Sexing the Rotifer: Reading Nonhuman Animals’ Sex and Reproduction in 19th-Century Biology

K. Smilla Ebeling
University of Salzburg
kirstensmilla.ebeling@sbg.ac.at

Abstract
This paper looks at the role nonhuman animals play in how we think about sex, gender, and sexuality in zoology and in society. In examining the history of ideas regarding a microscopic invertebrate species—rotifers—the paper explores how humans have projected aspects of their lives onto nonhuman animals and how they have extrapolated from nonhuman animals to human society. The paper emphasizes the intersections between knowledge about nonhuman animals and gender and sexuality politics.

Keywords
all-female species, dioecism, gender and sexuality politics, knowledge production in biology, parthenogenesis, rotifers, thinking with nonhuman animals

Introduction
Many hold the idea that animal kingdom is structured by sexual dimorphism and heterosexual reproduction. Yet a closer look into the animal kingdom shows that zoology records numerous nonhuman animals whose sexes, sexual behavior, and forms of reproduction do not fit such a bipolar sex order centered on heterosexuality. As a scholar of biology and gender and science studies, I am interested in how knowledge of animal sex and reproduction is produced. Feminist scholars have often questioned the epistemological perspective of objectively produced knowledge in the natural sciences, emphasizing instead an understanding of scientific knowledge as part of societal orders and power relations (e.g., Fausto-Sterling, 2000; Spanier, 1995; Schiebinger, 1993; Haraway, 1989).

Here, I focus on historically and culturally contingent concepts of sex, gender, and sexuality and the role they might play in knowledge production about nonhuman invertebrate animals. Are there connections between concepts of human sexes and sexualities and biological findings about diminutive
nonhuman animals far removed from ourselves? Are biologists influenced by the gender relations and legitimate sexualities of their time when they look at invertebrate nonhuman animals?

Biological knowledge about nonhuman animals’ sex and reproduction matters to sociology and gender studies because it impacts on understanding of sex, gender, and sexuality in society; it also matters to human-animal studies because it impacts on how we understand other species. In this paper, however, I focus on biological research on species very different from us—particularly those species of invertebrates in which males have never been found. Biologists believe that males do not exist in these species and so refer to them as all-female species. All-female species reproduce exclusively by parthenogenesis, which is Greek for “virgin birth.” It encompasses forms of reproduction involving egg development without fertilization by sperm. These all-female species provide a wonderful opportunity for exploring biological ideas about sex and reproduction since, although they reproduce sexually, they neither have two sexes nor do they engage in sexual reproduction relying on two sexes. How do biologists perceive the sexes and forms of reproduction among such strikingly nonheteronormative animals? And what impact does this have on how we understand other animals and our relationship to them?

Constructing Sex in Nonhuman Animals

Rotifers are a large group of microscopic animals that live in oceans, fresh water, and other bodies of water all around the world. Some species are all-female and reproduce parthenogenetically; some do so intermittently, switching from sexual reproduction to parthenogenesis if adverse environmental conditions arise.

In this paper my concern is to examine rotifer research in the 19th and 20th centuries in order to explore how rotifers’ patterns of reproduction challenged biologists’ ideas about sex, gender, and sexuality. I focus particularly on biologists’ findings of exclusively female rotifers and of exclusively female sexual organs, and the assumptions they brought to these discoveries. Today, biologists classify the all-female rotifer species that they believe reproduce exclusively by parthenogenesis into one big group called Bdelloidea. The Bdelloidea are not only far removed from humans but also deviate strikingly from human concepts of bipolar sex and reproduction. So how did observers make sense of such radically different organisms? To answer that, first, I will analyze how biologists dealt with them at a time when the concept of all-female species did not exist. I will then focus on how zoological narratives about Bdelloidea changed once the classification of these species had been established and the idea of all-female species had been accepted.
How to deal with exclusively female sexual organs

At the beginning of the 19th century, biology began to establish itself as a discipline for the study of all living organisms, and it was influenced by a positivist natural philosophy. Biology was, in the first half of the 19th century, mainly concerned with classification, concepts of life and organism, organismic development, comparative anatomy, and the development of (egg) cells. The concept of all-female species did not exist. So biologists found it odd when they observed only female sexual organs in many rotifers and had to seek explanations for the anomaly. They did this by looking for male organs within apparently female animals, or they looked for sexual dimorphism (two body forms), but all approaches entailed prioritizing maleness and assuming universal sexual dimorphism and heterosexual reproduction.

