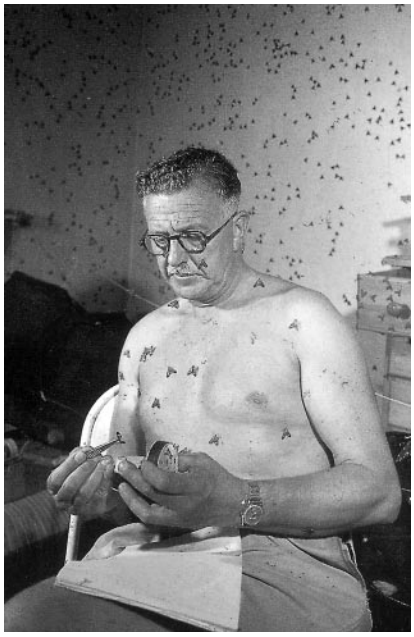
Evolution under pressure

A look at the controversy about industrial melanism in the peppered moth.

Of Moths and Men: Intrigue, Tragedy and the Peppered Moth
by Judith Hooper
Fourth Estate: 2002. 397 pp. £15.99

Jerry A. Coyne

A colleague described the physician and naturalist Bernard Kettlewell as "the best naturalist I have ever met, and almost the worst professional scientist I have ever known". And yet Kettlewell became one of the best-known evolutionary biologists, for his work produced the canonical example of evolution in action: industrial melanism in the peppered moth (*Biston betularia*). In *Of Moths and Men*, the science journalist Judith Hooper produces a lively history of this work, illustrated with fascinating but disturbing portraits of the principals. These include the ambitious but insecure Kettlewell, ill at ease in the rarefied atmosphere of Oxford University, and his mentor E. B. Ford, a foppish, manipulative man who used and misused Kettlewell in his own quest for fame. Hooper contends that the *Biston* story is not only wrong, but probably fraudulent.



Bernard Kettlewell was an enthusiastic naturalist who loved to surround himself with his work.

The scientific facts are familiar to biologists. The normal form of *B. betularia* (known as *typica*) is white, speckled with dark markings. In around 1850, a melanic, all-black form produced by a dominant mutation (*carbonaria*) became more numerous in England, at the same time as a rise in industrial pollution. By 1900, *carbonaria* reached a frequency of nearly 100% in manufacturing areas such as Birmingham. There was a parallel increase in industrial areas of the United States, although somewhat later. These evolutionary changes were reversed in the middle of the century when antipollution laws took effect, and *typica* once again became predominant both in Britain and in the United States.

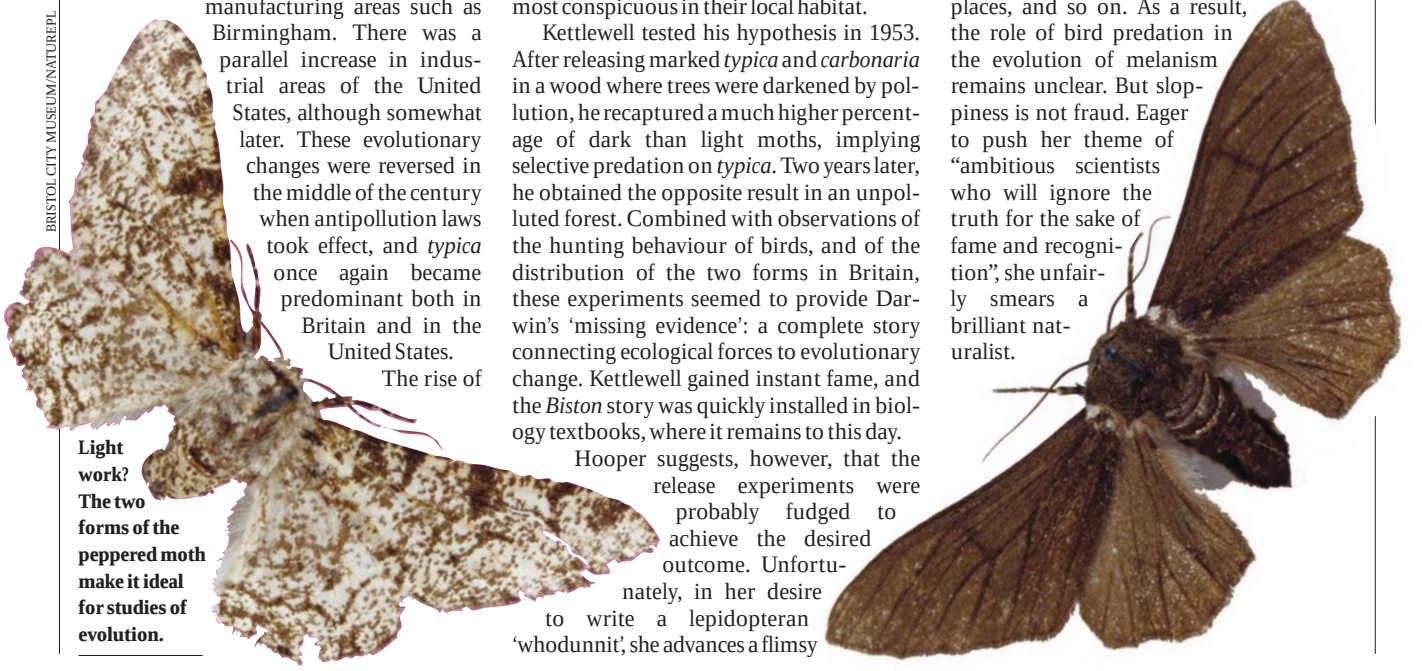
The rise of melanism offered Ford and Kettlewell an unparalleled chance to document and understand natural selection in the wild. Ford suggested, on the basis of breeding experiments, that *carbonaria* was more resistant than *typica* to pollution, and hence survived better. As a naturalist, Kettlewell believed that selection might be due to sharp-eyed birds that preyed on the moths that were most conspicuous in their local habitat.

