Book Reviews

Reproductive Energetics in Mammals

Edited by A.S.I Loudon and P.A. Racey
Zoological Society of London Symposia 57, 1987 Clarendon Press, Oxford
371 pp.

The significance of an understanding of reproductive energetics is highlighted in the Editors' preface where they argue that a knowledge of the energetics of reproduction, and the way or ways in which these costs are met, is central to our interpretation of the patterns of reproduction recorded by field biologists.

There is a very useful glossary of common terms, and a short introduction in which the reader is reminded of the laws of thermodynamics and given a historical perspective of studies of reproductive energetics. The 17 papers include single species studies and comparative studies of members of the same taxon, and of different taxa. All papers include estimates for parameters relevant to the energetics of reproduction (be they the calorific value of stored fat or milk, or changes in metabolic rate during pregnancy and lactation), and the authors and editors should be congratulated on the detailed and critical way in which methods are presented. All the papers are informative and interesting, some being more intellectually stimulating than others.

Reproductive energetics of marsupials and eutherians are compared in papers by Nicoll & Thompson, and McNab, and the suggestion that the elevated metabolic rate of eutherians is causally related to rate of development and fecundity is discussed. Two papers, by Loudon and Rose, examine energy transfer at lactation in macropodid marsupials, and interestingly, the former emphasizes the similarities between the energetics of lactation in macropodids and eutherian mammals, and the latter, the differences.

A theme that runs through many of the papers is that of energy compensation. Anderson and Fedak compare the phocid seals which rely entirely on energy stores during lactation, and the otariid seals which return to the sea to feed between bouts of suckling. The influence of these strategies on the duration of lactation is discussed. Watts and Hansen discuss a similar phenomenon in which the female polar bear, as a result of its use of a maternity den, does not feed during part of gestation and lactation and consequently relies on fat stores. Lockyer examines the relationship between body fat, food resource and reproduction in fin whales and shows that the reproductive cycle is timed so that food is abundant during the second half of gestation. Fat stores, developed during summer feeding, are used during winter lactation. The role of stored fat in pregnancy and lactation in the Svalbard reindeer is discussed by Tyler who shows that the very large fat store developed by these reindeer in summer is not primarily used to balance food shortage in winter but serves as a form of emergency ration. Prentice & Whitehead discuss the role of female nutrition in humans and indicate that, like other large mammals, compensation for the energetic costs of reproduction is not primarily through increased food intake, but through use of energy stores.

By contrast, in small mammals, such as the golden-mantled ground squirrel and the Djungarian hamster (papers by Kenagy and Weiner) the costs of reproduction are met by increased food intake and assimilation, with body reserves playing a small role during lactation. Millar shows that the degree of reliance on fat stores during lactation, in four species of vole, may be related to food quality and availability. McClure compares the energetics of reproduction of two rodent species, one with an r-selected life history, and the other, a K-selected life history. As expected, the daily energetic costs are much greater in the r-selected species where lactation and gestation are extremely short, than the K-selected species where gestation and lactation are longer. Racey and Speakman show that bats differ from other small mammals and compensate for the costs of reproduction by entering daily periods of torpor.

A common problem in compilation volumes is that the individual chapters, with their different authors, tend not to relate to one another. This is not the case in the volume under review, where the common themes (energy compensation and others) unite the chapters, which can then be read as one. Having read this book one can only be impressed by the important contributions that studies of reproductive energetics have made, and will continue to make, to our understanding of animal ecology.

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Classification of Southern African Mammals

J.A.J. Meester, I.L. Rautenbach, N.J. Dippenaar and C.M. Baker
Transvaal Museum Monograph No. 5.
359 pp.
Price R40.00

One of the criteria by which the appearance of a scientific book is measured is whether it fills a vacuum in the present literature. This applies particularly to publications on nomenclature. One should evaluate Meester *et al.* bearing this in mind.

G.M. Allen's (1939) *A Checklist of African Mammals* was the first comprehensive taxonomic work of its kind and remained the standard reference on pan-African

mammalian nomenclature for many decades. Although this checklist brought order into taxonomy it remained a list of names without any information on the classification of the species beyond their generic grouping. *The Mammals of South Africa* (Roberts 1951) not only updated Allen (1939) but was also a publication in a completely different category, providing both classification and extensive biological information. The first bold attempt to scrutinize the generally accepted classification, especially in the case of rodents, was contained in *Southern African Mammals: a reclassification* (Ellerman *et al.* 1953). The monumental work of Reay Smithers, *The Mammals of the Southern African Subregion* (1983), appeared thirty years later and was never intended to be a reference work on classification. This publication on general biology and distribution actually superseded Roberts (1951). The long-felt need for a revision based on the principles follwed by Ellerman *et al.* (1953), became even more pressing after the appearance of Smithers (1983). Furthermore, it was generally accepted that Prof. Meester should compile a publication of this nature, in view of his prominent role as co-editor of the Smithsonian Institution's pan-African identification manual.

Revisions of taxa and the description of new species led to changes and proposed changes in the nomenclature. Although most of these proposals were generally accepted by taxonomists and, henceforth, used in the literature, this was not necessarily the case with scientific and semi-scientific publications in the applied fields. The incorporation of these changes in nomenclature into a single volume remains the most important factor in the publication under review. These additions and changes include, amongst others, more recent views on the status of four of the orders and families, 26 new genera of which a number were regarded by Ellerman *et al.* (1953) as subgenera, the re-evaluation of five genera, 65 'new' species, and the changing of 16 names of species regarded herein as synonyms only. One should compliment the authors on their painstaking accuracy in all aspects of nomenclature, amongst others by accepting only the original texts and thus correcting the typographical errors that slipped into the literature over the years and went undetected.

In conclusion, this publication fulfilled a definite need and is not only an updating of Ellerman *et al.* (1953). However, I regret that it only covers the more traditional Kunene-Zambezi line as the northernmost boundary of southern Africa and does not include Angola, Zambia, Malawi and northern Mozambique as is the case with the aforementioned publication. I admit that a number of tropical forms would then have had to be added but it would have had the advantage of a far more comprehensive portrayal of the southern African arid savannah fauna. I sincerely hope the authors would consider adding this later.

