Assessment of the nature conservation values of the Byenup-Muir peat swamp system, southwestern Australia: physico-chemistry, aquatic macroinvertebrates and fishes.

Report prepared for

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by

A.W. Storey
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The views and opinions expressed in this report are those of the author and do not necessarily reflect those of the Executive Director of the Western Australian Department of Conservation and Land Management

Front cover: Noobijup Swamp, showing cover of *Baumea articulata* and margin of *Melaleuca* spp. (photo – Andrew Storey, January 1997)

1 Executive Summary

The Byenup-Muir wetlands form the most outstanding peat swamp system in southwestern Australia. There are seventeen named and many more un-named wetlands in the area, and the area contains Tordit-Gurrup Lagoon, the largest permanent freshwater wetland in southwestern Australia. The majority of wetlands are within nature conservation reserves and are in pristine or near-pristine condition. The system is included in *A Directory of Important Wetlands in Australia* and qualifies for Ramsar site nomination.

Land clearance is resulting in rising saline water tables causing secondary salination, with salt scalds appearing and salt loads in some wetlands increasing. Local landholders are concerned by this trend and there is mounting pressure to initiate drainage works to redirect and hasten surface flows. Proposed schemes, as well as the general rise in the water table have the potential to impact some of the most significant peat swamps. In response to this, the area has been nominated a Recovery Catchment under the State's Salinity Action Plan.

To assist with interpreting the potential impacts of a regional rise in the saline water table and proposed drainage schemes on the nature conservation values of the wetlands, the current study was initiated to:

- Review existing knowledge of the aquatic invertebrate and fish faunas, water chemistry and hydrology of wetlands in the Muir and Unicup catchments, and,
- Conduct extensive, seasonal surveys of aquatic invertebrate and fish faunas and physico-chemistry of wetlands and use the data to assess the conservation significance of the wetlands with respect to the aquatic fauna, relate the occurrence of the fauna to chemical, hydrological and other characteristics of the wetlands, and assess the likely impacts on the fauna of changes in water regime, salinities and nutrients.

Hydrology, geology and geomorphology of the area recently have been reviewed and, although complex, are relatively well understood. There is a slight gradient of increasing groundwater salinity from south to north reflecting the opposing gradients in rainfall and evaporation. There are three main water types: Main Groundwater (4 to 16ppt), Perched Groundwater (fresh) and Surface Drainage water (fresh, except where draining saline land or the course is incised into the saline Main Groundwater). In the wetlands, water levels increase rapidly with the onset of winter rains and are then maintained by a rise in groundwater levels in spring. Thereafter, drainage and evaporation reduce the amount of surface water and wetlands start to recede; salinities will increase if there is any salt to concentrate. Wetlands in direct contact with the Main Groundwater will be saline, although precipitation may reduce the salinity in winter. Wetlands on Perched Groundwater will tend to be fresh in the south of the catchment where precipitation is higher and evaporation lower, but perched wetlands in the north, where the net annual effect is salt concentration, will gradually become saline.

Previous studies of water quality in the area have tended to concentrate on measuring salinity, although there have been several studies that have also measured nutrients. These tended either to be at a few wetlands in the catchments or to be in association with broadscale surveys of aquatic macroinvertebrate and/or fish communities across larger parts of southwestern Australia.

The current study initially chose 15 basin-type wetlands for sampling in October 1996, January and May 1997, selected to provide good coverage of the study area and to represent the broad range of wetland types and states present.

- naturally saline, as a mark against which secondary salination of freshwater wetlands could be assessed,
- permanently inundated,
- seasonally inundated,
- dominated by *Baumea articulata*,
- dominated by emergent *Melaleuca* trees,
- currently receiving land drainage,
- adjacent to cleared land and/or in the path of future land drainage, and
- well buffered by reserve or state forest.

Subsequently 12 additional sites, predominantly seasonally inundated heathland-type wetlands were sampled in May and October 1997.

A seasonal cycle of increasing salt and nutrient levels as wetlands receded in summer and autumn was apparent. Some wetlands were showing the early stages of secondary salination, with increasing salt levels (up to 5 ppt) and declining quality of vegetation, especially *Baumea articulata*, the dominant emergent. On the basis of nitrogen levels, the majority of wetlands classified as eutrophic / hyper-eutrophic. The nitrogen was most likely released from the thick peat layers accumulated in the wetlands. Phosphorus levels were still relatively low and algal blooms were not evident. It is likely that the wetlands are phosphorus-limited, and increased phosphorus availability (e.g. from fertilisers) would likely result in a rapid decline in water quality.

A total of 219 taxa of aquatic macroinvertebrates were recorded during the study. Of these, 61 taxa (~ 27%) occurred on only one occasion, and only 13 taxa occurred in greater than 50% of all samples (n=61). Mean number of macroinvertebrate taxa at each wetland on any sampling occasion generally was greater than previous studies of wetlands in southwestern Australia. Highest species richness was recorded from two wetlands suffering from increased inundation, but which still were fresh. This may have been due to greater (but transient) diversity of habitat (e.g. dead and dying inundated *Banksia* and *Melaleuca*, a margin of emergent reeds/rushes, some aquatic macrophyte and open water). The current study did not consider microinvertebrates. The taxa lists for these wetlands will likely be much increased when the microinvertebrate component is included.

Thirty-two taxa endemic to the southwest and 7 locally endemic taxa were recorded. Eleven swamps had 10 or more southwest endemic taxa, with the greatest recorded from Poorginup Swamp (16), Loc. 12767 (15) and Yarnup (15). Generally, there were few locally-endemic species recorded in this study (maximum of 4 from Mulgarnup Swamp); 8 sites contained two locally endemic species and 13 sites contained one. The most common locally endemic species were the ceinid amphipod *Austrochiltonia* sp.2 (at 15 sites), which appears to be a new species, and the new dytiscid beetle *Sternopriscus* sp. nov (at 13 sites). Assessing levels of endemism at each site should be repeated once the microinvertebrate components have been identified.

Possible salinity tolerances of each species of macroinvertebrate were investigated. The majority of taxa (207) did not respond to the salinity range in wetlands sampled. Eight taxa decreased in abundance and 10 taxa increased in abundance with increasing salinity. Possible reasons for the lack in response included a.) the limited range in salinities sampled in the current study (i.e. under-representation of wetlands with high (> 20 ppt) salinities), b.) the exclusion of microcrustacea which tend to hold taxa tolerant of high salinities, c.) the presence of freshwater seeps in many of the saline wetlands at which taxa restricted from the main body of a saline wetland may survive, and d.) aquatic macroinvertebrate species in parts of the southwest of Western Australia may be adapted to higher than expected salinity due to historical exposure to saline groundwater.

Seven species of fish were recorded, with a maximum of six from one site and five from three other sites. Black-Stripe Minnow (*Galaxiella nigrostriata)* and Mud Minnow (*G. munda)* were the most infrequently encountered species, found at two sites, and Balston's Pygmy Perch (*Nannatherina balstoni)* was the next rarest species, found only at four sites. All three species are very scarce, with distributions restricted to the southwestern coastal area of Western Australia. The only introduced species was the Mosquito fish (*Gambusia holbrooki)* which was present at the majority of sites. Other species encountered, Western Pygmy Perch (*Edelia vittata),* Western Minnow *(Galaxias occidentalis)* and Nightfish (*Bostockia porosa)* were all relatively common in the study area, and although endemic to southwestern Western Australia, are widely distributed and relatively common.

Implications for increasing salinity on macroinvertebrate and fish faunas are discussed, both from direct effects and indirect effects as a result of changes in habitat structure, especially the possible loss of *Baumea articulata.*

Effects and management implications of eleven potential threats to the nature conservation values of the wetlands are discussed:

- Catchment clearing
- Increased salinity
- Increased inundation
- Reduced inundation
- Invasion by exotic species
- Fire
- Nutrient enrichment
- Drains
- Riparian buffer clearing
- Stock access for water/grazing
- Mining

2 Introduction

2.1 Project background

The Byenup-Muir system is located in the southwest of Western Australia, approximately 50 km east of Manjimup, which is 300 km southeast of Perth. It is the most outstanding peat swamp system in southwestern Australia. The system satisfied seven of the eight criteria used to identify sites for inclusion in ANCA's *A Directory of Important Wetlands in Australia* (ANCA, 1996). There are seventeen named wetlands within the system and many more un-named. Tordit-Gurrup Lagoon (690 ha) is the largest permanent freshwater wetland in the southwest. The majority of the wetlands are within nature conservation reserves and are in pristine or near-pristine condition. Some of the reserves adjoin State Forest, however most are surrounded by farmland. The system qualifies for Ramsar site nomination.

Regional water tables are rising due to clearing of native vegetation for farmland. Some salt seeps have appeared in the catchment and some streams are rising in salinity. Private land holders are concerned by this trend and wish to take action to a.) alleviate immediate problems and b.) reverse the trend. In the short term there is mounting pressure to permit drainage works and redirect and hasten surface flows. Proposals being contemplated may adversely alter water regimes and salinities of some of the most significant peat swamps. Even if no drainage is undertaken, the ecological character of these wetlands may deteriorate if action is not taken to restore the hydrological balance of the landscape.

The potential impacts of regional water table rise and proposed drainage works on the nature conservation values of the Byenup-Muir wetlands cannot be assessed without proper understanding of a.) those values and b) the physico-chemical tolerances of the aquatic biota. Current knowledge of the biota is limited to coarse descriptions of the emergent vegetation of a few of the swamps and limited studies of invertebrates, fish and waterbirds.

Therefore, in 1996 the Western Australian Department of Conservation and Land Management secured funding from the National Wetlands Program, Australian Nature Conservation Agency (now Biodiversity Group, Environment Australia) to 'Assess the nature conservation values and physico-chemistry of the Byenup-Muir peat swamp system'. Under this funding, three subprojects were planned:

- Review existing knowledge and undertake surveys of avian fauna,
- Review existing knowledge and undertake surveys of aquatic invertebrate and fish faunas and of the physico-chemistry, and,
- Review existing knowledge and undertake surveys of aquatic, emergent and fringing vegetation

2.2 Project aims

This report presents the background information, methods, results and preliminary assessments of the conservation significance and management implications with respect to the aquatic invertebrate and fish faunas and physico-chemistry of a representative sample of wetlands from the system. Specifically, the report reviews existing knowledge of the aquatic invertebrate and fish faunas, water chemistry and hydrology of wetlands in the Muir and Unicup catchments. Data derived from field sampling of aquatic invertebrate and fish faunas and physico-chemistry are then used to assess the conservation significance of the wetlands with respect to the aquatic fauna, relate the occurrence of the fauna to chemical, hydrological and other characteristics of the wetlands, and assess the likely impacts on the fauna of changes in water regime, salinities and nutrients.

2.3 Review of existing knowledge of hydrology and water chemistry

2.3.1 Hydrology

Hydrology, as well as geology and geomorphology of the Muir and Unicup catchments has recently been reviewed in the draft management plan for nature reserves in these areas (CALM, 1998). Information in the draft management plan is supported by additional information on geology, geomorphology and hydrology in Semeniuk & Semeniuk (1996) and AgWA (unpub. data). Geology and geomorphology have a strong influence on catchment hydrology and therefore all are here summarised.

In broad terms, the catchments lie within the Darling Plateau and the Ravensthorpe Ramp, which are the two main regional mega-scale geomorphic units of the area. The geology, through the varied rock and sediment types, aquifer properties and Precambrian structures such as faults, folds, shears, dykes, joints etc have an influence of the hydrology of the area by affecting development of aquifers, seepage points, discharge zones, perching patterns, drainage patterns etc (Semeniuk & Semeniuk, 1996). The main primary subdivision of geological material in the area is Precambrian bedrock and Cenozoic (regolith) material. The main units of Precambrian bedrock are the Yilgarn Craton and the Albany-Fraser Orogen. The former consists of Archean rocks (granite, granitoid and gneiss) and Proterozoic dolerite dykes and the latter consists of a variety of Proterozoic granites and gneisses. The Yilgarn Craton and Albany-Fraser Orogen contact along an east-west oriented interface (the Manjimup Lineament and the Pemberton Lineament). The predominant metamorphic trends in both rock types are east-west. The Precambrian materials are altered to saprolite (chemically rotted bedrock), and overlain by laterite and yellow to grey sand which are Cenozoic in age.

Two aspects of the geology have an effect on the geomorphology and hydrology of the area. These are the deep weathering of the Precambrian rock to produce saprolite which acts to perch wetlands, and the Manjimup and Pemberton Lineaments which may have influenced the development and location of the Jarrahwood Axis upward flexure which influences the deposition and style of drainage.

The overlying Cenozoic materials of Tertiary, Pleistocene and Holocene ages, which form sheets of laterite and various sands, initially appeared to be a Tertiary alluvial flat, but have been interpreted by Semeniuk & Semeniuk (1996) to be a large excavation basin related to arid zone weathering and erosion.

Within the two main regional mega-scale geomorphic units of the Darling Plateau and the Ravensthorpe Ramp, the area consists of four units: High Plateau, Old Basin, Young Basin and Young Rivers. The High Plateau is situated at > 200 m AHD and equates to the Darling Plateau. It is the oldest landsurface in the region and consists of an undulating landscape, composed of plains, shallow drainage lines, interconnected basins and drainage lines, and scattered round wetlands. The Old Basin lies at approximately 180 to 200 m AHD, is bordered peripherally by the High Plateau and is the older of two such structures. The Young Basin is located at approximately 160 m AHD and is bordered to the west by the High Plateau and on all other sides by the Old Basin. Its floor is flat and its margins are commonly cut into bedrock, saprolite and laterite. The Young Rivers are the incised drainage lines cut into the above three features. They are weakly meandering to straight channels with dendritic tributary channels. The main channels are incised into the High

Plateau by approximately 3 – 6 m, exposing bedrock, saprolite, laterite and other Cenozoic materials. The tributaries are broad and shallow; varying to steeply incised channels.

As well as geology and geomorphology, climate also affects hydrology through its effects on landform, precipitation, evaporation, water salinity and vegetation. Rainfall influences groundwater aquifer recharge and maintains wetlands through direct precipitation. Evaporation influences wetlands in the short term through seasonal changes in salinity, and in the long term through increasing groundwater salinity as evaporation exceeds precipitation. The catchments have a Mediterranean climate with approximately 900 mm rainfall per annum in the south, decreasing to approximately 700 mm towards the north. Rainfall is seasonal, the majority falling between May and October. Annual evaporation, which exceeds rainfall, increases from approximately 1400 mm in the south to 1600 mm in the north. There is also a slight gradient of increasing groundwater salinity from south to north reflecting the opposing gradients in rainfall and evaporation.

Hydrologically, the area consists of three main water types: Main Groundwater, Perched Groundwater and Surface Drainage water. The Main Groundwater is regionally inclined, located at 180 m AHD in the south to 220 m AHD in the north. Lake Muir and Unicup Lake are surface expressions (windows) of this main groundwater. Salinity of the Main Groundwater generally varies from approx. 4 ppt to 16 ppt, although locally it may be fresher (e.g. bores north of the Muirs Hwy produce fresh water (< 1.0 ppt) that is suitable for irrigation). The fresher groundwater is primarily located in recharge areas situated in the upper catchment, whereas the more saline water occurs in valleys and depressions underlain by shallow basement rock. The Perched Groundwater is of various heights depending upon the perching mechanism. Some is perched due to the relatively impermeable saprolite, and other perching is due to laterite, ferricrete in wetlands, and wetland fill deposits such as clay and peat. Perched aquifers are normally fresh and generally occur as saturated sand layers of aeolian and fluvial origin, which overlie impermeable clay layers. The Surface Drainage is derived from runoff of precipitation or from emergent springs, which are channelled into the creeks and rivers. Generally the Surface Drainage is fresh, except either where it is draining saline land upslope or the channels are incised to the underlying saline Main Groundwater.

Recharge of water into wetlands may be the result of direct precipitation (e.g. rainfall into clay-floored or peat-floored wetlands that have a perched groundwater), water table rise within an unconfined aquifer, local discharge from springs, or surface run-off into wetlands. Generally, seasonal rainfall determines water levels in the wetlands and variability in wetland salinity. Water levels increase rapidly with the onset of winter rains and are then maintained by a rise in groundwater levels in spring. Thereafter, drainage and evaporation reduce the amount of surface water, and wetlands start to recede and salinities increase as any salt is concentrated.

Generally, wetlands in direct contact with the Main Groundwater will be saline all year, although precipitation may reduce the salinity in winter and spring, but the longterm process of evaporation will tend to concentrate salt. Wetlands based on Perched Groundwater will tend to be fresh in the south of the catchment where precipitation is relatively higher and evaporation lower, as opposed to perched wetlands in the north of the catchment, where the net annual effect is salt concentration, leading to gradual salination. Wetlands that are part of a chain, and receive freshwater inputs, will remain fresh if salt loads are flushed into the downstream parts of the chain. Conversely, wetlands that receive Surface Drainage from saline land or via channels incised into the underlying saline Main Groundwater will progressively accumulate salt.

Historical stability in water quality in wetlands may be determined from vegetation structure in the wetlands. Semeniuk & Semeniuk (1996) identified nine broad vegetation assemblages in the wetlands of the Muir/Unicup area, with each assemblage indicating a certain salinity level:

Vegetation assemblage	Water salinity
Melaleuca rhaphiophylla	fresh
Baumea articulata	fresh
Astartea fascicularis	fresh
Agonis/Pericalymma	fresh
Melaleuca preissiana	fresh
Melaleuca hamulosa	fresh changing to brackish
Melaleuca cuticularis/hamulosa mix	fresh changing to brackish
Melaleuca cuticularis	brackish to saline
Halosarcia (samphire)	saline

Most of the assemblages indicate freshwater in the wetlands, however, the mixed *Melaleuca cuticularis* and *M. hamulosa* assemblages indicate wetlands which start off fresh in spring but progress to brackish in summer, and the *M. cuticularis* and *Halosarcia* assemblages indicate wetlands permanently brackish to saline. Semeniuk & Semeniuk (1996) noted that the majority of wetlands had stable vegetation structure, with no indications of changing conditions (e.g. dead or stressed assemblages). Stable conditions applied to both freshwater and naturally saline wetlands. However, there were wetlands where key vegetation indicators had died, suggesting a relatively recent change in water salinity. Examples from Semeniuk & Semeniuk (1996) included a drainage line north of Lake Noobijup, a sumpland north of Red Lake and the northern shore of Byenup Lagoon.

Semeniuk & Semeniuk (1996) identified four anthropogenic and two natural processes by which wetlands in the area are or become saline:

1. Land clearing proximal to a wetland, and a consequent reduction in transpiration losses, leading to a rise in the saline Main groundwater table, which under the effects of evaporation within a near-surface zone of capillary rise leads to land salination.
2. Land clearing leading to salts accumulating in the upper parts of the vadose zone, which leads to salt mobilisation in surface drainage under the effects of increased run-off and seepage via spring.
3. Increased salinity in areas distal to wetlands due to land clearing, resulting in export of salt to the wetland via surface drainage.
4. Artificial drainage of salt-affected areas into wetlands.
5. Evaporation of perched wetland groundwater systems, through gradual input of salts from precipitation and concentration of these salts by evaporation and transpiration. Generally, more prevalent in the northern parts where there is lower rainfall and higher evaporation.
6. Evaporation of large wetland basin surface areas where the wetland is a window to the underlying brackish/saline Main Groundwater.

Solutions to the anthropogenic causes of salination (#1 – 4 above) include the longer-term replanting of vegetation and the ‘quick-fix’, but usually temporary solution of land drainage. Currently, the use of drains is relatively common, especially on private farmland. There is one instance where a large drain has been constructed through a nature reserve. The drain was constructed in 1993 following a proposal from the Unicup Landcare Group to drain saline water from the Mordalup Lakes, south and then west, through the Kodjinup Nature Reserve and into the already saline Tone River (the application to construct this drain through a nature reserve was approved by the National Parks and Nature Conservation Authority, in whom the reserve is vested). There are other instances where natural drainage lines and seeps discharge directly into nature reserves containing fresh water wetlands (e.g. west and south side of Noobijup Swamp, southwest of Yarnup Swamp and west side of Cobertup Swamp), and where natural drainage lines have been artificially improved to assist drainage into wetlands (e.g. drainage south, across Muirs Hwy and into the Mulgarnup Swamp area, and the lower end of Noobijup Creek into Geordinup Swamp).

The usage of drains within the Muir and Unicup catchments will likely increase as land salination worsens. For example, in 1993 Agriculture Western Australia (AgWA), on behalf of Unicup Landcare Group prepared a drainage proposal for the Lake Unicup catchment. This proposal was initiated following concerns over the potential loss of extensive areas of the lower Lake Unicup Catchment (Kulunilup Creek) to waterlogging, salinity and vegetation decline following extensive clearing, in particular, of the upper catchment. The drainage scheme basically consisted of improving artificial and natural drainage lines across the northern end of the Unicup Nature Reserve to assist the flow of surface water in a westerly direction into the Tone River. A more recent suggestion has been the diversion of the now saline Noobijup Creek to the southeast and across the catchment boundary into the saline Frankland River, and so away from the Geordinup-Neeranup-Byenup chain of wetlands which is becoming increasingly saline.

2.3.2 Water chemistry

There has been quite extensive, but mostly uncoordinated monitoring of surface water quality in the catchments, generally in association with various drainage schemes:

- In May 1986 the Department of Industrial Development undertook the Unicup Hydrological Study (Passmore, 1986). Part of this study was comparing salinity data from May 1986 with data collected in 1979/1980 for Kulunilup, Bokarup, Noobijup, Pindicup, Muir, Red, Kodjinup, Buranganup, Unicup, Tolkerlup, West Tolkerlup wetlands and wetlands at Locs. 13031 (drain), 12660, 12682, 12686, 12640, 12639, 12634 and 12674.
- AgWA have monitored the Mordalup Lakes and Kodjinup Swamp since 1991.

- The Unicup Landcare Group has recently commenced monitoring of Noobijup Creek and two other creeks flowing into the Lake Muir system.
- AgWA presented water quality data for Kulunilup Creek, collected by the then Water Authority of Western Australia as part of the Lake Unicup Catchment Drainage Proposal.
- An EM38 survey of salinity of Pindicup Creek was undertaken in September/November 1994.
- In September 1996, the Water & Rivers Commission initiated the Lake Muir/Unicup Nature Reserves Inflow Study which involves sampling discharge (m^3 sec^{-1}) and salinity (as conductivity $mS\ m^{-1}$) at all points of inflow (n= 20) to Lake Muir.

Generally, all these projects have concentrated on salinity, as the main element of concern. An exception was the survey of salinity, nitrogen and phosphorus levels in several creeks and bores in the Unicup catchment in the winter of 1996 by AgWA. Several other studies in the catchments have collected a more extensive range of water quality parameters.

The Western Australian Department of Conservation and Land Management has been monitoring depth, salinity, pH and total phosphorus from Muir, Byenup, Tordit-Gurrup, Poorginup, Unicup, Yarnup and Red Lake wetlands for varying periods since the 1970's. This program recorded a sudden and, as yet unexplained increase in depth and pH and a decrease in salinity in Lake Unicup in the late 1980s. Allowing for between-year differences in rainfall (which affect water depth and therefore salinity), depth, pH and salinity have been fairly consistent at most of the other wetlands monitored over this period, with Yarnup Swamp being a notable exception (water salinity has increased and salt scalds are present to the south and southwest of the wetland).

DeHaan (1987) measured depth, salinity, pH, temperature, dissolved oxygen, chlorophyll-a, nitrogen and phosphorus in Poorginup Swamp and Tordit-Gurrup and Byenup Lagoons in late 1985 and mid 1986. Salinity in Poorginup Swamp ranged from 0.1 to 1.0 ppt, in Tordit-Gurrup from 0.8 to 2.7 ppt and in Byenup from 2.5 to 7.0 ppt. Concentrations were dependent upon water levels and season. Tordit-Gurrup and Byenup Lagoons were slightly alkaline (pH 7.0 to 9.0), whereas Poorginup was acidic (pH 5.0 to 6.6). Chlorophyll-a levels were relatively low in all wetlands, as was phosphorus, with Byenup and Tordit-

Gurrup Lagoons classifying as meso-eutrophic on this basis. However, nitrogen levels were elevated, possibly due to release from decomposing peat, and the wetlands classified as eutrophic to hyper-eutrophic, although in reality, neither Byenup nor Tordit-Gurrup Lagoons behaved as eutrophic wetlands.

Finally, Horwitz (1994) as part of a survey of aquatic invertebrates at 45 wetlands across the southern region of southwestern Australia, which were sampled quarterly throughout 1993 and early 1994, recorded conductivity, pH, redox potential, temperature, chlorophyll-a, gilvin, orthophosphate and total phosphorus at each wetland. The study included four sites in the Muir/Unicup catchments (Poorginup swamp, Lake Unicup, a Teatree swamp off Thompsons Road and low shrubland off Boyndiminup Road). Water quality data were not reported for each wetland, but may be available from the author upon request.

In addition to the above-listed surface water monitoring programs, AgWA installed 50 bores in the Muir/Unicup catchments in April and May 1995, recording water salinities, depths attained, and sediment types encountered. Salinities ranged from approximately 0.1 ppt to 40 ppt, with the majority of the bores having a salinity of approximately 7 ppt.

2.4 Review of existing knowledge of aquatic invertebrate and fish faunas

2.4.1 Aquatic invertebrate fauna

There have been comprehensive surveys of the aquatic invertebrate fauna of wetlands in various parts of southwestern Australia (e.g. Kemerton wetlands (Bunn, 1983), wetlands on the Swan Coastal Plain (Davis & Rolls, 1987; Davis *et al.*, 1993), southern acid peat flats (Pusey & Edward, 1990a), wetlands of the Two Peoples Bay Nature Reserve (Storey *et al.*, 1993), South Coast wetlands (Edward *et al.*, 1994), wetlands in the Perth Airport grounds (Halse & Storey, 1996), and wetlands in the Ellen Brook and Twin Swamps Nature Reserves (Stuart Halse, WA Dept. CALM, unpub. dat.)), however, there have been few studies of aquatic invertebrates in the Muir and Unicup catchments.

One of the earliest studies was by DeHaan (1987), who intensively sampled Poorginup, Tordit-Gurrup, Byenup and Cowerup wetlands in relation to a proposal to extract peat from Tordit-Gurrup Lagoon. Subsequently, Horwitz (1994) included the Muir catchment in a broad-scale survey of aquatic invertebrates in the southern peatlands and shrublands of WA as part of a study of endemism in the fauna (Horwitz, 1994), Darren Ryder (Edith

Cowan University, unpub. dat.) is currently studying the origin and fate of organic matter in Bokerup, east Kodjinup and Noobijup wetlands, and has sampled the aquatic invertebrates of these wetlands as part of this project, and there have been small collections of aquatic invertebrates from the catchments by the WA Museum (Harvey 1987, 1996 (cited CALM, 1998)).

DeHaan (1987) sampled aquatic invertebrates (and water chemistry; see section 1.3.2. above) by coring and sweep sampling (250µm mesh aperture) in December 1985 and April 1986 and used these data to speculate on the possible effects of a proposal to mine peat on aquatic invertebrate communities. A total of 103 taxa were recorded from the four wetlands, including 7 taxa of microcrustacea (Cladocera, 1 taxon; Ostracoda 5 species; and Copepoda 1 taxon). Ninety-seven taxa were recorded from the wetland suite consisting of Tordit-Gurrup Lagoon (52 taxa), Byenup Lagoon (43 taxa) and Poorginup Swamp (39 taxa) (NB Poorginup was not sampled as intensively as the other two sites and this may account for the lower species richness). Within each site, DeHaan (1987) reported seasonal differences in species composition and in richness. Tordit-Gurrup Lagoon declined from approx. 52 taxa in December 1985 to 28 taxa in April 1986, and Byenup Lagoon decreased from 40 to 10 taxa. At that time, DeHaan (op. cit.) considered taxa richness in these wetlands to be higher than any other freshwater wetlands in southwestern Australia. Three species of water-mite were recorded from Poorginup Swamp which were of particular interest because of their restricted distribution, and sediments from Tordit-Gurrup and Poorginup wetlands were carbon dated to 5270 ± 320 and 8300 ± 500 years BP.

Horwitz (1994) sampled 45 wetlands across the southern region of southwestern Australia, with sites sampled each season (quarterly) throughout 1993 and early 1994. Four sites were sampled in the Muir/Unicup catchments (Poorginup swamp, Lake Unicup, a Teatree swamp off Thompsons Road and low shrubland off Boyndiminup Road). Interstitial fauna was sampled from an auger hole, pholeteros (burrow fauna) by flushing crayfish burrows, and aquatic fauna by sweep samples of surface waters with a 125 µm net. Microcrustacea were not identified, Oligochaeta were taken to species level, and Gastropoda, Amphipoda, Isopoda, Ephemeroptera, Plecoptera, Trichoptera, Hemiptera and Coleoptera were not identified beyond Order. Horwitz (1994) recorded 217 taxa from the whole region (60 in interstitial habitat, 75 from burrows and 205 taxa from surface waters). An average of 27.2 taxa were recorded from the four sites in the Muir/Unicup catchments, and within these wetlands approximately three taxa per site were endemic to southwestern Australia, and no taxa were locally endemic. Approximate totals of 36 and 23 taxa were taken from Poorginup Swamp and Lake Unicup respectively.

The other major study in the area is currently being written-up as a PhD thesis and is not available for review (Darren Ryder, Edith Cowan University, unpub. dat.).

2.4.2 Fish fauna

In recent years there have been surveys and studies of the freshwater fishes of the lower southwest of Western Australia by Christensen (1982), Pusey & Edward (1990b), Jaensch (1992) and Morgan *et al.* (1996), some of which have sampled in the Muir and Unicup catchments. Christensen (1982) sampled fish from 120 locations in the lower southwest of Western Australia in late summer of 1978 and 1979. The sites were located between the Hay River to the east and Blackwood River to the west. The majority of sites were within 30 km of the coast, but several were in or adjoining the Lake Muir catchment. Christensen (*op. cit.*) recorded 7 native freshwater species (*Lepidogalaxias salamandroides*, *Edelia vittata*, *Bostockia porosa*, *Nannatherina balstoni*, *Galaxias occidentalis*, *Galaxiella munda* and *G. nigrostriata*), two introduced species (*Salmo trutta* and *Gambusia holbrooki*) and the native lamprey (*Geotria australis*) in the study. All species were reported as being relatively common, with the possible exception of *N. balstoni*. In addition, *E. vittata* and *B. porosa* were noted for their tolerance to salinity. Both species were present in the Tone River at 3.6 ppt, and in a small creek at 4.9 ppt, and *E. vittata* was taken from the Frankland River at 5.7 ppt.

Within and adjacent to the Lake Muir catchment, Christensen (1982) sampled 6 sites and recorded five species: Tone River at Muirs Hwy, *E. vittata*, *Galaxias occidentalis*, *Galaxiella munda*; man-made pool on Myalgelup Road, *E. vittata*; and four separate pools beside Muirs Hwy to the east of the catchment, *B porosa*, *E. vittata*, *Galaxias occidentalis*, and *N. balstoni*.

Pusey & Edward (1990b) investigated the structure of fish assemblages in the seasonally-inundated waters of the southern acid peat flats, situated close to the coast between Northcliffe and Broke Inlet. Six species were collected: *Lepidogalaxias salamandroides*, *Edelia vittata*, *Bostockia porosa*, *Nannatherina balstoni*, *Galaxiella munda* and *G. nigrostriata*. Permanent waterbodies were dominated by *E. vittata*, and aestivating species (*Lepidogalaxias salamandroides, Galaxiella munda* and *G. nigrostriata)* were restricted to the seasonal wetlands. This study did not extend northwards towards the Muir/Unicup catchments.

