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Faunas of unflooded saline wetland floors of the Western Australian wheatbelt

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Abstract – Five saline wetlands in the Western Australian wheatbelt were surveyed for their terrestrial invertebrate fauna (Araneae, Scorpionida, Coleoptera, Dermaptera, Formicidae and Isopoda). Surveys were restricted to dry lake floor and fringing samphire and woodlands with the aim of assessing whether there are species of native fauna restricted to one or more of these habitats. A total of 356 species were recorded (123 spiders, 6 scorpions, 173 beetles, 45 ants, 4 earwigs and 4 isopods). Of these, 198 were from the inundation zone (lake floor and samphire zones) and 229 from woodland; only 72 species were common to both areas. Thus, the inundation zone fauna is not a subset of that found in woodland. Assemblage richness and structure differed between wetlands, reflecting recorded levels of regional diversity. Classification and ordination of the data reflected differences in faunal composition both between habitats and between geographic areas, although all woodland habitats were more closely related to each other than to either lake floor or samphire habitats from the same wetland.

Permanent inundation of the wetlands surveyed would adversely affect the fauna associated with inundation zones. Further surveys are required to determine the extent of these effects and whether the species occur at neighbouring wetlands.

INTRODUCTION

The wheatbelt of Western Australia has a particularly high level of secondary salinisation (NLWA, 2000). This is the process whereby salt stored in the soil profile is mobilised by rising groundwater after the clearing of perennial native vegetation and its replacement with annual crops that transpire much less water (Mulcahy, 1978). Despite current high levels, the extent of salinisation is predicted to increase over the coming decades and several strategies have been proposed to deal with rising levels of salinity, including surface and groundwater drainage and groundwater pumping from agricultural land into saline wetlands (George and Coleman, 2002). Changes to the flooding and salinity regimes of these saline wetlands as a result of receiving drainage or pumped water may affect their nature conservation values, as well as the values of nearby areas.

The wheatbelt drainage system is characterized by chains of salt lakes following the courses of Tertiary palaeo-rivers. These salt lakes range from large playas tens of square kilometres in area to mosaics of small pans and interconnected braided channels. Elevation above groundwater of the different fluvial and aeolian landforms present in these systems varies significantly, providing a variety of habitat conditions for plant and animal communities.

Geomorphology and composition of aeolian material deposits change across the lake beds and palaeo-channels in relation to local prevailing winds and hydrological regimes (De Deckker, 1988; Lyons *et. al.*, 2004). Nevertheless, three main vegetation communities may be recognised around salt lakes: fringing chenopod communities; *Melaleuca* and *Acacia* dominated shrublands; and, at higher elevations, *Eucalyptus* woodlands (Lyons *et. al.*, 2004). Most wheatbelt salt lakes at least partially fill most winters, although salt lakes in semi-arid areas fill more episodically. Faunal surveys of these areas have generally been restricted to the aquatic biota which, although generally considered to be species-poor, shows considerable differences between salt lakes and levels of endemicity at least as great that as seen in freshwater wetlands of south-west Western Australia (Pinder *et. al.*, 2002, 2004; Halse and McRae, 2004).

In contrast, little is known about the terrestrial invertebrate fauna associated with saline lakes. Recent wide-scale surveys have shown that the species composition differs between vegetated saline and surrounding non-saline areas (Durrant, 2004; Guthrie and Waldock, 2004; Harvey *et. al.*, 2004). There is evidence to suggest that the small,

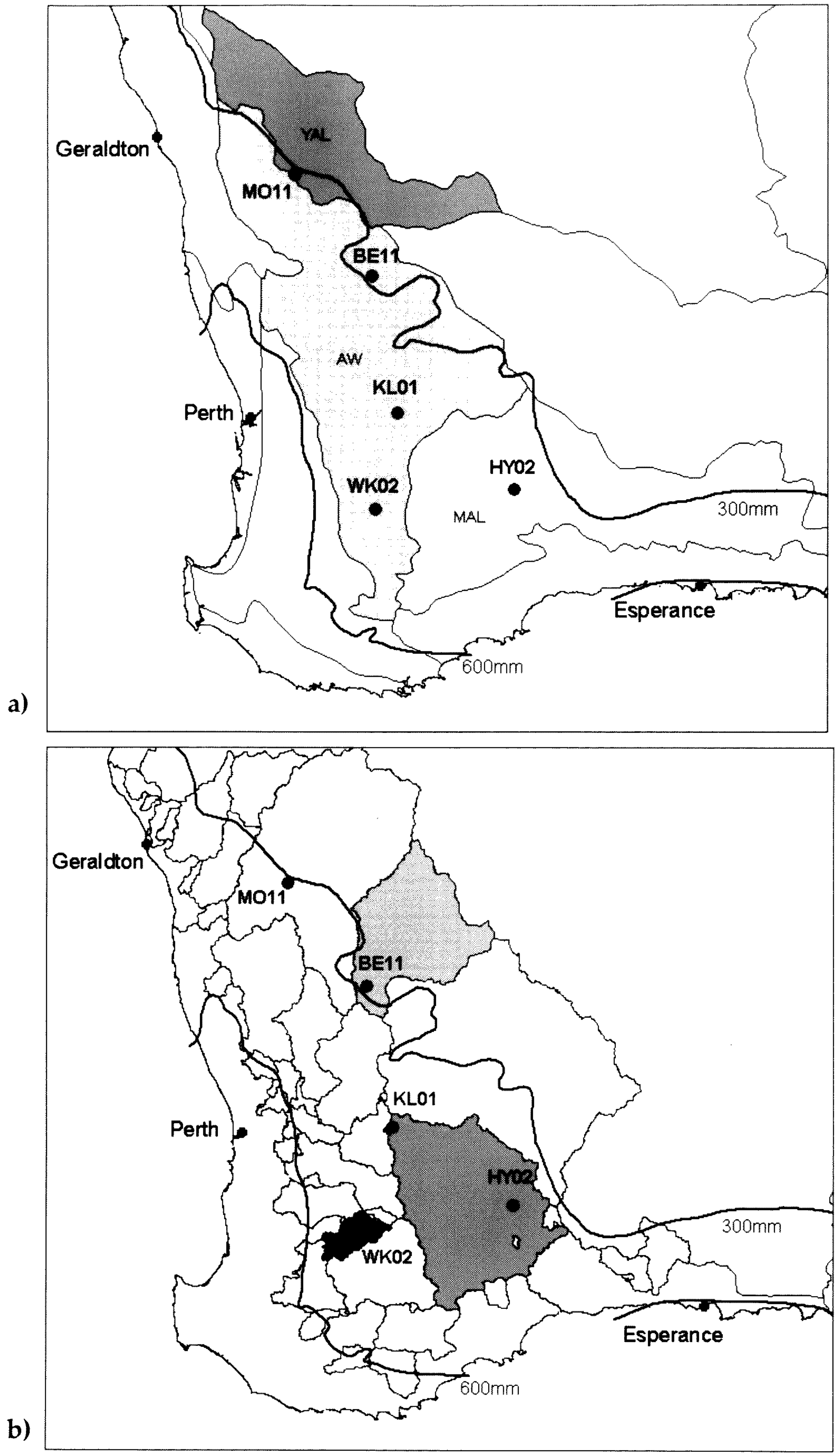

Figure 1 Location of survey sites in the wheatbelt region between 300 and 600mm isohyets: (a) showing IBRA regions: YAL-Yalgoo, AW-Avon Wheatbelt, MAL-Mallee (Thackway and Cresswell, 1985) and (b) showing catchment basins: Yarra Yarra (MO11), Ninghan (BE11), Lockhart of the Avon River (KL01, HY02) and northern region of the Upper Blackwood River (WK02).

less mobile terrestrial species living on salt lakes can be restricted to individual or regional groups of lakes, especially within the wolf spiders (Lycosidae), ground beetles (Carabidae) and scorpions (P. Hudson, pers. comm.).

This study sought to collect and identify the fauna associated with five saline wetlands and document species use of two broad habitat types, the salt lake inundation zone (while unflooded) and the adjacent woodland. Fauna examined in the study included spiders, scorpions, beetles, earwigs (Dermaptera) and slaters (Isopoda).

METHODS AND SITE DESCRIPTION

The five saline wetlands sampled (Figure 1) were representative of the main types of saline lakes across the wheatbelt region and, therefore, potentially contained much of the known regional invertebrate endemism recorded by the recent Salinity Action Plan (SAP) survey from the vicinity of saline wetland areas (see Durrant, 2004; Guthrie and Waldock, 2004; Harvey *et. al.*, 2004). The sites were:

Lake Moore (BE11, Figure 2b) is a large saline playa, consisting of a bare lake floor partially fringed by a low scattered shrubland of *Halosarcia* species, bounded upslope by dwarf *Atriplex* species shrubland with emergent Broombush (*Melaleuca atroviridis*) or *Acacia* shrubland over low mixed grasses, depending on elevation. Farther upslope tall *Eucalyptus salicola* woodland over very open mixed shrubs occurs.

The Salt River site (KL01, Figure 2c) is located in a small saline pan that is situated in a braided saline channel. The pan surveyed consists of a bare lake floor with *Halosarcia* species low shrubland on rises, bounded upslope by dwarf *Atriplex* scrub and *Melaleuca atroviridis* tall shrubland. Small pockets of *Eucalyptus salicola* over *Acacia* with *Olearia eremaea* and *Lomandra effusa* occur on elevated parts of the channel.

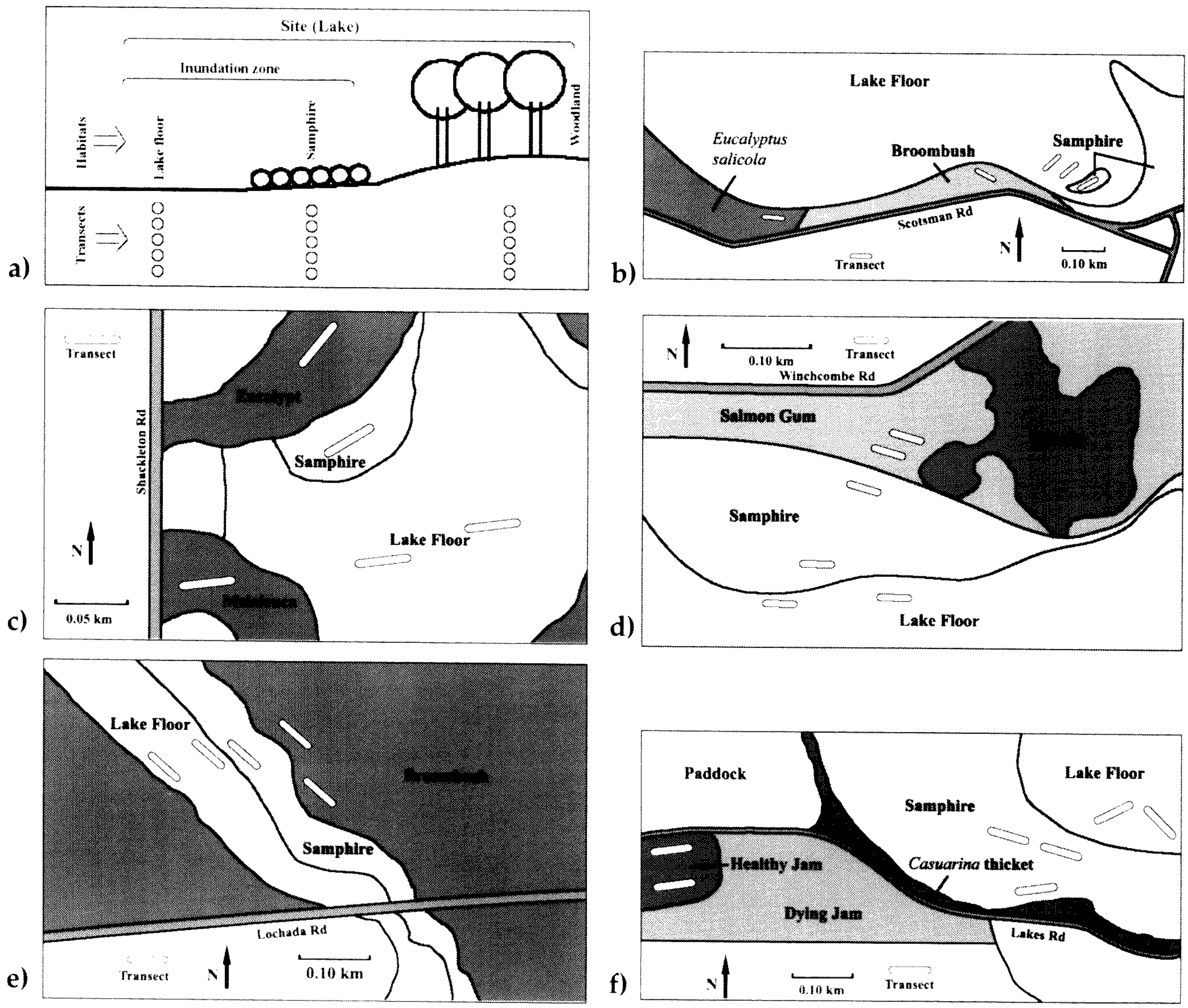

Figure 2 Relationship of transects and habitat at each lake surveyed. (a) transect profile, (b) Lake Moore (BE11), (c) Salt River (KL01), (d) Weelhamby Lake (MO11), (e) Lake Gulson (HY02), and (f) Taarblin Lake (WK02).

Table 1 Site locations and transect positions.

