Stalk-eyed Fly Relay Race: Do eyestalks affect turning behavior?

Written by: Brooke Ravanelli and John Swallow

Partners with the research presented in "The Flight of the Stalk-Eyed Fly" Data Nugget

Biology Background:

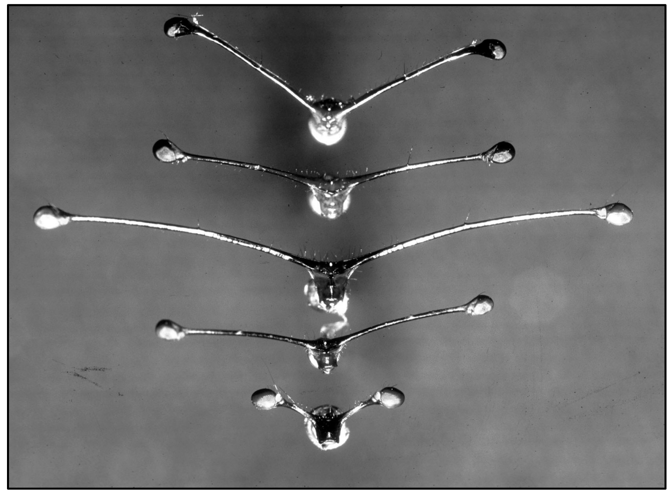

Fig. 1. Heads of large males showing variation in ornament size in one genus: *Teleopsis*.

Stalk-eyed flies are insects with eyes located on the ends of long projections on the sides of their head, called **eyestalks**. Male stalk-eyed flies have longer eyestalks than females, and this plays an important role in the flies' mating patterns. Female stalk-eyed flies prefer to mate with males with longer eyestalks. In this way, the eyestalks are much like the bright and colorful peacock's tail. This kind of **sexual selection** can lead to the evolution of longer and longer eyestalks over generations. But do these long eyestalks come at a cost? For example, longer eyestalks could make it more difficult to turn quickly when flying. As with all flies, stalk-eyed flies do not fly in a straight line all the time, and often zigzag in air. If long eyestalks make quick turns more difficult, we might expect there to be a trade-off between attracting mates and flight.

Physics Background:

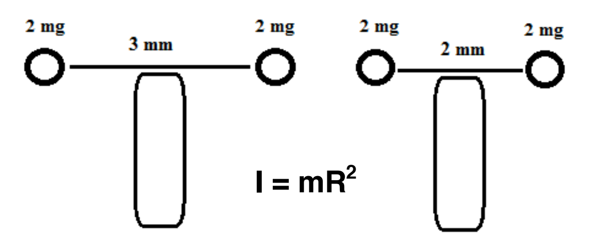

Fig. 2. Model of changes in the moment of inertia (I) of the body due to varying eyestalk length

Moment of inertia (I) is defined as an object's tendency to resist rotation – in other words how difficult it is to make something turn. An object is more difficult to turn (has a higher moment of inertia) when it is more massive, and when it is further from its axis of rotation. Imagine trying to swing around quickly holding a gallon of water – this is difficult because the water has a lot of **mass**. Now imagine trying to swing around holding a baseball bat with a jug of water attached to the end. This will be even more difficult, because the mass is further away from the **axis of rotation** (your body). Now lets bring that back to the stalk-eyed fly. The baseball bat now represents the eyestalk of the fly, while the gallon of water represents the eye at the end of the stalk. We can express the relationship between the mass of the object (m = mass of the eye), its distance from the axis of rotation (R = length of eyestalk), and the moment of inertia (I) using the following equation: $I = mR^2$. By inserting measurements into the equation, you can see that small changes in lateral displacement of the eye (eye span) can have a large effect on the moment of inertia of the body. For example, in Figure 1, the moment of inertia of a fly with an eye mass of 2 mg and an axis of rotation of 2 mm is 8, compared to a fly with the same mass, but an axis of rotation of 3, which is 18. A small change in the axis, just one millimeter, more than doubles the moment of inertia for that fly!

Because moment of inertia goes up with the square of the distance from the axis, we might expect that as the length of the flies' eyestalks goes up, the harder and harder it will be for the fly to maneuver during flight. If this is the case, we would predict that male stalk-eyed flies would make slower turns compared to similar sized female flies with shorter eyestalks.