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Pesticide impact on stream fauna with special reference to macroinvertebrates

R.C. Muirhead-Thomson
Cambridge University Press, 1987
275 pp.
Price: £30-00 U.K., $54-50 U.S.A. (Hardback)

Since Muirhead-Thomson's excellent review on *Pesticides and freshwater fauna* (1971) a vast quantity of literature dealing with studies on the impact of pesticides in freshwater fauna has accumulated. Over the last 15 years the most noticeable advances in studies on pesticide impacts in the aquatic environment have been made in streams and rivers. Although some comments regarding studies in standing waters and the impact of pesticides on fish and other aquatic organisms are made, the review concentrates on the impact of pesticides on the macroinvertebrates of running waters. This approach is to my mind to be commended, as the book extracts information pertinent to river ecologists without burdening the reader with a lot of information which can readily be obtained in other specific reviews.

The book comprising twelve chapters is divided into three parts. The first part, consisting of two chapters, starts off with a general introduction and then gives a good historical review of the origins and uses of pesticides in lotic waters. Direct application of pesticides to waterbodies and contamination of water from various sources of toxins and pesticides not necessarily used for pest control are briefly considered.

The second part comprises three chapters and reviews the role of laboratory and experimental methods in the evaluation of pesticides. This section alone makes the book an almost indispensable volume for biologists dealing with pest control of unwanted riverine fauna. The third chapter gives a good review of laboratory evaluation methods. In particular, a number of flowing water techniques are reviewed and the importance of standardizing methods is stressed. *Gammarus pulex* in Europe is an invertebrate that could be considered as a useful routine test animal for laboratory toxicity experiments. Unfortunately southern Africa does not have any widespread gammarids which could be

considered as likely candidates for routine toxicity tests. The pitfalls of extrapolating laboratory findings to the field situation are also emphasized. Chapter 4 deals with the development of artificial community streams where more than single species responses to the introduction of pesticides are taken into account. The development of experimental channels *in situ,* by the French ORSTOM biologists, to overcome the high mortality caused by handling of sensitive stream animals in the laboratory is also covered. In Chapter 5 the reaction of invertebrates under laboratory and experimental conditions are thoroughly reviewed. The shortcomings of static tests and the value of flow-through tests are highlighted. The reaction of various crustacean and insect test animals to a number of pesticides as well as the influence of water quality on the toxicity of these pesticides is discussed. The influence of duration of exposure of invertebrates to pesticides in relation to their concentration are noted to be at an exploratory stage of research. Invertebrate drift and behavioural reactions of invertebrates have been increasingly used in pesticide evaluations and are well covered in the review. There is also a section on the uptake of pesticides in macroinvertebrates and residues of pesticides in the aquatic environment. Chapter 5 rounds off with a discussion on the 'model ecosystem' approach which provides some interesting data on the accumulation of pesticides in different animals but uses a rather simplistic interpretation of the food chain pathway.

The final section of the book, divided into seven chapters, discusses a number of pest-control evaluation programmes. The sixth chapter provides a short overview of field sampling methods used in streams and rivers. The shortcomings of sampling drift could perhaps have been covered in more detail. No mention is made of Cushing-Mundie or Paddle-wheel samplers which both overcome to a large extent the problems of backwash and clogging of nets. Chapters 7–11 cover the impacts of pest control programmes on the non-target aquatic macroinvertebrate fauna of rivers and streams. Control of the spruce budworm in Canada and the USA covered in Chapter 7, provides an overview of the long-term use of the organophosphate fenitrothion and the pyrethroid permethrin in the environment. Chapter 8 deals with the impact of the organochloride endosulphan and a host of synthetic pyrethroids but mostly decamethrin used in the control of tsetse flies in Africa. The tsetse control programme in the Okavango swamps in Botswana is covered. Chapter 9 covers in detail the pesticide control of simuliids in the USA and Canada, the onchocerciasis control programme (OCP) in Africa and several small stream studies on the control of blackfly in California, Japan and Guatemala. Of note in this chapter is the development of new techniques in assessing river and stream ecology impact on both target and non-target organisms. It is interesting to note that the organochloride methoxychlor was used almost exclusively in North America whereas the organophosphate Abate was the preferred pesticide in Africa. Pesticide resistance in *Simulium damnosum sensu lato* in Africa has recently led to the use of alternative methods of control such as Bti (*Bacillus thuringiensis* var. *israelensis*). These control agents have not been included in this book which has been restricted to chemical pesticides. Chapter 10 covers the impact of piscicides and/or molluscicides and Chapter 11 the impact of herbicides on aquatic invertebrates. The direct toxic impact of herbicides as well as the effect of removing shelter of invertebrates and the ecological modification of the environment through for example oxygen depletion are all discussed.

Chapter 12 gives a summary and assessment of the presence and use of pesticides in the lotic environment. The importance of both field and laboratory trials in determining pesticide impact are noted. Most of the large pest control projects produced excellent field data but little in the way of experimental or laboratory data. The problem of sampling error and bias in obtaining comparable data and assessing pesticide impact is pointed out. Well developed physicochemical techniques which could be used to assess the spread and density of pesticides in the environment have with a few exceptions (the Athabasca River project on *Simulium* control in Canada) not been employed. The rather slavish adoption of 'Standard toxicity tests' and the undue preoccupation with median lethal toxic concentrations (LC_{50}) has long stultified the development of experimental methods to measure invertebrate response to pesticides.

There is an extensive reference list of nearly 500 entries citing many internal reports, World Health Organisation publications, theses and obscure journals not easily obtainable and readers will be grateful for this entree into the literature. There is also a short but useful Index dealing with subject and species names. The preface includes a useful list of abbreviations indicating the first page where they are mentioned in the text.

The book is well written with a few minor typographical and spelling errors. The terms larvae and nymph are occasionaly used erroneously in describing developmental stages of various holo- and hemi-metabolous insects. Figure 4.2 gave no indication of what the cross hatching in the experimental channels signified. I particularly liked the author's use of the term blackfly rather than the now all too frequently used ambiguous and confusing term black fly. The one criticism I would like to level is that in a number of instances when results are mentioned only the generic names of the animals dealt with are used. Although this is probably not the fault of the author I think that he could have mentioned this flaw in many of the studies carried out as species within one genus do show wide ranges of susceptibility to various toxins.

I believe that this book is an essential reference for anyone involved with the control and eradication of pest plants and animals. It provides an excellent entree into sampling methodology and points out many of the diverse ecological ramifications of pest control which single minded agencies so frequently overlook. Whether dealing with terrestrial or aquatic animal or plant pests I

strongly recommend this book for all agencies concerned with pesticide control and have no doubt that this will become a standard reference for workers in this field.