SAP Site	Location	Transect	Habitat	Traps	Site-habitat	Longitude	Latitude
BE11	Lake Moore, southern shore	01	Samphire	5	BE11-S	30°20'00.2" S	117°29'22.9"E
		02	Lake Floor	10	BE11-L	30°20'00.2" S	117°29'22.9"E
		03	Broombush Woodland	5	BE11-W	30°20'01.5" S	117°29'14.1"E
		04	Salmon Gum Woodland	5	BE11-W	30°20'06.3" S	117°28'39.2"E
HY02	Lake Gulson Nature Reserve	01	Lake Floor	5	HY02-L	32°45'38.7" S	119°24'12"E
		02	Lake Floor	5	HY02-L	32°45'38.7" S	119°24'12"E
		03	Samphire	5	HY02-S	32°45'38.7" S	119°24'12"E
		04	Samphire	5	HY02-S	32°45'38.7" S	119°24'12"E
		05	Salmon Gum Woodland	10	HY02-W	32°45'38.7" S	119°24'12"E
KL01	Shackleton Rd., Salt River	01	Eucalypt Woodland	5	KL01-W	31°53'30.7" S	117°49'46.4"E
		02	Samphire	5	KL01-S	31°53'30.7" S	117°49'46.4"E
		03	Lake Floor	10	KL01-L	31°53'30.7" S	117°49'46.4"E
		04	Melaleuca Woodland	5	KL01-W	31°53'30.7" S	117°49'46.4"E
MO11	Weelhamby Lake, west	01	Samphire	5	MO11-S	29°11'01.7" S	116°27'32.2"E
		02	Lake Floor	10	MO11-L	29°11'01.7" S	116°27'32.2"E
		03	Broombush Woodland	10	MO11-W	29°11'01.7" S	116°27'32.2"E
WK02	Taarblin Lake, southern shore	01	Lake Floor	10	WK02-L	32°59'20.1" S	117°32'37.4"E
		02	Samphire	10	WK02-S	32°59'20.1" S	117°32'37.4"E
		03	Samphire	5	WK02-S	32°59'20.1" S	117°32'37.4"E
		04	Jam Woodland	10	WK02-W	32°58'48.9" S	117°30'36.7"E

Weelhamby Lake west (MO11, Figure 2d) is a bare narrow linear saline playa fringed by *Halosarcia* species shrubland. On gentle elevations above this community a tall shrubland of *Acacia eremaea* over succulent shrubland of *Gunniopsis quadrifida* occurs, interspersed with pockets of tall open shrubland of *Melaleuca atroviridis* over low shrubland of *Halosarcia* species and *Atriplex paludosa*.

Lake Gulson (HY02, Figure 2e) is a large inland saline playa with considerable expanses of bare lake floor fringed by *Halosarcia* shrubland, with dwarf *Atriplex* scrub and low heath grading upslope into *Eucalyptus loxophleba* low woodland over open scrub of *Alyxia buxifolia, Pittosporum angustifolium* and sedges *Lomandra effusa* and *Dianella revoluta*.

Taarblin Lake (WK02, Figure 2f) is a secondarily saline wetland situated in a highly cleared, salt affected region of the wheatbelt and is currently used as a disposal basin for saline groundwater. About 10% of the lake floor is bare along the southern section of the lake, with the remaining area vegetated with *Halosarcia pergranulata* low shrubland. The narrow lake edge consists of *Atriplex* scrub and emergent *Casuarina obesa*. Upslope, there is tall open woodland of *Eucalyptus salmonophloia* over mixed shrubs but it is very fragmented with high levels of tree death and surface scalding by salt.

In this paper, the five saline wetlands are referred to as 'sites' and individual pitfall trap lines within the sites are referred to as 'transects' (Table 1). The term 'site-habitat' refers to a habitat within each site (e.g. BE11-L refers to the lake floor habitat at Lake Moore). 'Inundation zone' refers to the combined area of lake floor and samphire habitats. Ten pitfall traps were installed 10 m apart in the lake floor habitat, with at least five traps in the nearby samphire and ten in an adjacent healthy (undisturbed by salinity) woodland habitat, all immediately peripheral to the lake floor traps where possible.

Pitfall traps consisted of 2 L plastic containers (80 mm neck diameter) dug into the ground with the top flush with the ground surface. 400 ml of preserving liquid was placed in each trap, comprising 320 ml ethylene glycol, 64 ml tap water and 16 ml formaldehyde. The pitfall traps were installed at all five sites in October (mid-spring) 2002, then removed in March (early autumn) 2003 before the first heavy rains. Samples were returned to the laboratory, rinsed in water, sorted and identified to lowest possible taxonomic unit, then stored in 75% ethyl alcohol. The following groups were not identified or included in the analyses owing to taxonomic problems: beetles (Curculionoidea and Staphylininae) and spiders (Oxyopidae and Gnaphosidae). All specimens were lodged with the Western Australian Museum.

Species presence and absence data for transect samples were explored using the computer package PATN (Belbin, 1995). The Czekanowski association measure was used to compare site-habitats according to similarities in their species composition, and the Two-Step association measure was used to compare the distributions of species. Dendrograms were constructed from these association measures using an unweighted pair group arithmetic averaging (UPGMA) hierarchical

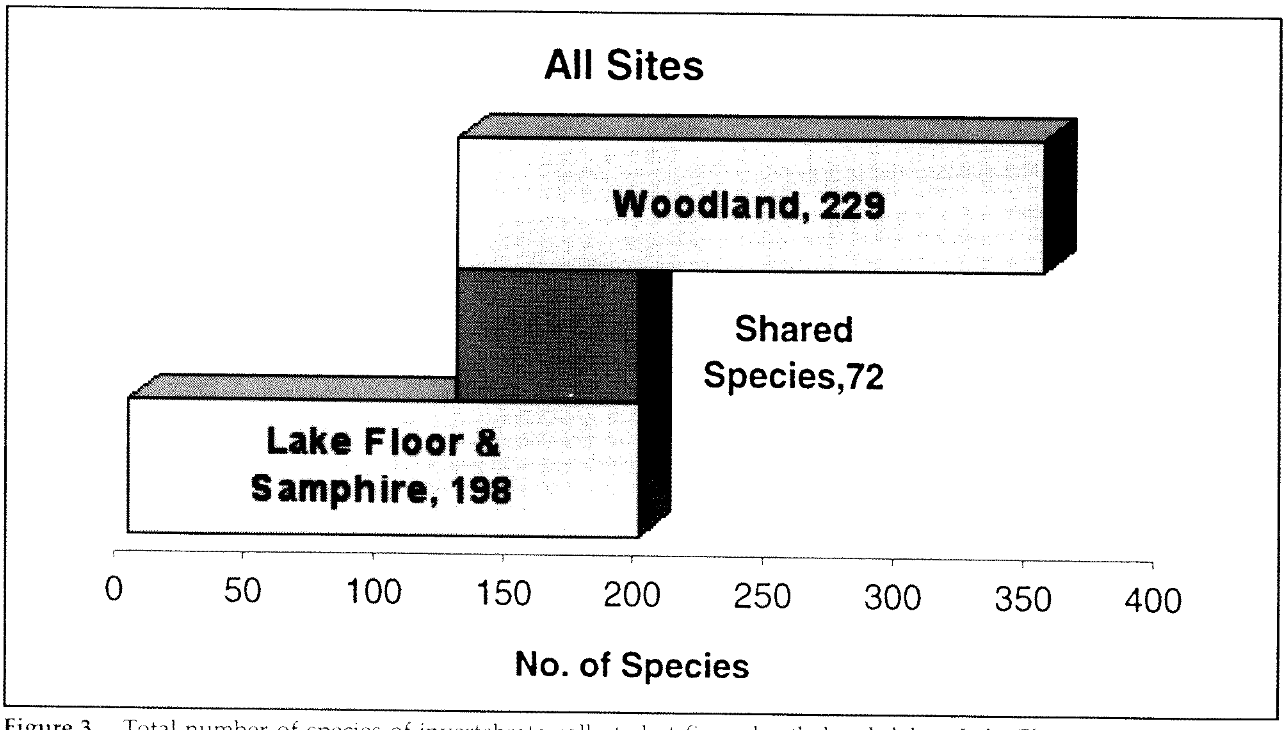

Figure 3 Total number of species of invertebrate collected at five wheatbelt salt lakes. Lake Floor & Samphire is the inundation zone of each lake, Woodland is the vegetation community on the uplands surrounding the lakes.

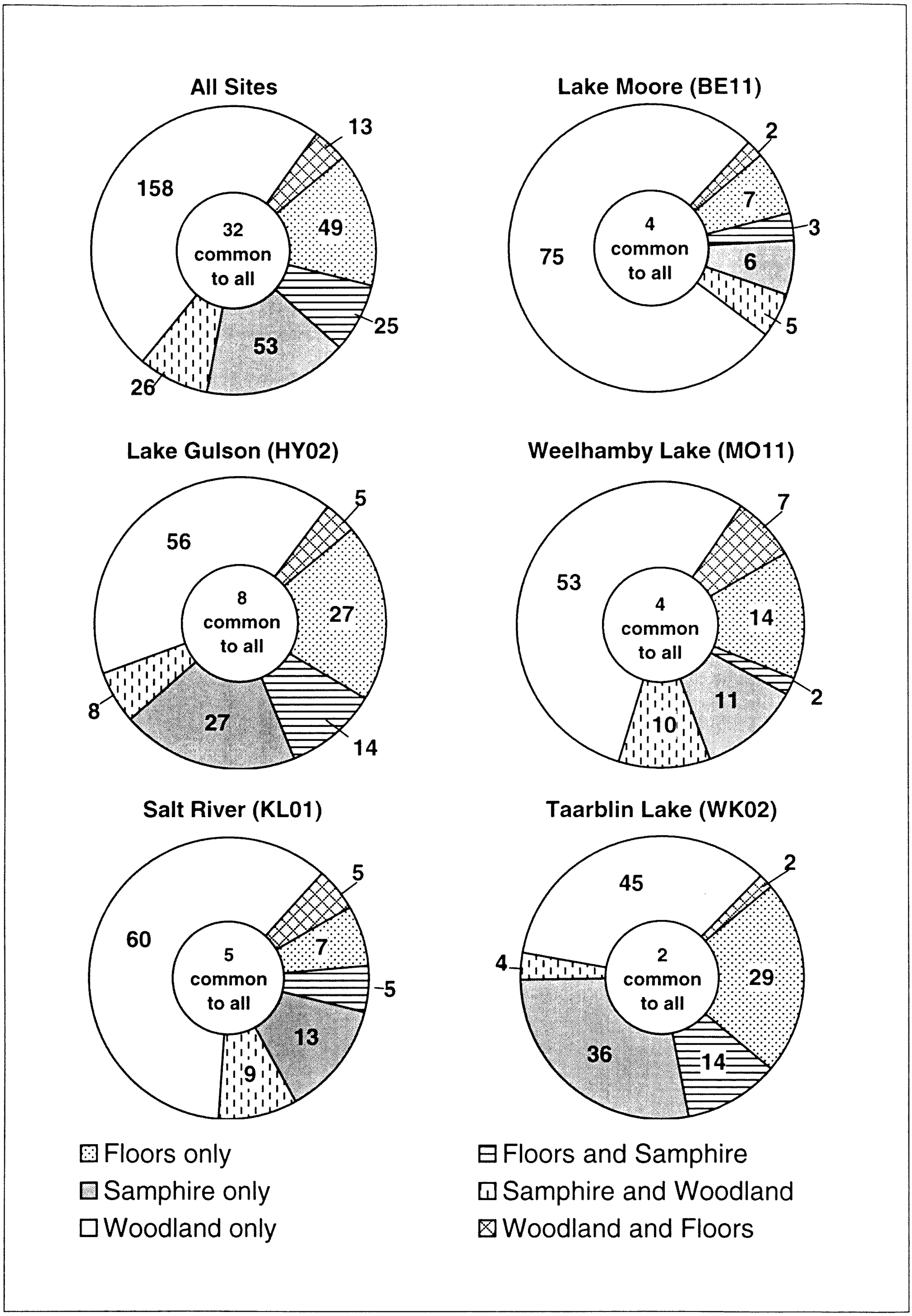

Figure 4 Total numbers of species caught in each habitat at all sites and each site individually.

clustering strategy (Sneath and Sokal, 1973; Belbin, 1995), and the reordered data displayed as a two-way table (Appendix 1).

RESULTS

A total of 355 species were recorded from the five saline wetland lakes surveyed (123 spiders, 173 beetles, 45 ants, 6 scorpions, 4 earwigs and 4 isopod species; Appendix 2). Across the five sites, a total of 198 species were collected from the inundation zones (lake floors and samphire habitats) and 229 species from the woodland habitat, with only 72 species common to both areas, indicating that the inundation zone fauna are not a subset of that found in woodland (Figure 3). The numbers of species restricted to lake floor, samphire and woodland habitats were 49, 52 and 157, respectively. There were 25 species common to lake floor and samphire habitats, 13 species common to lake floor and woodland habitats, 27 species common to samphire and woodland habitats and a total of 32 species common to all habitats (Figure 4).

Species richness differed between salt lakes, ranging from 101 species at Weelhamby Lake to 145 at Lake Gulson (Appendix 2). At Lake Moore, 27 species were recorded from the inundation zone, three of which were restricted to it. Eighteen species were recorded from samphire and 16 species from the lake floor, with six and seven species restricted to these habitats, respectively. Eighty-six species were recorded from woodland, 75 of which were restricted to it (Figure 4).

On Weelhamby Lake, 27 species were collected from each of the lake floor and samphire habitats, with 14 and 11 species restricted to these habitats, respectively. A further two species were collected only from the inundation zone. The woodland assemblage at Weelhamby Lake comprised 74 species, of which 53 were found only in that habitat (Figure 4)

At Salt River, 44 species were recorded from the inundation zone, five of which were restricted to it. Thirty-two species were recorded from samphire and 12 species from the lake floor with 13 and seven species restricted to these habitats, respectively. Seventy-nine species were recorded from woodland, 60 of which were restricted to it (Figure 4).

At Lake Gulson, 54 species were collected from the lake floor and 57 species from samphire, with 27 species restricted to each habitat and a further 14 species restricted to the inundation zone. The woodland assemblage comprised 77 species, of which 56 were only found in that habitat (Figure 4).

At Taarblin Lake, 47 species were collected from the lake floor and 56 species from samphire, with 29 and 36 species restricted to these habitats, respectively. A further 14 species were limited to the inundation zone. Fifty-three species were recorded from woodland, 45 of which were collected only from that habitat (Figure 4).