Kettlewell tested his hypothesis in 1953. After releasing marked *typica* and *carbonaria* in a wood where trees were darkened by pollution, he recaptured a much higher percentage of dark than light moths, implying selective predation on *typica*. Two years later, he obtained the opposite result in an unpolluted forest. Combined with observations of the hunting behaviour of birds, and of the distribution of the two forms in Britain, these experiments seemed to provide Darwin's 'missing evidence': a complete story connecting ecological forces to evolutionary change. Kettlewell gained instant fame, and the *Biston* story was quickly installed in biology textbooks, where it remains to this day.

Hooper suggests, however, that the release experiments were probably fudged to achieve the desired outcome. Unfortunately, in her desire to write a lepidopteran 'whodunnit', she advances a flimsy conspiracy theory. Her evidence rests largely on the fact that Kettlewell's first experiment began as a failure, for he recaptured too few moths to show differential survival. His forlorn letter to Oxford provoked a soothing response from Ford: "It is disappointing that the recoveries are not better… However, I do not doubt that the results will be very worth while."

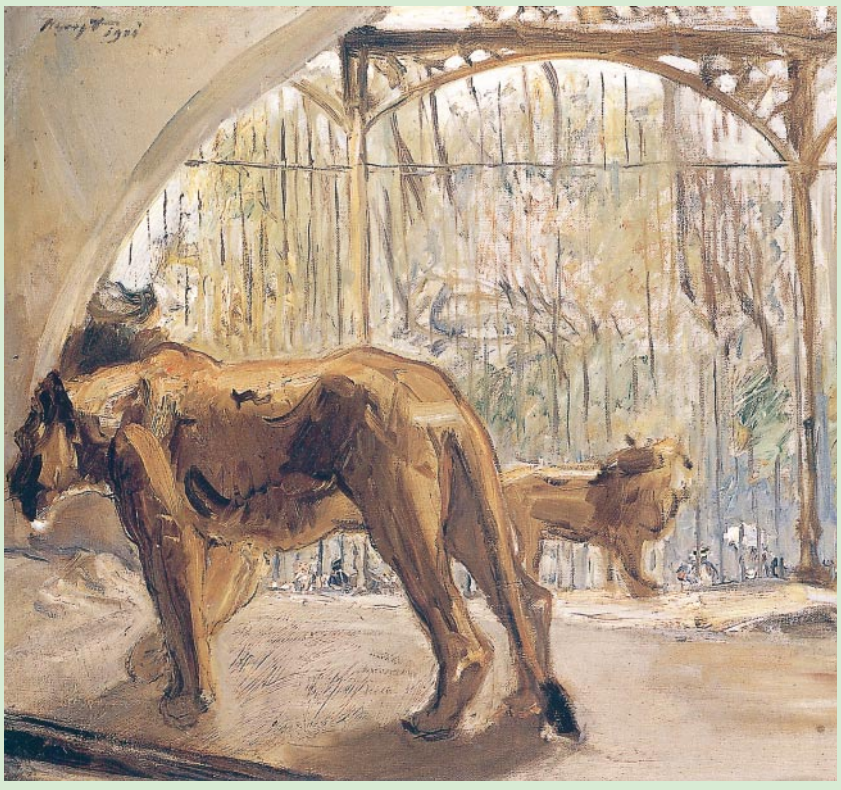
To a professional biologist this sounds familiar; many of us have offered similar consolation to students having a hard time in the field. But to Hooper, Ford's note is a coded message telling Kettlewell to get the right results at all costs. Sure enough, Kettlewell's recapture rate shot up, perhaps because he tripled the number of moths released. Hooper, however, finds this cause insufficient. Using meteorological records, she rules out a change in the weather, and suggests that the increased recapture rate reflected chicanery by Kettlewell — perhaps he changed the experimental design in midstream, or even mis-scored the moths. But many factors other than the weather can change recapture rates, including experimental modifications, such as relocating moth traps, that are completely innocuous. Anyone with experience of fieldwork knows how unpredictable such experiments can be.

