# Technical Guidance

## Sampling of short range endemic invertebrate fauna

The content of this Guidance has not yet been updated to reflect the EPA's framework for environmental considerations in environmental impact assessment

**Environmental Protection Authority**

December 2016

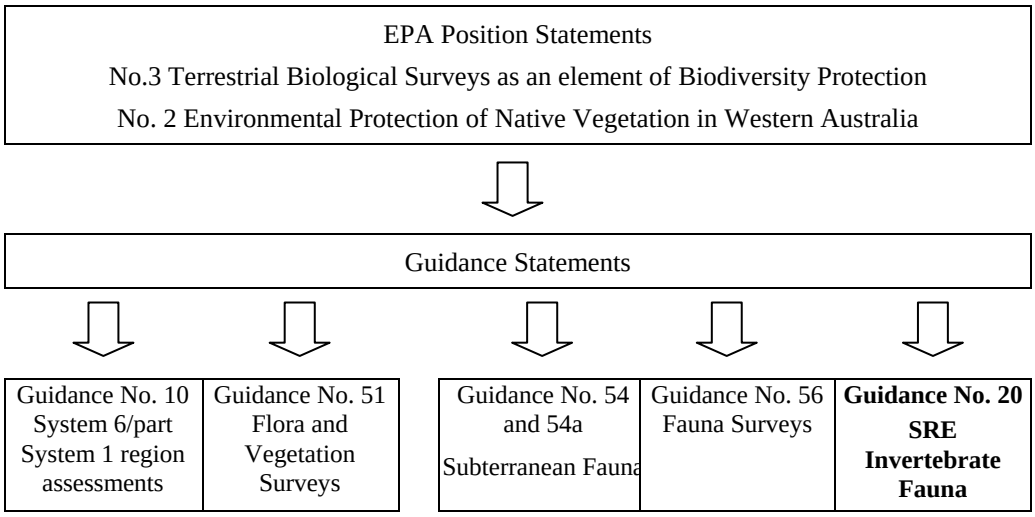
# FOREWORD

The Environmental Protection Authority (EPA) is an independent statutory authority and is the key provider of independent environmental advice to Government. The EPA's objectives are to protect the environment and to prevent, control and abate pollution. The EPA aims to achieve some of this through the development of environmental protection Guidance Statements for the environmental impact assessment (EIA) of development proposals and planning schemes or scheme amendments.

This document is one in a series being issued by the EPA to assist proponents, consultants and the public generally to gain additional information about the EPA's thinking in relation to aspects of the EIA process. The series provides the basis for EPA's evaluation of, and advice on, development proposals or schemes subject to EIA. The Guidance Statements are one part of assisting proponents and responsible authorities in achieving environmentally acceptable outcomes. Consistent with the notion of continuous environmental improvement and adaptive environmental management, the EPA expects proponents to take all reasonable and practicable measures to protect the environment.

The occurrence of Short Range Endemic (SRE) invertebrate taxa has emerged in recent years as a potentially significant biodiversity issue for the EIA process in Western Australia. Fauna with narrow distributions may be at greater risk of changes in conservation status as a result of habitat loss or other threatening processes. The assessment of SRE invertebrate fauna can therefore represent a relevant factor for formally assessed development proposals and planning schemes or scheme amendments.

This Guidance Statement provides guidance on the standards and methods of survey required to assist in collecting the appropriate data for decision-making associated with the protection of Western Australia's SRE invertebrate fauna and its habitat. The flowchart below shows the relationship between Position Statements and this and other Guidance Statements.




The EPA recognises that many faunal groups that may harbour SRE species are not well defined from distributional, taxonomic and conservation status perspectives. This can present challenges to both proponents and the EPA

when attempting to place the impacts of development proposals into wider context. The EPA believes that there are significant opportunities for collaboration and information sharing between proponents, practitioners, government and academia in respect of SRE fauna. Proponents are encouraged to contribute to improvements in knowledge in regards to this aspect of terrestrial biodiversity, which will in turn serve to improve the overall assessment context for both Government and industry in Western Australia.

This guidance provides an overview of the current state of knowledge on SRE invertebrate taxa and sets out the EPA's current approach to their assessment for development proposals and planning schemes or scheme amendments.

While guidance is provided specifically in relation to the Western Australian *Environmental Protection Act, 1986,* proponents are reminded to ascertain any responsibilities they may have in regard to this issue under the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999.*

This Guidance Statement has the status of "**Final**" which means that it has been reviewed by experts and the EIA Review Stakeholder Reference Group. The EPA has signed off the Guidance Statement and published it although it may be updated as new documents and information become available.

I am pleased to release this document.

**Dr Paul Vogel**

CHAIRMAN

ENVIRONMENTAL PROTECTION AUTHORITY

25th May 2009

# Table of Contents

# Guidance Statement No. 20

# Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia

**Key Words: short range endemic species, invertebrates, biodiversity, restricted distributions, biological surveys, terrestrial fauna, Specially Protected Fauna**

## 1 INTRODUCTION

### 1.1 Purpose

Guidance Statements are developed by the EPA to provide advice to proponents, and the public generally, about the minimum requirements for environmental management which the EPA would expect to be met when the EPA considers a proposal during the assessment process. The generic process is set out in Appendix 1.

This Guidance Statement is termed "Final", and thus the EPA expects that proponents and responsible authorities will give full attention to the information provided when they submit proposals or schemes for assessment.

### 1.2 Policy Content

This Guidance Statement specifically addresses the general standards and a common framework including risk-based assessment for the sampling and assessment of SRE invertebrate fauna for EIA in Western Australia. It also sets out the EPA's current expectations in respect of the quality and quantity of information derived from these surveys, and the consequent analysis, interpretation and reporting. The Guidance recognises and discusses limitations on current knowledge in respect to this fauna, and how this may affect the EPA's consideration of development proposals.

This Guidance provides information which the EPA will consider when assessing proposals where SRE invertebrate taxa is/are relevant environmental factor(s) in an assessment. It takes into account:

(a) protection of the environment as defined by the *Environmental Protection Act 1986* (WA) with a focus on the conservation and protection of biodiversity values; and

(b) the conservation of SRE invertebrate species as listed by the *Wildlife Conservation Act 1950* (and subsequent amendments).

# 2 SHORT RANGE ENDEMICS

## 2.1 What are Short Range Endemics?

For the purpose of this Guidance, SREs are defined as terrestrial and freshwater invertebrates that have naturally small distributions of less than 10,000 $km^2$ (after Harvey 2002). Within this distribution, the actual areas occupied may be small, discontinuous or fragmented. SREs have also been varyingly defined by other terms, including Narrow Range Endemics (Ponder and Colgan 2002), Narrow Range Taxa or Restricted Range Species (BirdLife International terminology). An extensive literature exists in this area and an internet search on any of these phrases yields numerous results.

Within the context of EIA in Western Australia, the term SRE has effectively been used in this Guidance Statement to refer only to surface dwelling invertebrates. Plants, subterranean fauna (including troglofauna and stygofauna), and terrestrial vertebrate fauna can also have naturally small distributions and fit the definition of SRE fauna. However, these latter groups have their own survey methods and are considered separately in EPA Guidance Statements No. 51, No. 54 and 54a, and No. 56, respectively. These taxa are therefore outside of the scope of this guidance and are not considered further here.

Harvey (2002) noted that SRE taxa typically display characteristic ecological and life-history traits, including:

- poor dispersal powers;
- confinement to discontinuous habitats;
- usually have highly seasonal activity patterns, many species only being active during cooler, wetter periods; and
- low levels of fecundity.

Harvey (2002) recognized specialised habitat characteristics of short-range endemics. These types of habitats with the potential to support short-range endemics can occur in all bioregions of Western Australia. Vine thickets, boulder piles, isolated hills and other landforms, vegetated gullies and freshwater habitats may all harbour short-range endemics. The widespread aridification of Australia that has occurred since the Miocene has resulted in the fragmentation of populations, contraction to these relictual habitats and the subsequent evolution of many new species with consequently small distributions. Many of these habitats have historical origins or mimic historical habitats as discussed by Main and Main (1991) and Hopper *et al.* (1996).

## 2.2 Taxonomic Groups that may include Short Range Endemics

In his review, Harvey (2002) identified a number of taxonomic groups known, or considered likely, to support SRE taxa. Major groups are summarised in Table 1 below.

**Table 1: Summary of taxonomic groups with known or likely SRE taxa in Western Australia** (modified from Appendix 1 of Harvey (2002)).

| Phylum | Class | Order | Relevant Generic Group |
|---|---|---|---|
| Mollusca | Bivalvia | Unionoida | Freshwater mussels |
| | Gastropoda | Sorbeoconcha | Freshwater snails |
| | | Eupulmonata | Land snails |
| Annelida | Oligochaeta | Haplotaxida | Earthworms |
| Onychophora | Onychophora | Onychophora | Velvet worms |
| Arthropoda | Arachnida | Araneae | Trapdoor spiders |
| | | Pseudoscorpiones | Pseudoscorpions |
| | | Schizomida | Schizomids |
| | | Acari | Mites |
| | Malacostraca | Isopoda | Slaters |
| | | Decapoda | Freshwater crayfish |
| | Diplopoda | Polydesmida | Millipedes |
| | | Sphaerotheriida | Pill Millipedes |
| | | Polyzoniida | Sucking Millipedes |
| | | Spirostreptida | Spirostreptid Millipedes |

A more complete taxonomic resume is provided in Appendix 1 of Harvey (2002), which has also been reproduced for reference as Appendix 2 of this Guidance Statement. Appendix 2 provides a summary statement on the current understanding of short-range endemism amongst major terrestrial and aquatic fauna in an Australian context. However one group which is poorly researched is crustaceans of inland saltlake systems. Surveys currently being conducted by researchers at the University of Western Australia indicate high levels of regional endemicity with local habitat based endemism depending on the type of lake. These groups are likely to be underrepresented in Appendix 2. Some representative examples of better documented SRE taxa from Western Australia are also provided in more detail in the following section.

## 2.3 Examples of Short Range Endemic Invertebrate Taxa from Western Australia

### 2.3.1 Millipedes of the Genus *Antichiropus*

Millipedes are a diverse group of animals comprising nine different orders in Australia (Harvey and Yen 1989). The most speciose millipede group in Western Australia is the genus *Antichiropus* of the family Paradoxosomatidae. The genus was originally named in 1911 for seven species (Attems 1911), with additional species added by Jeekel (1982) and Shear (1992).

