Characterising the subterranean aquatic fauna of the Lake Way Basin.

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Introduction

Calcrete aquifers in the arid zone of Western Australia have recently been found to contain variable and diverse subterranean faunas (Humphreys 1999) — termed stygofauna — that include a large number of new taxa, even at higher taxonomic levels (ordinal, familial, generic: Poore and Humphreys 1998). Such aquifers are a major source of water for mining communities in the arid zone and none have been surveyed specifically for subterranean fauna prior to the exploitation of the water resource.

Many of these calcrete aquifers are associated with palaeodrainage systems and most of those so far examined have drained towards the Indian Ocean. In 1998 a single aquifer on an easterly flowing palaeodrainage system at Paroo was examined briefly near Wiluna in the Lake Way Basin. It contains at least a new genus of crangonyctoid amphipod and the only specialised subterranean dytiscid water beetles water beetles in Australia comprising three new sympatric genera from only eight adult specimens. Two new species, congeneric with those at Paroo, occur at the southern end on the Lake Way-Lake Carey palaeodrainage system, at Windarra, also in groundwater calcretes (Humphreys, 1998; Watts and Humphreys in press).

The palaeodrainage channels in the Yilgarn are old — they contain patches of Permian fluvio/glacial sediments — and were deeply incised into a plateau of Precambrian rocks during the Permian or earlier: there is an absence of sediment between the Permian and Eocene throughout the Western Shield (Yilgarn and Pilbara blocks) as well as in the intervening Proterozoic basins (L. Worrall, personal communication 1998). Towards the south the minor palaeodrainage lines probably formed after the uplift of the Darling Plateau and Eocene marine transgressions deeply penetrated the palaeovalleys along the western margin of the Eucla basin (Jones, 1990; L. Worrall, pers. comm. 1998) when conditions were tropical. It is of interest that the amphipods from the southern sites are Ceinidae (J. Bradbury, pers. comm. 1998), a family of marine ancestry (Barnard and Karaman, 1984) site are crangonyctoids, an ancient freshwater lineage (J. Bradbury, personal communication).

Field work

Field work was conducted in May 1999 accompanied by Dr H.J. Hahn from Universität Koblenz- Landau, Germany.

Sampling was conducted around the Paroo calcrete to delineate the extent of the Paroo stygofauna. A total of about 120 sites was sampled comprising pastoral wells and boreholes constructed for water abstraction, groundwater investigation and mineral exploration (Appendix). A measure of the physico-chemical environment was recorded at some sites (temperature, conductivity, oxygen saturation, pH). Initial sampling was done to the west of the continental groundwater divide (Cue region) to establish the major regional limits of the general faunal assemblage, and then in the Lake Way region. Sampling to the north of Wiluna was prevented by refusal of access. Initial plans to sample throughout the Lake Way-Lake Carey palaeodrainage system were prevented by the diversity of new stygofauna found in the Lake Way region.

As detailed characterization of the fauna will take considerable time, this report provides a synopsis of the faunal characteristics, their distribution and the implications for conservation .

The fauna is here characterised primarily by the Dytiscidae (Coleoptera) for which specialist opinion has been received. However, the fauna is primarily crustacean comprising Amphipoda, Isopoda, cyclopoid and harpacticoid Copepoda, Ostracoda, and a great diversity of bathynellids (Syncarida), all of which are currently with specialists in Australia, Germany and Italy. There are also other major taxa present including phreodrillids (Oligochaeta).

The distribution of the nominal taxa of Dytiscidae is shown in Table 1.

Table 1: Preliminary characterization of the dytiscid water beetles from May 1999 field trip det. C.H.S. Watts. The distribution of the species in press is included (Watts and Humphreys in press).

