Invertebrates and threatened species legislation

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ABSTRACT

Invertebrates dominate both terrestrial and aquatic environments in terms of their diversity, yet few have been listed as threatened. Does this really mean that few species are threatened, or is it more likely that we just do not know enough about invertebrate populations? Realistically, given the slow acquisition of knowledge of invertebrates in Australia, it is argued that listing of invertebrates is suitable only for "iconic" species in order to raise community awareness. A more effective avenue is the conservation of habitats or communities for invertebrates as well as the implementation of legislation to identify and tackle key threatening processes. Until both the public and scientific community become aware of the importance of invertebrates in ecosystem functioning, there will be little pressure on conservation agencies to conserve invertebrates.

Key words: Invertebrates, threatened species legislation, conservation.

Introduction

Worldwide, invertebrates are represented by 38 phyla and it has been estimated that they contain over 30 million species of which most are arthropods, especially insects (Stork 1999). More than 315,000 Australian insects have been described, yet many more remain undescribed. This is certainly true for both the terrestrial and marine invertebrate fauna of Australia. For a review of the current status of our knowledge of the biodiversity of Australia's marine invertebrate fauna, see Ponder *et al.* (2002), and for terrestrial groups see Yen and Butcher (1997). It is difficult to see this situation changing in Australia given the current dearth of taxonomists in Australia and the minimal amount of funding provided for taxonomy. This lack of knowledge regarding Australia's invertebrate fauna contrasts strongly with our knowledge of the Australian vertebrate fauna which consists of a single phylum, the Chordata, and less than 2000 species (827 birds, 847 reptiles and amphibians, 224 mammals) and probably only a few species still remain to be described. As well as being well documented, most vertebrates have common names and there is a strong community awareness of their existence and in most cases it is much easier for people to relate to them than an earthworm or snail (Horwitz *et al.* 1999).

The requirements for listing under the NSW *Threatened Species Conservation Act 1995* (TSC ACT) are typically easier to fulfil for terrestrial vertebrates and vascular plants than for terrestrial invertebrates. The NSW *Fisheries Management Act 1994,* which covers aquatic plants and all animals except for marine mammals and reptiles, largely mirrors the TSC Act. While this paper discusses the NSW Acts, similar limitations are apparent with other State and Commonwealth Acts. All these Acts are based on the criteria developed by the World Conservation Union (IUCN) and in the Red List categories. They provide an explicit, objective, quantitative framework for classifying the risk of extinction for a species. The criteria provide quantitative thresholds for population size, trend, range size and modelled probability of extinction. They are used to assign species to categories of extinction risk that can be compared between different taxa (World Conservation Union 2001). These criteria have been widely adopted because of their wide applicability, objectivity and simplicity of use (Akçakaya *et al.* 2000). They include: documenting the size of the population, demonstrating that the numbers are declining and identifying the threatening processes which may be leading to these declines. Typically, these data are much easier to obtain for vertebrates than for invertebrates because usually there is some knowledge of the biology of the animal. A workshop, held in Sydney in 1997, looked at the usefulness of these criteria for invertebrates and agreed that they had limited applicability (Hutchings and Ponder 1999). However, no attempt to develop criteria more applicable to invertebrates was undertaken. Similar problems arise when considering non vascular plants. The reasons why the requirements for invertebrates are difficult to document include the fact that invertebrate populations fluctuate between seasons and between years. Hence estimates of population size and rates of change are extremely difficult to quantify. Marine species often have pelagic larvae and these may be transported considerable distances from the parent population and recruitment success is highly variable and often strongly influenced by external factors. Many invertebrates live in habitats occupying small areas, and if these are destroyed then the associated fauna also disappears. Examples of such specialised habitats include leaf litter, under logs or in rotting wood, or a particular plant with which the invertebrate is associated. Another complicating factor is that, in various stages of the life cycles, the invertebrate populations typically occupy different environments, for example butterflies have sedentary juvenile stages but their adult stages are highly mobile. In contrast, many marine invertebrates have free-swimming juveniles and sedentary adult stages.

