

## REPORT

R. A. FISHER ON J. A. COBB'S *THE PROBLEM OF THE SEX-RATIO*

by

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The logic of the rarer-sex effect, concerning how natural selection acts to balance the sex ratio among newborns, was long supposed to have originated with Ronald Aylmer Fisher in his 1930 book *The genetical theory of natural selection*. However, the principle is now understood to have originated with John Austin Cobb in his 1914 paper 'The problem of the sex-ratio'. Fisher did not provide a citation of Cobb's sex-ratio paper, and it has been unclear whether he was aware of its existence. Here, I show that Fisher was indeed aware of Cobb's paper in 1930, as revealed by him citing it elsewhere that same year. Fisher's willingness to highlight Cobb's sex-ratio work lends support to the view that his failure to mention it in his book reflects the less stringent citation standards of the time rather than an attempt to deceive readers as to the provenance of the rarer-sex effect.

**Keywords: Fisher's principle; John Austin Cobb; rarer-sex effect; Ronald Aylmer Fisher; sex allocation; sex ratio**

The 'rarer-sex effect'—concerning how natural selection acts to balance the sex ratio among newborns—is one of the most celebrated principles of evolutionary biology.<sup>1</sup> The total reproductive value (i.e. contribution of genetic ancestry to future generations) of all newborn females is equal to that of all newborn males, assuming a sexually symmetrical mode of genetic inheritance and a stable age distribution. Accordingly, if there is any imbalance in the sex ratio of newborns, individuals of the minority sex are of greater reproductive value, on average, than are individuals of the more common sex. Hence, all else being equal, parents making a greater investment of reproductive resources into the minority sex enjoy greater reproductive value. In this way, natural selection acts to restore balance to the sex ratio.

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<sup>1</sup> Andy Gardner, 'The rarer-sex effect', *Phil. Trans. R. Soc. B* **378**, 20210500 (2023).

The logic of the rarer-sex effect was long attributed to Ronald Aylmer Fisher, who gave the argument in his 1930 book *The genetical theory of natural selection*.<sup>2</sup> But Fisher was not the first to have considered the action of natural selection in relation to the sex ratio, with attention already having been given to this topic by Charles Darwin in 1871, Karl Gerhard Düsing in 1883, Corrado Gini in 1908 and John Austin Cobb in 1914.<sup>3</sup> Darwin's and Düsing's accounts are erroneously framed in terms of natural selection acting to balance the adult—rather than the newborn—sex ratio; Gini's account corrects their error, but incorrectly concludes that natural selection has no influence on the sex ratio at birth; and Cobb's account, given in his 1914 paper 'The problem of the sex-ratio', sets out the logic of the rarer-sex effect correctly for the first time.<sup>4</sup>

Fisher did not cite Cobb's sex ratio paper in *The genetical theory of natural selection*, but there are several grounds for supposing that he was aware of it,<sup>5</sup> including him contributing book reviews to the journal issue that carried Cobb's paper, using the same subset of Arthur Geissler's human sex-ratio data in his 1925 book *Statistical methods for research workers*<sup>6</sup> that Cobb had himself analysed, and having incongruously omitted Geissler's initial—A—in line with the citation style of Cobb's paper.<sup>7</sup> However, the evidence that Fisher was aware of Cobb's 'The problem of the sex-ratio' has remained circumstantial.

Here, I provide confirmation that Fisher was indeed aware of Cobb's paper in 1930, as revealed by his citation of it elsewhere that year. The citation appears in material that is somewhat off the beaten track of the evolutionary biology literature; in particular, it is to be found within administrative content appearing at the end of the October 1930 issue of *The Eugenics Review*, which does not appear among Fisher's collected papers<sup>8</sup> and is not covered by standard citation databases—which explains how it has come to be overlooked for so long. Among this end matter, under the heading 'Periodicals', appear short notes by a number of contributors highlighting papers that had recently appeared in other journals. In one such note,<sup>9</sup> concerning the journal *Genetics*, Fisher writes:

*The Correlation Between the Sex of Human Siblings*, by J. Arthur Harris and Borghild Gunstad, discusses the distribution of boys and girls in human fraternities recorded by Geissler. It is perhaps unfortunate that the authors should have chosen to resuscitate the use of Pearson's "equiprobable correlation"  $r_p$ , for in spite of a great expenditure of labour the analysis of these data is in no respect more thorough than that given by J. A. Cobb in the *Eugenics Review* for July 1914 (Vol. VI, p. 157).