Site-habitat classification

The three groups defined from the site-habitat classification (Figure 5) reflected differences in

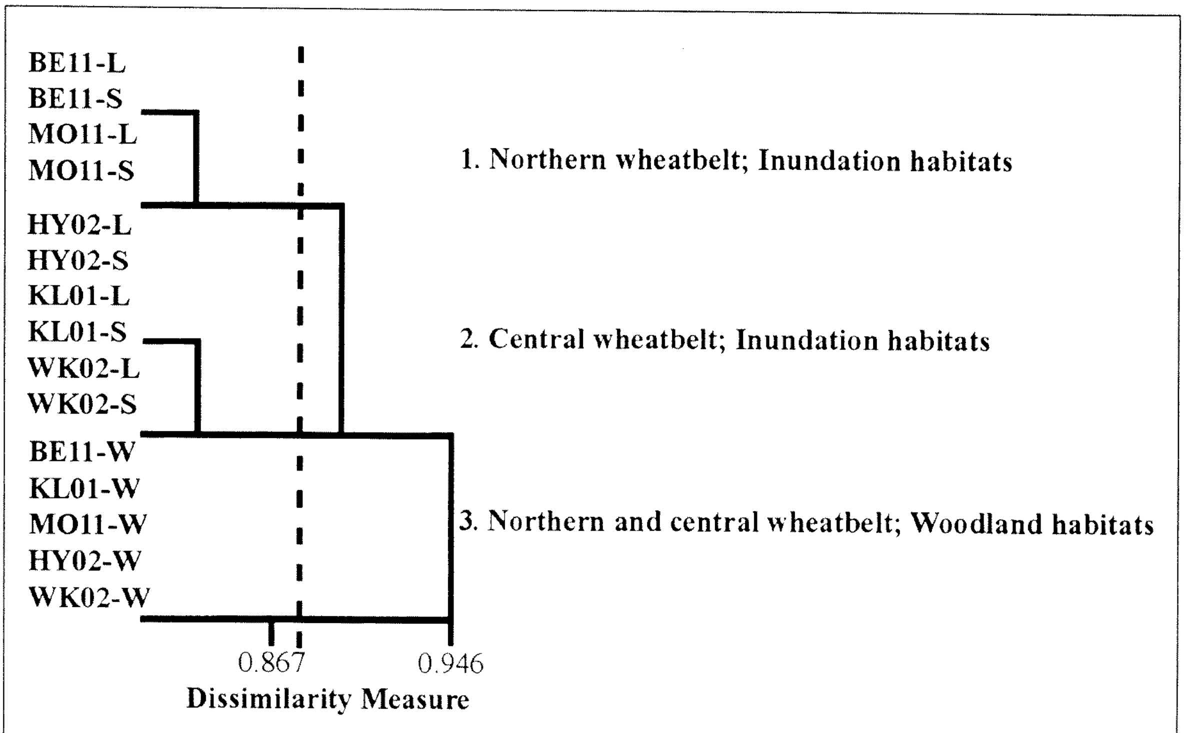

Figure 5 Site-habitats classified according to similarities in species composition. Dendrogram structure displayed to the 3-group level. See text for explanation of site-habitats.

faunal compositions that were based on both habitat preferences and broader geographic patterning. Site-habitat group 1 comprised lake floor and samphire habitats (inundation zones) from the northern sites of Lake Moore and Weelhamby Lake. The inundation zones from Lake Gulson, Salt River and Taarblin Lake comprised site-habitat group 2, while woodland habitats from all five sites comprised site-habitat group 3 (Figure 5).

Fourteen species assemblages were defined from the species classification (Figure 6). Assemblages 1 and 11–14 comprised species found at only one of any of the woodland sites. Assemblage 2 comprised species found at both Lake Moore and Salt River woodlands only. Species found at single samphire sites comprised assemblages 7 and 10 (Lakes Gulson and Taarblin, respectively), whereas species unique to lake floors from these sites formed assemblages 9 and 8, respectively. Assemblage 3 comprised species present at most sites and most habitats. Assemblage 4 comprised species common in, but not usually restricted to, northern woodland sites (Lakes Moore and Weelhamby). Species found in woodland habitats at Taarblin and, to a lesser extent, at Gulson and Salt River comprised assemblage 5. Species assemblage 6a comprised species common in, but not restricted to, non-northern inundation sites (i.e. only rarely found in Moore and Weelhamby). Species present in assemblage 6b were usually unique to Weelhamby samphire. Assemblage 6c comprised species unique to either the lake floor or samphire zone of Salt River (with one species common to both habitats), and assemblage 6d comprised species unique to Weelhamby lake floor (in addition to one species present in Moore samphire).

Ordination

Ordination of the site-habitat data was carried out to investigate further the relationships between the site-habitats (Figure 7). Three-dimensional results (stress level 0.17) support the interpretation that inundation zones of the salt lakes have different faunal assemblages from that

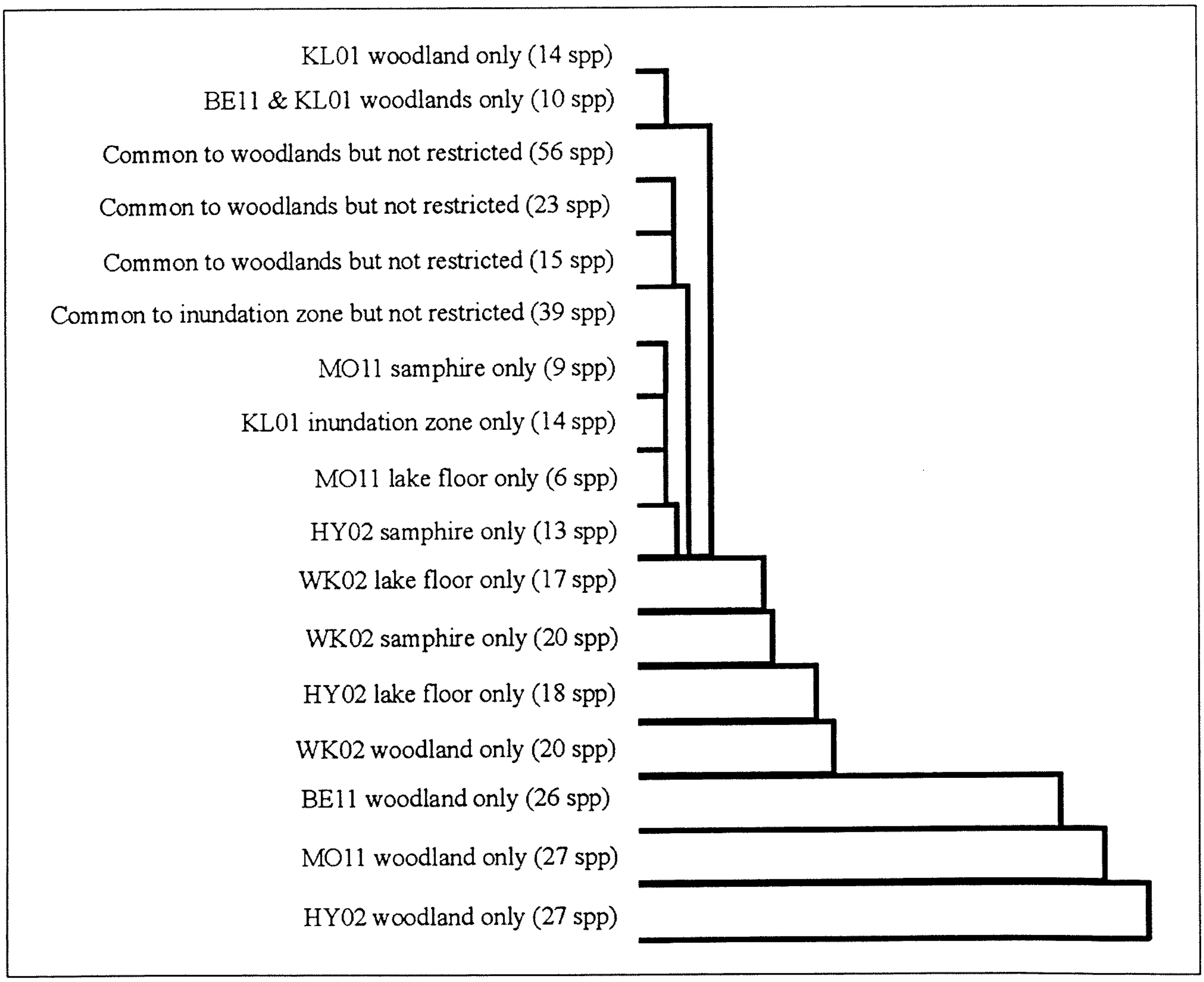

Figure 6 Species groups derived by classifying all species according to their co-occurrences at the same survey areas. Dendrogram structure is displayed and characterised at the 14-group level.

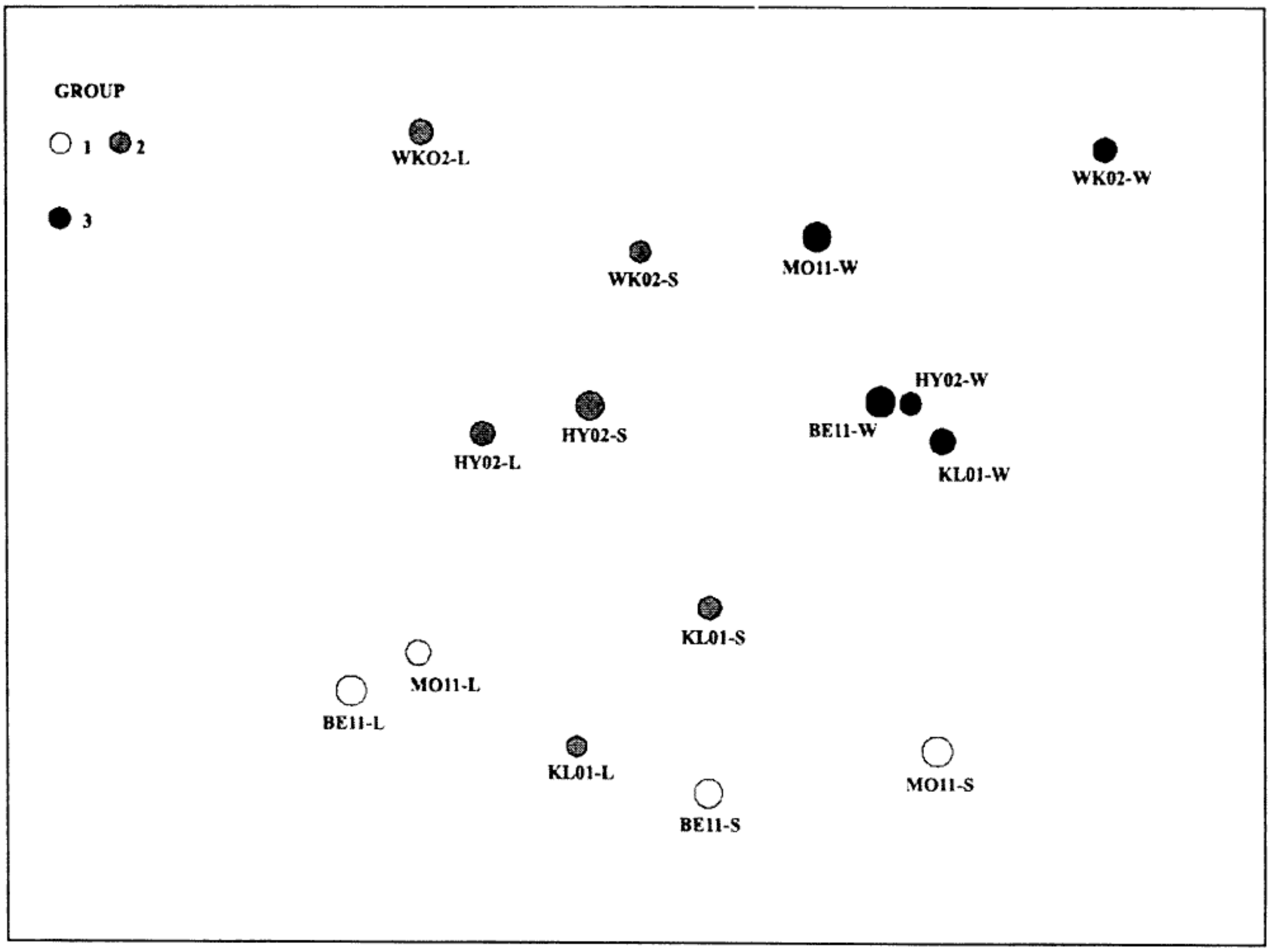

Figure 7 Three-dimensional ordination of the 15 site-habitats, showing the relationship of the three groups identified by classification (position on third axis is represented by size of the symbols).

of the neighbouring woodlands, rather than being a sub-set of the woodlands. The first and second axes separate woodland (group 3) from other habitats. In addition, the central inundation zone site pairs (group 2: HY02-L and HY02-S, KL01-L and KL01-S, WK02-L and WK02-S; see Figure 6 for pairings) can be separated from each other on these two axes (Figure 7). Axes one and three separate the northern inundation sites (group 1) from the other sites.

Fauna

Figure 8 shows the composition of the fauna (by order) for each site and all sites combined. Overall percentage composition of the fauna, regardless of habitat, was: beetles (48%), spiders (35%), ants (13%), scorpions, earwigs and isopods (4%). This composition was found at three of the five sites: Weelhamby Lake, Taarblin Lake and Lake Gulson, with an average variation of around three per cent. The major difference at the other two sites was a reduction in beetles to 34% at Lake Moore and 38% at Salt River; proportions of other taxa were consistent relative to each other.

Regionalised distributions were apparent both overall and within the two major groups, beetles and spiders. Figure 9 shows that 63% of the spiders, 78% of the beetles and 66% of all species occurred at only one site.

Beetles

A total of 173 beetle species representing 33 families were collected from the five salt lakes (Table 8, Figure 10). Eighty-one species were limited to the inundation zones (26 to samphire, 40 to lake floor and 15 species in both habitats), 28 species were found in both the inundation zone and surrounding woodlands, and 64 species were restricted to woodlands (Figure 10).

