HOW TO DO IT

The Mating Game: A Classroom Activity for Undergraduates That Explores the Evolutionary Basis of Sex Roles

RECOMMENDED FOR *AP Biology*

DANI MOORE, C. TATE HOLBROOK, MELISSA G. MEADOWS, LISA A. TAYLOR

Abstract

In species that reproduce sexually, an individual's fitness depends on its ability to secure a mate (or mates). Although both males and females are selected to maximize their reproductive output, the mating strategies of the two sexes can differ dramatically. We present a classroom simulation that allows undergraduates to actively experience how differences in parental investment lead to differences in reproductive behavior. Students will understand why males generally compete for mates whereas females generally choose among mates. The activity provides a foundation for exploring advanced topics in animal behavior, or it can be adapted for introductory biology courses.

Key Words: *Reproductive behavior; sexual selection; parental investment; classroom simulation; undergraduate.*

College students are intimately aware that males and females differ in sexual behavior, but most have never considered the evolutionary basis of sex roles in *Homo sapiens* or other animals. Understanding why males and females typically employ different mating strategies is necessary for grasping key concepts in animal behavior, including sexual selection, sexual conflict, mating systems, and parental care (Kokko & Jennions, 2008). We developed an active-learning exercise to simulate how differences in parental investment, beginning with gamete size, shape reproductive behavior. By playing "the mating game," students gain a visceral experience that they can reference when thinking about more advanced topics in animal behavior.

Understanding why males and females typically employ different mating strategies is necessary for grasping key concepts in animal behavior.

Males, by definition, produce many small gametes and usually provide little or no care to their offspring. Females, by contrast, produce fewer, larger gametes, and when offspring receive parental care, it is typically provided by the mother. Because females generally invest more resources per offspring than males and can produce a limited number of gametes, females usually have a lower potential reproductive rate (Trivers, 1972). This means that more males than females are available to mate at any given time (i.e., the operational sex ratio is male-biased). As a result, males tend to compete for sexually receptive females, whereas females can choose among males, using criteria such as mate quality or material donations. The causal relationship between parental investment and mating strategy is supported by cases of "sex role reversal"; for example, when males provide more parental care, females compete for mates and males choose (Gwynne, 1991).

○ Activity

We begin by asking students what makes a male a male and a female a female. This question captures students' attention because they are familiar with characteristics of males and females but not the most basic definitions of the sexes: males produce smaller gametes, or sperm, and females produce larger gametes, or eggs (Randerson & Hurst, 2001).

We then distribute a set of paper "gametes" to all students. Half of the students represent females; they receive four large gametes (1/4th sheet of paper each). The other half represent males; they receive 48 small gametes (1/48th sheet of paper each). Gametes are assigned irrespective of students' gender; this emphasizes that students are merely playing roles in the game and that the decisions they make in the simulation have no connection to the choices they make in their lives. Each gamete is labeled with a unique letter that identifies the parent and with a "quality score" for that parent (1 to 5, with 5 indicating the highest quality; Table 1). The quality scores should approximate a normal distribution, with most students being assigned intermediate scores and only a few receiving extreme scores. (Gametes and other materials are available for download at https://sites.google.com/site/theclassroommatinggame.)

In addition to gametes, each student receives a headband indicating his or her sex and quality score. We provide long strips of

The American Biology Teacher, Vol. 74, No. 9, pages 648–651. ISSN 0002-7685, electronic ISSN 1938-4211.
DOI: 10.1525/abt.2012.74.9.9

Table 1. Distribution of quality scores and identification letters for a class of 18 students.

Quality	Score	Number of Females	Female ID	Number of Males	Male ID
High	5	1	A	1	R
	4	2	B, C	2	S, T
	3	3	D, E, F	3	U, V, W
	2	2	G, H	2	X, Y
Low	1	1	I	1	Z

construction paper and binder clips to secure the strips around their heads. Males and females receive different color headbands (e.g., pink for females and blue for males), and each individual's quality score is signified by the number of large black dots on the front of his or her headband, so that the students can quickly and easily assess the sex and quality of their classmates.

