

BOOK REVIEWS

Under Bungonia. Julie and Peter Bauer, 1998. JB Books, Oak Flats NSW, 284pp + 10 maps. ISBN 0 9586998 0 1.

– reviewed by Dave Gillieson

Superb! This is without doubt one of the best written and produced books on Australian caves. It sets some new standards in terms of the quality of the text, photographs and figures, and the authors are to be congratulated on producing a book that is a delight both to read and to look at. The colour photographs are mostly well reproduced especially the shots of fauna. This is an achievement in itself given Bungonia's propensity to swallow flashlight.

This book is a worthy successor to the classic "Bungonia Caves", produced by the Sydney Speleological Society in 1972. That publication provided a clear synopsis of scientific and sporting knowledge of the Bungonia area at that time, and has remained the key reference for over twenty years. It also had a clear and strong conservation message, which did much to turn the tide of unrestrained exploitation of karst resources. It has been much quoted, and I suspect misquoted, both at home and abroad. This book fully updates that older volume, and provides a wealth of information on cave fauna, fossils and basic caving techniques. In short, it is the indispensable guide for anyone seeking to enjoy and understand Bungonia.

The first three chapters deal with the geology of Bungonia and its fossils, and clearly reflect Julie's strong interests in local geology. These are followed by a very good chapter on ideas about the evolution of the landscape and its caves by Robert Wray. Following an exposition of the history of cave exploration, two chapters deal with hydrology and lithological controls on cave development. I am not sure that the order of chapters here is ideal, and the interesting historical chapter might have been better placed

further on in the book. Two fine chapters on cave bats by Andy Spate and invertebrates by Stefan Eberhard complete the strictly scientific part of the book. A very short and useful chapter on foul air by Garry Smith precedes two chapters on techniques by the Bauers. The next one hundred pages of the book are filled with cave maps. These are well executed and are drawn to several standard scales, which is an aid to interpretation. Following this is a useful brief glossary, a good reference list and appendices with species lists for fossils and invertebrates.

Especially valuable is the accompanying volume of ten large-scale maps of Bungonia's longer caves and the surface topography. As one who has been lost several times going to and coming from caves there at night, this will be especially useful. The maps are clear and have the level of detail scientists have long sought from speleologists. They will undoubtedly provoke some new theories about the development of Bungonia's karst and caves.

Producing a book – any book – is an act of courage on the part of the author. You put your reputation and knowledge on the line, and staunch friends may just turn into your harshest critics. Julie and Peter Bauer are to be congratulated on seeing this long and difficult project to completion and publishing it themselves. I urge you strongly to support this and their future endeavours by purchasing a copy. At \$45 it represents exceptional value for money.

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Teacher's Pack and Pupil Booklets – Dan-yr-Ogof Caves, Wales.

Written by N. Pattenden.

- reviewed by Kent Henderson

Clearly not a new book, as such, but this "karst literature" is most worthy of a review. The material consists of three A4 size colour booklets. *The Teacher's Pack booklet* aims to assist teachers in planning and preparing for a visit to Dan-yr-Ogof, and organising future class activities. Each topic in the booklet links to the National (UK) School Curriculum, and contains background notes, possible areas to explore in the classroom, and suggested future activities. Topics cover such things as the caves, geology, decorations, stone age life, the Iron Age Farm, local history, flora, and dinosaurs.

The *Pupil Booklets* (for 5-7 year olds, and 7-11 years olds) are also impressive. They contain appropriate focused learning activities, and are expertly set out and illustrated. Each book is superbly targeted to the topic areas, both above and below ground.

As a trained teacher, I have not seen better material of this genre. It is something that is missing from most Australasian Show Cave locations, and indeed, karst education for school children, in particular, is one area that widely needs addressing – for its own sake, and of course, school visitation is unlikely to suffer as a result! We could do much worse than emulate the Dan-yr-Ogof example. Any cave manager who would like a loan of my copies of the booklets, please contact me. Alternatively, I am certain the Dan-yr-Ogof management would assist with copies, if requested. Contact: Dan-yr-Ogof Show Caves, Abercraf, Upper Swansea Valley, Wales. SA9 1GJ. Phone: + 1639 730 284, FAX: + 1639 730 293, email: info@dan-yr-ogof-showcaves.co.uk

Dependence of Ecosystems on Groundwater and its Significance to Australia, 1998, Tom Hatton (CSIRO Land and Water) and Richard Evans (Sinclair Knight Merz), Land and Water Resources Research and Development Corporation, Occasional Paper No 12/98, 77 pp + 3 maps.

