SALINITY IS NOT NECESSARILY BAD FOR BIODIVERSITY: CASE STUDIES OF INVERTEBRATES FROM SOUTH AUSTRALIAN STREAMS AND RIVER MURRAY WETLANDS

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A commonly held view is that increasing salinity reduces biodiversity and produces the catastrophic loss of species in the landscape. This view is not supported by the results of published studies of the biological responses to salinity within inland waters in Australia. Within streams and wetlands, salinity is better considered as a ‘driver’ of ecosystem structure. The two case studies presented herein complement other studies on aquatic ecosystems that show that while the total number of species declines with salinities greater than 1,000 mg L^{-1}, there is a suite of saline tolerant invertebrates that flourish in such waters, including species that are found only in waters with a high salinity.

<RUNNING HEAD: SALINITY AND AQUATIC BIODIVERSITY>

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Introduction

Increasing salinity is often regarded as the most significant threat to Australia's environment and recent estimates from the National Land & Water Resources Audit put the area at risk or affected by dryland salinity at 5.7 million ha (NLWRA 2001). In South Australia about 410,000 ha of land are affected by salinity with another 32,000 ha at risk (NLWRA 2001). Major parts of the Mid and Upper South East, Kangaroo Island, Lower and Western Eyre Peninsula and Coorong districts in particular are considered to be suffering significant impacts from salinity-related issues (ANZECC 2001).

Salinity has played a major role in the evolution of South Australia's inland waters. In geological time, many areas of the present land surface were covered by seawater (*e.g.* Drexel & Preiss 1995). Many plant and animal species from inland waters have near relatives in marine waters, for example crustaceans such as the palaemonid shrimps and amphipods. There is some evidence that a long history of natural salinity may have led to the evolution of salinity tolerance among the fauna of inland waters. In Western Australia (an old and geologically stable landscape with a relatively long history of natural salinity) aquatic invertebrates from wetlands of the wheatbelt are more salt tolerant than those elsewhere (Pyper 2000). Consequently, the salinity "threshold" at which biodiversity in the wheatbelt is greatly affected is also higher.

In historic time, the salinity regime of some inland waters has undergone great changes. Prior to river regulation, the salinity of the lower River Murray in South Australia was sometimes very different to the salinities seen since that time. During periods of low flow and drought conditions, salinities may have exceeded 10,000 mg L^{-1} (Anon 1987; Williams 1999). The aquatic biota in South Australia were thus exposed to highly variable water levels and water quality conditions in the past. Current arguments concerning threats to existing fauna and flora in relation to salinity must take this history of past exposures to high levels of salinity into account. Indeed, there is no evidence that current salinity levels exceed the tolerance of the native biota that is associated with the lower River Murray (Close 1990; Williams 1999).

Concentrations of total dissolved solids in South Australian surface waters are generally high (*e.g.* Glatz 1985) and a wide range of saline waters are present in South Australia. For example, saline streams are present in many catchments of Eyre Peninsula, the western Lake Eyre drainage, the Flinders Ranges, the Mid North, Kangaroo Island and many drains in the South East are saline. Since many South Australian surface waters are temporary, their biota are exposed to a larger amplitude in their physical and chemical parameters than are permanent waters (see Boulton & Suter 1986) and this would include greater variation in salinity.

AN ECOSYSTEM 'DRIVER'

From an aquatic ecological perspective salinity is just one driver that influences the organisation of biological communities. Appreciation of the role of salinity assists in understanding the impacts of broader water quality and habitat influences upon the invertebrate assemblages of surface waters. The significance of salinity in ordering invertebrate assemblages has been demonstrated in the results of the national AUSRIVAS (Australian River Assessment System) bio-assessment program. During the program, data were gathered from hundreds of streams across South Australia and used to construct computer models that predict the distribution of different invertebrate families at riverine sites. Together with variables quantifying aspects of landscape (such as latitude, longitude, altitude) and local environment (using measures describing the shape and composition of the channel), electrical conductivity (a correlate of salinity) was an important predictor in the models.