It has been widely recognized that Kettlewell's experiments were indeed flawed. Hooper enumerates the familiar problems: Kettlewell used mixtures of wild-caught and lab-reared moths, released them at the wrong time of day onto unnatural resting places, and so on. As a result, the role of bird predation in the evolution of melanism remains unclear. But sloppiness is not fraud. Eager to push her theme of "ambitious scientists who will ignore the truth for the sake of fame and recognition", she unfairly smears a brilliant naturalist.



BRISTOL CITY MUSEUM/NATUREPL

Light work? The two forms of the peppered moth make it ideal for studies of evolution.



Kept in captivity

***Lionesses Pacing in a Cage* by Max Slovegt depicts the experience of wild animals put on public display. From *Zoo: A History of Zoological Gardens in the West* by Eric Baratay and Elisabeth Hardouin-Fugier (Reaktion Books, £28, $40), recently translated from French.**

Many of the problems with Kettlewell's experiments and the 'classic' *Biston* story were first aired by the US biologist Ted Sargent. Curiously, when turning from Kettlewell to Sargent, Hooper's criticality evaporates. She claims that Sargent's criticisms of the moth work ruined his career by making him a pariah, rejected by a scientific establishment enamoured with *Biston*. But this is hyperbole. Sargent's career may have languished because he often published in little-known journals or (as Hooper notes) refused to apply for grants — the kiss of death for a US scientist.

Hooper also champions Sargent's view that industrial melanism was a case not of evolution but of "phenotypic induction" — a developmental change in the colour of moths, presumably caused by the larval ingestion of pollutants. But she conveniently glosses over the simple and unassailable fact that the light and dark alleles of *Biston* segregate as mendelian variants when tested under uniform experimental conditions. Perhaps Hooper embraces the induction theory because it makes for a better story, but surely good science journalism demands that drama takes a back seat to data. Numerous scientific errors (the American peppered moth is not *B. cognataria* but *B. betularia*, the same species as in Britain, for example), mar the book for biologists.

The biggest shortcoming, however, is Hooper's failure to emphasize that, despite arguments about the precise mechanism of selection, industrial melanism still represents a splendid example of evolution in action. The dramatic rise and fall of the frequency of melanism in *Biston betularia*, occurring in parallel on two continents, is a compelling case of evolution by natural selection. No force other than selection could have caused such striking and directional change. Hooper's grudging admission of this fact occupies but one sentence: "It is reasonable to assume that natural selection operates in the evolution of the peppered moth."

This issue matters, at least in the United States, because creationists have promoted the problems with *Biston* as a refutation of evolution itself. Even my own brief critique of the story (*Nature* **396,** 35–36; 1998) has become grist for the creationists' mill. By peddling innuendo and failing to distinguish clearly the undeniable *fact* of selection from the contested *agent* of selection, Hooper has done the scientific community a disservice. ■

Jerry A. Coyne is in the Department of Ecology and Evolution, University of Chicago, 1101 East 57th Street, Chicago, Illinois 60637, USA.

Competition between women

A Mind of Her Own: The Evolutionary Psychology of Women
by Anne Campbell
Oxford University Press: 2002. 402 pp. £21.99, $40

Elizabeth Cashdan

This provocative book argues that competition among women has been an important, yet largely ignored, force in human sexual selection. Competition between males is usually thought to be more intense than female competition because greater male variance in reproductive success means that men are playing for higher stakes. But Campbell suggests that this is misleading: "The variance may not be as great as between males but that is irrelevant because females are not in competition with males, they are in competition with other females." Mothers (not fathers) are critical to offspring survival, and differences among women in their success in this endeavour have shaped the way that women think, feel and behave.

The book opens with a sharp and satisfying critique of postmodernist biophobia and a skilful rebuttal to those who distrust evolutionary psychology's scientific methods and fear its political implications. It closes with an excellent in-depth account of the evolutionary reasons for individual variation. In between, Campbell shows us how and why women compete.

Women are clearly less physically aggressive and less risk-prone than men, but why? Campbell rejects the belief that it is a "default option that results from lower incentives for competition" and attributes it instead to women's greater parental investment: they have more to lose from violent and risky behaviour. This behavioural difference, she argues, is mediated by a sex difference relating to fear of injury and a neurochemistry that makes women better able to inhibit aggressive impulses.

These arguments are extended in Campbell's discussion of sex differences in dominance and status-seeking. The rewards of high status "are just as great for females as for males — arguably greater because resources fuel the survival of offspring in which they have already invested while for males it merely buys a ticket in the copulatory lottery of possible fatherhood", she argues. What differs, she continues, is not the rewards, but the costs (the risk of injury). This argument explains why women are less prone to seek high status through aggressive competition. It is also used to good effect in a later chapter on women and crime, in which Campbell explains why women commit