The survey of Jaensch (1992) also was restricted to the south coast, sampling 27 wetlands between Cape Naturaliste and Albany, and did not extend northwards into the Muir/Unicup catchments. Jaensch (1992) recorded 12 species of fish. In addition to the six species recorded by Pusey & Edward (1990b), Jaensch (*op. cit.*) also recorded *Tandanus bostocki*, *Leptatherina wallacei* (previously called *Atherinosoma wallacei*), *Afurcagobius suppositus* (previously called *Favonigobius suppositus*), *Galaxias maculatus*, *Galaxias occidentalis* and *Gambusia holbrooki*. The majority of wetlands were dominant by *Edelia vittata*.

Table 1. Sites sampled and fish species recorded by Morgan *et al.* (1996) from the Lake Muir watershed.

Site	*Galaxias occidentalis*	*Galaxiella munda*	*Bostockia porosa*	*Edelia vittata*	*Gambusia holbrooki*
Lake Muir	+			+	+
Noobijup Lake					
Byenup lagoon	+			+	+
Jn L. Unicup & Pindicup Rds	+			+	+
Cowerup Swamp	+	+		+	
Stream of Lake Muir	+		+		
Red Lake	+		+		+
Drain from Red Lake	+		+		+
Red Lake	+		+		+
Red Lake	+		+		+
Drain Red Lake/Lake Muir					
Lake Muir – Hanekamp Rd					
Lake Muir – Hanekamp Rd					
Pool adjacent L. Muir-Hanekamp Rd					
Pool adjacent L. Muir-Hanekamp Rd					
Pool adjacent L. Muir-Hanekamp Rd					
Pool adjacent L. Muir-Hanekamp Rd					
Stream adjacent L. Muir-Muirs Hwy					+
Stream adjacent L. Muir-Muirs Hwy					+
Pool adj L. Muir-Thomson Rd					+
Pool adj L. Muir-Thomson Rd					+
Pool adj L. Muir-Thomson Rd					+
Pool adj L. Muir-Thomson Rd					
Pool adj L. Muir-Thomson Rd					
Pool adj L. Muir-Thomson Rd					
Pool adj L. Muir-Thomson Rd					

The most comprehensive survey was by Morgan *et al.* (1996) in which 311 sites in the 19 major watersheds in the southwest corner of Western Australia, bounded by Capel in the northwest and Walpole in the southeast, were sampled for freshwater fish between 1994 and 1996. In addition to the twelve species recorded by Jaensch (1992), Morgan *et al.* (1996) also recorded *Pseudogobius olorum*, the lamprey, *Geotria australis,* and three additional introduced species; Rainbow and brown trout, *Oncorhynchus mykiss* and *Salmo trutta*, and redfin perch, *Perca fluviatilis*. The study included 26 sampling locations within the Lake Muir watershed, from which five species of fish were recorded (Table 1).

Apart from the above studies, there are no other published surveys of the fish fauna of the Muir/Unicup catchments.

3 Methods

3.1 Site selection and sampling regime

Prior to selecting a representative sample of wetlands in the Muir/Unicup catchments, a total of 53 wetlands (named and un-named) were considered. From these a suite of 15 wetlands were selected to provide good coverage of the study area and to represent the broad range of wetland types and states present in the study area. This included wetlands that were:

- naturally saline, as a mark against which secondary salination of freshwater wetlands could be assessed,
- permanently inundated,
- seasonally inundated,
- dominated by *Baumea articulata*,
- dominated by emergent *Melaleuca* trees,
- currently receiving land drainage,
- adjacent to cleared land and/or in the path of future land drainage, and
- well buffered by reserve or state forest.

Given this broad array of wetland types/issue, this initial selection concentrated on the well-defined basin-type wetlands. Sites were sampled on three occasions (October 1996, January and May 1997) to detect any seasonal changes in aquatic fauna and water chemistry. Vegetation structure in the selected wetlands indicated some were seasonal (i.e.

presence of plant species that require occasional drying). In addition, Semeniuk (unpub. dat.) has independently classified eight of the 15 sites as 'Sumplands: seasonally inundated basins', with six sites classifying as 'Lakes: permanently inundated basins' (one of the selected sites (Bokarup) was outside the range of mapping). Locations of the sites within the catchment are indicated in Figure 1, site names, map coordinates, basic description and classification by Semeniuk are listed in Table 2, and representative examples of the wetlands are illustrated in Plates 1 – 6.

Baseline botanical surveys of wetlands in the catchment (Greig Keighery & Neil Gibson, WADCALM, pers. comm.) identified an additional suite of seasonally inundated damplands and flatlands, containing distinctive floristic communities. These wetlands often bordered the basin-type wetlands and were not represented in the initial selection for fauna surveys because it was seen as a higher priority to provide adequate coverage of the larger, distinctive and numerous basin-type wetlands which tended to be more low-lying in the landscape. However, in mid-1997, additional funding was provided to expand the initial selection of 15 wetlands to include some additional basin-type wetlands (n=4), but also to include seasonally-inundated heathland-type wetlands (n=8). These additional 12 sites were to be sampled on two occasions, May and October 1997. The additional sites and their basic characteristics are listed in Table 2, locations illustrated in Figure 1 and representative examples illustrated in Plates 7 & 8.

There was high rainfall in the Muir/Unicup catchments in winter of 1996 and as a result the original 15 wetlands (seasonal and permanent) were very full at the end of winter and all held water throughout the following summer. Of the additional 12 wetlands, eight were dry in May 1997 (the seasonally-inundated heathland-type sites), but all 12 sites held water in October 1997.

The four field trips were conducted between 17 to 22 October 1996, 13 to 16 January 1997, 5 to 11 May 1997, and 20 to 24 October 1997 respectively. The location of each site was recorded by GPS to allow re-sampling of the same locations in subsequent visits (both for this study and any future investigations).

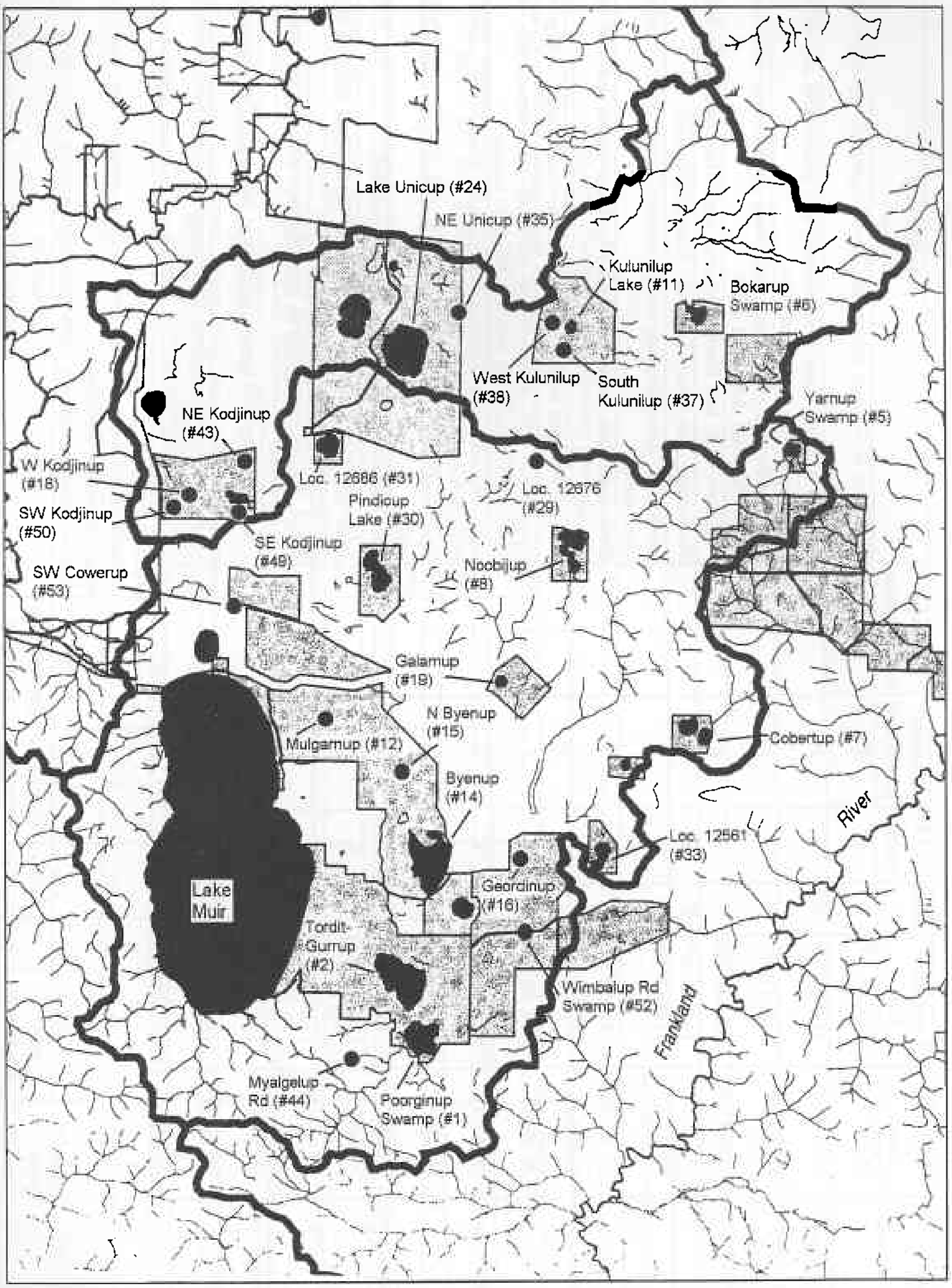

Figure 1. Location of the 27 wetlands sampled in the Muir and Unicup catchments, indicating wetland name and number, catchment boundaries and nature reserves (shaded areas).

Table 2. Sites sampled in the survey of wetlands in the Byenup-Muir area ('NR' refers to whether wetland is in a Nature Reserve (Y, yes; N, no), 'CALM gauge' refers to presence or absence of an established CALM depth gauge, 'seasonal/permanent' refers to flooding regime, 'Semeniuk classification' presents wetland types according to the classification of wetlands by Semeniuk (1987), * indicates the additional 12 wetlands sampled in May and October 1997.

Site No	Wetland Name	Latitude South	Longitude East	NR	CALM gauge	Seasonal/ permanent	Semeniuk classification	Description of wetland
1	Poorginup Swamp	34° 32' 53"	116° 44' 28"	Y	Y	P	2	*Melaleuca* & *Baumea* dominated, heavily vegetated, some open fresh water, peat base
2	Tordit-Gurrup Lagoon	34° 31' 41"	116° 44' 20"	Y	Y	P	1	Fresh to brackish, dense low rushland, with taller rushes and marginal trees, large area of open water, peat base
5	Yarnup Swamp	34° 22' 28"	116° 51' 40"	Y	Y	P	1	Cover of *Baumea* (in decline), with dense riparian cover of shrubs & trees, fresh to brackish, third open water
6	Bokarup Swamp	34° 20' 02"	116° 49' 40"	Y	N	S	-	Half open water, half *Baumea* covered, some Melaleuca stands, fresh water
7	Cobertup Swamp	34° 26' 26"	116° 45' 41"	Y	N	?P	1	Freshwater, open cover of *Baumea* & some *Melaleuca*
8	Noobijup Swamp	34° 23' 52"	116° 47' 22"	Y	N	P	2	Freshwater, dense *Baumea* along margins, lighter cover throughout, little open water
11*	Kulunilup Lake	34° 20' 20"	116° 46' 59"	Y	N	P	-	Deep open fresh water, surrounded by dense rushes and well buffered by reserve
12	Mulgarnup Swamp	34° 27' 28"	116° 42' 46"	Y	N	?S	1	Large, partly open wetland, with dense *Baumea* & margin of large *Melaleuca*
14	Byenup Lagoon	34° 30' 02"	116° 44' 29"	Y	Y	P	1	Open water with extensive low rushland, interspersed with tall rushes, fringed with paperbarks, peat bed. Brackish to saline
15	N end of Byenup at narrow neck	34° 27' 59"	116° 43' 10"	Y	Y	?S	2	Open *Baumea* with occasional *Melaleuca*. Brackish to saline – floods through from Byenup in winter
16	Geordinup Swamp	34° 29' 38"	116° 46' 02"	Y	N	?P	1	Open water lake with sparse *Baumea* (in decline), peat bottom & *Melaleuca* edge
18	Western swamp in Kodjinup NR	34° 23' 43"	116° 39' 11"	Y	N	S	2	Dense cover of *Baumea*, no open water, peat bed
19	Galamup Swamp	34° 26' 25"	116° 45' 42"	Y	N	P	2	Sparse cover of *Baumea*. Fresh, undisturbed and well buffered by reserve & pine plantations. Little riparian vegetation.
24*	Lake Unicup	34° 20' 18"	116° 43' 07"	Y	Y	S	1	Broad, shallow, open wetland, but with reasonable riparian zone of *Baumea* and *Melaleuca*
29	Loc. 12676, south side of E end of Pindicup Rd	34° 22' 47"	116° 45' 29"	N	N	S	2	Seasonal swamp with open cover of large *Melaleuca*. Few emergents
30*	Pindicup Lake	34° 24' 32"	116° 42' 53"	Y	N	S	2	Open shallow saline wetland, little vegetation except for a few riparian reeds (sparse *B. articulata*, denser *B. juncea*)

Table 2 (cont.)

Site No	Wetland Name	Latitude South	Longitude East	NR	CALM gauge	Seasonal/ permanent	Semeniuk classification	Description of wetland
31	Loc. 12686 – SW of Unicup NR – south side of Pindicup Rd	34° 22' 14"	116° 42' 11"	Y	N	S	2	Shallow, probably seasonal, clearwater saline wetland. Sand bottom, contains dense submerged macrophytes
33	Loc. 12561 SE of Geordinup Rd	34° 29' 44"	116° 47' 56"	Y	N	S	2	Appears as a seasonal, saline lake – with a sand/clay bed and extensive submergent macrophyte growth
35*	NE edge of Unicup NR	34° 20' 02"	116° 44' 46"	Y	N	P	?2	On NE boundary of Unicup NR, permanent with some *Baumea*, inundated *Melaleuca* and dead/declining shrubs/*Banksia*
37*	South Entrance of Kulunilup NR	34° 20' 22"	116° 47' 04"	Y	N	S	-	Seasonal dampland along south access track, with low, dense *Melaleuca ?lateritia* shrubs to 1.5 m, occasional large *Melaleuca* trees and sparse *Leptospermum*
38*	West side of Kulunilup NR	34° 20' 17"	116° 46' 33"	Y	N	S	-	Very shallow seasonal wetland on clay base - *M. lateritia* & *Pericelmia* sp. Generally, very open wetland/flat
43*	NE corner of Kodjinup NR	34° 22' 22"	116° 40' 14"	Y	N	S	5	Seasonal health at NE corner of Kodjinup NR (*Restio tremulus* present). Open *Melaleuca* with ?*B. juncea* understorey
44*	Swamp across Myalgelup Rd	34° 33' 00"	116° 44' 06"	N	N	S	5	Shallow, seasonal, coloured water peat flats covered in very dense *Melaleuca* sp.to 3 m
49*	SE Kodjinup NR	34° 23' 26"	116° 40' 02"	Y	N	S	5	Low, dense *Melaleuca ?lateritia* shrubs to 1.5 m with occasional large *Melaleuca* trees and sparse *Leptospermum* on S track to E swamp
50*	SW corner of Kodjinup NR	34° 23' 25"	116° 38' 24"	Y	N	S	5	Tall, large *Melaleuca preissiana* overstorey & canopy with thick understorey of *Leptospermum* on sand at SW corner of NR
52*	Swamp across Wimbalup Track	34° 30' 29"	116° 46' 29"	N	N	S	-	Shallow, seasonal flats covered in very dense *Melaleuca* sp. to 1.5 m across Wimbalup track
53*	West side of Cowerup NR	34° 25' 08"	116° 40' 04"	Y	N	S	5	Shallow, seasonal flats covered in *Melaleuca* sp.to 2.0 m

Semeniuk (1987) Wetland Classification categories:

1 Lake (permanently inundated basin)
2 Sumpland (seasonally inundated basin)
3 Dampland (seasonally waterlogged basin)
4 Floodplain (seasonally inundated flat)
5 Palusplain (seasonally waterlogged flat)
- site in area yet to be mapped

Plate 1. Collecting fish in Noobijup Swamp (site #8), amongst emergent *Baumea articulata* (photo – Andrew Storey, January 1997)

Plate 2. Galamup Swamp (site #19) (photo – Andrew Storey, January 1997)

Plate 3. Poorginup Swamp (site #1), sampling in channels amongst 'tussock islands' (photo – Andrew Storey, January 1997)

Plate 4. Location 12561 to SE of Geordinup Road (site #33), a naturally saline wetland with clear, shallow water (Photo – Andrew Storey, January 1997)

Plate 5. Location 12676, E end of Pindicup Road (site #29), showing dead vegetation as a result of increased inundation (photo – Andrew Storey, January 1997)

Plate 6. Bokarup Swamp (site #6), showing exposed peat and fringing *Baumea articulata* (photo – Andrew Storey, January 1997)

Plate 7. NE Unicup (site #35), showing dead trees indicative of increased inundation (photo - Andrew Storey, January 1997)

Plate 8. Seasonally-inundated heathland on the NE edge of Kodjinup Nature Reserve (site #43), (photo – Andrew Storey, January 1997)

3.2 Field sampling

3.2.1 Physico - chemical parameters

A large range of physico-chemical parameters (Table 3) were measured at each site on each occasion to assess the current status of water quality and to provide data on which to assess future changes due to land use practises.

Table 3. Physico-chemical parameters measured at each wetland on each occasion.

Parameter	Code	Units
Water Temperature	Temp	°C at surface and bottom
Water depth	Depth	cms
Dissolved oxygen	DO	% saturation at surface and bottom
pH	pH	pH units
Conductivity	Cond	μS/cm
Salinity	Salinity	ppt (mg/l)
Alkalinity	Alk	$CaCO_3$ mg/l
Turbidity	Turb.	NTU (Nepholemetric Turbidity Units)
Colour	Colour	TCU (True Colour Units)
Ammonia	N_NH_3	N_NH_3 mg/l
Nitrate+nitrite	N_NO_3	N_NO_3 mg/l
Total soluble nitrogen	Total_N	N_tot. sol. mg/l
Total soluble phosphorus	Total_P	P_tot. sol. mg/l
Soluble reactive phosphorus	P_SR	P_SR mg/l
Calcium mg/l	Ca	mg/l
Magnesium mg/l	Mg	mg/l
Sodium mg/l	Na	mg/l
Chloride mg/l	Cl	mg/l
Potassium mg/l	K	mg/l

To maximise information return for expenditure, only those key parameters likely to be indicative of local land use practises and which are indicative of different types of aquatic invertebrate assemblages were selected (see Davis *et al.*, 1993; Edward *et al.*, 1994). At each site and on each occasion, parameters were measured either *in situ* or from water samples returned to the laboratory. The Environmental Chemistry Laboratory of the Chemistry Centre of Western Australia undertook all laboratory analyses.

Concentrations of total soluble nitrogen and total soluble phosphorous were determined from water samples pre-filtered through a 0.45μm millipore filter. Soluble reactive phosphorus was recorded as an indication of the bioavailable component of phosphorus in the water column. Filtered samples were immediately frozen and unfiltered samples for determination of colour and turbidity were kept in the dark at approx. 2°C.

3.2.2 Wetland morphology

To assist in differentiating different wetland types, the extent, structure and cover of wetland vegetation was recorded at each site. These measurements consisted of an estimate of the percentage cover of the maximum wetted area (i.e. high water level in winter) by:

- open water,
- emergent reeds/rushes,
- *Melaleuca* and other riparian trees/shrubs, and
- submerged macrophytes.

The depth of the organic layer (to a maximum of 1.5 m) was estimated from replicate (n=3) coring in each wetland.

3.2.3 Macroinvertebrate fauna

At each site, **the aim of the sampling program was to maximise the number of taxa collected**, by sampling as many habitats as possible within each wetland. This included reed/rush beds, woody debris, open water column and benthic sediments. Sampling was conducted with a 250µm mesh net to selectively collect the macroinvertebrate fauna over a standardised 50m transect. This sampling protocol was based upon a standardised approach adopted for previous surveys of this type (see Storey *et al.* 1993; Edward *et al.* 1994, Halse & Storey, 1996) and will therefore produce comparable data. In large waterbodies, such as Tordit-Gurrup and Byenup Lagoons, sampling was stratified across several locations within the lake to provide a composite sample that will more fully characterise the wetland. This is in preference to a sample from a single location.

Samples were preserved in 70% alcohol and returned to the laboratory where they were sorted under low power microscope to remove animals. All taxa were identified to the lowest possible level (species, where possible) and enumerated to $\log_{10}$ scale abundance classes (i.e. 0 = absent, 1 = 1 to 9 individuals, 2 = 10 to 99 individuals, 3 = >100 individuals). Specialist taxonomic expertise was subcontracted on an 'as needs be' basis to identify specific groups (e.g. Dr D.H. Edward, The University of Western Australia, Chironomidae; Dr M. Harvey, Western Australian Museum, Hydracarina), and others confirmed identifications of vouchered specimens (e.g. Ms Sue Harrington, WA Health Dept, Culicidae; Dr Shirley Slack-Smith, WA Museum, Gastropoda; Dr S.A. Halse, WA Dept CALM, Hemiptera; Dr Brenton Knott, The University of Western Australia, Amphipoda and Isopoda). Given the nature of this survey, it was considered that log. scale abundance classes were adequate for detecting major changes in the fauna (e.g. change in relative abundance) and are a good cost-compromise over counting all animals, particularly as a quasi-quantitative sampling protocol was used. Because of the nature of the swamps, many samples contained large quantities of organic matter. Therefore, a specific protocol for sorting samples was developed, incorporating sequential sieving and subsampling. This protocol is described in detail in Appendix 1.

3.2.4 Microinvertebrate fauna

For the purposes of this study, the microinvertebrate fauna was defined as all microcrustacea (Copepoda, Ostracoda, Cladocera), rotifers and Protozoa. Previous studies have shown that for assessing the conservation value of aquatic system in southwestern Australia the rarer components of the aquatic invertebrate fauna tend to be in the microinvertebrate fauna (Storey *et al.*, 1993; Halse & Storey, 1996, Halse, Storey & Shiel, unpub. dat.). However, this may partly reflect sampling effort as the microinvertebrate fauna, historically has been less studied. In this study, microinvertebrate assemblages were sampled using a 53µm mesh net over a 50 m transect using the same sampling protocol as used for macroinvertebrates (with the exception that benthic sediments were not disturbed). All samples were then preserved in 3% formalin for several days, before being transferred into 70% alcohol for long term storage.

The microinvertebrate fauna requires specialist taxonomic expertise and it was too expensive to process and identify these samples under the available budget. Therefore, samples of the microinvertebrate fauna were preserved and archived in the Department of Zoology, The University of Australia for future processing. These components of the aquatic invertebrate fauna are not considered in any analysis or discussion in the current report.

3.2.5 Fish fauna

The fish fauna was sampled at each site on each occasion by a range of methods with the **aim of maximising the number of species recorded**. Methodology depended upon the characteristics of each site, but generally consisted of sweep netting, rotenone and trapping at each site. Seine netting was used occasionally in the larger, more open wetlands where sandy beaches were present.

Sweep netting consisted of aggressive sweeps of the marginal and emergent vegetation with 250 µm and 1 mm mesh aperture dip nets. Rotenone (Derris Root) was applied at a rate of 300g dry wt per wetland. The rotenone was mixed in a bucket of water (10 l) with a small quantity of detergent and then dispersed in a shallow (1 to 1.5 m depth), sheltered backwater or embayment in the wetland. This concentration was sufficient to affect an area approximately 25 m x 25 m. Rotenone was not applied in wetlands where this effective area would be greater than 1% of the total wetted area, to avoid significantly affecting fish populations in the wetland. This added restriction seldom needed to be applied, but tended to occur in late summer when wetlands were reduced in area. Affected fish were then collected using dip nets for a period of approximately 1 hr after application.

Fish traps consisted of mesh or plastic covered funnel traps baited with cat biscuits. Three types of fish trap (recreational 'whitebait' traps) were set over night at each wetland. Traps were cleared each morning and fish removed, identified to species level, length recorded and then returned alive to the wetland. Crustacea and Coleoptera caught in the traps were retained for later identification.

3.3 Data analysis

Inter-dependencies and relationships amongst the physico-chemical and morphological variables and macroinvertebrate community descriptors were investigated using Spearman Rank correlation analysis on data from each sampling trip. Significant correlations (+ve or –ve) would indicate parallel changes in variables, but not necessarily cause and effect relationships.

The conservation significance of the macroinvertebrate and fish fauna of the wetlands was directly assessed based upon,

a.) the occurrence of taxa with respect to their known levels of endemism and their distribution within the region, state and continent (see Horwitz, 1996), and,

b.) the total species richness of the fauna at each site with respect to other studies (Storey *et al.* 1993, Edward *et al.* 1994, Halse & Storey unpub. dat., Horwitz 1994).

Each taxon was classified to one of four categories, dependent upon the known distribution of the taxon:

- Common (C) (*viz*. taxon has been recorded in other States/Territories)
- Endemic (S) to the southwest of Western Australia (*viz*. is restricted to, but is widely distributed across the southwest of the state)
- Locally (L) endemic within the southwest of Western Australia (*viz*. appears restricted to a few locations within the southwest of the State)
- Indeterminate (I) distribution (*viz*. there is currently insufficient knowledge on either the distribution or taxonomy of the taxon to assess its level of endemism). Within this category, taxa only ever recorded from southwest Western Australia are highlighted (*)

The CSIRO Pattern Analysis package PATN (Belbin, 1995) was used to ordinate and classify sites on physico-chemical parameters and on macroinvertebrate assemblages, and then to investigate relationships between invertebrate assemblages and physico-chemical parameters. This approach demonstrated:

- groups of sites with similar/dissimilar chemical/physical characteristics, with a measure of this dissimilarity,
- between site differences in the fauna,
- groups of sites which contained similar/dissimilar macroinvertebrate assemblages, with a measure of this dissimilarity,
- relationships between macroinvertebrate assemblages and chemical/physical characteristics of the sites/site groupings, and,
- taxa that may be used as indicators of different groups of sites identified in the analysis (i.e. taxa that are indicative of specific water quality conditions such as increased salinity).

Data from each sampling trip were treated separately, with the exception that the four additional sites sampled in May 1997 were analysed together with data for all 12 sites sampled in October 1997 to assess the extent of seasonal changes at these sites. Data were classified and ordinated to identify between-site differences in physico-chemical composition and invertebrate community structure. Physico-chemical variables were standardised (*viz*. within each variable, values were divided by the maximum value for that variable to produce a scale 0 – 1) prior to ordination and classification. This was necessary to set all variables on the same scale and so avoid variables on a higher scale having an over-bearing influence on the analysis. Invertebrate data were analysed as a $\log_{10}$ abundance scale and only taxa that occurred at greater than 10% of wetlands in each season were included to avoid 'low-occurrence' taxa having a disproportionate effect on the results.

Wetlands were classified using **U**nweighted **P**air**g**roup Arith**m**etic **A**veraging (UPGMA), an agglomerative hierarchical fusion technique which produces a dendrogram in which sites with similar physico-chemistry/benthic community composition group together. This analysis was performed to identify groupings of sites with similar physico-chemistry/invertebrate communities. Sites were then ordinated using **S**emi-**S**trong **H**ybrid **M**ulti**d**imensional **S**caling (SSH MDS) to produce an n-dimensional scatter plot of sites. For each analysis, similarity between sites was determined using the Bray-Curtis association measure. UPGMA groupings were superimposed on the respective ordination plots to assess the distinctiveness of the site groupings. To test the significance of the separation of these groups of sites in ordination space, the ANOSIM option in PATN (Belbin, 1995) was invoked. The Principal Axis Correlation (PCC) option in PATN was used to place gradients of:

- physico-chemical parameters through the ordination of sites on physico-chemical data,
- physico-chemical parameters through the ordination of sites on invertebrate data, and,
- invertebrate taxa through the ordination of sites on invertebrate data.

Monte Carlo randomisations (n=100) of the data were performed to test the significance of these gradients.

To further assess the role physico-chemistry and wetland morphology may play in structuring invertebrate communities, the UPGMA groupings derived from the classifications of sites on physico-chemical data were superimposed on the ordination of sites by invertebrate data. Clear separation of these groupings would demonstrate that water quality and morphology influenced invertebrate community structure. The significance of separation of these groupings was tested using ANOSIM.

Finally, to provide an indication of the likely effects of increased salinity on macroinvertebrate community structure, the possible salinity tolerance of each taxon was investigated. Pearson product moment correlations were calculated for each taxon using the abundance of the taxon at each site on each sampling trip ($\log_{10}$ abundances) and salinity values for the site on each sampling trip (n = 61 samples). Taxa that decreased in abundance with increasing salinity would show a significant negative relationship, taxa that increased in abundance would have a significant positive relationship and there would be no significant correlation for taxa that did not respond to the salinity range recorded in this study. Sites were ranked according to increasing salinity, and taxa were then ranked according to the strength of the correlation coefficient (from –ve, through zero correlation to +ve relationships) to produce a two-way table of possible salinity tolerances for all taxa recorded.

4 Results

Physico-chemical data and taxa occurrences for each site on each sampling occasion are presented in Appendices 2 & 3 respectively and these data have been entered onto Excel spreadsheets and electronic copies lodged with the WA Department of Conservation and Land Management for future reference.

4.1 Physico-chemistry

4.1.1 Inter-dependencies within physico-chemical parameters

Rank correlation between all variables for each sampling trip demonstrated a range of significant relationships, many of which related to basic limnological processes (Tables 4 – 7). The strongest consistent relationships within each season were amongst variables relating to ionic composition, salinity, conductivity and alkalinity. Concentrations of all the major ions (Ca^{2+}, Cl^-, K^+, Mg^{2+} and Na^+) increased together, as did salinity/conductivity and alkalinity. As would be expected, conductivity, salinity and pH also were significantly positively correlated. The strengths of these relationships (e.g. the magnitude of the correlation coefficients and the significance levels) increased from spring through summer to late autumn, reflecting the concentration effect of these parameters as the wetlands receded (Appendix 2).

Table 4. Spearman rank correlations for physico-chemical parameters from October 1996 fieldtrip (ns = not significant, * = p<0.05; ** = p < 0.01; *** = p<0.001).