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An area of the IUCN criteria, which needs to be explored for listing of invertebrates, is the range criterion B. It has been used successfully for vascular plants (Auld personal communication). Distribution records from museum databases could be used to determine the extent of the occurrence of a species. The other components of the criterion are more qualitative and could take into account the fluctuations exhibited by the species over seasons and between years. Plants species, which exhibit massive fluctuations between years, are regarded as more vulnerable than species which exhibit little fluctuation, because threats operating during times of low populations may lead to extinction. The validity of using this range criterion needs to be tested on a range of invertebrates with varying reproductive strategies. In addition, the extent of museum records needs to be carefully assessed as to whether they do represent the sorts of habitats in which the species is likely to occur as well as the sampling techniques which were employed. This could be undertaken only by the relevant specialist.

An example of the complexity of invertebrate life cycles is the Bathurst Copper Butterfly *Paralucia spinifera*. This species lays its eggs on the native blackthorn *Bursaria spinosa* and the larvae feed on this plant. Eggs are laid either singly, or in groups up to five, on leaves towards the base of the host plant or on adjacent debris (Dexter and Kitching 1991) and they hatch within 14-17 days. The larvae of the butterfly graze on the host plant. The larval stages have a mutualistic relationship with the ant *Anonychomyrma itinerans,* which searches the host plant seeking newly-hatched larvae. During the first three larval instars, both larvae and ants are diurnal, but later instars become nocturnal. The ant protects the caterpillar from predation and hosts the pupae in its nest. In return, the ants receive nutritional secretions from the larvae (Dexter and Kitching 1991). This butterfly has been listed as an endangered species, and any factors which impact on either the ant or the host plant will also affect the butterfly. However, it is unclear if the butterfly has an impact on the host plant.

The Scientific Committee, which was established under the NSW *Threatened Species Conservation Act 1995*, must consider all the nominations it receives unless they are vexatious. Most nominations are unsolicited, they come primarily from the public, and often from urban areas. Of the faunal nominations, almost all are vertebrates, especially the larger species. The lack of invertebrate nominations is due to a combination of factors, including that they are small and largely hidden from view and the public's perception of invertebrates as having little value (Horwitz *et al.* 1999, Allen 1999).

Currently there are 167 vertebrates listed under the NSW *Threatened Species Conservation Act*. There are also 12 invertebrate species listed as endangered, one invertebrate population is listed as endangered, and one invertebrate species is listed as presumed extinct. Of these 12 endangered invertebrates, eight are insects, three are snails and one is an earthworm. Under the NSW *Fisheries Management Act* 1994, a single invertebrate is listed; a snail *Notopala sublineata,* known to occur only in the Murray-Darling system.

Similar patterns are found under the Commonwealth legislation, the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) where 15 invertebrates are listed compared to 309 species of vertebrates. Among the states, the number of invertebrates to vertebrates listed varies slightly. The highest percentage is in Tasmania, of the 130 animal species listed, 56 (43%) are invertebrates. In Victoria, of 168 animal species listed, 21 (12.5%) are invertebrates. In Western Australia, 118 animal species are listed, 38 (32%) are invertebrates. In the Northern Territory, 86 animal species are listed, 35 (40%) are invertebrates. In Queensland, 270 animal species are listed, of which only 7 (2.6%) are invertebrates. In contrast, in South Australia none of the 68 listed animal species is an invertebrate.

Invertebrates are also protected under CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, signed in 1973) and 2039 invertebrates are listed. This includes all scleractinian corals, some species of molluscs, insects and arachnids.

So the questions that must be asked are: why are so few invertebrates listed when they are numerically dominant in all ecosystems, and, more simply: how many invertebrates are threatened? Certainly those species confined to specialised but limited habitats, such as mound springs, are threatened (Ponder 1995, 1997, 2004) because that habitat is being degraded by reduced water flow and trampling by cattle. However, for most invertebrates, we just lack the information as to whether we should even be considering them for listing. For most invertebrates we lack basic information on the natural fluctuations of their populations. These fluctuations may change naturally by orders of magnitude between seasons or years. Also, as habitats become increasingly fragmented, knowing the gene flow between isolated populations of the species becomes critical in assessing the long-term viability of these populations (Clark and Richardson 2002, Clark 2004).

