Overview | Teaching Notes | Comments/Replies

Mom Always Liked You Best
Examining the Hypothesis of Parental Favoritism

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Abstract: This interrupted case study is based on a journal article on the parenting behavior of American coots. Working through the case, students develop hypotheses and design experiments to test their hypotheses as they are given pieces of the case in an interrupted, or progressive disclosure, case format. The case teaches students about the scientific method. As such, it would be useful in any course where one wishes to emphasize how scientists go about solving problems. The subject matter of the case makes it suitable for courses in biology, especially those focusing on evolution and ecology, and the case can be used with both science majors and non-science majors.

Objectives:

Help students develop a clear, rigorous, and structured approach to solving problems.

Give students practice in designing experiments.

Give students practice in making predictions and interpreting data.

Give students an explicit experience with the hypothetico-deductive method of reasoning, i.e., "the scientific method," where a question is asked, a hypothesis suggested, predictions or deductions made in light of the hypothesis, tests accomplished, and the data evaluated as to whether it supports or rejects the hypothesis.

Keywords: Coot; bird; plumage; parental favoritism; preferential feeding; animal behavior; experimental design

Topical Area: Scientific method

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Case Teaching Notes

for

"Mom Always Liked You Best: Examining the Hypothesis of Parental Favoritism"

by
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Introduction / Background

This case is based on a fascinating article that appeared in 1994 entitled "Parental choice selects for ornamental plumage in American coot chicks" (*Nature* 371: 240–243) written by B. Lyon, J. Eadie, and L. Hamilton. Also see the commentary by Mark Pagel, "Parents prefer pretty plumage," in the same issue on page 200. As the case reveals, the authors concluded that coot parents "feed ornamented chicks over non-ornamented chicks, resulting in higher growth rates and greater survival for ornamented chicks." They sum up "that parental preference is relative, rather than absolute, an important element in the evolution of exaggerated traits. These observations provide the first empirical evidence that parental choice can select for ornamental traits in offspring."

I have used this case in courses whenever I wished to emphasize how scientists go about solving problems. Obviously, the subject matter of the case is appropriate for courses in biology, especially those focusing on evolution and ecology. Yet the case is accessible to students without any background in science at all, so I have also used it in general courses in "Scientific Inquiry."

I am particularly fond of using this case for faculty development workshops where I wish to show instructors how to use case studies with small groups. The way that the case unfolds mimics the real way that scientists go about their work. Scientists do not have all of the facts all at once; they get them piecemeal. Moreover, the "interrupted case method" is far easier for most faculty to use than practically any other.

Objectives

There are several objectives for this case beyond teaching coot biology:

- Reinforce the value of the cooperative/collaborative learning method in which students work together to solve problems.
- Help students develop a clear, rigorous, and structured approach to solving problems, i.e., to enhance critical thinking.
- Give students practice in designing experiments.
- Give students practice in making predictions and interpreting data.
- Give students explicit experience with the hypothetico-deductive method of reasoning, i.e., "the scientific method," where a question is asked, a hypothesis suggested, predictions or deductions made in light of the hypothesis (i.e., if the hypothesis is true, then such and such should occur), tests accomplished, and the data evaluated supporting or rejecting the hypothesis. To reinforce this model, it is essential at every opportunity as new information and questions are added that the instructor always ask the students what they now expect *if the hypothesis were true.*

Classroom Management / Blocks of Analysis

If cases are stories with an educational message, as I contend, then there should be innumerable ways to teach them. This case is an example of one way of teaching a case, a technique I call the Interrupted Case Method in which information is fed piecemeal to students working in small groups. This method of "progressive disclosure" is characteristic of Problem-Based Learning (PBL), but in the Interrupted Case Method the case is accomplished in one class period rather than over several days. It shares with PBL the great virtue of engaging all students in problem solving.

A little background: *The New England Journal of Medicine* publishes cases called "Clinical Problem Solving" each week. The format of the exercise is that "information about a real patient is presented in stages to an expert clinician, who responds to the information, sharing his or her reasoning with the reader."

This is done in a series of steps: first, the case writer provides a paragraph or two of information about the patient. The clinician then reveals his thinking about the case, speculating on possible diagnoses and perhaps suggesting a test that might be performed. Next, the case writer gives some more information about the patient. Again the clinician responds. Several more rounds of case writer and clinician remarks follow, usually ending with the case author providing a summary analysis.