The first of these approaches put forth the explanation that rotifers were hermaphrodites and that hermaphrodites prove the dualism of sex, within a single organism. Christian Gottfried Ehrenberg, the rotifer expert of his time, was the first author who came up with a taxonomy for rotifers in 1838. He believed that rotifers were hermaphrodites and wanted to prove a “clear dualism of the sex order” (Ehrenberg, 1838, p. 385; translation S. Ebeling). He spent much time searching for, describing, and drawing what he thought were male sexual organs, though none were ever proven to be such. In fact, the “male sexual organs” that Ehrenberg painted later turned out to be different organs, like eyes, intestines, the circulation system, muscles, and ovaries.

When Ehrenberg could not find any organs that could have been male sexual organs, he simply presumed that they exist, stating, for example, that they had simply not been found yet, had been overlooked, or were covered by other organs. He believed that future research would discover them and would prove their existence for all rotifer species, “where research was behind” (Ehrenberg, 1838, p. 456; translation S. Ebeling). His thesis of hermaphroditic rotifers and his positive presumption that male sexual organs exist demonstrate the strength of the idea of a universal binary sex order. Sexual reproduction—meaning that a male germ cell had to fertilize a female egg cell—was assumed to be a law of nature.

Ehrenberg’s thesis also reflected a gender ideal, developed in the 18th century, which presumed exactly two sexes with opposite and complementary characteristics (Honegger, 1991). Confronted with exclusively female sexual organs, Ehrenberg and his contemporaries did not wonder whether these non-human animals might be females sexually reproducing without any males. Rather, they eagerly sought a male part and assumed the existence of a binary sex order within one organism. Ehrenberg (1838) was so convinced of his theory that he claimed all rotifers were hermaphrodites.
Yet, once Thomas Brightwell discovered dioecious rotifers—that is, species that have male reproductive organs in one individual and female reproductive organs in another (Brightwell, 1848)—dioecy was immediately considered the “true sex order” for all rotifers. The research focus then shifted from seeking male organs in hermaphrodites to finding male organisms. Brightwell (1848) described how, in some species, male bodies were much smaller (about three fifths the size of a female body) and did not have intestines or teeth, for instance. Not surprisingly, this upset previous classifications, as the newfound males had to be assigned to known species in which only females had previously been observed. Because of this sexual dimorphism—the systematic difference in form between individuals of different sex in the same species—biologists had to prove that the females and males belonged to the same species, and they paid great attention to every single anatomical detail of the males. Here again, sex lies in the eye of the beholder. Once rotifers without teeth and intestines were classed as males, researchers were able to recognize testicles among these rotifers.

Yet, even though males had, by the mid-1850s, been found only for some rotifer species, some authors insisted that dioecy and sexual dimorphism must be normal for all rotifers (see, for example, Cohn, 1856, and Leydig, 1855). Only one author considered that the males in some species could be exceptions to the norm (Gosse, 1856). To declare sexual dimorphism as a general feature for all rotifers was, then, another kind of response to the observation of exclusively female sexual organs in many rotifer species.

The language used by 19th-century biologists reflected and reinforced their binary assumptions about gender. They typically used the term it to refer to nonhuman animals, but there are some striking cases in which they used gendered language. Ehrenberg and his contemporaries described many rotifers in terms of human notions of reproduction, applying concepts of mother and daughter and referring to wombs and maternal bodies (see, for example, Schmarda, 1845, and Ehrenberg, 1838). By calling them “mother” and “daughter,” these biologists discursively turned hermaphrodites into females, thus mirroring the idea that reproduction is a female matter. In a different context, Gosse (1850) wrote about a rotifer: “It is a mason, who not only builds up his mansion, brick by brick, but makes his bricks as he goes on, from substances, which he collects around him, shaping them in a mould which he carries upon his body” (p. 59). By describing a rotifer as a mason, Gosse turned it into a male and discursively produced two sexes as well as stereotyped gender characters. Thus the diversity of the rotifera had to be made to fit 19th-century social beliefs.