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Evolution of sex determining mechanisms

James J. Bull
Benjamin-Cummings Publ. Company / Addison-Wesley Publishing Group, Johannesburg

The book is divided into two parts. The first deals with classical sex-determining mechanisms while the second deals with sex chromosome evolution. It is only after one has read Maynard Smith's *The evolution of sex* that one can begin to appreciate the scientific depth of this book. The author has organized the chapters very systematically. Each chapter ends with a summary which is very useful. I was particularly pleased to see that two chapters (9 and 10) have been devoted to environmental sex determination (ESD). This is an area not adequately covered in most books of this nature.

The book is interspersed with very informative tables which in most instances also include the pertinent references to the relevent taxa. The print is excellent and the bold subheadings in each chapter make it easy to zoom in to a specific animal group or subject matter. The book reads well and in spite of the publishing date being 1983 the author has included some 1983 literature. The 26 page reference list at the end is extensive and comprehensive.

This volume is the first in a series of three on Evolution. It is therefore a must for any natural scientist. Geneticists and evolutionary biologists in particular would find the information in this volume very valuable both for teaching and research purposes.

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The Ecology of Sex

P.J. Greenwood and J. Adams
Edward Arnold, London, 1987
74 pages

The catchy title of this little book conceals some ecological and evolutionary considerations of various aspects of reproduction. In the preface, the authors claim that this is a book about sex and not about reproduction yet within the various chapters there are discussions on the energetics of sexual reproduction, sex ratios, sexual dimorphism and mating systems, surely all topics that fall within the general field of reproduction. The distinction that should have been made is that this book does not examine reproductive processes, but looks at the ecological and evolutionary implications of these processes.

The topics covered are the advantages and disadvantages of sexual and asexual reproduction; sex determination, including environmental sex determination; simultaneous and sequential hermaphroditism; sex ratios; sexual dimorphism; sexual selection; and mammalian and avian mating systems. All these topics are examined from ecological and evolutionary standpoints, and are illustrated with examples. Only detailed examples are completely referenced, and most general statements are not supported by reference to published work.

This book is clearly aimed at the undergraduate level and may serve as an easy introduction to the subject for a naturalist or a non-biological scientist. However, its coverage is too superficial to satisfy the needs of a reproductive biologist.

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The evolutionary ecology of ant-plant mutualisms

Andrew J. Beattie
Cambridge University Press
182 pp.

The topic sounds rather specialized but in fact this book covers an important component of terrestrial ecology and should appeal to anyone interested in animal-plant interactions. The literature on ant-plant mutualisms has become increasingly burdensome and here at last is a comprehensive review of the subject. Following an introduction, there is a speculative discussion on the origins and early evolution of ant-plant mutualisms. Chapters 3 and 4 cover direct and indirect interactions between plants and ants. Direct ant attractants provided by some plants include nesting sites, food bodies and extrafloral nectaries while indirect attractants include the honeydew provided by homopterans and certain species of Lepidoptera. Ants foraging on plants often attack or disturb herbivores and Beattie shows that there is good evidence that the action of direct ant attractants often results in decreased herbivore damage to the plant. The net effect of indirect attractants is more difficult to gauge because the homopterans and lepidopterans are themselves damaging the plant and the ants often protect these herbivores from attack. However, in Chapter 4 a number of studies are mentioned which suggest that in some instances the net effect might be positive to the plant.

Chapter 5 concerns a highly specialized mutualism called myrmecotrophy in which ants supply nutrients to certain species of plants. This is followed by an important chapter on the dispersal of seeds and fruits by ants. It should be noted that seed predation by ants is not considered because it is not primarily a mutualistic interaction. Instead this chapter concerns the dispersal of seeds that have nutritive bodies called elaiosomes attached to them. Chapter 7 concerns ant pollination and poses the interesting question of why this particular mutualism is so rare. It seems that the main reason is that antibiotic substances on the ant cuticle, besides destroying harmful fungi and bacteria, also reduce viability of pollen grains adhering to the cuticle. In the following chapter the composition of food rewards for ant mutualists is considered. The final chapter rounds off the book by considering the variation and evolution of ant-plant mutualisms. I agree with one of Beattie's main conclusions, namely that most ant-plant mutualisms are non-specific and are not co-evolved. The majority of mutualisms seem to be the result of selection on the plant rather than on the ants. Plants are basically harnessing the ubiquitousness, social behaviour and aggressiveness of ants.

Beattie has done an excellent job in compiling a clear and coherent story from a large body of literature. I was impressed that instead of ignoring variability, the author has brought it into his scenario and shown the many factors that contribute to increasing variability in mutualistic interactions between ants and plants.

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The Dinosaur Heresies — a revolutionary view of dinosaurs

Robert Bakker
Published by Longman Scientific and Technical, 1987
Price U.K. £14.95

Where have all the 'flower-children' of the sixties gone? Most probably metamorphosed into the very Establishment they rebelled against in those tempestuous years; but not Bob Bakker! This book shows that he's still socking it to 'em! It might well have been subtitled 'A personal view of dinosaurs', because ever since his scientific debut in the sixties Dr Bakker has had a reputation as a heretic when it comes to dinosaurs — always seeking out the applecarts of dinosaurian orthodoxy to overturn them. Here he pulls together his long, often bitter, sometimes lonely crusade against the orthodox view of dinosaurs as a dynasty of flops and losers — the epitome of fatally flawed obsolescence. If you like detached neutrality in scientific debate, don't bother with this book. But if you like evangelistic fervour, or prefer a ringside seat where the real action is, then this is the book for you. 'Orthodox paleontologists' — as he derisively calls them throughout the book — take a verbal pasting from Dr Bakker, but it all adds up to an exciting, convincing tale.

The book is copiously illustrated with appealing and informative line drawings by the author — but perhaps not quite up to his usual very high standard. John Gurche's striking action shot on the dust-cover fits the theme of the book perfectly; it shows a life-and-death battle between a tyrannosaur and a ceratopsian (wrongly labelled *Triceratops* in the credit) — both depicted in attitudes far removed from the orthodox view of dinosaurs as sluggish reptiles. The message throughout the book is clear: dinosaurs have had a raw deal at the hands of orthodox palaeontologists since the thirties, and it is Bakker's crusade to put that right.

In Part I, 'The Conquering Cold-bloods: a conundrum', he briefly reviews the geological history and global distribution of dinosaurs, leaving no doubt that the whole Mesozoic world belonged to them. Even though mammals were around for all that time, they remained very much in the shadows until the dinosaurs finally quit the stage.

