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Are you my species?

Featured scientist: Michael Martin from the University of Maryland Baltimore County

Research Background:

What is a species? The **biological species concept** says species are groups of organisms that can mate with each other but do not reproduce with members of other similar groups. How then do animals know who to choose as a mate and who is a member of their own species? Communication plays an important role. Animals collect information about each other and the rest of the world using multiple senses, including sight, sound, sonar, and smell. These signals may be used to figure out who would make a good mate and who is a member of the same species.

Michael is a scientist interested in studying how individuals communicate within and across the boundaries of species. He studies darters, a group of over 200 small fish species that live on the bottom of streams, rivers, and lakes. Michael first chose to study darters because he was fascinated by the bright color patterns the males have on their bellies during the breeding season. Female darters get to select which males to mate with and the males fight with each other for access to the females during the mating season. Species identification is very important during this time. Females want to make sure they choose a member of their own species to mate with. Males want to make sure they only spend energy fighting off males of their own species who are competing for the same females. What information do females and males use to guide their behavior and how do they know which individuals are from their own species?

Across all darter species, there is a huge diversity of color patterns. Because only males are brightly colored and there is such a diversity of colors and patterns, Michael wondered if males use the color patterns to communicate species identity during

Michael (right) in the field, collecting darters. Photo by Tamra Mendelson.

Michael holding a male darter. The bright color patterns differ for each of the over 200 species. Photo by Tamra Mendelson.

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Michael snorkeling to look for darters

mating. Some darter species have color patterns that are very similar to those of other darter species. Perhaps, Michael thought, the boundaries of species are not as clear as described by the biological species concept. Some darter species may be able to **hybridize**, or mate with members of a different species if their color patterns are very close. Thus, before collecting any data, Michael predicted that the more similar the color patterns between two males, the more likely they would be to hybridize and act aggressively towards each other. If this is the case, it would serve as evidence that color pattern may indeed serve as a signal to communicate darter species identity.

Michael collected eight pairs of darter species (16 species in all) from Alabama, Mississippi, Tennessee, Kentucky, South Carolina, and North Carolina and brought them all back to the lab. In some **species pairs** the color patterns were very similar, and in some they were very different. For each species pair, he put five males of both species and five females of both species in the same fish tank and observed their behavior for five hours. He did this eight times, once for each species pair (for a total of 1,280 fish!). During the five-hour observation period, he recorded (1) how many times females mated with males of their own species or of a different species and (2) how many times males were aggressive towards males of their own species or of a different species. He used these data to calculate an index of bias for each behavior, to show whether individuals had stronger reactions towards members of their own species. He used the following equation, where A and B represent two different species and AxA represents how individuals in species A acted towards other members of species A:

$$index\ of\ bias = \frac{(\mathrm{AxA} + \mathrm{BxB}) - (\mathrm{AxB} + \mathrm{BxA})}{(\mathrm{AxA} + \mathrm{AxB}) + (\mathrm{BxA} + \mathrm{BxB})}$$

Another way to write the same equation is:

$$index\ of\ bias = \frac{(\#\ events\ within\ species) - (\#\ events\ across\ species)}{total\ \#\ of\ events}$$

If the index of bias value is positive (greater than zero), this means that the behavior happened more often with members of the same species. If the index of bias value is negative (less than zero), this means that the behavior happened more often with members from a different species. Michael also measured color differences between each pair using digital pictures. The larger the color difference score, the more different the color pattern is between the two species.