The Interrupted Case method models this form of problem-solving exercise. Perhaps the easiest way to use the method is to select an article from a scientific journal. The instructor chooses a question drawn from the introduction section of the paper. Small groups of students are asked to design an experiment to solve the problem that the article raises. After a suitable time for discussion, groups are called upon to present their experimental design and explain the reasons for their approach. Commentary is then solicited from other class members on the appropriateness of the approach.

In the next stage, the instructor briefly describes how the authors of the paper decided to attack the problem. Their actual methods are described. Then the groups are asked to predict what the results might look like. Perhaps a blank table or blank graph is given to the groups to fill in. Once again the groups are asked to report out their solutions to the entire class along with their reasoning. Commentary from other students and teacher follows.

At this point, the instructor reveals the actual data published in the article.

The groups are asked to interpret the results and draw conclusions in light of the original hypothesis. After a suitable discussion, the instructor reveals the author's actual interpretation of the results and their conclusions. Closure follows.

As noted below, the only parts of the case I hand out to the students are Part I and Figures 1 and 2. I do not hand out Parts II–IV, but instead read this information out loud to the entire class.

This case takes me about 75 minutes for analysis, but it can be easily shortened or lengthened. Let me lay out the timing of the case along with my strategy at each stage.

Part I—What's the Problem?

(Here students work in small groups and report out, then they receive new information.)

I use about 15 minutes for this. I first hand out Part I to each person in the class sitting in their groups. I instruct them to read the case and *as a group* answer the questions at the end of the page. (It is sometimes preferable to give each group only one copy of the case. This forces them to cooperate from the outset. If this is not done, individuals tend to read the case and then start making notes alone. It often takes them a long while to start talking together. To prevent this isolation, you must emphasize that the answers must be a group effort.)

After the small group discussion of Part I is in full swing, about five minutes along, I walk around the room with a color copy of the cover of *Nature* magazine (September 15, 1994) which has a photograph of the orange baby coots. The students don't know it at the time (some hardly glance at it, others are simply enamored with how cute the babies look), but what the youngsters look like is essential to what the authors did in the study. I then put a color overhead picture of the cover of the magazine on the projection screen for the remainder of the class period so the coots are omnipresent.

When the 15 minutes have passed, I interrupt the discussion, telling the students that I know that they aren't really finished, but I'd like to hear their thoughts. I ask for a representative from each group to *tell me what they thought the question was that the authors were addressing.* I quickly have the groups report out their conclusions. I do not comment at this point. There are always differences of opinion as to the question, usually because some groups have been specific, focusing on coots, while others have focused on the big evolutionary picture.

After this round robin is over, I ask the groups to *quickly report on the hypothesis that they think that the authors are pursuing.* Again, when the reporting is done, it will be apparent that there are differences among groups. I choose not to comment as this process is occurring except to say that clearly people differ even though they have the same information. I could intervene and tell them my version of the truth or explore the reasons for their differences, but I choose not to do this because I would never get to other critical points ahead.

At this point I say that I know that they have begun to consider the ways that the authors might test their hypothesis. But to help them on their way I thought that they might like to hear a little bit more from the authors.

Part II—The Authors Find a Method to Attack the Problem

(Again students work in small groups and report out, then they receive new information.)

I now read Part II out loud to everyone. I finish by saying that now that they know what the authors are up to, they are to use the method of clipping the feathers and design an experimental program which will test the hypothesis. It is essential at this point to emphasize that, yes, you know there are other ways to attack the problem, but you want them to use the authors' approach. If you don't do this, some groups tend to go off on their own and produce radically different designs, and although this might be productive in some ways, it will surely be diversionary to the present case strategy.

I give the groups about 10–15 minutes to come up with an experimental design using the feather clipping method of the authors. As the discussion occurs, I wander about from group to group checking on the students' progress and making sure that they are using the authors' method. I try not to answer many coot questions and do mention that, yes, I know that they don't know much about coots but they should just make some reasonable assumptions as they design their experiment. I do reassure them that they don't need to worry about budget at this point. Their goal is simple: design an experiment to test the hypothesis.

When the time is up, I once again interrupt. I ask the groups to take turns in reporting their findings. Incidentally, I always take the groups in a different order each time they report. Most groups will have very similar experimental designs now. All will have decided to have a nest with orange chicks and to have another with all black chicks. Some will stop there, not realizing that they have to have a third group, a nest condition with 50 percent black and 50 percent orange. It is only in this situation that the parents will have a choice between the two conditions. Also, there will be variations in what data to collect and how to go about collecting it. Once again, I really don't comment except occasionally to ask questions for clarification.