Following recent taxonomic work at the Western Australian Museum, the genus *Antichiropus* is now known to consist of over 100 species, ranging as far north as Tom Price in the Pilbara Bioregion, and extending onto the Nullarbor Plain and the Eyre Peninsula in South Australia (Fig. 1). With the exception of *Antichiropus variabilis* (which inhabits the Jarrah forests of south-western

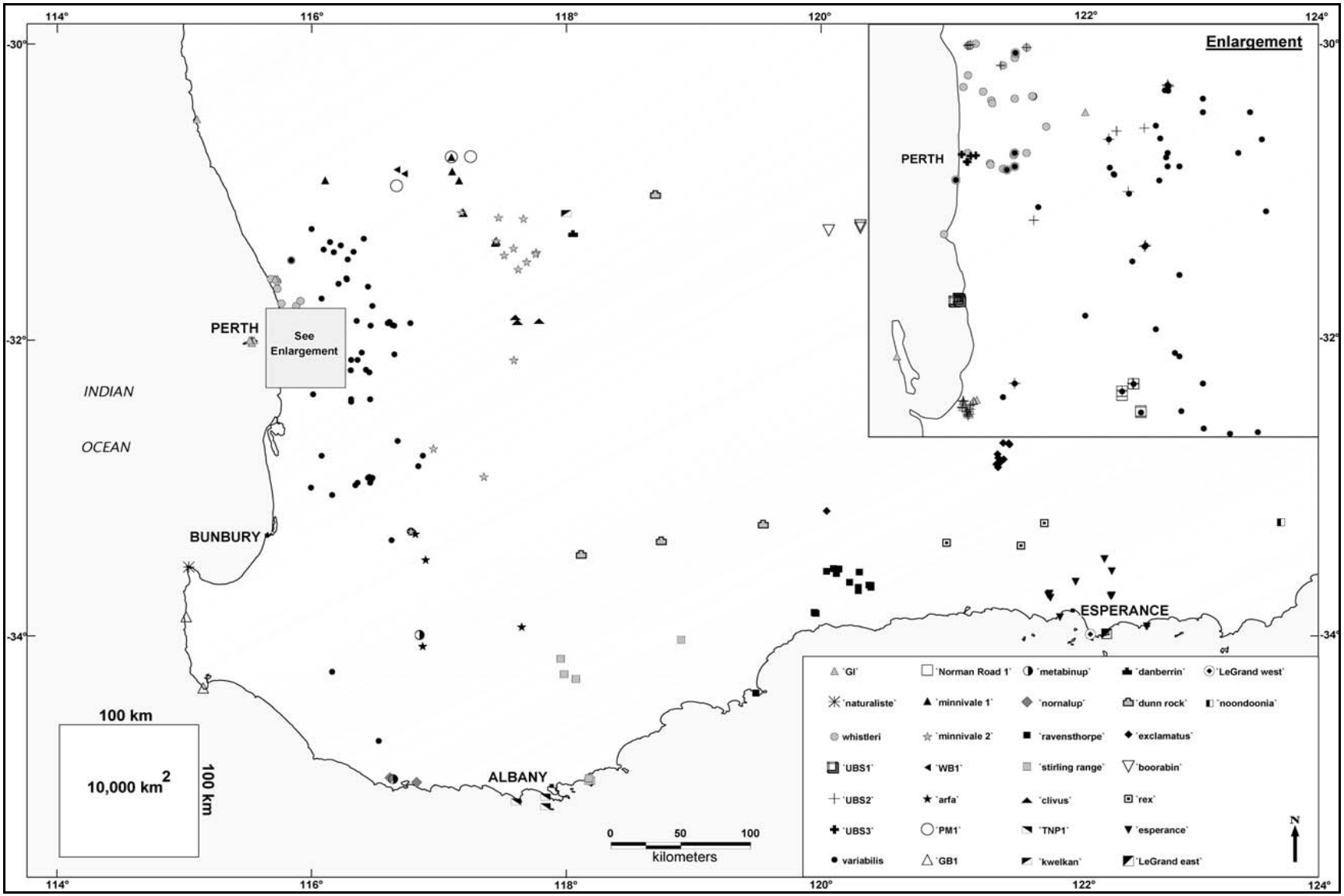



**Fig. 1: Distribution of recognised species of *Antichiropus* millipedes in south-west Western Australia** (distinct species represented by different symbols. Source data supplied by WA Museum).

WA), all species of the genus are known to be SREs, and many are known from only a few hundred square kilometres (Harvey *et al*. 2000; Harvey 2002). The distribution of individual *Antichiropus* species in the southern half of the State is shown relative to an area of 10,000 km$^2$ in Fig. 1 to illustrate this.

### 2.3.2 Millipedes of the Family Sphaerotheriidae

Pill millipedes (family Sphaerotheriidae) are currently only represented by two species in Western Australia, both of which are endemic to the south-west of the State. *Cynotelopus notabilis* is an SRE and is restricted to high rainfall areas on the south coast of the State (Fig. 2). The recently described *Epicyliosoma sarahae*, is also an SRE, having a total distribution of less than 10,000 km$^2$ (Moir and Harvey 2008). The latter species occurs in lower rainfall parts of the south coast and appears to be restricted to deeper leaf litter in well-shaded gullies (Moir and Harvey 2008).

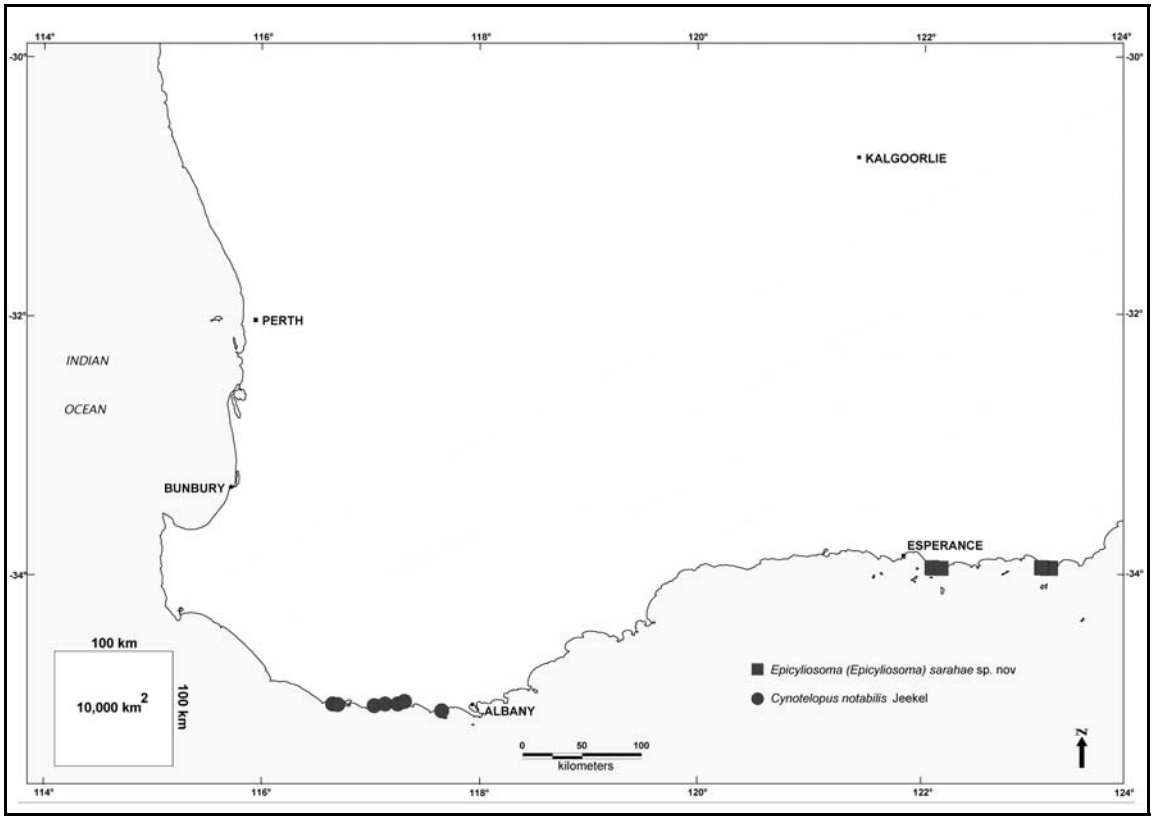



**Fig. 2: Distribution of two described SRE species of pill millipedes in south-west Western Australia** (source: Moir and Harvey 2008).

### 2.3.3 Freshwater Snails of the Genus *Austroassiminea*

The Cape Leeuwin Snail *Austroassiminea letha* (family Hydrobiidae) occurs in stream systems, coastal springs, and in and around freshwater seepages in the south-west corner of Western Australia (Solem *et al*. 1982, Fukuda and Ponder 2003). The species is formally recognised as having a restricted distribution and is listed as a Schedule 1 species under the *Wildlife Conservation Act 1950*.

### 2.3.4 Land Snails of the Genus *Rhagada*

With 29 species currently described, the Western Australian endemic *Rhagada* is the second most diverse genus of the family Camaenidae, which includes nearly half the terrestrial snails of Australia (Ponder 1997). The geographic range of the genus *Rhagada* extends from the northern Kimberley to the Carnarvon area. A number of *Rhagada* species inhabit coastal areas of the Pilbara region and the islands of the Dampier Archipelago (Solem 1997).

The distribution of *Rhagada* is of particular interest, as until recently no two species were found to co-occur (Fig. 3). Solem (1997) considered that only *R. convicta* occurred on the Burrup Peninsula, but more recent work suggests that at least three, possibly even four putative taxa are present on the Burrup that do not occur elsewhere. Several of these taxa qualify as SREs using the 10,000 km$^2$ criterion (Johnson *et al.* 2004).

