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The easy difference: Sex in behavioural ecology

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Abstract

Sex is pervasive in behavioural ecology. In this short paper I investigate one way sex features in behavioural ecological research: its use as a standard explanatory variable. Researchers often use sex to explain variation in a trait or phenomenon that they are studying. This practice is very widespread, partly because sex is often easy to identify and often explains some variation, thus making it easier to discover and test other causal patterns of interest. Yet sex also frequently fails to explain variation. Using a couple of recent examples, I show how the pervasiveness of sex as an explanatory variable is partly due to the structure of scientific research, including the use of data from large longitudinal studies and generalisation from previous studies. On this basis, I argue that researchers should more carefully assess and justify the relevance of sex to each new study, to avoid overgeneralisation and the perpetuation of assumptions about sexual difference and its importance in biology.

Behavioural ecologists have something going on with sex. Anyone having anything to do with this field, concerned with the study of animal behaviour in its ecological and evolutionary context, will have noticed it. Sex is everywhere. Some of behavioural ecologists' major questions are about sexual signalling, mating systems, parental investment, sperm competition, sex ratios, sex changes, and, yes, genitals. Many of the central theories in behavioural ecology are also about sex: sexual selection theory, the equal parental investment hypothesis, and the handicap principle of sexual signalling, to name a few. Sex makes up at least a third of one common introductory textbook to behavioural ecology (Davies, Krebs, and West 2012). And, as I discuss in this paper, sex is frequently called upon to explain variation in anything from metabolic rates to exploratory behaviour.

What is going on here? Why is sex so prominent in behavioural ecology? I ask this question as a feminist philosopher and a philosopher of science interested in scientific practice. There is a long tradition of feminist critiques of behavioural ecology and related disciplines, such as sociobiology, primatology, comparative psychology, and evolutionary psychology. Feminist philosophers and scientists have highlighted a number of problematic features of behavioural ecology: sexist and heterosexist assumptions about male and female roles, preferences and behaviour; overgeneralisations across species, time, and social systems; biased collection, interpretation and evaluation of evidence; and a general lack of diversity amongst researchers and the topics they choose to explore (e.g., Haraway 1990; Hrdy 1999; Roughgarden 2004; Lloyd 2005). Things are changing for the better, partly as a result of the cultivation of new, feminist approaches in behavioural ecology (Gowaty 2003; Roughgarden 2009). Yet sex is sticking around in behavioural ecology. I think it's important to investigate why sex is proving so persistent, in order to envisage how behavioural ecology could be different. Rather than asking what sex is in this context, I therefore focus on the use of sex as a biological category or variable in behavioural ecological research.

Feminist critics such as those cited above have largely focused on theories about sex as well as research on sex-related topics. Less attention has been granted to another way sex features in behavioural ecology: its role as an explanatory variable. In behavioural ecology, sex often treated as a categorical variable, for which individuals can be assigned values such as female or male (though sex may be better understood as gradual and multidimensional; see Griffiths 2021; Roughgarden 2004). This variable is often called on to explain variation in traits or features that aren't directly related to sexual development, mating, or parenting, such as metabolism, cognition, movement, or resource use. In these contexts, sex is not the primary topic of research, nor are researchers testing a particular sex-related theory. Still, sex is brought up and made potentially relevant to the phenomenon under study.

The practice of using sex as an explanatory variable is pervasive in behavioural ecology and related fields. This makes it interesting for feminist philosophers—perhaps here, in a relatively mundane research practice, is one reason for the persistence of sex. It also makes it interesting for philosophers of science. Questions about how scientific concepts are used in research accord with a shift in philosophy of science to pay more attention to scientific practice. Practice-based philosophy of science, or philosophy of science in practice, involves looking at the process of scientific research as it is carried out, rather than only at scientific products like theories and facts (Ankeny et al. 2011; Soler et al. 2014). In doing so, it draws on feminist insights about science as a material, embodied and social activity. A practice-based approach is thus well-suited to expand the feminist analysis of behavioural ecology.

Why is sex used so frequently to account for variation in behavioural ecology? One simple explanation is that sex is often relatively easy to identify and often does account for some variation. Biologists have standard practices for determining sex in many animal species. This can include visual identification of external genitalia or sexually dimorphic traits, that is, traits that differ consistently between the sexes, such as the comparatively large size of females to males in many species of spiders and fish. It can also take the form of identifying reproductive outputs like lactation or egg production, or more complex procedures such as genetic testing.