Do the reptiles today really deserve their relegation to second-class status in a mammal-dominated world? Bakker thinks not: 'Whenever I read Kipling's 'Rikki-Tikki-Tavi', I root for the snake'; the metaphor of the snake in Kipling's story — size and strength without brains or honour — is undeserved. It is a hangover from the attitudes of classical antiquity when Man was viewed (and, let's face it, still is) as the pinnacle of the Creator's efforts: those closest to him are the most superior or advanced; those furthest removed, the most inferior — especially loathsome creatures that slither and crawl, like reptiles. By this measure, then, reptiles are inferior 'lower vertebrates'.

But Bakker protests. Cold-blooded reptiles and amphibians are not inherently inferior to warm-blooded mammals; in any tropical rain forest — the richest habitats for vertebrate species — they are the dominant types, in both abundance and diversity. And in the realm of major riverine ecosystems the crocodile, not the lion, is king. If success is scored on the basis of species diversity, the cold blooded tetrapods beat the mammals hands down. And as he points out, the famous Komodo Dragons of Indonesia feed on goats, water buffalo, and German tourists! How much more superior can you get?

In examining ecological successes and failures, Bakker shows that the pattern in dinosaurs is far more like that of mammals than that seen among reptiles (relative success/failure in freshwater predator niches; as physically small species; as large terrestrial predators, etc). In virtually every area where modern reptiles succeed, the dinosaurs (and mammals) fail, and vice versa. Bakker's conclusion: dinosaurs were in important respects more like modern mammals than like modern reptiles; to be a successful big land animal when mammals are around, you must cope with mammals, and to cope with mammals you must be a mammal yourself, or at least have a metabolism as high as a mammal's.

Part 2 ('The Habitat of the Dinosaurs') looks at dinosaurs as living components of ancient ecosystems, and

it attempts to correct distorted views of the life-style of various dinosaurian groups. Taphonomic investigations and palaeosoil analyses show conclusively that sauropods lived on dry land, not in swamps. The long sauropod neck is shown to be a device to lift the head up to tall forest branches to browse, not to snorkel from great depths under water to breathe (there is even the intriguing suggestion that, by analogy with elephants; the rear-placed diplodocid nostrils might be explained by their having an elephant-like trunk!).

Even the 'pin-headed' build of some dinosaurs (like sauropods and stegosaurs) does not mean that they couldn't gather sufficient food to feed a metabolically supercharged multi-ton frame; ostriches and other large ratites cope perfectly well in maintaining some of the highest body temperatures on record today, yet they are built to a basically 'pin-headed' body plan. The reason is simple — both use gizzards far removed from the mouth to process the food (the task in the dinosaur gizzard was done by gastroliths instead of grit).

And what did dinosaurs eat? 'Orthodox paleontologists insist most of their dinosaurs ate mush'. Detailed study of dentitions, tooth wear facets, tooth replacement patterns, and normal head pose as shown by spinal curvature, lead to the conclusion that Jurassic sauropods and Cretaceous duck-bills ate tough fibrous plant foods, the sauropods as canopy-height high-browsers, the duck-bills feeding low to the ground. In the case of the Cretaceous dinosaurian herbivores, their complex dentitions were marvellously intricate with shredding surfaces every bit as specialized as those of any modern antelope or horse, if not more so. These adaptations were certainly not for eating 'mush'.

This part of the book ends with an interesting suggestion that dinosaurs had a direct hand in the evolution of flowering plants ('When dinosaurs invented flowers'). The earliest angiosperms appeared when dinosaurs were unquestionably the dominant terrestrial herbivores. The extinction episode at the end of the Jurassic had swept away a host of high-browsing dinosaurs, which had ignored the carpet of saplings and seedlings close to the ground. Once the low-browsing Cretaceous dinosaurs arrived, they attacked this low-growing carpet, clearing space for the pioneer angiosperms to establish themselves and lift their fast-growing tips above the threat from the dinosaurs. Their ability to produce and distribute many seeds also gave them the edge in the game of survival against herbivores and plant competitors.

Part 3 (Defense, Locomotion, and the Case for Warm-blooded dinosaurs) is probably the main reason why this book was written in the first place. It is an area of vertebrate palaeontology that Bakker has made virtually his own. He has often been accused by some of his peers of oversimplifying or overstating the case for dinosaurian warm-bloodedness, so this is his chance to give a definitive statement of his case. In my opinion, that is precisely what he has done.

First he reviews his own early work on dinosaurian limb anatomy which demonstrates that they had very unreptilian erect limb suspension, and that some (like *Triceratops*) were capable of galloping like rhinos. As he points out, many trackways are now known, all of which confirm his conclusions about stance and gait in dinosaurs — 'footprints', as he says, 'don't lie'!

Two chapters then review the variety of defensive and aggressive adaptations of different dinosaurs, drawing a practical distinction between structures used for non-lethal intraspecific, usually sexually related, behaviour, and those that were for serious interspecific confrontations; everyone knows the impressive variety of bony weaponry — horns, frills, spikes, knobs, plates, etc. — possessed by various dinosaurs. At the end of this section Bakker poses, but does not answer, an intriguing question: why is it that the dominant herbivores at the close of the Cretaceous, the duck-bills, totally lack any kind of armour or weapons while their contemporaries, the ceratopsians, represent the ultimate in vertebrate defensive heavy-armour?

A slight digression from groups traditionally accepted as dinosaurian allows Bakker to air another of his heresies: that pterosaurs are dinosaurs, not some distant vague relative as averred by orthodoxy. In building his case for warm-bloodedness there could be few better witnesses in support of his case — several pterosaur specimens are now known which bear clear traces of a 'woolly' body covering which must surely have been insulatory. What can be the purpose of insulation if not to regulate the uptake or loss of body heat? Other aspects of pterosaur palaeobiology, including their huge range in size (bat-size to something as big as a DC-3 aircraft — from Texas, of course!), their many and varied feeding adaptations, and even merely their highly specialized means of locomotion — powered flight — are advanced to build a compelling case that they had an elevated metabolism and were warm-blooded. *Archaeopteryx* too is a key witness. Ever since John Ostrom of Yale showed conclusively that birds and dinosaurs are directly linked via *Archaeopteryx*, controversy has raged over the status of this tantalising little fossil form. Notwithstanding the press prominence given recent claims by Sir Fred Hoyle and his colleagues that the feathers of *Archaeopteryx* are fakes, there can be no serious doubt about their genuineness. Again, why was it insulated with feathers if not to retain and regulate endogenic body heat?