The most speciose families were Carabidae, Tenebrionidae, Dermestidae and Scarabaeidae (33, 21, 14 and 11 species respectively). Twenty-four families were represented by five or fewer species (Table 8). The most abundant family in terms of numbers of specimens was the Cicindelidae, present primarily on lake floors and to a limited extent in samphire habitats but absent from any woodland habitat and Taarblin Lake. *Megacephala blackburni* and *M. pulchra* were widespread, being present at four sites in large numbers, with 268

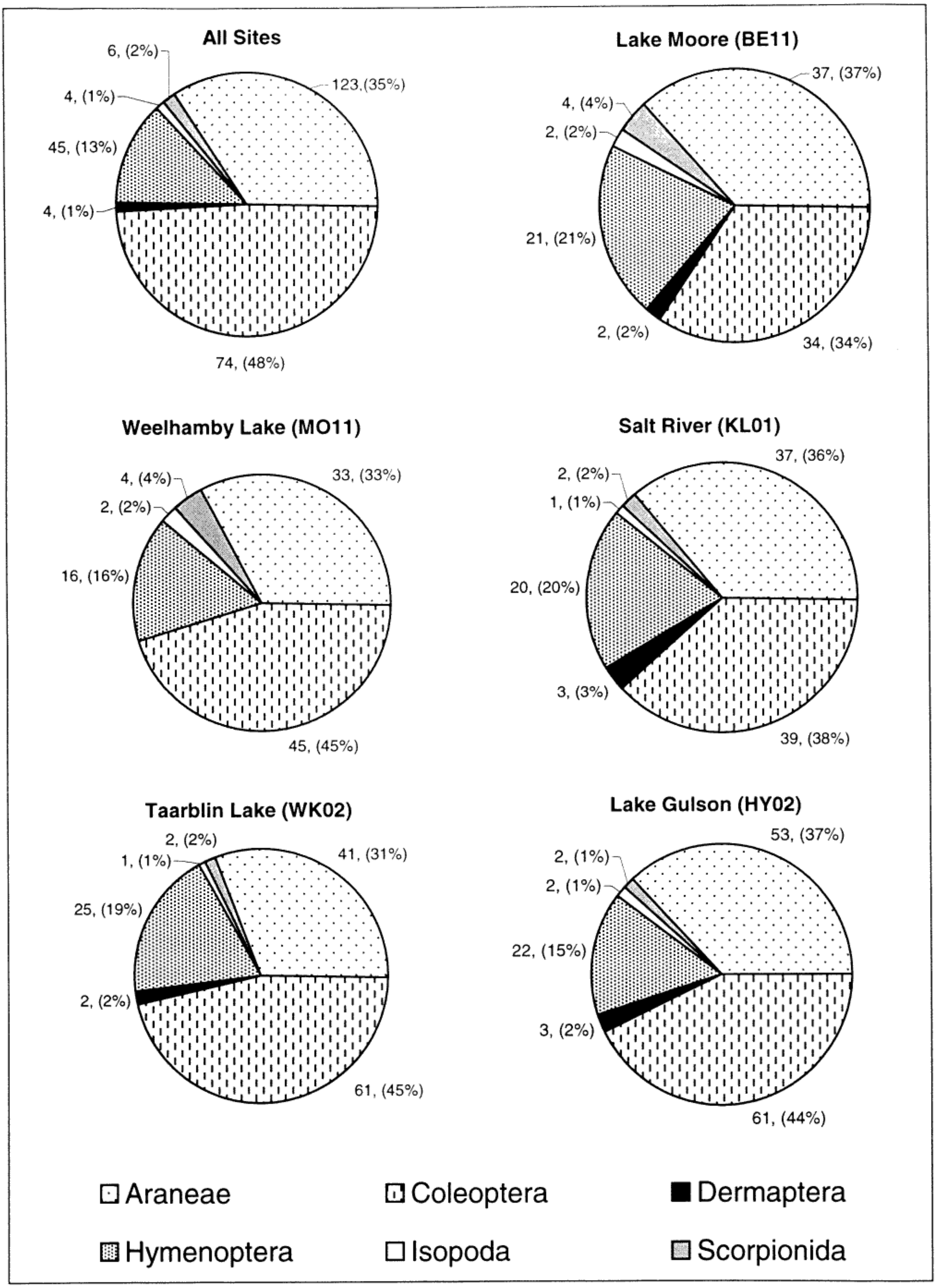

Figure 8 Proportions of species in each Order irrespective of habitat for (a) all sites, (b) Lake Moore, (c) Weelhamby Lake, (d) Salt River, (e) Taarblin Lake, and (f) Lake Gulson. Actual species numbers are presented first and percentage of total for each category at each site is shown in parentheses.

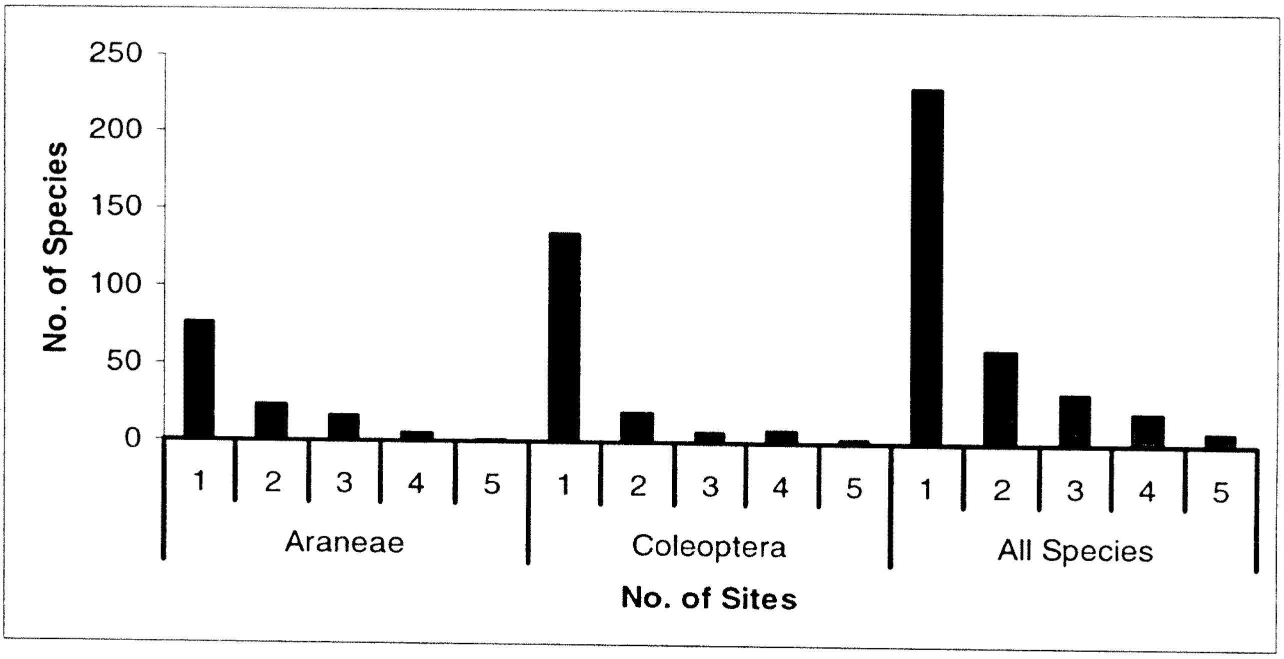

Figure 9 Numbers of Araneae (spiders), Coleoptera (beetles) and all species occurring at only one site, and at two-four sites.

individuals of *M. blackburni* collected. Of these, 251 were from lake floor habitats (183 from Salt River) and 17 from samphire habitats (14 from Salt River). In total, 71 *M. pulchra* were collected (63 from the lake floor and eight from the samphire). This species was absent from the samphire at Weelhamby and Salt River, and only three individuals were collected from the lake floor of Salt River. Single specimens of *Megacephala castelnaui* were collected from the lake floor habitats at Lake Moore and Salt River, and at Lake Gulson 62 individuals were collected (57 on the lake floor and 5 from samphire) but the species was not collected from Weelhamby Lake.

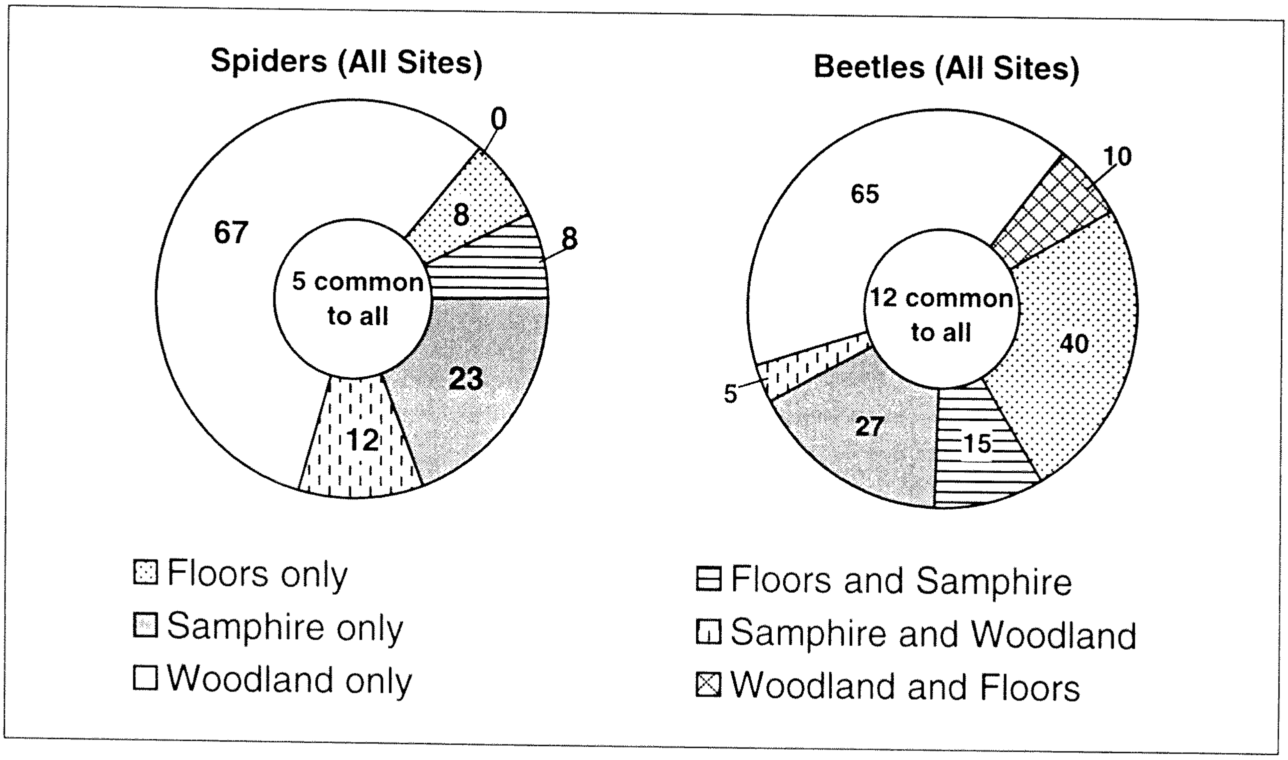

Figure 10 Numbers of spider and beetle species collected across the five salt lakes in each habitat.

Most other species were represented by ten or fewer specimens restricted to one or two habitats at a single site. Notable exceptions were: Tenebrionidae, *Celibe* sp. 1 (155 specimens from four sites), *Helea* sp. 2 (34 specimens from three sites) in woodland habitat only; Tenebrionidae, *Caedius* sp. 1 (82 specimens across four sites), *Cheriodes* sp. 1 (16 specimens across four sites) and *Gonocephalum* sp. 2 (149 individuals from two sites); Scarabaeidae, *Heteronyx* sp. (14 specimens across four sites); Latridiidae, *Corticaria* sp. 1 (48 specimens across all five sites); Elateridae, *Agrypnus* sp. 1 (39 individuals across two sites); Carabidae, *Cenogmus* sp. 1 (13 specimens from four sites) in both woodlands and inundation zone (Table 9). Both the Mordellidae and Mycetophagidae, represented by single species, had large numbers of individuals collected from more than one habitat (23 from two sites and 50 individuals across all five sites, respectively). Both *Dicranolaius* sp. 7 (Melyridae, 187 specimens from one site) and *Speotarus* sp. 3 (Carabidae, 39 individuals across three sites) were restricted to the inundation zone (Table 9).

Spiders

A total of 123 spider species representing 24 families were collected from the five salt lakes (Figure 10). Eight of the 21 spider species present on lake floors were found to be restricted to that

Table 2 Distribution of the Zodariidae species across each site and habitat. L lake floor, S samphire, W woodland.

		BE11			HY02			KL01			MO11			WK02		
		L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Asteron-complex	sp. 1														*	
Asteron-complex	sp. 4						*									
Australutica	*quaerens*												*			
Australutica	sp. 1			*												
Cavasteron	sp. 1												*			
Genus 4	sp. 1											*				
Habronestes	*grimwadei*															*
Habronestes	sp. 1						*									
Habronestes	sp. 12						*									
Habronestes	sp. 39					*	*									
Habronestes	sp. 4			*						*						
Habronestes	sp. 6			*						*						
Habronestes	sp. 8			*												
Kerasteron	sp. 1			*						*						
Neostorena	sp. 1						*									*
Neostorena	sp. 11						*									
Neostorena	sp. 12															*
Neostorena	sp. 3											*	*			
Neostorena	sp. 4			*												
Pentasteron	*intermedium*						*									

Table 3 Distribution of the Theridiidae species across each site and habitat. L lake floor, S samphire, W woodland.

		BE11			HY02			KL01			MO11			WK02		
		L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Theridiidae	sp. 1			*						*						*
Theridiidae	sp. 2											*				
Theridiidae	sp. 3		*			*					*					
Dipoena	sp. 1						*									
Enoplognatha	sp. 1									*						*
Euryopis	sp. 6											*				
Euryopis	sp. 9			*		*				*					*	
Genus 02	sp. 1					*								*	*	
Genus 05	sp. 1	*	*			*		*	*							
Genus 05	sp. 3	*	*	*	*				*			*				
Genus 1	sp. 3				*	*		*	*							
Gmogola	sp. U															*
Hadrotarsus	sp.														*	
Hadrotarsus	sp. C			*			*			*						
Latrodectus	*hasseltii*	*		*	*	*	*			*	*		*		*	
Phoroncidia	sp. 6															*
Steatoda	sp. 1					*				*		*	*			*
Steatoda	sp. B					*										

Table 4 Distribution of the Salticidae species across each site and habitat. L lake floor, S samphire, W woodland.

