

larly, this book will be helpful for those who plan to use genomic sequences for designing suitable experiments in the area of metabolic and gene-regulatory networks. Overall, the book is highly recommended not only for students of bio-informatics but also for those biologists who plan to use computational methods.

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**The Last Sorcerer – Echoes of the Rainforest.** Ethan Russo. The Haworth Integrative Healing Press, An Imprint of The Haworth Press, Inc, 10 Alice Street, Binghamton, New York 13904-1580, USA. 2002. 368 pp. Price not mentioned.

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Those who have visited tropical rainforests, even briefly, and seen its people, may never stop pondering over the question, 'how do these people lead healthy lives given the evidently harsh environmental conditions that the ecosystem provides?' This question becomes a lot more compelling to those who have experienced the rainforests of tropical America. Here the rainforest ecosystem is so extensive, often fragmented only by rivers. Isolated on these fragments and completely disconnected from each other and modern civilizations, several human communities have survived over millennia. The survival of these human communities has been primarily the result of their thorough knowledge of the ecosystem, the many components of biodiversity therein, and their value as food and medicine. It is this 'secret knowledge' that ethnobiologists world over are rather desperately trying to understand, document and exploit for the benefit of mankind.

Whereas there are a number of published documents and unpublished diaries written by traditional medical practitioners, early explorers, anthropologists and ethnobiologists on indigenous knowledge, culture and medical practices, there are few authentic accounts of the subject published by qualified doctors who practice Western medicine. The book under

review is one such publication, written as a novel, by an American neurologist, Ethan Russo. The author's interest in ethnobotany has taken him on a number of expeditions through the tropical American rainforests; and has also led to publications on psychotropic herbs and their therapeutic potential.

The story is of a medical doctor Abravanel's sabbatical to the Peruvian rainforest, to 'rejuvenate his spirit and learn about indigenous medicinal and shamanic plants'. Abravanel undertakes his study in the Amazon Jungle Centre – a research-cum-eco-tourist facility established by a businessman. The author brings an interdisciplinary focus to the novel by creating characters with varied research interests. Using these characters and their interaction with the medical doctor, the author lucidly portrays the flora and fauna of the Peruvian rainforests. The detailed explanation of the methods and tools each scientist uses in his study is certainly of interest to those who seek to know how field-based research is undertaken. There are, of course, certain sections that seem to reiterate the stereotypes that we have of *shamans* and local tribals, which the author uses to make the story interesting.

It is Abravanel's interactions with the local *brujo* or sorcerer and the *shamans*, Kuyuvi and Pikoro that discuss the ethnobotanical aspects of the story. The use of certain plant-based hallucinogens to 'cure', the accompanying rituals, music and invocation to spirits remind us of some of our own traditions! The note of caution that the *shaman* gives Abravanel that these sacred potions are to be used only in the presence of an experienced *shaman* who can guide the imagery (hallucination) reveals that the practitioners are fully aware of the properties of the plants. The gourmet's meal that the doctor enjoys during his stay at the centre is used by the author to describe the range of plants and animals that are used by the local tribals as food. In fact, a visit to the local shandy by Abravanel illustrates this.

The book is divided into four sections, including 28 chapters. In addition, there is an appendix that provides two dictionaries besides a general glossary of terms (including Spanish, Australian and English). The first is an Amerindian to English dictionary and the second is an ethnobotanical dictionary that includes specific details of the common and sci-

entific names of all the plants discussed in the book and their known uses.

On the whole, the book contains an authentic treatment of the subject. For those who are averse to reading hard science, Russo's novel would be ideal and as the comprehensive bibliography suggests, it is well researched. It may be a good venture for some of our own medical doctors and novelists to undertake, given the number of traditional medicinal practices distributed throughout India.

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**The Social Biology of *Ropalidia marginata* – Toward Understanding the Evolution of Eusociality.** Raghavendra Gadagkar. Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138, USA. 2001. 368 pp. Price: US \$90.

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A relevant question that I have often heard is 'What are the possible topics of biological research that can best be addressed by Indian researchers (i.e. something worthwhile, yet not requiring prohibitively expensive laboratories)?' In the late fifties and early sixties, Haldane asked and answered such questions, but I had my doubts. Today, I could reply, 'Follow the lead of *Ropalidia*'. Yes, in the story of 'my adventures with *Ropalidia marginata*' Gadagkar has shown how 20 long years of diligent observation on a lowly wasp, an easily available item of our rich biodiversity, coupled with an introspective mind can shed light on fundamental problems of biology. An absorbing story it is, full of twists and turns, and the two most salient features are: (i) a naturalist's insatiable curiosity that pries open all aspects of the wasps' life history; (ii) the evolutionary perspective of post-1964 (Hamiltonian) Darwinism.