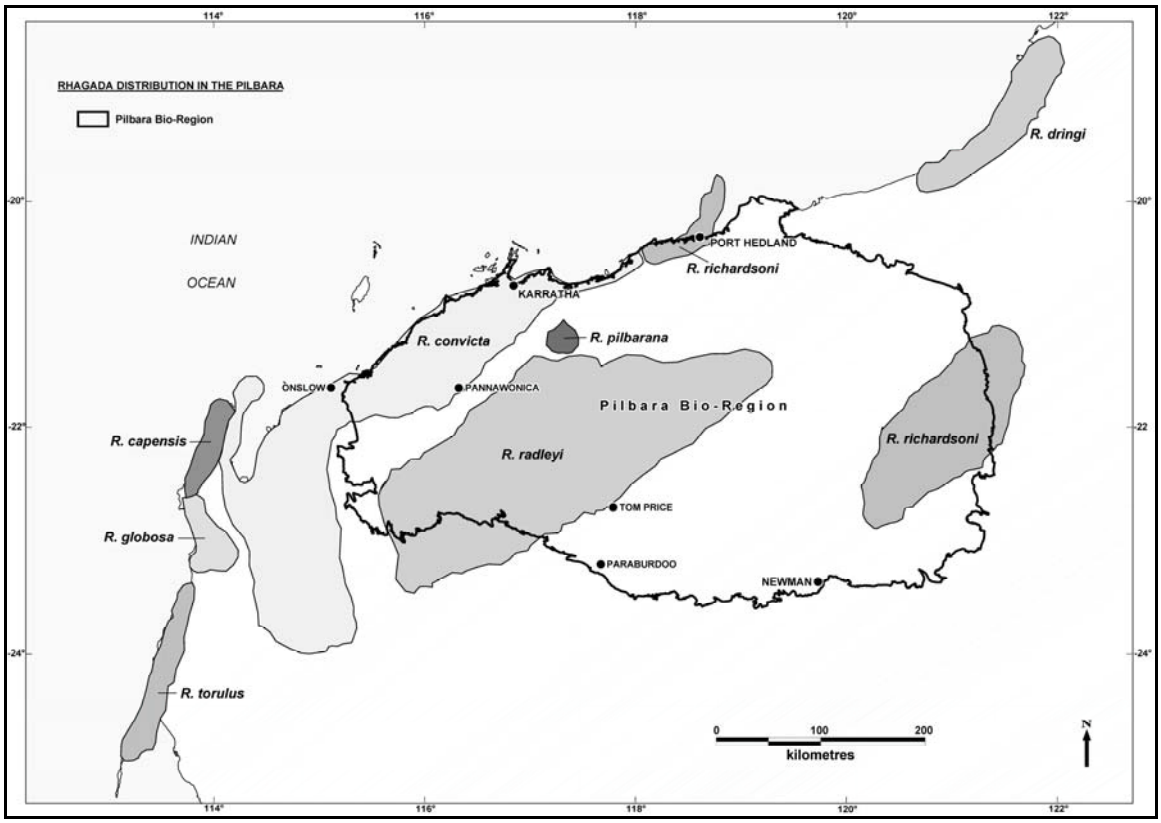



**Fig. 3: Distribution of described species of *Rhagada* from the Pilbara region of Western Australia** (modified from Solem 1977).

Recent molecular investigations, and more intensive sampling, of Pilbara *Rhagada* have yielded additional forms that may represent new taxa (Johnson *et al*. 2006, Biota Environmental Sciences 2007). These data are indicative of a more complicated picture than that originally presented by Solem (1985 and 1997). In this more recent work, molecular data have been used to infer possible species boundaries. This needs to be supported by anatomical studies that would test for concordance with the molecular data. More robust taxonomic descriptions of new taxa and confirmation of any species that qualify as SREs would then follow. It is illustrative to note that the current state of improved knowledge within this single land snail genus is the product of over five years of targeted field sampling and consolidated molecular analysis.

### 2.3.5 Spiders of the Genus *Moggridgea*

The WA Museum has completed detailed molecular and morphological studies on mygalomorph spiders of the genus *Moggridgea* (Araneae, Migidae) in the southwest of Western Australia. The mtDNA data for *Moggridgea* showed deep genetic structuring between populations that was partly concordant with lineages defined using both morphological characters, and a nuclear gene (rRNA ITS). *Moggridgea tingle* was found to occur from Walpole to Margaret River. Other populations from isolated montane refuges (Stirling Ranges, Porongurup Ranges and Mt Manypeaks) were represented by distinct and concordant lineages of mtDNA and nuclear genes, consistent with the presence of distinct species amongst each of these elevated regions. The combination of molecular and morphological data provides strong evidence supporting deep population divergences between elevated landforms in south-west Western Australia.

# 3 THE GUIDANCE

## 3.1 Application of the Guidance to Assessments

### 3.1.1 The Need to consider Short Range Endemics in EIA

Given their potential to be restricted at small spatial scales, SRE species are generally at greater risk of changes in conservation status, local population or taxon extinctions than other, more widely distributed taxa. This risk can be increased by pre-existing threatening processes or as a result of the cumulative impact of developments. Some key threatening processes for SRE fauna include:

- clearing of native vegetation (habitat removal);
- changes to fire regimes;
- introduction and/or spread of weeds and soil pathogens;
- fragmentation and subdivision of habitats; and
- changes to surface hydrology.

In recognition of their small distributions and ongoing threatening processes, a total of 47 SRE taxa are already listed as Schedule 1 Specially Protected fauna under the State *Wildlife Conservation Act 1950*. This listing is dominated by land snail taxa, the majority of which occur in the Kimberley, but also includes spiders, millipedes and decapod crustaceans. A summary of taxonomic representation in this Schedule 1 fauna listing is provided in Table 2 below, with a full listing of all current Specially Protected species provided in Appendix 3.

**Table 2: Summary of SRE faunal groups with taxa listed as Specially Protected (Schedule 1) fauna in Western Australia**.

| Taxon | No. of Taxa | Regions |
|---|---|---|
| Land and freshwater snails | 34 | Kimberley, South-west |
| Spiders | 7 | Mid-west, Wheatbelt, South coast |
| Decapod crustaceans | 4 | South-west |
| Millipedes | 2 | South coast |

As this listing is periodically updated, proponents and practitioners should refer to http://www.dec.wa.gov.au/management-and-protection/threatened-species/index.html to check for any updates at the time of completing assessments. Note also that there are additional SRE taxa listed as Priority species by the DEC, in addition to the taxa detailed in Appendix 3.

Given their elevated risk of change in conservation status, and that a range of SRE species are listed as Schedule fauna in most regions of the State, the potential presence of SRE taxa in development areas represents a relevant factor for proposals being assessed by the EPA.

### 3.1.2 EPA's Objectives and Guidance for Achieving Desired Outcomes

The objectives of the EPA in respect of SRE fauna are to:

- ensure the protection of key habitats for SRE species;
- maintain the distribution, abundance and productivity of populations of SRE taxa; and
- ensure that the conservation status of SRE taxa is not adversely changed as a result of development proposals.

In addition, and taking into account advice from the DEC, the EPA will aim to ensure that proposals do not potentially threaten the viability of, or lead to the extinction of, any SRE species. This is consistent with the purpose of the *Wildlife Conservation Act 1950*, which is 'to provide for the conservation and protection of wildlife' and also with principles 1 to 3 within Section 4A of the *Environmental Protection Act 1986* ('Object and principles') relating to the conservation of biodiversity and ecological integrity, intergenerational equity and the precautionary principle.

Proposals that, if implemented, could potentially have a significant impact on SRE taxa by:

- clearing of vegetation or habitats with known potential to support SRE fauna;
- changing hydrology or fire regimes, introduce weeds or soil pathogens, or otherwise indirectly affect such habitats; or
- directly affecting known populations of SRE fauna (particularly if listed as Specially Protected),

will require referral to the EPA under Section 38 of the *Environmental Protection Act 1986*.

The EPA recognises the difficulties that can be presented to both proponents and regulators when SRE fauna is a relevant factor in an assessment. Adequate sampling for this fauna, particularly in the context of EIA surveys, can be challenging. This, combined with the lack of regional and well-resolved taxonomic frameworks for some groups, can leave the question of the true impacts of a proposal on a species' conservation status unresolved. As discussed above, approval for a development cannot be recommended if there is a significant risk of a SRE species becoming extinct as a result of the proposal.

Where relevant to a formal assessment, the EPA seeks from the proponent sufficient information, through habitat assessment, sampling, and within the constraints of reasonably available knowledge, to assess the risk that the conservation status of a SRE taxon would be adversely affected as a result of the proposal. Where a SRE taxon is listed as Specially Protected, this risk assessment and sampling data would need to provide sufficient contextual information on habitat, distribution and abundance to allow a decision to be made as to whether or not approval could be given for the species to be 'taken', pursuant to the *Wildlife Conservation Act 1950*. For example, if only a small proportion of a listed species is proposed to be 'taken', it may be possible for conditional approval to be recommended. The likelihood of this will be increased where survey work has demonstrated new populations or habitat in addition to those on which existing conservation rankings have been based.

### 3.1.3 Current Assessment Limitations

#### 3.1.3.1 Limits on Current Knowledge

The EPA recognises that conclusively determining the conservation significance of potential SRE taxa is often made difficult by the absence of regional context. As Harvey (2002) observes: "The biology of these organisms is often little known and their precise distribution and life history are poorly documented." This information is lacking, primarily because of paucity in collecting, but also because of a lack of suitable reference collections and taxonomic revisions. Collections that do exist for many invertebrate taxa can also be limited by the proportion of juvenile specimens: these cannot be confidently ascribed to a particular species as taxonomy often relies on the morphology of the adult reproductive parts.

These problems are further compounded by the potential for so-called cryptic species (i.e. taxa that look morphologically similar but are genetically distinct). In some instances, these problems can be overcome in part through molecular studies. However, data solely from genetic based studies (so-called molecular taxonomy) needs to be viewed with caution, as purely molecular phylogenies may not necessarily agree with more robustly defined species that also consider morphological features, distributional and habitat parameters. Furthermore, the potential for deep genetic sub-structuring between populations of these less vagile invertebrates can make phylogenies difficult to interpret in respect of identifying reproductively isolated taxa.

As the review of Harvey (2002) shows, there are also several faunal groups for which the extent of short-range endemism is poorly defined or unknown. Some of these groups include the symphylans, palpigrades, geophilid centipedes, pauropods and several millipede orders (see Appendix 2). The limited

collecting, taxonomic and genetic work that has been done on these potential SRE groups means that their species-level distributions are not well understood. Proponents and regulators should also recognise that, to varying extents, this is also still the case for many of the better-studied SRE faunal groups. Knowledge of the biology, distribution and phylogeography of land snails, mygalomorph spiders and millipedes (amongst other SRE groups) is also changing rapidly. The extent of short-range endemism in these groups is still being defined through ongoing research, and it is possible that some taxa may not prove to be SREs, while others are confirmed as such. The EPA therefore encourages proponents and practitioners to remain current with the latest information in this respect, and to participate in, and contribute to, programmes that improve our overall knowledge of this fauna.

#### 3.1.3.2 Sampling Difficulties

In addition to taxonomic issues, many SRE taxa are difficult to detect in the field, even by experienced specialists. This can hamper the ability of proponents and regulators to place records of potential SRE taxa from proposed development areas into context. Mygalomorph spiders provide an illustrative example.

Many mygalomorphs are difficult to detect because they build burrows that have well camouflaged lids, and are ambush predators that rarely leave their burrows. When males do leave their burrows, it is often within a limited range of ambient conditions (typically humid or wet nights) that are unpredictable and usually seasonally restricted. During EIA surveys, pit-trapping of "wandering" males represents the most likely method of recording the majority of mygalomorph species, and in many cases records are serendipitous events.