		BE11			HY02			KL01			MO11			WK02		
		L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Bianor	sp. 1				*											
Genus 1	sp. 2					*					*					
Grayenulla	sp. 1			*												
Lycidas	*chrysomelas*				*	*			*	*					*	
Lycidas	sp. 1			*			*									
Lycidas	sp. 19		*									*				
Lycidas	sp. 2											*				
Lycidas	sp. 28			*									*			
Lycidas	sp. 3						*									
Lycidas	sp. 4												*			
Lycidas	sp. 8									*						
Maratus	*vespertilio*															*
Ocrisiona	cf *parmeliae*			*												
Opisthoncus	sp. 2									*						
Opisthoncus	sp. 3														*	
Pellenes	sp. 1			*						*						

Table 5 Distribution of the Lycosidae species across each site and habitat. L lake floor, S samphire, W woodland.

		BE11			HY02			KL01			MO11			WK02		
		L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Geolycosa	*tongatabuensis*					*										
Hogna	sp					*									*	
Hogna	sp. 10					*		*	*					*		
Hogna	sp. 11						*									
Lycosa	*ariadnae*									*						
Lycosa	*bicolor* group		*	*		*				*			*			
Lycosa	*godeffroyi*			*		*	*									
Lycosa	*leuckarti*					*			*	*					*	*
Lycosa	*salifodina*	*			*						*					
Lycosa	*tula*											*	*			
Lycosa	*woonda*									*						
Pardosa	*pexa*			*						*			*			
Tetralycosa	sp. 10					*			*					*		
Venator	*gibsoni* group			*			*									
Venator	sp.						*									*
Venator	sp. 8		*	*									*			

Table 6 Distribution of the Oonopidae species across each site and habitat. L lake floor, S samphire, W woodland.

		BE11			HY02			KL01			MO11			WK02		
		L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Gamasomorpha	sp. 7														*	
Grymeus	sp. 3			*						*						
Grymeus	sp. 9												*			
Myrmopopaea	sp.			*		*	*			*	*	*	*			
Opopaea	sp. 1			*			*			*						
Opopaea	sp. 2														*	
Opopaea	sp. 4					*										
Opopaea	sp. 5				*											
Opopaea	sp. 6												*			
Opopaea	sp. 8					*										

habitat. The samphire assemblage was richer, with a total of 48 species (23 unique to the habitat). A further eight species were restricted to inundation zones but were absent from the woodland. The woodland assemblage consisted of 84 species, of which 67 were only found in that habitat (Figure 10).

The Zodariidae was the most speciose family, with 20 species (Table 2). Four of the 16 woodland species were collected from two sites (three species

Table 7 Distribution of less commonly collected spider families across each site and habitat. L lake floor, S samphire, W woodland.

			BE11			HY02			KL01			MO11			WK02		
			L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Amaurobiidae		sp. 1									*						
Amaurobiidae	Genus 02	sp. 3														*	
Ctenidae		sp. 1			*		*	*			*						
Ctenidae		sp. 2															*
Ctenidae?		sp. 1															*
Desidae		sp. 1									*						
Desidae	Genus 02	sp. 1									*						
Desidae	Genus 02	sp. 3														*	
Filistatidae	*Wandella*	*barbarella*			*												
Hersiliidae		sp. 3						*									*
Lamponidae	*Lampona*	*braemar*													*	*	
Lamponidae	*Lampona*	*cylindrata*						*	*							*	
Lamponidae	*Lampona*	*quinqueplagiata*												*			
Lamponidae	*Lamponina*	*scutata*						*									
Lamponidae	*Longepi*	*woodman*														*	
Linyphiidae		sp. 13													*		
Linyphiidae		sp. 16						*									
Linyphiidae		sp. A				*											
Linyphiidae	Genus 02	sp. 1													*		
Linyphiidae	Genus 02	sp. 4				*						*			*		
Liocrannidae		sp. 12														*	
Micropholcommatidae	*Micropholcomma*	sp. 8														*	
Miturgidae	Genus 01	sp. 1												*			
Miturgidae	Genus 02	sp. 2									*						*
Miturgidae	*Miturga*	sp. 1			*												
Miturgidae	*Miturga*	sp. 2											*	*			
Nemesiidae	*Aname*	cf *mainae*			*												
Nemesiidae	*Aname*	*mainae*			*			*			*						*
Nemesiidae	*Aname*	sp.					*										
Nemesiidae	*Aname*	sp. 1			*												
Nemesiidae	*Aname*	sp. 2			*						*			*			
Nemesiidae	*Aname*	sp. 3									*			*			
Nemesiidae	*Kwonkan*	sp. 1												*			
Nemesiidae	*Kwonkan*	sp. 2?			*												
Nemesiidae	*Yilgarnia*	sp. 1												*			
Pholcidae	Genus 01	sp. 1			*											*	
Scytodidae	Genus 01	sp. 1									*						
Segestriidae	Genus 01	sp. 1					*										
Sparassidae	Genus 01	sp. 1			*												
Sparassidae	Genus 02	sp. 1						*									
Sparassidae	Genus 03	sp. 1															*
Stiphidiidae	*Corasoides?*	sp. 4					*			*						*	
Tetragnathidae	Genus 01	sp. 1				*											
Thomisidae	*Tharpyna*	sp. 11												*			
Trochanteriidae	*Rebilus*	sp. 1						*						*			

from Moore and Salt River and one from Gulson and Taarblin), the remaining species were found at single sites. No species was collected from the lake floors but two species were each found at only one samphire site. Two additional species were present in both samphire and woodland habitats from one site each.

The Theridiidae comprised 18 species while the Salticidae and Lycosidae were each represented by 16 species and the Oonopidae consisted of 10 species (Tables 3–6). Three of the six theridiid species restricted to woodland sites were present at two or more sites. Likewise, four of the eight species limited to inundation zones were present at two or more sites, the remaining species were found at single sites. *Latrodectus hasselti* and Genus 05 sp. 3 were each present at all three habitats at a single site (Lakes Moore and Gulson, respectively). The former was also present in at least one habitat at the other four sites, whereas Genus 05 sp. 3 was found at three other sites (two samphire and one lake floor).

Salticids were most speciose in woodland habitats, with three of the 10 species present at Lake

Moore and an additional site; the remaining species were found at one woodland site only. Five species were limited to inundation zones: one to the lake floor, one on both floor and samphire and three species restricted to samphire. Only the widespread *Lycidas chrysomelas* was present in all three habitats across three sites (Table 4).

Six lycosids were restricted to woodland habitats: *Pardosa pexa* was present at three sites and two *Venator* species were present at two sites, the remaining species were found at single sites. Four of the five species limited to inundation zones were present at two or more sites; *Lycosa salifodina* was found only on lake floors at three sites (Table 5). Of the five lycosids present in both woodland and inundation habitats, only members of the *Lycosa bicolor* group were found at four sites (two samphire specimens, one each from Moore and Gulson; four woodland specimens, two from Moore and one each from Weelhamby and Salt River). In contrast, two specimens of *Lycosa tula* were found at Weelhamby, one in samphire and one in woodland habitat (Table 5).

The five oonopid species with distributions restricted to the inundation zone were found at single sites and, of these, only *Opopaea* sp. 5 was present on the lake floor (Table 6). Four species were limited to woodland habitats; *Opopaea* sp. 6 and *Grymeus* sp. 9 were present only at Weelhamby, *Grymeus* sp. 3 and *Opopaea* sp. 1 were present at Moore and Salt River (with the latter species also at Gulson). Only *Myrmopopaea* sp. was collected from both the inundation zones and woodlands (Table 6).

Of the remaining 45 species, representing 19 families, only three species were collected from both inundation zones and woodlands (*Lampona cylindrata*; Lamponidae, Ctenidae sp. 1 and Pholcidae Genus 01 sp. 1, Table 7). Fourteen species were restricted to inundation zones and to either Lakes Gulson or Taarblin (Table 7). Twenty-six species were restricted to woodland habitats (13 represented by single specimens). Only *Rebilius* sp. 1, Hersiliidae sp. 3, *Aname* sp. 3 and Miturgidae Genus 02 sp. 2 were present at two woodland sites. *Aname* sp. 2 was present at Moore, Salt River and Weelhamby woodlands while *Aname mainae* was found at four woodland habitats (absent from Weelhamby).

Ants

Forty-five ant species were collected from 21 genera across the five sites (Table 10). Five species were limited to the inundation zone, 22 species were restricted to woodland and 18 occurred in either one or both inundation habitats and woodland. Thirteen species were found on the lake floor but only one, *Crematogaster frivola*, was not found at any other habitat. Eleven of the remaining lake species were also found in woodland; *Cerapachys princeps* was limited to the lake floor and samphire. The other three species absent from woodland were restricted to samphire: *Anochetus armstrongi*, *Aphaenogaster* sp. 2 and *Rhytidoponera* sp. 3.

Sixteen species were found at only one site, 12 at two, eight at three, five at two and four species at all five sites (Table 10). Taarblin Lake was the richest site with 25 species, while Weelhamby Lake had fewest with 16. All sites shared species and the only evidence of strong restriction in geographic distributions was that Weelhamby had three species that occurred at only one other site and Salt River had one species not occurring anywhere else.

Scorpions

Three scorpion species were collected at three or more sites (Table 11): *Cercophonius* sp. 1 at Weelhamby, Gulson and Salt River; *Isometroides* sp. 1 at Moore, Weelhamby and Taarblin; and *Lychas marmoreus splendens* Koch at all five sites. The other three species collected, all *Urodacus*, occurred at only one site each, with both species 1 and species 2 at Lake Moore (Table 11).

Only *Urodacus* sp. 1 was restricted to a particular habitat type (woodland at Lake Moore). All other species were caught in woodland and the inundation zone. Sixty-four specimens were collected from woodland compared with only 25 in the inundation zone (Appendix 1).

Dermaptera

Owing to limitations in currently available keys, supraspecific identification was not possible and all dermapteran specimens were allocated to morphospecies. Three of the four Dermapteran species were restricted to two sites each, with species 2 and species 3 limited to single habitats (single specimens at woodland at Lake Moore and Salt River, and six specimens each in the inundation zones at Lake Gulson and Taarblin Lake, Table 11). Species 1 was present in large numbers in the inundation zones at Lake Gulson (136 specimens) and Salt River (9 specimens, with a single additional specimen from woodland). Species 4 was present in the inundation zone at Lake Gulson (19 specimens) and in low numbers in woodland habitats at Lake Moore, Salt River and Taarblin Lake (Appendix 2).

Isopoda

The four isopod species had moderately restricted distributions, with *Laevophiloscia* sp. 1 and *Acanthodillo* sp. 1 restricted to woodland habitats at Weelhamby Lake and Lake Gulson, respectively. The two *Buddelundia* species were both present at Lake Moore woodlands but *B.* sp. 1 was also widespread across all three habitats at Salt River. *Buddelundia* sp.

Table 8 Distribution of Coleopteran species across each site and habitat. L lake floor, S samphire, W woodland.

			BE11			HY02			KL01			MO11			WK02		
			L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Anobiidae	*Deltocryptus*	sp. 1						*									
Anobiidae	*Dryophilodes*	sp. 1				*											
Anobiidae	*Lauroderma*	*serricorne*														*	
Anobiidae	*Mysticephala*	sp. 1				*											
Anthicidae	*Anthicus*	sp. 1													*		
Anthicidae	*Anthicus*	sp. 2														*	
Anthicidae	*Anthicus*	sp. 3					*										
Anthicidae	*Anthicus*	sp. 4													*	*	
Anthicidae	*Anthicus*	sp. 5				*	*	*		*	*						
Anthicidae	*Formicomus*	sp. 2			*	*	*	*	*	*	*	*		*	*	*	
Anthicidae	*Formicomus*	sp. 7						*									
Anthicidae	*Tomoderus*	sp. 1	*													*	
Anthicidae	*Tomoderus*	sp. 3							*								
Bostrichidae	*Bostrychopsis*	sp. 1														*	
Buprestidae	Genus 01	sp. 1											*				
Buprestidae	Genus 02	sp. 1				*											
Byrrhidae	*Microchaetes*	sp. 1														*	
Byrrhidae	*Morychus*	sp. 1												*			
Carabidae	*Adotela*	sp. 1												*			
Carabidae	*Carenum*	sp. 1			*												
Carabidae	*Cenogmus*	sp. 1		*		*	*	*	*		*		*	*			
Carabidae	*Cenogmus*	sp. 2					*										
Carabidae	*Clivinia*	sp. 1													*		
Carabidae	*Clivinia*	sp. 2				*											
Carabidae	*Clivinia*	sp. 3													*		
Carabidae	*Conopterum*	sp. 1												*			*
Carabidae	*Demetrida*	sp. 1					*										
Carabidae	*Dicrochile*	sp. 1					*										
Carabidae	*Euthenaris*	sp. 1									*						
Carabidae	Genus 01	sp. 1													*		
Carabidae	Genus 02	sp. 1					*										
Carabidae	Genus 03	sp. 1						*									
Carabidae	*Gigadema*	*?bostocki*												*			
Carabidae	*Gigadema*	sp. 1												*			
Carabidae	*Gnathaphanus*	sp. 1													*	*	
Carabidae	*Haplaner*	sp. 1										*					
Carabidae	Harpaline Genus01	sp. 1													*	*	
Carabidae	Harpaline Genus02	sp. 1								*							
Carabidae	*Homothes*	sp. 1			*												
Carabidae	*Mecyclothorax*	sp. 1					*	*							*		
Carabidae	*Microlestes*	sp. 2				*	*										
Carabidae	*Neocarenum*	sp. 1												*			
Carabidae	*Pogonus*	*?australis*													*		
Carabidae	*Promecoderus*	sp. 2															*
Carabidae	*Scaraphites*	*silenus*						*									
Carabidae	*Scopodes*	sp. 1						*									
Carabidae	*Scopodes*	sp. 2								*							
Carabidae	*Scopodes*	sp. 3									*						
Carabidae	*Scopodes*	sp. 4														*	
Carabidae	*Speotarus*	sp. 1													*		
Carabidae	*Speotarus*	sp. 3				*	*			*					*	*	
Cerambycidae	*Uracanthus*	sp. 1						*									
Chrysomelidae	*Aphthona*	sp. 1			*			*						*			
Chrysomelidae	*Aphthona*	sp. 3															*
Chrysomelidae	*Chaetocnema*	sp. 1						*				*		*	*	*	
Chrysomelidae	*Ditropidus*	sp. 1													*	*	
Chrysomelidae	*Ditropidus*	sp. 2												*			
Chrysomelidae	*Geloptera*	sp. 1			*												
Chrysomelidae	*Geloptera*	sp. 2						*									
Chrysomelidae	Genus 01	sp. 1															*
Cicindelidae	*Cicindela*	*?blackburni*										*					
Cicindelidae	*Megacephala*	*blackburni*	*	*		*	*		*	*		*	*				
Cicindelidae	*Megacephala*	*castelnaui*	*			*	*		*								