Another complicating factor is that the taxonomy of many groups is poorly known and often a species may be found to consist of a suite of sibling species, presumably with each having specific habitat requirements. For example, the polychaete *Marphysa* – known as the "bloodworm" - forms the basis of an important bait industry for recreational fishers. It was initially regarded as a widely distributed cosmopolitan species *M. sanguinea*. However, close examination revealed that the Australian material from Moreton Bay, Queensland, was an undescribed species. It was formally described by Hutchings and Karageorgopoulos (2003) as *M. mullawa*. Initially, it was thought that this species occurred south of Moreton Bay and along the New South Wales coast. Subsequent studies have shown that a suite of sibling species occurs along the NSW coast and that *M. mullawa* is currently only known from Moreton Bay. These species can be differentiated not only on morphological grounds, but also by their reproductive strategies (Hutchings unpublished). Some of these species appear to have distributions restricted to specific estuarine areas, often in seagrass beds. Hopefully, restrictions under the *Fisheries Management (General) Regulation* 2002 by NSW State Fisheries on bait digging will ensure their long term maintenance, and they still have to be formally described. The regulations prevent commercial and recreational fishers from digging in seagrass beds using either a spade or fork, although a yabbie pump is allowable. This example illustrates our lack of knowledge of even those species which have a commercial value. Such taxonomic impediments are widespread among marine invertebrate species (Ponder *et al*. 2002) and in many terrestrial groups.

There is also an apparent reluctance to list some of the colourful invertebrates which are collected and have a monetary value. Various interested groups perceive that listing will restrict their collecting ability. Certainly, listing of a species adds another layer of bureaucracy to obtaining permits to undertake research on the endangered species, and yet such research is critical to its long-term survival. This too has dampened the enthusiasm of some invertebrate specialists to nominate species in their groups for listing. There needs to be a closer working relationship between the regulation branch, which issues permits, with the scientists within the relevant department to ensure that permits for research, which will gather information necessary for managing that species, are given to the appropriate workers.

Another factor contributing to the lack of invertebrates being nominated for listing is the general ignorance within the community of the importance of invertebrates in the functioning of marine and terrestrial ecosystems. Most invertebrates are small, inconspicuous and very few are colourful or charismatic, although this latter characteristic relies upon the "human perception" of how a species acts or behaves. I contend that this is based upon ignorance, typically when one explains the reproductive behaviour of, say, a polychaete worm, then many people are amazed that such a "lowly" animal can do such things.

Conservation Outcomes of Listings

Despite these major hurdles to listing invertebrates, some species have been listed in most states, thus we also need to explore if listing has helped in its conservation? In New South Wales, once a species is listed there is a requirement that a recovery plan be developed within a reasonable time. However, of the 12 invertebrates listed, recovery plans have been developed for only three species. Once the recovery plan has been developed, its implementation depends on the necessary funds being allocated. The recovery plan for the Bathurst Copper Butterfly has certainly led to increasing public awareness of the species and encouraged plantings of its host plant, the native blackthorn, and also importantly the consideration of its habitat in hazard reduction burns. More details as to how the community, including school groups, has been involved in documenting the distribution and abundance of the species can be found in Nally (2004). More difficult to ascertain are the flow-on effects in raising the community awareness of other endangered species in the area. Certainly the local council has been highly supportive of the program. This is critical, because it is at the regional level where implementation occurs and largely determines if the species continues to survive.

Listing of the Cumberland Plain snail *Meridolum corneovirens* has raised the public awareness, although a recovery plan has not been developed. The snail occurs in the Cumberland Plain Woodland, Castlereagh Woodlands and the River Flat woodland, which are Endangered Ecological Communities found on the Cumberland Plain (Tozer 2003), for which recovery plans are being developed. The Cumberland Plain Woodland community - originally widespread across western Sydney - is now represented in many places by scattered fragments, which are often degraded or weed infested. Detailed mapping of these communities has also been undertaken as part of the development of recovery plans. However, even listing the snail and its associated ecological community has not prevented loss of snail habitat, which includes logs and debris under which the snail is found.