Even the notion of 'mass homeothermy' — which says that dinosaurs maintained their body temperatures within narrow limits because of the thermal inertia of their great bulk — cannot rescue the orthodox 'reptilian' view of dinosaurs, because even a multi-ton, warm-bodied brontosaur would have cooled to potentially lethal lows at night, and during rainy periods; furthermore, some dinosaurs are known to have inhabited areas of seasonal freezing. In any case, not all dinosaurs were huge.

The next four chapters make up Part 4 — 'The Warm-blooded Metronome of Evolution' — a consideration of some hidden aspects of dinosaurian palaeobiology, including: sexual signalling, particularly the likely use of colour and sound by dinosaurs; bone histology in relation to its significance in reconstructing the physiology of extinct animals; the fact that several dinosaurs probably had bird-like air-sac systems with extensions into their often pneumatic bones, and that they must have had large,

high-pressure, four-chambered hearts (large sauropods had to pump blood vertically up to 8 m to reach the brain); and a review of modern ideas on encephalization (brain:body indices) in dinosaurs. The link between a large brain and warm-bloodedness appears real to the extent that a large brain seems to be possible only in a warm body; no large-brained, cold-blooded organisms are known, but conversely some warm-blooded organisms have surprisingly small brains.

Bakker is particularly well-known for one thing in piecing together the biodynamics of past ecosystems: his often controversial analysis of fossil predator:prey ratios as a means of reconstructing the physiology of extinct animals — a way of metaphorically shoving a thermometer up the rear end of an extinct animal to measure its body temperature. There has been much criticism of his methods, especially because of the taphonomic and collecting biases that can so easily distort the potential demographic information of museum collections. But the fossil record is all we have. Where else can we get evidence of this kind? We must make the most of it — as Eldredge and Gould did in developing their 'punctuated equilibrium' theory - they accepted the 'incomplete' fossil record as it was and extracted from it the last scrap of useful data. I believe that Bakker's work on predator:prey ratios is in similar vein. Perhaps the ratios he calculates are not accurate to the *n*th decimal place, but they are at least first order estimates of bioenergetic balance sheets in the real but vanished world they represent. On his figures there can be little doubt that dinosaurian predators had energy requirements very much more like those of modern mammalian predators than like any known cold-blooded predator; in fact, if anything, the data indicate higher energy requirements for top dinosaur predators than for top mammalian predators!

The final four chapters make up Part 5, 'Dynastic Frailty and the pulses of Animal History'. Sauropod evolution in the Morrison Formation is shown to fit well with the Eldredge/Gould model of punctuated equilibrium, and it is noted that evolutionary turnover rates in dinosaur lineages are far more like those of mammals than those of reptiles. Bakker points out that dinosaur ancestors took over from a world dominated by the advanced mammal-like reptiles ('protomammals'), which, by all the available evidence, were warm-blooded. Yet even with these advantages, protomammalian predators had to yield to the 'crimson crocs' (erythrosuchid thecodontians, which probably include the ancestors of the dinosaurs). The conclusion seems inescapable: the early archosaurian predators must also have been warm-blooded to out-compete the advanced cynodonts. So, according to Bakker, the warm-blooded pedigree of the dinosaurs extends right back into their Triassic ancestors, and it should not surprise us when we see it in the dinosaurs themselves.

A brief and not altogether satisfying consideration of the great Cretaceous extinction event follows. Surprisingly, he dismisses the currently popular asteroid/comet impact theory and instead concludes that the most likely cause of the extinction was continental scale faunal interchange coupled with global sea-level changes. At a time of deteriorated ecological equability at the end of the Cretaceous, shallow epeiric seas drained, causing a crisis at sea and opening up migration routes between continents (notably between Asia and North America). Massive invasions of immigrants then took place in both directions, especially of warm-blooded animals because cold-blooded animals are far more strictly tied to their own local environments and tend not to travel very well; unchecked predation and unchecked spread of disease in turn wreaked havoc on communities. Global biogeographical chaos resulted, with mass extinction its ultimate consequence.

The final chapter is a better-argued restatement of Bakker's view, first published with Peter Galton in 1975, that the dinosaurs constitute a true monophyletic clade. To accommodate it taxonomically he proposes reinstatement of Owen's taxon, Dinosauria. His arguments seem sound. He has a few other marginally less radical taxonomic proposals to make, but one very important plea: that dinosaurs be removed from the Class Reptilia — because he believes to leave them there does positive harm to a proper understanding of them; instead, the Dinosauria should be elevated to Class status by themselves. Many are beginning to think he has a point.

So, finally — if dinosaurs were so hot, how come they're all dead? Bakker says they're all dead *because* they were so hot! Their elevated metabolism made them substantially more vulnerable to catastrophic changes because their metabolic requirements were so demanding and they were so finely tuned to their local environments.

Dr Bakker is an erudite advocate who writes in an upbeat, informal style, so the book should appeal to an audience much wider than just his scientific peers. While the 'popular' style means that arguments are not as rigorous or as meticulously referenced as would be expected in a more 'serious' work, there is much for the specialist in this book. The great current popular interest in dinosaurs and what caused their extinction will undoubtedly benefit sales. Most of the important primary literature is listed in the notes and references section, so skeptics can check his claims. There is an index, but it is far from comprehensive.

Right near the beginning of the book Bakker says: 'I'd be disappointed if this book didn't make some people angry'. Bob, I predict you won't be disappointed! But more power to you. In my opinion, if someone wants to know about dinosaurs, this is the book to read.

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Molecular Biology of the Gene

Watson, Hopkins, Roberts, Steitz and Weiner

Volumes I and II (Fourth Edition) (Benjamin/Cummings, Menlo Park); Addison-Wesley Publishing Group, Johannesburg 1163 pp.

The Molecular Biology of the Gene and the new Zoology. The debate on 'holism' versus 'reductionism' which has been recently pursued with vigour in certain quarters is of course not a new debate, although a dialectical approach has been formally introduced in recent times by Levins & Lewontin (1985). The distinguished embryologist Professor Pieter Nieuwkoop, who was director of the Hubrecht laboratory for so many years, remembers this debate as a prominent issue of his earlier years in the late thirties (Gerhart 1988), and the issue is also admirably dealt with by J.S. Haldane in his book *The philosophical basis of biology,* which was published in 1931. This debate clearly bears on the question of 'why molecular biology for zoologists'?