			BE11			HY02			KL01			MO11			WK02		
			L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Cicindelidae	*Megacephala*	*pulchra*	*	*		*	*		*			*					
Cleridae	Genus 01	sp. 1															*
Cleridae	Genus 01	sp. 4												*			
Cleridae	*Opilio*	sp. 1										*					
Cleridae	*Opilio*	sp. 2										*					
Coccinellidae	*Buccolus*	sp. 1				*					*						
Coccinellidae	*Coccinella*	sp. 1				*									*		
Coccinellidae	*Coccinella*	sp. 2				*											
Coccinellidae	*Coccinella*	*transversalis*			*	*		*	*		*				*		*
Coccinellidae	*Diomus*	sp. 1				*		*									
Coccinellidae	Genus 01	sp. 1				*											
Coccinellidae	*Telsimia*	sp. 1						*			*						
Cryptophagidae	*Cryptophagus*	*saginatus*				*											
Cryptophagidae	*Cryptophagus*	sp. (near *saginatus*)				*											
Cryptophagidae	*Henoticus*	sp. 1										*					*
Dermestidae	*Adelaidia*	sp. 1														*	
Dermestidae	*Attagenus*	sp. 1														*	
Dermestidae	*Dermestes*	sp. 1			*									*		*	
Dermestidae	*Everinea*	sp. 1						*									
Dermestidae	Genus 01	sp. 1			*								*	*			
Dermestidae	Genus 02	sp. 1									*						
Dermestidae	Genus 03	sp. 1												*			
Dermestidae	*Trogoderma*	sp. 1													*		
Dermestidae	*Trogoderma*	sp. 2				*		*									
Dermestidae	*Trogoderma*	sp. 3						*									*
Dermestidae	*Trogoderma*	sp. 4						*									
Dermestidae	*Trogoderma*	sp. 5											*				
Dermestidae	*Trogoderma*	sp. 6			*												
Dermestidae	*Trogoderma*	sp. 7		*							*			*			
Elateridae	*Agrypnus*	sp. 1					*	*			*						
Elateridae	*Agrypnus*	sp. 2											*				
Elateridae	*Agrypnus*	sp. 3								*							
Elateridae	*Agrypnus*	sp. 4	*	*	*												
Elateridae	*Agrypnus*	sp. 5			*												
Histeridae	*Saprinus*	sp. 2				*	*										
Histeridae	*Saprinus*	sp. 3														*	*
Hydrophilidae	*Berosus*	*munitipennis*							*	*							
Hydrophilidae	*?Cercyon*	sp. 1													*		
Laemophoeidae	*Cryptolestes*	sp. 1								*							
Latridiidae	*Corticaria*	sp. 1		*		*	*	*		*	*	*		*		*	
Latridiidae	*Cortinicara*	sp. 1						*							*	*	
Latridiidae	*Corticaria*	*subtilissima*												*			
Leiodiidae	*Dietta*	sp. 1			*							*					
Meloidae	Genus 01	sp. 1						*									
Melyridae	*Balanophorus*	sp. 1				*											
Melyridae	*Dasytes*	sp. 1								*	*						
Melyridae	*Dicranolaius*	sp. 2							*								
Melyridae	*Dicranolaius*	sp. 3														*	
Melyridae	*Dicranolaius*	sp. 4									*						
Melyridae	*Dicranolaius*	sp. 5						*									
Melyridae	*Dicranolaius*	sp. 6							*								
Melyridae	*Dicranolaius*	sp. 7													*		
Melyridae	*Dicranolaius*	sp. 8			*						*						
Mordellidae	*Mordellistena*	sp. 1						*	*		*						
Mycetophagidae	*Typhaea*	sp. 1	*	*	*	*		*		*		*		*	*	*	
Nitidulidae	*Brachypeplus*	sp. 1								*							
Nitidulidae	*Carpophilus*	sp. 1								*							
Nitidulidae	*Carpophilus*	sp. 2				*											
Nitidulidae	*Cybocephalus*	sp. 1												*			
Nitidulidae	*Thalycrodes*	sp. 1			*												
Nitidulidae	*Thalycrodes*	sp. 2															*
Oedemeridae	*Copidita*	sp. 1												*			
Oedemeridae	*Copidita*	sp. 2														*	

Table 8 (cont.)

			BE11			HY02			KL01			MO11			WK02		
			L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Pselaphidae	*Eupines*	sp. 1			*												
Ptinidae	*?Polyplocotes*	sp. 1			*												
Ptinidae	*?Polyplocotes*	sp. 2			*												
Ptinidae	*?Polyplocotes*	sp. 3										*	*				
Ptinidae	*Ectrephes*	sp. 1			*						*						
Ptinidae	*Ptinus*	*albomaculatus*						*									
Rhipiceridae	*Rhipicera*	sp. 1		*													
Scarabaeidae	*Automolus*	sp nova							*								
Scarabaeidae	*Biphyllocera*	*kirbyana*															*
Scarabaeidae	*Colpochila*	*mixta*			*												
Scarabaeidae	*Gnaphalopoda*	*solida*												*			
Scarabaeidae	*Heteronyx*	sp. 1				*		*			*			*	*		*
Scarabaeidae	*Liparetrus*	*ater*									*						
Scarabaeidae	*Liparetrus*	*atrox*												*			
Scarabaeidae	*Liparetrus*	*flavidus*							*		*						
Scarabaeidae	*Liparetrus*	*malara*						*									
Scarabaeidae	*Liparetrus*	*satannus*			*												
Scarabaeidae	*Liparetrus*	sp nova												*			
Scraptiidae	*Scraptia*	sp. 1						*									
Scydmaenidae	*Neuraphoconnus*	sp. 1														*	
Staphilidae	*Carpelimus*	sp. 1				*											
Staphylinidae	*Bledius*	sp. 2										*					
Staphylinidae	Genus 01	sp. 1	*				*				*				*		
Staphylinidae	*Tachinus*	sp. 1													*		
Staphylinidae	*Tachinus*	sp. 2				*											
Tenebrionidae	*?Gonocephalum*	sp. 1								*					*		
Tenebrionidae	*?Gonocephalum*	sp. 2				*	*	*							*	*	
Tenebrionidae	*Adelium*	sp. 1													*		
Tenebrionidae	*Agasthenes*	sp. 1	*														
Tenebrionidae	*Caediomorpha*	sp. 1												*			
Tenebrionidae	*Caedius*	sp. 1	*			*								*	*		
Tenebrionidae	*Caedius*	sp. 2													*		
Tenebrionidae	*Caedius*	sp. 3													*		
Tenebrionidae	*Celibe*	sp. 1			*						*			*			*
Tenebrionidae	*Chalcopteroides*	sp. 1															*
Tenebrionidae	*Cheriodes*	sp. 1	*			*	*				*				*		
Tenebrionidae	*Csiro*	sp. 1				*	*										
Tenebrionidae	*Ectyche*	sp. 1															*
Tenebrionidae	Genus 02	sp. 1												*			
Tenebrionidae	Genus 04	sp. 1												*			
Tenebrionidae	Genus 05	sp. 1			*												
Tenebrionidae	*Helea*	sp. 1															*
Tenebrionidae	*Helea*	sp. 2			*									*			*
Tenebrionidae	*Mithippia*	sp. 1										*			*		
Tenebrionidae	*Mithippia*	sp. 2				*											
Tenebrionidae	*Onosterrhus*	sp. 1											*				
Tenebrionidae	*Palorus*	sp. 1				*											
Tenebrionidae	*Pterohelaeus*	sp. 1													*		

2 was also found at the southern samphire habitats of Taarblin Lake and Lake Gulson (Table 10).

DISCUSSION

Few Australian salt lakes have been surveyed for their terrestrial invertebrate fauna, and sampling periods have generally been limited to only a few weeks (e.g. Lake Lefroy: Hudson, 1995, Brennan, 1999).

Beetles

Beetles exhibit a wider range of feeding behaviours than either spiders or ants and include fungivores, detritivores, scavengers, predators and specialized herbivores feeding on particular structures of specific host plants. Of the 173 beetle species collected, 81 from 33 families had distributions restricted to the inundation zone. Previously, Brennan (1999) collected 20 species from 11 families in similar inundation habitats

Table 9 Distribution of ant species across each site and habitat. L lake floor, S samphire, W woodland.

		BE11			HY02			KL01			MO11			WK02		
		L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Adlerzia	sp. 1			*					*	*	*		*	*	*	
Anochetus	*armstrongi*											*				
Anochetus	sp. 1															*
Anochetus	sp. 2			*												
Anochetus	sp. 3			*												
Aphaenogaster	sp. 1		*	*			*									
Aphaenogaster	sp. 2					*										
Camponotus	sp. 1			*		*	*			*			*			*
Camponotus	sp. 2						*									
Camponotus	sp. 3						*									
Camponotus	sp. 4						*									*
Camponotus	sp. 5						*			*		*	*			*
Camponotus	sp. 6						*			*						
Camponotus	sp. 7			*						*			*			
Cerapachys	*princeps*				*										*	
Cerapachys	sp. 1			*												
Cerapachys	sp. 2									*						*
Crematogaster	*frivola*													*		
Froggatella	sp. 1															*
Iridomyrmex	sp. 1			*			*			*				*		
Iridomyrmex	sp. 2				*	*	*	*	*	*			*			*
Iridomyrmex	sp. 3			*	*	*										
Iridomyrmex	sp. 4			*	*				*	*	*	*	*		*	
Iridomyrmex	sp. 5								*	*			*	*	*	*
Melophorus	sp. 1						*			*						
Melophorus	sp. 2						*									
Melophorus	sp. 3			*	*									*	*	
Melophorus	sp. 4			*						*	*	*	*			
Meranoplus	sp. 1			*									*			*
Meranoplus	sp. 2															*
Meranoplus	sp. 3			*						*						
Monomorium	sp. 1						*	*		*					*	
Monomorium	sp. 2					*							*		*	
Myrmecia	sp. 1						*									*
Notoncus	sp. 1			*						*						
Odontomachus	sp. 1											*	*			
Pachycondyla	sp. 1									*						
Pheidole	sp. 1			*				*	*	*	*		*		*	
Podomyrma	sp. 1			*									*			
Polyrhachis	sp. 1															*
Rhytidoponera	sp. 1		*	*			*		*	*			*		*	*
Rhytidoponera	sp. 2		*	*	*	*	*		*	*		*	*	*	*	*
Rhytidoponera	sp. 3					*										
Tetramorium	sp. 1			*						*						*
Turneria	sp. 1			*												*

around Lake Lefroy. This suggests that the inundation zone of salt lakes is a speciose beetle habitat, with high turnover in species composition between wetlands.

The Carabidae and Cicindelidae are two closely related families, with the latter often considered a subfamily of the former (e.g. Matthews, 1980; Lawrence and Britton, 1994). They are dominant terrestrial predators occupying three main ecological niches: dry ground, edge of water bodies or swamps, and vegetation (Darlington, 1961). Strong habitat preferences based on abiotic environmental factors have resulted in carabids and cicindelids being important indicator taxa in ecological studies (Margules, 1992; Niemelä and Spence, 1994; Petit and Usher, 1998; Michaels, 1999; Davies and Margules, 2000; Pearson and Vogler, 2001; Magura *et. al.*, 2003). Eighteen species of carabids and all four species of cicindelid were restricted to the lake floor and samphire habitats.

Megacephala blackburni, *M. pulchra* and *M. castelnaui* are present at salt lakes, swamps and riparian zones across southern arid Australia (Moore *et al.*, 1987), with Sumlin (1997) suggesting that the Kalgoorlie salt lakes are the western most limit for *M. blackburni*. Our records and others (A.

Table 10 Distribution of dermapteran, isopod and scorpion species across each site and habitat. L lake floor, S samphire, W woodland.

			BE11			HY02			KL01			MO11			WK02		
			L	S	W	L	S	W	L	S	W	L	S	W	L	S	W
Dermaptera		sp. 1				*	*		*	*	*						
Dermaptera		sp. 2			*						*						
Dermaptera		sp. 3				*	*								*		
Dermaptera		sp. 4			*	*	*				*						*
Isopoda	*Acanthodillo*	sp. 1						*					*	*			
Isopoda	*Buddelundia*	sp. 1			*				*	*	*						
Isopoda	*Buddelundia*	sp. 2			*		*	*								*	
Isopoda	*Laevophiloscia*	sp. 1												*			
Scorpionida	*Cercophonius*	sp. 1						*			*	*					
Scorpionida	*Lychas*	*marmoreus splendens*			*			*			*			*		*	*
Scorpionida	*Isometroides*	sp. 1	*	*	*									*			*
Scorpionida	*Urodacus*	sp. 1			*												
Scorpionida	*Urodacus*	sp. 2	*		*												
Scorpionida	*Urodacus*	sp. 3										*	*	*			

Szito, pers. comm.) indicate that all three species occur well into the southwest region, and extend north into the Geraldton Sand Plains. The lack of records from woodland habitats suggests that they are exclusively using the inundation zone. There did not appear to be biased use of the lake by either sex but the presence of large numbers of apparently gravid females would suggest that both breeding and general activity takes place in the inundation zone of the lakes.

The Staphylinidae are a very speciose group and occur in virtually every habitat. Only five species could be conclusively identified, despite at least another 20 forms (which could not be positively separated and were removed from analysis) being present within the survey. Of the identified taxa, five *Bledius* sp. 2 (Oxytelinae) specimens were collected from the lake floor of one site, suggesting this species may be actively hunting across this habitat.

