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CONSERVATION OF AQUATIC INVERTEBRATE COMMUNITIES IN CENTRAL AUSTRALIA

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Abstract

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Central Australian waterbodies are an important focus for both nature conservation and tourism within the arid zone. Recent sampling of the West MacDonnell Ranges in 1993 and 1994, and the George Gill Range, in 1986, revealed the presence of 'relict streams' containing elements of an invertebrate fauna, and possibly flora, that have persisted since the last 'wet' phase in central Australia. These streams appear to be sustained by localised regions of permanently discharging groundwater and the effects of past landuses, including aboriginal useage and cattle grazing, do not appear to have been major or irreversible. However, the popularity of ecotourism in the region is rapidly increasing and appropriate management is needed to ensure that these important aquatic habitats are not lost or degraded through over-utilisation of the groundwater resource.

Introduction

The ranges of central Australia, including the MacDonnells, James, Krichauff and George Gill Ranges, are dominant landscape features within the region and the gorges of the West MacDonnell and George Gill Ranges are very popular tourist destinations. The ranges lie within one of the driest regions of Australia and the climate is characterised by extreme diel and seasonal temperature differences. The average rainfall is 250 mm per annum and, although summer rain is dominant, rainfall variability is high. Annual total evaporation is in the order of 3200 mm. Aspects of the physical and biological characteristics of the area are described by Gibson and Cole (1993), Latz et al. (1981), Thompson (1991) and Van Oosterzee (1991).

The extreme aridity of the region has resulted in the common perception that it contains few waterbodies. Although large volumes of permanent surface water are not present, the central Ranges contain a wide variety of aquatic habitats, ranging from permanent groundwater fed seeps and springs to deep gorges, permanent and semi-permanent river pools, shallow river wetlands, temporary and ephemeral rock pools and claypans. The only waterbodies not represented are permanently flowing streams and rivers.

The aridity of the region and the belief (amongst limnologists, at least) that little surface water is present, have undoubtedly been the reasons as to why so little has been known of the aquatic ecosystems within the central Ranges. The Horn Scientific Expedition of 1894 was the first major scientific study of the ranges and remains one of the few publications on the aquatic invertebrate fauna of the region. The records of fishes and aquatic invertebrates published as part of the report of the expedition (Spencer, 1896) are now of considerable value because they provide an indication of species present in central Australia at the onset of European settlement. Keast (1959) briefly mentioned dragonflies, freshwater snails and fish in a discussion of the relict animals and plants of the MacDonnell Ranges, and Williams and Siebert (1963) noted the presence of some species of snails, microcrustaceans and insects in their paper on the chemical composition of central Australian waterbodies. Davis et al. (1993) described the aquatic invertebrate fauna of the George Gill Range and a small number of sites in the West MacDonnell Ranges (some 200 km to the southwest). The fishes of the region have been more extensively studied than the invertebrate fauna although much of this work exists as unpublished reports or as collections in museums. Published accounts include Glover and Sim (1978), Glover (1982), Larson and Martin (1989), Crowley and Ivantsoff (1990) and Kodric-Brown and Brown (1993). Recently, Gibson and Cole (1993) provided a list of species of fish known from some of the permanent waterbodies within the West MacDonnells.

Davis et al. (1993), in their work on the aquatic systems of the George Gill Range noted that a small proportion of the fauna appeared to be a relictual stream fauna. In particular, the presence of an obligate stream invertebrate, the waterpenny, *Sclerocyphon fuscus*, was of interest because it was unlikely to be capable of dispersal across the large tracts of arid land that now separate the George Gill Range from southern Australia where it is also found.

The objectives of this study were to extend the work of Davis et al. (1993) to describe the invertebrate fauna of the waterbodies of the West MacDonnell Ranges and to determine the extent of the distribution of the waterpenny, and relictual stream habitats, in central Australia.

Methods

Physico-chemical variables and the aquatic invertebrate and fish fauna of waterbodies in the West MacDonnell Ranges were sampled in September 1993 and over the period February to April, 1994. The locations of sampling sites are listed in Table 1 and illustrated in Fig. 1. The majority of the waterbodies studied occurred within the headwaters of tributaries of the Finke River, including Ellery Creek and the Hugh River. Data from an earlier study of the George Gill Range was also included to enable a wider comparison of aquatic invertebrate communities within central Australia.

Conductivity and pH were recorded at all sites. Semi-quantitative and qualitative collection methods were used to sample as wide a range of aquatic microhabitats as possible. Many sites could only be reached on foot which limited the amount, and type, of collecting apparatus that could be used. In the larger waterbodies six replicate samples were collected by sweeping a long handled net (250 micron mesh) through the water column and against the substrate, in a yo-yoing motion, over a distance of 10 m. In the smaller stream sites kick samples were collected by disturbing the sediments at the front of the net. Invertebrates were also hand-picked with forceps from individual rocks and wood. Expandable mesh traps, baited with chicken pellets, were set overnight at the larger waterbodies to catch yabbies.

Although some samples were sorted in the field most were preserved in 100% alcohol and returned to the laboratory for sorting and identification. Identified material is currently stored, in 70% ethanol, in the School of Biological and Environmental Sciences at Murdoch University.