For some scientists the ongoing debate has been a non-debate. This is seen, for example, in the approach of certain embryologists, who on the one hand analysed development in reductionist terms, yet were nevertheless also acclaimed for trying to see how the chosen parts interacted to represent the holistic picture of embryogenesis. Take for example Spemann's famous experiment of the transplanted dorsal lip which caused the induction of a secondary embryo within a developing egg. In commenting on the results of this experiment, it is specifically noted in an authoritative textbook of embryology that the parts, of the secondary embryo which forms, may be in a 'harmonious relationship with one another' and that an overriding 'gradient unites the parts of the developing embryo into one whole, into one morphogenetic system' (Balinsky 1981). This interpretation suggests that some researchers seem to have found a balance in the above debate which would be, unbeknown to them, in tune with the so called anti-reductionist point of view of Levins & Lewontin (1985, p. 288) which sees 'the various levels of organization as partly autonomous and reciprocally interacting', while at the same time also in tune with the reductionist approach of molecular biology. In fact many embryologists are struggling to integrate the detailed findings of how genes act within the complex system of the developing embryo, as well as to see how all this in turn bears on the adaptive complexity of animals and evolution.

Nevertheless, most zoologists have come across the viewpoint of those who believe that the study of the micronature of living systems, such as pursued by molecular biologists, is misleading in terms of understanding the 'holistic' nature of living systems. It is perhaps in this spirit that Levins and Lewontin write that, 'we must reject the molecular euphoria that has led many universities to shift biology to the study of the smallest units, dismissing population, organismic, evolutionary, and ecological studies as forms of "stamp collecting", and allowing museum collections to be neglected'(Levins & Lewontin 1985). This situation has certainly not been the case in zoology departments in South Africa. However, the converse is also true namely, that to ignore the remarkable findings of DNA biology, as well as the consequent effects which these findings and techniques are having on the interpretation of holistic zoology, is to miss out on one of the most exciting and influential explosions of biological knowledge in our time.

While the reductionist approach may be practised in zoological research, it is also surely practised in the teaching arrangement of zoology departments. Zoology departments teach components ranging from molecules to ecosystems, spanning the contemporary spectrum of zoological science. As the 'holding company' of zoological subdisciplines within the hierarchical organization of living systems, it is perhaps for zoology departments (and for zoology as a subject) to be charged with the responsibility, both holistic and reductionist, of holding together 'the various levels of organization as partly autonomous and reciprocally interacting'.

The make-up of zoology departments, influenced as they are by the contemporary science-scene, are obviously shaped by the forces prevailing in the job market. In a recent article in the *New Scientist* attention was drawn by Peter Calow to a particular proposal that zoology is out of date and that zoologists are unemployable. It was further pointed out that it was not well known what modern zoology entails and that 'misinformation about career prospects' was widespread. The Zoological Society of London, we are informed, responded to these pessimistic claims by conducting a number of fact-finding surveys. 'The results suggested that ... zoology as a subject has continued to evolve to embrace a wide range of other disciplines.' It was found that not only do zoology graduates find jobs, but that it could be possibly argued that 'with their broad-based education in relevant subjects, zoology graduates are better qualified than most to play a useful role in modern society'. It was also interesting to note that the number of research projects in the broad field of molecular biology in British zoology departments almost doubled between 1975 and 1985 (from 149 to 277). This increase in studies could be subdivided as follows: 150% for developmental biology, 125% for immunology, 115% for biochemistry, 60% for neuroscience and 28% for cell biology and ultrastructure. The next largest area of increase was in environmental studies (from 91 projects in 1975 to 130 projects in 1985), followed by studies of whole organisms (an additional 41 projects mainly in animal behaviour and parasitology). These changes were reflected by the recruitment of new kinds of academics in the fields of animal behaviour, embryology and development, neuroscience, biochemistry, molecular biology, immunology and ecology. It was pointed out that the number of endocrinologists, marine biologists, freshwater biologists and physiologists have however remained stable over the past decade. In conclusion we are reminded of Peter Medawer, who won the Nobel Prize for his pioneering work on immunological

tolerance, which he did while professor of zoology at University College, London, and of the words from his autobiography that 'A person who was really good at zoology .... would be qualified to turn his hand to most things — zoology graduates have at one time or another held such positions as Director General of UNESCO, Director of the London School of Economics, Director of the National Institute of Medical Research'.

As is known, some of the spectacular developments which are taking place in the 'new biology' are in the field of developmental biology; in the understanding of the generation of immunological specificity; in the understanding of viral action and cancer; and in the molecular trajectories tracing the evolution of the gene. These are the topics dealt with in the 416 pages of Volume II of the *Molecular Biology of the Gene*. The chapter on Developmental Biology (a field that this reviewer is reasonably up to date on) did not present me with any special new vision of the subject. It is however a clearly written and focussed account of recent developments in the field, and is a useful and digestible story for undergraduate and honours students. On the other hand I have been wanting to update and clarify my scanty knowledge of the 'how and why' of viruses, without reading a whole textbook. I found the virus chapter was extremely informative and succinct in this regard. Likewise for the other chapters. Reading through Volume II, one encounters partial or whole gaps in one's background knowledge. It was on these occasions that I first dipped into Volume I, with great benefit. Volume I is billed as containing the general principles, and is composed of the following chapter headings: (1) The Mendelian view of the World. (2) Cells obey the laws of chemistry. (3) Nucleic acids convey genetic information. (4) A chemist's look at the bacterial cell. (5) The importance of weak chemical reactions. (6) Coupled reactions and group transfers. (7) The genetic systems provided by *E. coli* and its viruses. (8) The fine structure of bacterial and phage genes. (9) DNA in detail. (10) The replication of DNA. (11) Recombination at the molecular level. (12) The mutability and repair of DNA. (13) The synthesis of RNA on DNA templates. (14) The genetic code. (15) Regulation of protein synthesis and function in bacteria. (16) The replication of bacterial viruses. (17) Yeasts as the *E. coli* of eukaryotic cells. (18) Recombinant DNA at work. (19) The unexpected structures of eukaryotic genomes. (20) The functioning of higher eukaryotic genes.