Relevant to this context is also the Watson–Wilson controversy. The famous author of *The Double Helix* had also pooh-

poohed Wilson and ecology; any worthwhile biology must be molecular biology, maintained Watson. Nonetheless, Wilson's monumental work on social insects, his highly controversial *Sociobiology* and the awe-inspiring tome on ants (jointly with Hoelldoebler) command respect. Interestingly, Gadagkar himself is a molecular biologist who turned to wasp ecology and ethology, and is heavily influenced by Wilson. They are fascinated by the evolution of eusociality and 'altruism' in the insect world.

A stumbling block for Darwin was altruism of workers in social insects like ants and bees who devote their life to caring for other's children. They defy natural selection, for, their 'unselfish genes' are not propagated and should be lost. Only in 1964 did Hamilton and Trivers provide a mathematical quantitative explanation. Wilson's magnificent work on eusociality does not forget this central issue. Now Gadagkar has pursued the theme to the uttermost limit in *Ropalidia*.

Some species like *R. montana* have large colonies boasting of up to 61,000 adults; here queen-worker dimorphism is distinct. *R. marginata*, Gadagkar's subject, forms colonies numbering hundreds of wasps under optimal conditions. But, usually in nature, considerably smaller colonies are formed, therefore, making them more amenable to study.

In this species there is no queen-worker dimorphism. Painstaking observations suggest that there is no morphological index which is unique for the queen (i.e. the solitary, egg-laying foundress of the colony). So, any worker should be a potential queen (see later, however), but only ~5% realize this potential. The central theme of this book is – why should ~95% of the females opt for raising their sister's progeny, rather than their own? A female wasp shares 0.75 of her genes with a sister, 0.25 with a brother and 0.50 with her progeny (because of haplodiploidy). If there are more sisters than brothers, then, by raising such a brood a wasp propagates

more of her genes than by begetting her own progeny.

The 'inclusive fitness' (the term used since Hamilton's discerning contribution) of the worker could be greater if the brood she raises is more related to her than in the case of the queen.

Or, workers may raise more brood because of better protection from predators and/or parasites, and thus propagate more genes. Again, the workers may have variable degrees of fertility; many might produce fewer eggs, and some might be altogether infertile. Such wasps would gain more by serving as workers. Furthermore, if a solitary foundress dies before the brood hatches she cannot propagate any genes, but all is not lost for the worker. Others would continue to care for the brood. The mortality rate of the workers and the effect thereof on the brood need to be investigated.

Gadagkar pursues the story through devious routes and the plot thickens, and the conclusions are like the dénouement of a good detective novel. He discovers with the help of gel electrophoresis, variant forms of a certain enzyme indicating that the offspring of a queen are the result of mating with more than one male (polyandry). This, by the way, is the only laboratory experiment involving apparatus, and it is modest by today's standard. Because of polyandry, relatedness of the worker to the brood is reduced and more so because of serial polygyny, i.e. successive changes in occupancy of the queen of a colony. Finally, the brood-worker relatedness is as little as 0.20 to 0.38 (as against 0.50 for the queen). So, the first alternative is ruled out, the worker stands to lose if she opts for raising such a brood rather than her own. Her altruism could not be shaped by natural selection under these circumstances.

With the help of rigorous statistical analysis of an enormous amount of data based on prolonged observation, the author finally solves the problem. He succeeds in proving that  $\rho\beta\sigma > rbs$ , where  $\rho$  is the

coefficient of genetic relatedness of the worker to the brood,  $\beta$  is the number of larvae reaching adulthood,  $\sigma$  is the correcting factor (by which  $\beta$  is devalued in case the worker dies before larvae reach adulthood);  $r$ ,  $b$ ,  $s$  are the corresponding values for the solitary foundress. The inequality is valid because even though  $\rho$  (0.20 to 0.38) is smaller than  $r$  (0.50),  $\rho\beta\sigma$  more than offsets it for several reasons. If a foundress dies before the brood hatches (61 days), she loses all. Not so with the workers. Rigorous calculations show that the 'assured fitness return' (which depends on  $\sigma/s$ ) is high for the workers.  $\sigma/s$  can be as high as 3.6. Also, depredations at nests of solitary foundresses are more than those in colonies. Again, all workers are not good egg-layers. An accidental factor, trophic condition, determines this physiological variability; well-fed larvae become good egg-layers on reaching adulthood. Seventy-nine behavioural patterns were studied and the wasps could be separated into three clear-cut categories – foragers, fighters and sitters. Interestingly, all queens were from the sitter category (rather than fighter).

Thus, natural variation and some environmental factors create the inequality  $\rho\beta\sigma > rbs$ , and this drives natural selection along the path to altruism and eusociality.

A convincing case has been made. From the range of values obtained for the variables (i.e.  $\sigma/s$  varies from 3.6 to 1.2), it even follows that the inequality is valid for ~95% cases. Furthermore, the author has delved deep into the subject of *Ropalidia*, including 'wasp politics'. Forty closely-printed pages of reference show that Gadagkar has worked hard to gain a proper perspective, but primary credit lies in his exhaustive treatment of *R. marginata*.

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