Fish were sampled in the larger waterbodies using a 1mm mesh seine net dragged over a distance of approximately 25 m. In smaller waterbodies fish were caught with a long handled net. All fish were identified in the field and returned to the water with the exception of a small number of representative specimens. These were preserved in 100% alcohol and stored for subsequent confirmation of identification in the laboratory.

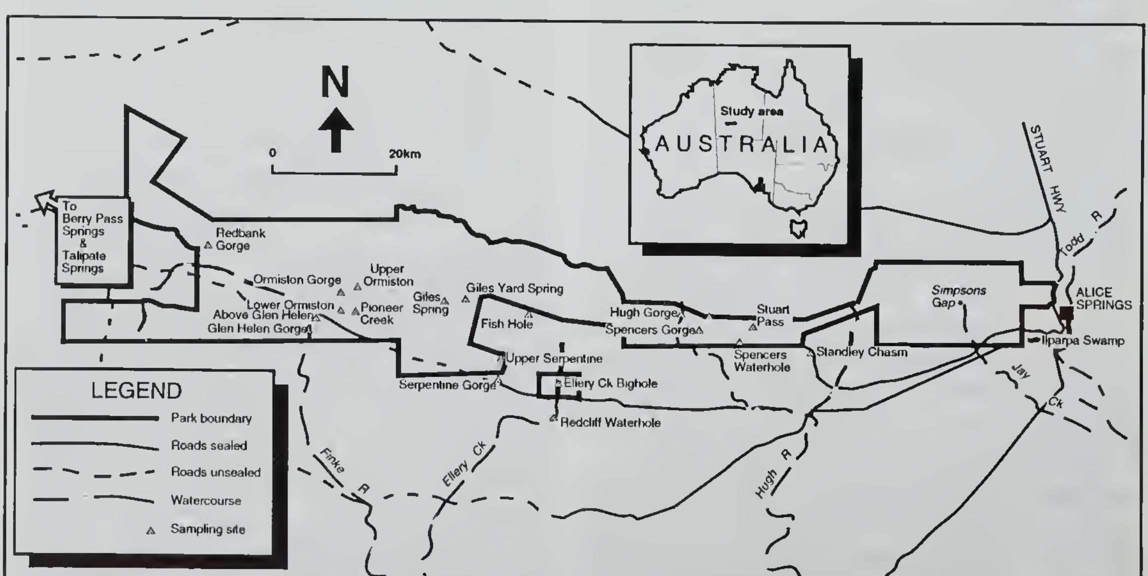

Figure 1. Location of waterbodies sampled in the West MacDonnell Ranges, Northern Territory.

Table 1. Names, codes, conductivity, pH and presence of fishes and waterpennies (denoted by *) for sites sampled in the West MacDonnell Ranges and other localities within the Central Ranges, Northern Territory.

Sites	Code	Conductivity uS/cm	pH	Presence of fish	Presence of waterpenny *Sclerocyphon fuscus*
West MacDonnell Ranges					
Redbank Gorge	REDB	190	7.1	*	
Upper Redbank Gorge	URED	190	7.1		
Pioneer Creek	PION	12 800	7.8	*	
Waterhole above Glen Helen	ABGH	8 140	7.8	*	
Glen Helen Gorge	GHG	2 330	7.8	*	
Ormiston Gorge	ORMG	160	7.4	*	
Pool above Ormiston Gorge	UORM	160	7.4		
Pool below Ormiston Gorge	ORMP	160	7.4		
Serpentine Gorge	SERP	134	7	*	
Upper Serpentine Gorge	USER	71	6.6		*
Ellery Creek Big Hole	ECBH	242	6.8	*	
Redcliff Waterhole	REDC	462	7.8	*	
Giles Yard Spring	GYS	27	5.8		*
Giles Spring	GS	53	4.8		*
Hugh Gorge		193	8		*
Spencers Gorge	SPEN	NA	NA	*	
Spencers Waterhole	SPW	440	7.8	*	
Stuart's Pass		400	8	*	
Fishhole on Ellery Ck		338	7.6	*	
Talipata Springs	TALI	80	8.2		*
Berry Pass	BERR	NA	NA		
Ilparpa Swamp	ILP	NA	NA		
East MacDonnell Ranges					
Emily Gap		300	7.7	NA	
John Hayes Rockhole		119	7.4	*	
Trephina Gorge	TRE	855	7.78	NA	
Glen Annie Gorge		690	9.5	NA	
Krichauff and James Ranges					
Kanara Ck (Oasis Ck)		1 400	8.76	*	
West Palm Paddock Spring		1 142	8.4	*	
Finke Gorge Pool 1		NA	NA	*	
Little Palm Ck		393	7.8	*	
Finke Gorge Pool 2		1 624	8	*	

Table 1 continued

Boggy Hole	BH	1 190	7.6	*	
Running Waters		1 880	8.2	*	
Illamurta Spring		NA	NA		
Illara Waterhole		1 830	7.5	*	
George Gill Range					
Kings Canyon	KC	27	5.7		
Penny Springs	PS	99	6.7		*
Tjindri Tjindri	TT	76	6.6		
Reedy Rockhole	RR	362	6.3		
Wanga Ck	WC	NA	NA		
Kathleen Springs	KS	540	6.8		
Stokes Ck	SC	73	6.3		*

A site by species matrix was constructed using an Excel spreadsheet. Multivariate analyses were performed using the cluster and ordination techniques available from the PRIMER software package of Clarke and Warwick (1994).

