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Overview

The saga of the short range endemic

Jonathan Majer*

Centre for Ecosystem Diversity and Dynamics in the Department of Environmental Biology, Curtin University of Technology, PO Box U1987, Perth, WA 6845

*J.Majer@curtin.edu.au

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Abstract

Short range endemic invertebrates (SRE's), by their very nature, can be threatened if an impending development overlaps their range. Since their extinction would be unacceptable under State and Federal legislation, surveys for their presence are often required before approval for a project can be granted. Annually, millions of dollars are being spent in Western Australia on surveys for SRE's. By contrast, funds for research on non-SRE terrestrial invertebrates, which probably represent around 98% of animal species, are extremely sparse. This paper outlines the current attention that is being paid to SRE surveys, and contrasts it to the situation with the rest of the invertebrate fauna. The perils of not including terrestrial invertebrates in survey and research agendas are discussed, and more inclusive solutions which consider all terrestrial invertebrates are outlined.

INTRODUCTION

Invertebrates feature prominently in almost any terrestrial ecosystem that we can think of. As the aptly named conference *The other 99%: The Conservation and Biodiversity of Invertebrates* (Ponder & Lunney 1999) suggests, they are exceptionally diverse, with most animal species classed as invertebrates. Their role in ecosystem functions and processes is no less dramatic, with essential roles being played in soil structuring, nutrient cycling, pollination and propagule dispersal. From a land management point of view, apparently negative interactions with invertebrates such as herbivory or parasitism can enhance biodiversity by regulating otherwise dominant plants or animals. The fact that most amphibian and reptile species, and a sizeable number of bird and mammal species depend at least in part on invertebrates for food should also be acknowledged. Without invertebrates, ecosystems would cease to function effectively, and many vertebrates would starve. So important are invertebrates in our ecosystems that Wilson (1987) has described them as “the little things that run the world”.

Despite their ubiquity and importance, their role in Australian land management issues has not always been appreciated. Taking habitat restoration as one example, Majer (1989) conducted a year-by-year review of published articles that included invertebrates. No such papers were published prior to 1970, although the numbers have progressively grown to modest levels since the late 1970’s. This has been due in part to a general increase in research activity over this period, and in part it has also been a response to awareness campaigns conducted on an *ad hoc* basis by various entomologists.

The attention paid to invertebrates by land managers and conservationists has progressively increased, although attention is still somewhat skewed towards the more “charismatic megafauna”. A researcher would rejoice at receiving a 3-year $220,000 ARC grant to study invertebrates, assuming that he or she overcomes the 20.4% success rate! An approach to an industry partner to fund an invertebrate-focussed project that is relevant to their activity is more than likely to be met with a reply that ‘the discretionary budget is committed for the rest of the year’. At best, a company may contribute perhaps $50-100K towards a PhD project or support an honours student to carry out studies that are of relevance to their operations. Although this is much appreciated, the shortage of funds restricts our ability to tackle important issues in entomology and invertebrate biology.

THE START OF THE SAGA

Despite these problems in funding invertebrate research, interesting events are happening in Western Australia. Here is where it all began. The Cape Range

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Peninsula in northwest WA is characterised by its Miocene reefs, which contain a complex system of underground freshwater aquifers, some of which are not interconnected. From the late 1960's onwards, speleologists and local scientists discovered a hitherto unknown group of animals in the subterranean water, including amphipods, shrimp and two species of fish (Knott 1993). These subterranean water-dwelling animals, collectively referred to as stygofauna, tended to be confined to localised aquifers, with a high degree of species turnover between aquifers. By the nature of their distribution, they are classified as short-range endemics (SRE's), which, according to Harvey (2002), are species whose range is less than 10,000 square km. Eberhard *et al*. (2007) define an even more restricted criterion of range less than 1,000 square km. It follows that species in such localised areas are particularly vulnerable to extinction if their range is impacted by human development. Any development that threatens a species with extinction would be regarded as causing significant environmental harm under the WA *Environmental Protection Act 1986* and, if it is a listed species, would require special protection under the WA *Wildlife Conservation Act 1950* and to be a matter of national significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Limestone mining was proposed in the Cape Range Peninsula in the late 1980's and concern was expressed that certain elements of the stygofauna would be impacted by destruction of particular groundwater systems or from interference with the water column and sub-surface hydrology. The mining proposal received a considerable degree of attention by the WA Environmental Protection Authority and, after much debate, mining was eventually deferred (in part, due to a lack of infrastructure to ship out the limestone).

