Australian Biodiversity - Salt Sensitivity Database

Methodology Report

1. Purpose

The Australian Biodiversity Salt Sensitivity Database contains information on the sensitivity and tolerance of over 1200 species of Australian taxa to salt. The database is supported by interpretive notes and a statistical analysis of species groupings.

2. Authors

The database was prepared for Land and Water Australia by Paul Bailey, Paul Boon and Kay Morris, 2002, Monash University and Victorian University of Technology, building on earlier scientific work. Hart *et al.* (1989, 1991) conducted an extensive and critical review of the available scientific information on the possible biological effects of increasing salinisation on freshwater biota. This information was subsequently developed and expanded into an Excel spreadsheet by Bailey (1998) and Bailey & James (1999). The current database includes additional information from recent published literature and results from field, laboratory and glasshouse experiments.

3. Source of data

The database consists of information derived from three sources:
- published scientific literature,
- government reports and,
- unpublished results from experiments conducted in the field and laboratory.

Every effort has been made to obtain copies of appropriate literature but, unavoidably, there will have been some that were missed. In the majority of cases, field data consists of results from monitoring programs undertaken by various government organisations during which biota samples were collected along with a measurement of water column conductivity.

These reports have been used to provide presence/absence data along with conductivity measurement. Field and glasshouse experiments provide more substantive data on magnitude of potential effects rather than simply, presence/absence data. Experimental studies are few in number and consequently encompass fewer organisms and, normally, have been undertaken at only one site (field experiments) or in laboratory or glasshouse experiments. They do however provide data, which provides better resolution of likely magnitude of salt impacts in terms of changes in abundance, growth, sensitive life stages, germination, and fecundity.

This development phase for compiling the database included:
- checking all entries against the original citation,
- amending and correcting inconsistent entries, and
- updating name changes for taxonomic entries.

4. Salinity Units and Conversions

The most accurate determination of salinity requires that the total ion concentration be determined from a full ionic analysis. Because this is very tedious, salinity is more frequently determined indirectly by measuring conductivity. Data in the database that have used conductivity units have been converted to units of total soluble salts (TSS) by applying the relationship: TSS mg/L = 0.68 x electrical conductivity in µS/cm (Hart *et al.* 1991).

There are a number of potential errors if conductivity is used as a surrogate for salinity. At very high salinities conductivity can decrease, and the relationship between total soluble salts and conductivity can vary depending on which ions are dominant (Williams and Sherwood, 1994). Consequently, where the dominant ions are not NaCl, or where the concentrations are substantially greater than seawater, estimates of salinity from conductivity readings may be incorrect. The error is unlikely to greatly influence interpretation of the database as the accuracy of salinity reading within the hypersaline range are less important in the context of freshwater biota.

Measurements of chlorinity are also used as an indirect measure of salinity. Data in the database that have used chlorinity units have been converted to salinity units by applying the relationship: Salinity mg/L = 1.80655 x chlorinity in mg/L (Williams and Sherwood, 1994).

Salinity can also be expressed as total dissolved solids (TDS). This refers to the residual weight following evaporation of a known volume of water that has been filtered to remove particulate matter (Peck et al., 1983). Measurements of total dissolved solids closely approximate measurements of total soluble salts (TSS=1.05 TDS) and the units are generally interchanged without adjustment. As such data in the database which have used units of TDS have been treated as equivalent to TSS**.**

5. The Salinity Database File

The data file consists of a Microsoft Excel ™ spreadsheet comprising a list of organisms (ranging from Bacteria to Mammals) arranged taxonomically.

For each entry (row of the spreadsheet) the first eleven fields (columns of the spreadsheet) give taxonomic classification of the organism (Kingdom, Phylum, Class, Subclass, Order, Suborder, Common name, Family, Subfamily, Genus/ Specific name, Species Common Name. The next two fields provide; (i) the Salinity Range (mg/L) and (ii) the Upper Salinity Level (mg/L) for that particular entry. This is followed by the Data Type field, which indicates whether the data source was field (f) or laboratory/glasshouse (l) based. The Life Stage, if described in the original reference, is given in the next field. The final two fields provide: (i) the geographical Location for field entries (not laboratory) and (ii) the Reference Number for the original source.

The Data Type Field refers to two types of data; i) field data (f) from monitoring reports or field based experiments, and ii) laboratory data (l) from laboratory or glasshouse experiments. The majority of the data is derived from field monitoring reports in which the presence or absence of taxa was reported along with the prevailing salinity of the water column at the time of sampling.

For field data, the salinity range (mg/L) over which taxa were reported is given. The upper salinity level (mg/L) reported is given separately, and has been used in subsequent data analysis.

For laboratory/glasshouse data the response of the reported taxa to the experimentally imposed salinity is summarised in the data file under "Salinity range (mg/L)".

Reports from salt lakes, and to a lesser extent estuarine or marine systems, have been included in the database. This approach has been necessary because some freshwater fish taxa enter seawater to spawn. For other groups, the inclusion of these reports in the database may help identify taxa that may begin to colonise highly salinised systems. For plant communities there is frequently an overlap in vegetation types that colonise salt marshes and salinised inland waters (ie. *Salicornia*, and *Suaeda*).