Despite such widespread use of gendered language, most authors described the general features of rotifers without mentioning that, for many species, they
wrote about exclusively female anatomy. Only after the reader had learned a great deal about the rotifer’s biology did some scholars give the information that “the general description has hitherto been taken from the female” (Dalrymple, 1849, p. 338). Or readers had to conclude for themselves that they read about females by recognizing that the author exclusively described female sexual organs or stated that he had never found a single male.

So, why did the biologists mention very late or not at all in their papers that they only described females? There are at least two possible explanations for this. It might have been so self-evident to them that they did not feel they needed to mention it; since the females did not lack intestines, the biologists might have regarded them as the standard organism among rotifers and males as deviation. Or, starting from an androcentric perspective, they might have found it difficult or even impossible to utter that they described only females.

In all these approaches, biologists dealt with the “odd” finding of exclusively female organisms or female sexual organs by telling narratives that implied a binary sex order—i.e., the existence of females and males. The narratives also focused on a search for males and relied on stereotyped gender roles—even for rotifers. From this heteronormative perspective, Ehrenberg (1838) dealt with the “problem” of finding only female sexual organs by assuming the existence of male sexual organs in the same organisms, thereby (re)constructing a binary sex order within individuals. After the first descriptions of male rotifers by the end of the 1840, however, biologists quickly denied hermaphroditism and generalized dioecy across all rotifers. Male and female rotifers perfectly fitted the binary sex order and prevailing ideas of heterosexual reproduction.

Dioecious rotifers were easily accepted, and researchers readily focused on their search for males. What these narratives indicate is an underlying belief in the existence of two sexes as a general structure for all species. Together, they show how human gender roles and cultural ideas of a binary sex order, as well as of female-coded sexual reproduction, are imposed on nonhuman animals—even on species very dissimilar to ourselves. These cultural ideas about gender are inscribed in zoological “facts” about rotifers and are represented as “natural” features. In other words, the narratives naturalize the concepts of a binary sex order and sexual reproduction and discourage the ideas of all-female species and unisexual reproduction.

How to deal with all-female species

The concept of all-female species was established in the 20th century as a technical term in biology. The cellular processes of parthenogenesis were clarified, for the most part, by the middle of the century, and biologists agreed that
all species of Bdelloidea reproduce exclusively by parthenogenesis (Voigt, 1957). Nevertheless, there are still unresolved questions about the Bdelloidea, and biologists still struggle with the concept of nonbinary sex.

One problem concerns the sheer existence of Bdelloidea species. Biologists assume, from an evolutionary perspective, that it is impossible for parthenogens to exist for a long time period. (Parthenogens are clones and would be highly susceptible to environmental change; their genetic homogeneity would mean they would be much less likely to survive adverse conditions. Parthenogenesis is therefore generally declared an “evolutionary blind alley” in evolutionary theory.) Nevertheless, the Bdelloidea are said to have existed for about 30,000 million years; biologists refer to them as an “evolutionary scandal” (Smith, 1992, p. 145). They contradict the evolutionary assumption that parthenogenesis provides only short-term benefits and disadvantages in the long run. Indeed, there should not be any Bdelloidea at all by now; they are a sensational, yet exciting, annoyance. The phrase “evolutionary scandal” implies that the problem is the Bdelloidea, rather than the theory. Hence, the Bdelloidea are again discursively negated in biology, even though by now the concept of an all-female species is accepted as a technical term. Throughout evolutionary theory, the assumption is that sexual reproduction is centrally important, with implications of sexual binaries. Within that framework, it becomes difficult to see the Bdelloidea as anything but anomalous.

