

as far as Greenewalt. (2) Why do bird sounds in different habitats have different characteristic time and frequency patterns? Gill presents the two main current hypotheses: sounds are designed by natural selection to overcome habitat-specific attenuation (Morton) or degradation (Wiley). The other two books mention only Morton's hypothesis. (3) Why do birds perform elaborate courtship displays? The accounts of both Welty and Baptista and of Faaborg start from the traditional view that courtship serves to "synchronise sexual arousal" or "maintain the pair bond". Gill, on the other hand, uses a more modern conceptual framework within which males and females are seen to have conflicting interests, so that much of courtship has to do with assessment of partner quality and fidelity. (4) Why do some gamebird populations show regular cyclic fluctuations? The red grouse is taken as a case study by Gill, and he summarizes the Watson-Moss view that cycles are driven by behavioural changes. The alternative view of Hudson, that the gut parasite *Trichostrongylus tenuis* causes the cycles, is not mentioned. But the other two books do not give worked examples and only make very general statements about possible causes of cycles such as food, predators and behaviour.

My test shows that Gill's book, although superficial in places, is more up-to-date and incisive than its rivals. It is also most attractively produced. I would recommend it as the preferred text for an ornithology class, unless it was essential to have the sections in the other two texts on "Birds and Man" — dealing with applied problems not covered as a separate issue by Gill.

Let me end by telling an historical anecdote. On page 9 of his introduction, Gill asserts that "Albert Szent-Georgy (*sic*) won a Nobel Prize for the elucidation of the Krebs cycle from studies of pigeon breast muscle". The crucial discovery for the cycle (conversion of oxaloacetate and pyruvate (via acetyl CoA) into citrate) was reported by H. A. Krebs (in a paper famously rejected by *Nature* on 14 June 1937). Szent-Györgyi discovered that several 4-carbon dicarboxylic acids are readily oxidized in suspensions of minced pigeon muscle and that these dicarboxylic acids can act 'catalytically' to accelerate the combustion of substances in the muscle suspension.

I remember once, as an undergraduate, hearing Szent-Györgyi in a lecture at Woods Hole claiming that the citric-acid cycle should have been named after him, not Krebs. I wonder if Frank Gill was in the same audience? □

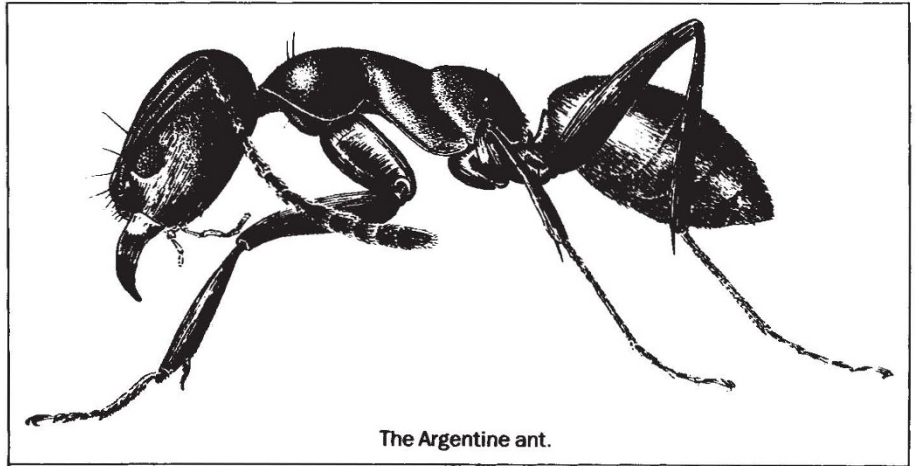
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The science of queens

Donald H. Feener Jr, Diane W. Davidson and Jon Seger

The Ants. By Bert Hölldobler and Edward O. Wilson. *The Belknap Press of Harvard University Press: 1990. Pp.732. \$65. Distributed in the United Kingdom by Springer-Verlag, £70.50.*

INDIVIDUALLY, ants are small and unremarkable; collectively, they rule the terrestrial world. They live almost every-



The Argentine ant.

where and eat almost everything. They make up only 0.1–1 per cent of all animal species but 10–25 per cent of the animal biomass in many places. Ants have pushed insect sociality to its limits in several different respects, and this is in large part the key to their ecological success. Yet they are hardly mentioned in many ecology textbooks, and "not one biologist in a hundred can describe the life cycle of any species". This state of relative neglect should soon end, because Bert Hölldobler and Edward Wilson have put most of myrmecology between covers.