Results

Physicochemistry

The waterbodies of the West MacDonnell Ranges display a wide range of salinities (Table 1). The freshest sites were Giles Yard Spring (27 µS/cm), Upper Serpentine Gorge (71 µS/cm) and Talipata Springs (80 µS/cm). Pioneer Creek (a pool adjacent to a small mound spring) was the most saline waterbody sampled, with a conductivity of 12,800 µS/cm. Conductivities were also high at waterbodies downstream of Pioneer Creek, with a conductivity of 8,140 µS/cm recorded at the waterhole above Glen Helen, and 2,330 µS/cm recorded at Glen Helen Gorge.

Many sites were circumneutral (Table 1) with respect to pH. Giles Spring was the most acidic site with a pH of 4.8 while Talipata Springs was the most alkaline at 8.2. The highest pH recorded from all waterbodies sampled within the region was 9.5 at Glen Annie Gorge at the eastern end of the East MacDonnell Ranges. The lowest pH was 5.7 recorded at the Garden of Eden in Kings Canyon, in the George Gill Range.

Aquatic invertebrate fauna

Although a total of 36 sites were sampled in the West MacDonnell Ranges, East MacDonnell Ranges and Krichauff Range (Palm Valley) during the period September 1993 to April 1994, only the fauna from 20 sites (18 West MacDonnell sites plus Boggy Hole and Trephina Gorge) were processed and analysed within the resources available for the project. The 20 sites for which entire macroinvertebrate community data are available are indicated by the presence of a code in Table 1. The presence or absence of taxa at the 20 sites is given in Table 2. The presence or absence of the waterpenny, *Sclerocyphon fuscus*, and the presence or absence of fish, were noted for all sites (Table 1) because this information could be determined directly in the field.

A total of 75 macroinvertebrate taxa was recorded from the West MacDonnell Ranges (Table 2). Although this total represents the majority of species present it remains an underestimate of the entire fauna for several reasons. Greater sampling effort, for example, at seasonal or monthly intervals and at additional sites, will undoubtedly increase this total. Additional species will be added when further groups, including the Oligochaeta, Hydracarina, Chironomidae and microcrustacea are fully identified to the level of species.

Ormiston Gorge (26 taxa), Ellery Creek Big Hole (23 taxa) and Boggy Hole (22 taxa) were the most species-rich sites while Pioneer Creek (4 taxa) and Trephina Gorge (4 taxa) were the most depauperate. A total of 19 species recorded in the West MacDonnell Ranges did not occur in the George Gill Range. These include the gastropods *Austropeplea lessoni* and *Thiara* sp., the freshwater prawn, *Macrobrachium* sp., the damselflies, *Austrolestes aridus* and *Caliagrion billinghursti*, the dragonflies, *Aeshna brevistyla* and *Notolibullela bicolor*, the water strider,

Table 2. Presence/absence of taxa recorded at waterbodies in the West MacDonnell Ranges and other sites within the Central Ranges region, NT. A key to site codes is given in Table 1.

Taxon	Common Name	TALI	BERR	URED	REDB	UORM	ORMG	ORMP	PION	ABHG	GHG	GYS	USER	SERP	ECBH	REDC	SPEG	SPW	BH	ILP	TRE
Porifera	FW Sponge						*														
Platyhelminthes	Flatworm													*							
Oligochaeta	Earthworm	*			*						*				*				*		
Hirudinea	Leech	*		*																	
Ferissia sp.	Limpet		*	*		*	*				*	*			*		*		*		
Austropeplea lessoni	Snail					*	*	*			*			*	*	*			*		
Physastra sp.A	Snail						*	*			*				*						
Isidorella sp.A	Snail		*	*							*			*			*				
Thiara sp.	Snail						*	*		*	*								*		
Gyraulus sp.	Snail										*			*			*		*		*
Hydracarina	Water Mite				*	*	*								*		*				
Cladocera	Waterflea		*												*				*		
Copepoda	Zooplankton		*		*		*	*		*	*					*				*	*
Ostracoda	Seed Shrimp				*		*			*	*				*	*			*	*	
Newnhamia fenestrata	Seed Shrimp																*				
Macrobrachium sp.	FW Prawn						*	*		*	*							*	*		
Cherax destructor	Yabby						*														
Atalophlebia australis	Mayfly		*			*	*				*	*		*							
Tasmanocoenis sp.	Mayfly			*	*	*	*			*					*	*		*			
Cloeon sp.	Mayfly																	*	*		
Austrolestes aridus	Damselfly									*											
Austroagrion watsoni	Damselfly						*							*					*		
Caliagrion billinghursti	Damselfly																		*		
Ischnura aurora	Damselfly																		*		
Xanthagrion erythroneurum	Damselfly														*	*			*		
Aeshna brevistyla	Dragonfly													*							
Austrogomphus gordoni	Dragonfly				*		*												*		
Hemianax papuensis	Dragonfly						*								*		*				
Hemicordulia tau	Dragonfly																			*	
Hemicordulia australiae	Dragonfly																		*		
Hemicordulia flava	Dragonfly	*			*									*							
Diplacodes haematodes	Dragonfly				*		*				*	*		*	*		*		*	*	
Diplacodes bipunctata	Dragonfly															*					
Orthetrum caledonicum	Dragonfly		*		*		*							*	*		*		*		
Orthetrum migratum	Dragonfly	*																			
Notolibellula bicolor	Dragonfly	*										*									
Gerridae	Water strider																		*		

