

# Symbiosis evolving

David L. Hawksworth

**Evolution by Association: A History of Symbiosis.** By Jan Sapp. Oxford University Press: 1994. Pp. 255. \$49.95, £37.50 (hbk); \$24.95, £18.95 (pbk).

SYMBIOSIS as a concept has evolved multifariously since its inception. The term now embraces associations at vastly different scales, from those of organelles within eukaryotic cells to the interplay of organisms in Gaia. Current usage also encompasses associations that are parasitic as well as mutualistic, concepts in themselves open to differing interpretations.

To appreciate how this situation originated necessitates an historical perspective. Jan Sapp has striven to provide such a back-cloth through extensive bibliographic research, supplemented by discussions with individuals, the list of which reads as one of potential nominees for a putative World Prize in Symbiology. But he has not shied away from presenting controversial and personal interpretations.

Despite the significance of symbiosis in evolution, the topic has received short shrift in discussions of the development of evolutionary biology. Indicative of this is its omission from Ernst Mayr's *The Growth of Biological Thought* (1982).

Contrary to most credits, the term originated in an 1877 paper by Albert B. Frank (1839–1900) on lichen anatomy. Frank used the word in a neutral way irrespective of the roles of the organisms living together, paralleling its use by H. Anton de Bary (1831–88) in an address the following year. De Bary did not refer to Frank in the printed version of that presentation, but he cited Frank's paper elsewhere. That two scientists addressing similar issues, and once based in universities 35 km apart (Halle and Leipzig) — a point not noted by Sapp — should arrive independently at the same term would be extraordinary. Such enthusiastic researchers must have discussed such issues. We may never know who first coined the word, but Frank had a particular interest in terminology, proposing "mycorrhiza" in 1885.

The strategies of 'commensalism', 'mutualism' and 'parasitism', already distinguished by the Belgian zoologist Pierre-Joseph van Beneden in 1873, were rapidly subsumed under the general term 'symbiosis'. Van Beneden opposed natural selection as the major evolutionary force, and before the turn of the century symbiosis was increasingly treated as synonymous with mutualism and a concept in opposition to the Darwinian 'struggle for existence'. Symbiosis assumed a sociopolitical dimension, moved out of the scientific comfort-zone, and its study fell into disrepute. Symptomatically, the status of the topic conspired with that of women in sci-

ence to divert Beatrix Potter's energies from studies of lichen symbiosis.

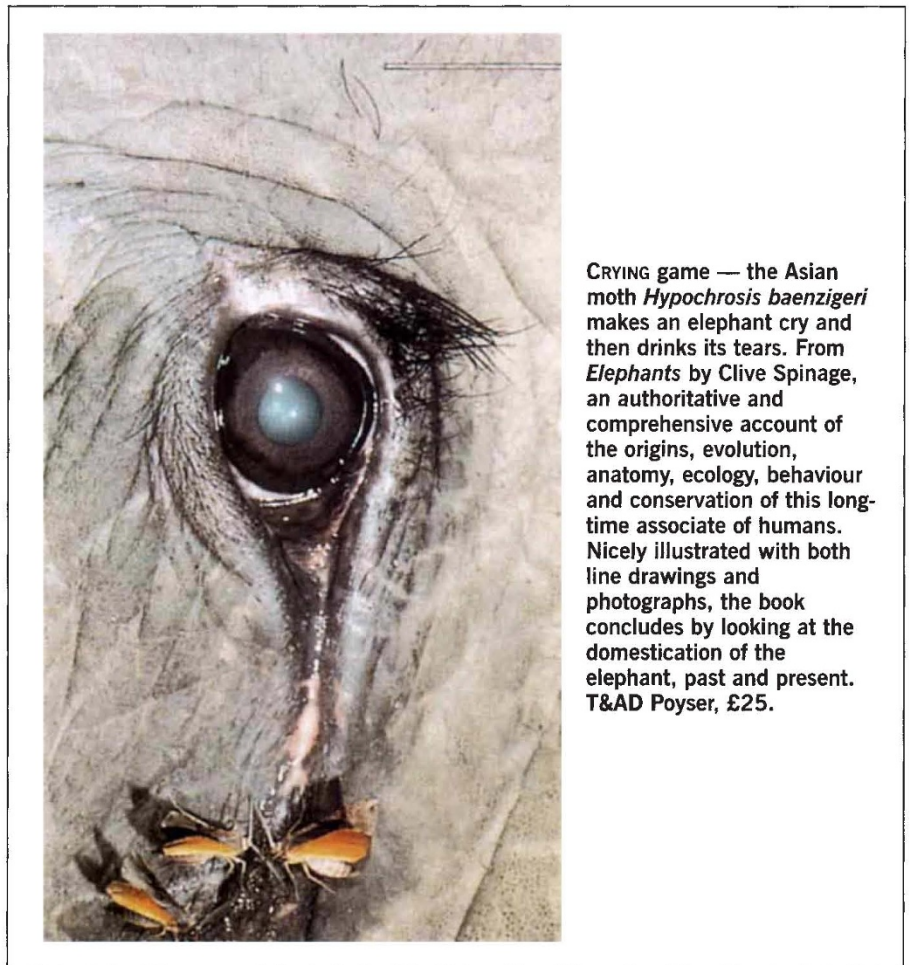
By 1899 the mutualistic concept was being extended by Herbert Spencer to the integration of the living world as a superorganism. This in part foreshadowed the debate started by James Lovelock's *Gaia* (1979), addressed in Sapp's penultimate chapter. Again, scientific hypotheses proposed for testing, and which in this case highlighted the importance of multidisciplinary approaches, moved into a sociopolitical and pseudoscientific arena — and thus tarnished its scientific standing.

