Addressing the gender gap in evolutionary biology

On attaining tenure after 23 years at Harvard, Ruth Hubbard remarked, 'I didn't know whether my being a woman had something to do with my getting tenure in 1973, but I was sure that my being a woman had something to do with my not even having been considered before'[1]. Twenty-three years later, many women scientists still question whether they really have the same academic career opportunities as their male counterparts. The great inroads women made into the sciences and engineering during the 1970s and early 1980s have leveled off long before women have achieved 'demographic parity and occupational equality with men'[2]. Women and men currently enter doctoral programs in the life sciences in nearly equal numbers, but women earn only about a third of the doctorates awarded[2]. Moreover, women's degrees are not converted into expected professional ranks, especially rank of full professor, over time[3]. In most science and engineering fields, women are underrepresented at all higher academic levels[2]. The unbalanced sex ratios among tenured faculty in the majority of life science departments make it strikingly clear that, although the number of tenured women scientists has increased since Hubbard won tenure at Harvard, it is nowhere near parity.

Why is this? What prohibits or discourages talented and capable female graduate students from completing their doctoral studies in life sciences? What complex social and political forces dissuade women from pursuing subsequent levels of academic achievement? In September 1996, evolutionary biologists concerned with addressing these questions and, ultimately, improving the representation of women in science, convened at the University of Arkansas to participate in a conference entitled 'Women In Evolution: A Gathering of Scientific Perspectives' organized by Sydney Cameron (University of Arkansas, Fayetteville, AK, USA). The attendees, both male and female, represented a spectrum of US experience ranging from high school students and college undergraduates to senior researchers at major universities, and representatives of governmental agencies.

One goal of the meeting was to recognize and communicate some of the primary research contributions made by women in evolutionary biology in the United States. A two-day series of lectures presented a diversity of evolutionary research, focused at all levels from the molecular to the biogeographical. A common theme was the integrative approaches used to address this broad range of evolutionary topics.

One of the best examples was the work of Catherine Craig (Bunting Institute and Harvard University, Cambridge, MA, USA), who studies the evolutionary ecology of aerial web-weaving spiders. Craig superimposed onto a phylogenetic framework components such as the spectral properties of forest light and of web silks, the physiological basis of silk production and the ecology of tropical forests to understand the extraordinary evolutionary radiation of web-spinning spiders. In an elegant series of experiments, she demonstrated that spiders can optimize the spectral properties of their webs to the visual system and behavior of bees, their target prey organisms.

Chris Simon (University of Connecticut, Storrs, CT, USA) also employed a phylogenetic analysis to demonstrate that life-cycle switching between 13- and 17-year periodical cicadas has occurred more frequently than previously thought, challenging current theories of cicada species relationships. Surprisingly, the mechanism may be as simple as a four-year life-cycle acceleration in the 17-year cicadas. Diana Wheeler (University of Arizona, Tucson, AZ, USA) explored the evolution of complex insect societies, analyzing the interrelationships of several hierarchical levels at which selection is thought to act. She hypothesized that nutritionally-influenced developmental plasticity may be a prerequisite for the extreme morphological and behavioral specializations associated with higher sociality in insects.

The application of multiple methodologies has brought improved resolution to several classic evolutionary problems. For example, Anna Graybeal (Field Museum of Natural History, Chicago, IL, USA) contrasted the use of molecular and morphological characters in inferring frog phylogeny, and Adrienne Zilhman (University of California, Santa Cruz, USA) integrated comparative studies of field behavior, anatomy and fossil and molecular data to re-examine traditional theories of hominid evolution. Marvalee Wake (University of California, Berkeley, CA, USA) called for a broad synthesis of functional morphology, evolution and development, exemplified by her work on caecilians. Hope Hollocher (Princeton University, Princeton, NJ, USA) used Caribbean *Drosophila* as a new model system for studying genetic mechanisms of speciation, and Kerry Shaw (Harvard University, Cambridge, MA, USA) analyzed the central role of acoustic behavior in speciation among Hawaiian crickets.

Other lectures focused on aspects of microbial molecular evolution, for example, Margaret Riley's (Yale University, New Haven, CT, USA) work on the evolution of microbial defense systems, Jennifer Wernegreen's (Yale University) exploration of the concordance between plasmid and host phylogenies for members of the Rhizobiaceae, and Sharon Messenger's (University of Texas, Austin, USA) use of bacteriophage in experiments on population dynamics and the evolution of virulence. Margaret Kidwell and Joana Da Silva (University of Arizona) described the recent evolution of transposable elements in *Drosophila*, applying methods of molecular biology, molecular evolution and population genetics.

A final group of talks used evolutionary methodology to shed light on areas usually assigned to other disciplines, such as Jessica Kissinger's (National Institutes of Health, Bethesda, MD, USA) research on the evolution of *Plasmodium* (the causative agent of malaria) and Jessica Bolker's (Indiana University, Bloomington, USA) use of comparative developmental research to explore the evolution of development. The keynote address, delivered by Professor Nina Fedoroff (Biotechnology Institute at the Pennsylvania State University, College Park, PA, USA) described how her own life experiences and career path intertwined with those of Barbara McClintock in their shared quest to reveal and understand the biology of maize transposable elements. Fedoroff outlined McClintock's cytogenetic discoveries and the later synthesis of molecular biology and genetics that she herself used to unravel the molecular mechanisms of transposition.