There are species and conditions where sex identification is truly problematic. For instance, researchers may have no reliable sex identification procedures for little known species, and restrictions on handling and intervening on animals in the field can also limit access to information about sex. In addition, some species such as earthworms are so-called simultaneous hermaphrodites, which means a single individual can produce both eggs and sperm at the same time and therefore cannot be categorised according to sex (Roughgarden 2004; Griffiths 2021). But for the most part, sex is an easy difference for behavioural ecologists to identify.

As well as being typically easy to identify, sex often does explain some variation in the data collected by researchers. Sex can sometimes account for differences in morphology, like body size, limb proportions, or colouration, especially in sexually dimorphic species. Often it can also explain some variation in physiology, such as hormone levels or metabolism, and behaviour, such as how animals interact with other members of their species or where and when they forage. This doesn't mean sex can explain all variation in these features. But, by splitting up data by sex or including sex as a factor in a statistical model, researchers often find that they can reduce variation enough to get a slightly clearer picture from their messy data. This reduction in variation is important for identifying other causal patterns that researchers are interested in. For instance, using sex to account for some variation can help to reveal the effect of an experimental intervention, physiological difference, or environmental change on animal behaviour or resource use.

So, one reason sex is prevalent as an explanatory variable is that it's easy and often works. Yet the story is not so simple. It is actually surprisingly common for sex to fail to explain any significant amount of variation in a trait or phenomenon of interest. Examining these cases of when sex doesn't explain reveals further reasons why researchers continuously bring sex into their research. These reasons go beyond the simple story of an easy difference to highlight instead the structure of science in shaping scientific practices.

Let's look at a couple of examples. This will get a little technical, but it is important for the goal of understanding why sex is called upon so often in practice. To find examples, I consulted the most recent issue of the journal *Behavioral Ecology* (Volume 33, Issue 4). Many papers in the issue were about clearly sex-related topics like mating or sexual signalling. In addition, various papers were only about one sex, which is a common strategy to reduce variation or to focus on particular behavioural phenomena such as male parental care or aggression between females. Finally, I identified two papers that were about topics not obviously related to sex, that reported the sexes of their animals, and that did not find sex to be explanatory. These two papers demonstrate different reasons why researchers bring sex into their research.

The first is a study of how Californian ground squirrels react to disturbances by coyotes, dogs and humans (Gall et al. 2022). This study focused in particular on the effect of disturbances on the squirrel's social interactions, such as play behaviour and greetings. The researchers report the procedure for sex identification (inspecting external genitalia) and the number of males and females studied each year studied and overall. Yet they don't present any analysis using sex. Instead, the squirrel's age (juvenile or adult) as well as the type of disturbance are used to explain variation in the response to disturbance. So, why mention squirrels' sex if it's not relevant to the study?

One possibility is that the researchers had tried sex as an explanatory variable but found that it didn't work, that is, that no significant proportion of the variation in the response to disturbance was accounted for by sex. If this analysis was conducted it should have been reported in the publication; not reporting negative results is considered a questionable research practice and thus heavily discouraged, especially recently in ecology and evolution (O'Dea et al. 2021). It could even be considered an interesting finding that sex doesn't explain differences in how a small mammal responds to a threatening disturbance in its environment. Hence, the fact that the sex-based analysis and result weren't reported suggests that the researchers did not conduct the analysis.

There is an alternative explanation of why sex was reported but not used for analysis. The data used in this study on disturbance response come from a larger longitudinal study of Californian ground squirrel behaviour at multiple locations in a large protected area (Smith et al. 2018). In large longitudinal projects like this, researchers collect many different sorts of data for different possible research questions. As a result, papers coming from a large study typically do not make use of all the available data. In the case of the Californian ground squirrels, an earlier publication from the project did in fact directly study the effect of sex on social interactions (Smith et al. 2018). The later study of responses to disturbances may thus have simply carried over the reports of sex identification and sex ratios from the larger project, without intending to use that sex data in the particular study at hand. Such transfer of data is understandable. Nevertheless, reporting sex when it hasn't been shown to be relevant is not necessarily benign. In particular, it risks implicitly perpetuating the idea that sex is in fact relevant to phenomena such as responses to disturbance.