- Andy Spate and Mia Thurgate

Research in groundwater-dependent environments in Australia has been ongoing since at least the 1960s – if not the 1950s or earlier (e.g. Eardley 1943, Whitely 1945). Although not as extensive as similar research overseas, there has been a wealth of information produced and published in refereed journals, speleological society newsletters and journals, and in other forms of the so-called "grey" literature. Much of the work has been taxonomic or based on general natural history topics (particularly in the early years), with ecological research *per se* being a more recent phenomenon. The types of habitats included in this research have included cave pools and streams, mound springs and karst springs, surface lakes associated with karst depressions or directly linked to karst aquifers or interstitial environments, particularly beneath streams.

Most of these groundwater environments have been canvassed in Hatton and Evans' discussion – with the exception of interstitial environments but their emphasis has been on vegetation communities dependent on groundwater. These, clearly, are far more easily identifiable than the cryptic animals of cave or interstitial waters.

Much of the world's population is dependent on karstic groundwater (Watson et al. 1997). Groundwater dependence is a way of life in many areas in Australia (e.g. Perth, the Mount Gambier Region, stock and domestic water across the whole continent and increasingly for irrigation in the Murray-Darling Basin and elsewhere). The ecosystems associated with the groundwaters are very variably understood – and probably not interpreted well to the wider community. The Hatton and Evans report is an attempt to do this but it does have a number of deficiencies.

As our expertise relates to karstic groundwaters we will primarily confine our comments to this area of Hatton and Evans' report. However, we wondered at a number of gaps omissions and perhaps misinterpretations across their review of the literature and their discussion thereon for a wider range of wetland ecosystem types. The work does seem deficient in its review of karstic groundwaters and thus one becomes a little uneasy about the quality of the review as a whole. This unease is reinforced by statements such as:

Other permanent water features [in the South-Eastern Uplands] are formed by faulting (Lake George) or in association with basalt flows (Monaro Lakes near Cooma). [emphasis ours]

Whilst some of the Monaro Lakes may be permanent by far the majority dry up every year or so – not all are associated with basaltic flows by any means – some are in granite terrains; others are deflation features. And it is well known that, since its discovery by Europeans around

1820, Lake George has had a dry bed for more years than it has held water – at least until recent decades.

It would have been useful if the authors had consulted the Register of the National Estate and the Directory of Important Wetlands in Australia (Usback and James 1993). Hatton and Evans do cite the *Checklist of Australian Caves and Karst* (Mathews 1979) as a reference to Australian caves, but not the *Australian Karst Index* (Mathews 1985). The former was not by any means complete; the latter would at least have alerted them to the presence of many references dealing with flow regimes in karstic terrains.

Thankfully, the report recognises the existence of karst groundwater faunas. However, under the heading *Aquifer and Cave Systems* we find the following extraordinary sentence:

There is effectively no literature on groundwater aquifer ecosystems in Australia, apart from faunal surveys of a few cave systems (e.g. Jasinska and Knott 1991) and one study of cave flow regimes (Nicoll 1977). [emphasis ours]

Certainly a great deal of the admittedly limited literature on karst waters in Australia is in unpublished or difficult-to-find sources. But there is certainly more than one study of karstic flow regimes. For example, looking at the list of Joe Jennings' papers (published in the mainstream peer-reviewed scientific literature, Spate and Spate 1985) one sees about 15 papers on flow regimes. It should be noted that Nicoll's paper was on stream captures from a geomorphological perspective rather than on the hydrologic issue of flow regimes – if one includes that sort of paper in Joe's listing his count would rise to 25 or more. In the conference proceedings in which Nicoll's paper is published two papers dealing with flow regimes can be found both immediately following his contribution.

Similarly, what about the work of Allison and Hughes (e.g. 1972, 1975) on groundwater regimes in the Gambier region? Waterhouse (1985) is well known, but not cited; it documents everything from the hydrologic zones of the karst aquifer to a total water budget. Hatton and Evans, despite their focus on systems with a terrestrial expression, appear to have failed to recognize springs, cenotes and most of the volcanic craters as important groundwater ecosystems. They confuse Blue Lake as a karst feature *per se* when in fact it is a volcanic feature with an associated lake system which is karst influenced, rather than a feature formed by karst processes. There are at least 30 reports on the groundwater ecology of the Mount Gambier region.

Hatton and Evans do cite Eardley (1943) on the vegetation of Eight Mile Creek but do not have

appear to have seen much other relevant literature on this karst groundwater area *non pareil*. However, they do not seem to have understood that the system is groundwater-fed rather than base flow dependent. They have also missed numerous articles and theses that have examined the vegetation of the Piccaninnie Ponds. The most telling of these (Scholz 1990) is readily available in the literature. Its title – *Physiochemistry and vegetation of Piccaninnie Ponds, a coastal aquifer-fed pond...* – gives no doubt as to the groundwater dependence of the system.