Table 2. continued

		TALI	BERR	URED	REDB	UORM	ORMG	ORMP	PION	ABHG	GHG	GYS	USER	SERP	ECBH	REDC	SPEG	SPW	BH	ILP	TRE
Microvelia sp.	Water bug											*		*							
Mesovelia sp.	Water bug						*								*				*		
Enithares sp.	Backswimmer	*										*									
Anisops occipitalis	Backswimmer											*									
Micronecta nr *annae*	Waterboatman		*		*					*				*	*						*
Agraptocorixa eurynome	Waterboatman						*								*						
Nepidae	Water scorpion											*		*							
Necterosoma penicillatum	Diving Beetle											*									
Necterosoma regulare	Diving Beetle				*	*	*	*	*	*	*				*	*	*	*	*		
Necterosoma sp. (larva)	Diving Beetle																			*	
Sternopriscus multimaculatus	Diving Beetle							*													
Hyphydrus elegans	Diving Beetle		*			*															
Sandracottus bakewelli	Diving Beetle	*		*																	
Eretes australis	Diving Beetle						*														
Cybister tripunctatus	Diving Beetle														*			*			
Macrogyrus gouldi ?	Whirligig Beetle	*				*						*		*							
Hydrochus sp. 1	Water Tiger					*							*	*	*						
Hydrochus sp. 2	Water Tiger				*							*									
Berosus sp.	Water Tiger					*					*					*				*	
Hydrophilidae sp.(larva)	Water Tiger																			*	
Hydrophilidae sp. (adult)	Water Tiger								*												
Hydraena sp.	Beetle					*															
Sclerocyphon fuscus	Waterpenny	*										*	*								
Chironomidae	Midge larva	*	*	*	*	*	*	*	*	*	*	*	*		*	*		*	*	*	*
Dicrotendipes nr *taylori*	Midge larva	*										*									
Ceratopogonidae	Sand Fly larva	*			*	*	*		*	*	*				*	*		*			*
Culicidae	Mosquito larva	*			*		*								*				*	*	
Simulium ornatipes	Blackfly larva											*									
Tabanidae	Marchfly larva														*						
Stratiomyidae	Fly larva	*																			
Ephydridae	Fly larva																			*	
Pyschodidae ?	Fly larva																				
Hellyethira simplex	Caddisfly larva					*	*														
Ecnomus continentalis	Caddisfly larva											*									
Oecetis sp. A	Caddisfly larva									*											
Oecetis sp. B	Caddisfly larva													*							
Triplectides australis	Caddisfly larva		*				*								*						
Triplectides volda	Caddisfly larva	*										*	*	*							
Total number of taxa		15	10	6	15	14	26	8	4	12	16	17	4	17	23	10	9	7	22	10	5

Gerridae, the caddisfly, *Triplectides volda*, and the beetles, *Necterosoma regulare*, *Sternopriscus multimaculatus*, *Eretes australis*, *Cybister tripunctatus* and *Berosus* sp. A further 18 species recorded in the George Gill Range have not been recorded from the West MacDonnells. These include the pea clam, *Pisidium*, the dragonfly, *Trapezostigma stenoloba*, the dipteran, Thaumaleidae, and numerous beetles.

The Insecta were more diverse, in terms of species richness, than the Crustacea, which probably reflects the predominantly fresh nature of these waterbodies. Similar to results recorded previously for the George Gill Range no Amphipoda, Isopoda or Plecoptera were recorded in the West MacDonnell Ranges.

The Odonata (dragonflies and damselflies) and the Coleoptera (beetles) were the most diverse groups of insects present, both being represented by 16 taxa. The Odonata are perhaps the most spectacular invertebrates associated with aquatic systems in central Australia. The most common species were *Diplacodes haematodes* and *Orthetrum caledonicum*. Distributional records (Watson 1974; Watson et al. 1991) indicate that these species and others, including *Austroagrion watsoni*, *Ischnura aurora*, *Xanthagrion erythroneurum*, *Diplacodes bipunctata*, *Hemicordulia tau*, *Hemicordulia watsoni*, and *Aeshna brevistyla*, are widespread throughout Australia. *Caliagrion billinghursti* has previously been recorded from Victoria, coastal NSW and southern coastal Queensland. *Orthetrum migratum* also occurs in coastal Queensland and northern Australia. *Trapezostigma stenoloba* which has a similar distribution to *Orthetrum migratum* and occurs in the George Gill Range, was not recorded in the West MacDonnells. *Austrogomphus gordoni* has only previously been recorded from the Pilbara region of WA and from the George Gill Range. *Notolibellula bicolor* which was only recorded from Giles Yard Spring and Talipata Springs, has also been recorded from the northern NT and the Kimberley region of WA. *Hemicordulia flava* appears to be endemic to the Central Ranges region.