Calcrete area	Species	Type	Approx Salinity ($g\ l^{-1}$)
Austin Downs			
	Gen nov. 1 sp nov 4	Stygofauna	17-25 annual range
	Necterosoma wollastoni (Hydroporini)	Epigean.	
Cue			
	Gen nov. 1 sp nov 5	Stygofauna	
	Gen nov. 2 sp nov 2	Stygofauna	-
Paroo[2]			
	Gen nov. 1 sp nov 1 (in press)	Stygofauna	1.4
	Gen nov. 2 sp nov 1 (in press)	Stygofauna	0.6
	Gen nov. 3 sp nov 1 (in press)	Stygofauna	
Lake Violet			
	Gen nov. 1 sp nov 6	Stygofauna	
Northeast Lake Way[4]			
	Gen nov. 1 sp nov 6.	Stygofauna	4.4
	Gen nov. 1 sp nov 7.		
	Gen nov. 4 sp nov 1	Stygofauna	20-41 stratified
	Gen nov. 2 sp nov 3		
Hinkler Well[1]			
	Gen nov. 5 sp nov 1	Stygofauna	1.2
	Gen nov. 1 sp nov 8	Stygofauna	1.6
Miscellaneous			
	Allodessus bistrigatus epigean	Epigean	-
Windarra[3]			
	Gen nov. 1 sp nov 2 (in press)	Stygofauna	
	Gen nov. 1 sp nov 3 (in press)	Stygofauna	

[1] Described in Mann and Deutscher (1978). [2] Described in Sanders (1973). [3] Discussed in Maczurad and Murphy (1997) and Humphreys (1998). [4] Discussed in Environmental Protection Authority 1981.

Findings and discussion

• The stygofaunal assemblage in the Paroo groundwater calcrete seems to be unique (sampling of the calcrete to the north of Lake Way would be useful).

• Each separate calcrete examined in the Lake Way-Lake Carey palaeodrainage system contains a separate stygofauna.

• Each separate calcrete examined in the upper Murchison palaeodrainage system contains a separate stygofauna (Cue and Austin Downs).

• All the separate groundwater calcretes so far examined contain unique stygofaunal assemblages (including the very different assemblages of the Pilbara — Eberhard 1998; Eberhard and Humphreys 1999; Poore and Humphreys 1998; Humphreys 1999).

• In the Murchison wells contain epigean fauna while bores, even those closely adjacent to wells, contain stygofauna.

• The stygofaunal assemblage characteristic, at the higher taxonomic level, of the Paroo calcrete is also present on the western side of the continental drainage divide (Cue and Lake Austin). The same genera are present on either side of the continental divide suggesting epigean ancestry for both Gen nov. 1 and Gen nov. 2. Evidence from the palaeodrainage system suggests that the continental divide was present before the Cretaceous.

• All calcrete areas examined in the Murchison by appropriate means (down bores rather than from wells) contain stygofauna.

• The combined evidence from the Kimberley, Yilgarn and Pilbara suggests that stygofauna survives — at least in part — abstraction of water but does not survive severe drawdown of

water below the karstic system such as occurs with dewatering operations.

• The northeast Lake Way calcrete has stygofauna in saline waters (50 - 114% seawater). This may be the first stygofauna known in the world from saline continental waters. It is occupied by the oniscoid isopod, *Haloniscus* sp. nov., the first representative of the genus in both continental waters and in the stygofauna.

• The data represents samples from only two of 42 major calcretes areas in the upper Murchison catchment, and five out of 18 major calcretes areas in the Lake Way /Lake Carey palaeodrainage system. In Western Australia alone there are about 210 major calcrete areas (fig. 1) divided between about five major drainage systems. Similar groundwater calcretes occur through the arid zone to about the Queensland Border (see Humphreys 1999). That all areas examined to date contain stygofauna suggest that there is considerable biodiversity to be unearthed in the arid zone stygofauna. As the fauna are localised and occur in systems of potential of actual resource developments, they present a real challenge in environmental management.

•The faunistic distinctiveness of the groundwater calcrete aquifers is consistent with the evolution of the hydrogeological system in the palaeodrainage channels as interpreted by Morgan (1993).

