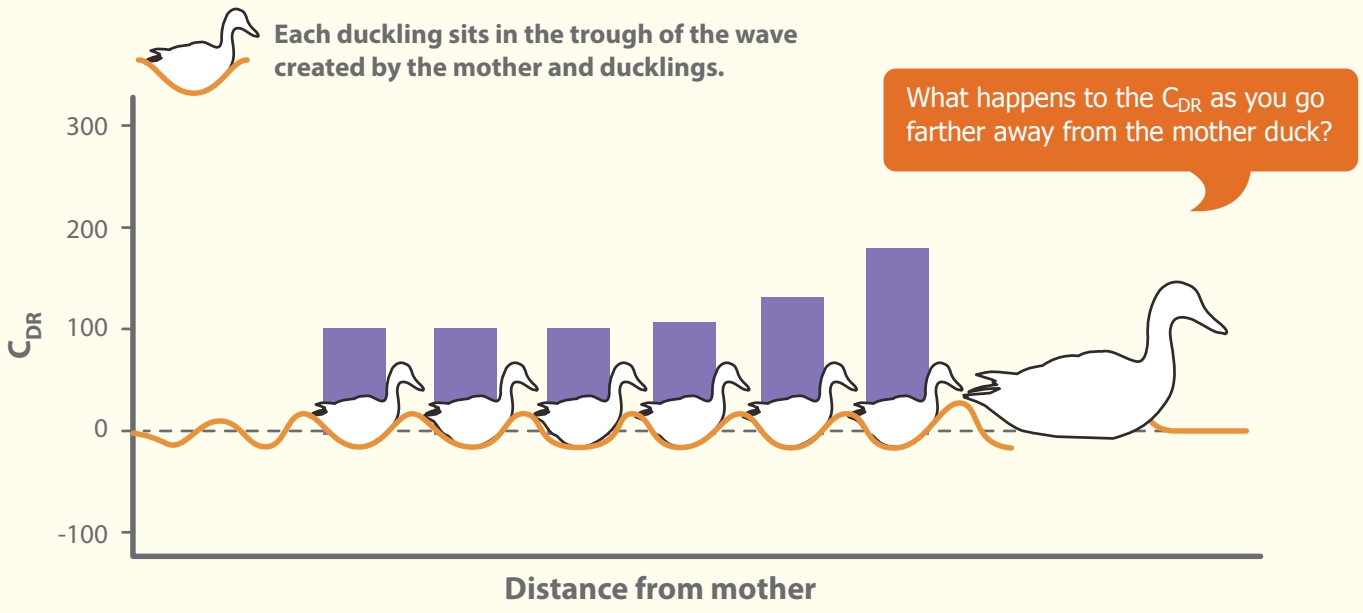
- Wave drag is the main type of drag affecting the ducks.
- The size, shape, and feather type of the ducks remains the same for both formation and independent swimming.
- Changes in wave drag caused any changes in the C_{DR}.
- The ducks move at a constant speed.
- The ducks instinctively stay in formation, so they don't need to consider what the other birds are doing.

Results

Our model determined the C_{DR} for three positions: in front of the mother duck, behind her, and to her side. We found that the only formation with multiple positions with a high C_{DR} was behind her. These positions were only at specific distances from the mother.

We also learned that the drag reduction decreased at a certain distance from the mother. After that, it remained the same. The two ducklings closest to the mother experienced a C_{DR} greater than 100%. The remaining ducklings all experienced a C_{DR} of 100% (Figure 1).

Figure 1:
The C_{DR} for the ducklings as they swim behind their mother.



Discussion

Our research proved that baby ducks and geese swim behind their mother because it is the best option. Only one spot in front of the mother had a high C_{DR}. That means most of the babies experienced a lot of wave drag. Swimming in front also placed them in danger of predators. To the side, the mother's waves caused the ducklings to rotate. That means they worked harder to swim in the correct direction. Only being behind the mother made swimming easier for all the ducklings. That's because this formation created two phenomena: wave riding and wave passing.

Wave riding occurred when the mother duck's wave interacted with the wave created by the babies in a particular way. This **wave interference** placed the front of the duckling in the **trough** of the wave. This caused the wave to propel the duckling forward. That means they moved without doing any work at all to overcome the wave drag! The first two ducklings experienced more wave riding. The other ducklings couldn't ride the mother's waves because the wave height decreases with distance. So the mother's wave was too small to propel them forward. But the remaining ducklings were also in a trough, which means they got a boost from the waves. All the remaining ducklings got the same boost. Each duckling collected the wave energy it received and concentrated it behind them. This made more energy available for the next sibling. We call this phenomenon **wave passing**.

For wave riding and wave passing to work, the ducklings must swim at the same speed as their mother. They must also swim at the correct distance from her and the other ducklings. If they don't, they lose all the benefits of the formation and must work hard to swim.

Conclusion

Understanding wave riding and wave passing in water birds can help society. We could use these principles to lower costs for transport boats. If we have ships moving in a line, then boats could transport cargo using less energy.

We can also reduce wave drag. Whenever you visit public swimming areas, remember your motion affects other people. If someone is swimming laps, give them space. That way your waves won't increase their wave drag, making it harder for them to swim. And make sure you have the space you need, too! Then everyone can enjoy the water without using extra energy.

Glossary of Key Terms

Drag – a force that opposes an object's motion as it moves through a fluid.

Fluid – a substance that can flow easily, such as a liquid or a gas.

Medium – a substance or material that carries a wave. For example, light waves can travel through air, water, and glass. Air, water, and glass are each a medium for light to travel through.

Trough – the lowest part of the wave.

Wave interference – what happens when two waves interact in the same medium. The resulting wave is a combination of the two waves.

Wave passing – when an object concentrates wave energy in one region so that more energy is made available for the object behind it.

Wave riding – when the waves created by two objects interfere, causing one of the objects to be propelled forward by the resulting wave.

Check your understanding

1. Why is swimming behind the mother duck the best option for baby ducks?

2. Why do the last ducklings experience a lower C_{DR} than the first two ducklings?

3. What do ducklings need to do to save energy while swimming?

4. Drag forces determined the amount of energy used by the ducks for swimming. Can you think of another example of drag forces affecting the motion of an object?

5. We proposed using the principles of wave riding and wave passing to make shipping products by boats more energy efficient. Do you think this idea should be explored? Explain your answer.

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