The Ants is a stunningly attractive volume that belongs as much on the coffee table as it does on the lab bench. It contains nearly 1,000 illustrations, including 24 spectacular colour plates that vividly portray the lives of various species. (How many children will slowly turn the pages of this book, and years later take up the study of ants?) The 20 chapters are organized thematically, and they are written in a clear, accessible and engaging style. The chapter on classification is a book within a book; it includes anatomical drawings and definitions, a genus-level taxonomy, keys to the 11 subfamilies and the 292 currently recognized genera (50 pages), and habitus drawings of every genus (60 pages). With this extraordinary tool, even a novice will be able to identify any ant to genus; the chapter could be made into a splendid

field guide, and we hope that the authors will do this. (At more than 2.5 kilograms, *The Ants* is not portable.) Other chapters include extensive tables summarizing biogeographical distributions, regional faunistic studies, modes of colony formation, pheromone chemistry, and many other subjects. There is a glossary of several hundred terms, and some chapters have what amount to mini-glossaries of their own. The bibliography (65 pages) contains 3,000 references. We doubt that any major taxon has ever received such a thorough and synthetic review.

With uninhibited enthusiasm (and flashes of humour), Hölldobler and Wilson begin *The Ants* with brief accounts of

the ecological and scientific importance of these and other social insects. Insiders will be thrilled, and even the most sceptical should be convinced that "the modern insect fauna has become predominantly social". In chapter 2, on classification and origins, the authors estimate that only about half of the world's ant species have been formally described. The vast majority of unknown species are confined to rapidly disappearing tropical rain forests — Wilson recently collected 42 species in 26 genera from a single tree in the Peruvian Amazon, for example. Although the taxonomy of ants is in better shape than that of many other insect groups, many phylogenetic relationships remain unclear, including those of the 11 subfamilies. These gaps in our understanding should soon yield to rigorous phylogenetic analyses applied to both morphological and molecular data.

Chapters 3 to 9 review what is known about colony life cycles and interactions among colony members; the topics include altruism and the origin of workers; differentiation and division of labour among worker castes; colony odor and kin recognition; communication; and colony homeostasis. Chapter 10, on foraging strategies, territory and population regulation, illustrates the authors' focus on general biological principles. In arguing for the importance of competition in ant communities, they draw on more different

kinds of evidence than are presented in any recent general ecology text; here the reader will learn about overt aggression, overdispersion of colonies, overdispersion and complementarity of traits, exclusion experiments, packing experiments, natural and experimental introductions, and several instances in which introduced species have subsequently evolved reduced levels of aggression.

In the next four chapters, the authors consider the symbiotic relationships of ants with one another, with other arthropods, and with plants. Again, general principles are stressed, but not at the expense of natural history. Then follow five chapters on the evolution and ecology of the most distinctive ant lifestyles: the specialized predators, the army ants, the fungus growers, the seed harvesters and the weaver ants. A final short chapter describes various techniques for collecting ants and for culturing them in the laboratory.

Only Hölldobler and Wilson could have written such a comprehensive and integrated treatment of ant biology. It represents a herculean labour of love, and it sets a new standard for synthetic works on major taxa. Every expert will find something to complain about; each of us has a list of quibbles concerning overlooked literature, misplaced emphasis or questionable interpretations of evidence, in those particular areas we happen to master. But such flaws are inevitable in any book that attempts to organize a large and complex field, and they do not detract from its value in any important way. Like a social-insect colony, *The Ants* is much more than the sum of its parts. (Incidentally, why entire ant colonies behave in ways that are far more precise and reliable than the behaviours of individual workers is explained in chapter 9.)