CASE STUDY 1. RIVERS AND STREAMS THROUGHOUT SOUTH AUSTRALIA

AUSRIVAS data from rivers, streams, creeks, and drains in the major drainage divisions provide one perspective on the richness of organisms inhabiting waters of different salinities. Generally, the higher the conductivity of sites, the fewer the number of invertebrate taxa that inhabit them (Figure 1). Though correlated with reduced taxonomic richness, higher salinities and invertebrate biodiversity are not mutually exclusive. Some species are only found in saline streams, examples being the larva of the caddis fly *Symphitoneuria wheeleri* Banks, the segmented worm *Paranais litoralis* (Muller), a water scavenger beetle *Laccobius zietzi* (Blackburn), the midge larva *Tanytarsus barbitarsis* Freeman, and members of the snail genus *Coxiella* Smith (Figure 1). Though they support fewer species in total, saline streams are important for maintaining genetic diversity, and they are significant habitats for biodiversity conservation within the State.

<LOCATION OF FIGURE 1>

CASE STUDY 2. RIVER MURRAY WETLANDS

The biology and physico-chemistry of eight wetlands on the River Murray flood plain were studied over three variable flood and drawdown cycles from 1990-1992

(Suter *et al.* 1993; Suter *et al.* 1995). These wetlands included swamps, lakes and an anabranch and they experienced a range of hydrological and salinity regimes.

Wetland physico-chemistry fluctuated in response to changes in water level associated with flooding and drawdown. Distinct cyclical patterns were evident in the structure and composition of the aquatic macroinvertebrate communities in response to different flooding and drying phases. Salinity, in particular, was a factor that was negatively correlated with the number of taxa present. Species richness was lower at Total Dissolved Solids (TDS) concentrations greater than about 1,000 mg L^{-1} (Figure 2). An even more marked reduction in species richness occurred in wetlands with a TDS concentration > 6,000 mg L^{-1}, where numbers ranged from 3-17 (Figure 2).

<LOCATION OF FIGURE 2>

Saline wetlands were characterised by their ‘resilience’ to change. They underwent major shifts in community structure during flood events to resemble floodwater assemblages but all returned to their own similar pre-flood assemblages within a further 1-4 months. In comparison, three permanent freshwater wetlands had more ‘resistant’ communities which did not undergo the same scale of community changes, but nonetheless did show some cyclical patterns which were also correlated to flooding and drawdown periods.

Aquatic systems containing few species (including saline lakes) are characteristically highly productive (Boulton & Brock 1999). At highly saline concentrations, conditions in River Murray wetlands were beyond the tolerance of many invertebrate species but some dipteran species continually thrived (*e.g. Procladius*

Skuse sp., *Tanytarsus* van der Wulp spp., Ephydridae and Ceratopogonidae larvae) and some corixids were occasionally able to persist in quite high numbers (*e.g. Micronecta robusta* Hale and *Agraptocorixa eurynome* (Kirkaldy)). These saline wetlands can provide significant refuges and sources of food for waterbirds (*e.g.* rare regional species such as Australasian shovelers congregating on Berri Basin and large numbers of common species such as grey teal, mountain duck, pink-eared ducks, and red-necked avocets).

DISCUSSION

The effects of increasing salinity leading to a loss of species has been documented in a number of other studies but the level of increase needed to eliminate sensitive species and hence induce community change has not yet been established (Hart *et al.* 1990). The available information does, however, indicate that toxic and reproductive effects are likely to occur in sensitive species at salinities in excess of 1,000 mg L^{-1}, and that sub-lethal and indirect effects (*e.g.* loss of micro-algal food sources) occur at even lower salinities (Hart *et al.* 1990; Metzeling 1993; Nielsen & Hillman 2000).

Salinity is a major driver of the spatial and temporal patterns of invertebrate biodiversity within South Australian inland waters. Although they are typically depauperate with respect to species richness, saline systems can provide opportunities for some tolerant species to survive. Saline inland waters may be significant locations for the maintenance of local and regional populations (both invertebrate and vertebrate) in the landscape. The driving role of salinity has important ramifications on the long-term condition of salinised wetlands. Increasing their flooding frequency will increase the diversity of aquatic communities during flood events. However, the saline-tolerant assemblages are likely to re-establish once salinity levels increase post-flood. This means that long-term changes in these wetlands will not occur without elimination of the source of saline water and the flushing of residual salt loads from soil profiles.

To deal effectively with salt in our landscapes, the broad community must make some choices. In south western Australia, some aquatic systems have experienced secondary salinisation for 30-50 years. Although in a different ecological state, these systems represent "...viable, functioning ecosystems." (Davis 2001). The objective for managing or rehabilitating salinised environments could be the prevention of their transition to a less "desirable" state, rather than the reduction of salinity *per se* (Davis 2001). Debate of the issues and decision making are important steps which society needs to take.