	No.Spp	Ca	Cl	K	Mg	Na	DOtop	DObot	TEMPtop	TEMPbot	COND	SALINITY	PH	DEPTH	ALKAL	COLOUR	N_NH3	N_NO3	TOT_N	PSR	TOT_P	TURBIDITY	ORGANICS	OPEN	REEDS	MELALEUCA
Ca	-0.046 ns																									
Cl	-0.145 ns	0.739 **																								
K	-0.227 ns	0.554 *	0.594 *																							
Mg	-0.121 ns	0.826 ***	0.939 ***	0.428 ns																						
Na	-0.268 ns	0.629 *	0.966 ***	0.648 **	0.857 ***																					
DOtop	-0.255 ns	0.465 ns	0.584 *	0.492 ns	0.481 ns	0.538 *																				
DObot	-0.066 ns	0.462 ns	0.501 ns	0.663 **	0.374 ns	0.457 ns	0.840 ***																			
TEMPtop	-0.018 ns	0.065 ns	0.083 ns	-0.005 ns	0.168 ns	0.072 ns	0.066 ns	-0.253 ns																		
TEMPbot	-0.312 ns	0.623 *	0.677 **	0.541 *	0.661 **	0.626 *	0.816 ***	0.654 **	0.355 ns																	
COND	-0.244 ns	0.620 *	0.940 ***	0.599 *	0.849 ***	0.978 ***	0.496 ns	0.359 ns	0.199 ns	0.610 *																
SALINITY	-0.244 ns	0.620 *	0.940 ***	0.599 *	0.849 ***	0.978 ***	0.496 ns	0.359 ns	0.199 ns	0.610 *	1.000 ***															
PH	-0.007 ns	0.381 ns	0.474 ns	0.494 ns	0.284 ns	0.497 ns	0.379 ns	0.284 ns	-0.029 ns	0.363 ns	0.489 ns	0.489 ns														
DEPTH	0.086 ns	0.598 *	0.447 ns	0.399 ns	0.444 ns	0.381 ns	0.399 ns	0.554 *	-0.154 ns	0.599 *	0.359 ns	0.359 ns	0.386 ns													
ALKAL	-0.034 ns	0.759 **	0.653 **	0.739 **	0.545 *	0.649 **	0.446 ns	0.574 *	-0.178 ns	0.540 *	0.615 *	0.615 *	0.713 **	0.696 **												
COLOUR	0.092 ns	-0.678 **	-0.804 ***	-0.619 *	-0.705 **	-0.732 **	-0.738 **	-0.751 **	0.104 ns	-0.689 **	-0.663 **	-0.663 **	-0.454 ns	-0.544 *	-0.698 **											
N_NH3	-0.181 ns	0.324 ns	0.085 ns	0.089 ns	0.157 ns	0.113 ns	0.233 ns	0.028 ns	0.374 ns	0.350 ns	0.211 ns	0.211 ns	0.387 ns	0.324 ns	0.260 ns	0.055 ns										
N_NO3	-0.032 ns	-0.101 ns	-0.299 ns	-0.335 ns	-0.199 ns	-0.308 ns	0.006 ns	0.104 ns	-0.234 ns	-0.107 ns	-0.276 ns	-0.276 ns	-0.385 ns	0.305 ns	-0.185 ns	0.210 ns	0.308 ns									
TOT_N	0.100 ns	0.319 ns	-0.088 ns	0.382 ns	-0.021 ns	-0.107 ns	-0.014 ns	0.100 ns	0.378 ns	0.176 ns	-0.081 ns	-0.081 ns	0.243 ns	0.161 ns	0.289 ns	0.082 ns	0.577 *	-0.052 ns								
PSR	-0.255 ns	0.248 ns	0.199 ns	0.324 ns	0.199 ns	0.272 ns	0.018 ns	0.139 ns	-0.212 ns	-0.042 ns	0.248 ns	0.248 ns	0.211 ns	-0.024 ns	0.273 ns	0.079 ns	0.403 ns	0.146 ns	0.419 ns							
TOT_P	-0.063 ns	-0.142 ns	-0.047 ns	-0.463 ns	0.016 ns	-0.047 ns	-0.252 ns	-0.536 *	0.395 ns	-0.126 ns	0.063 ns	0.063 ns	0.126 ns	-0.079 ns	-0.237 ns	0.284 ns	0.382 ns	0.254 ns	-0.016 ns	0.053 ns						
TURBIDITY	-0.004 ns	0.081 ns	0.080 ns	0.311 ns	-0.084 ns	0.113 ns	0.400 ns	0.359 ns	-0.275 ns	0.037 ns	0.083 ns	0.083 ns	0.618 *	-0.086 ns	0.345 ns	-0.257 ns	0.271 ns	-0.254 ns	0.214 ns	0.334 ns	-0.269 ns					
ORGANICS	0.206 ns	-0.130 ns	-0.289 ns	-0.603 *	-0.093 ns	-0.423 ns	-0.018 ns	-0.282 ns	0.268 ns	-0.154 ns	-0.346 ns	-0.346 ns	-0.455 ns	-0.387 ns	-0.597 *	0.189 ns	-0.006 ns	0.084 ns	-0.176 ns	-0.418 ns	0.079 ns	-0.031 ns				
OPEN	0.006 ns	0.200 ns	0.309 ns	0.126 ns	0.169 ns	0.285 ns	0.537 *	0.358 ns	0.047 ns	0.428 ns	0.288 ns	0.288 ns	0.716 **	0.397 ns	0.459 ns	-0.387 ns	0.400 ns	0.086 ns	0.066 ns	0.081 ns	0.407 ns	0.394 ns	-0.270 ns			
REEDS	0.016 ns	-0.093 ns	-0.203 ns	-0.125 ns	-0.038 ns	-0.260 ns	-0.290 ns	-0.149 ns	0.029 ns	-0.129 ns	-0.287 ns	-0.287 ns	-0.746 **	-0.201 ns	-0.433 ns	0.170 ns	-0.499 ns	-0.098 ns	-0.142 ns	-0.345 ns	-0.474 ns	-0.517 ns	0.388 ns	-0.886 ***		
MELALEUCA	0.344 ns	-0.200 ns	-0.143 ns	-0.013 ns	-0.252 ns	-0.032 ns	-0.546 *	-0.379 ns	-0.226 ns	-0.615 *	0.011 ns	0.011 ns	0.312 ns	-0.170 ns	0.161 ns	0.277 ns	0.069 ns	-0.073 ns	0.127 ns	0.356 ns	0.232 ns	0.274 ns	-0.370 ns	0.068 ns	-0.453 ns	
MACRPHYTE	0.120 ns	0.261 ns	0.390 ns	0.420 ns	0.216 ns	0.404 ns	0.715 **	0.716 **	-0.117 ns	0.519 *	0.358 ns	0.358 ns	0.335 ns	0.413 ns	0.499 ns	-0.606 *	0.014 ns	-0.044 ns	-0.161 ns	-0.232 ns	-0.415 ns	0.359 ns	-0.125 ns	0.403 ns	-0.262 ns	-0.174 ns

Table 5. Spearman rank correlations for physico-chemical parameters from January 1997 fieldtrip (ns = not significant, * = p<0.05; ** = p < 0.01; *** = p<0.001).

	No.Spp	Ca	Cl	K	Mg	Na	DOtop	DObot	TEMPtop	TEMPbot	COND	SALINITY	PH	DEPTH	ALKAL	COLOUR	N_NH3	N_NO3	TOT_N	PSR	TOT_P	TURBIDITY	ORGANICS	OPEN	REEDS	MELALEUCA
Ca	-0.377 ns																									
Cl	-0.199 ns	0.881 ***																								
K	-0.324 ns	0.654 **	0.809 ***																							
Mg	-0.208 ns	0.871 ***	0.983 ***	0.767 **																						
Na	-0.222 ns	0.879 ***	0.996 ***	0.836 ***	0.968 ***																					
DOtop	0.082 ns	0.499 ns	0.271 ns	-0.026 ns	0.307 ns	0.242 ns																				
DObot	-0.155 ns	0.674 **	0.488 ns	0.290 ns	0.483 ns	0.452 ns	0.603 *																			
TEMPtop	-0.170 ns	0.007 ns	-0.018 ns	-0.037 ns	0.018 ns	0.007 ns	-0.179 ns	-0.528 *																		
TEMPbot	-0.731 **	0.262 ns	0.098 ns	0.276 ns	0.129 ns	0.100 ns	0.196 ns	0.327 ns	0.066 ns																	
COND	-0.327 ns	0.882 ***	0.863 ***	0.562 *	0.850 ***	0.854 ***	0.468 ns	0.563 *	-0.025 ns	0.228 ns																
SALINITY	-0.327 ns	0.882 ***	0.863 ***	0.562 *	0.850 ***	0.854 ***	0.468 ns	0.563 *	-0.025 ns	0.228 ns	1.000 ***															
PH	-0.141 ns	0.561 *	0.461 ns	0.104 ns	0.468 ns	0.421 ns	0.752 **	0.658 **	-0.294 ns	0.242 ns	0.704 **	0.704 **														
DEPTH	0.068 ns	0.234 ns	0.031 ns	-0.233 ns	0.077 ns	-0.009 ns	0.835 ***	0.530 *	-0.454 ns	0.123 ns	0.199 ns	0.199 ns	0.648 **													
ALKAL	-0.569 *	0.549 *	0.404 ns	0.334 ns	0.357 ns	0.411 ns	0.469 ns	0.454 ns	-0.116 ns	0.615 *	0.668 **	0.668 **	0.720 **	0.296 ns												
COLOUR	0.250 ns	-0.721 **	-0.559 *	-0.205 ns	-0.611 *	-0.514 *	-0.743 **	-0.799 ***	0.355 ns	-0.321 ns	-0.732 **	-0.732 **	-0.864 ***	-0.674 **	-0.577 *											
N_NH3	-0.631 *	0.205 ns	0.000 ns	-0.007 ns	-0.040 ns	0.020 ns	-0.108 ns	-0.009 ns	0.313 ns	0.255 ns	0.239 ns	0.239 ns	0.029 ns	-0.166 ns	0.399 ns	0.062 ns										
N_NO3	0.147 ns	-0.185 ns	-0.372 ns	-0.196 ns	-0.369 ns	-0.353 ns	0.094 ns	-0.146 ns	0.209 ns	-0.055 ns	-0.519 *	-0.519 *	-0.373 ns	-0.002 ns	-0.241 ns	0.330 ns	-0.003 ns									
TOT_N	-0.240 ns	-0.105 ns	-0.328 ns	0.091 ns	-0.376 ns	-0.276 ns	-0.062 ns	-0.032 ns	0.180 ns	0.445 ns	-0.291 ns	-0.291 ns	-0.341 ns	-0.281 ns	0.137 ns	0.323 ns	0.185 ns	0.554 *								
PSR	0.232 ns	-0.557 *	-0.650 **	-0.638 *	-0.711 **	-0.650 **	-0.109 ns	-0.217 ns	-0.171 ns	-0.264 ns	-0.402 ns	-0.402 ns	-0.155 ns	0.077 ns	-0.093 ns	0.402 ns	0.408 ns	0.084 ns	0.078 ns							
TOT_P	0.232 ns	-0.557 *	-0.650 **	-0.638 *	-0.711 **	-0.650 **	-0.109 ns	-0.217 ns	-0.171 ns	-0.264 ns	-0.402 ns	-0.402 ns	-0.155 ns	0.077 ns	-0.093 ns	0.402 ns	0.408 ns	0.084 ns	0.078 ns	1.000 ***						
TURBIDITY	-0.491 ns	0.250 ns	-0.016 ns	-0.034 ns	0.045 ns	0.007 ns	0.125 ns	0.053 ns	0.197 ns	0.321 ns	0.136 ns	0.136 ns	-0.163 ns	0.038 ns	0.081 ns	-0.179 ns	0.307 ns	0.187 ns	0.293 ns	-0.173 ns	-0.173 ns					
ORGANICS	-0.001 ns	-0.161 ns	-0.315 ns	-0.403 ns	-0.245 ns	-0.331 ns	-0.094 ns	-0.057 ns	0.320 ns	-0.013 ns	-0.175 ns	-0.175 ns	-0.270 ns	-0.284 ns	-0.298 ns	0.140 ns	0.272 ns	0.313 ns	0.256 ns	0.171 ns	0.171 ns	0.500 ns				
OPEN	0.174 ns	0.170 ns	0.108 ns	-0.167 ns	0.076 ns	0.087 ns	0.510 ns	0.246 ns	-0.447 ns	-0.248 ns	0.330 ns	0.330 ns	0.679 **	0.514 *	0.473 ns	-0.491 ns	-0.038 ns	-0.098 ns	-0.313 ns	0.192 ns	0.192 ns	-0.208 ns	-0.278 ns			
REEDS	-0.275 ns	-0.151 ns	-0.158 ns	0.034 ns	-0.068 ns	-0.168 ns	-0.268 ns	-0.081 ns	0.398 ns	0.504 ns	-0.276 ns	-0.276 ns	-0.427 ns	-0.264 ns	-0.298 ns	0.229 ns	0.040 ns	0.102 ns	0.268 ns	-0.217 ns	-0.217 ns	0.260 ns	0.388 ns	-0.886 ***		
MELALEUCA	0.368 ns	0.015 ns	0.085 ns	0.184 ns	-0.026 ns	0.139 ns	-0.176 ns	-0.256 ns	-0.025 ns	-0.476 ns	-0.004 ns	-0.004 ns	-0.331 ns	-0.230 ns	-0.170 ns	0.343 ns	-0.141 ns	-0.025 ns	0.120 ns	0.130 ns	0.130 ns	-0.092 ns	-0.370 ns	0.068 ns	-0.453 ns	
MACRPHYTE	0.113 ns	0.298 ns	0.174 ns	-0.048 ns	0.128 ns	0.142 ns	0.470 ns	0.743 **	-0.447 ns	0.157 ns	0.307 ns	0.307 ns	0.669 **	0.413 ns	0.440 ns	-0.564 *	-0.172 ns	-0.160 ns	-0.035 ns	0.000 ns	0.000 ns	-0.326 ns	-0.175 ns	0.403 ns	-0.262 ns	-0.174 ns

Table 6. Spearman rank correlations for physico-chemical parameters from May 1997 fieldtrip (ns = not significant, * = p<0.05; ** = p < 0.01; *** = p<0.001).

	No.Spp	Ca	Cl	K	Mg	Na	DOtop	DObot	TEMPtop	TEMPbot	COND	SALINITY	PH	DEPTH	ALKAL	COLOUR	N_NH3	N_NO3	TOT_N	PSR	TOT_P	TURBIDITY	ORGANICS	OPEN	REEDS	MELALEUCA
Ca	-0.276 ns																									
Cl	-0.428 ns	0.885 ***																								
K	-0.243 ns	0.853 ***	0.833 ***																							
Mg	-0.447 ns	0.921 ***	0.968 ***	0.841 ***																						
Na	-0.407 ns	0.929 ***	0.958 ***	0.901 ***	0.965 ***																					
DOtop	0.075 ns	0.661 **	0.490 *	0.499 *	0.494 *	0.538 *																				
DObot	0.004 ns	0.687 **	0.533 *	0.558 *	0.527 *	0.589 **	0.966 ***																			
TEMPtop	0.015 ns	-0.125 ns	-0.332 ns	-0.092 ns	-0.268 ns	-0.258 ns	0.129 ns	0.128 ns																		
TEMPbot	-0.159 ns	0.260 ns	0.058 ns	0.296 ns	0.093 ns	0.159 ns	0.383 ns	0.451 ns	0.817 ***																	
COND	-0.416 ns	0.839 ***	0.900 ***	0.730 ***	0.923 ***	0.921 ***	0.396 ns	0.451 ns	-0.345 ns	-0.039 ns																
SALINITY	-0.416 ns	0.839 ***	0.900 ***	0.730 ***	0.923 ***	0.921 ***	0.396 ns	0.451 ns	-0.345 ns	-0.039 ns	1.000 ***															
PH	-0.261 ns	0.863 ***	0.864 ***	0.814 ***	0.842 ***	0.868 ***	0.581 **	0.632 **	-0.310 ns	0.043 ns	0.795 ***	0.795 ***														
DEPTH	0.210 ns	0.159 ns	0.022 ns	-0.030 ns	0.001 ns	-0.062 ns	0.136 ns	0.161 ns	-0.106 ns	-0.120 ns	-0.116 ns	-0.116 ns	0.216 ns													
ALKAL	-0.145 ns	0.781 ***	0.810 ***	0.742 ***	0.768 ***	0.784 ***	0.493 *	0.524 *	-0.256 ns	0.009 ns	0.767 ***	0.767 ***	0.886 ***	0.202 ns												
COLOUR	0.258 ns	-0.571 *	-0.439 ns	-0.405 ns	-0.507 *	-0.421 ns	-0.490 *	-0.529 *	0.068 ns	-0.146 ns	-0.288 ns	-0.288 ns	-0.486 *	-0.635 **	-0.338 ns											
N_NH3	-0.560 *	0.289 ns	0.358 ns	0.266 ns	0.308 ns	0.371 ns	-0.049 ns	0.011 ns	-0.196 ns	0.043 ns	0.369 ns	0.369 ns	0.293 ns	-0.038 ns	0.356 ns	0.034 ns										
N_NO3	0.141 ns	0.004 ns	-0.022 ns	0.208 ns	-0.027 ns	0.104 ns	-0.055 ns	-0.086 ns	-0.236 ns	-0.152 ns	-0.021 ns	-0.021 ns	-0.010 ns	-0.116 ns	-0.097 ns	0.150 ns	0.192 ns									
TOT_N	-0.318 ns	0.339 ns	0.404 ns	0.529 *	0.329 ns	0.422 ns	0.213 ns	0.252 ns	0.147 ns	0.274 ns	0.375 ns	0.375 ns	0.436 ns	-0.230 ns	0.561 *	0.169 ns	0.651 **	0.088 ns								
PSR																										
TOT_P	0.093 ns	-0.196 ns	-0.083 ns	-0.010 ns	-0.165 ns	-0.062 ns	-0.021 ns	0.041 ns	-0.062 ns	-0.052 ns	0.052 ns	0.052 ns	-0.124 ns	-0.426 ns	0.072 ns	0.466 *	0.145 ns	-0.023 ns	0.435 ns							
TURBIDITY	-0.254 ns	0.189 ns	0.246 ns	0.410 ns	0.228 ns	0.257 ns	-0.054 ns	-0.143 ns	0.037 ns	0.070 ns	0.112 ns	0.112 ns	0.047 ns	-0.204 ns	0.191 ns	0.014 ns	0.344 ns	0.318 ns	0.484 *		0.104 ns					
ORGANICS	-0.084 ns	-0.069 ns	-0.074 ns	-0.274 ns	-0.109 ns	-0.130 ns	0.151 ns	0.024 ns	0.080 ns	0.113 ns	-0.195 ns	-0.195 ns	-0.269 ns	-0.264 ns	-0.301 ns	0.158 ns	0.087 ns	-0.225 ns	-0.116 ns		-0.104 ns	0.123 ns				
OPEN	-0.092 ns	0.336 ns	0.358 ns	0.354 ns	0.359 ns	0.390 ns	0.341 ns	0.355 ns	-0.458 ns	-0.344 ns	0.403 ns	0.403 ns	0.516 *	0.325 ns	0.483 *	-0.426 ns	0.206 ns	0.317 ns	0.200 ns		0.095 ns	0.126 ns	-0.532 *			
REEDS	0.106 ns	-0.232 ns	-0.302 ns	-0.269 ns	-0.276 ns	-0.323 ns	-0.190 ns	-0.213 ns	0.439 ns	0.346 ns	-0.369 ns	-0.369 ns	-0.440 ns	-0.239 ns	-0.413 ns	0.245 ns	-0.188 ns	-0.397 ns	-0.179 ns		-0.104 ns	-0.089 ns	0.606 **	-0.938 ***		
MELALEUCA	0.246 ns	-0.255 ns	-0.105 ns	-0.125 ns	-0.220 ns	-0.158 ns	-0.260 ns	-0.283 ns	-0.014 ns	-0.140 ns	-0.077 ns	-0.077 ns	-0.103 ns	-0.213 ns	0.037 ns	0.539 *	-0.197 ns	0.248 ns	0.074 ns		0.246 ns	0.040 ns	-0.278 ns	-0.030 ns	-0.263 ns	
MACRPHYTE	0.042 ns	0.390 ns	0.313 ns	0.467 *	0.323 ns	0.374 ns	0.449 ns	0.524 *	-0.082 ns	0.113 ns	0.270 ns	0.270 ns	0.542 *	0.333 ns	0.399 ns	-0.489 *	-0.125 ns	-0.131 ns	0.109 ns		-0.046 ns	-0.044 ns	-0.416 ns	0.604 **	-0.490 *	-0.260 ns

NB missing values represent variables that were invariant

Table 7. Spearman rank correlations for physico-chemical parameters from October 1997 fieldtrip (ns = not significant, * = p<0.05; ** = p < 0.01; *** = p<0.001).

	No.Spp	Ca	Cl	K	Mg	Na	DOtop	DObot	TEMPtop	TEMPbot	COND	SALINITY	PH	DEPTH	ALKAL	COLOUR	N_NH3	N_NO3	TOT_N	PSR	TOT_P	TURBIDITY	ORGANICS	OPEN	REEDS	MELALEUCA
Ca	-0.211 ns																									
Cl	-0.367 ns	0.881 ***																								
K	0.000 ns	0.739 **	0.734 *																							
Mg	-0.375 ns	0.936 ***	0.982 ***	0.723 *																						
Na	-0.435 ns	0.751 **	0.945 ***	0.714 *	0.895 ***																					
DOtop	0.287 ns	0.051 ns	-0.183 ns	0.450 ns	-0.132 ns	-0.190 ns																				
DObot	0.349 ns	0.112 ns	-0.109 ns	0.478 ns	-0.041 ns	-0.097 ns	0.945 ***																			
TEMPtop	0.418 ns	0.100 ns	-0.152 ns	0.119 ns	-0.109 ns	-0.100 ns	0.402 ns	0.464 ns																		
TEMPbot	-0.118 ns	-0.120 ns	-0.041 ns	-0.117 ns	-0.096 ns	0.124 ns	0.293 ns	0.294 ns	0.550 ns																	
COND	-0.411 ns	0.905 ***	0.889 ***	0.596 ns	0.946 ***	0.774 **	-0.060 ns	0.048 ns	-0.217 ns	-0.158 ns																
SALINITY	-0.411 ns	0.905 ***	0.889 ***	0.596 ns	0.946 ***	0.774 **	-0.060 ns	0.048 ns	-0.217 ns	-0.158 ns	1.000 ***															
PH	-0.109 ns	0.674 *	0.724 *	0.926 ***	0.711 *	0.752 **	0.348 ns	0.411 ns	0.329 ns	0.172 ns	0.357 ns	0.357 ns														
DEPTH	-0.012 ns	0.655 *	0.307 ns	0.300 ns	0.451 ns	0.082 ns	0.170 ns	0.187 ns	0.021 ns	-0.477 ns	0.517 ns	0.517 ns	0.141 ns													
ALKAL	-0.292 ns	0.812 **	0.906 ***	0.695 *	0.917 ***	0.845 **	-0.218 ns	-0.098 ns	-0.004 ns	-0.077 ns	0.621 *	0.621 *	0.804 **	0.287 ns												
COLOUR	-0.014 ns	-0.407 ns	-0.145 ns	-0.326 ns	-0.262 ns	0.052 ns	-0.722 *	-0.702 *	-0.014 ns	0.077 ns	-0.413 ns	-0.413 ns	-0.168 ns	-0.650 *	-0.077 ns											
N_NH3	-0.426 ns	0.269 ns	0.436 ns	0.202 ns	0.377 ns	0.640 *	0.000 ns	0.091 ns	0.332 ns	0.791 **	0.256 ns	0.256 ns	0.407 ns	-0.332 ns	0.323 ns	0.222 ns										
N_NO3																										
TOT_N	-0.153 ns	-0.174 ns	-0.028 ns	0.298 ns	-0.081 ns	0.214 ns	0.151 ns	0.171 ns	0.214 ns	0.089 ns	-0.277 ns	-0.277 ns	0.487 ns	-0.305 ns	0.155 ns	0.378 ns	0.272 ns									
PSR	0.008 ns	-0.186 ns	-0.084 ns	-0.477 ns	-0.118 ns	-0.130 ns	-0.550 ns	-0.552 ns	0.043 ns	0.302 ns	-0.226 ns	-0.226 ns	-0.156 ns	-0.024 ns	-0.027 ns	0.091 ns	0.125 ns		-0.256 ns							
TOT_P	0.296 ns	-0.236 ns	-0.162 ns	-0.394 ns	-0.241 ns	-0.111 ns	-0.523 ns	-0.486 ns	0.220 ns	0.299 ns	-0.417 ns	-0.417 ns	-0.118 ns	-0.202 ns	-0.059 ns	0.464 ns	0.229 ns		-0.091 ns	0.732 **						
TURBIDITY	0.178 ns	-0.553 ns	-0.436 ns	0.037 ns	-0.523 ns	-0.320 ns	0.367 ns	0.217 ns	-0.298 ns	-0.204 ns	-0.371 ns	-0.371 ns	-0.312 ns	-0.410 ns	-0.620 *	0.119 ns	-0.330 ns		0.258 ns	-0.471 ns	-0.335 ns					
ORGANICS	-0.176 ns	0.882 ***	0.625 *	0.530 ns	0.744 **	0.469 ns	0.164 ns	0.247 ns	0.390 ns	0.020 ns	0.671 *	0.671 *	0.577 ns	0.733 **	0.642 *	-0.507 ns	0.219 ns		-0.133 ns	-0.030 ns	-0.175 ns	-0.684 *				
OPEN	-0.035 ns	0.803 **	0.762 **	0.822 **	0.801 **	0.625 *	0.161 ns	0.236 ns	0.039 ns	-0.267 ns	0.633 *	0.633 *	0.802 **	0.577 *	0.810 **	-0.456 ns	0.023 ns		0.103 ns	-0.076 ns	-0.207 ns	-0.375 ns	0.725 **			
REEDS	-0.051 ns	0.171 ns	0.057 ns	0.151 ns	0.127 ns	0.103 ns	0.181 ns	0.266 ns	0.688 *	0.313 ns	0.025 ns	0.025 ns	0.423 ns	0.021 ns	0.276 ns	0.032 ns	0.255 ns		0.399 ns	-0.108 ns	-0.250 ns	-0.364 ns	0.448 ns	0.164 ns		
MELALEUCA	0.188 ns	-0.564 ns	-0.328 ns	-0.593 ns	-0.457 ns	-0.271 ns	-0.708 *	-0.793 *	-0.363 ns	0.027 ns	-0.388 ns	-0.388 ns	-0.666 *	-0.449 ns	-0.554 ns	0.481 ns	-0.094 ns		-0.282 ns	0.471 ns	0.569 ns	0.339 ns	-0.714 **	-0.585 *	-0.636 *	
MACRPHYTE	-0.021 ns	0.628 *	0.434 ns	0.788 **	0.528 ns	0.352 ns	0.649 ns	0.711 *	0.288 ns	-0.140 ns	0.419 ns	0.419 ns	0.793 **	0.530 ns	0.608 *	-0.583 *	0.006 ns		0.298 ns	-0.414 ns	-0.484 ns	-0.230 ns	0.705 *	0.803 **	0.423 ns	-0.912 ***

NB missing values represent variables that were invariant

Number of macroinvertebrate taxa at a wetland was negatively correlated with N_NH_3 in summer and autumn, but not spring. This suggested a decrease in taxa richness with increasing ammonia in summer and autumn, however, dilution effects may have reduced this relationship in spring. Taxa richness did not correlate with any other physico-chemical parameter. The only other consistent significant relationships were amongst characters of wetland morphology. There were significant positive relationships between the percentage of open water and the percentage cover of submerged macrophyte, and between the percent cover of reeds/rushes and the depth of the benthic organic layer. Also, there was a negative relationship between the percent cover of reeds/rushes and the percentage of open water. These relationships suggest that submerged macrophyte is only abundant in open wetlands, open wetlands have a low cover of reeds/rushes (principally *Baumea articulata*), and a high cover of reeds/rushes produces a deep organic layer. Generally, the same suite of variables demonstrated significant relationships for the reduced set of 12 wetlands sampled in October 1997, although the strength of the correlations were less due to the smaller dataset, covering a limited range of wetland types (i.e. no highly saline wetlands).

4.1.2 Nutrient status

Generally, nutrient levels in the wetlands were not elevated, although there was a trend of higher levels in summer and autumn as nutrients were concentrated in receding wetlands. Classifying wetlands to a trophic status is a useful means to summarising nutrient data in that it provides an indication of current wetland status, allows comparisons amongst wetlands and may be used to assess change in a wetland over time. There are a number of classification schemes whereby wetlands may be classified to a trophic status based on nutrient concentrations (e.g. Wetzel, 1975; OECD, 1982; Salas & Martino, 1991). The classification by Wetzel (1975) is from the classic text on limnology based on temperate northern hemisphere lakes, and uses ranges in concentrations of Total-P, Total-N and inorganic N (Table 8). The OECD classification (Table 9) is based on a survey of a large number of lakes, mainly from northern temperate areas, particularly glacial lakes from high latitudes. The system was produced by qualitatively classifying each lake to a trophic state, and then using measurements of nutrient concentrations and loads, chlorophyll-a and Secchi disc transparency to set boundary values and the mean and variance of each parameter for each trophic category (Davis *et al.*, 1993). A similar approach was used by the Pan American Centre for Sanitary Engineering and Environmental Sciences (CEPIS, Table 9; Salas & Martino, 1991) to develop a classification system for warm-water tropical lakes. Forty lakes were individually assigned to a trophic state based on qualitative criteria, and site-measurements of mean annual total phosphorus were then used to determine standards (means ± standard deviations) for each category. For the CEPIS study, warm-water lakes were defined as lakes with a minimum temperature of greater than 10°C, with a minimum annual average of 15°C. All wetlands sampled in the current study classified as warm-water lakes and therefore, the classification by CEPIS is most appropriate for classifying wetlands in the Muir/Unicup system to a trophic status.

Table 8. Classification of lake trophic status based on ranges in nutrient concentration (mg/l) (Wetzel, 1975)

Category	Total P (& Ortho P)	Total N	Inorganic N
Ultra-oligotrophic	0 – 0.005	0 – 0.25	0 – 0.20
Oligo-mesotrophic	0.005 – 0.01	0.25 – 0.60	0.20 – 0.40
Meso-eutrophic	0.01 – 0.03	0.30 – 1.10	0.30 – 0.65
Eutrophic	0.03 – 0.1	0.50 – 1.50	0.50 – 1.50
Hyper-eutrophic	> 0.1	> 1.50	> 1.50

Table 9. Mean annual total phosphorus levels (mg/l) for each trophic category under the OECD (1982) and CEPIS (Salas & Martino, 1991) classifications (means and range over 2 standard deviations).

	Category		
	Oligotrophic	**Mesotrophic**	**Eutrophic**
OECD	0.008	0.0267	0.084
(± 2 SD)	(0.003 – 0.022)	(0.08 – 0.091)	(0.017 – 0.424)
CEPIS	0.021	0.0396	0.1187
(± 2 SD)	(0.010 – 0.045)	(0.021 – 0.074)	(0.028 – 0.508)

OECD and CEPIS do not classify lake trophic status according to Total-N. However, according to Wetzel (1975), the majority of sites in this study classified as eutrophic. Of the 61 samples taken, there were 48 occasions when Total-N exceeded 1.1 mg/l (upper limit for meso-eutrophic). On 39 occasions Total-N exceeded 1.5 mg/l (Table 10) and therefore classified as hyper-eutrophic on the basis of Total-N.

Spot measurements of Total-P exceeded 0.02 mg/l on only two occasions (Wimbalup Rd swamp #52, October 1997, 0.05 mg/l and SW Kodjinup NR #50, October 1997, 0.04 mg/l), and, therefore, wetlands in this study generally classified as oligotrophic based on Total-P and the CEPIS classification.

4.1.3 Ionic composition

Ionic concentrations were determined from all seasons (Appendix 2), and relative cation and anion concentrations were determined for all October samples, when all wetlands contained water. Ionic composition amongst lakes was extremely consistent (Table 11). In all instances the wetlands were dominated by the anion Cl^-. Of the cations, Na^+ was dominant, followed by Mg^{2+}, Ca^{2+} and K^+. The only exceptions were Loc 12561, SE of Basil/Geordinup Rd and W Kulunilup NR in which Ca^{2+} was marginally sub-dominant to K^+. The overall dominance of Cl^- and Na^+ in all wetlands indicated that their relative ionic composition is largely determined by marine influences (e.g. marine incursions in previous geologic times, airborne sea spray, or long-term accumulation of salts from marine-derived precipitation). Davis *et al.* (1993) noted Ca^{2+} as the sub-dominant cation in the majority of wetlands on the Swan Coastal Plain, suggesting that this indicated the influence of limestone aquifers. The sub-dominance of Mg^{2+} in this study indicates a granite-influenced geology.