The Ants can be viewed as a sequel to Wilson's *The Insect Societies*. Published nearly 20 years ago, that book was a similarly ambitious synthesis of natural history, experimental ecology, physiology and evolutionary theory. It convinced several generations of graduate students that the termites and the social Hymenoptera (ants, bees and wasps) are inherently fascinating organisms, and that they can be used very effectively to address fundamental issues in behaviour, ecology and evolution. Despite its age, *The Insect Societies* is still in print and still invaluable; our well-worn copies are always close at hand. Like its predecessor, *The Ants* will undoubtedly remain in active service for decades, guiding both tourists and seasoned travellers through a strange and wonderful world. □

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Guardian of the gates

Steven Dickman

The Cuckoo's Egg. By Clifford Stoll. *Bodley Head: 1990. Pp. 326. £12.95. Published in the United States by Doubleday: 1989. \$19.95, and in Germany by Fischer: 1990. DM29.80.*

PEOPLE who break into computers no longer do it just for fun. What used to be a diversion for lonely teenage savants has now become big business for criminals and spies.

A case in point was when West German 'hackers' — as these computer burglars have come to be called — in 1986 and 1987 broke into a number of United States



Stoll — ebullient charm.

military and academic computers. Gaining access through open academic networks, the hackers penetrated supposedly secure computers at US defence contractors and at military bases from Alabama to West Germany to Okinawa.

Although the hackers may have begun with innocent motivations, they quickly discovered that computer crime does pay, especially when military secrets are at stake. Until they were arrested in 1989, the hackers 'earned' DM90,000 (about \$53,000) for delivering information to the KGB.

In the end, not that much damage was done to US national security; none of the information the hackers stole turned out to be classified. But the psychological damage was immense. For most computer users, military or otherwise, the thought of having intruders tromping through data files or changing the operating system are enough to bring on a cold sweat.

Fortunately, the individual user has an ally in fighting the battle for computer security — Clifford Stoll, a mopheaded astronomer-turned-computer-sleuth with a weakness for chocolate-chip cookies. Just a week after starting a job as a computer jack-of-all-trades at Lawrence Berkeley Laboratories in California (where, Stoll says, they "recycle used astronomers"), he was confronted with an accounting problem: the internal records showed an error of 75 cents. He thought it might take an afternoon to locate the source of the error. But when it became clear what was at stake, Stoll stayed up at night for two years, tracking a professional intruder nine time zones away who was rifling through dozens of computer systems.

Stoll narrates the tale of the chase in his fast-paced book *The Cuckoo's Egg*, from the first puzzling day when the computer's books did not balance until the triumph more than two years later when a hacker (and later his accomplices) was arrested in Hannover, West Germany, and charged with espionage. Stoll's editors must have faced a tough decision when they read his unique jargon-laced prose: whether to clean up the hippy, computer and California slang in the interests of clarity, or to leave it to the reader to make sense of it.

They chose the latter, allowing Stoll's ebullient personality to shine through. The British publishers have left the vocabulary alone, a decision that might leave non-technical (or non-US) readers justifiably perplexed by words like 'grinch' and 'kludge'. But despite a few rough spots, even someone completely 'computer-illiterate' will be able to follow the chase.

Much of the book's charm lies in Stoll's apparently unembellished descriptions of his extracurricular activities as an overage hippy in Berkeley — knitting quilts, going to costume parties, bicycling in the rain and drying his sneakers in the microwave oven. In between the anecdotes and the chocolate-chip cookie recipes, Stoll describes in painstaking detail how he made hacker-hunting a science, complete with lab notebook, scientific meetings and publications. His detailed records became valuable documents that were later used to reconstruct the break-ins before a West German court, where the hackers were eventually convicted of espionage.

Despite his continuing reluctance to identify himself as anything but an astronomer, Stoll belongs to a new — and necessary — breed of public servant: the hacker tracker. In his book, he reveals how little anyone — users, network managers, even intelligence agencies, had thought about security. Because of his efforts and the publicity they attracted, Stoll himself has already brought about some improvements in the system.

Military networks, recognizing that the