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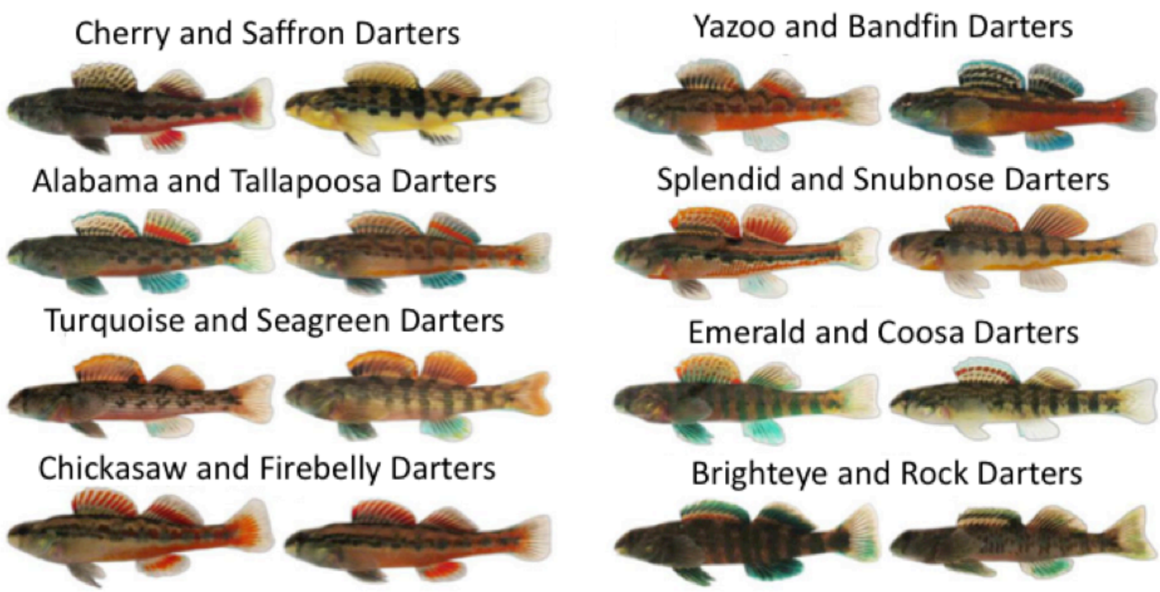
Scientific Question: In what ways do color pattern differences between different darter species influence female mating decisions and male aggression?

What is the hypothesis? Find the hypothesis in the Research Background and underline it. A hypothesis is a proposed explanation for an observation, which can then be tested with experimentation or other types of studies.

Scientific Data:

Use the data below to answer the scientific question:

	Female Mating					**Male Aggression**				
Species Pair	AxA	AxB	BxA	BxB	Total	AxA	AxB	BxA	BxB	Total
Cherry (A) - Saffron (B)	102	37	35	108		150	8	5	161	
Alabama (A) - Tallapoosa (B)	68	55	51	61		173	176	170	125	
Turquoise (A) - Seagreen (B)	62	65	72	70		124	118	131	176	
Chickasaw (A) - Firebelly (B)	83	46	44	70		185	219	214	180	
Yazoo (A) - Bandfin (B)	24	28	35	36		194	219	251	210	
Splendid (A) - Snubnose (B)	73	72	69	65		154	74	73	176	
Emerald (A) - Coosa (B)	52	13	10	64		146	41	55	162	
Brighteye (A) - Rock (B)	52	14	15	47		132	189	194	173	



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Now, compute an index of bias for female mating using the formula given earlier. Remember, positive values mean that females mated with males of their own species. Negative values mean that females mated with males of a different species.

Finally, compute the male aggression index in the same way. Positive values mean that males were more aggressive towards males of their own species. Negative values mean males were more aggressive towards males of different species. A value of 0 (or values close to 0) means that females and males treated all the fish in the tank the same.

Use the table below to record your index of bias scores for each species pair:

Species Pair	Color Difference Score*	Female Mating Bias	Male Aggression Bias
Cherry-Saffron	9.98		
Alabama-Tallapoosa	2.18		
Turquoise-Seagreen	1.89		
Chickasaw-Firebelly	0.86		
Yazoo-Bandfin	3.33		
Splendid-Snubnose	3.65		
Emerald-Coosa	6.12		
Brighteye-Rock	2.87		

** High values of the color difference score are interpreted as the two species being very different in coloration. Low values mean the two species had more similar male coloration.*

What data will you graph to answer the question?