Volume I is written with remarkable lucidity. One recognises paragraphs from the text of the previous editions of Watson's *Molecular Biology of the Gene*, as well as approaches from Watson, Tooze and Kurtz — *Recombinant DNA: A short course* (1983). The figures are extremely clear and informative. I am convinced that any general zoologist who wants to update his or her knowledge of molecular biology will find him- or herself mesmerized by the fascinating and easily assimilable text. Reading up on topics that one is not familar with is a journey of enchantment. Do you need to check up on transposons, on DNA replication, on transgenic animals, or on oncogenes? The time is ripe for more zoologists to be integrating the wondrous findings of molecular biology into their particular subject areas. Here's to the continued polymorphic strength of Zoological Science in future eons!

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Evolutionary Biology

Eli C. Minkoff

Addison-Wesley Publishing Company, Massachussets, 1983 627pp.

The book comprising 28 chapters grew out of the author teaching a course in evolution. It attempts to redress a problem often faced by students taking a course in evolution.

> 'In searching for a textbook for the course, I found that there were several good books treating evolution from the standpoint of genetics, or paleontology, or some other component discipline, but no one book covered all the necessary subjects together. I thus found myself using a series of three or more texts to cover different aspects of the course.....' (preface).

The book is divided into two introductory chapters and four units. In Chapters 1 and 2 the author briefly discusses the meaning of evolution, properties of life, the nature of science, the overall philosophies about living things and basic principles of genetics.

Unit I, comprising Chapters 3–6 of the book, traces the historical development of evolutionary biology from the times of the Greek philosopher Anaximander to the 1940s when Julian Huxley proclaimed the modern synthetic theory of evolution. It is full of interesting snippets of historical information ranging from a very early theory of natural selection as suggested by

Lucretius in his *De Rerum Natura* (circa 55BC) to the denounciation of the chromosomal theory of heridity by Lysenko as 'burgeois capitalist idealism' in 1936.

The remainder of the book deals with the modern synthetic theory of evolution, and the advances that have been made since the 1940s. Unit II, made up of Chapters 7–15, discusses evolution at and below the species level, whilst Unit III, Chapters 16–24, is devoted to evolution above the species level. Thus the core material of modern evolutionary synthesis is dealt with in Units II and III and covers wide-ranging topics such as speciation, evolutionary trends, electrophoretic measurement of natural population variability, biochemical tracing of relationships and the evolution of altruism. However, this important core material of evolution is not covered in sufficient depth to satisfy the needs of advanced students. In a way this is understandable. Evolution is such a vast field and in attempting to cover all aspects of it in 627 pages some areas will have to suffer. Unfortunately it is depth in the areas of microevolution and macroevolution that suffers. This, however, is compensated for by the exhaustive reference list for each chapter at the end of the book.

These areas of evolutionary theory are fraught with controversies and I would like to have seen Minkoff drawn into these debates. Minkoff has strong gradualistic learning.

> 'It has now been definitely established that nearly all speciation is gradual' (p. 245).

Although he gives the punctionalist's view coverage he does not defend his standpoint. In practically all debatable areas of evolution he merely presents the views of opposing schools. It would have made more interesting reading if he clearly stated and defended his stand on these issues. In a book of comprehensive coverage where the author attempted to include all new developments and ideas in evolutionary biology I was pleasantly surprised to find that no mention is made of the Recognition species concept and SMRS. Perhaps Minkoff views that the recognition concept and the isolation (Biological species) concept as being two sides of the same coin and saw no reason for differentiation!

Unit IV titled 'The Course of Evolution' is a bit of a disappointment. In tracing the evolution of the major phyla I would have expected some inferences to be made to phylogenetic relationships. But the treatment of these, especially the animal phyla, is so generalized that it reads as a simple resumé of the animal groupings. Here again this is, perhaps, the penalty paid for attempting to cover too much in one book.

These shortcomings should in no way detract from the usefulness of this book. It is written in a style that is easily readable and, by and large, the illustrations and photographs are sharp and clear. The book would be of great benefit to undergraduate students who have had some exposure to introductory biology. It could also be meaningfully read by those with no formal training in biology for the approach adopted presumes no prior biological training. It defines all new terms as they are encountered and concludes with a useful glossary. The book does fill the gap between specialized books on evolution and the sketchy accounts of evolution in the more generalized biology books. Since it fulfills this important role it should find a place in all biological libraries.

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An ecosystem approach to aquatic ecology. Mirror Lake and its environment

Edited by Gene E. Likens
Springer-Verlag, New York
xiv – 516 pages; 197 figures
Price DM 169,00

This compilation by 23 contributors describes and synthesizes the aquatic ecology of Mirror Lake, a small (15 ha) waterbody in a small watershed (85 ha) of the well-studied Hubbard Brook ecosystem in New Hampshire, USA. As such, it is a valuable sister volume to two much more concise volumes dealing principally with the forest ecosystem of the watershed, and is a useful addition to the limnological and ecological literature. The relatively small dimensions of this watershed have permitted more refined quantification of linkages between air, land and water than can be achieved in larger systems, and the book is imbued with the authority and conviction bred of observations spanning more than two decades.

The book is organized into nine chapters. The first serves as a short introduction which outlines the holistic ecosystem approach, and identifies the principal input-output pathways upon which the watershed system is structured. The second summarizes the environmental parameters and biogeochemistry of the Hubbard Brook valley. Chapter 3 describes the physiography of Mirror Lake and summarizes the vegetational history of the catchment as interpreted by pollen analysis of lake cores, as well as recorded events of recent history relevant to the ecology of the lake. Chapters 4 to 6 which deal with the lake itself comprise more than half the volume. They describe the physical and chemical characteristics of the lake, its biota, and assess ecological interactions within the lake ecosystem. Chapter 7, on palaeolimnology, contains sections styled rather like separate papers, in the format of introduction, methods, results and discussion, which deal sequentially with diatoms, animal microfossils, fossil pigments and sediment chemistry, but are integrated in a concluding section.

The final chapters contain much of the new insight provided by this comprehensive study. Chapter 8 considers the ecosystem in relation to air-land-water interactions, while Chapter 9 assesses the applied implications of air and watershed management of the ecosystem. Particularly as a result of these chapters, I consider that the book meets its early claim as being 'one

of the first attempts to evaluate the historical and current limnology of a lake relative to the influences of its watershed and airshed'. It is abundantly clear that our knowledge and understanding at this level is rudimentary, but useful patterns are explored — particularly in regard to the influence of developmental phase of the catchment upon hydrologic and biogeochemical flux and mobility. Earlier assessments of carbon sources and fates in systems differing especially in water retention time are especially thought-provoking. The volume closes with an extensive and up-to-date reference list (over 1100 citations), and taxonomic, locality and general indexes.