The Experiment:

To address this idea, the effect of eyestalk elongation on the moment of inertias of the body needs to be measured. Because male stalk-eyed flies have longer eyestalks than females, the differences in flight patterns can be compared to study whether longer eyestalks lead to higher moments of inertia, and decreased flight performance. The estimated moment of inertia of the head in males is more than double the moment of inertia of females. If this is true, then longer eyestalks will have a negative effect on free flight and aerial turning behavior by studying the free-flight trajectories. If there is no difference in flight performance or turning behaviors between flies with significantly different eyestalk lengths, then males must have a way to compensate for the added moment of inertia.

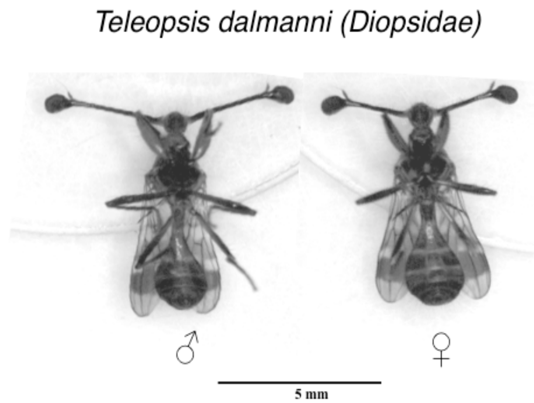

Fig. 3. This image shows the differences in eyestalk length between male (left) and female (right) stalk-eyed flies.

In today's experiment, you are going to simulate the flying experience of stalk-eyed flies. Two of your group members will become stalk-eyed flies, and experience what it would be like to make sharp turns and move with large and weighted projections coming out of the side of your head. Each team will go through an obstacle course carrying their eyestalks with them as they maneuver through the cones to the finish line. After completing the course once (and allowing enough time to recover) the same runners will complete the course again with either different sized eyestalks or no eyestalks (but still carrying the same weighted eyes). The differences in time to complete the course will be recorded, and as a group you will graph and analyze your data.

Materials (each group will need):

- Timer
- Traffic cones and tape to make obstacle course
- 1 set of short “eyestalks”
- 1 set of long “eyestalks”
- 2 milk jugs, or “eyes” filled with water to attach to eyestalks

Instructions:

1. Decide what role each member of your group will play.
    a. Maze Runner #1: this person will run through the course carrying the long eyestalks as fast as they can. After a 4-minute break, this person will run the course again, either carrying the short eyestalks OR carrying the water jugs while running (your team must pick ONE and stick to that option)
    b. Timer: this person will tell the runner when to begin, and stop the timer as soon as the runner is finished.
    c. Referee: this person will monitor all activity of the runner, assuring the course is completed correctly, and provide encouragement to the runner to assure they are trying to run through the course as fast as they can both times.
    d. Maze Runner #2: this person will run through the course carrying the long eyestalks as fast as they can. After a 4-minute break, this person will run the course again, either carrying the short eyestalks OR carrying the water jugs while running (your team must pick ONE and stick to that option).
    e. If time allows, have each runner repeat the course three times, and record the average times.

Before you begin the activity:

What is the scientific question your team would like to ask?

____

____

What is your hypothesis? *(Remember, a hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.)*

____

____

Record your Data:

Trial #	Runner #	*Time with long eyestalks (seconds)*	*Time with short or no eyestalks (seconds)*
1	Maze Runner 1		
2	Maze Runner 1		
3	Maze Runner 1		
1	Maze Runner 2		
2	Maze Runner 2		
3	Maze Runner 2		

Graph your data:

a. What factors were controlled in this experiment?

b. What changed from trial to trial?

c. What was measured?

Discussion:

1) Calculate the predicted moment of inertia for each condition you completed in your trial runs.

2) Compare the differences in the moments of inertia of each condition to the data trends in your graph; do your results match this predicted offset? Why or why not?

3) What kind of traits do to think male stalk-eyed flies might have in order to compensate for their larger eyestalks?

Interpret the data:

a. Make a claim that answers your scientific question.

b. Support your claim using data as evidence. Reference specific parts of the table or graph.

c. Explain your reasoning and how the data supports your claim.

d. What do the data from this study tell us about your hypothesis?