In more recent popular science, biologists have also told interesting stories about Bdelloidea. Margulis and Sagan, for example, state that, due to its maleless life, the Bdelloidea “represent an answer to the women’s liberation movement” (Margulis & Sagan, 1997, p. 142). This metaphorical statement about female parthenogenetic invertebrates produces meanings about nonhuman and human animals: the parthenogens are contextualized within feminism, which, depending on the reader’s opinion, suggests a negative or a positive meaning. Furthermore, since feminists are sometimes said by critics to aim at abolishing men, this statement transfers the antagonistic relation of women and men in Western societies onto nonhuman animals, thereby naturalizing and strengthening it. Especially striking are these authors’ descriptions of the Bdelloidea, which serve as a resource for ideas of wanted or feared human animal features:

Might human males, like rotifer males, become evolutionarily redundant? Certainly, the cloning of women’s eggs could, in principle, circumvent our two-parent sexual cycle. But it is doubtful that meiosis and fertilisation in such women can be entirely abandoned. Rather these hardy mothers will be self-fertilising. Their haploid eggs will probably require a fertile boost of self-fusion—the egg nuclei fertilised by an egg equivalent such as another haploid nucleus from the female’s own body. Indeed, this is what occurs today in all-female rotifers.” (Margulis et al., 1997, p. 118)
The authors thus transfer the (feared or welcomed) utopia of superfluous men and an all-women society onto nonhuman animals. Simultaneously, they picture it as something that already exists in nonhuman animals and that is likely to become reality in human society. We therefore find transfers in both directions—from human animals onto nonhuman animals and vice versa. Both statements produce knowledge about sex and about gender relations in nonhuman and human animals.

The narratives of the *Bdelloidea* from the second half of the 20th century illustrate that, although the concepts of parthenogenesis and all-female species are established in biology, the norm of bipolar sex is not dismissed but rather assumed, even in species that do not fit the model. The narratives told by biologists convey the message that there is something wrong with all-female species, and they negate them discursively. Examples from popular science also show that biologists extrapolate from nonhuman animals to human animals. Parthenogenesis seems to provoke different associations, like a threatening or idealized all-female world that, according to evolutionary theory, has to die out eventually; only sexual reproduction that involves two sexes will survive.

**Conclusion**

In this paper, I have tried to show that there is reciprocal interaction between the production of knowledge about nonhuman—and human—animals. Even research on animals as markedly different from us as rotifers appears to be structured by the cultural interpretive patterns of gender dimorphism and heterosexual reproduction. The heteronormative reading of sex and reproduction among rotifers by biologists in the 19th and 20th centuries conflicted with the observation of exclusively female organs and organisms, like all-female rotifer species, which do not fit into biologists’ assumptions about gender order in the natural world.

These biologists constructed dioecy within organisms and species, while also discursively negating all-female species. The concept of dioecy builds on two relational sexes; since in all-female species, by definition, only one sex exists, all-female species challenge the centrality of the idea of dioecy. Yet this does not take place in the field of zoology. Rather, the rotifer narratives support and legitimate ideas about the naturalness of sexual binaries.

Similarly, descriptions of parthenogenesis in other organisms (lizards, fish, rotifers, and aphids) discursively construct them as forms of reproduction that should not exist or that will eventually die out (Ebeling, 2006). These biological narratives about parthenogenesis or all-female species thus strengthen
ideas of heteronormativity. Yet biologists have also observed queer nonhuman animals, like hermaphroditic, homo-, trans-, and intersexual nonhuman animals. Here again, in most cases zoologists did not name them as such but glossed over their existence (see Ebeling, 2006; Hird, 2004; Roughgarden, 2004; Bagemihl, 1999). Since scholars project knowledge about sex and reproduction from a variety of nonhuman animals onto humans, particularly in popular science, zoological narratives about rotifers can be said to be part of a wider discourse on sex and sexuality in society. They take part in the production of meaning about sex and sexuality and have an impact on cultural norms. In turn, these interactions between knowledge about rotifers and about human animals function as negotiations of sex, reproduction, and sexuality, and the rotifers serve as a resource for those negotiations.

These examples of research on rotifers in the 19th and 20th century illustrate the concept of “thinking with animals” introduced by Daston and Mitman (2005). It encompasses the idea that it is a very common and widespread practice for humans to use nonhuman animals in order to think about themselves, society, politics, and their being. Moreover, humans express themselves through nonhuman animals, and they “recruit animals to symbolise, dramatise, and illuminate aspects of their own experience and fantasies” (Daston & Mitman, 2005, p. 2), which may or may not be done intentionally. The example of rotifers illustrates that “thinking with nonhuman animals” applies to all kinds of animals, in popular science and research narratives. Biologists of the 19th century read their own societal norms regarding sex and sexuality into the lives of rotifers. They imagined a heteronormative nonhuman animal world and in doing so projected their cultural patterns onto nature as the only thinkable and legitimate sexes and sexualities. By the late 20th century, biologists were explicitly using the Bdelloidea to think about an all-women society—yet still within a framework of binary assumptions.