A similar situation arose in 2007 in association with proposed iron ore mining in the Pilbara region of WA. The area concerned contains a series of flat-topped mesas, which represent patches of the original land surface, separated from each other by eroded land surfaces. The company concerned wished to mine banded ironstones in a particular mesa, and was first required by the State government to carry out a survey of subterranean fauna. In this case the fauna were present in air filled spaces and, like cave fauna, these are referred to as troglofauna. Bore holes were drilled and a range of invertebrates were found, including a schizomid arachnid that was subsequently described as *Paradraculoides anachoretus* (Harvey *et al.* 2008). Most mesas in the chain had their own species of schizomid and, unfortunately for the company, *D.*

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anachoretus was only present on this mesa, the proposed site for mining. In view of the obvious threat to this species, the Environmental Protection Authority recommended against the application to mine in this area until evidence could be provided that the schizomid occurred elsewhere or mining could be carried out without threatening the species. This represented a threat to $AUS12 billion of revenue from the proposed mine. The company employed consultants to carry out further surveys and, although the schizomid was not found outside of the mesa, mapping of its distribution in a series of purpose-drilled boreholes enabled a new mining footprint to be designed that would hopefully allow for the survival of a subset of the population. After expenditure well in excess of $1 million, approval was eventually granted to mine this mesa.

TROGLOBITES, STYGOBITES AND OTHER SHORT RANGE ENDEMICS

Both stygofauna and troglofauna are believed to be relics of a more mesic time in Australia; they probably retreated into the only remaining cool, moist environment, namely beneath the ground surface. As a consequence, they provide links with the time when Australia was part of Gondwana, bordered by the Tethys Sea (Humphreys 1993a,b). They are therefore of extreme biogeographic interest. They tend to occur in caves, in calcrete and alluvial aquifers of areas such as Cape Range, in coastal karst systems, in palaeodrainage areas and iron ore mesas of the Pilbara, and in inland deserts (Austin *et al.* 2008), all areas of intense interest to the Australian mining industry. Because of the isolated nature of these habitats, the inability of most of the inhabitants to emerge and/or survive in the harsh conditions above ground, and due to the limited dispersal abilities of most groups, they tend to evolve *in situ*, leading to high endemism and, apparently by world standards, high diversity (Eberhard *et al.* 2005). Although their densities are generally low by above-ground standards, they provide important ecosystem services such as purification of water and enhancing infiltration (Boulton *et al.* 2008).

A range of surface-dwelling invertebrates also tend to occur as SRE's. Camaenid snail species exhibit an exceptional degree of endemism within the various small patches of rainforest that persist in the Kimberley of WA (Solem 1991). Mygalomorph spiders similarly exhibit a degree of endemism associated with the naturally fragmented landscapes of the WA wheatbelt (Main 1987). Other groups with

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poor dispersal powers, such as onychophorans, slaters and millipedes also have a propensity to short range endemism.

WHERE HAS THIS LED US TO?

The inclusion of short-range endemics, particularly stygofauna and troglofauna, in environmental assessments has now escalated, so much so that the WA Environmental Protection Authority has published a series of guidelines for conducting fauna surveys (EPA 2004), for the consideration of subterranean fauna in groundwater and caves (EPA 2003) and on sampling methodology for subterranean fauna (EPA 2007). An additional guideline that addresses the specific issue of above-ground SRE's is currently in preparation.

The need to carry out such surveys has increased to such a level that there are now at least five consulting companies specialising in carrying out this work. As a result of discussions with these companies, based on the number of jobs being undertaken and the mean cost per job, I conservatively estimate that $3.6 million per annum is being spent by industry in WA on carrying out these surveys. Contrast this with the amounts mentioned earlier which are provided for terrestrial invertebrate research! There seems to be an imbalance in the priorities, particularly if one compares the abundance, diversity and ecological role of subterranean versus above-ground invertebrates.

THE OTHER 99% OF THE OTHER 99%

We are now at a stage in the environmental assessment process where vegetation is almost always considered, as are the vertebrates. SRE's now receive a similar degree of attention.

There is no doubting that SRE's should be considered, if only for the legislative reason that we cannot knowingly carry out actions that lead to their extinction. There are also philosophical reasons for this – what right do we have to cause the extinction of any organism? Few biologists would argue with this. There are also ecological reasons – these organisms may play a vital role in ecosystem functioning. Although subterranean fauna exist at low densities and are often highly localised, they may over time contribute to maintaining the ability of the earth to absorb and purify water (Boulton *et al.* 2008). For this reason alone we should adhere to the precautionary

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principle, and conserve them. Thirdly, the utilitarian argument suggests that we should conserve all organisms as they may have future uses for human-kind, such as sources of pharmaceuticals. Although this may be true, the morphological and presumably genetic differences between some of the subterranean invertebrates are very slight, so the future benefits to humans of one such invertebrate would probably also be possessed by closely related taxa.