Table 10 Wetlands and sampling trips in which Total-N was >= 1.5 mg/l.

Site	No.	Trip No	Tot_N (mg/l)
Galamup Swamp	19	3	12.00
Location 12561, SE of Basil/Geordinup Rd	33	3	6.50
Galamup Swamp	19	2	4.70
N end of Byenup Lagoon	15	3	4.00
Lake Unicup	24	3	3.60
Location 12686, SW of Unicup NR	31	3	3.50
Byenup Lagoon	14	3	2.70
N end of Byenup Lagoon	15	2	2.70
Geordinup Swamp	16	3	2.60
Mulgarnup Swamp	12	3	2.20
Location 12686, SW of Unicup NR	31	1	2.20
NE Unicup NR	35	3	2.20
Tordit-Gurrup Lagoon	2	3	2.00
Bokarup Swamp	6	3	2.00
Cobertup Swamp	7	2	2.00
Mulgarnup Swamp	12	2	1.90
Byenup Lagoon	14	2	1.90
Tordit-Gurrup Lagoon	2	1	1.80
Tordit-Gurrup Lagoon	2	2	1.80
Noobijup Swamp	8	3	1.80
Byenup Lagoon	14	1	1.80
Galamup Swamp	19	1	1.80
W Kulunilup NR	38	4	1.80
Poorginup Swamp	1	1	1.70
Poorginup Swamp	1	2	1.70
Mulgarnup Swamp	12	1	1.70
Location 12561, SE of Basil/Geordinup Rd	33	2	1.70
Pindicup Lake	30	3	1.70
NE Unicup NR	35	4	1.70
Noobijup Swamp	8	1	1.60
N end of Byenup Lagoon	15	1	1.60
Geordinup Swamp	16	2	1.60
Location 12676, S of E end of Pindicup Rd	29	2	1.60
Bokarup Swamp	6	2	1.50
Noobijup Swamp	8	2	1.50
Western swamp in Kodjinup NR	18	2	1.50
Location 12676, S of E end of Pindicup Rd	29	3	1.50
Location 12686, SW of Unicup NR	31	2	1.50
NE Kodjinup NR	43	4	1.50

Table 11. Relative ionic composition for all wetlands sampled in October of each year.

Site	No	Relative Ionic Concentration								
Poorginup Swamp	1	Cl	>	Na	>	Mg	>	Ca	>	K
Tordit-Gurrup Lagoon	2	Cl	>	Na	>	Mg	>	Ca	>	K
Yarnup Swamp	5	Cl	>	Na	>	Mg	>	Ca	>	K
Bokarup Swamp	6	Cl	>	Na	>	Mg	>	Ca	>	K
Cobertup Swamp	7	Cl	>	Na	>	Mg	>	Ca	>	K
Noobijup Swamp	8	Cl	>	Na	>	Mg	>	Ca	>	K
Kulunilup NR	11	Cl	>	Na	>	Mg	>	Ca	>	K
Mulgarnup Swamp	12	Cl	>	Na	>	Mg	>	Ca	>	K
Byenup Lagoon	14	Cl	>	Na	>	Mg	>	Ca	>	K
N end of Byenup Lagoon	15	Cl	>	Na	>	Mg	>	Ca	>	K
Geordinup Swamp	16	Cl	>	Na	>	Mg	>	Ca	>	K
Western swamp in Kodjinup NR	18	Cl	>	Na	>	Mg	>	Ca	>	K
Galamup Swamp	19	Cl	>	Na	>	Mg	>	Ca	>	K
Lake Unicup	24	Cl	>	Na	>	Mg	>	Ca	>	K
Loc 12676, S of E end of Pindicup Rd	29	Cl	>	Na	>	Mg	>	Ca	>	K
Pindicup Lake	30	Cl	>	Na	>	Mg	>	Ca	>	K
Loc 12686, SW of Unicup NR	31	Cl	>	Na	>	Mg	>	Ca	>	K
Loc 12561, SE of Geordinup Rd	33	Cl	>	Na	>	Mg	>	K	>	Ca
NE Unicup NR	35	Cl	>	Na	>	Mg	>	Ca	>	K
S Kulunilup NR	37	Cl	>	Na	>	Mg	>	Ca	>	K
W Kulunilup NR	38	Cl	>	Na	>	Mg	>	K	>	Ca
NE Kodjinup NR	43	Cl	>	Na	>	Mg	>	Ca	>	K
Myalgelup Road	44	-		-		-		-		-
SE Kodjinup NR	49	Cl	>	Na	>	Mg	>	Ca	>	K
SW Kodjinup NR	50	Cl	>	Na	>	Mg	>	Ca	>	K
Wimbalup Rd	52	Cl	>	Na	>	Mg	>	Ca	>	K
SW Cowerup NR	53	Cl	>	Na	>	Mg	>	Ca	>	K
Median concentrations (mg/l)		**635.0**		**335.0**		**47.5**		**20.0**		**6.0**

4.1.4 Ordination and classification

Classification and ordination of sites on physico-chemical data for each sampling trip are illustrated in Figures 2 to 9. Significant gradients in physico-chemical parameters are presented for each ordination and groupings from the UPGMA classifications are overlaid on each ordination. In all instances there was a significant separation of groups in ordination space ($P<0.0001$). In October 1996, classification detected four main groups, with the most saline sites (#31, Loc. 12686 SW of Unicup NR and #33, Loc. 12561 SE of Geordinup Rd) showing the strongest separation from all other sites (Group 4), but with Byenup and Tordit-Gurrup Lagoons also forming a sub-group (Group 3). The remaining sites formed two groups, which appeared to differentiate between sites with some open water, higher cover of *Melaleuca* and increased Total-P concentrations (Group 1) from sites with dense cover of reeds/rushes (Group 2).

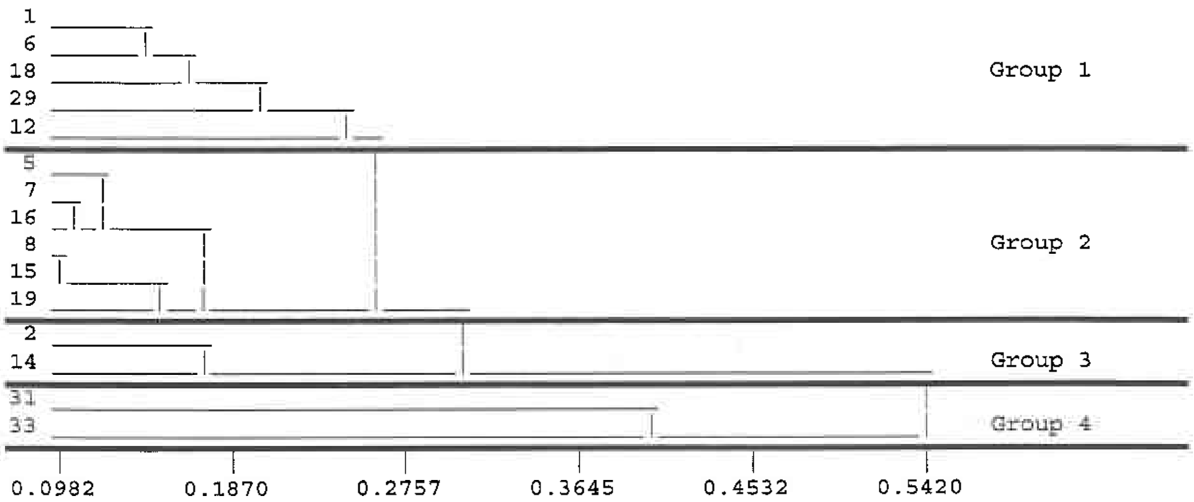

Figure 2. UPGMA classification of wetlands by physico-chemical variables sampled in October 1996, indicating four main groups. Refer to Table 2 for site codes and names.

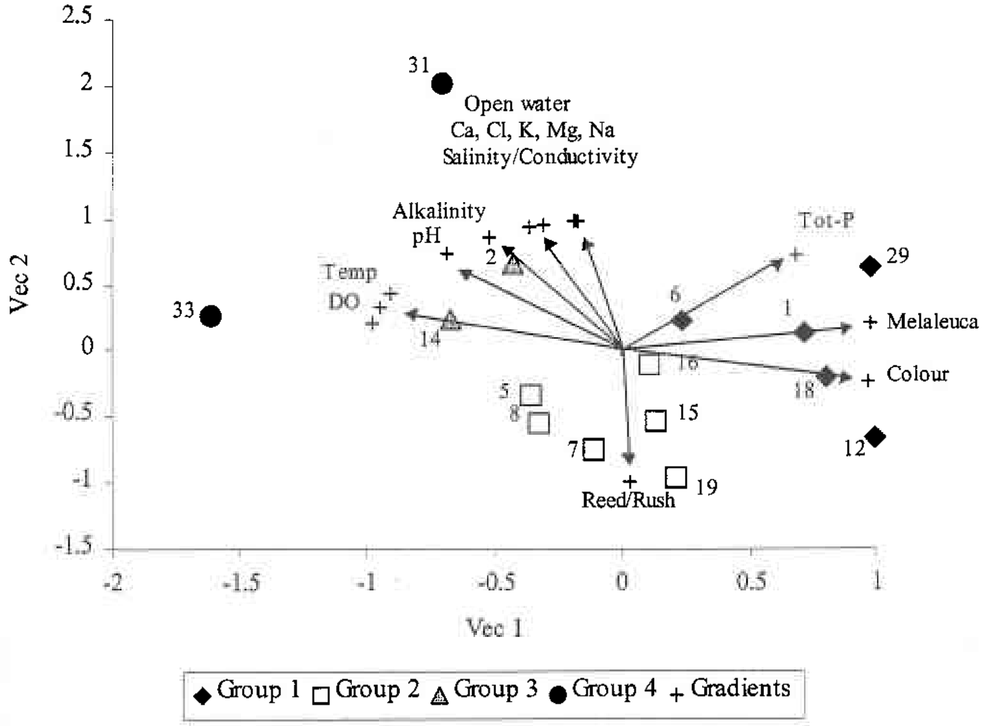

Figure 3. MDS ordination of wetlands by physico-chemical variables sampled in October 1996. Groupings from the UPGMA classification and significant gradients in physico-chemical variables are overlain. Numbers refer to wetland names (refer to Table 2). Optimum solution to the ordination was achieved with 2 dimensions and a stress of 0.1678.

These groupings were supported by gradients in physico-chemical parameters. For example, all variables relating to increasing salinity (*viz*. ionic composition, alkalinity, pH, salinity and conductivity) were in the direction of the saline sites (Group 4). Generally, wetlands were not separating on the basis of nutrient status (Figures 2 & 3).

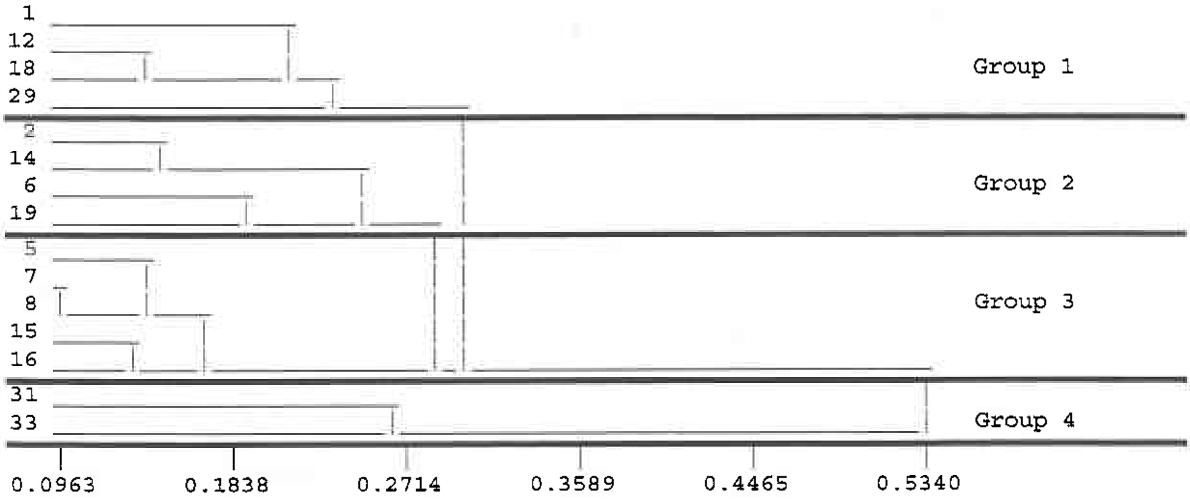

Figure 4. UPGMA classification of wetlands by physico-chemical variables sampled in January 1997, indicating four main groups. Refer to Table 2 for site codes and names.

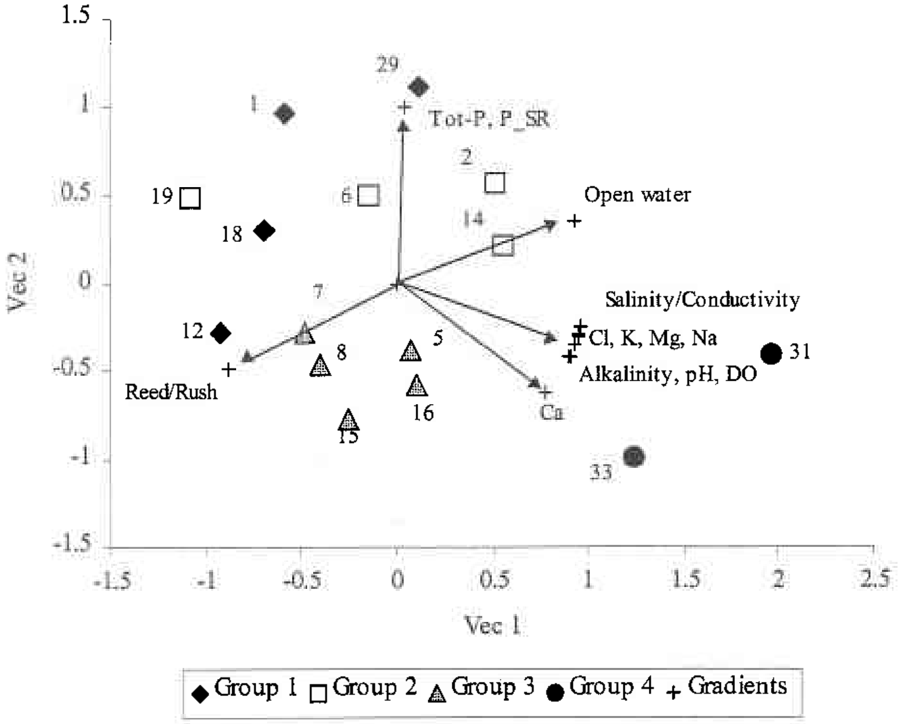

Figure 5. MDS ordination of wetlands by physico-chemical variables sampled in January 1997. Groupings from the UPGMA classification and significant gradients in physico-chemical variables are overlain. Numbers refer to wetland names (refer to Table 2). Optimum solution to the ordination was achieved with 2 dimensions and a stress of 0.1808.

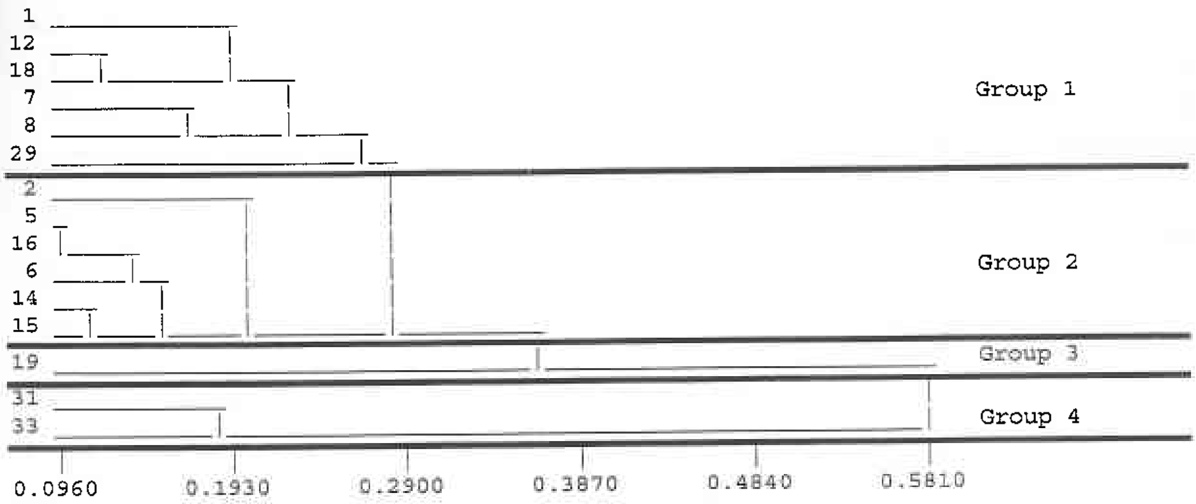

Figure 6. UPGMA classification of wetlands by physico-chemical variables sampled in May 1997, indicating four main groups. Refer to Table 2 for site codes and names.

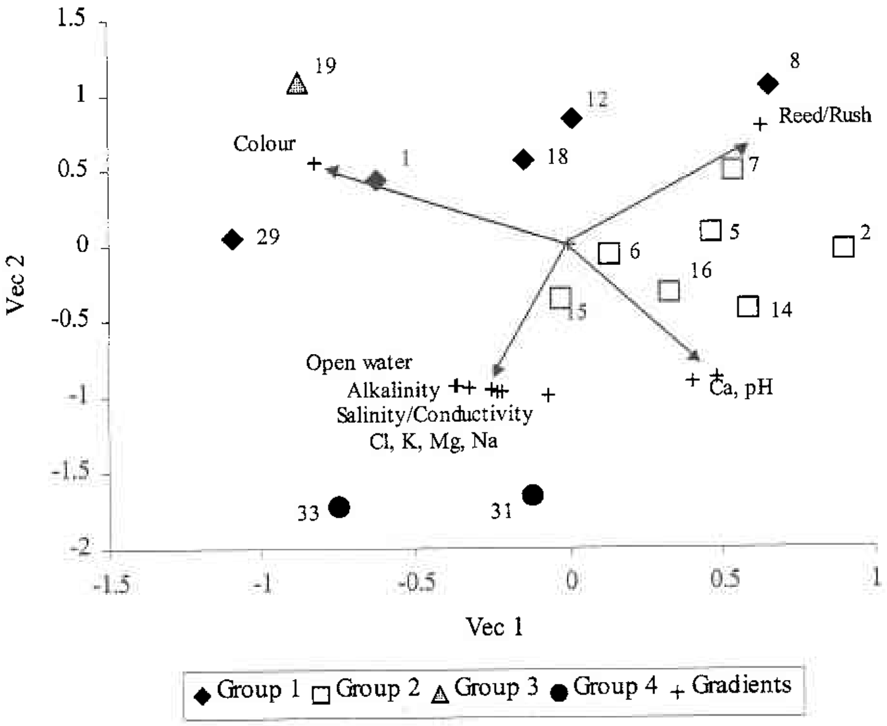

Figure 7. MDS ordination of wetlands by physico-chemical variables sampled in May 1997. Groupings from the UPGMA classification and significant gradients in physico-chemical variables are overlain. Numbers refer to wetland names (refer to Table 2). Optimum solution to the ordination was achieved with 2 dimensions and a stress of 0.1779.

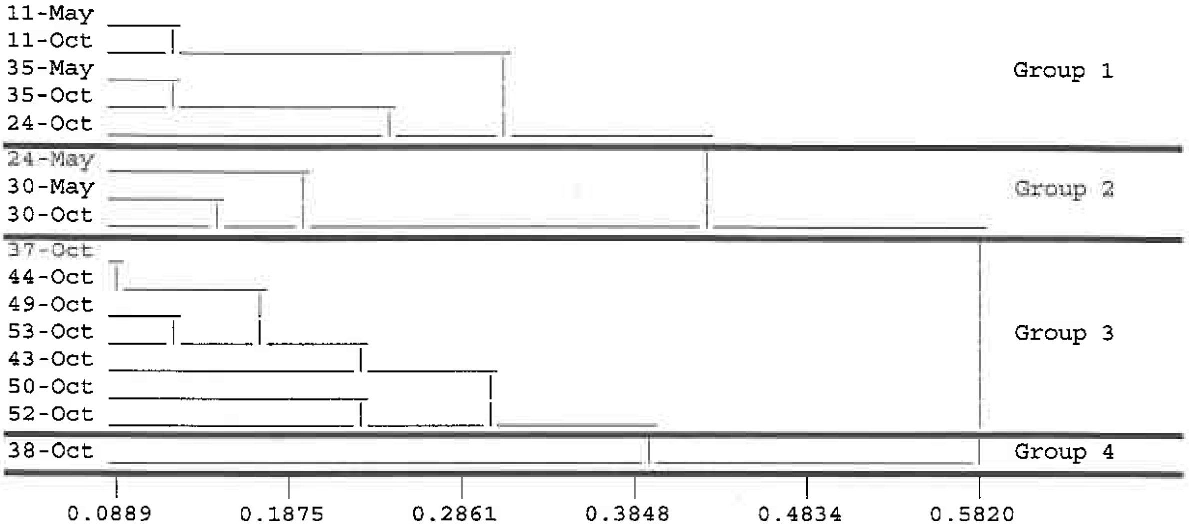

Figure 8. UPGMA classification of the additional wetlands by physico-chemical variables sampled in May and October 1997, indicating four main groups. Samples are labelled by site number and month, refer to Table 2 for site codes and names.

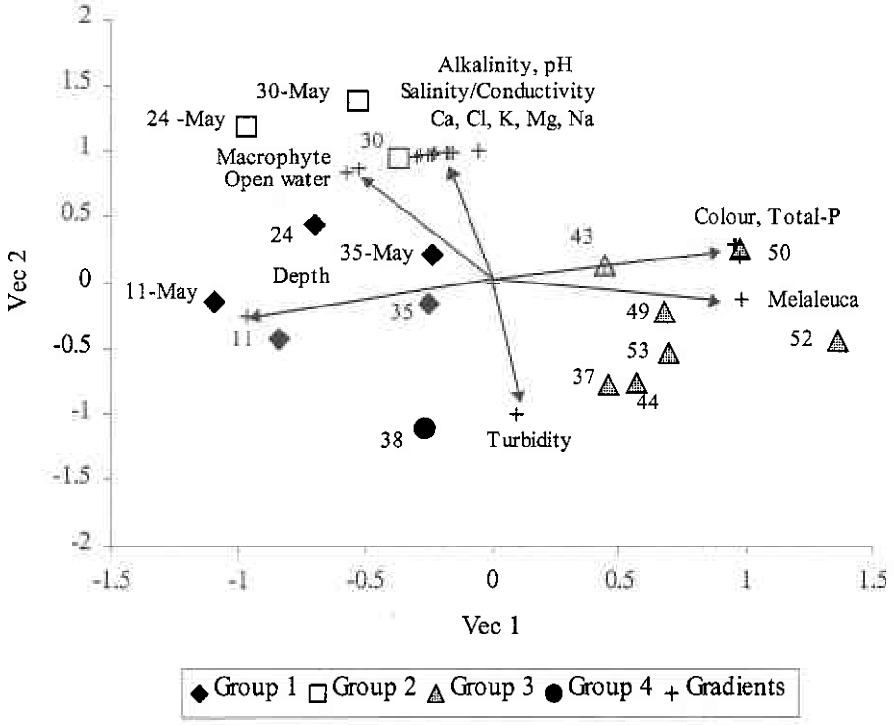

Figure 9. MDS ordination of the 12 additional wetlands by physico-chemical variables sampled in May and October 1997. Groupings from the UPGMA classification and significant gradients in physico-chemical variables are overlain. Numbers refer to wetland names and the four sites sampled in May 1997 are indicated (nn-May) (refer to Table 2 for site names). Optimum solution to the ordination was achieved with 2 dimensions and a stress of 0.1485.

4.2 Macroinvertebrate fauna

4.2.1 Taxa richness

Throughout the study, a total of 219 taxa of aquatic macroinvertebrates were recorded. Of these, 61 taxa (~ 27%) occurred on only one occasion, and only 13 taxa occurred in greater than 50% of all samples (n=61). Within the original suite of 15 wetlands, the number of taxa varied between seasons and between sites (Figure 10). Seasonally, there were significantly more taxa (ANOVA, df. 2,42, F = 5.75, p = 0.006) recorded from wetlands in October 1996 (mean = 30.3) and January 1997 (mean = 32.6) than in May 1997 (mean = 21.4). The reduced taxa richness in late summer probably related to the time of year and the state of the wetlands (e.g. water levels reduced and many taxa will have completed their life-cycles and either be as terrestrial adults or in a resting stage to avoid the hotter, drier months).

Using seasons as replicates, site #29 (Loc. 12676 at E end of Pindicup Rd) had significantly greater taxa richness than sites #6 (Bokarup) and #31 (Loc. 12561, SW of Unicup NR) (ANOVA, df. 14,30, F = 2.31, p = 0.026). Site #29 has been artificially dammed by a badly designed culvert on Pindicup Rd, which appears to have provided a greater diversity of habitat than in most other wetlands in the area (e.g. dead and dying inundated *Banksia* and *Melaleuca*, a margin of emergent reeds/rushes, some aquatic macrophyte and open water). Conversely, Bokarup Swamp is dominated by deep, unconsolidated organic deposits with low pH and DO, and site #31 has high salinity: conditions that restrict faunal diversity.

In terms of the total number of taxa recorded from each of the 15 wetlands over the three seasons, the most taxa were recorded from site #29 (Loc. 12676 at E end of Pindicup Rd, 81 taxa), with the fewest from site #31 (Loc. 12561, SW of Unicup NR, 25 taxa), followed by site #6 (Bokarup Swamp, 40 taxa) (Figure 11).

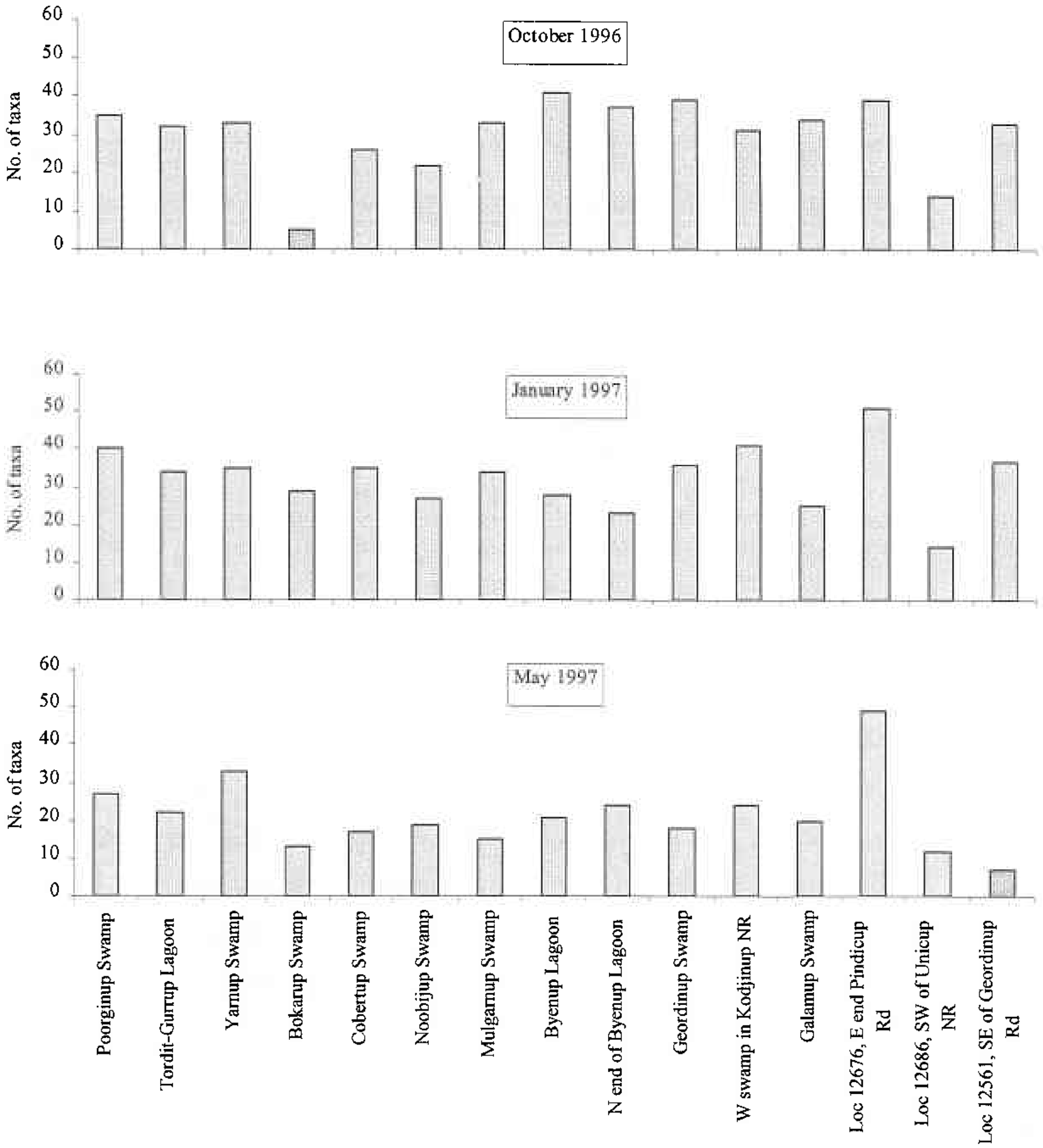

Figure 10. Number of taxa recorded on each sampling occasion (October 1996, January and May 1997) at each of the original suite of 15 wetlands.

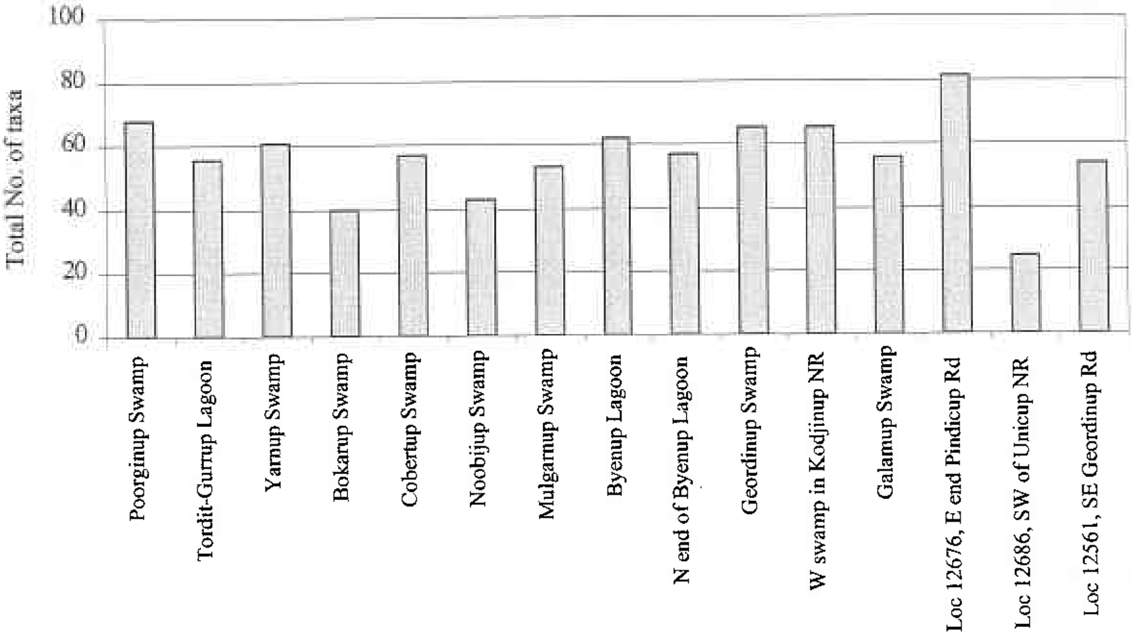

Figure 11. Total number of taxa recorded over three sampling occasions at the original suite of 15 wetlands sampled in October 1996, January and May 1997.