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Figure Captions

Figure 1: The distribution of groundwater calcrete aquifers in Western Australia (from Humphreys 1999). Modern and palaeo- drainage (respectively continuous and dashed lines) and calcrete areas (black) are shown. Derived from data in Geological Survey (1989, 1990), drawn by Julianne Waldock on a base map provided by Philip Commander.

Figure 2: Detail of fig. 1 showing the groundwater calcrete deposit sampled and containing stygofauna. Town sites are shown for orientation.

Appendix

Sites with fauna — 1

Location	Latitude	Longitude
Abercrombie Well	26.84	120.31
Alice Well, Austin Downs Station Murchison	27.41	117.75
Barlanga Well Yarrabubba Stn	27.18	118.85
Bore at Quinns Lake Well	27.06	118.63
Calcrete quarry north of Lake Austin Murchison	27.41	117.68
Crobar Well Yarrabubba Stn	27.06	118.75
Dawsons Well	26.88	120.16
east most bore in Bore row next to ADP1 bore Austin Downs Borefield	27.39	117.73
GSWA#15 north (small) Paroo Station	26.40	119.76
GSWA#5 Paroo Stn	27.28	119.04
GSWA#6 large bore Paroo Stn	26.43	119.77
Lakeside Well, Austin Downs Station Murchison	27.40	117.72
Leemans Well	26.47	121.78
Little Milly Well	27.31	117.93
Mid east bore in Bore row next to ADP1 bore Austin Downs Borefield	27.39	117.73
Milly Well	27.28	117.91
Mineral exploration bore Lake Way Uranium Exploration area Sample 3 (SITE 262)	26.68	120.35
Mineral exploration bore Lake Way Uranium Exploration area Sample 4 (263)	26.68	120.32
OB next to Pump 1 Wiluna Gold Lake Violet Borefield	26.67	120.23
OB next to Pump 3 Wiluna Gold Lake Violet Borefield	26.68	120.22
OB next to Pump 4 Wiluna Gold Lake Violet Borefield	26.68	120.22
OB next to Pump 5 Wiluna Gold Lake Violet Borefield	26.68	120.21
Observation Bore N 16 Wiluna Borefield South	26.63	120.30
Observation Bore W13 Wiluna Borefield East	26.60	120.34
Observation Bore W34 Wiluna Borefield West	26.60	120.29
Old Cue Water supply bores	27.26	117.98
Old exploration bore near Pump 3 Wiluna Gold Lake Violet Borefield	26.68	120.22
Old pumped bore at Wiluna Gold old mine site	26.64	120.13
PAT 1 monitoring bore Austin Downs Borefield	27.38	117.72
PAT 2 monitoring bore Austin Downs Borefield adjacent to pump MCC 20-19.	27.39	117.70
PAT 3 monitoring bore Austin Downs Borefield	27.39	117.70
PAT 5 monitoring bore Austin Downs Borefield	27.41	117.74
PAT 8 monitoring bore Austin Downs Borefield	27.42	117.74
PAT 9 monitoring bore Austin Downs Borefield	27.41	117.74
Piezometer next to Wiluna -Kalgoorlie road	26.68	120.21
Piezometer site 236 sample 1	26.68	120.21
Quartz Well	26.36	122.09
Riverside Bore Austin Downs Station Murchison	27.45	117.73
saline mineral exploration bore Lake Way Uranium Exploration area Sample 5	26.68	120.30
Sample 1	26.68	120.21
Sample 2	26.86	120.30
Sample 2 Site 284	26.68	120.35
Sample 3	26.86	120.30
Sample 3 Site 285	26.68	120.33
Sample 4 Site 263	26.68	120.32
Sample 5B (0-8 m) Site 264	26.68	120.30
Sample 6 Site 286	26.68	120.29
Sample 7C (0-bottom m) Site 261	26.65	120.32
SB 25/4	26.88	120.16

