they were a larger fraction of the book. But then I am not the 'layperson' for whom it was written or selected by the Commonwealth Fund book programme. I can certainly recommended it for someone wanting a readable overview of modern astronomy, livened up with anecdotes and without the myriad glossy pictures common in many such books. □

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Rodent preserve

Donald K. Grayson

Packrat Middens. The Last 40,000 Years of Biotic Change. Edited by J. L. Betancourt, T. R. Van Devender and P. S. Martin. *University of Arizona Press: 1990. Pp. 467. $55.*

FROM Nicaragua to northern Canada, packrats (*Neotoma*, Muridae) accumulate plant material and other items in and near their dens. In arid settings, the impregnation of these accumulations by packrat urine produces dark, indurated middens. During the 1960s, P. V. Wells and C. Jorgensen demonstrated the existence of plant-rich middens of Pleistocene age in southern Nevada, and in so doing introduced a formidable tool that could be used to probe the palaeoecology of the arid west: a source of late Pleistocene and Holocene plant fossils that could be accurately dated.

More than a thousand packrat middens from arid western North America have now been analysed and dated, much of that work done by students of Paul S. Martin of the University of Arizona's Desert Laboratory. *Packrat Middens: The Last 40,000 Years of Biotic Change* summarizes what has been learned, where the problems may lie, and what the future may bring. With the exception of Wells himself, all the major names in this small discipline are represented here.

Packrat Middens begins with an assessment of the methodological difficulties that these middens present, emphasizing that different species of packrats have markedly different diets and that all packrats collect biased samples of plants from around their dens. Indeed, reoccupation of identical midden sites by different species of packrats can result in the accumulation of very different plant assemblages. There is bias in the accumulated sample as well: most middens date to the late Pleistocene or late Holocene, with a conspicuous lack of examples from the mid-Holocene. In addition, our current midden sample is not randomly distributed across slope aspects or rock substrates. Given that plants respond sensitively to these variables, the potentials for bias are clear.

It is a necessary hallmark of palaeoecologists that they worry about severe biases in their data at the same time as they go about their business. This book is no exception, presenting superb midden-based syntheses of the past vegetation of the Chihuahuan, Sonoran, Mojave and Great Basin deserts, as well as of the Colorado plateau and the Grand Canyon. Readers may be astonished to learn that the lower elevation of North America's warm deserts were covered by woodlands during the end of the Pleistocene and into the early Holocene, and that the vast ponderosa pine forests of the Colorado plateau appear to be a Holocene phenomenon.

The dynamic plant histories are fascinating, but the themes and debates that tie these syntheses together give them global value. The authors are unanimous in emphasizing the individualistic responses of plant species to climate change; there are no plant communities marching across space to be found here. Less unanimity is to be found over the issue of vegetational inertia, the argument that plants may respond very slowly to major aspects of climate change. Even more debate greets the results of the climate modellers. W. G. Spaulding argues that there were strengthened summer monsoons in the Mojave desert in the early Holocene, as is required by the COHMAP model, but T. R. Van Devender amasses equally convincing evidence that the Holocene monsoonal maximum in the Sonoran desert occurred in the middle, not the early, Holocene. For the Great Basin desert to the north, R. S. Thompson notes that the early Holocene thermal maximum called for by the COHMAP model simply did not happen.

Potential directions for the future are also provided. A series of analyses focuses on subsets of materials from packrat middens–grasses, mammals, insects and the deuterium content of plant cellulose. These analyses are weaker than the general syntheses: samples are smaller, the causes of variations in deuterium content poorly understood, and modern arthropod faunas and morphology insufficiently known to tap fully the information provided by their fossil counterparts. The potential, however, is clear. Grasses identified to the species level allow Van Devender and his colleagues to question the argument that parts of the Sonoran desert supported a climax grassland before the introduction of domestic herbivores; Van Devender and G. L. Bradley show that during the past 15,000 years, arthropod assemblages seem to have been far more stable than plant assemblages in southwestern Arizona.

These studies demonstrate that increasingly detailed analyses of packrat middens are likely to bring spectacular results. Similar opportunities exist in other parts of the world. Hyraxes (Procaviidae) and dassie rats (Petromuridae) create middens in Africa and the Middle East; stick-nest rats (*Leporillus*) created them in arid Australia. An ancient world clearly awaits discovery.

Packrat Middens provides splendid accounts of the dynamic vegetational histories of North American deserts. Like other fossil-based assessments of Quaternary plant and animal histories, this book shows that modern biotic distributions cannot be understood without deep historical data. Let us hope that the Desert Laboratory, the intellectual source of this remarkable volume, will continue to thrive as long as there are packrats gathering plants in the American deserts. □

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Problems with diversity

Alan Brafield

Invertebrates. By R. C. Brusca and G. J. Brusca. *Sinauer: 1990. Pp. 922. £27.95, $47.50.*

THERE are some problems in zoology which defy solution but which will not go away. One is how to make sense of invertebrate diversity. There are more than 30 invertebrate phyla, each built on a unique ground-plan. How can they (and the subgroups within them) be meaningfully related, particularly with so little fossil evidence? Most invertebrate textbooks simply deal with each group in turn, but a few consider 'systems' on a comparative basis — feeding, respiration, movement and so on — a functional rather than a taxonomic view. Two years ago I wrote here of how successfully R.S.K. Barnes *et al.* in *The Invertebrates: A New Synthesis* had attempted both approaches, by first surveying the groups and then reviewing comparative functional biology. Brusca and Brusca have here tried to fuse the two. In the opening chapters they develop three themes: functional body architecture, patterns of development and life histories, and evolution and phylogeny. They then embark on the familiar tour through the phyla, but keep these themes well to the fore.

Unfortunately, the authors are not completely successful with their dual aims. They provide an immense amount of detailed information about all the groups, including the recently discovered ones, and so this is an invaluable and