Both aquatic and terrestrial Hydrophilidae occur, with adults generally being herbivores or scavengers while larvae are mainly predacious. The mainly terrestrial Sphaeridiinae and aquatic Berosinae were represented by one specimen of *?Cercyon* and several *Berosus munitipennis*, respectively, on lake floor and samphire habitats. *Berosus munitipennis* has a widespread distribution across southern Australia (Watts, 1987) occurring in fresh, secondarily saline and naturally saline lakes in south-western Australia (Pinder *et al.*, 2002).

Representatives of the Scarabaeidae belong to the largely plant feeding Melolonthinae subfamily. Seven described and one undescribed species of *Liparetus* were collected. This genus, which is associated with *Eucalyptus*, is extremely speciose and widespread, having 239 species Australia-wide and 101 known from Western Australia. A widespread, undescribed species of *Heteronyx* was collected, as was an unplaced species of *Automolius*. The latter genus is speciose, with representatives occurring from arid regions through to mountainous forest (Houston and Weir, 1992). Of the three remaining species, representing three genera, *Colpochila mixta* is widespread across southern Australia (Britton, 1990; Houston and Weir, 1992). Monotypic *Biphyllocera kirbyana* is present throughout south-western Australia (Houston and Weir, 1992) and *Gnaphalopoda solida* (one specimen only) represents a significant southern range extension for this arid zone species.

Seven Dermestidae genera were recognised from inundation zone habitats: *Trogoderma*, a speciose genus with adults that feed on flowers and larvae known to scavenge in social insect nests, spider webs, wood boring insect burrows, and under bark; *Dermestis*, also a widespread genus known for being present under carrion; *Attagenus*; the carpet beetle; and *Adelaidia*, a genus currently only known from the holotype from South Australia. It is possible the latter record is mis-identified and that the specimen is a *Trogoderma* species. Two unplaced dermestid genera were also identified, suggesting that there may be many more species of dermestid in the semi-arid region of Western Australia.

Doyen *et al.* (1990) recognized seven subfamilies of Tenebrionidae in Australia: of these, representatives of the Lagriinae (Adeliini), Diaperinae (Hyoclini) and Tenebrioninae (Amarygmimi, Heleini and Opatrini) were collected, in addition to two taxa which could not be assigned to subfamilies. Other than broad distributions and generalized life histories, little is known about the ecology of Australian tenebrionids but the distribution patterns presented here conform with what is recognised at the generic and tribal levels (see Matthews, 1987; Lawrence and Britton, 1994)

Many forms of the beetle family Anthicidae were collected during the survey. The family is widespread, speciose and common but has not been revised since Abdullah and Abdullah (1969), Uhmann (1976) and Lawrence (1982; cited in Matthews, 1987). The many morphospecies recently encountered suggest the family is much more speciose in semi-arid regions than previously thought.

Several *Dicranolaius* (Melyridae) were collected, including large numbers of one species found only on the floor of Taarblin Lake. Three members of the Lathridiidae family were collected: *Corticaria* sp. 1 was present at all salt lakes surveyed and *Cortinicara* sp. 1 was collected from both Taarblin and Gulson, neither species was restricted to any one habitat type. *Corticaria subtilissima* was restricted to Weelhamby woodland. Both genera have representatives with distributions extending beyond Australasia (Matthews, 1992).

Spiders

One of the greatest barriers to spider distribution is aridity. Their susceptibility to desiccation, particularly among small spiders, means that adaptations are required for life within semi-arid areas, such as the wheatbelt with its dry salt playas and associated samphire vegetation. Successful adaptation to these environments has been accomplished primarily by fossorial species, which include most of the mygalomorphs and some araneomorphs, particularly members of the Lycosidae, Zodariidae and Sparassidae. Main (1981) suggested that in salt lake systems where inundation is infrequent the only resident spiders are long-lived fossorial species (mygalomorphs and lycosids), which have evolved strategies to tolerate extreme soil chemistry and periods of inundation. The salt lakes sampled during this study are usually at least partially inundated each year, but some areas of samphire would likely remain unflooded for many years at a time.

Three groups of spiders were recognised in our inundation zone samples: fossorial spiders (lycosids, some zodariids, mygalomorphs and segestriids), which may be capable of living permanently within the floor, as well as in the samphire and fringe vegetation; vagrant hunters (primarily salticids, non-fossorial zodariids, lamponids and ctenids), which take refuge in the samphire or fringe vegetation and forage on the lake floor; and small web-builders and litter dwellers (mainly theridiids, oonopids, linyphiids and stiphidiids), most likely blown on to the floor, either accidentally or through normal dispersal, from either the samphire or fringe vegetation. The small size in the third group, and what is known of their habits, suggest they are unlikely to be regular users of the lake floor environment.

The fossorial spiders that were recorded only on the lake floor/samphire environment during this survey comprised two zodariids, five lycosids, one mygalomorph and one segestriid. Both zodariids were collected during the recent SAP survey in the wheatbelt (Durrant, 2004). *Asteron*-complex sp. 1 had a wide distribution throughout the SAP area and was found across a suite of different landforms although it appeared to have a preference for environments low in the landscape, of which a few were saline. The second species, Genus 4 sp.1, was only found at three SAP sites, all saline, low in the landscape and within 40 km of Weelhamby Lake (Durrant, 2004). This suggests either south-western endemism or that the cluster of sites where it has been recorded lies on the south-western or western boundary of the species' range.

Genus 4 sp.1 (a new genus of zodariid) had heavy spination, particularly on the legs, as well as a noticeably more robust third and fourth femur, which would likely aid digging. This new genus is most likely a fossorial salt lake specialist, although further collecting and study is needed. *Asteron*-complex sp. 1 may prefer valley floor environments but is probably a vagrant hunter which would account for its distribution across the SAP study area and different landforms.

Lycosids are active, free-running hunters, most of which have permanent retreats, usually burrows. They are found in nearly all types of habitats, including high-tide lines on the beach, swamps and bogs, mountains, forests and deserts (Main, 1976). Most species show pronounced habitat specificity (McKay, 1979). The life span of lycosids is usually one to two years but some, particularly arid species, may require several years to mature (Main, 1976). Most species use ground dispersal but some geographically isolated species, like those associated with inland rivers and salt lakes, may disperse aerially through the use of gossamer (Main, 1976).

Many of the fossorial lycosids are capable of overcoming disturbance (e.g. flooding) by relocating their burrows, although this is less true of more sedentary and specialised arid species (Main, 1976), some of which protect themselves from short-term flooding by using mud plugs, palisades or other physical barriers to water. Major flooding may cause localised extinctions (Hudson and Adams, 1996). Of the five lycosid species in this survey that were limited to inundation zones, only *Lycosa salifodina* is known to be a salt lake specialist. This species occurs across the arid salt lake systems of southern Australia, from Western Australia to South Australia and the Northern Territory (McKay, 1976; Hudson, 1996; Hudson and Adams, 1996; Hudson, 2000). Individuals are found scattered across open salt lake floors. At Lake Lefroy, Koch (1977a) found the largest individuals about 90m from the shore and the smaller individuals towards the middle of the lake, with few near the periphery. This species was captured at the three most arid sites (Weelhamby, Moore and Gulson) possibly reflecting the western limit of its distribution.

Hogna sp. appears to be common through Western Australia and South Australia, with occasional records from New South Wales and Queensland. They seem most frequent near fresh water, but sometimes occur in saline areas (V. Framenau, pers. comm.). *Hogna* sp. 10 is known only from the south-west of Western Australia and appears to prefer claypans and saline lake floors. It does not extend into the arid northern wheatbelt or the goldfields. *Geolycosa tongatabuensis* is very common throughout Australasia, including New Zealand and Pacific islands, where it frequents beaches and freshwater habitats (V. Framenau, pers. comm.). *Tetralycosa* sp.10 is a new lycosid species, known only from Salt River, Taarblin and Gulson. This was the only species with a significant difference between sexes in numbers of individuals. At Taarblin, 38 females were captured with 19 juveniles and no adult males at all. This may reflect a short, distinct mating season where the males mate and die shortly after maturing.

Only a single segestriid was found at Lake Gulson samphire during this survey. However, populations may be effectively isolated, with dispersal from natal burrows only occurring over tens of metres (Main, 1976; Dippenaar-Schoeman and Jocqué, 1997). Harvey *et al.* (2004) indicated that populations occur across the wheatbelt.

The vagrant hunting spiders restricted to the inundation zone during this survey comprised the Salticidae and the Lamponidae. These spiders take refuge in samphire or fringing vegetation and forage on the lake floor.

The salticids are diurnal, and are among the most speciose spider families with approximately 340 species known from Australia (Żabka, 1999). The five salticds recorded in this survey were first collected during the SAP survey and therefore ecological information is restricted (Guthrie and Waldock, 2004). Of the five species, only *Lycidas* sp. 19 is known exclusively from samphire and valley floor sites. It has a distribution centred on northern samphire lakes, extending as far south as Lake Campion Nature Reserve (SAP site MN09, Guthrie and Waldock, 2004). Isolated populations were also found at SAP sites UN08 and UN12; however these two sites are secondarily saline seeps and probably represent opportunistic establishment of the particular species (Guthrie and Waldock, 2004).

Distributions of the other four species were more widespread and they were not restricted to low-lying habitats. *Opisthoncus* sp. 2 was previously collected from two widely separated samphire sites and two valley slopes (Guthrie and Waldock, 2004) in addition to a single site in this current survey (Taarblin). *Bianor* sp. 1 was previously only known from two sites 110 km apart, both relatively low in the landscape, and this species may be restricted regionally. *Lycidas* sp. 2 and Genus 1 sp. 2 were previously recorded from many widespread sites across the wheatbelt, indicating their distributions were not centred on salt lakes (Guthrie and Waldock, 2004). Four other salticid species encountered during the SAP survey (three at Taarblin Lake; 1 at Lake Moore) were not collected during the current survey (Guthrie and Waldock, 2004).

Of eleven salticid species not restricted to the lake floor/samphire habitats, ten were restricted to woodland habitats. Three of them were not collected in the previous SAP survey. This indicates that further survey work is required to document the full salticid fauna of both the Wheatbelt and, in particular, the five salt lakes sampled during this study.

Two species of Lamponidae, *Lampona braemar* and *Longepi woodman* were found to be restricted to lake floor/samphire habitats in this survey; however both species have previously been collected from a variety of habitats over a broad geographical range (Platnick, 2000; Harvey *et al.*, 2004). Therefore the association with lake/samphire habitats suggested by the survey data presented here is probably an artefact of collecting.

Small web-builders and litter dwellers belonged to the families Amaurobiidae, Desidae, Linyphiidae, Liocrannidae, Micropholcommatidae, Oonopidae, Stiphidiidae, Tetragnathidae and Theridiidae. Of the 23 species found only in the floor/samphire habitats, 15 species (representing seven families) were previously collected during the SAP survey. Previous distributional data indicates that, of these species, only five were restricted to either samphire or valley floor sites (Harvey *et al.*, 2004). Moreover, only Genus 02 sp. 3 (Amaurobiidae) appeared to have a relatively restricted range regionally, being found in an area bounded by Darken, Dumbleyung and Wickepin. In contrast, *Corasoides* sp. 4 (Stiphidiidae), Genus 1 sp. 3, Genus 02 sp. 1 and Genus 05 sp. 1 (Theridiidae) were fairly widely dispersed across the wheatbelt (Harvey *et al.*, 2004).

Small web builders and litter dwelling families are normally found in woodland and forest environments (Main, 1976; Dippenaar-Schoeman and Jocqué, 1997) and their presence on the lake floor habitats may be artefacts of balloon dispersal. However, the lake floor surface morphologies are not entirely uniform, which may provide enough habitat variability for these species to establish, thereby accessing tourist insects.

Ants

Five species of ants were limited to the lake floors: *Anochetus armstrongi*, *Aphaenogaster* sp. 1, *Cerapachys princeps*, *Crematogaster frivola* and *Rhytidoponera* sp. 3. None of these species was found in large numbers, putting in doubt the validity of their absence from other habitats. *Anochetus armstrongi* has a broad range across the southern half of Australia and is found infrequently in the drier areas of the south west. Few, if any, workers of *Aphaenogaster* are seen beyond the entrance of the nest, which makes trapping data for this genus unreliable. Species of the genus *Cerapachys* are specialist predators of other ants (Shattuck, 1999). Their foraging behaviour has meant that specimens are rarely collected, and even then usually in small numbers. *Cerapachys* also occurs in South Australia.

Crematogaster workers are usually found in large numbers and are common throughout Australia, frequenting all habitats (Shattuck, 1999). *Crematogaster frivola* is found frequently in the south-west, both on the ground and in vegetation. The few specimens collected in this study were probably stray foraging workers. *Rhytidoponera* are extremely common general predators and scavengers with workers usually foraging singly or sometimes in small groups (Shattuck, 1999).

Scorpions

Endemic salt lake scorpions have been recorded in Australia; however, none of the species trapped in this survey are known as such. No evidence of burrowing was recorded on the lake floor of any of the sites but burrows were prevalent in samphire. Scorpion distributions in Australia are governed more by rainfall, temperature and biotic factors associated with competition and prey than by vegetation or soil types (Koch, 1981).

Dermaptera

Approximately 63 species of Dermaptera are known from Australia, with seven families represented. Owing to taxonomic uncertainties, unless more localities surrounding the five lakes are examined, few inferences can be drawn from the distributions of these taxa. However, it appears there are one or two taxa (species 3 and, to a lesser extent, species 1) that preferentially use lake floors, and one taxon with a distribution centred on woodland environments (species 2).

Isopods

Terrestrial isopods are moisture-dependant detritivores, with a limited capability for dispersal and high potential for speciation and extinction at the local population level (Judd and Horwitz, 2003). The distributions of the four isopod taxa collected (*Buddelundia* sp. 1, *B.* sp. 2, *Laevophiloscia* sp. 1 and *Acanthodillo* sp. 1) were centred on woodlands and samphire, and reflect distribution patterns found by Judd and Horwitz (2003). *Buddelundia* is widespread throughout Western Australia and has species associated with inland salt pans (Judd and Horwitz, 2003). However, further collection and taxonomic revision is required to establish both the wider distributions of the species reported here and the significance of the distribution patterns.