While numerous males of a single taxon may be recorded after rain, in other cases a taxon may be represented by only a single capture event. This is a common pattern in fauna sampling programs, which typically record an abundance of individuals of a few common species, while only single or occasional records are obtained of numerous less common or rare species. This can present an issue for EIA when single records of potential SRE species are situated inside a proposed development area. Additional pit trapping may have a low probability of recording additional specimens of low-frequency target taxa because of inappropriate ambient conditions or season.

In situations where such uncommonly recorded species also build cryptic burrows, further targeted mygalomorph surveys may also have a low likelihood of yielding additional specimens. While some techniques are available for detecting cryptic burrows (e.g. the use of a shovel to remove the superficial soil layer in an attempt to intersect burrows), these are very time consuming, not species-specific, and destructive of microhabitats. While EPA will expect reasonable effort to be expended in an attempt to place single SRE records from impact areas into context, the EPA recognises that in some cases this may not yield any further records in a reasonable timeframe.

### 3.1.4 Initial Assessment and Risk-based Approach

As noted in Section 2, SREs are defined as those species with a distribution that encompasses an area less than 10,000 $km^2$, which is considerably greater than even a large mining proposal or other development. This observation is qualified by the observation that there are examples of restricted habitats or geographic features of smaller size that may be more likely to support unique taxa (e.g. isolated rock outcrops, drainage features or elevated coastal areas that have undergone periods of isolation due to changing sea levels). Any such habitats and geographic features present should be identified by the proponent, and the risk of such areas supporting restricted SRE taxa clearly discussed. The EPA will also take cumulative impacts into consideration, especially where these may have already affected similar habitats in the locality.

The likelihood of SRE fauna occurring within a given development area should be considered early in the environmental scoping stage of proposals. Preliminary SRE fauna risk assessments can then be used to set the context for a given assessment and as a reasoned basis to identify the extent of any surveys required. The likelihood of SRE fauna occurring can be inferred from the occurrence or otherwise of geographic boundaries, landform changes or habitat isolates, the results of previous surveys, and advice from the WA Museum and the DEC. In the context of most assessments, habitat isolates can be identified from vegetation type mapping (assuming this is available at sufficient scale of resolution early in the assessment), as this represents the smallest thematic unit. Vegetation types reflect changes in geology, landform, soil type and hydrology – all of which are likely factors in governing the distribution of SRE taxa. Other habitat mapping, such as detailed geomorphological mapping or soil surveys, may also be informative, provided these are also of suitable resolution (i.e. existing regional datasets are unlikely to be of the appropriate scale to be informative).

If vegetation units are restricted to the potential impact area, and are especially different from adjoining units, then there is the potential for some SREs to be similarly confined (an example might be a granite outcrop in an otherwise sandy environment). In contrast, if similar vegetation units are contiguous and broadly distributed outside of the proposed impact area then the likelihood of SREs being confined to the impact area is reduced. The EPA expects initial assessments to provide a review of the potential for SRE fauna to occur, especially if these are used to justify a risk-based argument for not proceeding to field survey. Field sampling will be expected where high levels of uncertainty remain, or the WA Museum or the DEC advise that field survey is still required.

A risk based approach will also be adopted for situations where surveys have been completed, but potential SREs are only recorded from planned impact areas. In this situation a risk-based approach will be considered in cases where:

- a potential SRE taxon is represented by one or few specimens from only within proposed development areas;
- contextual data on the wider distribution and status of the taxon is unavailable from the WA Museum or the DEC; and
- additional targeted surveys appear unlikely to yield results in a reasonable timeframe.

For potentially restricted taxa that meet the above criteria, the use of habitat as a surrogate for inferring distributional boundaries can again be considered. While there are limitations to the use of such surrogates, this provides the only practicable method of undertaking an informed assessment as to the likelihood of small-scale SRE distributional restrictions. Consideration can also be given to the known distribution patterns and ecology of other species belonging to the same genus, to inform assessment of potential restriction. Proponents will be expected to seek advice from the WA Museum and the DEC in preparing these assessments.

Risk-based assessments for SRE fauna will only be considered by the EPA under circumstances described in this section. The EPA will expect the requirements of this Guidance to be met when SRE fauna is a relevant factor for proposals, including sampling outside of the proposed impact area when searching for SREs. Advice will be taken from the DEC and WA Museum in respect of this where appropriate. It is noted that there may be inherent difficulties in sampling on neighbouring properties or leaseholds outside of the proposed impact area.

### 3.1.5 The Importance of Incremental Knowledge Gain

Given some of the issues that exist with SRE taxa, it is important for regulators and proponents to recognise the value of discrete improvements in knowledge in incrementally addressing and ultimately overcoming some of the limitations identified above. A number of regional scale research programmes investigating the phylogeography of various SRE faunal groups are currently underway in academic, government and private industry contexts. These over-arching programmes will ultimately assist in resolving many of the issues outlined above, but individual proposal assessments can also play an important role.

Much of the SRE field survey work that is currently occurring in Western Australia is for the purposes of EIA process. This will also allow for the ongoing and progressive testing of potential short-range endemism models via a series of case studies in different bioregions of Western Australia. The adequacy of vegetation and landform units in predicting the distribution of SRE taxa can also be progressively evaluated, allowing the role of this as a surrogate measure for impact assessment to become better defined.

The EPA recognises that while related to the EIA process, these are longer-term research programmes, the outcomes of which are beyond the timeframe of individual development proposal assessments. The EPA expects, however, that proponents will still pursue a best practice approach during the assessment of individual proposals, consistent with this Guidance. This will maximise the incremental knowledge gain from each assessment and move toward an environment of greater certainty for future assessment for both proponents and regulators in respect of SRE fauna.

## 3.2 Approaches to Survey Design

In assessments where SRE fauna has been identified as a relevant factor, field survey may be required.

Proponents are encouraged to give early consideration to this requirement, as seasonality can be an important factor in completing adequate survey work

(Section 3.3). The EPA also suggests the preparation of an outline scope and approach for SRE surveys, identifying target taxa (giving consideration to the region and habitats), methods and preliminary sampling locations. This should be used as the basis for discussion with EPA Service Unit (EPASU), the DEC and the WA Museum as to the adequacy of the survey. Once agreed, the planned scope of the work should also be incorporated into the environmental scoping document for the assessment for formal EPA consideration. In cases where the survey work is proceeding ahead of the setting of a level of assessment, proponents should treat the content of this Guidance as setting out the EPA's views, and consult directly with WA Museum and DEC officers regarding specifics as appropriate.

As a guide, proponents should ensure that surveys aim to sample proposed ground disturbance areas, and any other areas where the project influence could indirectly affect SRE taxa. Given the issues discussed in Section 3.1, proponents are strongly encouraged to also carry out sampling in equivalent habitats outside of their proposal footprint. Dependent on the direction of individual assessments, this information could be of significant value in establishing the wider distribution of taxa that may otherwise only be recorded from project impact areas.

## 3.3 Sampling Considerations

### 3.3.1 Where to Sample

There are no prescriptive guidelines to identify the habitats that must be searched when looking for potential SRE taxa. Guidance to identify and target the most prospective habitats for this fauna is provided below.

#### 3.3.1.1 Sheltered Habitats and Microhabitats

SREs often belong to relictual faunal groups with origins that can be traced back to the mesic climates of the early Miocene. Mesic environments contracted during the on-set of aridification, resulting in the isolated and restricted distributions of many of today's SREs. As such, extant SREs are most likely to be encountered in sheltered, relatively mesic environments such as slopes with south-west facing aspects, vine thickets, rock piles, drainage systems, deep gorges, mound springs/natural springs, fire refuge areas such as cliffs/isolated rock piles, and other similar habitats. This is also true at a finer habitat scale, with, for example, individual land snails aggregating amongst the roots and rocks on the south-west side of boab trees, or on the south-west side of large termitaria in otherwise exposed settings.

#### 3.3.1.2 Habitat Isolates

Habitat isolates are more likely to yield SREs than are extensive swathes of contiguous habitat. Examples of habitat isolates that should be considered for sampling SREs include islands, the Devonian Reef system in the Kimberley, isolated sandstone/limestone outcrops, isolated mesas, volcanic vents, granite outcrops, banded ironstones of the Mid-west and Goldfields, exposed dolomites or calcretes, boulder piles, isolated birridas, and lakes. This can also include plateau remnants in the Wheatbelt, where the ridges or divides of drainage lines follow the courses of the frayed palaeoriver systems. Ancient soil profiles are

retained and microhabitats preserved which support mygalomorph species (Main 1996). Hopper (1979) also noted, in referring to this region as the "transitional rainfall belt", the botanical endemicity and species richness which he interpreted partly due to these types of edaphic features and weather patterns.

Whether a habitat is considered as isolated will depend on the specific habitat requirements of the target species and the geomorphological, hydrological and pedological context of the specific project area.

### 3.3.2 When to Sample

The optimum time to search for SRE taxa is dependent on the biology of the target species, the techniques being employed and the experience and skill of the individual practitioner.

Typically, SRE taxa are easier to locate and collect during seasonally wet conditions, the timing of which varies throughout the State (see http://www.bom.gov.au/climate/averages/tables/ca_wa_names.shtml for summary data). For many SREs, adults (and particularly adult males) are required for identifications (e.g. the gonopod of *Antichiropus* millipedes is considered a reliable indicator of biological species), and many taxa reach maturity timed to coincide with these seasonally wet conditions. For the purpose of providing general guidance, optimal timing for the various regions is provided in Table 3, corresponding to peak rainfall periods in each region.

**Table 3: Optimal timing for SRE surveys in Western Australia.**

| Region | Optimal Survey Period | Rationale |
|---|---|---|
| South-west, South coast | Winter - early spring (May-Oct) | Presence of adults for key SRE groups in the region such as millipedes and onychophorans. Enhanced activity in otherwise cryptic groups such as *Bothriembryon* land snails, male mygalomorph spiders |
| Goldfields, Mid-West | South: Winter (May-Aug)<br>North: Cyclone Season (Nov-Apr) | Rainfall in these regions can be influenced by south-west fronts in the south and cyclone events in the north. Enhanced activity in otherwise cryptic groups such as *Bothriembryon* land snails, male mygalomorph spiders |
| Pilbara | Cyclone Season (Nov-Apr) | Presence of adults in some key groups. Enhanced activity of cryptic groups including mygalomorph spiders and some land snails such as *Quistrachia* species |
| Kimberley | Wet Season (Nov–Apr) | Presence of adults in some key groups. Enhanced activity of some land snail species and other taxa in vine thickets. |

While optimal periods are nominated based on the typical life history characteristics of many SREs, it is recognised that peak activity often coincides with rainfall events, which can be difficult to predict and are not always conducive to field sampling. Considerable periods of time may also elapse in some regions without reliable or predictable rainfall. The EPA recognises these issues and SRE survey work for EIA can take place outside of these dates. In

this case, suitable searching methods must be employed taking into account target taxa and actual seasonal conditions at the time of survey. A discussion of limitations must also be provided within the report.

