

might control sperm usage within their reproductive tracts have been obtained by rapidly freezing insects *in copula* (Hosken and Ward 2000), but such a chilling form of coitus interruptus is obviously not appropriate for all species.

Other supposed examples of male bias may also stem from practicality rather than chauvinism. As Zuk points out, technological innovations such as DNA haplotyping have yielded findings that have challenged the prevailing view that promiscuity is beneficial only for males. This notion grew largely out of observational studies of mating behavior, usually a more important determinant of fitness for males than for females. This does not imply that female behavior is unimportant, but merely that it is more convenient to study overt behavior by males than covert paternity allocation inside females. Developments in methodology have provided the evidence that females do have something to gain from mating with multiple males. For example, there are

possible benefits of extrapair paternity in socially monogamous species, such as “good genes” for offspring or genotypic diversification as a hedge against environmental unpredictability. Feminist scientists like Zuk may be entitled to say “we told you so,” but developments in science, not ideology, have made it possible for them to say it.

Ultimately, although Zuk draws attention effectively to the dangers of anthropomorphism, her message on the role of ideology in scientific research is rather confused. On the one hand, she asserts repeatedly that “feminism has more to offer biology than vice versa,” since it can, for example, help keep science “honest” (by ensuring that it focuses on phenomena that are not merely “sexist spandrels”). On the other hand, she acknowledges that “taking an ideological stance” can actually *prevent* researchers from asking interesting questions. With the benefit of hindsight, we see that male behavior is only half the

story, but it does not follow that what science needed all along was a healthy dose of feminism. In the end, it isn't clear in which direction the majority of insight has flowed. Feminism seems to have more to offer to biologists than to biology itself, but biology clearly has a great deal to offer feminism.

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DO ANIMALS HAVE GENDER?

Evolution's Rainbow: Diversity, Gender, and Sexuality in Nature and People. Joan Roughgarden. University of California Press, Berkeley, 2004. 474 pp. \$27.50 (ISBN 0520240731 cloth).

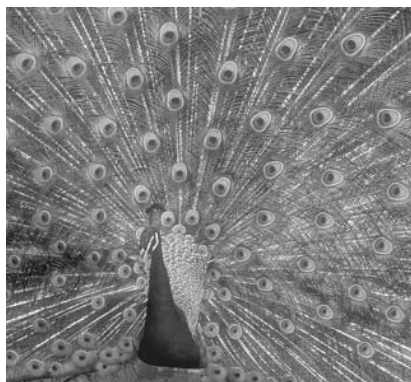
Soon after transitioning as a transgendered woman, Joan Roughgarden, professor of biological sciences at Stanford University, undertook a book-writing project to celebrate and explain diversity in sexual presentation. To do so, she explored all aspects of sexual reproduction, including the sexual behavior of animals, the development of human sex differences, and the varied role that gender plays in world cultures. As she became deeply engrossed, how-

ever, Roughgarden also concluded that experts in each of the academic disciplines she explored were disparaging of diversity. Particularly in her home fields of evolution and ecology, she found “diversity in gender and sexuality denigrated by sexual selection theory, a perspective that can be traced to Darwin.” So in addition to celebrating diversity, she determined to set the record straight and to proclaim that “Darwin’s theory of sexual selection was false” (p. 5).

Because my interests are in animal behavior and sexual dimorphism, I was preadapted to enjoy the book, and enjoy it I did. The style, informal and personal, makes it highly readable, and the numerous facts and controversial ideas it presents are certain to stimulate future research. I came away more convinced than ever that, when it comes to sex and gender, we are not all alike. That said, I also found the book frequently annoying and occasionally infuriating, in part because of the author’s relentless stereotyping of the academy.

The author convincingly builds her case that animals frequently deviate from simple stereotypes about sex differences. Female animals are not always coy and nurturing, nor are males always big, colorful, and aggressive. In fact, females are commonly the larger sex, and in some vertebrates, they are dominant to nurturing males. In two extreme examples, female spotted hyenas possess a penis-like clitoris that they erect during social interactions, and the female blue-headed wrasse, a fish, can change sex from female to male.

But somehow her review of the inadequacy of popular stereotypes leads Roughgarden to conclude that Darwin was wrong about sexual selection, and on this point she fails utterly to convince me. Darwin sought to account for all sex differences by attributing the origin of some to a process that “depends on the advantage which certain individuals have over other individuals of the same sex and species, in exclusive relation to reproduction” (Darwin [1871] 1981). The peacock’s tail is the classic sexually selected trait, but Darwin was aware that in some systems females, not males, compete for mates. In these exceptional systems, the



“sex roles” are reversed, and brightly colored, aggressive females leave the care of offspring to males. Darwin’s powerful insight did not make him a champion of women—hardly (see, for example, Darwin [1871] 1981, p. 327). But it’s Darwin’s ideas on sexual selection that are on trial in Roughgarden’s book, not his attitudes toward women, and his ideas have stood the test of time.