When prompted by the instructor, students mingle around a designated "breeding area" and "mate" with their classmates (Figure 1). A successful mating takes place when a male and female agree to mate and the female takes one sperm from the male and pairs it with one of her eggs. After each mating, the female must carry the pair of gametes outside of the breeding area to the instructor, who sums the quality scores of the male and female to determine the "reproductive success points" earned by each parent from that mating. The objective for each student is to maximize the total number of reproductive success points earned during the game. The same male and female can mate multiple times, but only one egg can be fertilized at a time (i.e., females can accept only one sperm per mating event). Males remain in the breeding area and are free to mate again as soon as they have passed their gametes to a female. When nearly all females have used all of their eggs, usually after a few minutes, the instructor declares that "mating season is over," after which no more fertilizations can take place.

To facilitate data entry and instant discussion of the results, we created a Microsoft Excel spreadsheet that requires the instructor to enter just the identities of the mated male and female during the game (e.g., "B" and "T"). With this information, the spreadsheet automatically calculates the number of matings and the total reproductive success points earned by each student. It also generates four plots showing the number of matings and the total reproductive success points earned by each individual, separated by sex (Figure 2; spreadsheet available at https://sites.google.com/site/theclassroommatinggame).

We discuss the Excel plots as a class. First, the students characterize the data presented in each graph, paying special attention to the range on the *y*-axis and the variation among individuals on the *x*-axis (Figure 2). Then we ask a high- and a low-quality individual from each sex to describe their experience. What was their mating strategy? Did it work? Was it hard for them to get a mate? Was there anyone they would not agree to mate with? Students typically have no trouble articulating the appropriate reproductive strategy for an individual of their sex and quality and justifying their answer. Sometimes, individuals or groups develop alternative strategies that can be discussed. For example, we have seen males form a lek, attempt to disguise their quality, and act as "sneakers" to obtain mates. If time permits, we ask students to think about scenarios that might cause them to alter their strategy. For example, what if assessing the quality of a potential mate takes time (and is not as easy or reliable as simply counting dots on a hat)? What if females had to walk a mile to deliver their gametes to the instructor, rather than just across the room?

At this point, we introduce the terms *parental investment* and *operational sex ratio*. To formalize the relationship between parental investment, operational sex ratio, and sex roles, we ask students to choose the right words to complete a conceptual flowchart (Figure 3; adapted from Alcock, 2001).

Finally, we present a test of the theory of sex differences: if females usually choose among mates because they invest more per offspring and, thus, have a lower potential reproductive rate, what happens in species in which males make the larger parental investment and/or have the lower potential reproductive rate? We introduce the pipefish *Nerophis ophidion*. In this species, a female deposits her eggs on the ventral surface of a male, and the male cares for the embryos until independent young emerge several weeks later. Males have a lower potential reproductive rate in this species because one female can impregnate two males during the time of one male pregnancy (Vincent et al., 1992). As predicted, males are choosier than females (Rosenqvist,

Figure 1. In the mating game, students experience how differences in parental investment between males and females lead to differences in reproductive strategies. Here, five males compete for the opportunity to mate with one receptive female.