In cases involving specific SRE taxa where adult specimens are required to permit taxonomic resolution, survey timing needs to coincide with the presence of adults. Where adults are not essential for taxonomic resolution, or where adults are present in the population at all times (e.g. land snails), optimal timing is less constrained. In the particular case of land snails for example whilst they are most conspicuous during wet conditions, difficulties with accessing survey areas during wet periods may preclude field collecting. Where this is the case, it may be more practicable to search during cool dry conditions. In this event, practitioners must have suitable experience in searching for and collecting the target groups and be able to demonstrate such in the proposed methodologies.

### 3.3.3 How to Sample

A variety of techniques are available for collecting SRE taxa and a range of techniques should be employed when conducting SRE surveys.

#### 3.3.3.4 Wet pit traps

There are significant ethical concerns about the use of wet pits, predominantly in relation to by-catch of vertebrate fauna. Wet pit methods can also preclude the use of molecular techniques on collected specimens in resolving the distribution of SRE species. The EPA therefore does not consider the use of wet pits as a standard component of SRE surveys. Any planned use of wet pits should be discussed with the DEC and the WA Museum prior to their installation.

#### 3.3.3.5 Dry pit traps

For the purpose of a targeted SRE surveys, dry pits may be of limited use unless rain is expected during the course of the survey. Proponents and practitioners should evaluate the relative merit of effort that can be expended during pit installation versus time that could be spent on hand foraging methods. Many SRE taxa that may be recorded in pits remain largely inactive during dry periods and are only active during rain events or humid evenings. However it may be useful for practitioners to have smaller pits (as opposed to the larger pits employed during vertebrate surveys) such as ice-cream containers, plastic or paper cups, or small jars on hand. These could then be deployed in the event of unforeseen rain.

In the event that SRE surveys are being carried out simultaneously with vertebrate surveys then clearly there is value in collecting any potential SRE taxa that are captured in the installed dry pits.

#### 3.3.3.6 Hand foraging

To effectively hand forage for SRE fauna, a basic knowledge of the target species' biology is required. Where this is not known, an understanding of the broad group is required. Hand foraging techniques can then be tailored to maximise the likelihood of collecting specimens. Techniques that can be employed include:

- **Sieving of leaf litter / soil**

Sieving and extraction methods such as the use of Berlese or Tullgren funnels are effective in sampling invertebrates in leaf litter and soil. These methods can be particularly productive for recording some species of millipedes, pseudoscorpions and micro-snails (e.g. *Gastrocopta*, *Pupoides*, *Discocharopa*). A series of leaf litter concentrate samples can produce most of the ground dwelling species from any particular locality. Some specimens are difficult to distinguish with the naked eye and sorting may need to be conducted using a stereo-microscope.

- **Raking through soil, leaf litter and debris**

This technique can uncover the entrances to camouflaged mygalmorph spider burrows and uncover buried land snails that may aestivate a few centimetres below the surface. Hand raking and searching through moist leaf litter can also yield millipede specimens under suitable conditions.

- **Searching amongst rock piles**

Turning over large rocks or boulders can be particularly productive when searching for some taxa. Practitioners should be mindful of returning rocks to their original location and orientation.

- **Searching on trees and beneath bark**

To obtain a good sample of tree dwelling SRE taxa, trees with smooth and exfoliating bark will need to be closely inspected. Pseudoscorpions and millipedes can be collected from beneath loose bark, with the latter group also present in fallen and rotting trees.

The optimal foraging methods will depend on the ecology of the target groups in much the same way as different techniques are employed to record different vertebrate fauna species. Proponents will need to demonstrate that an appropriate range of methods have been employed to survey for different SREs, taking into account the timing of the survey, the region and the faunal groups involved.

### 3.3.4 Example of Appropriate Sampling Approaches for Land Snails

As an example, a summary of sampling considerations for land snails is provided below to illustrate the appropriate combination of habitat targeting, survey timing and sampling method for example SRE groups and regions. This account is not intended as exhaustive, but should be viewed as a guide to proponents and practitioners on how the sampling method, region and survey timing needs to recognise the biology of the target groups.

#### 3.3.4.1 Example of Land Snail Sampling Considerations

Land snails are most readily collectable during wet conditions when animals are active, and some species may only emerge from rock crevices etc at night. During seasonally dry conditions, camaenids aestivate in sheltered cool locations and can be difficult to locate.

In the Pilbara, productive places to search include beneath *Triodia* hummocks on loamy flats or along drainage lines, particularly when searching for *Rhagada* species. The presence of shells scattered over the surface is typically a good indication of the presence of live specimens under *Triodia* hummocks.

Species of *Strepsitaurus* on Cape Range are often found sealed to vertical rock faces under large over-hanging *Triodia* hummocks. The base of *Ficus* trees can also be productive in yielding camaenids as well as a diverse assemblage of non-camaenid micro-snails. Beneath turnable boulders or rocky scree in sheltered locations are often productive places to search for rock-sealing land snail species such as several *Quistrachia* and *Plectorhagada* species.

In the Kimberley, vine thickets can be particularly productive in yielding camaenid species. Good places to search include beneath large slabs of rock sitting atop other rocks, within rock crevices, under logs, and within hollow and rotting logs. Some species, such as *Xanthomelon*, may be buried several centimetres below the surface and extensive raking may be required to locate them.

Micro-snails are relatively easy to collect. Some are tree-dwellers and some ground dwellers. One of the tree-dwelling taxa with a cryptic habit, *Amimopina macleyi*, is frequently found under bark on dead trees or in holes on tree trunks. However, the majority of the tree-dwelling taxa aestivate in the open and are commonly found on trunks and branches or on smooth leaves 1 - 2 m above the ground. Most of the ground-dwelling species are very small and common, sometimes abundant. Some species, such as *Westracystis lissus*, are larger, aestivate sealed to a substrate, and can be abundant in crevices on laterite and in curled up leaves in leaf litter.

## 3.4 Preservation and Lodgement of Specimens

The EPA expects that specimens collected from EIA surveys will be lodged with the WA Museum to add to the State's collection. This will also serve to facilitate the consolidated development of reference collections, enable comparisons between projects, and therefore contribute to incremental knowledge gain.

A variety of curatorial techniques is available and the most appropriate needs to be selected for each taxon. A detailed protocol of data labelling and curatorial techniques is provided in Appendix 4 of this Guidance. Proponents and practitioners should consult WA Museum staff if there is any uncertainty in regards to preservation or lodgement requirements for specific groups.

## 3.5 Specimen Identification and Analysis

The majority of the taxonomic expertise relating to SRE taxa resides with the staff of the WA Museum. Some groups are also worked on by researchers within other government departments and academic institutions. Taxonomic treatments are available for some SRE groups, particularly for camaenid land snails (prepared by Solem in a number of publications which have been listed in Appendix 5). Advice on equivalent taxonomic treatments for other groups is available from the WA Museum.

The EPA's expectation is that all potential SRE specimens will be identified to the lowest taxonomic level possible. Ideally, this will be the species level, but the EPA recognises the limitations associated with juvenile specimens and lack of taxonomic framework for some groups. In these cases, other methods (such as DNA analysis) or the definition of morphotypes by a suitable experienced taxonomist, should be pursued. Any limitations on the assessment that stem

from the nature of the specimens should be clearly identified in reports. Proponents are also advised that there can be considerable lead time on both morphological specimen identification and molecular analysis. The EPA therefore encourages early consideration of these issues in assessment timing, and the provision of realistic time allowance for identifications by the WA Museum and other specialist groups.

While adults (and typically males) are important for confirming taxonomy, in some instances molecular techniques can be used to help identify juvenile or female specimens. This can have the benefit of providing a more thorough analysis of species-level distributions. The adequacy of the assessment can be substantially improved by allowing the inclusion of the additional range of collecting locations where only juvenile specimens may have been collected. Proponents are therefore encouraged to utilise molecular analysis methods in situations where traditional taxonomic identification is not possible or will not adequately address questions of SRE restriction to proposed impact areas. Such studies can also usefully contribute to incremental knowledge gain in respect of overall phylogeographic models being developed for various SRE groups (Section 3.1.4).

## 3.6 Reporting Standards

### 3.6.1 Statement of Methods and Limitations

It is essential that reporting on SRE fauna surveys presents a section describing the methods used and the limitations of these methods. This will enable assessment officers to determine whether the survey is adequate to address particular issues. The survey techniques for each of the faunal groups sampled should be detailed, including the effort expended, sampling locations and habitats targeted.

Reports should also clearly discuss any limitations that apply to the survey or the findings. This should give consideration to field collecting adequacy, seasonal factors (particularly rainfall), and the level of resolution of specimen identifications. The personnel who contributed to the study should also be identified, particularly in regards to any specialist identifications or genetic work completed.

### 3.6.2 Presentation of Results

As far as possible, data collected for SRE fauna surveys being conducted for EIA should be gathered and presented in quantitative form. Results presented in SRE survey reports can be used to interpret data or make qualitative observations, but the information to support the key results should be presented in a form that would allow for evaluation by an appropriately qualified third party.

The EPA also seeks to ensure comparability between different EIA reports, both in regard to methodologies and especially in the nomenclature of species involved. The WA Museum is the agency with the primary responsibility for compiling the State's faunal species listings, including SRE taxa. EIA reports will therefore be expected to use current taxonomy and nomenclature as advised

by the WA Museum. For groups for which there are no current comprehensive taxonomic frameworks, it is expected that EIA reports will use the most recently available names and the appropriate departments within the WA Museum should be consulted for advice.

Survey reports should clearly set out the findings of surveys, identifying and discussing the taxa collected within each of the target SRE faunal groups. It is useful to the assessment for this to include discussion of:

- the local (proposal area) distribution and abundance of each potential SRE taxon;
- the wider status of the SRE taxa involved (particularly if they are Specially Protected fauna), where this is known;
- the vegetation types / habitats from which the potential SRE taxa were recorded; and
- whether these records appear to spatially correspond to any identifiable landform features.

Proponents are encouraged to utilise GIS approaches to these aspects of the SRE studies and reporting, to facilitate more reliable spatial assessments of project impacts.