Part III—What Should Be Measured?

(Small groups work, then report out, and new information is added.)

Next I read out Part III, telling the students what the authors really did. This passage is instructive because it reveals details about how the authors handled the coots that some groups will have considered. At the end of the passage, I specifically ask them to decide what data the authors should collect and how might they do it. The groups will have talked about this earlier, but now they have a chance to revise their ideas in light of other groups' comments and the further information. Also, it is essential to emphasize to them that they should begin to seriously think about what the data might show.

After about five minutes, I have the groups briefly report out their proposals. There will be a few surprises here as some groups will have some novel and often very expensive ways to monitor the birds.

Part IV—At Last, Here Are Some Data!

(Small group work and the students plot some data.)

Then I read Part IV to them and hand out Figure 1 to everyone. Sometimes I only hand out a single copy of the data to save paper and to force each group to work together.

The figure shows part of the data where the coots have been left orange. The data show what happens in a nest where every chick has the normal plumage. Now I want them first to predict (guess) what would happen to the chicks that are in nests where all are black. Of course, there are several possibilities, but I tell them to plot the data that they would *hope to see occur if the hypothesis were correct.* Recall they have the data for nests where all the chicks are orange for comparison.

This point is troublesome. I have not figured out how to say this so everyone clearly understands the issue without telling them the answer. Most students get the point when I say: "Let's consider the ideal experiment, the one with the least complications in interpretation. Now, if the hypothesis were correct that parents feed some chicks better than others based on their plumage when there is a choice, what do you want to happen when all of the chicks are black?" (Obviously, you are hoping that they will realize that the ideal would be that the chicks in the all-black nests will have the same survival rates as the chicks in the all-orange nest. If this didn't happen, and say, the black chicks fare more poorly even without orange ones in the nest, then this complicates the story a lot. It would mean that any survival differences that occurred when both orange and black were in the same nest could not be simply attributed to parental feeding.

It could be due to problems of temperature regulation facing the black chicks, etc.)

Then I tell the students that after they have filled in the graphs for the all-black nestlings, they should fill in the data for the experimental nests where there is a 50:50 mixture. Again you emphasize the point, *what would they predict if the hypothesis were correct.*

Part V The Rest of the Story

(You show them the actual results and ask them what they make of it.)

The plotting of the data will take about 10 minutes and after some hemming and hawing, most groups end up with the appropriate predictions. You will see this as you meander around the class. If a group is having difficulties, invariably it will be that they haven't gotten the black ones correctly positioned. They typically will have given them a lower survival rate than the all orange normals. You'll have to spend time with these folks to work through what the ideal would be.

I don't have the groups report out here at this point. But when they have filled in their graphs I hand them a competed version of what happened (Figure 2). After they have had a few moments to compare their predictions with the real data, I ask the entire class to respond to the questions listed at the end of the passage. Do black chicks survive more poorly because they are black or because they are "inferior" (less fit) than the orange chicks? Do the data support the hypothesis? Do the data prove the hypothesis? By this point students will recognize the distinction between support and prove.

At this point I stop. The case is over but the work is not. The authors are still working on the problem. To intrigue them further I might mention what the authors say at the end of their abstract:

They write:

> *...the survival benefits from increased parental care did not accrue to all orange chicks in experimental broods, but depended strongly on a chick's position in the hatching order. Late-hatched orange chicks had dramatically higher survival than late-hatched black chicks, but there was little difference in survival between early hatched black and orange chicks.*

So we could continue the case by giving the students the graph depicting hatching order and ask them what they make of it.

As a last point, the authors of the *Nature* article suggest three possible answers to the question "Why do parents prefer orange feathered chicks?"

1. Ornamental plumage may be a signal of a chick's high genetic or phenotypic quality, leading the parents to invest more care-giving in them.
2. Orange plumage may be a signal of age, allowing parents to selectively feed the chicks in an optimum way.
3. The color preferences may not be directly related to feather color but simply due to a parent color preference for other reasons. Perhaps it is the chick's head color that signals the offspring's need.

What experiments might resolve the issue?

References

Lyon, B., J. Eadie, and L. Hamilton. 1994. "Parental choice selects for ornamental plumage in American coot chicks," *Nature* 371: 240–243.