Sites with fauna — 2

Location	Latitude	Longitude
SB 32/1	26.87	120.20
SB32/1	26.87	120.20
Shed Well	27.11	118.75
Site 261 sample 2, Saline Maireana flat anaerobic piezometer Lake Way	26.65	120.32
South Mill Well	27.25	118.92
TPB 25/4	26.88	120.16
Unmarked bore in Wiluna Borefield sample 3	26.60	120.30
Wiluna Borefield W2B	26.61	120.30
Wiluna Borefield W36#3 new bore	26.60	120.29
Wiluna Gold Mine south borefield site 245	26.65	120.17
Worral Well	27.07	118.73

Sites sampled — 1

Location	Latitude	Longitude
Inclined drill hole SW of Cue	27.43	117.80
Government Well Austin Downs Station Murchison	27.43	117.79
Alice Well Austin Downs Station Murchison	27.41	117.75
PAT 8 monitoring bore Austin Downs Borefield	27.42	117.74
Lakeside Well, Austin Downs Station Murchison	27.40	117.72
PAT 2 monitoring bore Austin Downs Borefield adjacent to pump MCC 20-19	27.39	117.70
Inclined drill hole W of Cue on mine site	27.38	117.79
50 mm piezometer W of Cue on mine site	27.38	117.79
Little Milly Well	27.31	117.93
Milly Well	27.28	117.91
Pats Well	27.25	117.94
PAT 7 monitoring bore Austin Downs Borefield a	27.41	117.71
PAT 3 monitoring bore Austin Downs Borefield	27.39	117.70
Riverside Bore Austin Downs Station Murchison	27.45	117.73
PAT 9 monitoring bore Austin Downs Borefield	27.41	117.74
PAT 5 monitoring bore Austin Downs Borefield	27.41	117.74
Unmarked bore 70 m S of Austin Downs Borefield pump ADP1	27.39	117.73
east bore in Bore row next to ADP1 bore Austin Downs Borefield	27.39	117.73
Mid east bore in Bore row next to ADP1 bore Austin Downs Borefield	27.39	117.73
east most bore in Bore row next to ADP1 bore Austin Downs Borefield	27.39	117.73
PAT 1 monitoring bore Austin Downs Borefield	27.38	117.72
Old Cue Water supply bores	27.26	117.98
Calcrete quarry North of Lake Austin Murchison	27.41	117.68
MB 7/80 New Cue WC Borefield	27.37	117.96
MB 1/81 New Cue WC Borefield	27.37	117.96
MB 8 m N of 1/81 New Cue WC Borefield	27.37	117.96
MB 5/80-T New Cue WC Borefield	27.37	117.97
MB next to bore 5/85 New Cue WC Borefield	27.37	117.97
Garden Bore	27.27	118.15
Shed Bore	27.24	118.24
Two Wells Bore	27.24	118.26

Sites sampled — 2

Location	Latitude	Longitude
Twenty-Five Mile Well	27.24	118.67
Yarra Well Yarrabubba Stn	27.13	118.72
Barlanga Well Yarrabubba Stn	27.18	118.85
South Mill Well	27.21	118.92
South Mill Well	27.25	118.92
Winnie Creek Well	27.28	119.04
Worral Well	27.07	118.73
Crobar Well Yarrabubba Stn	27.06	118.75
Kelly Bore	27.07	118.76
Shed Well	27.11	118.75
Exploration bore near Nowthana Hill	27.06	118.67
Exploration bore near Nowthana Hill	27.06	118.67
Exploration bore near Nowthana Hill	27.06	118.67
Bore at Quinns Lake Well	27.06	118.63
Bore at Quinns Lake Well	27.06	118.63
Bore at Desert Well	26.42	119.13
Location of GSWA #10 DRY	26.44	119.69
GSWA #5	26.44	119.77
GSWA #6 small	26.43	119.77
GSWA #6 big	26.43	119.77
Wiluna Borefield new bore W36#3	26.60	120.29
Wiluna Borefield new bore W2 B	26.61	120.30
Unmarked bore in Wiluna Borefield	26.60	120.30
Morrissay Well	26.62	120.30
Unmarked piezo dry	26.62	120.30
Piezo on Gunbarrel h'way 1A	26.61	120.29
Piezo on Gunbarrel h'way 1A DRY	26.61	120.29
GSWA# 7	26.42	119.79
GSWA#15 BIG	26.40	119.76
GSWA#15 small	26.40	119.76
•	26.38	119.80
•	26.48	119.68
•	26.48	119.72
unmarked bore	26.68	120.21
adjacent to above; very vermiform harpacticoid copepods	26.68	120.21
unmarked bore	26.74	120.22
Abercrombie Well	26.84	120.31
Unnamed Well south of Hinker Well	26.87	120.23
piezo SB 32/1	26.87	120.20
Dawson Well	26.88	120.16
TBF 25/4	26.88	120.16
SB 25/4	26.88	120.16
Wiluna Gold South uncapped piezometer	26.76	120.22
Wiluna Gold Mine south borefield site 245	26.65	120.17
Wiluna Gold Mine south borefield site 246	26.68	120.16
Wiluna Gold Borefield south	26.65	120.16
Wiluna Gold Borefield south	26.64	120.13
Wiluna Gold Borefield south	26.64	120.17
New unmarked piezo	26.69	120.20
Calcrete Quarry Wiluna Gold	26.67	120.22
OB next to Pump 1 Wiluna Gold Lake Violet Borefield	26.67	120.23