Several species of Coleoptera displayed specific environmental preferences. The waterpenny, *Sclerocyphon fuscus* which displays a disjunct distribution occurring in the George Gill Range, South Australia and western Victoria, was restricted to the relict stream habitats. To date it has been recorded from Giles Yard Spring, Giles Spring (sampled in 1986), Talipata Springs, Upper Serpentine Gorge, upper Hugh Gorge and Penny Springs and upper Stokes Creek in the George Gill Range. Additional records of the waterpenny at Talipata Gorge and Bowmans Gap were provided by David Albrecht and Terry Mahney, respectively. The large diving beetle, *Sandracottus bakewelli*, which has been recorded from Upper Redbank Gorge, Talipata Springs, upper Hugh Gorge and the George Gill Range appears to only occur in waterbodies where fish are absent. A similar distribution has also been recorded for the large backswimmer *Enithares* sp. In contrast to the restricted distributions of *Sclerocyphon* and *Sandracottus*, the small dytiscid, *Necterosoma regulare*, appeared to be a highly tolerant species, being widespread and the only organism recorded in large numbers in the most saline waterbody, Pioneer Creek.

Although the Chironomidae, as a family, are diverse and widespread, occuring within almost all aquatic habitats in the West MacDonnell Ranges, one species, *Dicrotendipes* nr *taylori*, appeared to be restricted to Giles Yard Spring and Talipata Springs. Within these habitats it was both abundant and conspicuous on the upper surfaces of the rocky substrate, where it occurred within cases constructed from sediment and algae.

Fishes

Eleven species of fish have been recorded from the waterbodies of the West MacDonnell Ranges (Davis, in press). Eight species were recorded from central Australia by the Horn Expedition (Zietz, 1896), of which five were new. With the exception of one species, *Nematocentris winnecki*, which is a synonym of *Melanotaenia splendida tatei* (the desert rainbowfish) all species are still present within central Australia. Fish were not recorded from Upper Redbank Gorge, Upper Serpentine Gorge, Hugh Gorge, Giles Yard Spring, Giles Spring, Talipata Springs, Berry Pass Springs, nor any sites in the George Gill Range.

Introduced fish are generally absent from central Australia with the exception of the mosquitofish, *Gambusia affinis*, recorded from John Hayes Rockhole and the swordtail, *Xiphophorus helleri*, recorded in a dam near Pine Gap (both of which are isolated from the Finke drainage system).

Multivariate analyses

The dendogram produced by the PRIMER program CLUSTER from the presence/absence macroinvertebrate data for 20 sites (Table 2) is given in Fig. 2. Samples (sites) were grouped using a Bray-Curtis similarity matrix and hierarchical agglomerative clustering. The sites regarded as relict streams formed the first major group comprising Upper Serpentine Gorge, Giles Yard Spring and Talipata Springs. Serpentine Gorge also grouped within this cluster, which is possibly not surprising as it was separated by only 400 m (approximately) and a small waterfall from the Upper Serpentine site. Upper Redbank Gorge, Spencers Gorge and Berry Pass Springs formed a second cluster on the basis of the similarity of their macroinvertebrate fauna. None of the sites which clustered first contained fish, with the exception of Serpentine Gorge. Spencers Waterhole, the pool above Glen Helen, Trephina Gorge and Pioneer Creek formed a discrete group. These appeared to be the poorest sites with respect to water quality. The largest grouping comprised all the Ormiston sites, Redbank and Glen Helen gorges, Ellery Creek Big Hole, Redcliff Waterhole and Boggy Hole.

A slightly different clustering pattern was evident when all sites, from both the West MacDonnell Ranges 1993/94 study and the George Gill Range 1986/87 study were included in a single analysis (Fig. 3). Upper Serpentine separated first, however, it must be noted that only a small number of species were recorded from this site due to the difficulties with sampling (this site could only be reached by swimming through the gorge). All George Gill Range sites were within the same group at the second division, indicating that the fauna of these sites were more similar to each other than to the majority of the West MacDonnell Range sites, with the exception of the relict stream sites. Talipata Springs, Giles Yard Spring, Giles Spring and Serpentine Gorge also grouped with the George Gill Range sites. The remaining sites formed groups which were essentially identical to those of the previous dendogram (Fig. 2).