Amongst the suite of 12 additional wetlands sampled in May and October 1997 there were trends of between site and season differences. Generally, taxa richness for the four sites sampled in both seasons was lower during May (mean = 25 taxa) than October (mean = 33 taxa) (Figure 12). This was the same trend recorded from the suite of 15 wetlands. Comparisons of the total number of taxa recorded should be treated with caution, since four of the sites were sampled twice, as opposed to the eight seasonally-inundated sites, which were sampled only once. Site #35 (NE Unicup NR) held the most taxa (68) (Figure 13). Interestingly, this site appears to be affected by increased inundation, possibly from land clearing. Evidence for increased inundation is the presence in the wetland of permanently inundated dead and dying *Banksia* and *Melaleuca* trees, and the fact that the original track to the wetland is now underwater and has been redirected along higher ground to the west of the wetland. It is likely that the provision of additional habitats contributes to the increased taxa richness at this site (*cf.* wetland #29).

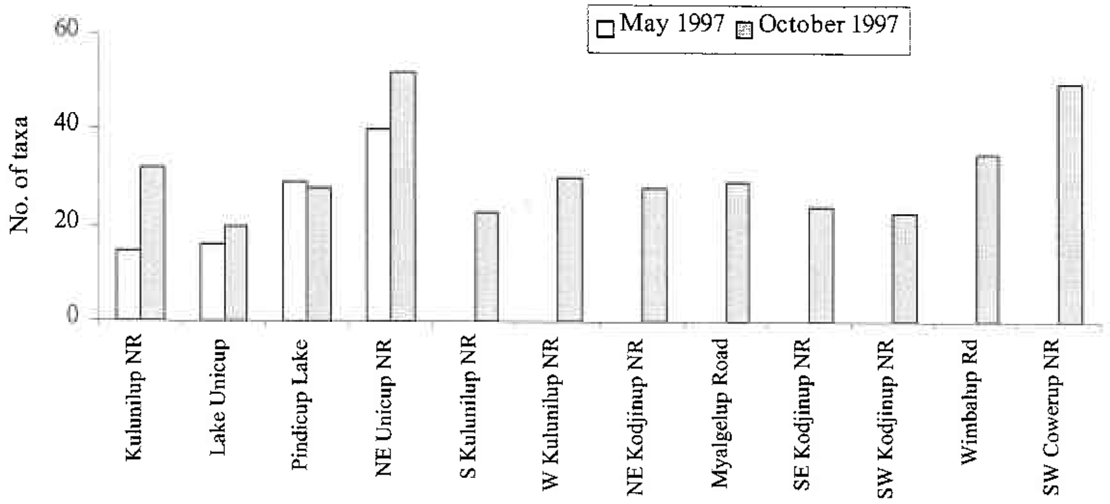

Figure 12. Number of taxa at each of the additional 12 sites sampled in May and October 1997.

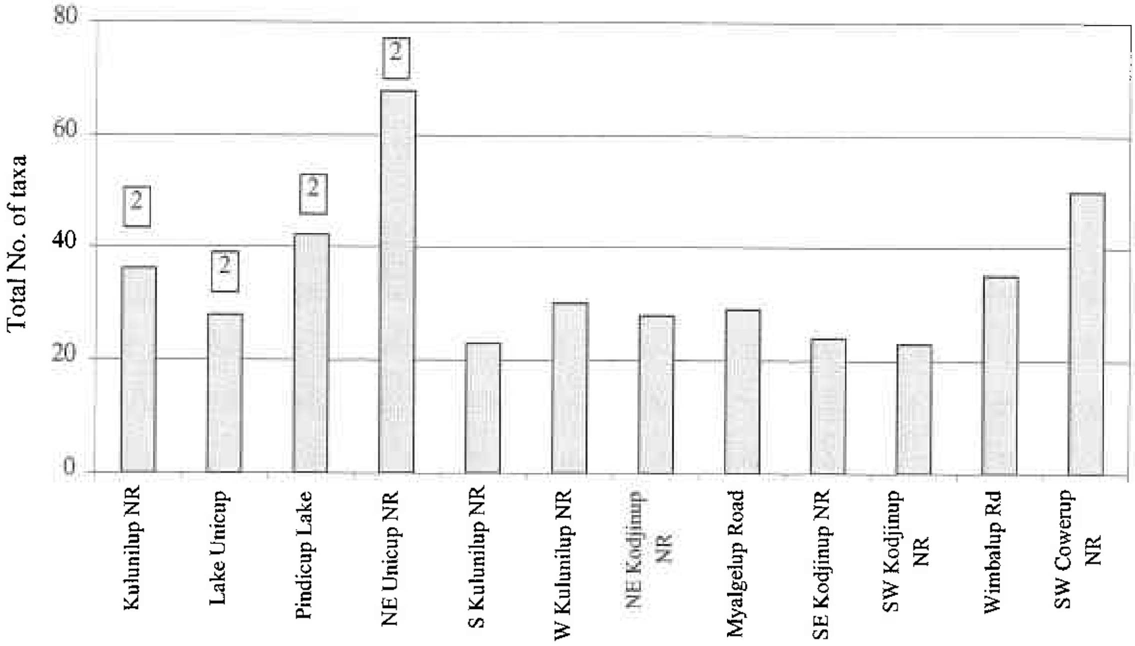

Figure 13. Total number of taxa recorded over all sampling occasions at the additional suite of 12 wetlands. All sites were sampled in October 1997, and those indicated (2) were sampled twice, in May and October 1997.

Comparisons in taxa richness between this and other studies are possible, but must be treated with caution because of differences in sampling method (e.g. standardised sweeps of open water versus rigorous sweeps of all habitats), level of taxonomic resolution, exclusion of micro-fauna/micro-crustacea in this study, and number of times each wetland was sampled. Allowing for these limitations (e.g. where possible, excluding micro-crustacea from taxa counts in other studies, and adjusting for sampling effort), comparisons are possible with studies of wetlands in Two Peoples Bay Nature Reserve (Storey *et al.*, 1993), wetlands on the Swan Coastal Plain (Davis *et al.*, 1993), South Coast wetlands (Edward *et al.*, 1994), southern peatlands and shrublands in WA (Horwitz, 1994), and wetlands in the Perth Airport (Halse & Storey, 1996).

In the present study, average numbers of macroinvertebrate taxa per season were 30.3 (October 1996), 32.6 (January 1997), 22.0 (May 1997), and 31.2 (October 1997) with maxima at a site of 41, 51, 49 and 52 taxa in each season respectively, and an average total (and maximum) number of taxa per site across all sampling occasions of 46.6 (81) taxa.

Storey *et al* (1993) sampled three wetlands in the Two Peoples Bay Nature Reserve (Lakes Angove, Moates and Gardner Lakes) in winter 1990 and summer 1991, and recorded a total of 170 taxa, which included 47 taxa of Protozoa and Rotifera, 52 taxa of microcrustacea (Cladocera, Copepoda and Ostracoda), and 71 taxa of macroinvertebrates. The average number of macroinvertebrate taxa (e.g. excluding the micro-faunal elements) recorded in each season at the three lakes were 22.3 (winter) and 20.6 (summer), with respective maxima of 26 and 31 taxa from any one site.

Davis *et al.* (1993) studied the physico-chemistry and invertebrate fauna of 41 wetlands on the Swan Coastal Plain in summer of 1989 and spring of 1989 and 1990. A total of 253 taxa were recorded, which included 73 taxa of micro-invertebrates (37 species of Cladocera, 26 species of Ostracoda, and 10 species of Copepoda). Totals of 140, 203 and 187 taxa were recorded in summer 1989, spring 1989 and spring 1990, respectively. The average (and maximum) number of macroinvertebrate taxa per wetland were 25.8 (50), 35.1 (65), and 34.6 (66) in summer 1989, spring 1989 and spring 1990 respectively, with an average total (and maximum) per site of 52.8 (95) taxa for the three sampling occasions combined.

Edward *et al.* (1994) sampled 15 permanent wetlands in winter and 12 wetlands in summer 1991 along the south coast of WA between Cape Naturalist and Albany. A total of 209 taxa were recorded, including 33 taxa of microcrustacea. Mean number of taxa (including microfauna) recorded in winter and summer were 32.4 and 39.0, with respective maxima of 51 and 56 taxa.

Horwitz (1994) sampled 45 wetlands in the southern region of southwestern Australia, with sites sampled each season (quarterly) throughout 1993 and early 1994. The study directly overlapped with the current study, with four sites sampled in the Muir/Unicup catchments, and both studies had two sites in common (Poorginup Swamp, site #1; and Lake Unicup, site #24). Comparisons are restricted by differences in sampling methodology (e.g. Horwitz (1994) sampled interstitial fauna from an auger hole, pholeteros (burrow fauna) by flushing crayfish burrows, and aquatic fauna by sweep samples of surface waters with a 125 µm net, as opposed to the present study which sampled aquatic fauna from surface waters with a 250µm mesh net), and taxonomic resolution (e.g. although Horwitz (1994) did not identify microcrustacea, Oligochaeta were taken to species level, but Gastropoda, Amphipoda, Isopoda, Ephemeroptera, Plecoptera, Trichoptera, Hemiptera and Coleoptera were not identified beyond Order level). Horwitz (1994) recorded 217 taxa from the whole region (60 taxa in interstitial habitat, 75 from burrows and 205 taxa from surface waters). An average of 27.2 taxa were recorded from the four sites in the Muir/Unicup catchments, with approximate totals of 36 and 23 taxa in Poorginup Swamp and Lake Unicup respectively. The current study recorded totals of 68 and 28 taxa from these same two sites.

Halse & Storey (1996) sampled nine swamps around Perth Airport in September and November 1995 and recorded a total of approximately 125 taxa, including 42 taxa of micro-crustacea. A maximum of 56 taxa (including 12 taxa of microcrustacea) was recorded at a wetland on one occasion, with an average per wetland of 30 taxa (including microcrustacea).

Generally, allowing for the above-listed differences between the various studies, macroinvertebrate taxa richness in this study appears to be greater than most previous studies. Qualitatively, this is partly due to the high number of Coleoptera (62 taxa of adults and larvae) and Chironomidae (42 taxa), and quite a diverse Odonata fauna (17 species). Considering that most other studies recorded a high proportion of micro-invertebrates (e.g. of the total number of taxa recorded by Davis *et al.* (1993), 15% were Cladocera, 10% Ostracoda and 4% Copepoda), the taxa lists for the current study will likely be much increased when the micro-invertebrate component is identified. Therefore, these comparisons of taxa richness should be repeated once the micro-faunal components have been identified from the Muir/Unicup wetlands.

4.2.2 Taxa distributions and degree of endemism

This report uses a similar classification to Horwitz (1994) who assessed the degree of endemism of the aquatic fauna of wetlands in the southern region of southwestern Australia. In the current study, all taxa were allocated to one of four categories:

- Common (C) (*viz.* taxon has been recorded in other States/Territories)
- Endemic (S) to the southwest of Western Australia (*viz.* is restricted to, but is widely distributed across the southwest of the state)
- Locally (L) endemic within the southwest of Western Australia (*viz.* appears restricted to a few locations within the southwest of the State)
- Indeterminate (I) distribution (*viz.* there is currently insufficient knowledge on either the distribution or taxonomy of the taxon to assess its level of endemism).

The levels of endemism of each taxon recorded are summarised in a systematic listing, and as sites ranked by richness and number of endemic species (Table 12a & b). There were 32 taxa endemic to the southwest and 7 locally-endemic taxa recorded from the study area. Eleven swamps had 10 or more southwest endemic taxa, with the greatest recorded from Poorginup Swamp (16), Loc. 12767 (15) and Yarnup (15). Generally, there were few locally-endemic species recorded in this study. Mulgarnup had the greatest number (4), eight sites had two locally endemic taxa and 13 sites contained one locally-endemic species The ceinid amphipod *Austrochiltonia* sp.2, which appears to be a new species (B. Knott, pers. com.) occurred at 15 sites, and the new dytiscid beetle, *Sternopriscus* sp. nov. (C. Watts pers. com.) was recorded from 13 sites. Generally, it is difficult to allocate many southwest endemic taxa to this level because of insufficient survey effort and inadequate taxonomy. There was also a high proportion of indeterminate taxa, some of which may classify as southwest or locally-endemic once their taxonomy has been better resolved.

Assessing levels of endemism at each site should be repeated once the micro-faunal components have been identified. Based on other studies (e.g. Storey *et al.*, 1993; Halse & Storey, 1996), there is likely to be a relatively large component of southwest endemic, locally-endemic and new species in the microfauna.

Table 12a. Mean abundance ($\log_{10}$) of each taxon at each site over all sampling trips, with total number of taxa and numbers of southwest Western Australia endemic and restricted endemic taxa. The level of endemism (E) of each taxa is indicated (C = common taxa recorded from other states/territories, S = endemic to southwestern Australia, but commonly occurring, L = endemic to southwestern Australia, but with a restricted occurrence, I = indeterminate status due to insufficient taxonomic information, I* = indeterminate but probably occurs only in southwestern Australia, ? = awaiting taxonomic identification).

Order	Family	Species	Endemism	1	2	5	6	7	8	11	12	14	15	16	18	19	24	29	30	31	33	35	37	38	43	44	49	50	52	53
PORIFERA	Spongillidae	*Spongilla* sp.	C	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CNIDARIA																														
Hydrozoa	Hydridae	*Hydra* sp	C	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEMATODA		*Nematoda*	C	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
MOLLUSCA																														
Gastropoda	Ancylidae	*Ferrisia petterdi*	C	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrobiidae	*?Glacidorbis* sp	S*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lymnaeidae	*Austropeplea ?lessoni* (juveniles)	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Planorbidae	*Glyptophysa* (*Glyptophysa*) sp1	I*	0.67	1.33	1.67	0.67	0.00	1.33	0.50	1.00	1.00	1.00	0.67	1.33	0.67	0.00	0.67	0.00	0.00	0.00	0.00	0.00	3.00	0.00	1.00	1.00	2.00	1.00	1.00
		Glyptophysa (*Glyptophysa*) sp2	I*	0.00	1.00	0.67	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
	Assimineidae	*Assiminea* sp.	I	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pomatiopsidae	*Coxiella* (*Coxiella*) *striatula*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Coxiella (*Coxiella*) *striatula/exposita*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.67	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ANNELIDA																														
Oligochaeta		Oligochaetae V1	C	1.00	1.00	0.67	0.67	1.33	0.67	1.00	0.67	1.00	1.00	0.67	0.67	1.00	1.00	0.00	1.00	1.33	0.00	1.50	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Hirudinea		Hirudinae spB1	I	0.00	0.33	0.00	0.00	0.33	0.33	0.50	0.00	0.00	0.00	0.33	0.00	0.33	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
		Hirudinae sp2	I	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.33	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Hirudinae sp3	I	0.00	1.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Hirudinae sp4	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Hirudinae sp5	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ARTHROPODA																														
Hydracarina	Arrenuridae	*Arrenurus* (*Arrenurus*) *australicus*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Arrenurus (*Arrenurus*) *balladoniensis*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Arrenurus (*Micruracarus*) *forpicatoides*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Arrenurus (*Truncaturus*) *tasmanicus*	C	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	1.00
		Arrenurus sp.	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Eylaidae	*Eylais* sp.	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.67	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	2.00
	Halacaridae	Halacaridae sp.	I	0.33	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrachnidae	*Hydrachna* sp.	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrodromidae	*Hydrodroma* sp.	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydryphantidae	*Hydryphantes* sp. 1	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
		Pseudohydryphantes doegi	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
	Limnesidae	*Limnesia longigenitalis*	C	1.00	0.00	0.00	0.00	0.00	0.00	0.50	0.67	0.00	0.00	0.00	0.33	0.67	0.00	0.33	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	2.00	1.00
	Limnocharidae	*Limnochares australica*	C	0.67	1.00	0.00	0.00	0.67	1.00	0.00	0.00	0.67	1.00	0.67	0.67	0.00	0.00	0.33	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mideopsidae	*Tillia* sp. 1	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Oxidae	*Oxus australicus*	C	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Oxus sp. 1	I	0.33	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pezidae	*Peza* sp. 1	S	0.33	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.67	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pionidae	*Larri laffa*	L	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Piona murleyi	S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Unionicolidae	*Koenikea verrucosa*	C	0.33	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CRUSTACEA																														
Brachiopoda	Concostraca	*Lynceus* sp1	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Isopoda	Oniscoidea	Oniscoidea sp1	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
		Oniscoidea spV2	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Phreatoicidea	*Paramphisopus* sp nov.	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Amphipoda	Ceinidae	*Austrochiltonia* sp1	L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Austrochiltonia sp2	L	0.00	2.00	2.33	0.67	0.00	0.00	1.50	1.67	2.67	2.00	1.33	1.33	0.00	2.50	3.00	3.50	3.67	3.67	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Gammaridae	*Perthia acutitelson*	S	0.33	0.00	0.33	0.00	1.00	0.67	0.00	1.00	0.67	0.67	0.67	1.67	1.67	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	1.00	0.00	1.00
		Perthia branchialis	S	1.67	0.00	0.67	1.00	0.33	0.67	0.50	0.67	0.00	0.33	0.00	1.67	1.33	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	2.00	0.00	2.00

Order	Family	Species	Endemism	1	2	5	6	7	8	11	12	14	15	16	18	19	24	29	30	31	33	35	37	38	43	44	49	50	52	53
Decapoda	Palaemonidae	*Palaemonetes australis*	S	0.33	2.00	0.00	1.00	0.00	0.00	1.50	0.67	2.00	1.33	2.33	0.67	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	2.00	2.00
	Parastacidae	*Cherax preisii*	S	0.33	0.00	0.33	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.00	0.33	0.67	0.00	0.67	0.50	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	1.00	0.00	1.00
		Cherax quinquecarinatus	S	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INSECTA																														
Diptera	Chaoboridae	Chaoboridae sp.	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Culicidae	*Culex ?Cx. annulirostris*	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.67	0.00	1.33	0.00	0.00	0.00	0.00	0.00	1.00	2.00	0.00	0.00	3.00	0.00	2.00
		Coquillettidia sp.	I	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Anopheles (*Cellia*) sp.	I	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
		Anopheles (*Anopheles*) *?atratipes*	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
	Chironomidae																													
		Tanypodinae *Alotanypus dalyupensis*	S	1.00	0.00	1.67	0.67	0.33	0.67	1.00	1.00	0.33	0.33	1.33	1.67	0.67	0.50	2.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	0.00	1.00	1.00	1.00
		Tanypodinae *Paramerina levidensis*	S	2.33	1.00	2.33	0.67	1.67	1.67	1.50	2.00	0.00	0.33	0.67	2.33	1.33	0.50	3.00	0.50	0.00	0.33	2.50	3.00	0.00	3.00	3.00	2.00	3.00	2.00	2.00
		Tanypodinae *Paramerina* sp (VBM3)	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Tanypodinae *Pentaneurini* Genus C	S	1.00	0.00	0.00	0.00	0.67	0.33	0.00	0.00	0.00	0.67	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00
		Tanypodinae *Procladius villosimanus*	C	0.00	0.67	1.67	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	2.50	1.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
		Tanypodinae Tanypodinae ?genus (VBM7)	I*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae *?Paralymnophyes* sp	I*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae *Corynoneura* sp	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.50	0.00	0.00	0.00	0.00	1.00	1.00	2.00	0.00	0.00	0.00	2.00	0.00	1.00
		Orthocladiinae *Cricotopus ?albitibia*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae *Larsia ?albiceps*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae *?Limnophyes pullulus*	C	1.67	0.33	1.33	0.00	0.67	0.67	1.00	1.67	1.67	1.33	1.00	0.67	0.33	1.50	0.33	0.00	0.00	0.67	1.00	2.00	3.00	3.00	2.00	2.00	3.00	3.00	0.00
		Orthocladiinae Orthocladiinae (VSC11)	I*	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae Orthocladiinae (VSCL38)	I*	0.00	1.67	1.33	0.00	0.33	0.00	2.50	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae Orthocladiinae (VSCL7)	I*	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae Orthocladinae (V31)	I	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae Orthocladinae (V43)	I	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae Orthocladinae (V44)	I*	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae Orthocladinae ?genus	I*	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae *Procladius paludicola*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthocladiinae *Thienemanniella* sp (V19)	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae Chironomini Genus (VSCL35)	I*	0.67	0.33	1.33	0.00	0.33	2.00	1.00	0.67	0.00	0.33	0.67	1.33	0.00	0.00	1.33	0.00	0.00	0.00	2.50	2.00	0.00	0.00	0.00	0.00	0.00	2.00	1.00
		Chironominae *Chironomus* aff. *alternans*	C	1.67	1.00	1.67	0.33	0.67	1.00	1.00	1.67	0.67	0.33	1.33	1.67	2.00	0.00	2.67	0.00	0.00	0.67	1.50	2.00	0.00	2.00	2.00	2.00	2.00	0.00	1.00
		Chironominae *Chironomus occidentalis* Skuse	S	0.00	0.33	0.00	0.67	0.00	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Cladopelma curtivalva*	C	0.67	1.67	3.00	1.00	1.67	0.00	1.00	0.67	0.67	1.00	1.00	1.33	0.33	1.50	2.67	0.50	0.67	0.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	1.00
		Chironominae *Cladotanytarsus* sp (VBM4)	I	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Cladotanytarsus* sp (VBM6)	I	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Cryptochironomus griseidorsum*	C	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Dicrotendipes ?conjunctus*	C	0.33	1.00	2.67	0.33	0.33	2.00	0.50	0.67	1.00	0.67	1.00	2.33	1.67	2.00	2.00	1.00	0.00	1.33	3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
		Chironominae *Dicrotendipes* sp. V47	S	1.00	1.00	2.33	0.67	0.33	1.33	0.50	1.67	0.67	0.67	2.00	2.00	0.33	0.50	2.00	0.00	0.00	0.00	1.50	1.00	0.00	2.00	2.00	2.00	1.00	2.00	1.00
		Chironominae *Harrisius* sp (VBM5)	I*	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Kiefferulus intertinctus*	C	0.00	0.00	0.67	1.33	0.00	0.33	0.00	0.00	0.00	0.00	0.33	0.67	0.33	0.50	1.33	0.00	0.00	0.67	0.50	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Kiefferulus martini*	C	0.67	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	2.67	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
		Chironominae *Polypedilum nubifer*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Polypedilum* sp (VSCL8)	I	0.00	1.33	0.00	0.00	0.00	0.00	0.50	0.00	2.33	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
		Chironominae *Procladius* sp(VBM2)	I	0.00	0.00	2.33	0.33	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	2.50	1.67	0.00	1.33	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Tanytarsini* ?genus	I	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Tanytarsus ?barbitarsus*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Tanytarsus* sp (VSCL18)	I	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Tanytarsus* sp (VSCL9)	I	0.00	0.67	1.00	0.00	0.67	0.00	2.50	0.00	0.33	0.00	1.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Chironominae *Tanytarsus* sp(VBM1)	I	1.33	0.33	3.00	1.00	2.00	2.00	2.50	2.00	2.00	1.33	1.33	2.67	1.67	2.50	3.00	1.50	0.33	1.67	3.00	3.00	1.00	3.00	2.00	2.00	3.00	2.00	3.00
		Chironominae *Tanytarsus* sp(VSCL5)	I	0.00	0.33	1.33	0.00	0.33	0.00	2.00	0.00	0.00	0.00	0.33	1.00	0.67	0.50	0.67	0.00	0.00	0.00	0.00	2.00	0.00	2.00	2.00	1.00	0.00	2.00	2.00
		Chironominae *Xenochironomus* sp1	I*	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ceratopogonidae	Ceratopogonidae spp	I	0.33	1.33	0.33	0.00	0.67	1.67	0.50	1.00	0.33	1.00	1.00	0.33	0.00	0.50	1.33	1.50	0.33	1.00	1.50	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00
		Forcipomyiinae sp1	I	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tabanidae	Tabanidae spB1	I	0.00	0.67	0.00	0.33	0.00	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.50	0.67	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tipulidae	Tipulidae spB1	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Tipulidae sp B2	I	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Empididae	Empididae sp1	I	0.33	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ephydridae	Ephydridae sp1	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Order	Family	Species	Endemism	1	2	5	6	7	8	11	12	14	15	16	18	19	24	29	30	31	33	35	37	38	43	44	49	50	52	53
		Ephydridae sp2	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Stratiomyidae	Stratiomyidae sp	I	0.00	0.67	0.33	0.33	0.00	0.33	0.00	0.33	0.67	1.00	0.33	0.00	0.00	0.00	0.33	0.00	0.33	0.67	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Muscidae	Muscidae sp1	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sciomyzidae	Sciomyzidae sp1	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pyralidae	?Pyralidae sp	I	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	1.33	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Scirtidae	Scirtidae	I	0.67	0.00	0.00	0.33	1.00	0.00	0.00	0.33	0.33	0.00	0.33	0.67	0.33	0.00	0.00	0.00	0.67	0.00	0.50	0.00	0.00	1.00	0.00	0.00	1.00	0.00	2.00
Odonata																														
Zygoptera	Coenagrionidae	*Austroagrion coeruleum*	S	0.00	0.33	0.33	0.00	0.33	0.33	0.00	0.00	0.33	0.00	0.67	0.00	0.33	0.00	2.33	2.00	0.00	0.67	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Ishnura aurora	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Xanthagrion erythroneurum	C	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.67	0.50	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Megapodagrionidae	*Argiolestes pusillus*	S	0.33	0.00	0.33	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	1.00
	Lestidae	*Austrolestes analis*	C	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.33	0.33	0.00	0.67	0.67	0.00	0.67	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	1.00	2.00	0.00	3.00
		Austrolestes annulosus	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.33	2.00	0.67	1.33	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Austrolestes io	I	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Austrolestes psche	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anisoptera	Cordulidae	*Hemicordulia tau*	C	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.00	0.50	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Procordulia affinis	S	0.33	0.67	1.00	0.67	0.67	1.00	0.50	1.00	0.00	0.67	1.00	0.00	0.33	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
		Synthemis macrostigma	S	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Libellulidae	*Austrothemis nigrescens*	C	0.00	0.00	0.67	0.00	0.67	0.67	0.00	0.00	0.33	0.33	0.67	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Diplacodes bipunctata	C	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.50	0.00	0.67	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Hemianax papuensis	C	0.00	0.33	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.33	0.00	0.00	0.67	0.00	0.00	0.33	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Orthetrum caledonicum	C	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.00	1.00	0.00	0.33	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Aeshnidae	*Aeshna brevistyla*	C	0.33	0.00	0.00	0.33	1.00	0.00	0.00	0.33	0.33	0.00	0.33	0.33	0.67	0.00	1.00	1.50	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Gomphidae	*Austrogomphus collaris*	S	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemiptera	Hemiptera	Hemiptera sp2	I	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Hemiptera sp3	I	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Corixidae	*Micronecta robusta*	C	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.67	0.50	0.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
		Corixidae sp (juvenile)	I	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.67	0.50	0.33	0.00	0.00	0.33	0.00	0.00	0.00	1.00	2.00	0.00	0.00	0.00	0.00
		Agraptocorixa eurynome	C	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Sigara mullaka	S	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.33	0.50	0.00	0.33	0.50	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
		Diaprepocoris personata	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.67	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
	Gerridae	Gerridae sp1	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Gerridae sp2	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Nepidae	*Laccotrephes tristis*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Notonectidae	*Anisops ?elstoni*	C	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.33	0.00	0.00	1.00	1.33	0.00	2.00	2.50	0.33	1.67	2.50	0.00	2.00	2.00	0.00	1.00	2.00	0.00	1.00
		Notonecta sp ?	I	1.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	1.33	0.33	1.67	1.00	0.00	1.67	1.50	0.00	0.67	1.50	0.00	2.00	3.00	0.00	0.00	1.00	0.00	2.00
		Anisops sp (juveniles)	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.50	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pleidae	Pleidae sp	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	1.33	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Veliidae	Veliidae sp1	I	0.67	0.00	0.67	0.00	0.33	0.67	0.00	1.00	0.00	0.67	0.67	0.67	0.67	0.00	0.33	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Veliidae sp4	I	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ephemeroptera	Baetidae	*Cloeon* sp	I	0.00	0.00	1.33	0.00	0.00	0.33	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.33	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Caenidae	*Tasmanocoenis tillyardi*	C	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	2.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trichoptera	Ecnomidae	*Ecnomus* sp	C	0.67	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.33	0.33	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Ecnomina sentosa	C	0.33	0.00	0.00	0.00	0.67	0.00	0.00	0.67	0.00	0.67	0.00	0.00	0.33	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Leptoceridae	*Notalina ?fulva*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Notoperata tenax	S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Triplectides spB	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
		Leptoceridae sp1	I	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Leptoceridae sp2	I	0.00	0.67	0.00	0.33	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.00	1.00	0.50	0.00	0.33	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
		Leptoceridae sp3	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Leptoceridae sp4	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
		Leptoceridae spH	I	1.00	0.00	0.67	0.00	0.00	0.00	0.00	1.00	0.00	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	2.00	2.00
		Leptoceridae spI	I	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Oecetis sp1	I	0.00	1.67	0.33	0.00	0.00	0.33	1.00	0.00	0.67	0.00	0.33	0.00	0.00	0.00	0.67	0.50	0.00	0.33	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Oecetis sp3	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Oecetis sp2	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydroptilidae	*Acritoptila globosa*	S	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Hellythira sp1	I	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.50	0.33	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Hellythira sp2	I	0.00	1.33	0.00	0.00	1.00	0.67	0.00	0.00	0.00	0.00	0.67	0.33	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00