Overall, the style is consistent for a multi-authored volume, which I found very readable. However, there is considerable duplication between these covers, although it was seldom obtrusive and often helpful. Expanded scales justified duplication of Figures V.A. 5-4 and V.B. 5-2, although this format of sequential numbering used for figures and tables is very awkward and cumbersome. The book is well produced, with numerous clear figures and tables, and I encountered few typographical errors.

Although the book is a serious advance in its field, it also selectively provides some very basic information, such as on the general features of particular zooplankton taxa — for example their feeding and life-history traits. Brief methodological descriptions are scattered through the book, generally at points where such considerations are relevant to the conclusions being drawn. Potentially complex concepts are generally explained clearly and increase the book's educative value even for specialist readers. Regrettably, in a very important section (V.C) describing the organic carbon budget of Mirror Lake, and drawing extremely valuable insights, quantitative textual comparisons with other lakes were difficult to resolve with the tabulated data presented in support thereof.

Much of the information contained in the book is familiar as a result of prior publication. However, the synthesis provided in this volume which integrates the nutrient cycling and fluxes within this ecosystem is undoubtedly a major advance worthy of publication. My only reservation concerns its length. More rigorous selection of information to support and advance the central tenets of the volume might have led more concisely to the principal conclusions concerning ecosystem 'structure and function' — that widely cited but vaguely understood phrase. Nonetheless, the information included provides a comprehensive and thorough limnological case study of this beautiful lake in the idyllic fall landscape portrayed in the colour cover photograph of the volume.

The book could well become what it describes — a watershed. While its emphasis focuses more sharply upon the 'water' than the 'shed', this is obviously justified in a volume on aquatic ecology. The new insight provided at the ecosystem level of organization is particularly valuable. It is undoubtedly an authoritative reference text for aquatic ecologists, but contains snippets of interest to a more general readership. Sections of the volume will be useful reading for postgraduate students, and I expect to draw extensively upon this welcome addition to my bookshelf. I have already returned more than once to the stimulating section (IV.A) on 'Importance of perspective in limnology'.

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The Physiological Ecology of Seaweeds

C.S. Lobban, P.J. Harrison and M.J. Duncan
Cambridge University press, Cambridge, 1985
242 pages
Price £35

This book is an invaluable review of macro-algal physiology/ecology. It is clearly written and highly readable with a uniformity of layout and style (despite three authors) which makes it an easy volume to work from. Each chapter has an introductory section and provides the basic background to the subject covered. It is further broken down into short, manageable and logically linked sections and builds up to a clear exposition of our present understanding and of gaps in our knowledge. The synopsis at the end of each chapter is especially useful. This approach is one of the strongest attributes of the book. The logical build-up removes much of the mystique of the subject and is particularly helpful to the non-specialist.

The first half of the book is physiological and provides the background for the more ecological second half. Following an introductory first chapter, Chapters 2–6 cover five key environmental factors in turn: light, temperature, salinity, water movement and nutrients. Each of these chapters begins with the physics and/or chemistry involved. It then examines the effect of each factor on the organism, working up from the molecular or cellular level to the whole organism, finally covering populations and biogeographic effects. Chapter 7 covers carbon metabolism in detail, including structural polysaccharides as well as anabolic and catabolic pathways.

The second half of the book begins with Chapter 8 which covers pollution and considers the origins and effects of various forms of pollutants. Chapter 9 deals with intertidal communities. As with the other chapters the scene is first thoroughly set by detailing variations in tidal regimes and the development of biological and physical zonation schemes. Only then do the authors move on to population dynamics, zonation, grazing and competition ending by considering interactions of these factors. As this is in my own field of research I can appreciate the vast quantity of literature available and the effectiveness of this synthesis. Chapter 10 examines morphogenesis, beginning with cell and thallus

morphogensis and followed by reproduction and regeneration. The book finishes with a very short chapter on mariculture.

Figures, tables and plates are all well set out and useful. The reference section is thorough and comprehensive, including much valuable information. I recommend the book highly to the non-phycologist who has an interest in seaweeds, and indeed to the seaweed specialist. It is also an excellent summary of the subject for post-graduate and senior undergraduate courses on seaweeds or ecology.

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Principles of ecology

R.J.Putman and S.D. Wratten
Croom Helm, London, 1984
388 pages
Price £10.95 (paperback), £22.50 (hard cover)

This book is designed to be a thorough review of ecological principles for use as a text for 2nd or 3rd year students. It succeeds admirably in the first aim but is too advanced and contains too much detail for students who are not undertaking a sizeable course in ecology. The ideas contained are generally clear but the style is erratic. While parts are clearly expressed, others require very careful attention, detracting from the readability of the book as a whole. It provides a sound mathematical background to many of the concepts explained, without going to excess, and benefits from using examples from a wide range of systems and environments, though with a terrestrial bias. One minor point is that many of the figures are poorly reproduced. Despite these drawbacks this is a very useful overview of ecology and ecological theory, especially as the basis for the theory is thoroughly and critically examined. The book as a whole is logically structured and, while it is not a text concerned with current ecological issues (few of the references are more recent than 1980), I recommend it to teachers and postgraduate students as a valuable analysis of ecological principles.

There are 13 chapters which, I feel, fall into 3 broad sections: community ecology; population biology and evolutionary aspects of ecology. Chapter 1 examines the relationship between the organism and its physical environment, giving a brief summary of ecophysiological principles. The following three chapters develop the concept of the ecological community and ecosystems and how they function. They cover food webs and community structure; nutrient and energy flow, and temporal changes in the community such as colonization and succession. Having established this framework the authors examine the relationship between the organism and the community in a discussion of niche theory (Ch. 5). Questions of niche overlap then lead logically to competition and how this affects community structure (Ch. 6).

This links the first section of the book to the second which deals with the question of what controls numbers of organisms i.e. population biology. This is dealt with in three chapters: definitions of population structure and population analysis (Ch. 7); competition and population stability (Ch. 8); predation, parasitoids and population stability (Ch. 9).

The final part of the book covers evolutionary aspects of ecology. Chapter 10 sets out the relationship between ecology and evolution by examining adaptation, including reproductive adaptation (r and K selection) and behavioural adaptation (optimal foraging theory). This is followed by an examination of co-evolution in Chapter 11. The book ends with two chapters on evolutionary aspects of the community, diversity (12) and stability (Ch. 13).

All in all a little heavy going in places but a useful review of the subject as a whole.

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