The certainty that all SRE's are really so localised is also under question. The study of subterranean fauna is a frontier one, with the degree of survey effort being at best of a preliminary nature. Some subterranean fauna have been listed by the Western Australian government as rare or threatened, only to be taken off the list once further surveys have been carried out.

If we make the assumption that 1% of invertebrates are SRE's, and that invertebrates comprise 99% of all animal species, this leaves around 98% of species that are largely ignored during environmental appraisals. How can we justify this?

WE IGNORE THEM AT OUR PERIL

There is no doubting that SRE fauna, including subterranean invertebrates, should be considered during and after environmental appraisals. Their taxonomic, biogeographic and ecological importance is beyond question. However, failing to consider the majority of invertebrates is fraught with danger. There is often an assumption that all other taxa are widespread and can absorb any impacts, provided they do not cover their entire range. Population viability analyses and dynamics of metapopulations tells us that this isn't necessarily the case. Previously widespread taxa may ultimately be threatened as a result of cumulative and long-term effects of disturbances. Here are some problems that could, and sometimes actually have, occurred in mining or industrial developments and which could have been prevented if we had derived a sound understanding of the invertebrate fauna in the project area.

Soil that is initially replaced in rehabilitated areas may not be colonised by the full suite of tunnelling invertebrates, leading to it not developing the appropriate texture or cavities. This can lead to problems in nutrient uptake by plants, aeration of roots and infiltration by rainwater.

Trees in rehabilitated areas may initially grow well due to the fertilizers that are applied during restoration, but may ultimately cease to increase in girth once these are

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exhausted. Colonisation of the litter layer by invertebrates which comminute the litter and stimulate micro-organisms would ensure that nutrients are cycled back into the soil for further plant growth.

Plants that have been seeded or planted in restoration areas, often at considerable expense, may be killed or deformed by herbivorous insects, possibly because they are enriched by fertilizers or because they are alien to the area, and possibly lack defences against local herbivores.

Conversely, plants that have been selected for restoration programs on the basis of their spectacular growing habits may dominate the area and outcompete other herb or shrub species. The existence of certain herbivores that 'prune' back the dominant plants might lessen the chances of this happening.

Restoration of disturbed areas with the full compliment of plant species is difficult and expensive to perform. Furthermore, pioneer plants that dominate the initial stages of rehabilitation may die out, leaving gaps in the landscape. Here, seed dispersing organisms such as ants may benefit the area by introducing diaspores that may subsequently colonise the restored areas.

Some species of plants used in restored areas may be pollinated by specialised pollinators. Although the plant may have been propagated at great expense to a company, these efforts will be wasted if the pollinator that is necessary for the plant to reproduce and create an ongoing population does not colonise or have access to the area.

Disturbed areas are particularly vulnerable to invasion by introduced species, such as certain ants. There are numerous cases where such species having colonised the area, have reached high numbers and have had profound effects on the associated vegetation and its fauna. A good example of this is the breakdown in myrmecochorous ant-seed relationships in areas where Argentine ants (*Linepithema humile*) have been introduced (Bond & Slingsby 1984).

Invertebrates, by way of their abundance and diversity, offer tremendous utility as bioindicators of the 'condition' of the environment. A sound understanding of at least some invertebrate groups in the project area can allow for informed and valuable biomonitoring programs to be devised and carried out in order to monitor environmental change.

Many of the vertebrates that occur in a particular project area are insectivores, or at least partly so. Although developers are generally requested to consider and conserve vertebrates in their areas, feeding specialists could be impacted if the appropriate invertebrate food source is absent or scarce.

Most developments have the potential to change the hydrology of an area, possible leading to an increase in standing water. This could lead to increases in mosquitoes, which in turn could increase the threat from arboviruses.

There are many other potential consequences of failing to understand the invertebrates that occur within a development area. One unexpected one afflicted a company that failed to make any consideration of invertebrates in an otherwise comprehensive environmental impact statement. The problem was that the industry was situated in the tropics and operated at night under intense illumination. The ease with which this industry operated was greatly impeded by the constant bombardment from night-flying insects.

CONCLUSIONS

The purpose of this overview is not to suggest that we should lessen the attention that is paid to SRE's, and particularly to subterranean fauna. Of course we have to consider them – I am not advocating that we do not. What I am calling for is a balance – one in which resources are allocated to important issues concerning how invertebrates impact upon developments, how they can assist the development process, how they can be conserved in the presence of development, and how post-development amelioration can be performed in order to maximise the return of biodiversity. A balance in the allocation of resources to both SRE's and key elements of the remaining invertebrate fauna, during the environmental appraisal process and during the operating phase, and during post-development amelioration, would ensure that adverse environmental consequences are avoided. The subsequent attention that would be given to terrestrial invertebrates would also lead to a valuable increase in our knowledge of this important component of the biota.

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