Symbiogenesis, the role of symbiosis in the evolution of the eukaryotic cell, was explored independently by the Russian scientists K. S. Merechovsky and A. S. Famintsyn, and later also by B. M. Kozopolianski, in the first decades of this century. Contrary to the claims of some modern symbiologists, Sapp shows this to have been a sideline rather than a major element of Soviet evolutionary thought. Paul

Portier's *Les Symbiotes* (1918), published in Paris and suggesting that all organisms other than bacteria were formed of associations between different kinds of creatures, also became embroiled in debates on microorganisms as disease agents, the resulting controversy further reducing the subject's standing. It was not until advances in ultrastructural and subsequently molecular techniques from the 1970s that the 'serial endosymbiosis theory' of the eukaryotic cell regained scientific respectability. In the second edition of *Symbiosis in Cell Evolution* (1993), which appeared too late for Sapp to cite, Lynn Margulis considered that only spirochaete origins for undulipodia remained the truly "questionable aspect".

In keeping with issues still under debate, Sapp highlights the treatment of symbiosis in *The Science of Life* (H. G. Wells, J. S. Huxley and G. P. Wells; 1929–30) — although referencing the Doubleday (New York) edition rather than the Amalgamated Press (London) original with an identical text but different chapter headings and pagination. These authors stressed that although superficially many associations between organisms might appear to be mutually beneficial, more detailed examination often made it difficult "to distinguish service from slavery".

The "unscientific aura of teleology" was



**CRYING game** — the Asian moth *Hypochrosis baenzigeri* makes an elephant cry and then drinks its tears. From *Elephants* by Clive Spinage, an authoritative and comprehensive account of the origins, evolution, anatomy, ecology, behaviour and conservation of this long-time associate of humans. Nicely illustrated with both line drawings and photographs, the book concludes by looking at the domestication of the elephant, past and present. T&AD Poyser, £25.

considered by the editors of the Society for General Microbiology's symposium volume *Symbiotic Associations* (1963) to "disguise a fundamentally parasitic relationship". Held at the Royal Institution in London, the meeting included presentations of elegant experimental work on the nature of certain symbiotic associations and stimulated critical scientific work that developed exponentially over the next two decades, mainly through the energy of David Smith's group in Oxford. I would have welcomed more analysis of the results of such investigations, of experimental work on isolated partners, and the insights from synthesis experiments and ultrastructural studies.

For lichens, new evidence of 'controlled parasitism' at the cellular level has prompted the question whether mutualism should be defined at the individual cell

level or in terms of increased fitness of the partners at the social level. Within lichen associations in which neither partner occurs in a free-living form, the symbiosis cannot be other than mutually beneficial at the social level. As lichens are such a key element in the development of the original concept of 'symbiosis', I would have enjoyed commentary on this topical scaling controversy.

Overall, the book is a delightful historical complement to the available texts describing symbiotic associations and a scholarly overview of the conceptual aspects of the subject. It will be enjoyed both by symbiologists and by those interested in the history of biological thought. □

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## Juicy beetle and other stories

S. J. Simpson

**Bugs in the System: Insects and their Impact on Human Affairs.** By May R. Berenbaum. Addison-Wesley, 1995. Pp. 337. \$25 (hbk); £19.95 (pbk).