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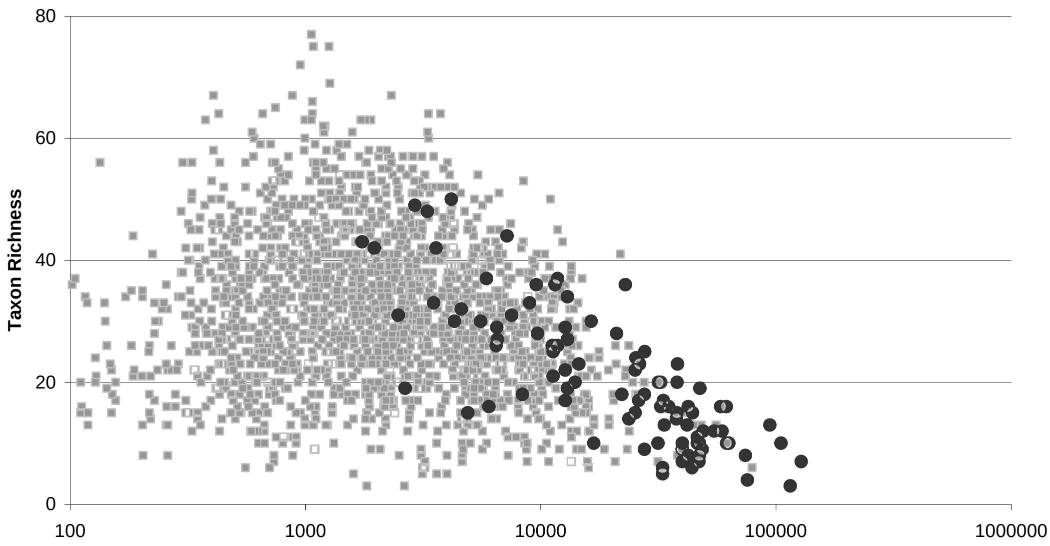
CAPTIONS

FIGURE 1. Levels of macroinvertebrate taxonomic richness in stream samples of varying electrical conductivity between 1994 and 1999 (AWQC, unpublished data). Dark circles indicate samples which contained one or more of the five salt-tolerant species mentioned in the text.

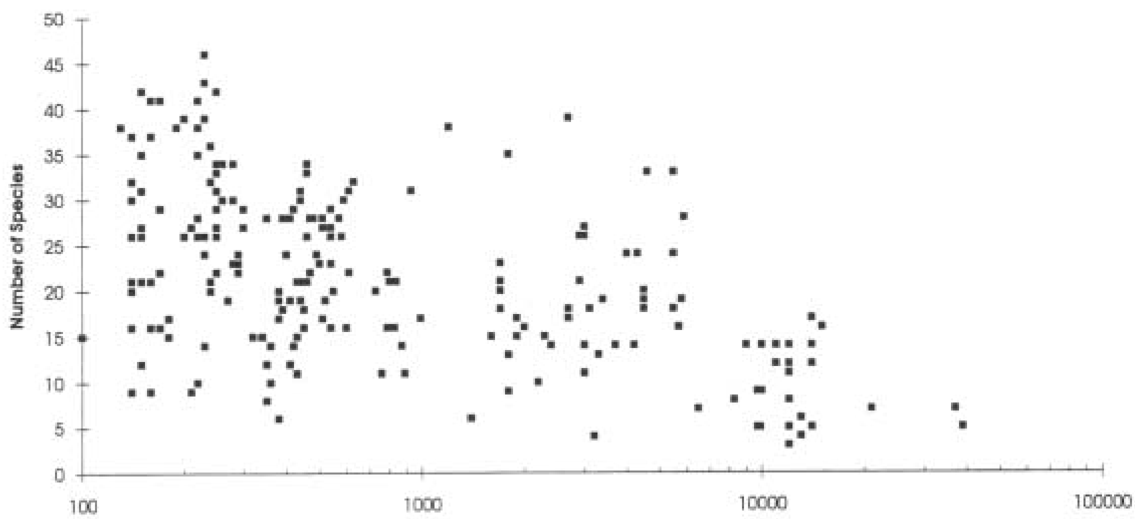
FIGURE 2. Relationship between the number of macroinvertebrate species and salinity for River Murray flood plain wetlands in South Australia (from Suter *et al.* 1993).

FIGURE 1



Conductivity (µS cm^{-1})

FIGURE 2



TDS (mg L^{-1})