# 4 APPLICATION

## 4.1 Area

This Guidance Statement applies to all development proposals and planning schemes or scheme amendments throughout the State of Western Australia that are subject to the EIA processes set out in Part IV of the *Environmental Protection Act* 1986 that have the potential to impact significantly on short-range endemic invertebrate fauna species.

## 4.2 Duration and Review

This Guidance Statement remains current until such time the EPA decides to review it. While generally the review period would be after five years, circumstances may require it to be reviewed earlier.

# 5 RESPONSIBILITIES

## 5.1 Environmental Protection Authority Responsibilities

The EPA will apply this Guidance Statement during the assessment of proposals under Part IV of the *Environmental Protection Act 1986* where the factor of short range endemic invertebrate fauna is relevant.

## 5.2 Department of Environment and Conservation Responsibilities

The DEC will assist the EPA in applying this Guidance Statement in environmental impact assessment and in conducting its functions under Part IV of the *Environmental Protection Act 1986.*

## 5.3 Proponent Responsibilities

Where proponents demonstrate to the EPA that the requirements of this Guidance Statement are incorporated into proposals, in a manner which ensures that they are enforced and audited, the assessment of such proposals is likely to be assisted.

# 6 DEFINITIONS AND ABBREVIATIONS

**EIA** - Environmental Impact Assessment

**EPA** - Environmental Protection Authority

**DEC** - Department of Environment and Conservation

**DNA** - Deoxyribonucleic Acid: the fundamental genetic material of living organisms (mtDNA = mitochondrial DNA).

**GIS** - Geographic Information System

**Phylogeny** - The history, origin and evolution of a set of organisms, usually of a species

**Phylogeography** - The study of historical and evolutionary processes responsible for the contemporary geographic distributions of species and populations.

**SRE** - Short Range Endemic

**Taxa** - A taxonomic group. Depending on context this may be a subspecies, species, genus or higher taxonomic grouping (singular = taxon).

**Vagile** - Organisms that are able to freely move or change distribution over time

# 7 LIMITATIONS

This Guidance Statement has been prepared by the Environmental Protection Authority to assist proponents and the public. While it represents the contemporary views of the EPA, each proposal which comes before the EPA for environmental impact assessment will be judged on its merits. Proponents wishing to deviate from the Guidance provided in this document should provide a robust justification for the proposed departure.

# 8 ACKNOWLEDGMENTS

The EPA acknowledges the contributions of Roy Teale and Garth Humphreys (Biota Environmental Sciences), John Dell and Bridget Hyder (EPASU), Dr Mark Harvey (WA Museum), Brad Durrant (DEC), and Dr Barbara York Main (UWA).

# 9 REFERENCES/BIBLIOGRAPHY

Attems, C.G. (1911). Myriopoda exkl. Scolopendridae. In: *Die Fauna Südwest-Australiens* (W. Michaelsen and R. Hartmeyer eds). Vol. 3: 147-204. Gustav Fischer, Jena.

Biota Environmental Sciences (2007). Molecular Systematics of *Rhagada* from the Pilbara and the Brockman Syncline 4 Project Area. Unpublished report prepared for Pilbara Iron Pty Ltd, Perth.

Fukuda, H. and Ponder, W.F. (2003). Australian freshwater assimineids, with a synopsis of the recent genus-group taxa of the Assimineidae (Mollusca: Caenogastropoda: Rissooidea). *Journal of Natural History* 37:1977 - 2032

Harvey, M.S. (2002). Short-range endemism in the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* 16: 555-570.

Harvey, M.S., Sampey, A., West, P.L.J. and Waldock, J.M. (2000). The Chilopoda and Diplopoda of the southern Carnarvon Basin, Western Australia. *Records of the Western Australian Museum* Supplement 61: 323-333.

Harvey, M.S. and Yen, A.L. (1989). *Worms to wasps: an illustrated guide to Australia's terrestrial invertebrates*. Oxford University Press, Melbourne.

Hopper, S.D. 1979. Biogeographic aspects of speciation in the south western Australian flora. *Annual Review of Ecology and Systematics* 10: 399-422.

Hopper, S.D., Harvey, M.S., Chappill, J.A., Main, A.R. and Main, B.Y. (1996). *The Western Australian Biota as Gondwanan Heritage - a review*. Chapter 1, pp. 1-46. In S.D. Hopper, M.S. Harvey, J.A. Chappill and A.S. George (eds) Gondwanan Heritage- Past, Present and Future of the Western Australian Biota. (Surrey Beatty & Sons, Chipping Norton, N.S.W.).

Jeekel, C.A.W. (1982). Millipedes from Australia, 1: Antichiropodini from South Australia (Diplopoda, Polydesmida, Paradoxosomatidae). *Bulletin Zoologisch Museum, Universiteit van Amsterdam* 8: 121-132.

Johnson, M.S., Hamilton, Z.R., Murphy, C.E., MacLeay, C.A., Roberts, B. and Kendrick, P.G. (2004). Evolutionary genetics of island and mainland species of *Rhagada* (Gastropoda: Pulmonata) in the Pilbara Region, Western Australia. *Australian Journal of Zoology* 52: 341-355.

Johnson, M.S., Hamilton, Z.R. and Fitzpatrick, J. (2006). Genetic diversity of *Rhagada* land snails on Barrow Island. *Journal of the Royal Society of Western Australia* 89: 45-50.

Main, B.Y. (1996). Microcosmic biogeography: trapdoor spiders in a time warp at Durokoppin. Chapter 13, pp 163-171. In : *Gondwanan Heritage: Past, Present and Future of the Western Australian Biota*. Eds S.D. Hopper, J.A. Chappill, M.S. Harvey and A.S. George. (Surrey Beatty & Sons, Chipping Norton, N.S.W.).

Main, A.R. and Main, B.Y. (1991). *Report on the southern forest region of Western Australia*. Australian Heritage Commission, Canberra. 8 pages, 4 pages supplementary notes, 6 tables, 8 maps.

Moir, M.L and Harvey, M.S. (2008). Discovery of the pill millipede genus *Epicyliosoma* (Diplopoda: Sphaerotheriida: Sphaerotheriidae) in Western Australia, with the description of a new species. *Records of the Western Australian Museum* 24: 113-119.

Ponder, W.F. (1997). Conservation status, threats and habitat requirements of Australian terrestrial and freshwater Mollusca. *Memoirs of the Museum of Victoria* 56: 421-430.

Ponder, W.F. and Colgan, D.J. (2002). What makes a narrow-range taxon? Insights from Australian fresh-water snails. *Invertebrate Systematics* 16: 571-582.

Shear, W.A. (1992). A new genus and two new species of millipedes from the Cape Range, Western Australia (Diplopoda, Polydesmida, Paradoxosomatidae). *Records of the Western Australian Museum* 15: 777-784.

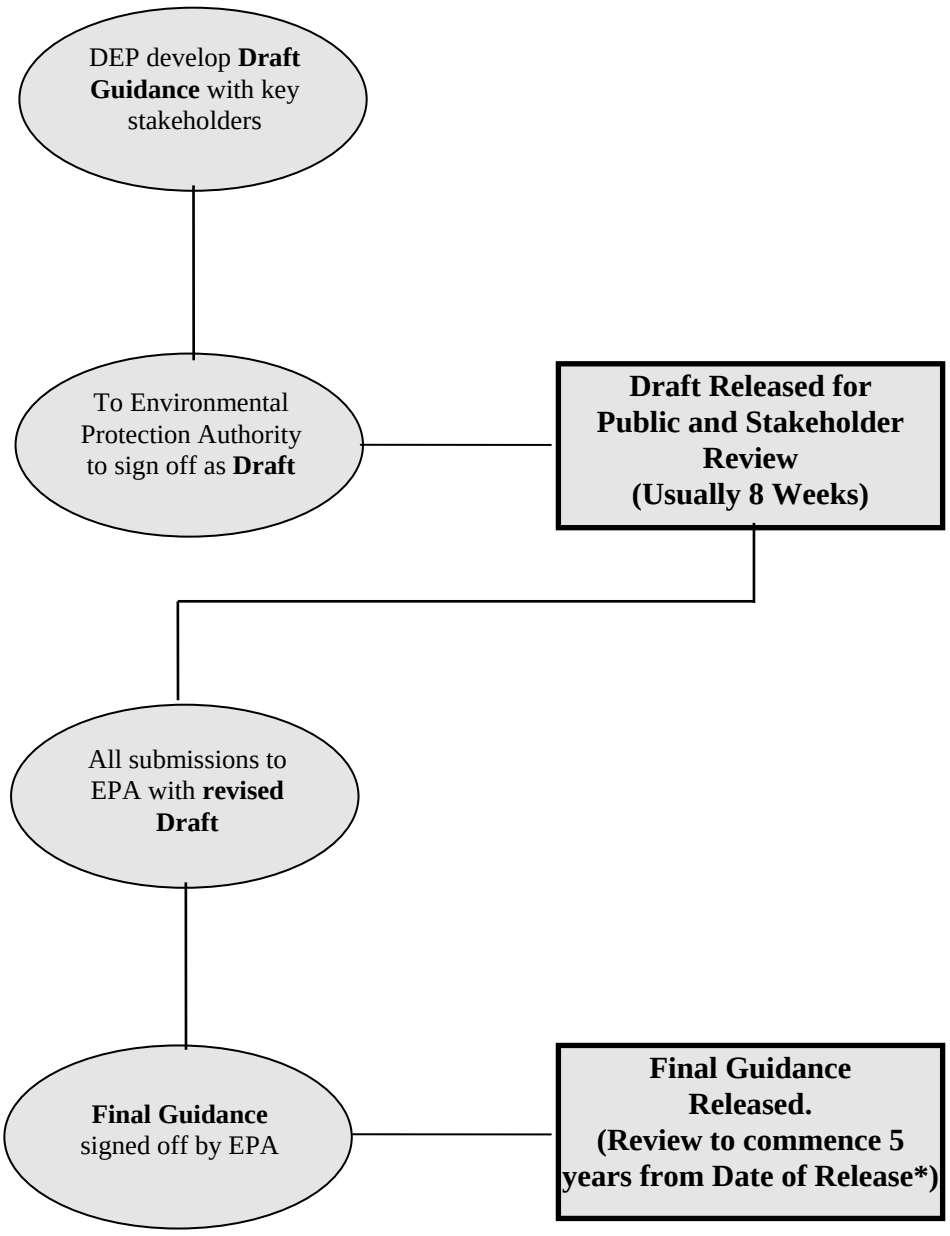
Solem, A (1985). Camaenid land snails from Western and central Australia (Mollusca: Pulmonata: Camaenidae). V Remaining Kimberley Genera and Addenda to the Kimberley. *Records of the Western Australian Museum* Supplement No.20.