The reason for the loss of these communities in western Sydney is that these areas are regarded as prime sites for residential development. Nevertheless, one consequence of listing may have been the undertaking of a detailed study on the gene flow between these isolated snail populations by Clark and Richardson (2002). This study will be relevant to other sedentary terrestrial species, which live in isolated and fragmented habitats, and it will highlight the problems of conserving fragmented populations. Another consequence is a detailed mapping of the snail's distribution, undertaken by Clark (in prep), and additional sites have been found, but others have now been destroyed by development. This listing engendered complaints from consultants undertaking 8 part tests because of the difficulty in identifying these snails (Denny 2004).

The Lord Howe Island endemic earthworm *Pericryptodrilus nanus* was listed by the NSW Scientific Committee for several reasons. The species is restricted to the leaf litter on the summit of Mount Gower, Lord Howe Island, a World Heritage Area and this earthworm is an important food resource for the listed Lord Howe Island woodhen *Tricholimnas sylvestris*. Although it would have been preferable to have listed the entire leaf litter community, which contains a range of invertebrates, this was not feasible because all the other species are as yet undescribed. One of the desirable consequences of listing was the creation of an awareness of the value of the leaf litter community and for this to be taken into account when issuing permits for tourist activities and bird watching studies on the summit. To date, no recovery plan has been developed, although hopefully this listing has been taken into account when granting permission for various activities on Mount Gower. A Biodiversity Plan for all taxa on Lord Howe Island (excluding those under the NSW Fisheries Act) is currently being developed by the NSW Department of Environment and Conservation and this will include this fragile leaf litter community.

The way forward

In view of the large number of invertebrates present in both marine and terrestrial environments, and acknowledging that some are threatened, it is not an efficient process to list them apart from some iconic species, which can become flagships, that is the invertebrate equivalent to the koala. So what do we need to do?

Using the *Threatened Species Conservation Act* in NSW, two other options are available:- listing endangered ecological communities and listing key threatening processes. As the Scientific Committee in New South Wales came to terms with the complexities of listing ecological communities, and in response to comments received after advertising the preliminary determinations as required under the Act, we included in all the later listings two catch-all phrases, one which included the seed bank and some which included the invertebrates in the community without listing them. For those communities which tend to be defined largely by the vegetation, the listing will include, virtually by default, seeds in the soil which may or may not germinate given the right conditions and therefore the plants listed as defining that community may change over time. Similarly, the soil will contain a suite of invertebrates, many of which will be restricted to that particular community although in most cases they will still be undescribed. Loss of that community, or its degradation, will lead to local extinctions of some of the associated invertebrates, or even a complete loss of species. However, these losses have been poorly documented, although it is known that after land is cleared for agriculture it has a much poorer soil fauna, especially with regard to earthworms, than uncleared areas. However, this process can be reversed. Abandoned tropical pastures have been shown to be able to recover their native earthworm fauna (Sanchez-De Leon *et al.* 2003). Introduced European earthworm species are dominant in Sydney urban areas (Blakemore 1999) and have displaced native species, which may be more efficient at processing native Australian soils than introduced species although this has yet to be tested. There is also a dearth of information available on the impact of frequent fires on the invertebrate fauna, but the loss of this fauna, even on a temporary basis, would have major impacts on the large number of vertebrates that feed on them.

While several Key Threatening Processes (KTP) have been listed, it appears that the former NSW NPWS (as it was known until recently- now part of the Department of Environment and Conservation) had been concentrating its resources on developing recovery plans for species rather than on preparing Threat Abatement Plans, which are required under the legislation. No Threat Abatement Plans have been prepared for the two KTPs which have major impacts on terrestrial invertebrates, namely "Clearing of native vegetation" (gazetted September 2001) and "High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition" (gazetted March 2000), both of which impact on soil and arboreal invertebrates (Baker 2004, Campbell and Tanton 1981).