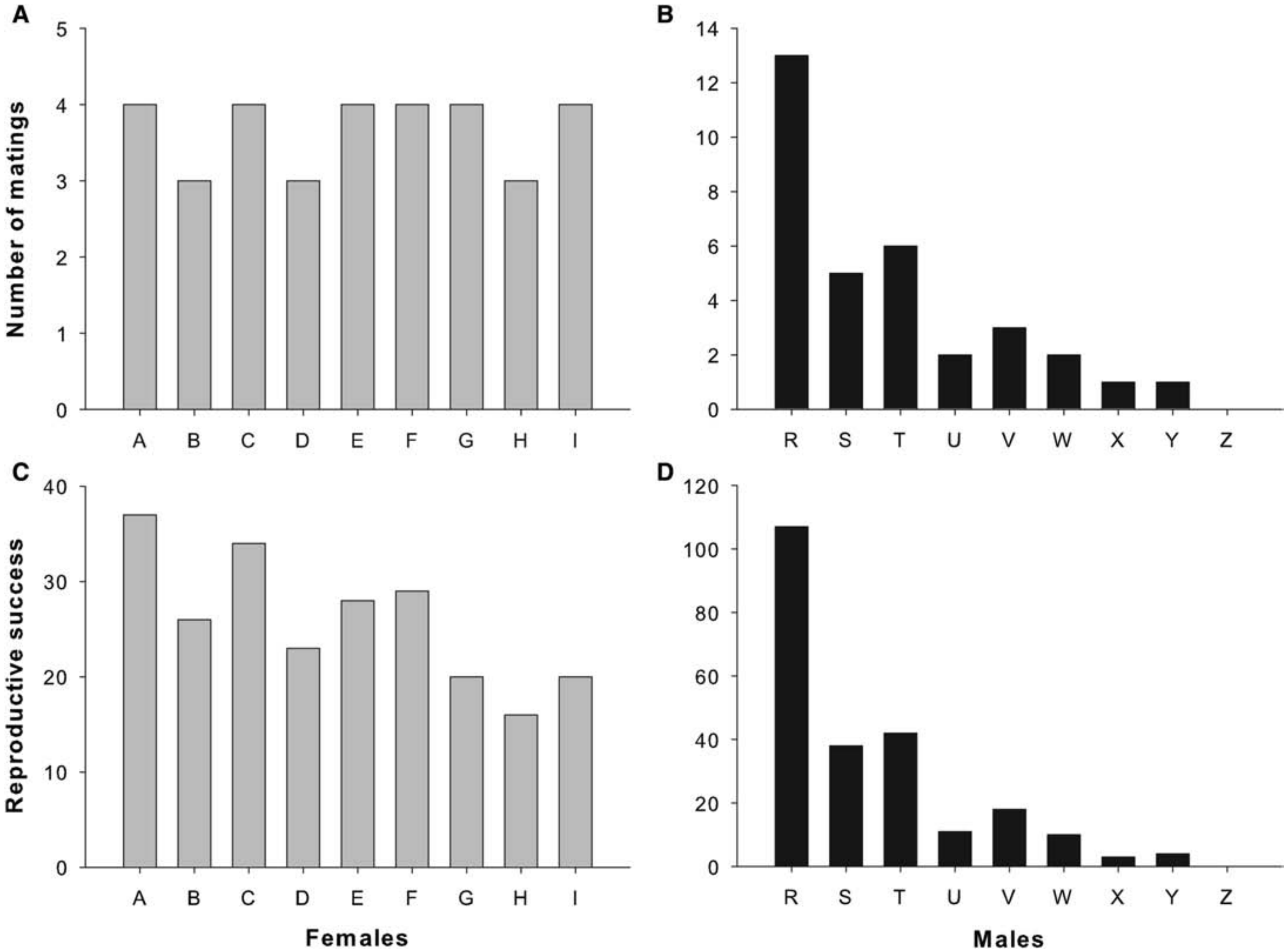

Figure 2. Expected results, showing (A) number of matings obtained by each female, (B) number of matings obtained by each male, (C) total reproductive success points earned by each female, and (D) total reproductive success points earned by each male. Data were modified from actual classroom results to represent a class size of 18 students with the quality score distribution specified in Table 1 (quality decreases from left to right across each *x*-axis).

1990; Berglund & Rosenqvist, 1993). When given a choice between females, males show a strong preference for larger females, which are more fecund (Rosenqvist, 1990). Females, by contrast, do not demonstrate a preference for large males (Berglund & Rosenqvist, 1993) and compete among each other for mates (Rosenqvist, 1990).

○ Conclusion

Active-learning methods can enhance understanding and retention in undergraduate science courses (Handelsman et al., 2007). Our students report that the mating game is a fun, effective, and memorable demonstration of the evolutionary forces that shape mating strategies. Thus, it is an excellent springboard for exploring more advanced topics in reproductive behavior that build upon the underlying concept of sex differences. For example, the mating game introduces mate "quality" but does not specify characteristics that make a male more valuable to a female. Referring back to the game, ask students to brainstorm potential benefits a female might receive from mating with a high-quality male. This list can be used to launch a discussion of intersexual selection. Similarly, the students' experience with the mating game can carry over into lessons about intrasexual selection, honest signaling, sexual conflict, parental care, and mating systems. The parameters of the game can also be modified and/or expanded to address these themes through subsequent iterations, or for a more basic treatment of reproductive behavior in an introductory biology course.

In our experience, students have participated enthusiastically in the game. In surveys, no student has ever reported feeling awkward or uncomfortable during the simulation. Of course, any activity that deals with sex has the potential to become sensitive. Instructors should be prepared to discuss that human behavior, though sculpted by evolution, is more immediately shaped by social and cultural forces. We recommend that this activity be used only with advanced high school or college students who possess the maturity to handle these topics.