Solem, A. (1997). Camaenid land snails from Western and Central Australia (Mollusca: Pulmonata: Camaenidae). VII Taxa from Dampierland through the Nullarbor. *Records of the Western Australian Museum* Supplement No 50: 1461-1906.

Solem, A., Giradi, E.L., Slack-Smith, S. and Kendrick, G.W. (1982). *Austroassiminea letha*, gen. nov., sp. nov., a rare and endangered prosobranch snail from south-western Australia (Mollusca: Prosobranchia: Assimineidae). *Journal of the Royal Society of Western Australia* 65: 119-129.

# Appendix 1

## Generic Flow Diagram for the Guidance Statement Process




* Guidance may be reviewed earlier if circumstances require it.

**Summary of short-range endemism in the Australia terrestrial and freshwater fauna** (source: Harvey (2002) and references therein)

| Phylum | Class | Order | SRE status |
|---|---|---|---|
| Platyhelminthes | Turbellaria | Tricladida | Unknown, but extremely likely. |
| Nemertea | Enopla | Hoplonemertea | Unknown, but extremely likely. |
| Nematomorpha | Gordioida | Chordodea | Unknown. |
| | | Gordea | Unknown. |
| Mollusca | Bivalvia | Unionoida | Some SRE (Smith 1992). |
| | | Veneroida | None (Smith 1992). |
| | Gastropoda | Architaenioglossa | Many SRE (Smith 1992). |
| | | Sorbeoconcha | Numerous SRE (Smith 1992; Ponder *et al.* 1993; Miller *et al.* 1999). |
| | | Systellommatophora | The sole indigenous Australian member of this order, *Prisma prismatica* (Tapparone-Canefri), is widespread in eastern Australia and New Guinea (Smith 1992). |
| | | Basommatophora | The few indigenous Australian basommatophorans are mostly widespread species (Smith 1992). |
| | | Eupulmonata | Numerous SRE (see text). |
| Annelida | Oligochaeta | Haplotaxida | Many indigenous terrestrial earthworms are extremely localised and most represent SRE (e.g. Jamieson 1971, 1974, 1994; Blakemore 1998) (see text). |
| | | Tubificida | Pinder and Brinkhurst (1997) have shown that the Australian phreodrilids consist of some localised species and some widespread species. |
| | Hirudinea | Arhynchobdellida | Unknown. |
| Tardigrada | Tardigrada | Eutardigrada | Unknown, but unlikely. |
| | | Heterotardigrada | Unknown, but unlikely. |
| Onychophora | Onychophora | Onychophora | Extensive, almost ubiquitous, presence of SRE (see text). |
| Arthropoda | Arachnida | Scorpiones | The current taxonomic arrangement (Koch 1977) includes many species-complexes that once studied will eventually increase the size of the fauna extensively. Some of these species may then qualify as SREs (E. S. Volschenk, personal communication). |
| | | Araneae | Some SRE, mostly amongst the Mygalomorphae (see text). |
| | | Amblypygi | One species widespread in Queensland rainforests, two species known only from single localities (Harvey and West 1998). |
| | | Schizomida | Extensive, almost ubiquitous, presence of SRE (see text). |
| | | Pseudoscorpiones | Very few (e.g. Harvey 1998), except for some troglobites. |
| | | Opiliones | Many harvestmen possess small ranges (e.g. Hunt 1985, 1992, 1993, 1995; Hunt and Cokendolpher 1991), but often larger than SRE threshold of 10,000 $km^2$. |
| | | Palpigradi | The known Australian fauna only consists of two introduced species (Walter and Condé 1997), plus a single specimen of a presumably endemic species from north-western Australia (W. F. Humphreys, personal communication). |
| | | Acari | Some SRE. |
| | Branchiopoda | Notostraca | None. |
| | | Anostraca | None. |
| | | Cladocera | Some SRE. |
| | | Conchostraca | Unknown. |
| | Remipedia | Nectiopoda | The sole Australian remipede, *Lasionectes exleyi* Yager and Humphreys, is restricted to a single anchialine locality in Western Australia (Yager and Humphreys 1996). |
| | Ostracoda | Podocopida | Few SRE. |

**Summary of short-range endemism in the Australia terrestrial and freshwater fauna** (source: Harvey (2002) and references therein)

| Phylum | Class | Order | SRE status |
|---|---|---|---|
| | Maxillipoda | Copepoda | Few SRE. |
| | Malacostraca | Spelaeogriphacea | The sole Australian spelaeogriphacean, *Mangkurtu mityula* Poore and Humphreys, is restricted to aquatic stygal habitats in Western Australia (Poore and Humphreys 1998). |
| | | Thermosbaenacea | The sole Australian thermosbaenacean, *Halosbaena tulki* Poore and Humphreys, is restricted to aquatic stygal habitats in the Pilbara region of Western Australia (Poore and Humphreys 1992). |
| | | Mysidacea | |
| | | Anaspidacea | |
| | | Isopoda | All Phreatoicidea are SRE (Wilson and Johnson 1999). Many indigenous slaters (Oniscoidea) will most likely be found to represent SRE. |
| | | Amphipoda | The Australian terrestrial amphipod fauna contains some localised species, but very few that possess distributions of less that 10,000 $km^2$ (Friend 1982, 1987). |
| | | Decapoda | Extensive presence of SRE, especially amongst Parastacidae (see text). |
| | Chilopoda | Scolopendrida | None. |
| | | Geophilida | Some SRE but Australian fauna poorly known. |
| | | Lithobiida | Few SRE. |
| | | Craterostigmatida | The sole Australian species, *Craterostigmus tasmanianus* Pocock, is restricted to Tasmania, where it is widespread (Mesibov 1995). |
| | | Scutigerigida | Unknown, but unlikely. |
| | Symphyla | Symphyla | Unknown. |
| | Diplopoda | Polyxenida | Unknown, but unlikely. |
| | | Sphaerotheriida | Unknown, but many of these large rolling millipedes will most likely be found to represent SRE, like *Cynotelopus notabilis* Jeekel (Main *et al*. 2002). |
| | | Polydesmida | Unknown, but many of polydesmids will most likely be found to represent SRE |
| | | Spirobolida | Unknown |
| | | Julida | None (all julids in Australia are introduced species). |
| | | Chordeumatida (= Craspedosomatida) | Many SRE (see Shear and Mesibov 1997). |
| | | Spirostreptida | Unknown. |
| | | Siphonophorida | Unknown. |
| | | Polyzoniida | Unknown. |
| | Pauropoda | Pauropoda | Unknown. |
| | Collembola | Collembola | Many species appear to be widespread, but others (e.g. many Neanuridae) appear to be SRE (e.g. Greenslade 1994). |
| | Protura | Protura | Few SRE (Houston 1994b). |
| | Diplura | Diplura | Many species appear to be widespread, but others appear to be SRE (e.g. Houston 1994a). |
| | Insecta | Archaeognatha | Many species with small ranges (Sturm and Smith 1993). |
| | | Thysanura | Smith (1998) found that Australian nicoletiids possessed small ranges. |
| | | Odonata | Most dragonflies and damselflies are strong flyers and many species are widely distributed. Even the sole species assessed by Hawking (1999) as Critically Endangered, *Archaeophya adamsi* Fraser (Gomphomacromiidae) was previously known from mid-east Queensland to mid-coastal New South Wales (Hawking 1999). |
| | | Ephemeroptera | Few mayfly species are widespread, and many appear to be locally distributed; thus some may eventually represent SRE. |
| | | Blattodea | Nil, except for some troglobites. |
| | | Isoptera | None. |
| | | Mantodea | None. |
| | | Dermaptera | None. |
| | | Plecoptera | Many stoneflies have restricted ranges, but others are relatively widespread. |

**Summary of short-range endemism in the Australia terrestrial and freshwater fauna** (source: Harvey (2002) and references therein)

| Phylum | Class | Order | SRE status |
|---|---|---|---|
| | | Orthoptera | Few. |
| | | Phasmatodea | Few. |
| | | Embioptera | Few. |
| | | Hemiptera | Few. |
| | | Thysanoptera | Few species appear to possess restricted distributions (Mound 1996). |
| | | Psocoptera | Few species appear to possess restricted distributions (Smithers 1996). |
| | | Phthiraptera | Few species appear to possess restricted distributions (Palma and Barker 1996). |
| | | Megaloptera | Some dobsonfly species are widespread, but many appear to be locally distributed (Theisinger and Houston 1988); thus some may eventually represent SRE. |
| | | Neuroptera | Few Australian lacewings appear to possess restricted distributions (New 1996*a*). |
| | | Coleoptera | Some. |
| | | Strepsiptera | Many strepsipterans are known only from single localities (e.g. New 1996*b*), but there is little evidence that this represents the real situation. |
| | | Mecoptera | Most of the Australian species are relatively widespread (Lambkin 1996), with few, if any, SRE. |
| | | Siphonaptera | Few Australian fleas appear to possess restricted distributions (Calder 1996). |
| | | Diptera | Few. |
| | | Trichoptera | Few. |
| | | Lepidoptera | Few. |
| | | Hymenoptera | Few. |
| Chordata | Cephalaspidomorphi | Petromyzontiformes | Of the three Australian species, one, *Mordacia praecox* Potter, may be an SRE (see Allen *et al.* 2002). |
| | Chondrichthyes | Carchariniformes | None (see Allen *et al.* 2002). |
| | Actinopterygi | Anguilliformes | None (see Allen *et al.* 2002). |
| | | Atheriniformes | Some species are highly restricted, including some hardyheads (*Craterocephalus*), and some rainbowfish (Melanotaeniidae) (see Allen *et al.* 2002). |
| | | Beloniformes | None (see Allen *et al.* 2002). |
| | | Clupeiformes | None (see Allen *et al.* 2002). |
| | | Cyprinodontiformes | The only species present in Australian waters are introduced (see Allen *et al.* 2002). |
| | | Osteoglossiformes | None (see Allen *et al.* 2002). |
| | | Perciformes | A few Perciformes possess restricted distributions (see Allen *et al.* 2002), especially amongst the Gobiidae (Larson 2001). |
| | | Pleuronectiformes | None (see Allen *et al.* 2002). |
| | | Salmoniformes | The only Salmoniformes in Australia are introduced (see Allen *et al.* 2002). |
| | | Scorpaeniformes | None (see Allen *et al.* 2002). |
| | | Siluriformes | The only geographically restricted Australian catfish is *Neosilurus gloveri* Allen and Feinberg from the Dalhousie Springs, South Australia (see Allen *et al.* 2002). |
| | | Synbranchiformes | Of the four species of swamp-eels present in Australia, only one, the Blind Cave Eel, *Ophisternon candidum* (Mees), is highly restricted (see Allen *et al.* 2002). |
| | Sarcopterygii | Ceratodontiformes | The sole species, *Ceratodontus forsteri* Krefft, occurs in a restricted area of Queensland (see Allen *et al.* 2002). |
| | Amphibia | Anura | Few (Cogger 1994). |
| | Reptilia | Testudines | None (Cogger 1994). |
| | | Squamata | Some (Cogger 1994). |
| | | Crocodylia | None (Cogger 1994). |