My work connects to various studies that highlight the interplay between the natural sciences and social relations and cultural values. The historian Londa Schiebinger (1993), for instance, demonstrates the relationship between societal discourse about wet nursing and the naming of the mammals (literally “carrying breasts”) by Carl von Linné in the 18th century. Similarly, Haraway (1989) explores ideas in the history of primatology in the 20th century; discourses of primatology, she argues, are social processes and meaning productions, which comprise complex narratives about family, language, technology, cooperation, dominance, wars, and technological innovations. Myra Hird (2004) points out that “nature” does not structure sex in a dichotomous way—either among human or among nonhuman animals—and that dioecy is not provided by something like the body. Rather, nature provides sex diversities.
These studies from gender perspectives indicate that biological knowledge emerges from societal orders and power relations. The example of the *Bdelloidea* shows that this not only works for nonhuman animals to whom human animals might feel “close,” like primates and other mammals, but also for microscopic, invertebrate rotifers. Biology thus appears to be a part of the societal heteronormative order, which in turn structures how we “think with nonhuman animals”—of whatever species. Since biological knowledge about sex and reproduction among nonhuman animals serves as a means for gender and sexuality politics, it seems to be a valuable venue to highlight the broad spectrum of sexes and sexualities described in zoology. Understanding how biological knowledge is produced through social processes enhances not only our understanding of sex but also of all kinds of other animals.

**Notes**


2. For an approach to human and nonhuman animals that regards nonhuman and human individuals not as separate entities but as interwoven agents within a performative relation see Birke, Bryld, and Lykke, 2004.

3. There are different opinions about whether parthenogenesis is sexual or asexual reproduction. Some regard it as sexual, since it involves gametes, while others regard as a sexual form of reproduction only those forms of parthenogenesis that involve meiosis during egg development (Ebeling, 2002).

4. At Oldenburg University (Germany), I found excellent conditions for this historical analysis on rotifers, since biologist Wilko Ahlrichs generously provided me with access to his extensive library of scientific material on rotifers. I analyzed about 70 scientific studies on rotifers (monographs and papers in scientific journals) published from 1800 to 1860. I collected all statements about concepts having to do with sex, gender, and sexuality—for instance, sex, female, male, sex organs, femininity, masculinity, sex roles, reproduction, copulation, fertilization, birth, eggs, child, family, marriage.

5. Biologists have been describing all-female species among rotifers since the 1880s. That eggs could develop without fertilization was proven by Charles Bonnet in 1744. The term *parthenogenesis* was coined about 100 years later, in 1848, by Richard Owen.

6. Sexual dimorphism and atrophy of the intestines among males were accepted for all rotifers (Gosse, 1856).

7. The major aim of Gosse’s (1856) paper was to falsify Ehrenberg’s (1838) thesis of hermaphroditism. He almost exclusively described males. He also argued that only “lower” rotifers could possibly be hermaphrodites, which mirrors the idea of a hierarchical development from hermaphroditism to dioecy. A biologist who specializes in rotifers told me that it is nevertheless the secret wish of biologists to find males—that is, they still search for males in these all-female species.

8. Brightwell (1848) was one of the very few authors who specified that he described females and males, stressing his discovery of dioecious rotifers.

9. The concept of heteronormativity questions the assumption of the exclusive existence of
two sexes that mutually desire each other as a human basis that excludes, degrades, ignores, or pathologizes everything that deviates from that norm (Warner, 1993).

10. The formerly derogatory term \textit{queer} has been adopted by gay rights movements, which revalued it with a proud and positive meaning. Queer theorists aim to analyze and destabilize societal norms of heterosexuality and sexual dimorphism in order to transcend the dualistic conceptions of hetero- and homosexuality as well as the homogeneity of homosexuals. Rather, they want to open up a diversity of sexualities. The general understanding is that sexuality is a historical and naturalized concept (Haller, 2001). Together with sexual dimorphism, sexuality forms structural elements of politics, economy, social relations, culture, and institutions (de Lauretis, 1991).

\textbf{References}