CONCLUSIONS AND RECOMMENDATIONS

The terrestrial invertebrate community associated with saline wetlands in the wheatbelt region comprised a mixture of widespread, regionally restricted and apparent short range endemic species in all three habitats sampled. The fauna collected from the inundation zone (lake floor and samphire habitats) varied between wetlands and was shown to be a distinct community, rather than a subset of that collected from the adjacent woodland. However, caution is required because lack of knowledge about the majority of species collected prevents us from determining how many are truly restricted to the inundation zone and how many are 'tourist' species.

The predictability and extent to which these lakes are naturally flooded is dependent upon the climatic regime: flooding is by no means rare although it is sporadic. Those species living within the inundation zone must have strategies that enable them to cope with flood events. However, human-induced changes to the flooding regime of these lakes, particularly permanent inundation, are likely to have a severe impact on the fauna. Quantifying the extent of impact requires more information about the ecology of the fauna, which can probably be gathered only after a better taxonomic base is established.

Where permanent flooding does occur as a result of drainage into a lake, its impact is likely to be minimised if a buffer zone of unflooded lake bed is left between the water's edge and the samphire. However, permanent water in the centre of the lake may still adversely affect dispersal across what would normally be a dry lake. Further study of the effects of prolonged flooding is required to determine (a) whether changes in community structure occur away from the edge of the lake towards the centre, (b) whether changes in soil chemistry associated with the extra salt load affect the burrowing fauna (lycosids, mygalomorphs, zodariids, ants and scorpions) which can be sensitive to chemical changes, and (c) to what extent permanent inundation impacts on the samphire vegetation around the lake.

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REFERENCES

Belbin, L. (1995). *PATN technical reference*. CSIRO, Canberra.

Brennan, K. (1999). Terrestrial invertebrates. *In* J.M. Osbourne and N.J. Dunlop (eds), *Baseline ecological study of Lake Lefroy*: 82–139. School of Environmental Biology, Curtin University of Technology, Perth.

Britton, E.B. (1990). Synopsis of the Australian Liparetrini (Coleoptera: Scarabaeidae: Melolonthinae). *Invertebrate Taxonomy* **4**: 159–195.

Carnaby, K. (1986). *Jewel beetles of Western Australia*. Keith Carnaby, Wilga, Western Australia.

Darlington, P.J. (1961). Australian carabid beetles. V. Transition of wet forest faunas from New Guinea to Tasmania. *Psyche Cambridge* **68**: 1–24

Davies, K.F. and Margules, C.R. (2000). The beetles at Wog Wog: a contribution of Coleoptera systematics to an ecological field experiment. *Invertebrate Taxonomy* **14**: 953–956.

De Deckker, P. (1988). Biological and sedimentary facies of Australian salt lakes. *Palaeogeography, Palaeoclimatology, Palaeoecology* **62**: 237–270.

Dippenaar-Schoeman, A.S. and Jocqué, R. (1997) *African spiders: an identification manual*. Handbook No. 9. Plant Protection Research Institute, Pretoria.

Doyen, J.T., Matthews, E.G. and Lawrence, J.F. (1990). Classification and annotated checklist of the Australian genera of Tenebrionidae (Coleoptera). *Invertebrate Taxonomy* **3**: 229–260.

Durrant, B. (2004) Biogeographical patterns of Zodariid spiders (Araneae: Zodariidae) in the wheatbelt region, Western Australia. *Records of the Western Australian Museum Supplement* **67**: 217–230.

George, R. and Coleman, M. (2002). Hidden menace or opportunity – groundwater hydrology, playas and commercial options for salinity in wheatbelt valleys. In V.A. Read (ed.), *Dealing with salinity in wheat belt valleys: processes, prospects and practical options*: 1–21. Water and Rivers Commission, Perth (Available on CD).

Guthrie, N.A. and Waldock, J.M. (2004). Patterns in the composition of the jumping spider (Arachnida: Araneae: Salticidae) assemblage from the Wheatbelt region, Western Australia. *Records of the Western Australian Museum Supplement* **67**: 203–216.

Halse, S.A. and McRae, J.M. (2004). New species of 'giant' ostracods (Crustacea: Cyprididae) from Australia. *Hydrobiologia* **524**: 1–52

Harvey, M.S., Waldock, J.M., Guthrie, N.A., Durrant, B.J. and McKenzie, N.L. (2004). Patterns in the composition in ground dwelling araneomorph spider communities in the Western Australian Wheatbelt. *Records of the Western Australian Museum Supplement* **67**: 257–291.

Hawkeswood, T. (1987). *Beetles of Australia*. Angus & Robertson, Sydney.

Houston, W.W.K. and Weir, T.A. (1992). Melolonthinae. *In* W.W.K Houston (ed.), *Zoological catalogue of Australia, vol. 9. Coleoptera: Scarabaeoidea*: 174–358. AGPS/CSIRO, Canberra.

Houston, W.W.K. (ed.) (1992). *Zoological Catalogue of Australia. Coleoptera: Scarabaeoidea*. AGPS/CSIRO, Canberra.

Hudson, P.J. (1995). Report on a survey of the terrestrial invertebrate fauna of Lake Lefroy. Unpublished report to Western Mining Corporation, Perth.

Hudson, P. (1996). New records of salt lake lycosids in Australia. *Australasian Arachnology* **51**: 4–5.

Hudson, P. (2000). First record of the salt lake spider, *Lycosa salifodina* McKay from Northern Territory, Australia. *Australasian Arachnology* **58**: 5–6.

Hudson, P.J. and Adams, M. (1996). Allozyme characterisation of the salt lake spiders (*Lycosa*: Lycosidae: Araneae) of southern Australia: systematic and population genetic implications. *Australian Journal of Zoology* **44**: 535–567.

Judd, S. and Horwitz, P. (2003). Diversity and biogeography of terrestrial isopods (Crustacea: Oniscidea) from south-western Australia: organic matter and matter and microhabitat utilisation in seasonally dry landscapes. *Crustaceana Monographs* **2**: 191–215.

Koch, L.E. (1977a). The biology and burrow of a salt lake wolf spider. *Western Australian Naturalist* **13**: 204.

Koch, L.E. (1981). The scorpions of Australia: aspects of their ecology and zoogeography. *In* A. Keast (ed), *Ecological biogeography of Australia*: 873–884. Dr W. Junk, The Hague.

Lawrence, J.F. and Britton, E.S. (1994). *Australian beetles*. Melbourne University Press, Melbourne.

Lyons, M.N., Gibson, N., Keighery, G.J. and Lyons, S.D. (2004). Wetland flora and vegetation of the wheatbelt of southwestern Australia. *Records of the Western Australian Museum Supplement* **67**: 39–89.

Magura, T., Tothmeresz, B. and Elek, Z. (2003). Diversity and composition of carabids during a forestry cycle. *Biodiversity and Conservation* **12**: 73–85.

Main, B.Y. (1976). *Spiders*. Collins, Sydney.

Main, B.Y. (1981). Australian spiders: Diversity, distribution and ecology. *In* A. Keast. (ed), *Ecological biogeography of Australia*: 809–852. Dr W. Junk, The Hague.

Main, B.Y. (2000). Habitat template for invertebrates on granite outcrops. *Journal of the Royal Society of Western Australia.* **83**:139–167.

Main. B.Y. (1996). Microcosmic biogeography: trapdoor spiders in a time warp at Durokoppin. *In* S.D. Hopper, J.A. Chappill, M.S. Harvey and A.S. George (eds), *Gondwanan Heritage: past, present and future of the Western Australian biota*: 163–171. Surrey Beatty & Sons, Sydney.

Margules, C.R. (1992). The Wog Wog habitat fragmentation experiment. *Environmental Conservation* **19** (4): 316–326.

Matthews, E.G. (1980). *A guide to the genera of beetles of South Australia. Part 1. Archostemata and Adephaga.* Special Educational Bulletin Series No. 3. South Australian Museum, Adelaide.

Matthews, E.G. (1982). *A guide to the genera of beetles of South Australia. Part 2. Polyphaga: Staphylinoidea and Hydrophiloidea.* Special Educational Bulletin Series No. 4. South Australian Museum, Adelaide.

Matthews, E.G. (1984). *A guide to the genera of beetles of South Australia. Part 3. Polyphaga: Eucinetoidea, Dascilloidea and Scarabaeoidea.* Special Educational Bulletin Series No. 6. South Australian Museum, Adelaide.

Matthews, E.G. (1985). *A guide to the genera of beetles of South Australia. Part 4. Polyphaga: Byrrhoidea, Buprestoidea, Dryopoidea, Elateroidea, Cantharoidea, Derodontoidea and Bostrichoidea.* Special Educational Bulletin Series No. 7. South Australian Museum, Adelaide.

Matthews, E.G. (1987). *A guide to the genera of beetles of South Australia. Part 5. Polyphaga: Tenebrionoidea.* Special Educational Bulletin Series No. 8. South Australian Museum, Adelaide.

Matthews, E.G. (1992). *A guide to the genera of beetles of South Australia. Part 6. Polyphaga: Lymexyloidea, Cleroidea and Cucujoidea.* Special Educational Bulletin Series No. 9. South Australian Museum, Adelaide.

Matthews, E.G. (1997). *A guide to the genera of beetles of South Australia. Part 7. Polyphaga: Chrysomeloidea: Cerambycidae.* Special Educational Bulletin Series No. 10. South Australian Museum, Adelaide.

Matthews, E.G. and Reid, C.A.M. (2002). *A guide to the genera of beetles of South Australia. Part 8. Polyphaga: Chrysomeloidea: Chrysomelidae.* Special Educational Bulletin Series No. 11. South Australian Museum, Adelaide.

McKay, R. J. (1976). The wolf spiders of Australia (Araneae: Lycosidae): 8. Two new species inhabiting salt lakes of Western Australia. *Memoirs of the Queensland Museum* **17**: 417–423.

McKay, R.J. (1979). The wolf spiders of Australia (Araneae: Lycosidae): 12. Descriptions of some Western Australian species. *Memoirs of the Queensland Museum.* **19**: 241–275.

McKenzie, M.L., Burbidge, A.H. and Rolfe, J.K. (2003). Effect of salinity on small, ground-dwelling animals in the Western Australian wheatbelt. *Australian Journal of Botany* **51**: 725–740.

Michaels, K. (1999). Carabid beetles (Coleoptera: Carabidae) communities in Tasmania: classification for nature conservation. *In* Ponder, W. and D. Lunney (eds), *The other 99%.The conservation and biodiversity of invertebrates*: 374–379. Surrey Beatty & Sons, Sydney.

Moore, B.P., Weir, T.A. and Pyke, J.E. (1987). Rhysodidae and Carabidae. *In* D.W. Walton (ed.), *Zoological Catalogue of Australia, vol. 4. Coleoptera*: 20–320. AGPS/ CSIRO, Canberra.

Mulcahy, M.J. (1978). Salinisation in the southwest of Western Australia. *Search* **9**: 269–72.

Niemelä, J.K. and Spence, J.R. (1994). Distribution of forest dwelling Carabidae (Coleoptera): spatial scale and the concept of communities. *Ecography* **17**: 166–175.

NLWRA (2001). *Australian dryland salinity assessment 2000: extent, impacts, processes, monitoring and management options.* National Land and Water Resources Audit, Canberra.

Pearson, D.L. and Vogler, A.P. (2001). *Tiger beetles. The evolution, ecology, and diversity of the Cicindelids.* Cornell University Press, Ithaca.

Petit, S. and Usher, M.B. (1998). Biodiversity in agricultural landscapes: the ground beetle communities of woody uncultivated habitats. *Biodiversity and Conservation* 7:1549–1561.

Pinder, A.M., Halse, S.A., Shiel, R.J. Cale, D.C. and McRae, J.M. (2002). Halophile aquatic invertebrates in the wheatbelt region of south-western Australia. *Verhandlungen Internationale Vereinigung Limnologie* **28**: 1687–1694.

Pinder, A.M., Halse, S.A., McRae, J.M. and Shiel, R.J. (2004). Aquatic invertebrate assemblages of wetlands and rivers in the wheatbelt region of Western Australia. *Records of the Western Australian Museum Supplement* **67**: 7–37.

Platnick, N.I. (2000). A relimitation and revision of the Australasian ground spider family Lamponidae (Araneae: Gnaphosoidea). *Bulletin of the American Museum of Natural History* **245**:1–330.

Rentz, D.C.F. and Kevan, D.K.McE. (1991). Dermaptera. *In* I.D. Naumann *et al.* (eds), *The insects of Australia, 2nd edn*: 360–368. Melbourne University Press, Melbourne.

Robinson, J.V. (1981). The effect of architectural variation in habitat on a spider community: an experimental field study. *Ecology* **62**:73–80.

Shattuck, S.O. (1999). *Australian ants: their biology and identification.* CSIRO, Melbourne.

Sneath, P.H.A. and Sokal, R.R. (1973). *Numerical taxonomy: the principles and practice of numerical classification.* Freeman, San Francisco.

Sumlin, W.D. (1997). Studies on the Australian Cicindelidae XII: Additions to *Megacephala, Nickerlea* and *Cicindela* with notes (Coleoptera). *Cicindelidae: Bulletin of Worldwide Research* **4**: 1–56.

Thackway, R. and Cresswell., I.D. (eds) (1995). *An interim biogeographic regionalisation for Australia: a framework for setting priorities in the National Reserves System Cooperative Program, version 4.0.* Australian Nature Conservation Agency, Canberra.

Watts, C.H.S. (1987). Revision of the Australian *Berosus*

Leach (Coleoptera: Hydrophilidae). *Records of the South Australian Museum* **21**: 1–28.

Żabka, M. (1990). Salticidae (Arachnida: Araneae) of Oriental, Australian and Pacific Regions, IV. Genus *Ocrisiona* Simon, 1901. *Records of the Australian Museum* **42**: 27–43.

Żabka, M. (1999). Salticidae (Arachnida, Araneae) of islands off Australia. *Journal of Arachnology* **27**: 229–235.

Żabka, M. (2001). Salticidae (Arachnida: Araneae) from the Oriental, Australian and Pacific regions, XIV. The genus *Adoxotoma* Simon. *Records of the Western Australian Museum* **20**: 323–332.

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