Ordination of the West MacDonnell Ranges sites (Fig. 4) on the basis of their macro-

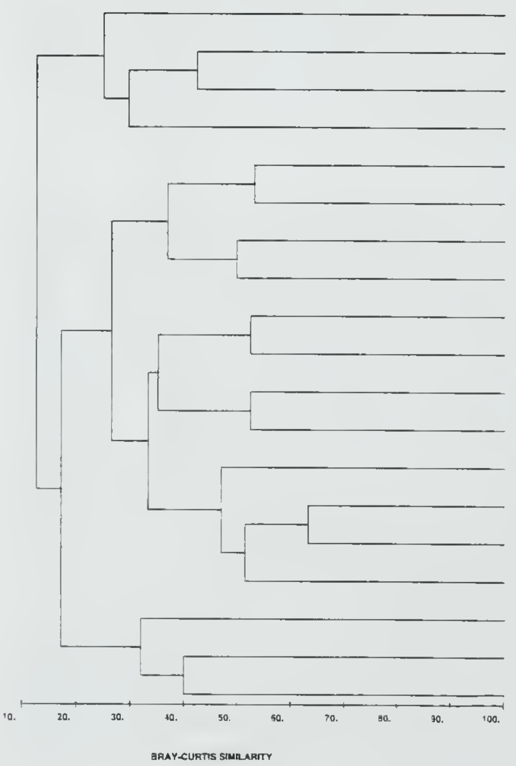

Figure 2. Dendogram produced by hierarchical clustering of macroinvertebrate communities at waterbodies in the West MacDonnell Ranges and other Central Ranges localities, using group average linking of Bray-Curtis similarities. Site codes are defined in Table 1.

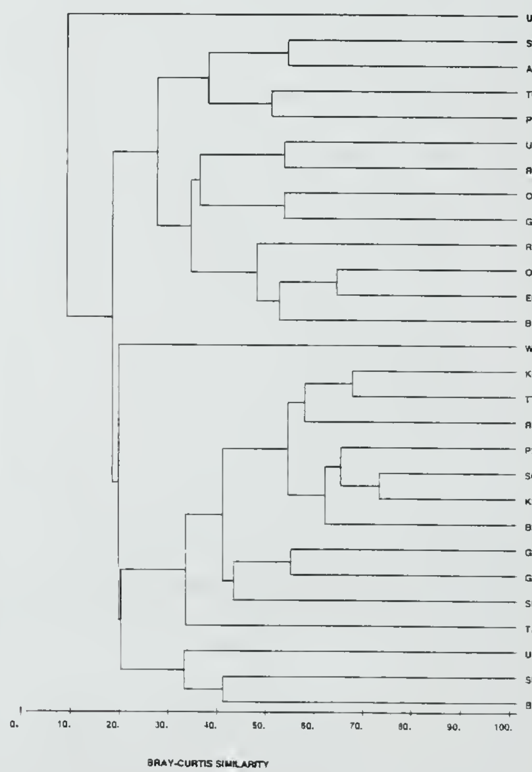

Figure 3. Dendogram produced by hierarchical clustering of macroinvertebrate communities at waterbodies in the West MacDonnell Ranges, George Gill Range and other Central Ranges localities using group average linking of Bray-Curtis similarities. Site codes are defined in Table 1.

invertebrate fauna using non-metric multi-dimensional scaling, from the PRIMER package MDS, revealed the interrelationships between sites. Three relict stream sites, Giles Yard Spring, Upper Serpentine Gorge and Talipata Springs, plus Upper Redbank Gorge were located some distance from the main group which comprised all other sites.

Ordination of the same sites, by MDS, on the basis of environmental variables (Fig. 5), revealed a similar but more discrete separation into two groups. Giles Yard Spring, Upper Serpentine Gorge, Talipata Springs and Upper Redbank Gorge were all located towards the righthand side of the plot. Fish were absent at these sites and conductivities were low. The remaining sites, which were all located towards the left side of the plot contained fish. A gradation in conductivity was also evident within these groups with the freshest sites at the top of the plot and the saltiest at the base.

An ordination of all sites from both the West MacDonnell Ranges 1993/94 study and the George Gill Range 1986/87 study is given in Fig. 6. Some sites, in particular Wanga Creek (in the GGR), Trephina Gorge, Pioneer Creek, the pool below Ormiston Gorge, Upper Redbank Gorge and Spencers Gorge are clearly outliers. Relict stream sites from both regions were located together on the left side of the plot.

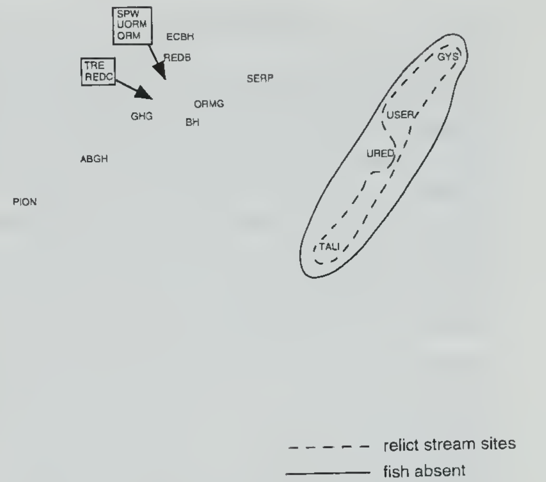

Figure 5. Ordination of waterbodies in the West MacDonnell Ranges, on the basis of environmental variables (conductivity, pH, presence/absence of fish, substratum and exposure) using non-metric multi-dimensional scaling (MDS). Site codes are defined in Table 1.