# Appendix 3

## Western Australian SRE taxa currently listed as Schedule 1 fauna in the *Wildlife Conservation (Specially Protected Fauna) Notice 2008(2)* (Last updated 13th March 2008)

(source: http://www.dec.wa.gov.au/management-and-protection/threatened-species/index.html; tabulation excludes subterranean taxa).

| Taxon | Common Name | Region |
|---|---|---|
| **Freshwater and Land Snails (34 taxa)** | | |
| *Amplirhagada astute* | - | Kimberley |
| *Austroassiminea letha* | Cape Leeuwin Freshwater Snail | South-west |
| *Carinotrachia carsoniana* | - | Kimberley |
| *Cristilabrum bubulum* | - | Kimberley |
| *Cristilabrum buryillum* | - | Kimberley |
| *Cristilabrum grossum* | - | Kimberley |
| *Cristilabrum isolatum* | - | Kimberley |
| *Cristilabrum monodon* | - | Kimberley |
| *Cristilabrum primum* | - | Kimberley |
| *Cristilabrum rectum* | - | Kimberley |
| *Cristilabrum simplex* | - | Kimberley |
| *Cristilabrum solitudum* | - | Kimberley |
| *Cristilabrum spectaculum* | - | Kimberley |
| *Mouldingia occidentalis* | - | Kimberley |
| *Mouldingia orientalis* | - | Kimberley |
| *Ningbingia australis australis* | - | Kimberley |
| *Ningbingia australis elongata* | - | Kimberley |
| *Ningbingia bulla* | - | Kimberley |
| *Ningbingia dentiens* | - | Kimberley |
| *Ningbingia laurina* | - | Kimberley |
| *Ningbingia octava* | - | Kimberley |
| *Ningbingia res* | - | Kimberley |
| *Ordtrachia elegans* | - | Kimberley |
| *Turgenitubulus christenseni* | - | Kimberley |
| *Turgenitubulus costus* | - | Kimberley |
| *Turgenitubulus depressus* | - | Kimberley |
| *Turgenitubulus foramenus* | - | Kimberley |
| *Turgenitubulus opiranus* | - | Kimberley |
| *Turgenitubulus pagodula* | - | Kimberley |
| *Turgenitubulus tanmurrana* | - | Kimberley |
| Rhytidid species (WAM 2295-69) | Stirling Range Rhytidid Snail | South-west |

| Taxon | Common Name | Region |
|---|---|---|
| *Westraltrachia alterna* | - | Kimberley |
| *Westraltrachia inopinata* | - | Kimberley |
| *Westraltrachia turbinata* | - | Kimberley |
| **Spiders (7 taxa)** | | |
| *Aganippe castellum* | Tree-stem Trapdoor Spider | Mid-west |
| *Austrarchaea mainae* | Western Archaeid Spider | South coast |
| *Idiosoma nigrum* | Shield-backed Trapdoor Spider | Wheatbelt |
| *Kwonkan eboracum* | Yorkrakine Trapdoor Spider | Wheatbelt |
| *Moggridgea* sp. (BY Main 1990/24) | Stirling Range Trapdoor Spider | South-west |
| *Moggridgea tingle* | Tingle Trapdoor Spider | South-west |
| *Teyl* sp. (BY Main 1953/2683, 1984/13) | Minnivale Trapdoor Spider | Wheatbelt |
| **Decapod Crustaceans (4 taxa)** | | |
| *Cherax tenuimanus* | Margaret River Marron | South-west |
| *Engaewa pseudoreducta* | Margaret River Burrowing Crayfish | South-west |
| *Engaewa reducta* | Dunsborough Burrowing Crayfish | South-west |
| *Engaewa walpolea* | Walpole Burrowing Crayfish | South-west |
| **Millipedes (2 taxa)** | | |
| *Cynotelopus notabilis* | Western Australian Pill Millipede | South coast |
| *Epicyliosoma sarahae* | Sarah's Pill Millipede | South coast |

# Appendix 4

# Preservation Protocols for SRE Groups

## Arachnids and Myriapods

- **Preservation**

All specimens are to be fixed in ethanol as rapidly as possible after collection. Small specimens (e.g. pseudoscorpions, schizomids) preferably to be fixed in 100% ethanol to provide for potential molecular analysis. 75% ethanol is also acceptable. All containers should include a small printed label specifying the concentration of the ethanol (e.g. "100% ETOH" or "75% ETOH").

For large specimens (e.g. scorpions, trap-door spiders), the third left leg should be removed at point of death using clean, small scissors (wash the scissors in water, and dry with clean paper towel between each specimen). The leg should be placed in 100% ethanol in a 2 ml Cryotube with screw cap (available from Interpath Service Pty Ltd, Melbourne). The remainder of the specimen should be placed in a jar containing 75% ethanol, with the Cryotube then placed in the same jar as the source specimen.

- **Storage**

Specimens should be stored in suitable glass containers. Plastic vials are not suitable as they deteriorate over time. Smaller specimens should be stored in SAMCO "Specimen Tubes Soda Glass Poly Stopper" vials (size code G050/26). Larger specimens should be in small glass jars. Other vial sizes of SAMCO vials are available for different sized animals. Preserved specimens should be kept in a cool place, ideally in a refrigerator.

- **Labelling**

Each container should contain a unique coded identifier that can be quoted by WA Museum staff when supplying identifications. Each vial should contain a small, neatly trimmed printed label with the following specifications:

- Arial 4.5 font;
- locations must be provided as Latitudes and Longitudes (DD°MM'SS") not UTMs or decimal degrees;
- the datum must be specified; and
- dates with month spelled out, not given as a numeral.

e.g.
W.A.: Mesa Y-09, ca. 64 km SSW. of Pannawonica
25°18'23"S, 117°51'03"E (WGS 84)
14 Dec. 2007-5 Jan. 2008
J.A. Brown, T.R. Smith (Eco-company site 667-898A)
Pitfall trap

If the vial is suspected of containing multiple species, ensure that sufficient labels are included to provide for the transfer of individual specimens to new vials. If additional information (e.g. field identifications or habitat notes) is to be included with specimens then it can be provided on additional labels. Labels should be printed on "Tablex System Board, 250 GSM" cut to A4 sheets (210 x 297mm) (available from Spicers Stationery, Bassendean, ph: 9279 6860). The

labels should be printed on a laser printer and baked in an oven @100°C for 20-30 minutes to fix the printing onto the card.

If printed labels are not available for a particular survey, a hand written label on good quality paper incorporating the above data specifications can be used instead. The label should be written in soft pencil or black rotring pen, making sure that the ink is completely dry (to avoid smudging) before being immersed in the preservative. Ballpoint pens should not be used as the ink is not stable in fluids.

- **Lodgement**

Specimens should be delivered to the WA Museum after an appointment is made with an appropriate staff member. A printed copy of the relevant locality data should be supplied with the specimens, along with the name, address, telephone and email address of the company representative. An electronic copy of the spreadsheet containing the relevant data should also be emailed to the Museum.

Specimens preserved in ethanol cannot be transported via regular mail, as ethanol is classified as Dangerous Goods. All samples must be shipped using a recognised freighting company and accompanied with a Materials Safety Data Sheet.

## Land Snails

- **Dead Shells**

Land snails are often recorded as dead shells and these can either be stored in calico bags or small containers. It is important to note the context (position in landscape) in which these shells were recorded as they may have been transported away from the original area of occupancy by flood events etc. This information can be written on the reverse side of the label.

Appropriate preservation and lodgement methods for live specimens are discussed below.

- **Live Specimens**

For the most part, free-sealing species (i.e. those belonging to genera that aestivate with a calcified epiphram such as *Rhagada*, *Amplirhagada*, *Bothriembryon*) can be stored in calico bags (or similar) and kept in a cool location. Avoid placing specimens in plastic bags or sealed plastic containers. Labels should be prepared in the same format as outlined above for arachnids and myriapods. These must be placed within a plastic bag or otherwise protected from snails, which will consume them if left unprotected.

Those species which adhere to rock (or other) surfaces during aestivation (rock sealers such as *Strepsitaurus*, *Carinotrachia* some species of *Plectorhagada* and *Quistrachia*), will require more care should the intention be to lodge them as live specimens. These species can quickly dry out unless they are kept cool. In some instances it may be sufficient to place fresh leaf litter in a calico bag and then place the bag in a cool environment. As above it is important that labels be placed in small plastic bags. Alternatively, specimens can be transferred to either 70% or 100% ethanol in the field. Before storing them in 70% ethanol it is important to relax the animals first. This can be achieved by drowning the snails overnight in water. For those specimens to be stored in 100% ethanol it is

first important to crush the top of the shell to allow the ethanol to penetrate and hence preserve the specimen. Ideally individual specimens in 100% ethanol should be stored separately.

# Appendix 5

# Example Reference Taxonomic Treatments for Pulmonate Land Snails

Solem, A. (1979). Camaenid land snail from Western and central Australia (Mollusca: Pulmonata: Camaenidae). I Taxa with a trans-Australian distribution. *Records of the Western Austrlian Museum* Supplement No.10.

Solem, A. (1981). Camaenid land snails from Western and central Australia(Mollusca: Pulmonata: Camaenidae). II Taxa from the Kimberley *Amplirhagada* Iredale, 1933. III Taxa from the Ningbing Ranges and nearby areas. *Records of the Western Australian Museum* Supplement No.11.

Solem, A. (1984). Camaenid land snails from Western and central Australia (Mollusca: Pulmonata: Camaenidae). IV Taxa from the Kimberley, *Westraltrachia* Iredale, 1933 and related genera. *Records of the Western Australian Museum* Supplement No.17.

Solem, A. (1985). Camaenid land snails from Western and central Australia (Mollusca: Pulmonata: Camaenidae). V Remaining Kimberley Genera and Addenda to the Kimberley. *Records of the Western Australian Museum* Supplement No.20.

Solem, A. (1993). Camaenid land snails from Western and central Australia (Mollusca: Pulmonata: Camaenidae). VI Taxa from the Red Centre. *Records of the Western Australian Museum* Supplement No.43.