Order	Family	Species	Endemism	1	2	5	6	7	8	11	12	14	15	16	18	19	24	29	30	31	33	35	37	38	43	44	49	50	52	53
		Hellythira sp3	I	0.00	0.33	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coleoptera	coleoptera	Coleoptera sp10	?	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	coleoptera	Coleoptera sp3	?	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	coleoptera	Coleoptera sp9	?	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00
	Curculionidae	Curculionidae sp(L)	I	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Curculionidae	Curculionidae spA	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
	Curculionidae	Curculionidae spB	I	0.00	0.33	0.00	0.00	0.33	0.00	0.50	0.33	0.67	0.00	0.33	0.33	0.00	0.50	0.33	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
	Curculionidae	Curculionidae spC	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Allodessus bistrigatus*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	1.00	0.00	2.00
	Dytiscidae	*Antiporus femoralis*	C	0.00	0.67	0.00	0.33	0.00	0.33	0.50	0.00	0.00	0.33	0.00	0.00	0.33	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00
	Dytiscidae	*Antiporus* sp (L)	I	0.33	0.00	0.00	0.00	0.67	0.00	0.50	0.33	0.00	0.33	0.00	0.33	0.67	0.00	0.00	0.50	0.00	0.67	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
	Dytiscidae	*Antiporus* sp1	?	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Copelatus ater*	S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
	Dytiscidae	*Copelatus* sp(L)	S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
	Dytiscidae	*Cybister* sp (L)	C	0.33	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.33	0.67	0.33	0.67	0.00	0.00	0.00	0.50	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00
	Dytiscidae	*Homeodytes* sp (L)	C	0.00	0.33	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Hydaticus* sp (L)	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00
	Dytiscidae	*Hyphydrus elegans*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Hyphydrus* sp (L)	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Lancetes lanceolatus*	C	0.00	0.33	0.33	0.33	0.00	0.33	0.50	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
	Dytiscidae	*Lancetes* sp (L)	C	0.00	0.33	0.00	0.33	0.00	0.33	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
	Dytiscidae	*Liodessus dispar*	S	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Liodessus inornatus*	S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.50	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Megaporus solidus*	C	0.33	0.33	0.67	0.67	0.33	0.00	0.50	0.67	0.67	0.33	0.33	1.00	0.00	0.00	1.67	0.00	0.00	0.67	1.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	1.00
	Dytiscidae	*Megaporus* sp (L)	S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	1.00	0.50	0.00	1.00	0.50	1.00	2.00	0.00	0.00	1.00	0.00	0.00	1.00
	Dytiscidae	*Necterosoma darwini*	S	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.67	0.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Necterosoma* sp (L)	S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	1.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Platynectes* sp (L)	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Rhantus suturalis*	C	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00
	Dytiscidae	*Spencerhydrus pulchellus*	S	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Sternopriscus browni*	S	0.00	0.00	0.67	0.00	0.67	0.67	0.50	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
	Dytiscidae	*Sternopriscus marginatus*	S	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Sternopriscus minimus*	S	0.33	0.00	0.67	0.33	0.67	0.67	0.50	0.33	0.00	0.00	0.33	0.67	0.67	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
	Dytiscidae	*Sternopriscus multimaculatus*	I	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dytiscidae	*Sternopriscus* sp nov	L	0.67	0.00	0.33	0.00	1.00	0.00	0.00	0.33	0.33	1.00	0.33	0.33	0.67	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00
	Dytiscidae	*Sternopriscus* sp (L)	I	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.33	0.00	0.00	0.50	0.00	0.67	0.50	1.00	2.00	2.00	1.00	0.00	0.00	1.00	2.00
	Dytiscidae	*Uvarus pictus*	S	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.33	1.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	2.00
	Gyrinidae	GYRINIDAE sp1 (L)	I	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Gyrinidae	*Macrogyrus ?angustatus*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
	Haliplidae	HALIPLIDAE sp (L)	I	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
	Haliplidae	*Haliplus gibbus/fuscatus*	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	2.00	1.00	2.00	0.00	1.00	2.00
	Hydraenidae	*Hydraena* sp1 (A)	I	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
	Hydrophilidae	*Berosus discolor*	C	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.33	0.33	0.00	0.00	0.00	0.50	0.33	0.67	0.00	0.00	0.00	1.00	0.00	2.00	0.00	1.00	2.00
	Hydrophilidae	*Berosus munitipennis*	C	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.33	0.00	0.00	0.50	0.00	0.00	0.33	0.67	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
	Hydrophilidae	*Berosus* sp (L)	C	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	1.33	0.33	0.33	0.00	0.00	0.00	0.33	1.00	2.00	1.67	1.00	0.00	1.00	1.00	0.00	0.00	0.00	1.00	2.00
	Hydrophilidae	*Enochrus eyrensis*	C	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.33	0.00	0.00	0.33	0.00	0.00	0.67	0.00	0.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00
	Hydrophilidae	*Helochares tenuistriatus*	C	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrophilidae	*Hydrochus* sp1	I	0.00	0.33	0.33	0.33	0.33	0.33	0.00	0.33	0.00	0.00	0.33	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrophilidae	*Hydrochus* sp2	I	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.33	1.67	0.33	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
	Hydrophilidae	*Hydrochus* sp3	I	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.33	0.00	0.33	0.33	0.67	0.00	0.00	0.33	0.50	0.00	0.33	0.50	0.00	1.00	0.00	1.00	1.00	0.00	1.00	0.00
	Hydrophilidae	HYDROPHILIDAE sp1 (L)	I	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	1.00	0.33	0.67	0.00	0.00	0.00	0.33	0.00	0.33	0.67	0.50	2.00	3.00	0.00	0.00	1.00	0.00	1.00	1.00
	Hydrophilidae	HYDROPHILIDAE sp2 (L)	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrophilidae	HYDROPHILIDAE sp3 (L)	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrophilidae	HYDROPHILIDAE sp4 (L)	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hydrophilidae	*Limnoxenus zealandicus*	C	0.33	0.33	0.67	0.33	0.67	0.33	0.50	0.00	0.00	0.67	0.33	0.33	0.00	0.00	0.67	0.00	0.00	0.67	0.50	1.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00
	Hydrophilidae	*Paracymus pygmaeus*	C	0.33	0.33	0.33	0.33	0.33	0.33	0.50	0.33	0.67	0.00	0.67	0.67	0.33	0.00	0.67	0.00	0.00	0.33	0.50	2.00	2.00	1.00	1.00	0.00	1.00	1.00	1.00
	Limnichidae	Limnichidae sp1 (A)	I	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
	Limnichidae	Limnichidae sp1 (L)	I	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Scirtidae	Scirtidae (L)	C	1.00	0.00	0.00	0.33	1.00	0.00	0.00	0.67	1.00	1.00	1.33	1.33	0.33	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Order	Family	Species	Endemism	1	2	5	6	7	8	11	12	14	15	16	18	19	24	29	30	31	33	35	37	38	43	44	49	50	52	53
		Total number of taxa		68	56	62	40	58	44	37	51	59	56	65	66	55	28	83	42	25	54	69	23	30	28	29	24	23	36	51
		No. of sw Western Australia endemics		16	8	15	9	14	11	8	11	10	11	9	14	11	6	15	6	2	8	6	4	1	5	8	7	8	8	13
		% of total no. taxa		24	14	24	23	24	25	22	22	17	20	14	21	20	21	18	14	8	15	8.7	17	3.3	18	28	29	35	22	25
		No.of sw WA restricted endemics		2	1	2	1	1	0	1	4	2	2	2	2	1	1	1	1	1	1	2	0	1	0	1	0	0	2	1
		% of total no. taxa		2.9	1.8	3.2	2.5	1.7	0.0	2.7	7.8	3.4	3.6	3.1	3.0	1.8	3.6	1.2	2.4	4.0	1.9	2.9	0.0	3.3	0.0	3.4	0.0	0.0	5.6	2.0

Table 12b. Sites ranked in descending order by species richness, number of southwest Western Australian endemic species and number of southwest WA endemics with restricted distributions (see Table 12a).

Sites by total number of taxa	No. taxa	Sites by no. sw WA endemics	No endemics	Sites by no. restricted endemics	No. restricted
Loc. 12676, S of E end of Pindicup Rd	83	Poorginup Swamp	16	Mulgarnup Swamp	4
NE Unicup NR	69	Loc. 12676, S of E end of Pindicup Rd	15	Poorginup Swamp	2
Poorginup Swamp	68	Yarnup Swamp	15	Yarnup Swamp	2
Western swamp in Kodjinup NR	66	Western swamp in Kodjinup NR	14	Byenup Lagoon	2
Geordinup Swamp	65	Cobertup Swamp	14	N end of Byenup Lagoon	2
Yarnup Swamp	62	SW Cowerup NR	13	Geordinup Swamp	2
Byenup Lagoon	59	N end of Byenup Lagoon	11	Western swamp in Kodjinup NR	2
Cobertup Swamp	58	Galamup Swamp	11	NE Unicup NR	2
Tordit-Gurrup Lagoon	56	Mulgarnup Swamp	11	Wimbalup Rd	2
N end of Byenup Lagoon	56	Noobijup Swamp	11	Tordit-Gurrup Lagoon	1
Galamup Swamp	55	Byenup Lagoon	10	Bokarup Swamp	1
Loc. 12561, SE of Geordinup Rd	54	Geordinup Swamp	9	Cobertup Swamp	1
Mulgarnup Swamp	51	Bokarup Swamp	9	Kulunilup NR	1
SW Cowerup NR	51	Tordit-Gurrup Lagoon	8	Galamup Swamp	1
Noobijup Swamp	44	Loc. 12561, SE of Geordinup Rd	8	Lake Unicup	1
Pindicup Lake	42	Kulunilup NR	8	Location 12676, S of E end of Pindicup Rd	1
Bokarup Swamp	40	Wimbalup Rd	8	Pindicup Lake	1
Kulunilup NR	37	Myalgelup Road	8	Location 12686, SW of Unicup NR	1
Wimbalup Rd	36	SW Kodjinup NR	8	Location 12561, SE of Geordinup Rd	1
W Kulunilup NR	30	SE Kodjinup NR	7	W Kulunilup NR	1
Myalgelup Road	29	NE Unicup NR	6	Myalgelup Road	1
Lake Unicup	28	Pindicup Lake	6	SW Cowerup NR	1
NE Kodjinup NR	28	Lake Unicup	6	Noobijup Swamp	0
Loc. 12686, SW of Unicup NR	25	NE Kodjinup NR	5	S Kulunilup NR	0
SE Kodjinup NR	24	S Kulunilup NR	4	NE Kodjinup NR	0
S Kulunilup NR	23	Loc. 12686, SW of Unicup NR	2	SE Kodjinup NR	0
SW Kodjinup NR	23	W Kulunilup NR	1	SW Kodjinup NR	0

4.2.3 Ordination and classification

Classification and ordination of the original 15 wetlands on macroinvertebrate fauna are presented in Figures 14 – 19. For each season, the groupings identified from the respective UPGMA classification of the sites are overlain on the ordination plots, and the most significant gradients in taxa abundances and all significant gradients in physico-chemical parameters are indicated on each ordination. In all seasons, there was a significant separation of the UPGMA groupings in ordination space ($p<0.0001$). This demonstrates that there are distinct groups (*viz.* types) of wetlands based on macroinvertebrate fauna. The gradients in taxa abundances and physico-chemical variables show (a.) taxa that are responsible for the separation of sites in ordination space and (b.) physico-chemical variables which may be influencing community composition.

In the ordination of sites sampled in October 1996 there was a significant separation of sites into groups, but only one physico-chemical gradient was significant (pH; Figure 15). The absence of strong gradients in physico-chemical variables probably reflects the high water levels in all wetlands in October 1996, with little differentiation between wetlands in terms of water quality. As the summer progressed (January and May 1997), those variables related to increasing salinity became more significant (Figures 17 & 19), and the separation of sites more distinct. This reflects the progressive effects of concentration in the receding wetlands.

Ordination of sites sampled in May 1997 (Figure 19) demonstrates this to the greatest effect, with a very strong separation of the naturally saline (sites #31 Loc. 12686 SW of Unicup NR and #33 Loc. 12561 SE of Geordinup Rd) and secondary saline sites (site #14 Byenup Lagoon & #15 North end of Byenup Lagoon) from the remaining fresher wetlands. Within the fresher wetlands, the freshest (e.g. < 2.0 ppt) are furthest from the saline sites, with sites suffering some secondary salination (e.g. 2.0 to 4.0 ppt; site #5 Yarnup, #6 Bokarup, #12 Mulgarnup, #16 Geordinup) in an intermediate position. There are strong gradients in all water quality variables relating to increasing salinity (e.g. all ions, salinity, conductivity, alkalinity, and pH) and in co-dependent variables (e.g. increasing area of open water and area of submerged macrophyte) in the direction of the saline wetlands. Also, there are gradients in taxa abundances in the direction of the saline sites, and in the opposite direction. This indicates those taxa likely to increase in abundance with increasing salinity (e.g. *Austrochiltonia* sp.2, *Peza* sp1, Leptoceridae sp3, Oniscoidea spV2, *Coxiella striatula/exposita*, *Berosus* sp.(L)), and the converse (e.g. *Perthia branchialis*, *Dicrotendipes ?conjunctus*, *Austroagrion coeruleum*, *Hyphydrus elegans*, *Sternopriscus minimus*, *Tasmanocoenis tillyardi*, *Cloeon* sp., Hirudinea sp3, Veliidae sp4) (Figure 19).

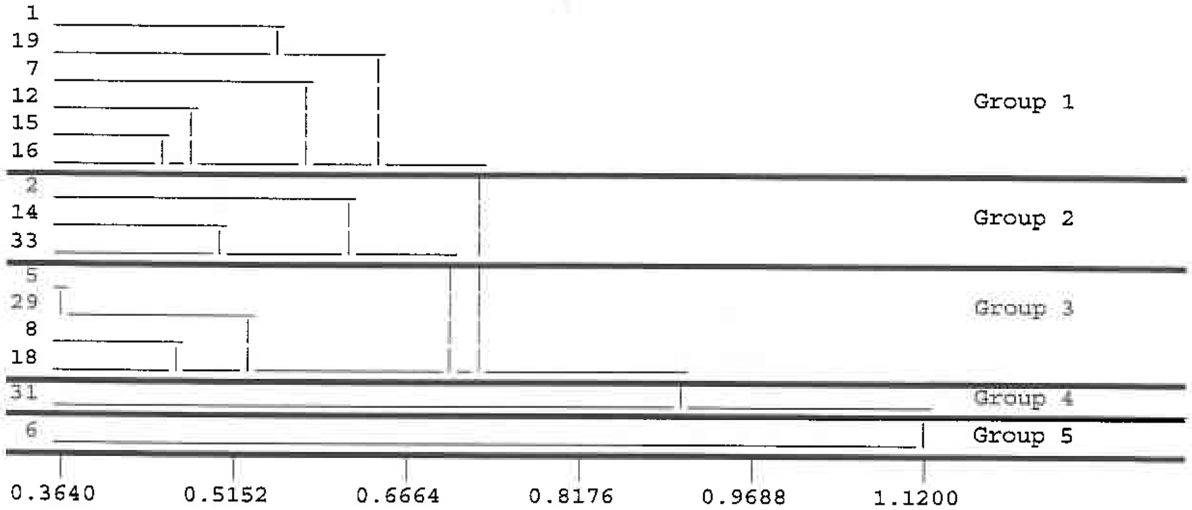

Figure 14. UPGMA classification of wetlands by macroinvertebrate taxa sampled in October 1996, indicating five main groups. Refer to Table 2 for site codes and names.

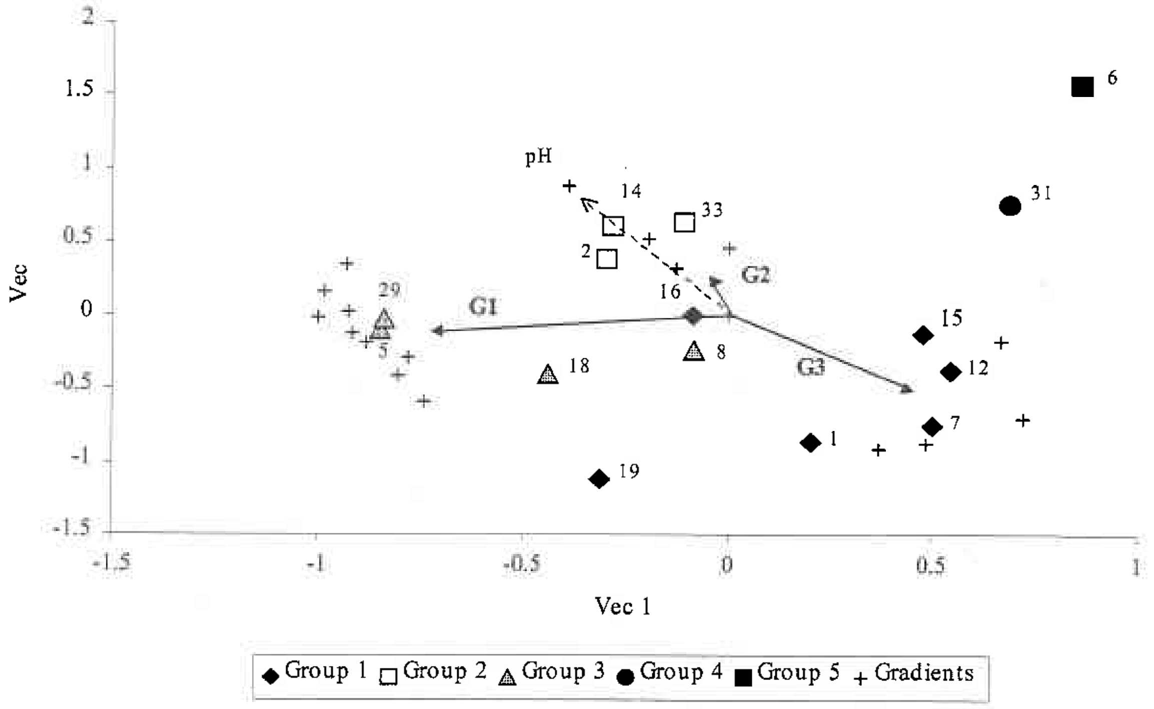

Figure 15. MDS ordination of wetlands by macroinvertebrate taxa sampled in October 1996. Groupings from the UPGMA classification and significant gradients in macroinvertebrate taxa (solid lines) and physico-chemical variables (dashed line) are overlain. Taxa are grouped under three general gradients (G1 – G3), refer to Table 13 for taxa on each gradient. Refer to Table 2 for site names. Optimum solution to the ordination was achieved with 3 dimensions and a stress of 0.1509.

Generally, there were very few instances where the separation of sites correlated to changes in nutrient concentration in the wetlands. This probably reflects that at this stage nutrient status has minimal influence on community structure (i.e. the wetlands do not behave as eutrophic, even though nitrogen levels are relatively high).

Table 13. Taxa in three general gradients (G1 – G3) through the ordination of wetlands sampled in October 1996 on taxa abundance data (Figure 15).

Gradients	Taxa gradients
Gradient 1	*Chironomus* aff. *alternans*, *Dicrotendipes* sp. V47, *Cladopelma curtivalva*, *Orthetrum calidonicum*, *Tanytarsus* sp.VBM1, *Alotanypus dalyupensis*, *Tanytarsus* sp VSCL5, *Dicrotendipes ?conjunctus*, *Paramerina levidensis*
Gradient 2	Hydrophilidae spH1, *Palaemonetes australis*, *Uvarus pictus*
Gradient 3	*Perthia acutitelson*, Corixidae sp(juv.), Leptoceridae spH, *Ecnomina sentosa*

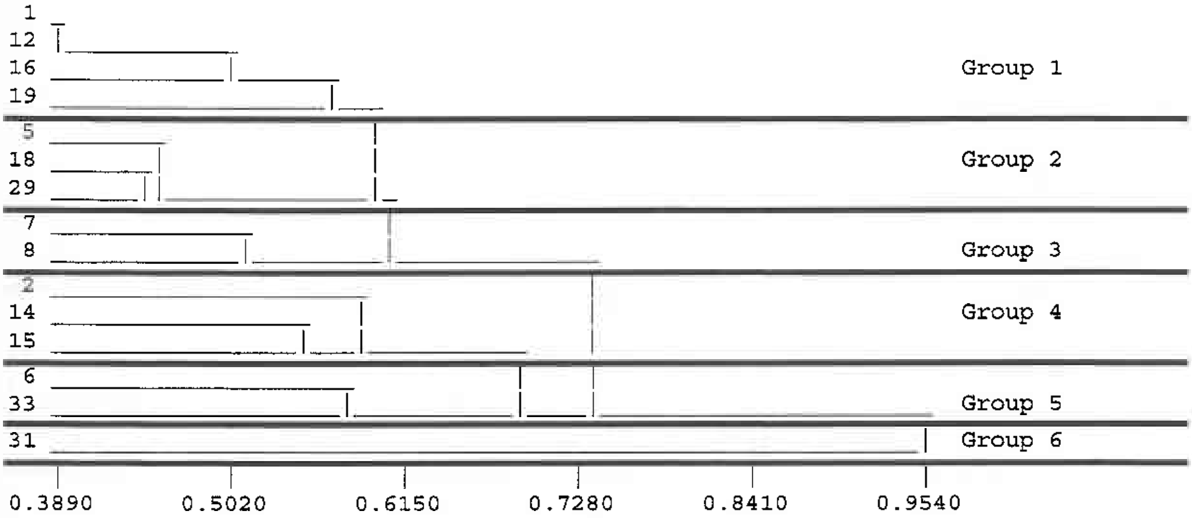

Figure 16. UPGMA classification of wetlands by macroinvertebrate taxa sampled in January 1997, indicating six main groups. Refer to Table 2 for site codes and names.

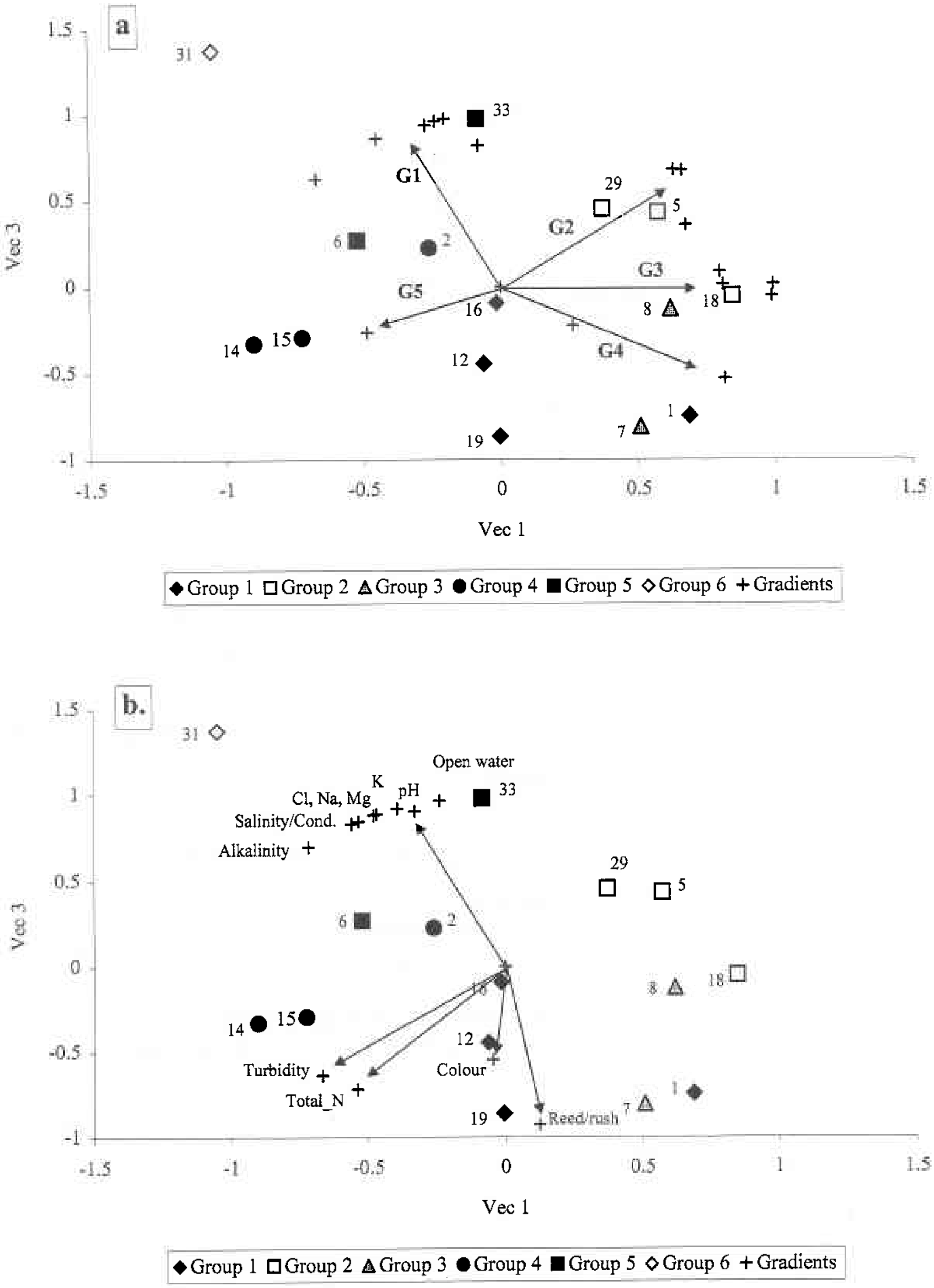

Figure 17. MDS ordination of wetlands by macroinvertebrate taxa sampled in January 1997. Groupings from the UPGMA classification and significant gradients in (a) macroinvertebrate taxa and (b) environmental variables are overlain. Taxa are grouped under five general gradients (G1 – G5), refer to Table 14 for taxa on each gradient. Refer to Table 2 for site names. Optimum solution to the ordination was achieved with 3 dimensions and a stress of 0.1613.

Table 14. Taxa in five general gradients (G1 – G5) through the ordination of wetlands sampled in January 1997 on taxa abundance data (Figure 17).

Gradients	Taxa gradients
Gradient 1	Stratiomyidae sp1, *Austrochiltonia* sp2, *Berosus* sp (L), *Coxiella striatula/exposita*, Oniscoidea spV2, *Procladius* sp VBM2, *Austrolestes annulosus*,
Gradient 2	*Kiefferulus intertinctus*, *Micronecta robusta*, *Hyphydrus elegans*,
Gradient 3	Hydrophilidae spH1, Chironomini genus VSCL35, Veliidae sp1, *Paramerina levidensis*
Gradient 4	*Hellythira* sp3, *Sternopriscus minimus*
Gradient 5	*Polypedilum* sp VSCL8

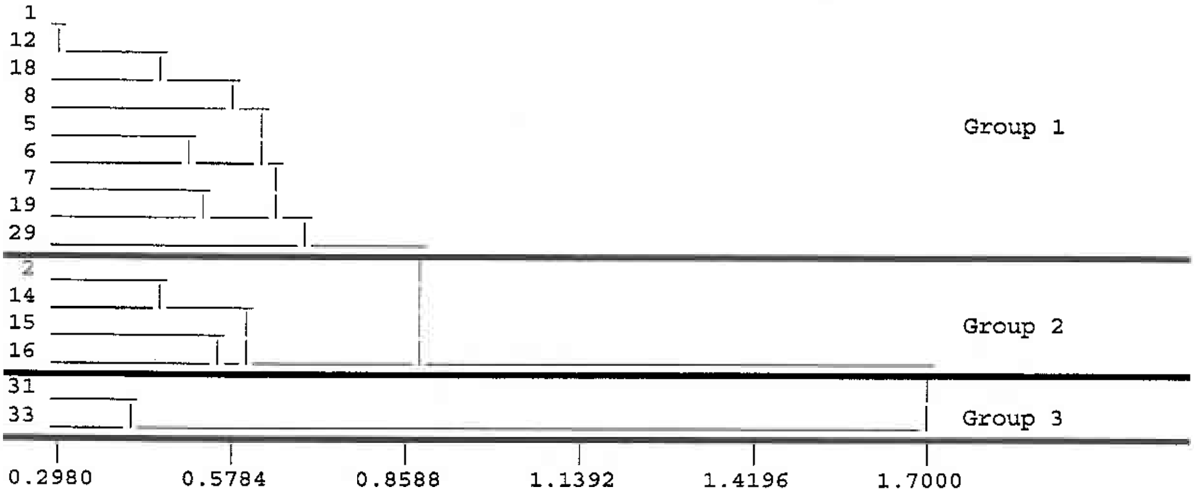

Figure 18. UPGMA classification of wetlands by macroinvertebrate taxa sampled in May 1997, indicating three main groups. Refer to Table 2 for site codes and names.

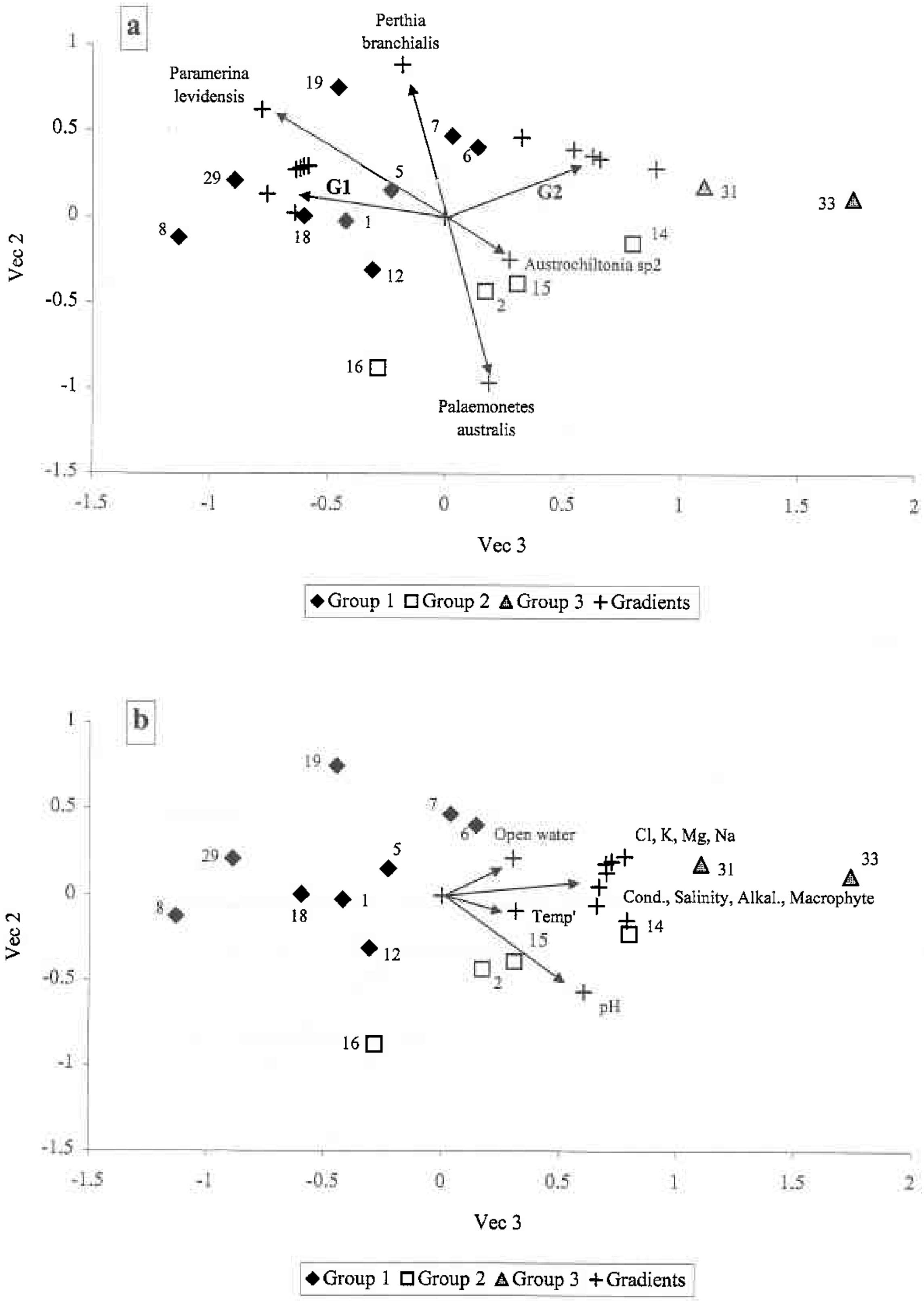

Figure 19. MDS ordination of wetlands by macroinvertebrate taxa sampled in May 1997. Groupings from the UPGMA classification and significant gradients in (a) macroinvertebrate taxa and (b) environmental variables are overlain. Taxa are grouped under two general gradients (G1 & G2), refer to Table 15 for taxa on each gradient. Refer to Table 2 for site names. Optimum solution to the ordination was achieved with 3 dimensions and a stress of 0.1190.