Lesson Plan: Mom Always Liked You Best

Objectives:

*Reinforce the value of the cooperative/collaborative learning method in which students work together to solve problems.

*Help students develop a clear, rigorous, and structured approach to solving problems, i.e., to enhance critical thinking.

*Give students practice in designing experiments.

*Give students practice in making predications and interpreting data.

*Give students explicit experience with the hypothetico-deductive method of reasoning, i.e., "the scientific method," where a questions is asked, a hypothesis suggested, predictions or deductions made in light of the hypothesis (i.e., if the hypothesis is true, then such and such should occur), tests accomplished, and the data evaluated supporting or rejecting the hypothesis. *To reinforce this model, it is essential at every opportunity as new information and questions are added that the instructor always ask the students what they now expect if the hypothesis were true.*

Interrupted Case Method

Day 1: Divide class into groups of 3 (leader, reporter, and secretary).

Hand out Part I (1 to each group). Read the case *as a group* and answer the questions at the bottom of the page.

After a few minutes put a colored picture of a baby coot on the smart board.

After about 15 minutes the reporters are to tell the class *what they thought the question was that the authors were addressing.* No comments are needed by the teacher or students at this point.

Will take about 40 min

Next, groups are to quickly report on the hypothesis that they think that the authors are pursuing.

At this point I know that students have begun to consider the ways that they authors might test their hypothesis. But I am going to let them hear more from the authors tomorrow, no assignment.

← Have students go over possible designs.

Day 2: Students need to get back into their groups and the reporter needs to read the notes the secretary made on the question and hypothesis that we went over yesterday.

I will read Part II out loud. Now the students know how the scientists are doing their research. Yes there may be others ways but the students are to use the authors approach.

Give students 10-15 minutes to come up with an experimental design using the feather clipping method. Their only goal is to design an experiment to test the hypothesis.

When time is up groups will report their design to the class. (Most will have a design that has a nest with all black chicks and another nest with all colored chicks. Hopefully some will also have a nest with a 50/50 mix)

Only ask questions for clarification.

Now I will read Part III.

Ask the students to decide what data the authors should collect and how might they do it. Groups may have talked about it earlier but now they have a chance to revise their ideas in light of further information.

After 5 minutes, groups will briefly report their proposals.

Day 3: Read Part IV and hand out Figure I (1 to each group).

Have students predict what would happen to the chicks that are in nests where all are black and plot the data you would hope to see occur if the hypothesis were correct.

Here is where it can get troublesome. Ask, "Let's consider the ideal experiment, the one with the least complications in interpretation. Now, if the hypothesis were correct teat parents feed some chicks better than others based on their plumage when there is a choice, what do you want to happen when all the chicks are black?"

You are hoping that they will realize that the ideal would be that the chicks in the all-black nests will have the same survival rates as the chicks in the all-orange nest. If this didn't happen, and say, the black chicks fare more poorly even without orange ones in the nest, then this complicates the story a lot. It would mean that any survival difference that occurred when both orange and black were in the same nest could not be simply attributed to parental feeding. It could be due to problems of temperature regulation facing the black chicks, etc.

Next, students should fill in the data for the experimental nests where there is a 50/50 mixture. What would they predict if the hypothesis were correct.

Day 4: Show the students the actual results and ask them what they make of it.

Answer the questions listed at the end of the passage. (I will put them on the smart board.)

Read the following abstract from the actual authors:

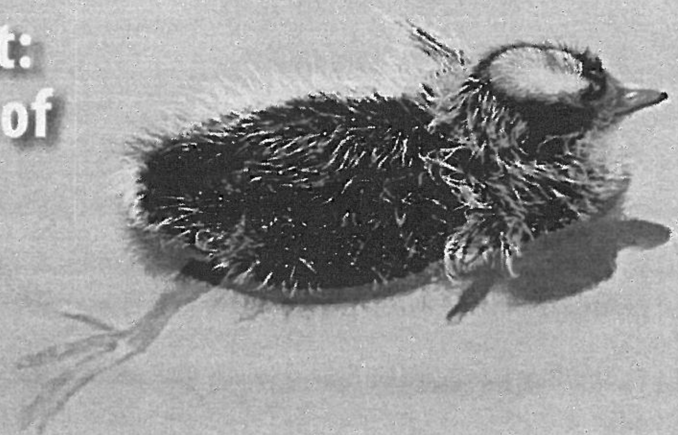
> *...the survival benefits from increased parental care did not accrue to all orange chicks in experimental broods, but depended strongly on a chick's position in the hatching order. Late-hatched orange chicks had dramatically higher survival than late-hatched black chicks, but there was little difference in survival between early hatched black and orange chicks.*

Read three possible answers to the original questions:

1. Ornamental plumage may be a signal of a chick's high genetic or phenotypic quality, lading the parents to invest more care-giving in them.
2. Orange plumage may be a signal of age, allowing parents to selectively feed the chicks in an optimum way.
3. The color preferences may not be directly related to feather color but simply due to the parent color preference for other reasons. Perhaps it is the chick's head color that signals the offspring's need.

NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Mom Always Liked You Best: Examining the Hypothesis of Parental Favoritism



by
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Many birds have bright, ornamental plumage. Most often it is displayed by the male of the species, who is believed to use the plumage to attract females. The female may select male breeding partners on the basis of this feather advertisement, perhaps assessing their health. According to evolutionary theory, it behooves the female to choose a strong, healthy male to be the father of her chicks, not only because the male helps to feed them but also because the chicks will carry dad's healthy genes. Darwin labeled such mate choice "sexual selection."

Another possible form of plumage selection has been studied by biologists in Canada. They think that the parents of certain bird species may select the "prettiest" chicks out of a nest as favorites and feed them better (why they might do this is an interesting question).

American coots are birds that live in the marshes of western North America. As adults they are grayish-black and have a spot of white on their bills. The chicks are unusual, for unlike most birds whose nestlings are usually drab, coot chicks are surprisingly conspicuous. They have long, orange-tipped, slender feathers, brilliant red papillae around their eyes, a bright red bill, and bald red head. The chicks lose this colorful appearance at three weeks. The Canadian biologists speculated that the plumage may make some chicks more attractive to their parents; possibly the most "attractive" chicks might be able to successfully beg for more food from their parents and have a better chance of survival. That seemed possible since sometimes one-half of all chicks died from starvation. But how could the authors test such an unusual notion?

Here is your challenge:

- First, identify the specific question(s) the authors are asking.
- Second, what is the hypothesis that they suggest?
- Third, what predictions (deductions) can you make if the hypothesis is correct?
- Fourth, how can we test the predictions, i.e., what exactly might we do if we were the authors who had studied coots for several years?

Mom Always Like you Best: Examining the Hypothesis of parental Favoritism

Many birds have bright, ornamental plumage. Most often it is displayed by the male of the species, who is believed to use the plumage to attract females. The female may select male breeding partners on the basis of this feather advertisement, perhaps assessing their health. According to evolutionary theory, it behooves the female to choose a strong, healthy male to be the father of her chicks, not only because the male helps to feed them but also because the chicks will carry dad's healthy genes. Darwin labeled such mate choice "sexual selection."

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Part II—The Authors Find a Method to Attack the Problem

During the breeding season of 1992, Bruce Lyon, John Eadie, and Linda Hamilton studied 90 pairs of coots nesting in the marshes of British Columbia. They decided to try and alter the plumage of the chicks by dyeing them. Unfortunately, the dye made the chicks sick and it removed the oils from their feathers. They next tried to alter the appearance of the chicks by cutting the orange tips off their body feathers. This produced black chicks that seemed to act the same as the normal orange chicks. The scientists now began a test of their hypothesis using this technique. What do you expect they might do?

Part III—What Should Be Measured?

The biologists decided to set up three types of nest conditions. In the first group of nests (let's call this the experimental group), they trimmed half of the chicks and made them black, and they left half of the brood with orange feathers. In a second group (call this a control group), all of the chicks were trimmed so they appeared black. In a third group of nests (call this another control group), all the chicks were left their natural color, orange. In all three groups, the chicks were captured within a day of hatching and were generally handled the same way even though some were trimmed. The chicks were kept in captivity for 30 minutes before being replaced in their nest. To control for the effects of hatching order in the experimental groups, the first chick hatched was randomly assigned to be trimmed or left orange. Thereafter, treatments were alternated with hatching order. The biologists worried about what kinds of data to collect, how to collect the data, and what kinds of results to expect. What would you suggest they do?

Part IV—At Last, Here Are Some Data!