In the marine environment, loss of particular habitats such as clearing of mangroves, salt marsh or seagrass beds, will lead to the local extinction of species restricted to these habitats. Changes to water flows may restrict freshwater habitats or allow salt water intrusions into the river, as well as allowing the accumulation of pesticides and excess fertilisers in soils leading to a change in soil structure. Drainage of wetlands to create agricultural land often exposes acid sulphate soils, which results in the leaching of acids into the river causing massive fish kills. This drainage, often as part of flood mitigation works, has been undertaken in northern NSW and Queensland. Other consequences of the loss of coastal wetlands, or clearing of vegetation on land, are increased soil erosion and the transport of excess fertilisers and pesticides down the rivers and into shallow coastal environments. Some pesticides, such as diuron, have been shown to have deleterious effect on the growth of seagrass beds (Haynes *et al.* 2000). This has been highlighted along the Queensland coast with the inshore waters of the Great Barrier Reef receiving excessive levels of sediments and pollutants leading to widespread degradation of inshore reefs (Baker 2003).

Instead of using Threatened Species legislation, there is a recent Commonwealth and Queensland Government initiative, the Reef Water Quality Protection Plan, to deal with the matter. One aspect of the plan is to minimise the loss of riparian habitats and to encourage their rehabilitation. Parts of the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* have been enacted as the Great Barrier Reef Marine Park is listed as a World Heritage Area, over which this Act has jurisdiction. The problems highlighted for the Queensland coast are not unique, and similar management strategies need to be put in place in NSW. The recently-established Catchment Management Authorities in NSW will become responsible for developing catchment management plans, which hopefully will consider river flows and the restoration of riparian vegetation. Previously, catchment and water management policies were developed by regionally-based committees with government and community representation (Fairfull and Williams 2003). These committees have now become statutory authorities, which presumably will improve the development and implementation of such policies. It also seems likely that threat abatement plans will be incorporated into these management plans (Leys 2004), but as to who will actually develop these plans is currently unclear.

Conclusions

So, to answer the question: "Is Threatened Species legislation appropriate or even useful for invertebrates?', one would have to conclude that it is of limited value and should be restricted to flagship species and to raise community awareness of the value of invertebrates. Of more concern is our lack of knowledge, and therefore our ability, to be able to identify species as being threatened. As we are unlikely to obtain that data in the near future, we should concentrate on conserving representatives of all our habitats and hopefully, by default, protect our invertebrate fauna.

This review of the legislation has aimed to highlight the need to raise the awareness of the numerous important roles, which invertebrates play both in the scientific community as well as the community at large. Invertebrates are critical for ecosystem functioning in all environments (New 1995, Snelgrove *et al.* 1997, Wall *et al.* 1997), such as in the breakdown of organic matter, recycling of organic material, and in the bioturbation and aeration of sediments. Sediments devoid of invertebrates are typically disturbed and polluted (Ward and Hutchings 1996). Most vertebrates (64%), including threatened vertebrate species, feed either entirely or largely depend on invertebrates (Lunney *et al*. 2000). Also, the loss of many insects will lead to changes in many key plant interactions, such as decreased pollination rates (Cane 2001, Cane and Tepedino 2001). All these examples draw attention to the real need to increase our awareness of the role that invertebrates play in all communities. Yet how to create that increased awareness is a major challenge. The majority of funds expended by various agencies on conservation, or even research, is geared towards vascular plants and vertebrates. There are far more vertebrate biologists than invertebrate biologists. This is reflected in the bias of the scientific community. There is thus a danger of ignoring the urgent need for more taxonomic and ecological work on invertebrates in both universities and government departments. Similarly, much more education is needed for senior management and bureaucrats on the key importance of the role and function of invertebrates in sustaining natural landscapes. So perhaps it is not surprising that the general community knows little about invertebrates, other than those which they wish to eradicate from their houses and gardens, such as cockroaches and snails and slugs. We invertebrate biologists have an uphill battle in front of us.

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