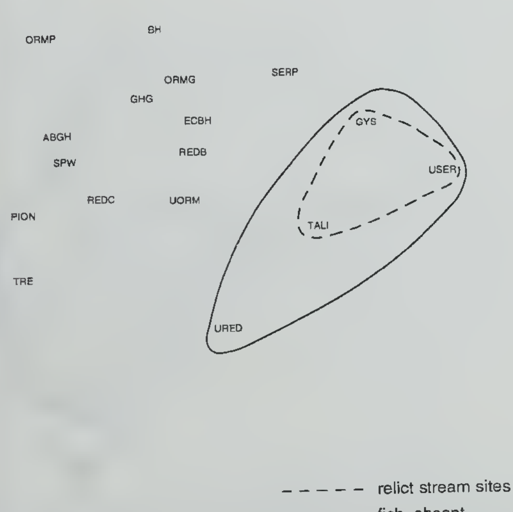

Figure 4. Ordination of macroinvertebrate communities at waterbodies in the West MacDonnell Ranges, using non-metric multi-dimensional scaling (MDS). Site codes are defined in Table 1.

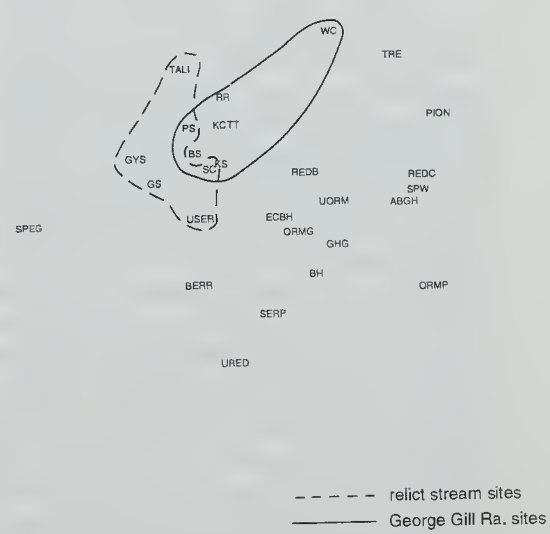

Figure 6. Ordination of macroinvertebrate communities at waterbodies in the West MacDonnell Ranges and George Gill Range, using non-metric multi-dimensional scaling (MDS). Site codes are defined in Table 1.

Discussion

As noted by Williams and Siebert (1963), the waterbodies of the West MacDonnell Ranges are probably the most isolated freshwater habitats in Australia, being separated by arid or semi-arid lands from the the high rainfall regions of the north by approximately 1000 km and from the southeast and southwest by approximately 1600 km. Despite the isolation, and the aridity, the waterbodies support a rich and abundant invertebrate fauna, although species richness appears to be slightly lower than that of the waterbodies of the George Gill Range, to the southwest, where 109 taxa were recorded by Davis et al. (1993). The fauna of the West MacDonnell Ranges is markedly different to that of the mound springs of South Australia. The mound springs to the south and west of Lake Eyre are moderately saline environments with conductivities ranging from 5,600 to 14,700 uS/cm (Mitchell 1985). Important elements of the fauna of these springs, such as the phreatoicid isopod, *Phreatomerus latipes*, hydrobiid gastropods and an unidentified amphipod (Mitchell 1985) were not present in the West MacDonnell Ranges.

Previously, Davis et al. (1993) had suggested that a small proportion of the fauna present at the George Gill Range appeared to be a relictual stream fauna. This supported Chippendale (1963) who regarded some of the ranges of central Australia, including the MacDonnell, James, Krichauff and George Gill Ranges as relict areas 'where plants of a higher rainfall period have survived'. These results also supported the work of Latz et al. (1981) who found the George Gill Range to be very floristically rich with a small but significant percentage of the flora being rare or of relict distribution.

The present study of the West MacDonnell Ranges, together with that of Davis et al. (1993) indicates that a total of nine relict stream sites, Giles Yard Spring, Giles Spring, Upper Serpentine Gorge, Bowmans Gap, Upper Hugh Gorge, Talipata Springs, Talipata Gorge, Stokes Creek and Penny Springs, are now known within the Central Ranges based on the occurrence of the waterpenny, *Sclerocyphon fuscus* (Coleoptera: Psephenidae) an obligate, rocky stream invertebrate. Waterpennies graze the biofilm associated with rocky substrates and so are restricted to cobble and pebble, rather than sand or mud, substrates. Davis et al. (1993) suggested that *S. fuscus*, which also occurs in South Australia and Victoria, would not be capable of dispersal across the large tracts of arid land that now separate the Central Ranges from the other localities where it occurs in southern Australia. This species, and several others, appear to be members of a relictual stream fauna that have persisted since the interior of the continent was much wetter than it is today.

The occurrence of the waterpenny in central Australia is not a recent discovery, however the occurrence of a number of populations spanning a region of several 100 km in area was not previously known. Spencer (1896: 77–78) noted the presence of 'a curious Orthopteran insect resembling a small flattened-out cockroach which adheres almost as closely to the surface of submerged leaves as a limpet to a rock' at Penny Springs in the George Gill Range. This description more closely describes a waterpenny, than any other aquatic invertebrate.