I grant that there has been excess in the name of Darwin. Like Roughgarden, I too have experienced impatience or embarrassment with the language of behavioral ecology, including the oversimplification of the evolutionary process, the annoying tendency to speak of genes as being “for” this or that, and, perhaps most of all, the presumption of “good genes.” Some researchers who study animal behavior have certainly been carried away with the iconic contrast between the supposedly bold, aggressive, sexually rapacious male and the passive, dependent female. But I know of others who have quantitatively explored the evolutionary implications of sex differences in the opportunity for selection (Shuster and Wade 2003). These scholars and many others do not receive their due.

The book makes five additional important assertions. First, Roughgarden states that evolutionary biologists have overemphasized the role of competition in explaining behavior and have underestimated cooperation. She claims that evolution can give rise to group-level, cooperative adaptations that promote sexual access, without relying solely on reciprocal altruism or kin selection, through a process known as social selection. This troubling aspect of the book is presented as novel and straightforward,

when it is neither. Second, Roughgarden argues that sexual differentiation is a complex but comprehensible subject that involves the interaction of many genes that lead to numerous equally viable and stable outcomes, which medical scientists have failed to appreciate as normal. Rather, they have made pathologies of healthy departures from the norm. This section of the book is extremely effective. The book’s third assertion is that, like animals, humans form a rainbow of diversity in their sexual presentation, and that while anthropologists and social scientists have successfully cataloged this variety, they have too often treated Western culture as the norm and denigrated diversity. The fourth and fifth assertions are the ones I found most intriguing, namely that animals have gender, and that while animals come in only two sexes, based on the size of their gametes, they often come in more than two genders.

Do animals have gender? Over the past few years I have objected to the substitution of the phrase “gender differences” for “sex differences” in biological writing. When asked, my colleagues in the Department of Gender Studies agreed that the term *gender* could be properly applied only to humans, because it involves one’s self-concept as man or woman. Sex is a biological concept; gender is a human social and cultural concept. But Roughgarden defines it this way: “Gender is the appearance, behavior, and life history of a sexed body” (p. 27).

In reading this book, I realized that the distinction between sex and gender (i.e., between gonadal sex and external phenotype) might be useful and informative when applied to animals. Typically, I determine the sex of the animals I study by examining their external morphological or behavioral phenotype. In the dark-eyed junco, a songbird, males are darker, bigger, and have whiter tails than females. They also sing, but they do not produce precopulatory displays, build nests, develop a brood patch, or incubate eggs. Females are their opposite in all these attributes. To be certain in my determination of a bird as a male or a female, I can inspect the gonads or use a molecular technique to verify the pres-

ence or absence of a marker on a heteromorphic sex chromosome. But a multivariate statistical technique can properly classify 95 percent of juncos as male or female simply on the basis of body size and plumage, and this method will typically suffice, because morphological and behavioral sex are so nearly identical to gonadal and chromosomal sex.

But what of that 5 percent that cannot be classified by size and color: Does their "intermediate status" not demand an explanation? And how reliable were the additional external criteria I relied on? Having observed many thousands of juncos by now, I have seen most of these criteria break down. I have encountered many dark females and small males, as well as a few males that helped to build a nest or incubated eggs. On the other side, I have heard females sing, and seen them court other females when treated with testosterone. This leaves brood patches and egg laying as the only strictly

female characteristics in juncos. These may connote sex, but all the rest could fairly be called indicators of gender, suggesting that ambiguous individuals deserve more focused study.

Can there be more genders than sexes? Roughgarden posits that while animals come in only two sexes, many species have more than two genders. How can this be? Sex refers to the size of the gametes, and, quibbling exceptions aside, sexually reproducing species have only two types of gamete, big and small (eggs and sperm). Salmon, sparrows, and damselflies, however, are examples of species with multiple, recognizable external phenotypes that cluster by body size or color, which Roughgarden calls "genders." Again, I asked my colleagues who study gender in humans about this idea, and one reaction was, "Why do we need more categories? I thought we were trying to get away from categories." While I agree with that, I also agree that multiple genders are a logical extension of Roughgarden's de-

finition. Recognizable by their definable phenotypes, they are the raw material of further evolution and demonstrate that there is indeed more than one way to be a male or a female. I'm not sure what will follow from this novel form of description, but think it bears watching.

To conclude, this is a provocative book that prompted serious introspection and a renewed desire to sift the good from the bad in my discipline. The author has synthesized huge, interdisciplinary literatures, and interpreted them in relation to her theme that diversity in sexual presentation is everywhere and is incompletely appreciated and understood. For this she is to be admired. Any book that promotes tolerance through knowledge is welcome; unfortunately, one that does it by stereotyping the opposition loses some of its force.

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THE LIFE AND TIMES OF A LIVING FOSSIL

The American Horseshoe Crab. Carl N. Shuster Jr., Robert B. Barlow, and H. Jane Brockmann, eds. Harvard University Press, Cambridge, MA, 2004. 427 pp., illus. \$95.00 (ISBN 0674011597 cloth).

Each spring, unnumbered thousands of American horseshoe crabs (*Limulus polyphemus*) approach the edge of