Table 15. Taxa in two general gradients (G1 & G2) through the ordination of wetlands sampled in May 1997 on taxa abundance data (Figure 19).

Gradients	Taxa gradients
Gradient 1	*Dicrotendipes ?conjunctus, Austroagrion coeruleum, Hyphydrus elegans, Sternopriscus minimus, Tasmanocoenis tillyardi, Cloeon* sp., Hirudinea sp3, Veliidae sp4
Gradient 2	*Peza* sp1, Leptoceridae sp3, Oniscoidea spV2, *Coxiella striatula/exposita, Berosus* sp.(L)

Ordination and classification of the additional 12 wetlands sampled in May and October 1997 (Figure 20 & 21) also demonstrated a significant separation of UPGMA site groupings in ordination space (p<0.0001). The greatest separation was of the permanent from the seasonally-inundated wetlands (Figure 21). The four sites sampled in May and October tended to classify together indicating that seasonal changes were small relative to the difference between permanent and seasonally-inundated wetlands. Generally, the seasonally-inundated wetlands were all very fresh, and the permanent wetlands were positioned closer to these wetlands in October than May, when salinities were higher due to concentration effects in receding wetlands.

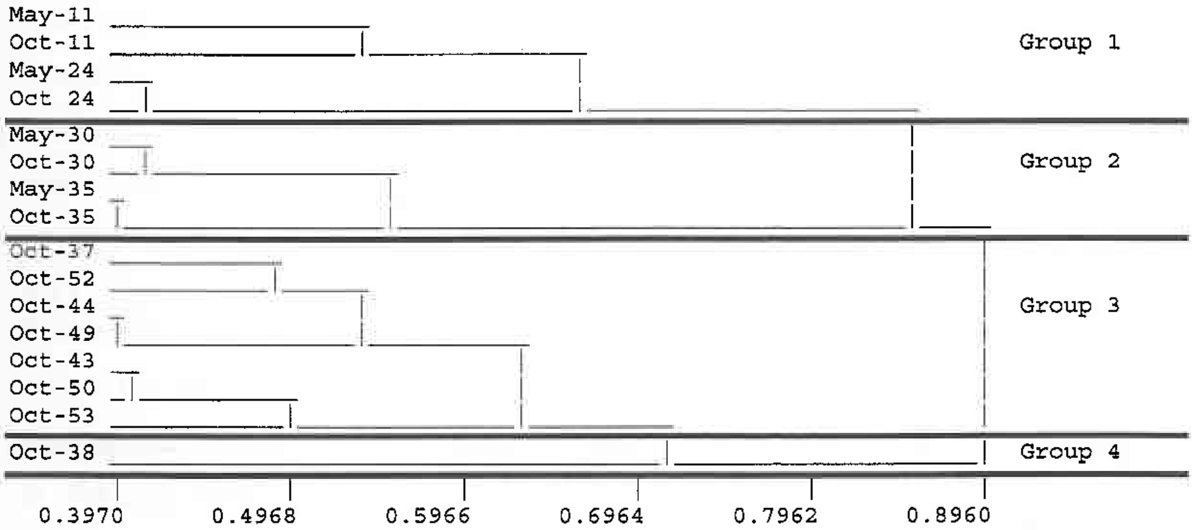

Figure 20. UPGMA classification of the additional 12 wetlands by macroinvertebrate taxa sampled in May and October 1997, indicating four main groups. Refer to Table 2 for site codes and names.

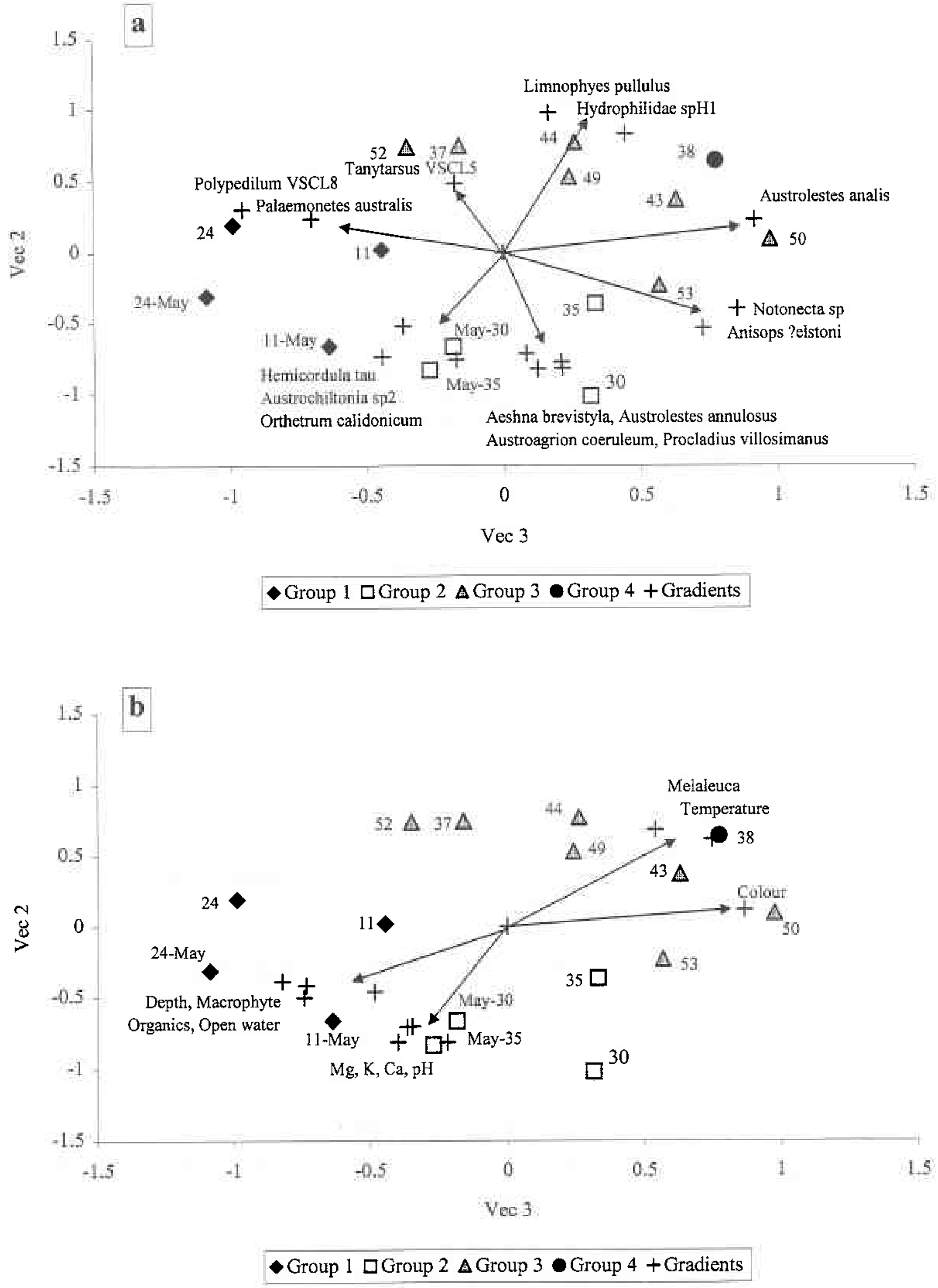

Figure 21. MDS ordination of the additional 12 wetlands by macroinvertebrate taxa sampled in May and October 1997. Groupings from the UPGMA classification and significant gradients in (a) macroinvertebrate taxa and (b) environmental variables are overlain. Sites sampled in May 1997 are indicated. Refer to Table 2 for site names. Optimum solution to the ordination was achieved with 3 dimensions and a stress of 0.1559.

The main physico-chemical gradients separating these wetland groups were higher cover of *Melaleuca* and higher water colour and water temperature in the seasonal wetlands, and greater depth of water and organic layer, cover of submerged macrophyte, area of open water and higher concentrations of ions/salinity in the deeper, permanent wetlands (Figure 21). The majority of taxa that were in higher abundance in the permanent wetlands were Odonates, reflecting their need, in many instances for a longer period of inundation in which to complete their life cycles.

Site-groupings derived from UPGMA classification of wetlands by physico-chemical and morphological characteristics for each season (see Section 3.1.4, Figures 2, 4, 6 & 8) were overlain on the MDS ordination of sites by macroinvertebrate community structure (Figure 22). Distinct separation of groupings would indicate that macroinvertebrate community structure in the wetlands was influenced by physico-chemical and morphological conditions. ANOSIM was applied to test for significant separation of the physico-chemical groupings in macroinvertebrate ordination space. There was no significant separation of site-groupings in October 1996 ($p = 0.10$), however, separation became significant as the year progressed (January 1997, $p < 0.01$; May 1997, $p < 0.0001$), with the more saline sites becoming more distinct. There was a highly significant separation of site-groupings for the additional 12 sites sampled in May and October 1997 ($p < 0.0001$), mostly related to the distinction between seasonal and permanent sites.

4.2.4 Possible salinity tolerances

A two-way table of samples (all sites on all sampling occasions - ordered by increasing salinity) by taxa (ordered by magnitude of the correlation between abundance and salinity) is presented in Appendix 3. The majority of taxa (207) did not respond to the salinity range in wetlands sampled. Eight taxa (*Paramerina levidensis, Chironomus* aff. *alternans, Tanytarsus* sp(VBM1), *Limnophyes pullulus,* Planorbidae spB1, *Dicrotendipes* sp. V47, *Notonecta* sp. and *Chironomini* genus (VSCL35) decreased in abundance with increasing salinity and 10 taxa (*Austrolestes annulosus,* ?Pyralidae sp, Gastropoda V2, *Berosus* sp (larva), *Tanytarsus ?barbitarsus,* Ceinidae sp2, *Necterosoma darwini*, Viviparidae sp2, Leptoceridae sp3 and Oniscoidea spV2) increased in abundance with increasing salinity.

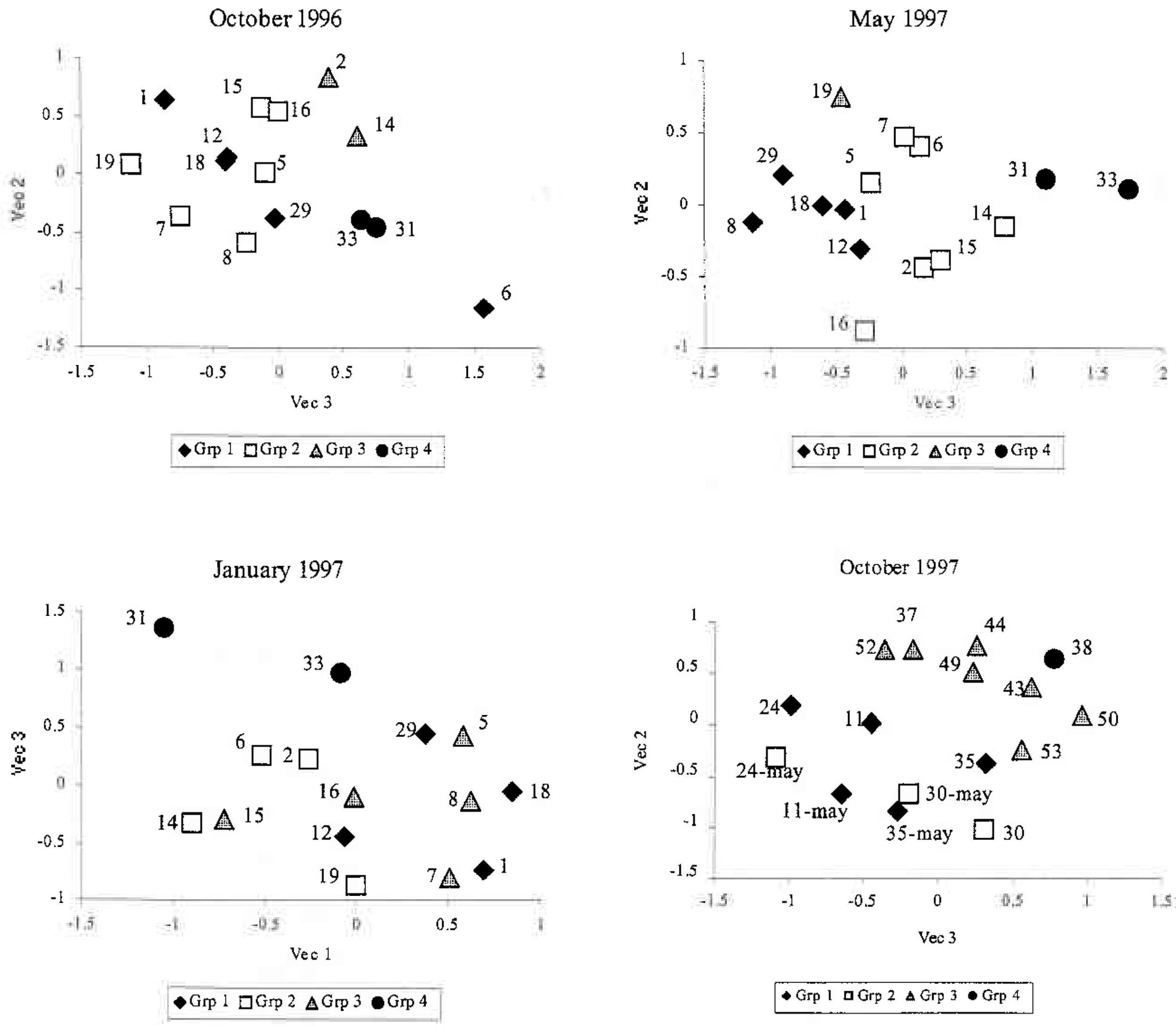

Figure 22. Site -groupings derived from UPGMA classification of wetlands on physico-chemical parameters for each season (see Figures 2, 4, 6 & 8) overlain on MDS ordination of wetlands by macroinvertebrate community structure.

4.3 Fish fauna

A total of seven species have been recorded from the area, with a maximum of six species at Poorginup Swamp, and five species from three other sites (Bokarup Swamp, Kulunilup Lake and Mulgarnup Swamp) (Table 16, Figure 23). The introduced *Gambusia holbrooki* was present at each of these four sites. *Galaxiella nigrostriata* and *G. munda* were the most infrequently encountered species, found only at Poorginup and Myalgelup Road Swamps. *Nannatherina balstoni* was the next rarest species, found only at four sites (Bokarup Swamp, Kulunilup Lake, Mulgarnup Swamp and Lake Unicup). All three species are very scarce, with distributions restricted to the southwestern coastal area of Western Australia. *Edelia vittata* was the most ubiquitous native species, recorded at 17 sites, followed by

Galaxias occidentalis at 11 sites. The only non-native fish species encountered was *Gambusia holbrooki,* which was present at 16 sites. Native species co-occurred with *G. holbrooki* at 15 of these sites, and *G. holbrooki* was absent from three sites where native species were recorded: Yarnup Swamp (three native species), Noobijup Swamp (two native species) and SW Cowerup NR (one native species). Interestingly, additional species have been recorded from many sites after the first sampling in October 1996 (Table 16). This may reflect increased dispersion of species with period of inundation, increasing body size (*viz.* catchability) of individuals as they mature, or inherent difficulties of catching fish in these habitats. The surveys indicate the difficulty of compiling species lists based on single surveys.

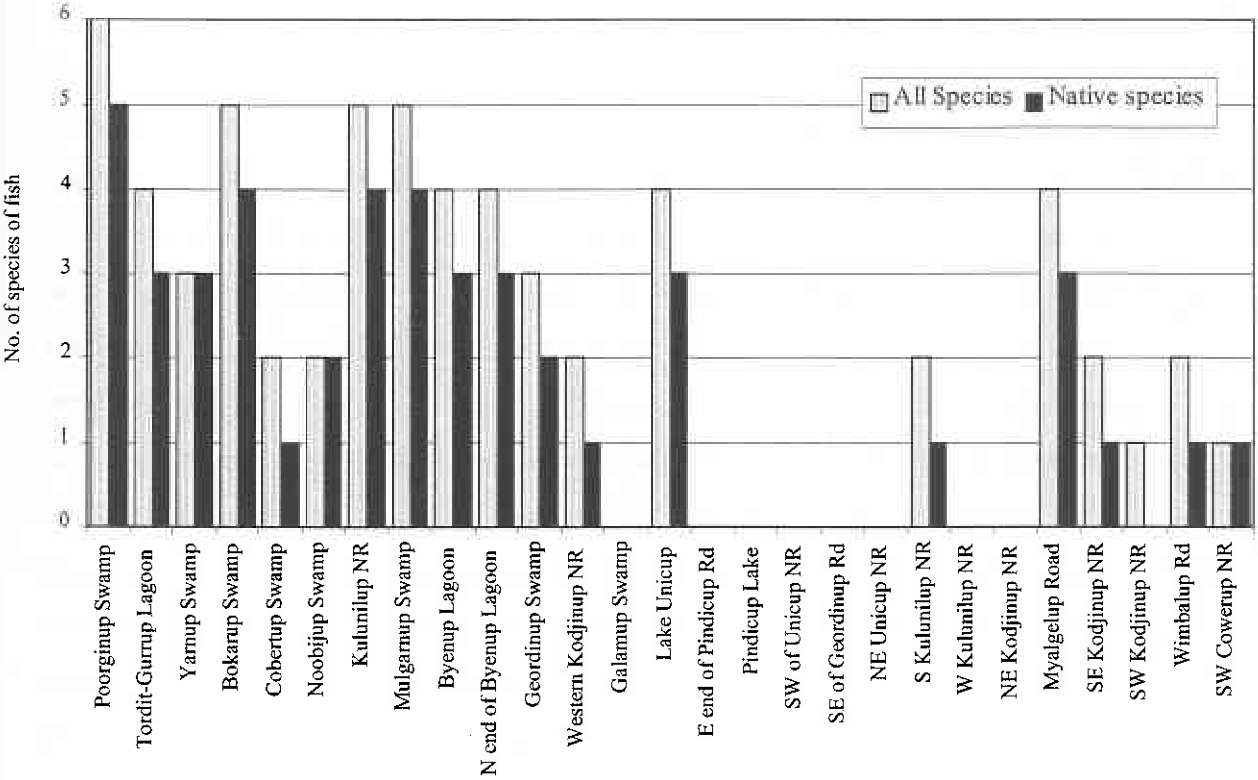

Figure 23. Total number and number of native fish species at each site.

Table 16. Fish species caught at each wetland on each sampling occasion from the Byenup-Unicup area (1,2,3,4 refers to the sampling trip in which each species was recorded:1 = October 1996; 2 = January 1997; 3 = May 1997; 4 = October 1997).

Site	No.	*Edelia vittata* (Western Pygmy Perch)	*Nannatherina balstoni* (Balston's Pygmy Perch)	*Bostockia porosa* (NightFish)	*Galaxias occidentalis* (Western Minnow)	*Galaxiella nigrostriata* (Black-Stripe Minnow)	*Galaxiella munda* (Mud Minnow)	*Gambusia holbrooki* (Mosquito fish)	No. of Species	Number of times sampled	Seasons in which sampled	Number of Native species
Poorginup Swamp	1	2 3		2 3	2 3	1 2 3	1 2 3	1 2 3	6	3	1 2 3	5
Tordit-Gurrup Lagoon	2	1 2 3		2 3	1 2 3			1 2 3	4	3	1 2 3	3
Yarnup Swamp	5	1 2 3		1	1 2 3				3	3	1 2 3	3
Bokarup Swamp	6	1 2 3	2 3	1 2 3	2 3			1 2 3	5	3	1 2 3	4
Cobertup Swamp	7	3						2 3	2	3	1 2 3	1
Noobijup Swamp	8	1 2 3			3				2	3	1 2 3	2
Kulunilup NR	11	3 4	3 4	3 4	3			3 4	5	2	3 4	4
Mulgarnup Swamp	12	1 2 3	2 3	2 3	3			2 3	5	3	1 2 3	4
Byenup Lagoon	14	1 2 3		2 3	1 2 3			1 3	4	3	1 2 3	3
N end of Byenup Lagoon	15	1 2 3		2 3	2 3			2 3	4	3	1 2 3	3
Geordinup Swamp	16	1 2 3			1 3			1 2 3	3	3	1 2 3	2
Western swamp in Kodjinup NR	18				1			2 3	2	3	1 2 3	1
Galamup Swamp	19								0	3	1 2 3	0
Lake Unicup	24	3 4	4	3 4				3 4	4	2	3 4	3
Loc. 12676, E end of Pindicup Rd	29								0	3	1 2 3	0
Pindicup Lake	30								0	2	3 4	0
Loc. 12686, SW of Unicup NR	31								0	3	1 2 3	0
Loc. 12561, SE of Geordinup Rd	33								0	3	1 2 3	0
NE Unicup NR	35								0	2	3 4	0
S Kulunilup NR	37	4						4	2	1	4	1
W Kulunilup NR	38								0	1	4	0
NE Kodjinup NR	43								0	1	4	0
Myalgelup Road	44	4				4	4	4	4	1	4	3
SE Kodjinup NR	49	4						4	2	1	4	1
SW Kodjinup NR	50							4	1	1	4	0
Wimbalup Rd	52	4						4	2	1	4	1
SW Cowerup NR	53	4							1	1	4	1
No. of occurrences of each species		17	4	9	11	2	2	16				

5 Discussion

5.1 Physico-chemistry and wetland morphology

The suite of sites sampled in this study covered a range of salinity conditions, from fresh, through brackish to saline. Those wetlands that were fresh throughout the year (i.e. < ~1.0 ppt) either tended to be in the south of the study area and/or well buffered by remnant vegetation (e.g. Poorginup, Tordit-Gurrup, Galamup and Kulunilup wetlands) or were shallow seasonal healthland-type wetlands probably filled by direct rainfall (e.g. seasonal wetlands in Kulunilup, Cowerup and Kodjinup nature reserves and wetlands along Myalgalup and Wimbalup Roads). Exceptions were NE Unicup and site #29 at the east end of Pindicup Road. Both sites were fresh, but adjoined cleared land. It is likely that these wetlands were receiving additional run-off as a result of clearing, but this water was still fresh.

Several wetlands were brackish to saline, particularly in late summer. These included Yarnup, Bokarup, Byenup, North end of Byenup, and Geordinup wetlands, which were between 1.0 and 2.0 ppt in springtime, but by late autumn had reached 4.5 to 5.0 ppt. Given that water levels were generally high in all wetlands because of good winter rainfall in 1996, concentration effects were likely not as great as may be expected in drier years. For example, DeHaan (1987) recorded 7.0 ppt in Byenup Lagoon in late summer. These wetlands may be showing elevated salinities either because they are receiving saline run-off from cleared catchments, or they are showing long-term accumulation of salt as a result of progressive effects of evaporation and concentration. Changes in the condition of vegetation in these wetlands suggested a change in salinity. Stands of *Baumea articulata* in Yarnup and Geordinup Swamps, in particular, and to a lesser extent in Bokarup Swamp were in very poor condition (very sparse, no new growth with only 4 or 5 living stems per plant). This may be reflecting prolonged stress (i.e. over the last 3+ years) due to increased salinities; the decline of *B. articulata* in Lake Towerrinning was attributed to increased salinities (Froend & McComb, 1991).

Several of these wetlands are on the Noobijup Creek drainage line. This system arises to the south of Lake Noobijup and flows southwards into Lake Muir via Geordinup Lagoon, Neeranup Lake and Byenup Lagoon. Salinity in this creek as it crosses Muirs Hwy was 6.7 ppt in October 1997 and 10.4 ppt in May 1997. The presence of flowing and saline water in Noobijup Creek in late autumn may be the result of increased groundwater levels due to clearing in the catchment upstream and indicates a continual salt-load to the Muir/Byenup wetland chain. In October 1997, a spot measurement of salinity from a salt scald on the west side of Noobijup Swamp, at the head of this catchment, was 15.5 ppt, again indicating secondary salination due to clearing.

A final suite of wetlands were saline, but the vegetation appeared in good condition, suggesting that the salinity in these wetlands was not changing. These included site #31 (Loc. 12686 SW of Unicup nature reserve), site #33 (Loc. 12561 SE of Geordinup Road) and Pindicup Lake. It is likely that these wetlands are in direct contact with the saline Main Groundwater (Semeniuk & Semeniuk, 1996).

Therefore, the wetlands sampled in this study appear to cover the range of hydrologic types and are affected by the range of salination processes referred to by Semeniuk & Semeniuk (1996; see section 1.3 of this report): wetlands with Perched Groundwater that is fresh, wetlands in direct contact with saline Main Groundwater, wetlands suffering from longterm natural salination due to evaporative processes, and wetlands suffering secondary salination due to rising groundwater and inflows of saline surface drainage waters.

With respect to nutrient enrichment, water quality in the wetlands appears relatively good. Many of the wetlands would classify as eutrophic to hyper-eutrophic on the basis of nitrogen levels. DeHaan (1987) also noted elevated nitrogen levels in a subset of the current suite of wetlands, and suggested this was due to the release of nitrogen from decomposing peat. However, wetlands in this study did not behave as eutrophic (e.g. extensive algal blooms were not observed). The absence of algal blooms and the fact that phosphorus levels were relatively low, may indicate that the wetlands are phosphorus-limited. The potential therefore exists for substantial algal activity if phosphorus levels become elevated (e.g. as a result of agricultural run-off). Lake Towerrinning (Froend & McComb, 1991) and Lake Powell (Edward *et al.*, 1994) appear to have become eutrophic as a result of human activities.

There was a range of pH conditions in the wetlands, mostly reflecting either high salt levels (alkaline) or dominance by peat (acidic). The main seasonal effect in all wetlands was the concentration effects, with salinity increasing as wetlands receded. The extent of this concentration effect will vary between years depending upon rainfall in the preceding winter.

5.2 Macroinvertebrate fauna

There were 32 southwest endemic taxa and 6 locally-endemic taxa recorded from the study area. Eleven swamps had 10 or more southwest endemic taxa, with the greatest recorded from Poorginup Swamp (16), Loc. 12767 (15) and Yarnup (15). Generally, there were few locally-endemic species recorded in this study. Mulgarnup had the greatest number (4), eight sites had two locally endemic taxa and 13 sites contained one locally-endemic species The ceinid amphipod *Austrochiltonia* sp.2, which appears to be a new species (B. Knott, pers. com.) occurred at 15 sites, and the new dytiscid beetle, *Sternopriscus* sp. nov. (C. Watts pers. com.) was recorded from 13 sites. Generally, it is difficult to allocate many southwest endemic taxa to this level because of insufficient survey effort and inadequate taxonomy. There was also a high proportion of indeterminate taxa, some of which may classify as southwest or locally-endemic once their taxonomy has been better resolved.

The four wetlands sampled in the Muir/Unicup catchments by Horwtiz (1994) held approximately three taxa per site that were endemic to southwestern Australia, and no taxa which were locally endemic. The current study has recorded a greater number of both categories.

Assessing levels of endemism at each site should be repeated once the micro-faunal components have been identified. Based on other studies (e.g. Storey *et al.*, 1993; Halse & Storey, 1996), there is likely to be a relatively large component of southwest endemic, locally-endemic and new species in the microfauna.

Allowing for differences in sampling technique, level of taxonomic resolution and sampling intensity, comparisons were made of taxa richness between this and previous surveys of aquatic invertebrates of wetlands in southwestern Australia (Storey *et al.*, 1993; Davis *et al.*, 1993; Edward *et al.*, 1994; Horwitz, 1994; and Halse & Storey, 1996). Total number of taxa per study could not be compared because of differences in the number of wetlands sampled and number of sampling occasions. However, on the bases of mean number of taxa per site on each sampling occasion and total number of taxa recorded from each site over the duration of the study, wetlands in this catchment have equivalent or slightly greater taxa richness than other surveys of aquatic invertebrates in wetlands of southwestern Australia. This is somewhat surprising, given that the wetlands appear to have relatively low habitat diversity (e.g. many are dominated by dense stands of *Baumea* *articulata*, with deep, unconsolidated peat deposits characterised by low dissolved oxygen levels). However, sampling was conducted in spring, summer and autumn, which would allow for seasonal changes in taxa composition. In addition, some wetlands progressed from fresh to saline over the duration of the study, providing the potential for representatives of freshwater and haline fauna.

Interestingly, the highest taxa richness in this study was recorded from two wetlands (site #35, NE Unicup and site #29, east end of Pindicup Road) that are affected by increased inundation, presumably from land clearing. Evidence for the increased inundation was dead, inundated *Melaleuca* and *Banksia* spp and flooded fence lines through the wetlands. Both wetlands were downstream of large areas of cleared land, which presumably had resulted in increased run-off. It is likely that the increased inundation had provided additional habitats (dead, flooded trees, open water, flooded marginal reeds/rushes etc) and permanent water, allowing colonisation by additional taxa. Water in both wetlands was fresh throughout the year. Presumably, land clearing had not resulted in salination in these instances – at this point in time. If these wetlands start to suffer from secondary salination, then taxa richness is likely to decline.

It is well accepted that salinity will play a major role in structuring invertebrate communities in a wetland, and that species richness will decline as salinity increases. Aspects restricting the fauna include the lowest salinity achieved when a wetland is at its freshest, and the highest salinity achieved during the annual cycle of evapoconcentration as a wetland recedes. There is growing scientific literature documenting the types of fauna associated with saline waterbodies in Western Australia (Halse, 1981; Geddes *et al.*, 1981; Edward, 1983; Cruse *et al.*, 1989; Bunn & Davies, 1992) and Australia (Bayly & Williams, 1966; Geddes, 1976; Timms, 1981; DeDeckker & Williams, 1982; DeDeckker, 1983; Hart *et al.*, 1991 (cited Bunn & Davies, 1992)), and this literature indicates four broad categories into which the fauna may be classified:

1. taxa adapted to freshwater and tolerant of salt up to 2 or 3 ppt
2. taxa adapted to freshwater and tolerant of salt up to ~15 ppt
3. taxa occurring at 20 to 50 ppt
4. taxa occurring at > 50 ppt

It was anticipated that the aquatic invertebrate fauna of wetlands in the Muir/Unicup area would be restricted by a.) minimum salinity achieved in spring (i.e. if minimum salinity achieved in spring is above ~ 3 ppt then component #1 will be removed), and b.) maximum salinity achieved as wetlands dry and salinity increases through evapoconcentration (i.e. component #2 will be removed if salinity rises above ~ 15 ppt).

Based on salinity ranges recorded in this study, the majority of wetlands fell within the first two of the above categories, with only two wetlands (#31 and #33) classifying into category three, and then only in autumn, reaching maximum salinities of 23 and 28 ppt respectively (Appendix 3). No wetlands in this study classified into category four. As a result, few taxa showed a preference for or against different salinities. In comparison, Edward (1983) reported strong preferences for the majority of 49 taxa recorded from 16 lakes on Rottnest Island. However, the lakes on Rottnest Island exhibited a wide range in salinities, with > 20 ppt recorded on occasions from 11 lakes and > 100 ppt recorded from three lakes.

The limited range in salinities sampled in the current study, especially, the under-representation of wetlands with high salinities (e.g. > 20 ppt) probably influenced the ability of the current analysis to detect significant responses by individual taxa to salinity and to allocate taxa to salinity ranges. The restriction of the current analysis to macroinvertebrate taxa further limited the ability to detect salinity responses, because many taxa tolerant of high salinities tend to be microcrustacea, not considered at this stage.

Another contributing factor was the presence of freshwater seeps in many of the saline wetlands (AWS pers. obs., Greg Keighery, CALM, pers. comm.). For example, healthy stands of *Baumea articulata* were present on the northeast shore of site #31, in which salinities of 17, 18 and 23 ppt were recorded. The sampling method used in the current study (a composite sample across different habitats) meant that a single sweep sample could cover a relatively large part of the shoreline. It is quite possible that taxa restricted from the main body of a saline wetland may survive in limited areas associated with freshwater seeps and therefore, they could be included in the composite samples. This would provide an apparent record for a taxon at a higher than expected salinity.