Eberhard et al. (1994) produced an atlas of Tasmanian cave invertebrate fauna – many aquatic species are listed. Clarke (1977) built on this and produced management prescriptions for Tasmania's cave fauna – including stygofauna. In a similar survey of New South Wales caves, Eberhard and Spate (1995) surveyed around fifty cave areas with an emphasis on aquatic fauna and give a number of references to groundwater dependent fauna. Humphreys has done much work at Cape Range, the Pilbara and the Kimberley (see, for example, Humphreys 1993, 1995).

There is a readily available and fairly numerous literature dealing with syncarids in Tasmania (Lake and Coleman 1977). A recent paper by Bradbury and Williams (1997) lists around ten papers dealing with Australian freshwater amphipods. Admittedly many of these are taxonomic rather than ecologic in nature. However, their title does strike a chord in regard to groundwater ecosystems and their significance. It reads:

Amphipod (Crustacea) diversity in underground waters in Australia: An Aladdin's Cave [of treasures] [addition and emphasis ours].

Hatton and Evans do not give a complete reference for Jasinska and Knott (1991). We may have tracked down the citation (see reference list). Jasinska et al. (1996) is published in a refereed journal and does properly cite the 1991 reference.

How a Western Australian-based author could have missed the three papers dealing with subterranean aquatic fauna (stygofauna) to be found in Humphreys (1993) is difficult to understand? This is especially the case when two taxa are vertebrates – Australia's **only** troglobitic vertebrates, one a fish, the other an eel. The first of these, *Milyeringa veritas*, was described by Whitely as long ago as 1945. And there have been many other published references to these very exotic taxa since Whitely. One of the three papers in Humphreys (Knott 1993) alone contains 15 references to stygofauna across Australia. Hatton and Evans do make several references to Cape Range – consistently getting its name wrong – but do not cite any of the numerous papers by Humphreys, Knott and others on this internationally significant site. Hamilton-Smith et al. (1998) recommended to the Western Australian government that the area be considered for World Heritage listing – primarily for its groundwater fauna.

Members will recall that ACKMA and the Australian Speleological Federation jointly nominated Cape Range as an Endangered Karst Ecosystem to the Karst Waters Institute in 1997. The area was subsequently placed by the Institute on the *World's Top Ten List of Endangered Karst Ecosystems*. Hatton and Evans state:

Much less is known [about mound springs in the Great Artesian Basin and the Swan Plain groundwater than] about the vulnerability of the karstic groundwater ecosystems of Exmouth Cape [sic]; their distance from major centres and other development may make this less moot.

Hamilton-Smith et al. (1998) point out that there are many threatening processes at Cape Range – some quite acute. The Karst Waters Institute press release on the Top Ten says:

The peninsula contains a karst system with mostly endemic cave species and is amongst the most diverse in the world. The peninsula is threatened by a variety of land uses including water extraction, urban development, limestone quarrying, petroleum exploration, over pumping of water resources within the aquifer, and waste disposal. [To this one could add potential saltwater incursion into the aquifer]

Admittedly the Hamilton-Smith et al. report was not made public until March 1998 and we have no real idea when the Hatton and Evans report was commissioned and written. However, the Hamilton-Smith et al. document was submitted to the Western Australian Department of Environmental Protection in August 1996. It was immediately leaked to the press and considerable publicity resulted. It seems difficult to understand why Hatton and Evans did not become aware of the significance of the site at that time. This is especially puzzling given that one member of the steering committee for their project was heavily involved in the Hamilton-Smith et al. study.

Of the twenty people listed as having been consulted in the preparation of the report (including the steering committee of three) none are known to us as having any particular expertise in karst or interstitial groundwater ecosystems.

Hatton and Evans state in their conclusions:

Conclusion 1. The majority [sic] of Australia supports ecosystems with little dependence on groundwater, at least as defined in this report with an emphasis on vegetation. However, there are many localized or extensive ecosystems in Australia with at least a high dependence, and would suffer or cease to exist in its absence. These systems tend to have a high ecological and social significance....

The latter two sentences are undoubtedly true.

Conclusion 5. We conclude that vulnerability is too complex an issue to be treated meaningfully and comprehensively at a national level. Suffice to say, many of Australia's groundwater dependent ecosystems are vulnerable to the above kinds of impacts, but groundwater resource managers and investigators tend to underestimate ecosystem vulnerability with respect to groundwater development, pollution and land use change.

Again this conclusion must be fervently supported from a karst waters perspective.