The biologists decided to compare feeding rates, relative growth rates, and survival rates of the chicks in the different nests. Since the chicks had been individually color-marked, they could be easily observed and identified from floating blinds. To estimate growth rates, swimming chicks were photographed at known distances and their body length at waterline was estimated from projected slides. This measure of size is strongly correlated with body mass ($r=0.97$, $n=43$). Part of the data have been reproduced in the handout showing Figure 1. Predict the results of the other values by plotting the values on the graph. Why have you made these predictions?

Part V—The Rest of the Story

In the handout showing Figure 2 you will see the real results that the authors collected. How do the data compare with your predictions?

The authors ran a series of statistical tests and noted that there were no significant differences between the two control groups in any of the measures--that is, when the orange and black chicks were in separate nests, they had similar feeding, growth, and survival rates.

But in the experimental group where both black and orange chicks occurred together and the parents had a true choice of whom to feed, statistical analysis showed that the orange chicks fared better. Orange chicks were fed at a higher rate, had a higher growth rate, and enjoyed a higher survival rate than the black chicks in the same brood. What conclusions might the biologists make about their original hypothesis?

For example:

1. Do black chicks survive more poorly simply because they are black or because they are "inferior" relative to the orange?
2. Do the data support the hypothesis?
3. Do the data prove the hypothesis?

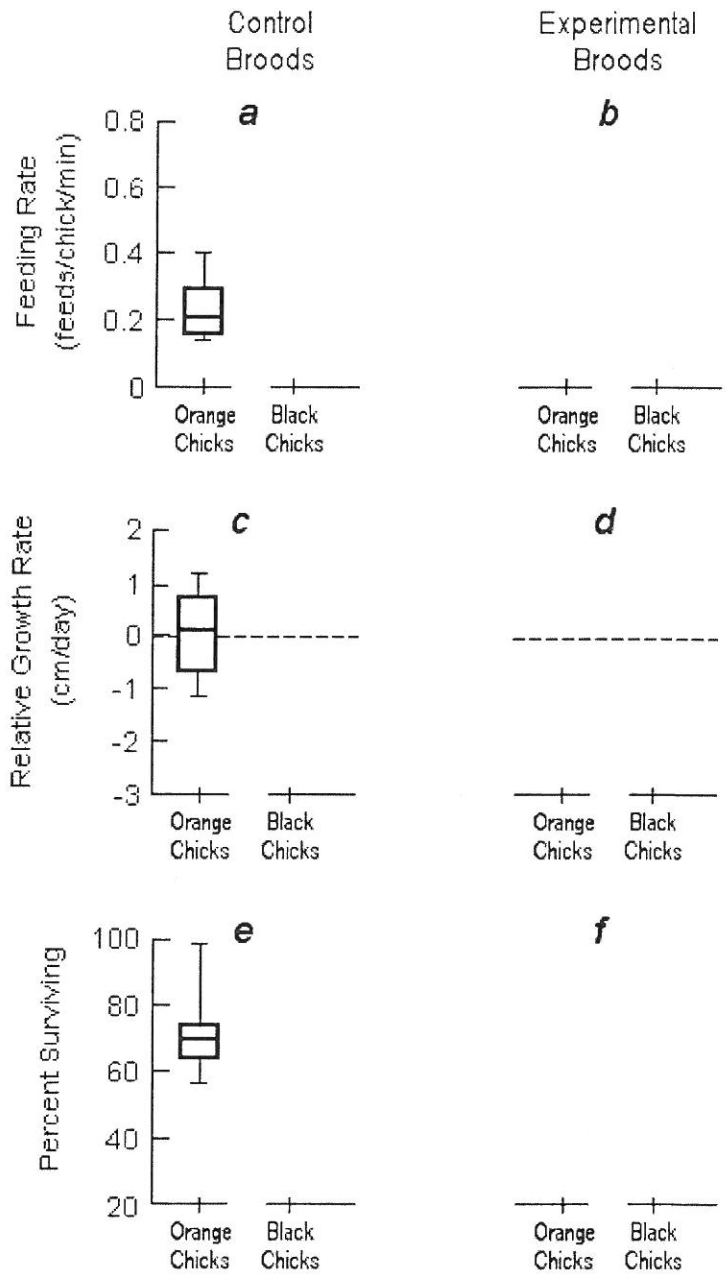

Figure 1: Feeding, growth, and survival rates of coot chicks

On the left side of the figure (panels a, c, and e) are the values for the two control groups (nests with either all orange chicks or nests with all black chicks). But the only data shown are for the nests composed entirely of orange chicks. Remember this is the normal situation that we find in the wild. The values shown are the medians, interquartile ranges, and 10–90 percentiles. With this knowledge, plot the values on the graph you would expect for the control black chicks raised with only black nest mates.