WE entomologists are a frustrated lot. It is blindingly obvious that insects are both beautiful and amazing, so why doesn't everybody else realize this? Granted, the aesthetic appeal of many insects is perhaps a tad difficult to convey to those poor souls without an entomocentric view, but insects *are* amazing. And how do we entomologists try to convert our long-suffering colleagues, friends and, in fact, anyone else unfortunate enough to enquire politely what we do for a living? Why, we tell them amazing things about insects. May Berenbaum has provided us

with the ultimate source of incredible entomological facts. As I read the book I folded back the corner of each page containing an extraordinary piece of entomologia. My copy will not close now. There is enough here to keep entomological evangelists in stories for generations to come.

Did you know that the production of 1 kilogram of honey involves 10 million visits to individual flowers and bees flying the equivalent of 10 times around the Earth? Or that the extraordinary abundance of chamber pots excavated from the Aztec capital was due to human urine being used as a mordant for cochineal dye? Or that the larvae of some flea species attach to the anus of the adult and imbibe their faeces? Or that there is a club in Washington, DC, that specializes

in organically produced mealworm wontons and cricket peanut-butter cups? Or that an elephant-dung pat in East Africa was removed in 2 hours by 16,000 dung beetles? Do you know what cantharidiasis or autothysis are? Or that...?

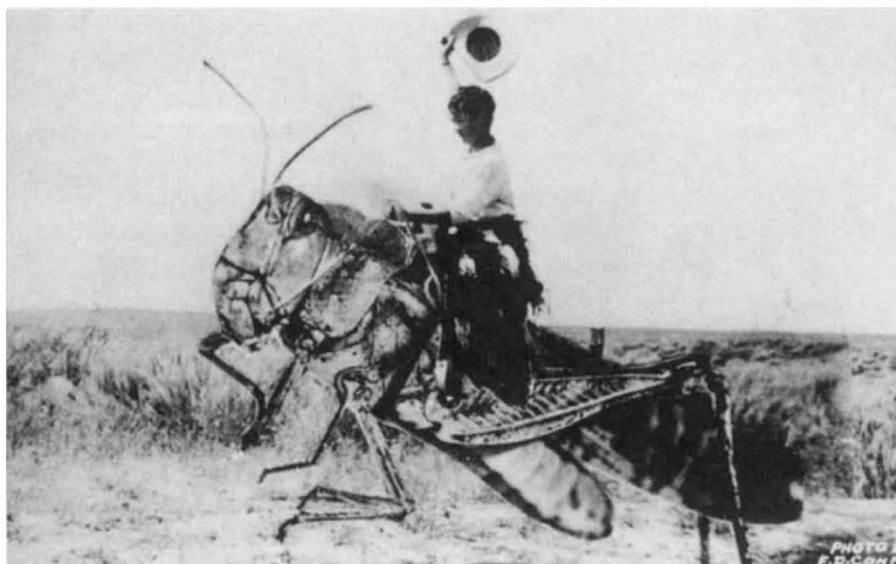
Berenbaum has provided a comprehensive account of the ways in which insects have influenced human affairs, along with salient features of insect behaviour, physiology, social organization and life history. Aspects as diverse as the importance of insects in art, agriculture, food, fly fishing, forensic medicine, mythology, warfare, social structure and even human evolution are covered. Implicating insects in the evolution of the opposable thumb (for social grooming) may be over-entomocentric, but emphasizing their impact on other aspects of human society and biology clearly is not.

For example, the Second World War was the first ever war in which louse-transmitted typhus did not kill more people than the number who died in battle. In 1812 Napoleon embarked on his attempt to conquer Russia with an army of 600,000 men. A year later only 3,000 remained, most of the rest having died of typhus. Thanks to its demographic effects, the Black Death contributed greatly to the decline of the manorial system in Europe. The automobile was encouraged as a non-polluting alternative to horse-drawn vehicles, which were associated with dung-breeding, disease-transmitting fly populations.

This fascinating compendium is written in an appropriately light-hearted style. There are plenty of bad puns (when referring to the extreme competition among carrion-feeding insects, for example, the author says: "It's a dead-dog-eat-dead-dog world out there") and, inevitably, in the interests of a balanced coverage, there is a lot of sex and defecation, so the book will appeal to all biologists. Whether, with its mass of detail, it will hold the attention of lay readers, particularly those with a delicate constitution, is perhaps doubtful. But then again, they will receive the information second-hand from us entomologists on aeroplanes and buses and at dinner parties all over the globe — whether or not they want to hear it.

Finally, I must just mention the case in 1970 when a hotel owner was sued by a guest "who, while attempting to get rid of a cockroach which crawled up her thighs, got her legs entangled in a bedspread and stumbled and fell over". Cantharidiasis? That is the infestation of the rectum by dung-feeding beetles. And autothysis? Explosive defecation in which the abdomen is blown off. □

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From *Bugs in the System*

Leap of imagination — a novelty postcard from the turn of the century.