○ Acknowledgments

We thank Shelley Haydel, Ron Rutowski, Valerie Stout, Melissah Rowe, Mike Butler, and the students in their Scientific Teaching course

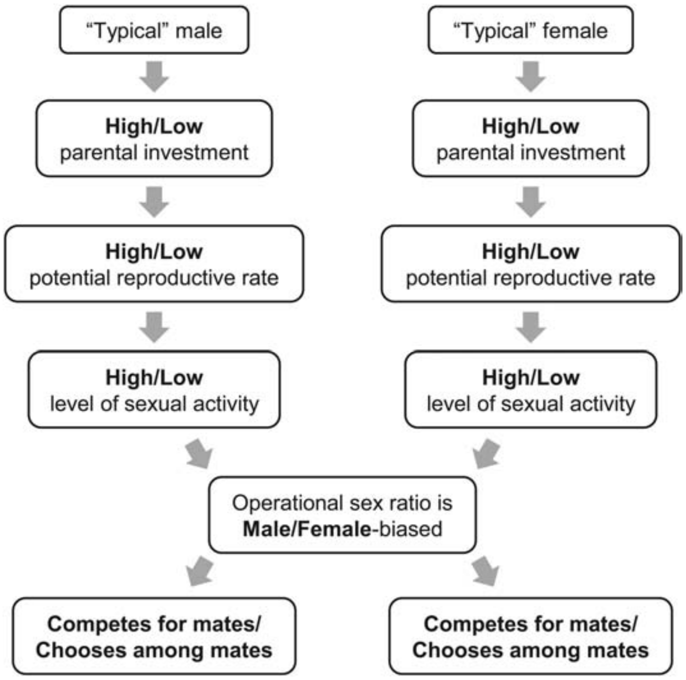

Figure 3. Following the exercise and discussion, we ask students to complete this conceptual flowchart to formalize the relationship between parental investment and sex roles. Students are instructed to select the correct bold word(s) in each box. (Adapted from figure 11-6 in Alcock, 2001.)

for help in developing this activity; Nicola Plowes for allowing us to test it in her Animal Behavior class; and two anonymous reviewers for their comments on the manuscript.

References

Alcock, J. (2001). *Animal Behavior: An Evolutionary Approach, 7th Ed.* Sunderland, MA: Sinauer Associates.

Berglund, A. & Rosenqvist, G. (1993). Selective males and ardent females in pipefishes. *Behavioral Ecology and Sociobiology*, *32*, 331–336.

Gwynne, D.T. (1991). Sexual competition among females: what causes courtship-role reversal? *Trends in Ecology & Evolution*, *6*, 118–121.

Handelsman, J., Miller, S. & Pfund, C. (2007). *Scientific Teaching*. New York, NY: W.H. Freeman.

Kokko, H. & Jennions, M.D. (2008). Parental investment, sexual selection and sex ratios. *Journal of Evolutionary Biology*, *21*, 919–948.

Randerson, J.P. & Hurst, L.D. (2001). The uncertain evolution of the sexes. *Trends in Ecology & Evolution*, *16*, 571–579.

Rosenqvist, G. (1990). Male mate choice and female–female competition for mates in the pipefish *Nerophis ophidion*. *Animal Behaviour*, *39*, 1110–1115.

Trivers, R.L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual Selection and the Descent of Man 1871–1971* (pp. 136–179). Chicago, IL: Aldine-Atherton.

Vincent, A., Ahnesjö, I., Berglund, A. & Rosenqvist, G. (1992). Pipefishes and seahorses: are they all sex-role reversed? *Trends in Ecology & Evolution*, 7, 237–241.

DANI MOORE (dani.moore@asu.edu) is a doctoral student in Life Sciences at Arizona State University, PO Box 874601, Tempe, AZ 85287-4601. C. TATE HOLBROOK (holbrook.c@lynchburg.edu) is Visiting Assistant Professor of Biology at Lynchburg College, 1501 Lakeside Dr., Lynchburg, VA 24501. MELISSA G. MEADOWS (melissa.meadows@uni-tuebingen.de) is a postdoctoral fellow at Universität Tübingen, Institut für Evolution und Ökologie, 72076 Tübingen, Germany. LISA A. TAYLOR (lat57@pitt.edu) is a postdoctoral fellow at the University of Pittsburgh, 4249 Fifth Ave., Pittsburgh, PA 15260.