On the right side of the figure (panels b, d, and f) is a space for the expected values for the chicks in the experimental broods. Here half of the chicks are black and half are kept orange. Now plot what you predict the values will be *if the authors' hypothesis is correct.*

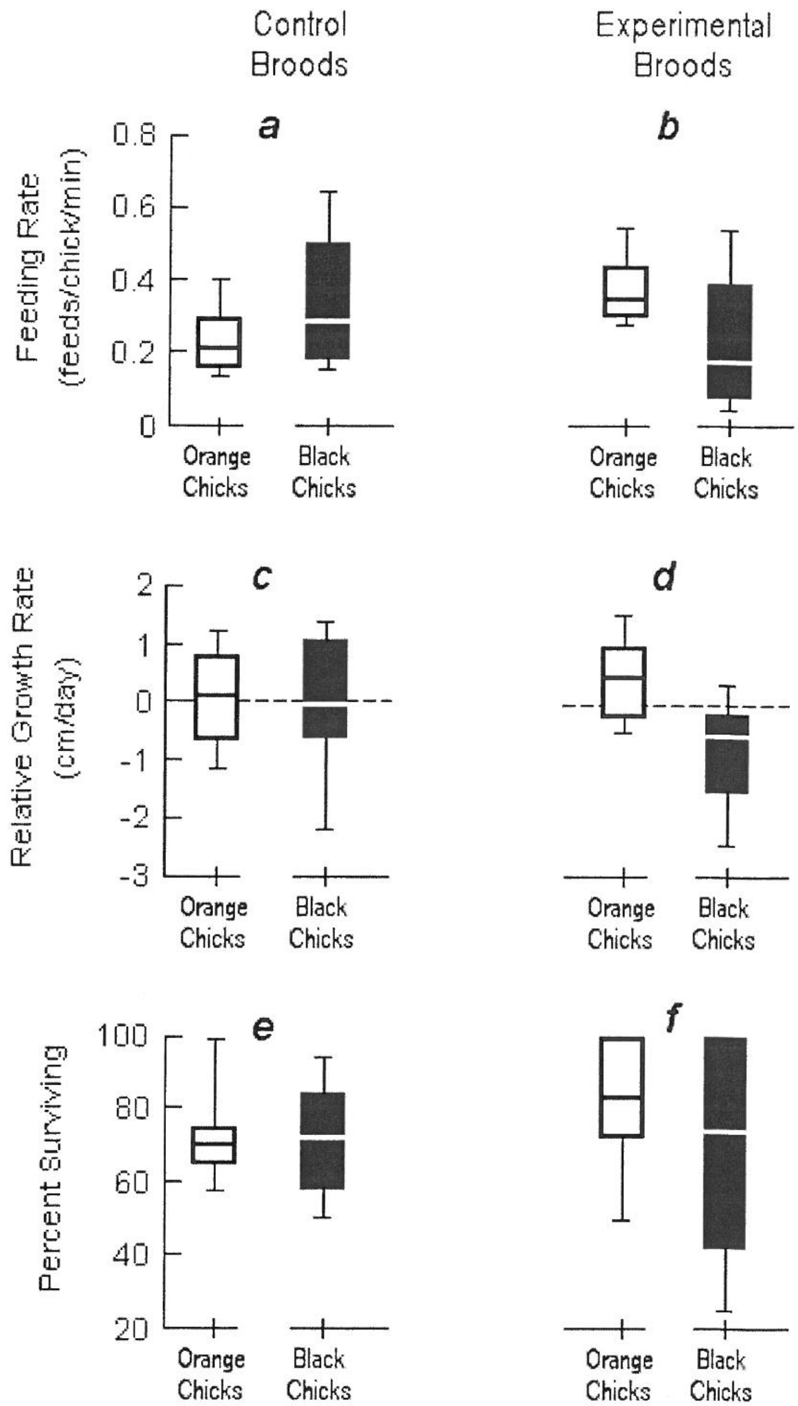

Figure 2: Feeding, growth, and survival rates of coot chicks

The values shown are the medians, interquartile range, and 10–90 percentiles.

Note: There are no statistical differences between orange and black chicks (controls) in separate nests. In the experimental nests, there were significant differences between the orange and black chicks in feeding, growth, and survival rates.