The context of Fisher's remark is that Cobb—in an effort to provide evidence in support of his view that human populations harbour heritable variation in the sex ratio—had contrasted the

2 R. A. Fisher, *The genetical theory of natural selection* (Clarendon Press, Oxford, 1930), pp. 141–143. Fisher's priority had been asserted by, for example: James F. Crow and Motoo Kimura, *An introduction to population genetics theory* (Harper & Row, Manhattan, NY, 1970), p. 289; Richard Dawkins, *The selfish gene* (Oxford University Press, 1976), p. 154.

3 Charles Darwin, *The descent of man, and selection in relation to sex* (John Murray, London, 1871); Karl Düsing, 'Die factoren, welche die Sexualität entscheiden', PhD dissertation (Gustav Fischer, University of Jena, 1883); Corrado Gini, *Il sesso dal punto di vista statistico* (R. Sandron, Milan, 1908); J. A. Cobb, 'The problem of the sex-ratio', *Eugen. Rev.* **6**, 157–163; A. W. F. Edwards 'Natural selection and the sex ratio: Fisher's sources', *Am. Nat.* **151**, 564–569 (1998); Gardner, *op. cit.* (note 1).

4 Gardner, *op. cit.* (note 1).

5 A. W. F. Edwards, 'The Galton lecture 1997: the Eugenics Society and the development of biometry', in *Essays in the history of eugenics* (ed. Robert A. Peel), pp. 156–172 (The Galton Institute, London, 1997); Edwards, *op. cit.* (note 3).

6 R. A. Fisher, *Statistical methods for research workers* (Oliver & Boyd, Edinburgh, 1925), pp. 69–71.

7 *Ibid.*, p. 234.

8 J. H. Bennett (ed.), *Collected papers of R. A. Fisher* (University of Adelaide, 1971–1974).

9 R. A. Fisher, 'Genetics', *Eugen. Rev.* **22**, 223–224 (1930).

distribution of boys and girls across families in Geissler's data with the distribution expected under the null hypothesis that the sex of siblings is statistically independent, so as to demonstrate that there is a statistically significant tendency for siblings to be of the same sex. Harris and Gunstad's analysis of Geissler's data had attempted to go further,<sup>10</sup> by explicitly computing a  $p$ -value (i.e. the probability of the discrepancy between observed data and theoretical expectation, or a greater discrepancy, arising purely by chance under the null hypothesis), and they had erred—in Fisher's eyes—by making use of a method that employs a  $\chi^2$  distribution that is strictly appropriate only for infinitely large samples. Fisher instead advocated the use of statistical methodology that enables exact tests of significance even for small sample sizes.

Crucially, Fisher's remark confirms that he was aware of Cobb's 'The problem of the sex-ratio'. Indeed, it shows that he was sufficiently familiar with the content of the paper to evaluate the comparative thoroughness of Cobb's analysis of Geissler's data. This also strengthens the suggestion that Fisher sourced Geissler's data from Cobb's paper—without providing the citation—in the writing of his 1925 book, in much the same way that he appears to have sourced the account of the rarer-sex effect from Cobb's paper—again, without providing the citation—in the writing of his 1930 book. His willingness to highlight Cobb's sex ratio work in the journal note—16 years after the publication of Cobb's paper and 10 years after Cobb's death—lends support to the view that his failure to mention it in his 1930 book simply reflects the less-stringent citation standards of the time rather than an attempt to deceive readers as to the provenance of the rarer-sex effect.<sup>11</sup>

#### DATA ACCESSIBILITY

There are no data associated with this article.

#### DECLARATION OF AI USE

I have not used AI-assisted technologies in creating this article.

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10 J. Arthur Harris and Borghild Gunstad, 'The correlation between the sex of human siblings. I: The correlation in the general population', *Genetics* 15, 445–461 (1930).

11 Edwards, *op. cit.* (note 5).