Sites sampled — 3

Location	Latitude	Longitude
Wiluna Gold borefield south of pump No 2	26.67	120.22
Old exploration bore near Pump 3 Wiluna Gold Lake Violet Borefield	26.68	120.22
Old exploration bore Wiluna Gold Lake Violet Borefield nr pump 3	26.68	120.22
OB next to Pump 3 Wiluna Gold Lake Violet Borefield	26.68	120.22
OB pump 5 Wiluna Gold Lake Violet Borefield	26.68	120.21
OB next to Pump 5 Wiluna Gold Lake Violet Borefield	26.68	120.21
OB next to Pump 4 Wiluna Gold Lake Violet Borefield	26.68	120.22
W27 piezo just east of Ngargganawil Community abandoned	26.64	120.31
Site 261 sample 2, Saline Meiriana flat anaerobic piezometer Lake Way	26.65	120.32
Mineral exploration bore Lake Way Uranium Exploration area Sample 3 (SITE 262)	26.68	120.35
Mineral exploration bore Lake Way Uranium Exploration area Sample 4 (263)	26.68	120.32
saline mineral exploration bore Lake Way Uranium Exploration area Sample 5	26.68	120.30
start of track to Lake Way Uranium deposit	26.65	120.31
Observation Bore W13 Wiluna Borefield East	26.60	120.34
OB N13 Wiluna Borefield east	26.61	120.34
new unmarked pump bore OB N13 Wiluna Borefield east	26.61	120.34
OB at W14 pump OB N13 Wiluna Borefield east	26.62	120.34
OB at W14B pump OB N13 Wiluna Borefield east	26.62	120.34
OB N11 OB Wiluna Borefield east	26.62	120.33
Observation Bore W34 Wiluna Borefield West	26.60	120.29
Observation Bore N 16 Wiluna Borefield South	26.63	120.30
Roads department bore	26.65	120.65
Roads department bore	26.65	120.65
new bore at Pope Well	26.67	120.76
Mitchell Well	26.64	121.18
Quartz Well	26.36	122.09
Jackie Well	26.33	122.15
Leemans Well	26.47	121.78
Shallow bore next to Gunbarrel Highway	26.64	121.19
Old bore 150 m west of Mitchell Well	26.64	121.17
Piezo W26 55 mm PVC	26.63	120.29
Exploration bore 110 mm PVC sample 2 site 284	26.68	120.35
Exploration bore 110 mm PVC sample 3 site 285	26.68	120.33
Exploration bore 110 mm PVC sample 6 site 286	26.68	120.29
general area of 2 new piezos next to Wiluna-Kalgoorlie road	26.86	120.30
Northern piezometer next to Wiluna-Kalgoorlie road 15 m from 289	26.86	120.30
Southern piezometer next to Wiluna-Kalgoorlie road	26.86	120.30