The restriction of the distribution of the genus *Sclerocyphon* to primarily southern and coastal regions of Australia (Fig. 7) indicates a Gondwanan origin. Reconstruction of the phylogenetic history of the waterpenny genus *Sclerocyphon* places *S. fuscus* in one of the most recently derived species groups (Davis, 1986), suggesting that dispersal of this species may have occurred during a pluvial phase of the Quaternary, rather than earlier in the Tertiary. Dispersal of this species from localities in coastal South Australia and western Victoria is most likely to have

Figure 7. Currently known distribution of waterpennies (genus *Sclerocyphon*) and possible route of dispersal of *Sclerocyphon fuscus* from southeastern Australia to the headwaters of the Finke River, prior to the onset of aridity in central Australia.

occurred through the Finke River system (Fig. 7) when it existed as a major flowing water system in central and southern Australia, possibly as recently as 18 000 years ago.

Species such as the case dwelling chironomid, *Dicrotendipes*, the larval dipteran, Stratiomydae, which clings to wet rock walls, the large golden-spotted beetle, *Sandracottus bakewelli* and the large backswimmer, *Enithares*, and the dragonflies, *Hemicordulia flava*, *Orthetrum migratum* and *Notolibullela bicolor*, all appear to predominantly associated with relict stream sites. The low conductivities recorded at the relict stream sites suggest that the presence of permanently discharging groundwater is vital to the maintenance of these habitats. The groundwater that supports the relict stream communities also supports mosses and ferns and further work is needed to fully document the plant communities associated with relict stream habitats. The presence of damp terrestrial microhabitats at these relict sites may be an important environmental requirement for *S. fuscus*, as both the pupa and adults of species recorded elsewhere in Australia are often associated with damp moss and leaf litter.

The presence, or absence, of fish appears to be important in determining invertebrate community structure in the waterbodies of the West MacDonnell Ranges. Different invertebrates were present at sites where fish were present compared to those where fish were absent. The lack of large numbers of introduced species of fish in central Australian waterbodies suggests that the composition of fish communities in this region may be largely unchanged since European settlement. The lack of exotic species, in comparison to those of waterbodies in more populous regions of Australia, may be explained by low human population densities within the region, reduced dispersal opportunities and the highly variable hydrological regimes and physico-chemical attributes of many arid zone waterbodies. It is extremely important, for the conservation and preservation of the aquatic ecosystems, that exotic fish are not introduced into central Australia at any time in the future.

Spencer and Hall (1896) recorded the yabby, *Astacopsis bicarinatus*, now recognised as *Cherax destructor*, from Running Waters and Hermannsburg and noted that it occurred frequently in waterholes along the Finke River. Anecdotal information suggests that the distribution of the yabby in central Australia has increased since the time of the Horn Expedition as a result of active translocations. No record of the yabby in the George Gill Range was given by Spencer and Hall (1896) but it appears to have been introduced to Bagot Creek in the 1930s and Stokes Creek in the 1960s to provide a food source and for recreational fishing (Davis et al., 1993). The translocation of yabbies in central Australia mirrors widespread translocations elsewhere in Australia (Horwitz and Knott, 1995) but the introduction of yabbies to waterbodies where they did not previously occur must be regarded as a serious threat to the conservation of the original aquatic communities through both habitat alteration and potential competition.

European settlement, and the advent of the pastoral industry, have had a major and continuing effect within the region. The use of waterholes as drinking points by introduced vertebrates associated with the pastoral industry, including cattle, horses, camels and donkeys has severely degraded many waterbodies, particularly within the lower regions of the Central Ranges. Trampling of banks and excess algal growth as a result of nutrient enrichment are evident at many waterbodies, particularly those that lie outside the West MacDonnell National Park. Nutrient enrichment may also have promoted the growth of submerged aquatics such as *Myriophyllum* at the expense of other species such as *Potamogeton* and *Vallisneria*. Similarly, the spread of the bulrush, *Typha*, is promoted by disturbed and nutrient-rich conditions.

As more people visit central Australia the demand for water for consumption, sanitation and other associated support activities (swimming pools, gardens, aquaculture ventures, etc) increases. As noted by Shepard (1993), water to support these activities has to come from nearby sources or associated aquifers to be economically feasible. There is a very real risk that human uses will compete with aquatic ecosystems for the limited supplies of water present in arid Australia. This risk must be acknowledged and addressed to ensure that overpumping of groundwater aquifers does not occur.

Shepard (1993) noted, with regard to North American desert springs, that 'with few exceptions, aquatic biologists have avoided work in deserts. The result is that a high diversity fauna full of vicariant strandings and speciations, unusual adaptations and varying responses to a harsh environment, remains unstudied.' Replace the word 'desert' with 'arid zone' and the same statement can be applied to the waterbodies of central Australia. Comparison of the records of the Horn Expedition with the results of this study and other recent research (Davis, in press) suggests that the aquatic fauna of central Australia has essentially survived the impacts of European settlement, despite problems such as nutrient enrichment and bank erosion. The challenge is to ensure that these communities, particularly the relictual stream communities, continue to survive undiminished by human activities.

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