The second paper is about the learning abilities of chestnut thrushes, a wild bird that breeds in the western Himalayas and south-west China (Lou et al. 2022). The researchers subjected birds to a novel skill test and a spatial memory test. They found that individuals with larger heads were more likely to learn a novel skill and learn a skill faster, but that head size had no effect on spatial cognition. As with the previous paper on squirrels, this paper reports how sex was identified (genetic testing) as well as the number of males and females used. Unlike in the squirrel paper, however, these researchers do report the statistical tests of sex and a number of other variables, including age and exploratory tendency, none of which were found to explain variation in learning or spatial performance.

The paper is framed as a test of the effect of head size (and thus brain size) on cognition in birds. So why did these researchers bother to test sex in the first place? Identifying the birds' sex required putting in some extra effort to draw blood and do a genetic test; this additional intervention would usually require some justification. One option may be that the researchers expected head size to vary with sex, such that distinguishing males and females could give a clearer picture of how head size affects cognition. However, the chestnut thrush is not sexually dimorphic, and the researchers found no difference in head size between the sexes.

Another explanation is provided in the paper. In the introduction the researchers cite a number of previous studies demonstrating differences in learning and spatial cognition between juveniles and adults in various bird species. These citations form the background to testing whether age affects learning and spatial cognition in chestnut thrushes. The researchers also cite one previous study on birds in which sex differences in spatial cognition were found. This one citation, it seems, is a justification for including sex as a potential explanatory variable in the study.

The cited paper found that female cowbirds perform better in a spatial memory task than males (Guigueno et al. 2014). Yet this study doesn't really support any hypotheses about sex differences in chestnut thrushes. Cowbirds are obligate brood parasites; like cuckoos, the females locate nests from other species and lay their own eggs in those nests. Guigueno et al. wanted to test for sex differences in spatial cognition because only female cowbirds must search for nests and, by hypothesis, should have good spatial cognition. The same sort of hypothesis is unjustified for the chestnut thrush, which is not a brood parasite.

The existence of empirical findings of sex differences in the same or a similar phenomenon, in the same or a similar species or study system, is in fact a very common reason to include sex as a potential explanatory variable. However, the study on chestnut thrushes reveals a danger in this practice of building on previous research. Sex can readily be mistaken for an easily transferrable explanatory variable, overlooking important differences between the study systems or phenomena under study that make sex more or less relevant.

These two papers on Californian ground squirrels and chestnut thrushes reveal two reasons why researchers bring up sex even when it doesn't explain variation in the phenomenon they are interested in: using data from larger, longitudinal projects, as well as building on previous findings of sex differences. Both of these practices are widespread in behavioural ecology; building on past findings is of course best practice in any science, and ecologists have generated many longitudinal, individual-level datasets that are used and reused for many different research purposes (Clutton-Brock and Sheldon 2010; Culina et al. 2021). These widespread practices perpetuate the attention to sex as a potential explanatory variable. In doing so, they generate a number of risks. By making sex seem relevant when it may not be, these practices exacerbate the risk of overlooking important differences in study systems and overgeneralising findings. They also risk perpetuating assumptions about sexual difference and its importance for biological phenomena. Such risks are especially significant given that much behavioural ecology research on non-human animals is also used to make inferences about human behaviour and social systems, and thus can carry serious implications for how we understand and treat sexual difference in society.

Avoiding these risks requires vigilance. Here I draw on Sarah Richardson's investigation of sex difference research in medicine, where she argues that "while sex may be a relevant variable in some cases, finding differences between the sexes should not be an end in and of itself. Sex difference research should be grounded in valid medical research questions, motivated by sound biology, and rigorously designed." (Richardson 2013, 223) The same goes for behavioural ecology: sex should be introduced into studies only when it is well-justified by biological relevance or past evidence from systems that are demonstrably similar in the relevant respects. This means resisting the inertia of the structure of scientific research and its standard practices and adopting a more responsible attitude towards sex.

Of course, many other factors contribute to sex's high-profile status in behavioural ecology. Reproduction, mating and parenting are important for evolutionary processes, and sex is involved in many prominent theories about the evolution and ecology of behaviour. Nevertheless, attending to the standard practices of identifying and reporting sex differences and using sex as an explanatory variable reveals additional elements behind the pervasiveness of sex in behavioural ecology. As well as raising important questions about how sex is understood and how it explains variation, this indicates work to be done on the part of behavioural ecologists to pay greater attention to when and how they bring sex into their research.

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