In some instances the family, genus or species name has changed from that cited in the original report. In these instances the revised name is given first and that used in the original report is given in parentheses.

To accommodate different search terms, higher taxonomic classifications (Family, Order, Class, Phylum and Kingdom) of reported taxa are given along with common names where possible.

For invertebrates, the common name listed generally relates to either Order (eg waterbeetles, Order Coleoptera), or Family (eg diving beetles, Family Dytiscidae). We have attempted to use the most familiar common name. For birds, the common family name is listed as well as the common species name. Vegetation is classified as either riparian, emergent, submerged or floating in the "Common name" field. In addition, species common names for vegetation are provided where possible.

Life stages other than adults are identified in the data file under "Life stage". For invertebrates the life stage is also identified in parenthesis after the species name.

The reference for the data source can be accessed from the Reference List using the reference number given in the data file under "Reference No."

6. The Data Analysis and Summary Notes

Patterns and key findings have been drawn out that would be useful to water-resource managers and other potential users of the database by:

- graphically analysing the field data for major taxonomic groups and
- providing brief, summary notes to assist in its interpretation.

The summary notes refer primarily to the database entries, but have been supplemented with information on laboratory and glasshouse experiments. The statistical and graphical analysis of database entries have been restricted to field data (i.e. presence/absence data) only.

The data analyses carried out demonstrate patterns in the distribution of reported biota over a range of salinity categories. Salinity categories were selected that i) produced a reasonable level of resolution of salinity groupings, ii) reflected distinctions between fresh water environment (0-500 mg/L), saline environments and seawater (>35,000 mg/L), and iii) represented levels reported to affect freshwater biota. For example, it has been proposed that freshwater invertebrates may be adversely affected at salinities greater than 1,000 mg/L (Hart *et al*. 1991), and that few freshwater macrophytes persist at salinities of ~ 4,000 mg/L (Brock and Lane 1983).

Analysis could be undertaken only at the level of genera, as the number of reports were too low to allow analysis at the species level, or insufficient taxa were identified to the species level.

However, as the analyses were conducted only at the level of genera, variability in salinity tolerance of a single genus is not represented. This is particularly a limitation where many species are represented within a genus.

Taxonomic groups were only analysed if the number of genera reported was ten or more. Due to the importance of Rotifers in food webs, this group was analysed although only nine genera were reported.

For consistency, data from laboratory and glasshouse experiments were not included in the data analysis. The findings of laboratory and glasshouse experiments are, however, summarised in the text.

The emerging patterns revealed by the analyses may be useful as a framework to guide further investigation. The analysis however, should not been viewed as definitive given the limitation described below.

For each taxonomic group examined two types of analyses are provided as shown in the two examples below (Figs A and B)

Fig. A

- The number of genera for which each salinity category represents the maximum salinity recorded across all reports. A genus can occur only in one salinity category.
- This analysis provides an indication of the salinity levels that may potentially restrict the distribution of taxa.

Fig. B

- The number of genera occurring in each salinity category. A given genus can occur in a number of different salinity categories depending on the upper limit for the genus in each report.
- This analysis provides an indication of the salinities at which the abundance of genera may be altered.

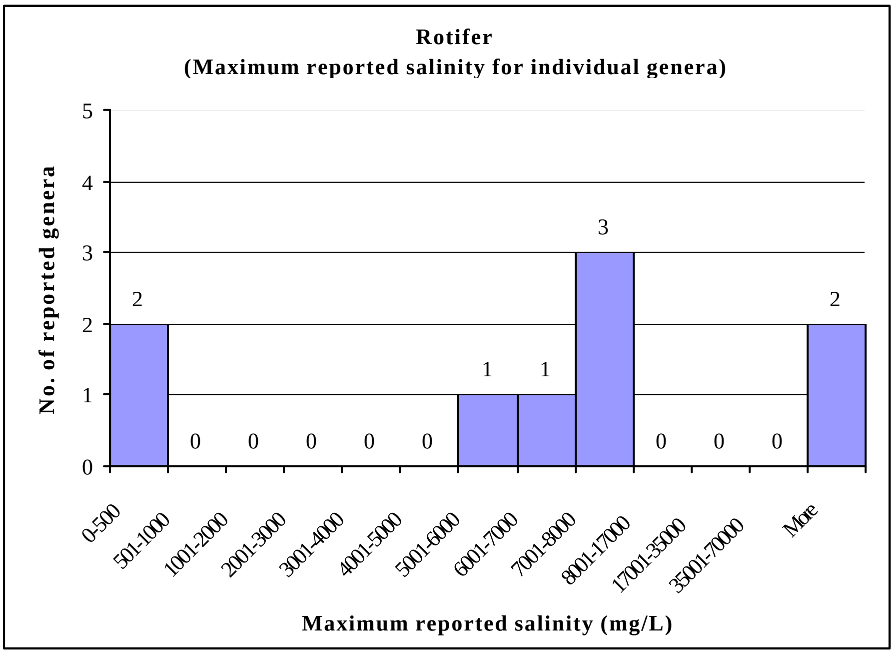

Fig. A. The maximum reported salinity for individual genera of Rotifer taken across all reports. A given genus can occur in only one salinity category.

