long-range predictions of rival hypotheses. For specialists and those developing a research interest in cooperative breeding it is indispensable. While there is much of interest to general ornithologists, sociobiologists, behavioral ecologists, and evolutionary biologists, not all of these may wish to read each data-rich chapter. It is thus unfortunate that there are no summaries for individual chapters. However, each chapter is subsectioned in detail, and the overall introduction by Stacey and Koenig and the summary by Smith point the way to studies that may be of particular interest to non-specialists.

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## Caste Systems

**Social Insects.** An Evolutionary Approach to Castes and Reproduction. WOLF ENGELS, Ed. Springer-Verlag, New York, 1990. vi, 265 pp., illus. $52.40.

The castes of social insects provide a challenge to biologists at two levels of analysis: Why did they evolve, and how is a developing insect channeled into becoming a sterile worker or a reproductive queen? This volume describes advances in our knowledge of caste formation that have occurred in the 19 years since the publication of E. O. Wilson's classic *The Insect Societies*. The 13 authors, only one of whom is a North American, bring a decidedly European view. All groups of social insects are represented in the volume, and the literature reviewed is both extensive and up to date.

The emphasis is functional. The interplay of nutrition, hormones (especially juvenile hormone), and behavioral dominance in determining the fate of a developing social insect is presented in detail. Considerable information is also presented on the diversity of caste systems occurring in termites, ants, wasps, and bees. The resulting picture is more complex and interesting than the rather simple paradigm that has been adopted by most modelers of social evolution.

Especially noteworthy are the chapters by Michener on halictine (sweat) bees and xylocopine (carpenter) bees. Michener presents a new caste terminology for sweat bees, summarizes recent findings in reproduction and caste determination, and convincingly argues for multiple origins of true sociality within the Halictinae and the need to study variation among and within populations. He characterizes carpenter bees by their long adult life and their tendencies for extended parental care, mutual tolerance, and partial reproductive division of labor. This has led to the frequent evolution of facultative castes rather than true sociality in the Xylocopinae.

Engels and Imperatriz-Fonseca present a stimulating contrast between the reproductive strategies of meliponine (stingless) bees and honey bees, both based on advanced social colonies founded by swarms. Stingless bee workers are unmated but fertile, and they are responsible for a large proportion of the male offspring in a colony. Moreover, stingless bees are rarely completely monogynous, in contrast to honey bees.

The book does have its drawbacks. Bees are heavily emphasized (six of nine chapters), and termites and ants with their diverse caste systems are allocated only one short chapter each. Despite the book's subtitle, an evolutionary approach is nearly lacking in most chapters. Hypotheses concerning the evolution of castes from the viewpoints of inclusive fitness and the ecological costs and benefits of reproductive altruism are given brief mention at best. The authors generally do not recognize that patterns of evolution of social behavior can be best hypothesized by phylogenetic analysis of non-behavioral characters. The book is poorly edited for grammar, especially the contributions from authors whose native language is not English. A summary chapter should have been included to synthesize the diverse caste systems of the different taxonomic groups.

Nevertheless, this book presents a wealth of information on caste formation and reproduction in social insects that would otherwise be overlooked. It is a valuable building block for future research from a more evolutionary viewpoint.

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## Physiological Darwinism

**Nature as the Laboratory.** Darwinian Plant Ecology in the German Empire, 1880–1900. EUGENE CITTADINO. Cambridge University Press, New York, 1990. xii, 199 pp., illus. $44.50.

In 20th-century America, we do not usually think of physiology as a field with much potential for Darwinian theorizing. Darwinism belongs to systematics, population genetics, ethology, and other related branches of outdoor biology, not to the laboratory-bound study of organic functioning; and it is hard to imagine that anyone might have ever thought otherwise. However, as Eugene Cittadino reveals in *Nature as the Laboratory*, some people have indeed thought otherwise: in the late 19th century, a whole school of German botanists once set out to interpret plant structures as physiological adaptations to the external environment, established and maintained through the action of natural selection.

Simon Schwendener, who initiated this movement with his book *Das mechanische Princip im anatomischen Bau der Monocotylen* (1874) and who trained or supervised many of its practitioners, was not himself a Darwinist. He was simply interested in applying mechanical principles to anatomical structures. However, his more radical follower, Gottlieb Haberlandt, who had a special interest in tissues engaged in photosynthesis, argued that the forms he studied were adaptations to the external environment. Haberlandt initially encountered strong criticism from scientists steeped in the morphological traditions of German botany, who considered structure and function as essentially unrelated phenomena and who insisted that trying to *explain* morphological forms was to speculate beyond the bounds of empirical science. Haberlandt countered that Darwinian theory justified his seemingly teleological assertions: natural selection had divised increasingly complex mechanisms for effecting photosynthesis and other processes as evolution proceeded.

Despite the criticism, Haberlandt soon convinced other botanists to investigate the adaptive significance of anatomical features, and many of them set out to test their assumptions in a variety of environmental settings. Georg Volkens studied transpiration in the deserts of Egypt and Arabia. An enthusiastic imperialist, he later conducted botanical expeditions to the new German colonies of East Africa, the Caroline, Mariana, and Marshall islands of the Pacific, and North East New Guinea. Haberlandt and Ernst Stahl separately worked at the Dutch experimental station established by Melchior Treub in Java. Heinrich Schenck and A. F. W. Schimper spent time working with the Darwinian naturalist Fritz Müller at his home in southern Brazil. The tropics held a special interest for all these investigators, since they assumed that most plants had originally evolved there. Temperate and arctic forms were simply specialized survivors that managed to adapt to the less favorable conditions further north.

According to Cittadino, these late-19th-century Darwinists had their greatest influence on the nascent science of ecology. He acknowledges that 20th-century ecology has been primarily concerned with the study of plant associations, not individual adaptation