One imagines that Bradbury, Humphreys, Jasinska, Knott, Eberhard and others might not agree wholeheartedly with conclusion 13 nor with recommendation 5 that follows:

Conclusion 13. Virtually nothing is known about Australia's aquifer ecosystems, their importance in terms of biodiversity, and their importance to the systems into which they discharge. The whole topic is so new that it is hard to judge as to whether or not it is just a research fad or if there are substantial issues to be addressed. Insufficient data exists in Australia to provide any scientifically rigorous assessment of the significance and nature of aquifer and cave ecosystems. Nonetheless, based solely on overseas (principally European) experience [much North American experience is also valid], it is expected that these ecosystems, at least those associated with shallow or karstic aquifers, represent a key part of the food chain and ecological processes which emerge as river base flow and flow into wetlands.

Recommendation 5. We do not recommend a large investment in aquifer ecosystems investigations. There may be some worth in assessing the potential of aquifer organisms to serve as indicators of ecosystem health.

Given the spread in time, geographic range and in-depth nature of many of the studies of karst groundwater ecosystems we **utterly** reject the notion of a "research fad". There are substantial issues to be addressed. For example:

- Perth is increasingly dependent on groundwater for its water supply. Effects on groundwater-dependent ecosystems are evident.
- the population of the south east of South Australia region depends on groundwater to support its timber, agricultural, viticultural, paper manufacturing and tourism industries as well as potable water supplies. The watertable has been drawn down by a number of anthropogenic processes and effects on the dependent ecosystems are evident.

- we have referred above to possible impacts on such sensitive and important sites as Cape Range peninsula.
- there may be threats to groundwater ecosystems from mining in Tasmania, Queensland and probably elsewhere. Potential threats are evident in areas like Colless Creek/Lawn Hill where proposed mining operations may cause a major catastrophe. In a study of interstitial groundwaters at Lawn Hill, Thurgate (1998) found two taxa of syncarids (both probably new species as none have yet been recorded from here) and a total of 40 species of macroinvertebrates in this specialised environment. Many of these taxa were not found in benthic samples from the adjacent stream beds.
- as the Murray-Darling Basin "cap" and the NSW Water Reforms process, in particular the Harvestable Rights policy, start to "bite" there is an increasing pressure to utilise (= mine?) groundwater resources. We know little about the interstitial fauna of the aquifers involved.

Their first recommendation may be more palatable:

Recommendation 1. Groundwater dependent ecosystems should be recognised as a key component in planning and groundwater allocation processes in Australia. This should involve an assessment of ecosystem susceptibility, analogous perhaps to vulnerability mapping for groundwater pollution. [emphasis ours]

The report includes an appendix titled Review of Australian Ecosystems and Potential Groundwater Dependency. Space precludes a complete discussion of the review but it can be said that discussion of karst groundwaters region by region using a modified version of Jennings and Mabbutt's (1977) regionalisation of Australia produces some strange bedfellows. For example, the karstic groundwater system south east of Mount Gambier including Ewens Ponds on Eight Mile Creek fall into a unit called the South-Eastern Uplands. The remainder of the Otway Basin groundwater system seems to be discussed under the heading of Murray Lowlands; the Otway Basin is stated to be underlain by the Murray Basin sediments. The Otway and Murray sedimentary basins are quite different. Either way, the rich ecosystems in caves and cenotes around the Mount don't rate much of a mention.

The region by region review fails to address karst-based groundwater ecosystems in very many places where they are most important but it does mention Cape Range, the Nullarbor and the aquatic fauna of the Swan Plain. Detailed discussion of the regional significance of the aquatic fauna of Australia's karstlands will be

addressed by the present authors and others – perhaps at the Naracoorte conference next year.

The regional review does include a section headed "Aquifer and Cave Systems" which briefly reviews the international state of play in this field. Citing Gibert (1996; not yet seen by us) they identify the following gaps in our understanding of aquifer ecosystems:

- impact of physical perturbation on the functioning of groundwater ecosystems
- ecological recovery following remediation
- impact of chemical perturbations on biodegradation processes
- changes on groundwater invertebrate communities and on organism viability
- the impact of land use practices on the structure and function of groundwater ecosystems.

These seem laudable goals.

We also need to know a bit more about these systems. The following knowledge gaps are also evident to us:

- we need more survey of karst aquatic ecosystems in both space and time
- we need to better understand the biology and ecology of the stygofauna
- we need to better understand community dynamics of the stygofauna
- we need to address the question of taxonomic "lag".

Let's conclude on a positive note. Hatton and Evans have noted and noticed the presence of karst-based stygofauna! They have addressed the issue and have pointed out needs for future information gathering and reinforced the need for consideration of groundwater dependent ecosystems in land use planning and management. Hopefully this will aid ACKMA and others in bringing attention to the fact that water under the ground surface is not sterile. ACKMA needs to build on this and demonstrate the significance of these faunas so that the wider community can relate to our pet position.

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