Beyond recognizing the achievements of women in evolution, the lecture series accomplished a second goal of the conference by providing role models for women just entering the field. The importance of role models for women scientists was one of the topics in two workshops addressing issues that strongly influence the climate for women in the sciences. In designing these workshops, Sydney Cameron identified two critical topics for aspiring women in evolutionary biology. In the first workshop, participants examined the need for mentors and the dearth of female role models for young scientists, identified specific career stages where mentoring was critical to career advancement, and evaluated gender-specific mentoring issues. The second workshop assessed institutional responsibilities for creating a climate more

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attractive to female scientists. Discussions covered formalized mentoring at all levels of science education, parental leave policies, affordability and availability of high-quality day-care, identification of systemic factors that impede female career advancement in the sciences, and the installation of deliberate remediation programs to increase the number of women at higher levels of authority in university science and science administration.

The conference itself addressed several of the issues it raised – in particular, increasing the visibility of women in evolutionary biology, the need for female role models in the field, and the importance of forming professional networks. A central result of this highly successful meeting was that it clearly demonstrated the value of discussing these issues, and an atmosphere of cautious optimism developed during the course of the conference. Most importantly, the meeting fostered communication among women and men about the causes of women's underrepresentation in evolutionary biology. As certain issues such as the availability of day care and the significance of role models repeatedly rose to the surface, it became clear that some of the most important strategies for supporting women scientists are easy to identify and should be straightforward to implement: now we need to put them into action.

Identification of gender-specific inequities is only a first step toward improving female representation in the sciences, and it will take more than a meeting of this sort to resolve the more complex issues raised. However, as we come to understand and appreciate the diverse ways in which science is accomplished, we may eventually lose the impetus for a conference of this type. As we work to create a climate in which more female scientists can flourish, and take steps to address the needs of other underrepresented groups, we will be able to focus more exclusively on scientific research, assured that all talented people have an equal opportunity to participate.

Readers interested in obtaining more information about issues facing women in science are directed to:
http://www.artsci.wustl.edu/~wie/

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Estimating impacts of a dominant detritivore in a neotropical stream

Ecologists increasingly have a more than academic motivation to learn how species affect ecosystems. We often find ourselves in a race with time to find out how species interact with their environment while these environments are still relatively intact. Research in more natural habitats has two practical justifications. First, fundamental natural processes are often clearer in places that have not been destabilized by multiple anthropogenic disturbances. Second, understanding and documentation of the functioning of natural ecosystems may provide an essential guide if we have future opportunities to restore damaged environments.

The fresh waters of South America face massive, profound and imminent human impacts. Rivers and their floodplains are altered abruptly, over huge spatial scales, by damming and dredging. On a continental scale, plans in South America for interbasin navigational waterways linking historically isolated drainages from the Caribbean to the Rio de la Plata have been entertained for at least two centuries[1]. Imminent construction of the Paraguay-Paraná Hidrovia (a 3400 km navigational canal) will link the headwaters of the Paraguay River near Caceres to the port of Nueva Palmira, near Buenos Aires. This project will drain much of the Pantanal, the largest and biologically richest floodplain wetlands remaining on the earth[2,3].

On a more local scale, dredging is in progress in the Apure and Orinoco rivers to extend the distance ocean-going ships can travel up the Orinoco[4]. Simultaneously, increased human fishing pressure throughout tropical South America is shifting the composition of the catch from larger, long-lived species to high-yield, faster-growing fishes such as *Prochilodus*[4,5]. Against this backdrop, Flecker[6] has investigated community and ecosystem influences of *Prochilodus mariae*, a dominant detritivorous fish that migrates seasonally into Andean piedmont streams from lower reaches of the Rio Apure drainage of the Rio Orinoco.

There are good reasons, as Flecker points out, to suspect that this species is a strong interactor, *sensu* Paine[7]. First, *Prochilodus* species are extremely successful in South American rivers, often dominating the biomass of fish assemblages[6,8]. Second, detritus is a nutritionally poor food source, so detritivores must process large volumes. Hence, in addition to being abundant, *Prochilodus* probably have high per capita effects.

Flecker manipulated *Prochilodus* abundance to study their effects on sediment accrual and the composition and abundances of benthic algae and invertebrates in an Andean piedmont stream. In cages excluding *Prochilodus*, more sediment built up, more invertebrates accumulated and diatoms increased. Where *Prochilodus* were enclosed, and in semi-open cage controls accessible to the entire natural fish assemblage, the bluegreen *Calothrix* dominated periphyton. The relatively large mesh (25 mm) and size (4 m^2) of cages and the low suspended sediment load of the stream during this dry-season study suggest that cage effects on sediment outfall, which frequently plague experimental manipulations in streams, were probably minimal. Treatment effects attributed to *Prochilodus*, however, were often stronger in cage controls that admitted the entire fish assemblage, than in *Prochilodus* enclosures. This result leaves open the question as to how effects of enclosed *Prochilodus* compare with those of the entire, free-swimming assemblage of fishes. Were *Prochilodus*, which dominated this natural assemblage, more effective when free-ranging, or were other fishes such as the larger loricariid catfish also contributing to the effects?

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