Independent variable(s): ____

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Dependent variable(s): ____

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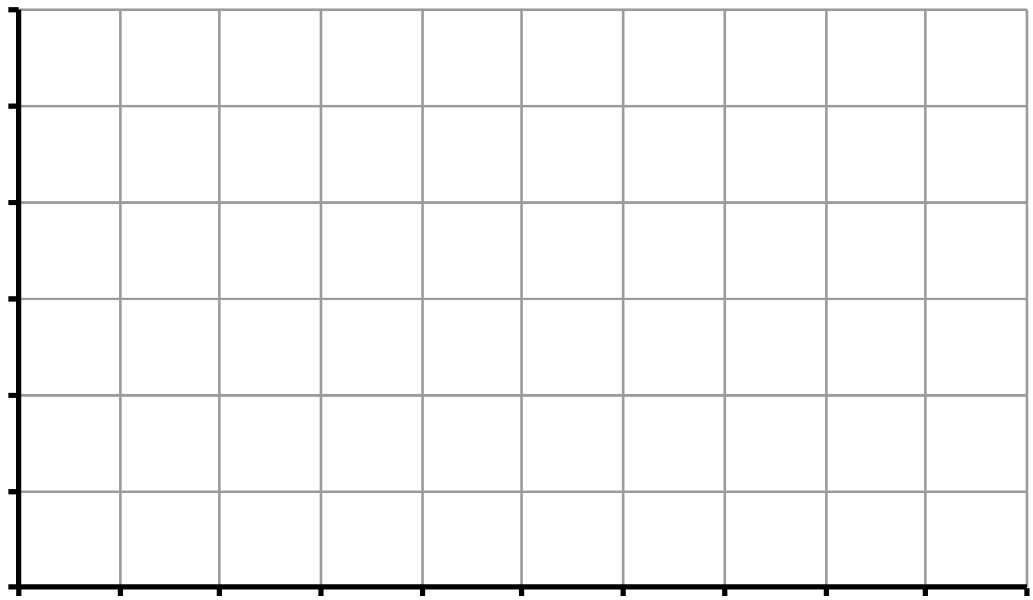
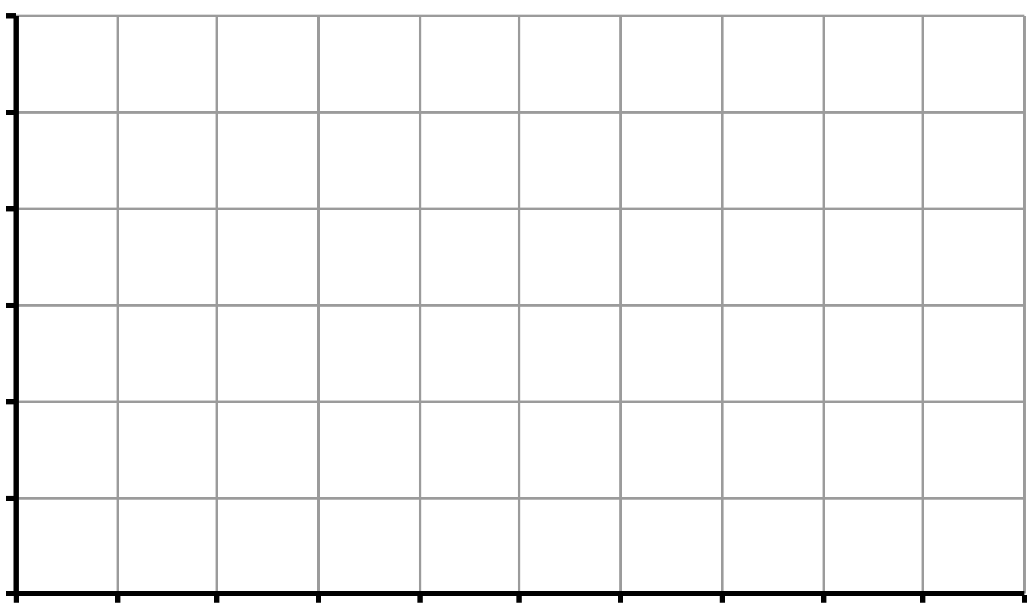
Draw your graphs below: Identify any changes, trends, or differences you see in your graphs. Draw arrows pointing out what you see, and write one sentence describing what you see next to each arrow.





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Interpret the data:

Make a claim that answers the scientific question.

What evidence was used to write your claim? Reference specific parts of the tables or graphs.

Explain your reasoning and why the evidence supports your claim. Connect the data back to what you learned about color patterns in male darters and how these may serve as signals to members of the same or different species.

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Did the data support Michael’s hypothesis? Use evidence to explain why or why not. If you feel the data were inconclusive, explain why.

Your next steps as a scientist: Science is an ongoing process. What new question(s) should be investigated to build on Michael’s research? What future data should be collected to answer your question(s)?