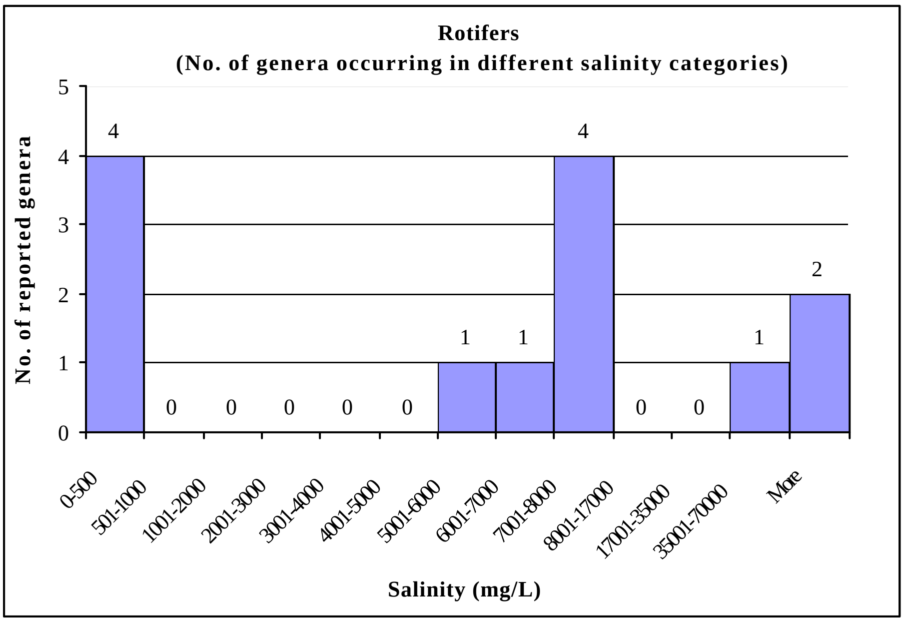

Fig. B. The number of Rotifer genera occurring in different salinity categories across all reports. A given genus can occur in a number of salinity categories depending on the upper limit given for the genus in each cited report.

7. Limitations of analyses

The database contains primarily field data, in which the presence or absence of taxa was reported along with the prevailing salinity of the water column at the time of sampling. As salinities can demonstrate considerable temporal and spatial variability, the reported salinities that organisms have been found at in the field on single occasions may not always accurately describe the salinities they are exposed to over the longer term. Observations made at a time when salinities are lower than usual will result in an artificially lower tolerance limit for the existing species.

Surface water salinities may also differ considerably to soil salinities, which may differ again to that of the groundwater. Consequently, aquatic vegetation and other organisms that inhabit the sediment or hyporheic zones may experience quite different salinities to those indicated by measurements of surface waters alone. Emergent vegetation is likely to be influenced primarily by the salinity of the soil than that of the water column, and deeply rooted vegetation may avoid high soil salinity by utilising groundwater where it is less saline.

In most cases, adults or juveniles only have been sampled, and it is impossible to extrapolate across an organisms life cycle from field samples alone.

Finally, salinity is often treated as an ecological factor as if only the direct effects of the ions were significant. Salinity can also influence, for example, pH, dissolved oxygen and the nutrient balance of plants. It may be that biota respond as much to these indirect effects as to the direct ionic effects of increased salt.

The most important limitation of the analytic approach is that the observed distribution patterns across salinity categories are probably influenced strongly by sampling bias. If a greater sampling effort has been undertaken in fresh systems than in saline systems, the distribution of taxa across a salinity gradient is likely to reflect this bias, with more taxa being reported in fresh systems than in saline ones, irrespective of any effect of salt on biodiversity. To clearly differentiate patterns driven by salinity from those driven by sampling bias, it would be necessary to quantify sampling intensity across salinity categories and to compare it against the distribution patterns for each taxa. However, even were this done, the geographical range of a species may also bias distribution patterns.

As only the upper range of salinity has been used in our analyses, the broad range of salinities over which some genera are found is not readily apparent in the graphical analyses provided. However it is possible to infer the range of salinities over which some taxa are found by comparing between the two types of analyses that we have undertaken. For example, Fig. B below shows that four Rotifer genera are reported between 0-500 mg/L, whilst Fig. A shows that only two of these genera are restricted to these salinities. Consequently, two genera must also occur at higher salinities. Examining Figure A we find that the next highest salinity maxima for a genus was between 5,001 and 6,000 mg/L, thus two genera must have a salinity range of at least 0-5,000 mg/L.

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The Salinity Database File also includes a data-reference using the reference numbers below under “Reference No.”

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