

symbiosis. Unfortunately, the algal partner is very important, and may vary within a single thallus, leading to lot of difficulty in the concept of individuals, let alone species (Purvis). Recent DNA samples of soil bacteria and other prokaryotes reveal a wealth of unknown, uncultivable types; it is quite likely that these forms outnumber eukaryotic species, as well as far outranking them in overall DNA diversity. Species definitions applying mainly to eukaryotes (like the BSC) can hardly be called general, since they can only apply to a small twig on the tree of life (Embley and Stackebrandt).

Finally, a word about the BSC: it is not well known that its practical application, known as the 'polytypic species concept', pre-dated Mayr by about 50 years and was generally accepted in bird, insect and mammal systematics until recently (the PSC and distance-based species concepts are now eroding that consensus). Corbet provides perhaps the best and most spirited recent defence of the BSC: 'A species is a set of contemporary individuals that [are capable of interbreeding to an extent that] precludes the coexistence in the same place of discrete subsets ...'. I have added square brackets to indicate that reproductive isolation could be viewed as a supporting statement about causes, rather than a required part of the definition. The species problem will, I guess, drag on until evolutionists, systematists and philosophers agree on a criterion of the *status* of species, and leave the underlying causes – 'biological reality', reproductive isolation, cohesion, phylogeny and so on – of that status open.

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Behavioural ecology at thirty-something

Behavioural Ecology: An Evolutionary Approach (4th edn)

edited by J.R. Krebs and N.B. Davies

Blackwell Science, 1997.
£26.50 pbk (viii + 456 pages)
ISBN 0 86542 731 3

Because it is a synthetic field, the precise time of the birth of behavioural ecology is hard to pin down. The subject emerged during the late 1960s and early 1970s from five schools of thought: (1) Tinbergen's four questions¹, (2) connections between ecology and behaviour, (3) economic models of behaviour, (4) evolutionarily stable strat-

egies, and (5) kinship, social evolution and breeding systems. However, the roots of behavioural ecology were to illuminate the role played by behaviours of individuals in determining the distribution and abundance of animals, with the intention of providing answers to questions that are central to ecology. Early on, behavioural ecologists recognized the importance of reciprocity: behaviour influences population processes, and the outcomes cause selection on behaviours themselves. Thus, population processes can be fully understood only via the behaviour of individuals, and in terms of the evolutionary pressures that have forged them². Detractors tend to characterize behavioural ecology as too inward-looking, focusing on 'optimality' of this or that behaviour. However, all organisms face tradeoffs and behavioural ecology is concerned with how we can analyse these tradeoffs.

The vantage from this book is that behavioural ecology is outward-looking and expansive and involves links across different levels of biological organization. For example, the first part of the book shows how behavioural ecologists have revitalized the interest in linking mechanism and function, to the point that an author writes 'Behavioural ecologists and physiologists share a mutual interest in each other's efforts...recent developments in behavioural ecology have had an impact on the way physiologists started to think in evolutionary terms ...'. More generally, the expansive approach means that behavioural ecology involves links across levels of biological organization.

I was particularly pleased to see a chapter on information use, because the entire business of life involves 'guessing what was on the other side of the hill'^{3,4}. This chapter, like the book, traverses a wide range of subjects and levels – from Bayesian analysis of information to the role of the hippocampus in information processing – as the questions are analysed. This, indeed, is the future of behavioural ecology. I was also particularly pleased to see chapters on mechanism and genetics. Even a dozen years ago, many behavioural ecologists would have considered such studies 'too reductionist'. The chapter on genetics, appropriately titled the 'Social Gene', makes the case for analyzing tradeoffs faced by organisms in the context of strategic thinking, rather than the usual infrastructure of population genetics. On the other hand, the chapter on life histories was too rooted in the past, and particularly ignored state-dependent life histories⁵. There are wonderful chapters on the phylogenetic foundations of behavioural ecology and population structure that emphasize historical constraints. This is important: we must understand the role that history plays

in shaping the tradeoffs that organisms face. (One of the past charges against behavioural ecology, as too adaptationist, was the claim that historical constraints were ignored.)

The forward- and outward-looking approach is followed in most chapters, where the future and new horizons are identified. These include information processing ability of animals and its implication, quantifying the fitness consequences of recognition mechanisms⁶, the integration of structure and function in sperm competition, the roles of multiple signals in animal communication, the influence of social cues on mating preferences (mate-copying), and the evolution of multiple mating. These horizons will help guide the next generation of researchers as they analyse the key questions.

The maturity of behavioural ecology, as a conceptual discipline, is clear throughout the volume. For example, the pieces for a unified science of sociality consist of theories concerning ecological constraints, kin selection, social dominance and reproductive skew. Together they determine the dynamics and structure of families. This unified theory leads to a set of 15 predictions, which will guide experimental and observational work. It is now possible to conduct experiments and observations in systems that even 10 years ago seemed inconceivable and to analyse the data using computer intensive methods.

Most fittingly, the last chapter deals with individual behaviour, populations and conservation. Considering that conservation is almost always concerned with small numbers of individuals, it is amazing that conservation biologists pay such little attention to individual behaviour: there is a need for the study of individual behaviour in conservation⁷. There are a couple of important gaps – no chapters on the behavioural ecology of disease or plant behavioural ecology (plants face tradeoffs too, and plant structure can be viewed in analogy to animal behaviour).

Behavioural ecology is indeed in its prime. In the future behavioural ecologists will embrace a wide range of techniques, from gene splicing to computational descriptions of behaviour to magnetic resonance imaging, as we move towards deeper understanding of how organisms deal with the challenges put to them by the environment.

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Not for chewing

Evolution (CD-ROM)

by M. Ridley

Blackwell Science, 1996.

\$29.50

ISBN 1 86542 757 7

Tom Rush, a rock icon of the 1970s, once sang that 'kids these days ... don't like chewing, but they sure can swallow'. As a professor facing the products of California public schools, I might say instead that they don't like reading, but they sure can play video games (if only they were like me). Since this is what culture and commerce have condemned me to, I may as well learn to work with it. It is with this attitude that I approached a review of the CD for Mark Ridley's fine *Evolution* textbook, which I have used for the past two years in my Evolution course. I reviewed this disk on the most stupendous PC that money could buy in April 1997, and it sustained this zenith for a full ten days after purchase, so computing power was not a limitation in the process.

The CD is designed for use with Macintosh computers or PCs equipped with Windows 3.1 or Windows 95. It contains and automatically loads the necessary software for its implementation. It is very user-friendly. I would rank myself as electronically disadvantaged, but I had no difficulty calling up the menu or working through the entirety of its contents without recourse to an instruction manual.

The CD has two main components – a Browser Menu and a Tutorial Menu. The Browser Menu contains six entries: an A–Z browser, an evolutionary time line, 20 classic references from evolutionary biology, six virtual experiments, an image gallery and a video gallery. The Tutorial Menu contains 23 tutorials, corresponding to the 23 chapters of the text.

The A–Z browser is actually an enhanced glossary. It is illustrated with the same photos and drawings contained in the image gallery. It is also interspersed with 'hypertext', or highlighted terms in each definition that are defined elsewhere in the glossary. I found this one of the more useful features of the text, since it adapts com-

puter technology so well to the chicken-and-egg problem that students face when learning such material for the first time, which is that new words are often defined in terms of still other words that are also foreign. One can either continue to wander forward by seeking the definition of a highlighted term, or move backwards to the terms originally reviewed. A student could make good use of the glossary when mastering the vocabulary of evolution and studying for exams.

The Time Line is an abbreviated history of life, beginning with prokaryotes, then progressing to eukaryotes, multicellular life and a brief sketch of the main features of the paleontological record. This feature was relatively brief and a fun adjunct to the disk, but was perhaps too preoccupied with vertebrates.

The 'Classic Texts' contain 20 classic publications from the field of evolutionary biology, which can be printed out as facsimiles of the original publications. They range from relatively current, empirically oriented papers, such as Coyne and Orr's 'Patterns of speciation in *Drosophila*' to selected chapters from classic texts, such as *The Origin of Species* or Fisher's *The Genetical Theory of Natural Selection*. Having ready access to these references will encourage and facilitate the use of original literature in undergraduate courses.

The Virtual Experiments are simple simulations that illustrate some general principles of evolution or population genetics. They follow the tradition of the Populus series, but tend to allow the specification of fewer parameters and are simpler to implement. They include simulations of genetic drift, directional selection, gene frequency, mutational load, sexual reproduction and sex ratio. Each 'experiment' allows the student to specify the starting conditions of the simulation, then charts the progress of an imaginary population through a specified number of generations. Each run of the program is a true simulation in the sense that it is independent of a repetition with the same starting conditions. This feature is one that instructors could put to very good use as an aid in teaching difficult concepts, such as genetic drift.

The image gallery is a menu of the 140 photos and drawings that are also scattered throughout the tutorial and A–Z Browser. They provide a good opportunity for our increasingly urbanized student body to see what some real organisms look like. Each image is accompanied by a brief text that corresponds to the way the image is used in the tutorial. The effectiveness of the text and illustration would be enhanced if it were cross-referenced to the tutorial so that one could easily follow up on each image to see how it is used as an illustration.

Finally, the video gallery is a series of short film clips of renowned evolutionary bi-

ologists responding to a series of questions. For example, students can see John Maynard Smith respond to 'What is an adaptation?', Richard Lewontin answer 'Does natural selection explain every detail of an organisms structure?', or Richard Dawkins respond to 'What are evolutionary arms races?'. The videos are important because they carry the subtle message that the study of evolution is an ongoing enterprise done by real people. They also highlight some of the important areas of dispute in the discipline, although the nature of the disputes cannot be fully developed there. An instructor could certainly use them as a basis for a further discussion of topics like 'What is an adaptation and what are the limits of natural selection?'. An unfortunate feature of the videos is that, even with a computer as stupendous as mine, the images were jerky and there was a lack of synchrony between the sound and videotracks.

The 23 tutorials represent the 23 chapters in the text, but they are not simply a duplication of the text. Each tutorial begins with a short, general introduction and a series of questions, then proceeds to answer each question in turn. The screen is always split between text and illustrations. The text is interspersed with the same images, animations, virtual experiments, and videos seen in the Browser Menu. Each tutorial ends with a series of multiple guess questions that tend to fall far below what I would hope for from my students. The tutorials follow the same topic sequence as the text, but they are briefer and in more of an outline form to highlight specific questions and details. One unfortunate feature of the tutorials is that they do not contain the rich detail of tables and figures from original publications, as does the text, and hence are less demanding of the student's abilities to interpret scientific data. The substitution of animations and videos for hard data definitely caters to the desire to swallow without having to chew.

One of my colleagues who has used the second edition of the text with the CD found that his students could not turn to the CD as a means of explaining difficult portions of the text, since the CD tends to be an appealing synopsis, rather than an enhanced explanation of the more difficult aspects of the text. I thus think that it would be a step backwards in the learning process if students thought of the tutorials as a substitute for the text. As they exist now, they would be most effective as an introduction to the text.

In summary, when viewed from my perspective as a pre-PC-age student (a painful admission, since I do not think of myself as all that old), I find the CD a mixed blessing. Some elements of the CD use the unique features of the medium to good advantage, such as by providing simulations, videos, and an interactive, cross-referenced glossary. I can