A final consideration as to the lack of a salinity response is that aquatic macroinvertebrate species in parts of the southwest of Western Australia may be adapted to a higher background salinity due to the historical exposure to saline groundwater. Therefore, the salinity ranges used in the above categories may need to be adjusted. The presence of the relatively shallow, saline Main Groundwater in the Muir/Unicup catchments, with naturally saline wetlands certainly provides a mechanism for adaptation.

In addition to the response of individual species, the literature also suggests there should be a reduction in taxa richness with increasing salinity. The present study failed to detect a significant negative relationship between taxa richness and salinity using rank correlation. This is somewhat misleading, and probably relates to the conservative method of analysis (rank correlation as opposed to product-moment correlation) and the fact that most wetlands had salinities less than 5 ppt for most of the year. General trends of declining taxa richness with increasing salinity in each wetland in each season are presented in Figure 24.

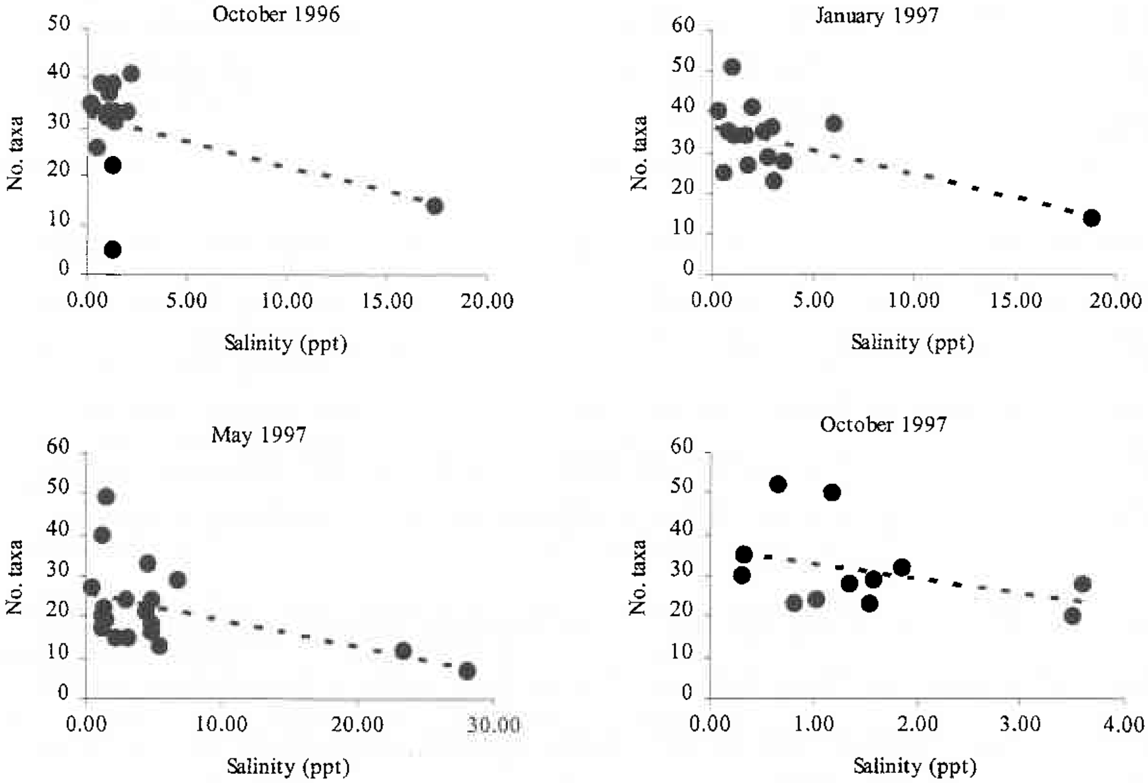

Figure 24. Relationships between taxa richness and salinity at each wetland in each season, with trend lines showing general gradients.

The ordination and classification techniques identified obvious differences in macroinvertebrate community structure between fresh, brackish and saline wetlands, indicating that changes in community structure may be anticipated in response to changes in salinity. Froend & Storey (1996) recommended that a cost effective approach for future monitoring of the effects of salinity on aquatic invertebrate community structure for

Toolibin Lake would be to classify species into broad abundance categories (i.e. on a $\log_{10}$ scale; 1, 10, 100, >1000). Ongoing monitoring would then look for a change in the dominance hierarchy of key aquatic invertebrates (e.g. a change from species requiring freshwater to salt tolerant species) that may indicate an increase in salinity. The same approach is again encouraged for wetlands in the Muir/Unicup catchment, but ordination and classification techniques also should be utilised. NB. It is likely that the response to salinity will be greater once the microinvertebrate data are added to the current analyses.

5.3 Fish fauna

Of the sites sampled, four had notable species richness in terms of total number of native fish species sampled. One site held five native species (Poorginup Swamp), and three sites held four native species (Bokarup Swamp, Kulunilup Lake and Mulgarnup Swamp), however, these sites also contained the introduced *Gambusia holbrooki*, which, by its presence has lowered the conservation value of these sites, and may further lower their value if any of the native species is ever displaced. Compared to the study by Morgan *et al.* (1996) for the same area, this study recorded two additional native species (*Galaxiella nigrostriata* and *Nannatherina balstoni*). Morgan *et al.* (op. cit.) sampled 26 locations in the Lake Muir watershed, and recorded 4 native and one introduced species, with a maximum of three native species at a site. All sites sampled by Morgan *et al.* (1996) were visited only once, as opposed to upto three times in the current study, and their site selection tended to target a few of the larger wetlands (Red Lake, Lake Muir and Byenup Lagoon) as well as a high proportion of smaller, probably seasonal wetlands (see Table 1). Given this sampling design, and the fact that additional species were recorded from wetlands in the current study on subsequent sampling trips, it is not unexpected that this study should find additional species to that report by Morgan *et al.* (1996).

The two sites (Poorginup and Myalgalup Rd Swamps) at which *Galaxiella nigrostriata* and *G. munda* were recorded have a high conservation value because of the limited distribution of these relatively rare endemic species, found only in the far southwest of Western Australia. These species are listed as 'Lower Risk (Near Threatened)' under the IUCN Species Survival Commission 1996 Red List (IUCN, 1996). The two sites where these species occurred had very fresh water (Poorginup = < 0.5 ppt and Myalgelup Road = 1.4 ppt). Locations where other studies have recorded these species also tended to have fresh water (e.g. Pusey & Edward, 1990b). It seems likely that these species will be particularly susceptible to salinity. In particular, *G. nigrostriata* which is thought to aestivate in the benthic sediments, burrowing into the bed as the wetland recedes, will be exposed to maximum salinities experienced in the wetland through evapoconcentration. Small increases in wetland salinity may lead to the demise of these species.

The four sites at which *Nannatherina balstoni* occurred (Bokarup Swamp, Kulunilup Lake, Mulgarnup Swamp and Lake Unicup) are considered to have a high conservation value because of the limited distribution of this relatively rare endemic species. This study probably represents a range extension for this species as reported by Allen (1989). The species is listed as Data Deficient under the IUCN Species Survival Commission 1996 Red List (IUCN, 1996), however, Christensen (1982) suggested that *N. balstoni* was one of the rarer native freshwater species in southern Western Australia.

Edelia vittata, Galaxias occidentalis and *Bostockia porosa* were all relatively common in the study area. Although all three are endemic to southwestern Western Australia, they are widely distribution and are relatively common within the region.

Only one introduced species, *Gambusia holbrooki* was recorded from the area. However, it was relatively common, present at 16 of the 27 sites sampled and occurred at 83% of the sites at which native species were present. The presence of this exotic species lowers the conservation value of those sites at which it occurred as it is known to have an adverse effect on native species (Morgan *et al.*, 1996).

Those sites at which *G. holbrooki* did not occur but at which native species were present (e.g. Yarnup and Noobijup Swamps and SW Cowerup NR) might be considered to have a higher conservation value over sites containing *G. holbrooki*. However, these three sites were not particularly noteworthy in terms of composition of native species.

5.4 Likely threats to wetland condition and management implications

Although not all-encompassing, the current study has identified a range of threats to the 27 wetlands surveyed in the Muir/Unicup catchments (Table 17). Generally, threats to wetlands in the Muir/Unicup catchments can be classified into eleven broad categories:

- Catchment clearing
- Increased salinity
- Increased inundation
- Reduced inundation

- Invasion by exotic species
- Nutrient enrichment
- Fire
- Drains
- Riparian buffer clearing
- Stock access for water/grazing
- Mining

The processes by which these threats occur and management implications for each threat are discussed below.

Table 17. Summary of apparent threatening processes observed at the 27 wetlands visited.

Wetland Name	No	Possible threatening processes
Poorginup Swamp	1	None apparent - good reference site
Tordit-Gurrup Lagoon	2	None apparent - good reference site
Yarnup Swamp	5	No buffer on west side (road) - possible effects from catchment clearing, frequently burnt, salt scalds draining into wetland from SW
Bokarup Swamp	6	Vegetation in decline, possible loss of peat to fire ~ 1920s? Slightly elevated salinity, but for no apparent reason
Cobertup Swamp	7	Saline drain from east, salt scald to west, surrounded by cleared land which may result in increasing height of water table
Noobijup Swamp	8	Good condition, but receiving saline water from seeps and a drain to W & S, burnt 1984
Kulunilup Lake	11	None apparent – well buffered by reserve, good reference site
Mulgarnup Swamp	12	Well buffered by reserve. Receives sheet flow in winter from N. of Muirs Hwy
Byenup Lagoon	14	Receives saline drainage from Noobijup Creek via chain of wetlands
N end of Byenup at narrow neck	15	Receives saline drainage from Noobijup Creek via chain of wetlands
Geordinup Swamp	16	Receives saline drainage from Noobijup Creek
Western swamp in Kodjinup NR	18	Possible inundation from overflow from Mordalup drain
Galamup Swamp	19	Reasonably well buffered in marri/banksia forest, but 200 ha to be cleared to NW of wetland may have an effect
Lake Unicup	24	Changes in inundation, pH and salinity have occurred – possibly anthropogenic. Effects of water skiing are unknown.
Loc. 12676, south side of E end of Pindicup Rd	29	General land clearing and nearby saline seeps. Dead *Banksia* and *Melaleuca* suggest increased inundation – most likely due to bad road culvert design. Currently fresh, but clearing may result in increased groundwater levels and so increasing salinity.
Pindicup Lake	30	Most likely expresses undisturbed conditions of a naturally brackish/saline wetland.
Loc. 12686 – SW of Unicup NR – south side of Pindicup Rd	31	Most likely a naturally saline wetland. Has a good buffer from reserve to the north and pine/blue-gum plantation to the east & south, cleared to west.
Loc. 12561 SE of Geordinup Rd	33	Probably naturally saline. In a reserve, but surrounded by cleared land
NE edge of Unicup NR	35	Appears to be deeper & more permanent than normal - original road to east is now under water with new road along west side – dead vegetation within wetland presumed due to inundation Currently fresh, but clearing to east may result in increased groundwater levels and so increasing salinity
South Entrance of Kulunilup NR	37	Well buffered in nature reserve. General catchment clearing to the south may have some effect
West side of Kulunilup NR	38	Well buffered in large nature reserve
NE corner of Kodjinup NR	43	Possible effects from cleared land – only a 300 m buffer from cleared paddocks to east and north
Swamp across Myalgelup Rd	44	None apparent - good reference site, well buffered by State Forest
SE Kodjinup NR	49	General increase in water level and salinity due to land clearing to east and south
SW corner of Kodjinup NR	50	Drain enters swamp from pasture to the south. Possibility for increasing groundwater levels and so increasing salinity
Swamp across Wimbalup Track	52	Well buffered by State Forest on all side – recent fire on northern perimeter (May 1997)
West side of Cowerup NR	53	Cleared farmland to W of site, with drain running N to S through site. Nature Reserve to N, S & E forms an extensive buffer.

5.4.1 Catchment clearing

As has been seen across the majority of the Wheatbelt Region of Western Australian, broadscale catchment clearing is a driving force for many of the identified threats (e.g. secondary salination, increased inundation, increased nutrient runoff from agricultural applications etc). The effects of these threats on wetlands are detailed below. However, the general implications of catchment clearing are here further discussed.

Generally, clearing of native vegetation leads to secondary salination of wetlands and other, mainly low-lying parts of the landscape. Deep-rooted native, perennial vegetation intercepts more rainfall and uses more water at greater depths than the shallow-rooted, annual, pastures and cereals with which it has been replaced. As a consequence, when native vegetation is removed, water tables rise bringing stored salt to the surface. Some of the best evidence for this process comes from the catchment of Toolibin Lake in the Wheatbelt Region.

Farming in the Toolibin catchment first started in the 1890s, but widespread clearing did not occur until after the First World War. By the mid-1930s about $^1/_3$ of the native vegetation in the catchment had been cleared. Most of the remainder was cleared in the late 1940s and early 1950s. By 1972, at least 90% had been removed (NARWRC 1978). Fifty-seven bores were sunk in the catchment between 1907 and 1913. When first drilled, most bores were 25 to 30 m deep and bottomed onto rock. About half were dry and in the others the water tables generally were deep and saline (~ 30 ppt) (NARWRC 1978). By 1977 water tables had risen by 12 - 15 m (Watson 1978). Continued monitoring of bores in the catchment suggested that the effects of land clearing on the water table had yet to be fully expressed and the situation would deteriorate further in years to come. **This highlights the lag-period between clearing and an increase in the water table, and by inference, a response to replanting.** This has major implications for management of the Muir/Unicup catchments in that prompt action is required to reverse salination, and even when mitigation is started, the situation may further deteriorate before improving.

Secondary salination may occur as a result of saline groundwater rising under the wetland or as a result of flushing of salt from affected land upstream of a wetland. Reduced vegetation cover in the catchment also results in increased runoff. This contributes to secondary salination of wetlands by causing more waterlogging and flooding in the catchment and increased flushing of surface-salt into the drainage system from salt-affected land. Wetlands, by their nature, tend to be low-lying in the catchment and therefore, tend to suffer most from salination (both by increasing water tables and flushing of salt into watercourses).

Much of the Muir/Unicup catchments have been planted with eucalypt and pine plantations. Although not native, they are deep-rooted and perennial and will assist in lowering/maintaining the water table. However, many of these plantations have been established and will be ready for cropping at approximately the same time. This presents a management issue in that broadscale cropping of these plantations will effectively be the same as catchment clearing and may result in (renewed) secondary salination. It is important that cropping **and replanting** is planned to avoid broadscale clearing in any one catchment/subcatchment.

The majority of the well-defined basin-type wetlands in the Muir/Unicup catchments are in Nature Reserves or surrounded by state forest and *appear* to be protected by adequate buffers. This may give a false sense of security with respect to avoiding salination, particularly for those wetlands in reserves. In many instances the reserves are relatively small, and are bounded by cleared land (or plantations that will be cropped). The nature of catchment clearing, rising water tables and secondary salination means that these reserves may not be large enough to maintain groundwater levels in the face of a broadscale rise in the water table across a subcatchment. Management cannot assume that these wetlands will be protected from secondary salination, especially as these areas are low-lying in the landscape and therefore more prone to be affected by rising water tables.

In addition, in many instances the seasonal, heath-type wetlands are either not in reserves, or are on the outer margins of reserves. It appears that many reserves were planned for the protection of the basin-type wetland contained within, using the seasonal heathland as the effective buffer. These areas are important wetlands in their own right and, ideally, would have a buffer of terrestrial vegetation between them and private land. The margins of the reserves, often comprised of heathland, will be more susceptible to the effects of land clearance and associated impacts because of their proximity to the cleared land. Therefore, a large proportion of the seasonal heathlands may be susceptible to degradation from land clearance and associated factors.

As previously discussed (Section 2.3) there are naturally saline wetlands in the Muir/Unicup catchments which reflect the complex hydrology and geomorphology of the area. Because of this complex hydrology, and the variety of processes by which a wetland may suffer from primary or secondary salination, each wetland must be considered on an individual basis when considering its susceptibility to salination and in planning future clearing or revegetation.

5.4.2 Increased salinity

Secondary salination of wetlands may occur as a result of a.) a rise in the saline water table beneath the wetland or b.) draining of salt-affected land into a wetland (either via natural watercourses/seeps or by man-made drains).

The effects of increased salinity on wetland flora, waterbirds and aquatic macroinvertebrates are discussed by Froend & Storey (1996). Generally, plants and animals dependent upon freshwater will have a tolerance to some salt that will vary between species. Once this tolerance is exceeded, the plant or animal will no longer be able to survive in the system, but over time may be replaced by other species with a higher tolerance. The demise of wetland vegetation due to salinity and associated effects (e.g. increased inundation; see below) has been recorded by Froend & McComb (1991) and Froend & Storey (1996). Emergent reeds/rushes are relatively intolerant and will die if salinity in the wetland is increased above a specific threshold. This has occurred in Lake Towerrinning and Toolibin Lake. Thresholds are hard to determine due to the absence of good historical data and the absence of controlled experiments, but the threshold for *Baumea articulata* is likely to be approximately 3 ppt (Ray Froend, pers. com.). Similarly, freshwater-adapted emergent trees, such as *Melaleuca* spp and *Eucalyptus rudis*, will die if saline groundwater rises to be in contact with their root systems or wetland salinity increases. These species will likely be more tolerant than freshwater-adapted reeds/rushes, but not excessively so (e.g. a threshold of 5 – 10 ppt).

The majority of peat swamps in the Muir/Unicup catchments are characterised by dense cover of *B. articulata*, and this cover undoubtedly is responsible for the thick peat deposits in the wetlands. The low tolerance of *B. articulata* to salt should be a major concern to managers. Wetlands are already showing the effects of rising salinity, and in some of these wetlands large areas of *B. articulata* appear affected (e.g. Yarnup and Geordinup Swamps). Given the dominance of this vegetation type in these wetlands (e.g. > 90% cover), and the likelihood of total loss of *Baumea* due to salinity, the vegetation structure of the wetlands will be dramatically altered, and this will have devastating effects on how these systems function ecologically.

Waterbird usage of wetlands in the Muir/Unicup catchments has been the subject of separate investigation. However, it is worth noting that increasing salinity will have direct effects on waterbirds, fish and aquatic invertebrates, and these faunal elements also will be affected by such a dramatic change in the structure provided by the natural vegetation in the wetlands.

Halse (1987), when discussing the effects of salinity on the waterbirds of Toolibin Lake, summarised that waterbirds feed throughout the lake and around its margin, and eat invertebrates, small vertebrates (fish and frogs), algae, aquatic macrophytes, and vegetation on the mudflats surrounding the lake. Based on the usual location of their nests, breeding waterbirds were allocated to four nesting guilds (Halse, 1987): floating or anchored nest of rushes, aquatic macrophyte or sticks; nest of sticks in, or under cover of, trees over water; nest in tree hollows; nest on ground in grass or rushes.

Live vegetation was seen as of paramount importance in providing suitable nesting sites for most of the species breeding on the lake. Therefore, for feeding and nesting, waterbirds tend to be very dependent upon the structure of the vegetation in the wetland. This was re-inforced in a study which analysed the characteristics of wetlands of southwestern Australia and showed that wetlands with inundated trees or sedge-type vegetation supported more breeding species than wetlands with open water, fresh/brackish wetlands tended to have the highest number of breeding species, and permanence of the lake had little effect so long as water was present in spring of most years (Halse, 1987).

Therefore, loss of habitat, through death of vegetation as a result of increased salinity (or as a result of increased inundation due to drainage modifications) will likely result in a loss of waterbird species utilising a wetland. Species likely to be directly affected include those which prefer dense tree vegetation (i.e. Freckled Duck), most of the tree-nesting wading birds (i.e. Herons, Egrets and Spoonbills) as well as Cormorants, and also secretive species that prefer dense reeds/rushes (i.e. Australasian Bittern and Purple Swamphen).

Water potability for young birds is also of concern. For the first week or so after hatching, young birds must have freshwater to drink. This is because their salt glands are not developed and the birds are unable to regulate salt intake (Halse, 1987). This applies to salt-tolerant as well as salt-intolerant species. However, species will breed successfully on saline wetlands if freshwater seepages are available for drinking. Subsequently, adult birds of most species can survive by drinking brackish/saline water.

Therefore, so long as water is fresh in spring, when most breeding occurs, it does not matter in terms of drinking water for waterbirds, if salinity rises later in the year. From unpublished data of breeding attempts of waterbird species on various wetlands in different salinity categories in southwestern Australia, Halse (1987) determined that if salinity in Toolibin Lake in September rose to >10 ppt at least 11 species known to breed on the lake between 1981 and 1992 would stop. Similar effects may occur to waterbirds utilising wetlands in the Muir/Unicup catchments if they become saline.

As well as the direct effects of salinity on waterbird populations through habitat and physiological limitations, there will be indirect effects through changes to factors such as food supplies. The salinity tolerance and effects of increasing salinity on the macroinvertebrate fauna has been previously discussed (Section 5.2). Loss of species of fish or macroinvertebrates on which species of waterbird are dependent may lead to the demise of that species.

Manipulation of water levels to flush salt out of a wetland is an option to reduce salt loads in a system (Froend & McComb, 1991; Froend & Storey, 1996). In the Muir/Unicup catchments this may not be a viable option for some wetlands, however, it may be a realistic option for other wetlands. Also, some wetlands may be flushed naturally following average winter rains, to such an extent that salt loads may never increase above levels critical to fauna or flora.

5.4.3 Increased inundation

Previous studies of catchment clearing have shown that the clearing of native vegetation will lead to increased runoff which leads to longer periods of inundation in seasonal wetlands and, where excessive, the death of emergent species. It is thought that this was the initial reason for the death of vegetation in Lake Taarblin (Watson 1978), and death of fringing vegetation in Lake Towerrinning was attributed to increased inundation and salinity (Froend & McComb, 1991). Fringing rush and tree vegetation requires a particular inundation regime and if depth and duration of inundation increase, vegetation of lower elevations may die and the lake margin will retreat to a higher elevation of suitable inundation regime. If the change in inundation is rapid and combined with increasing salinity, then the result may be local extinction rather than changes in distribution (Froend & McComb, 1991).

The effects of increased inundation (i.e. death of emergent/fringing vegetation) are apparent at two wetlands visited in the Muir/Unicup catchments. In one instance it is most likely due to increased runoff as a result of catchment clearing to the east of the wetland (site #35), and in the second occurrence it is due to a mis-placed road culvert raising the outflow from the wetland (site #29). In both situations the water is still fresh, illustrating the effects of an altered inundation regime in isolation from salinity. The change in vegetation structure will have similar effects on wetland processes (e.g. waterbird breeding) as discussed above.

5.4.4 Reduced inundation

Although not observed at any of the wetlands surveyed in the current study, a reduction in the inundation regime of a wetland may occur. This will have an adverse effect on the ecology of the system by re-establishing vegetation zones as discussed above. An extreme situation would be the loss of species due to insufficient inundation (e.g. aquatic plants or fish that require permanent water would disappear if the wetland became seasonal). Reduced inundation may occur by physical draining of a wetland, diversion of inflows, extraction of water for irrigation purposes (either directly from the wetland or from its groundwater), or transpiration by inappropriately placed plantations. Draining has been used in the Mordalup wetlands to the west of the Unicup catchment where a drain was constructed, in this instance to lower water levels elevated as a result of increased runoff. There is a small horticultural industry to the north of Lake Muir (potato growing). It is conceivable, especially with the current historically low rainfall, that crops in this or other parts of the catchment could be irrigated in late spring/summer by diversions/extractions. The final process by which inundation regime could be reduced is through increased transpiration by plantations set close to a wetland. This could apply to lowering the local water table of basin-type wetlands, or reducing run-off and length of inundation of heathland wetlands.

5.4.5 Invasion by exotic species

Currently only one exotic species of fish, the Mosquitofish, *Gambusia holbrooki* has been recorded from the Muir/Unicup wetlands. This species is now widespread throughout the southwest of Western Australia, and throughout the Muir/Unicup catchments. Once established, it is virtually impossible to eradicate, without taking extreme action (e.g. poisoning a whole wetland). Even if removed, there is a high probability the species will re-invade via watercourses or in sheet flooding. It is accepted that the Mosquitofish will compete with native species and may reduce the populations of some, however, it is not as damaging as other non-native species, such as Redfin Perch (*Perca fluviatilis*), Rainbow trout (*Oncorhynchus mykiss*) or Brown trout (*Salmo trutta*) that possibly could be introduced to these wetlands. As a general policy, any introductions should be discouraged, and any ventures, such as aquaculture, from which species could escape into these wetlands should be located away from the wetlands and their watercourses.

Introductions of weed species of plants will be discussed in a separate report addressing flora of the wetlands.

5.4.6 Nutrient enrichment

Another consideration with respect to catchment clearing is the potential for eutrophication of wetlands due to the flushing of nutrients applied for agricultural purposes into watercourses and then into wetlands. Water quality data collected in this study show that many wetlands classify as eutrophic based on nitrogen levels, but phosphorus levels are still low. The absence of extensive algal blooms during this study suggests that these systems are probably phosphorus limited. The flushing of fertiliser-derived phosphorus into the wetlands would quickly lead to algal blooms with associated decreases in biodiversity. The potential would also exist for bird deaths through algal poisoning or the outbreak of botulism, especially towards the end of summer as wetlands dry and nutrients are concentrated.

The application of only slow release fertilisers, maintenance of effective buffers around wetlands and redirection of drains away from wetlands is recommended to avoid nutrient enrichment of wetlands.

5.4.7 Fire

Fire, under certain situations, will be extremely detrimental to the peat wetlands in the Muir/Unicup catchments. Horwitz (1994) highlights fire as a threat to the far southern peatlands of southwestern Australia. Local history suggests that the open areas of Byenup Lagoon and Tordit-Gurrup, and the total absence of peat from Lake Muir are a result of wildfire – probably during drought. Although all surface waters may have disappeared, normally the peat wetlands will remain damp in summer, the peat acting as a sponge and retaining water, and so preventing the peat from burning. However, in drought periods, it is very likely that the peat may dry-out to the extent where it may burn, resulting in the total loss of peat from parts or all of a wetland. Horwitz (1994) documented a peatland near Mt Chudalup from which 30 cms of peat was lost following the escape of a prescription burn in 1992, exposing tree roots. Differences in aquatic fauna were detected at another area, considered to be due to differences in habitat quality of identical shrublands as a result of different fire ages. The incidence of fires resulting in loss of peat in wetlands in the Muir/Unicup catchments appears relatively low, given that the peat coverage of most wetlands is still intact. However, the potential exists for the risk to increase as average rainfall in the southwest decreases. Increased care should be taken when prescription burning is conducted beside peat swamps. Burning should be avoided when these swamps are dry and this should be considered as a key criterion when assessing suitability of conditions for prescribed burning.

Fire has another potentially deleterious effect on wetlands in that it releases nutrients that then may be flushed into wetlands (Davies & Lane, 1996). As discussed above, wetlands in the Muir/Unicup catchments appear to be phosphorus-limited. Fires in forest adjacent to wetlands or in wetland buffers may result in algal blooms following flushing of the released nutrients into the wetlands. Maintaining adequate buffers will reduce the potential for flushing of nutrients into wetlands and avoiding prescribed burning in buffers will limit nutrient availability.

5.4.8 Drains

Many landholders in the Muir/Unicup catchments see land drainage as a partial solution to salinity. Man-made drains can be used to quickly remove surface water from low-lying, salt-affected areas, thereby removing salt, lowering the local water table and returning the land into production. However, natural watercourses are often the routes taken by drains, and wetlands and rivers are often seen as the repositories for this excess water (and associated contaminants). Inappropriately constructed and located drains can result in salination, increased inundation and eutrophication of wetlands (the effects of which are discussed above). Every care must be taken to avoid draining agricultural/saline land into wetlands. Currently, rivers in the area are already saline (e.g. Tone and Frankland). If drains are to be constructed, it is preferable to drain degraded land into these systems rather than into relatively undisturbed wetlands.

5.4.9 Riparian buffer clearing

Maintenance of adequate buffer zones around wetlands in the Muir/Unicup catchments should be a management priority. Buffers prevent wind mixing and associated turbidity in open wetlands, provide waterbird habitat and nesting sites, and assist in preventing overland flow of nutrients into wetlands and thus prevent eutrophication. There are few empirical data on what constitutes an adequate buffer zone, however, Davies & Lane (1996) recommend a buffer zone of at least 200 m to minimise nutrient enrichment of wetlands on sandy soils (*viz*. Swan Coastal Plain wetlands). Buffers should not include part of the wetland itself, but should be formed from non-wetland dependent vegetation (e.g. vegetation that lies above the high water level of the wetland).

5.4.10 Stock access for water/grazing

Access of livestock to wetlands should be avoided because of the associated effects of degradation of wetland vegetation through grazing and trampling, disturbance to the substrate (peat) of the wetland, and introduction of nutrients ultimately leading to eutrophication. Wetlands and their buffers should be fenced-off to prevent stock access. If water is required during summer, then watering points should be provided remote from the wetland (e.g. either by pumping or gravity feed via a pipe or channel). The amount of water removed should be restricted so that the inundation regime of the wetland is not altered.

5.4.11 Mining

The only significant mining activity in the Muir/Unicup catchments is peat mining (to supply horticultural demands) which currently occurs in Red Lake and has been proposed, but was rejected for Tordit-Gurrup Lagoon. The possible effects of peat mining on the aquatic fauna and ecology of Tordit-Gurrup Lagoon, with reference to Byenup Lagoon and Poorginup Swamp was addressed by DeHaan (1987). Basically, peat swamps in the Muir/Unicup catchments are characterised by dense cover of *Baumea articulata* growing on deep deposits of peat. The ecology of these systems is adapted to these characteristics. Peat mining involves the removal of the peat. It is predicted that this activity will irrevocably change the nature of a peat wetland.

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8 Appendices

Appendix 1. Protocol to be followed for sorting preserved samples of aquatic macroinvertebrates from wetlands in the Muir/Unicup Area

Aims:

The principal aim is to maximise the number of species recovered.
The secondary aim is to recover relative abundance data. For this purpose, four broad categories are identified:

1 = 1 individual
2 = 2 - 10 individuals
3 = 11 - 100 individuals
4 = > 100 individuals

Sampling:

Macroinvertebrates samples were taken with a 250µm mesh pond net using a standardised 50 m transect approach, maximising the number of different habitats sampled.

Sorting protocol:

Because of the nature of most of the wetlands (acidic, peaty substrate with large quantities of organic material), the samples tend to be large, with a lot of coarse and fine organic material. Therefore, a sequence of sieving should be followed.

Step 1.

Sieve sample through a stack of sieves decreasing from very coarse (i.e. 10 - 15 mm), to medium (2 mm) and then fine (250µm). The coarse and medium fractions should be sorted in their entirety, to remove all species. The coarse fraction may be sorted by eye, and the medium fraction sorted under low power magnification (i.e. anglepoise magnifying glass or jewellers vision visors). If there are large volumes of material, do not attempt to place the whole sample into a tray and try to sort it. Take small portions so that the organic material is evenly dispersed across the tray, reducing the possibility of animals being obscured by organic material. This approach is much more efficient and, in the long run, often is faster than trying to labour over a packed tray!

In certain instances, there may be some moderately to very abundant species. It is not necessary to remove all individuals (i.e. tens, hundreds or thousands of Corixidae). If you are sure they are all one species, remove a representative sample (i.e. 20) and estimate the total number in the sample and record this on the data sheet. These numbers will be converted to the abundance categories at a later date. So, at this stage, estimate the actual number of animals. Even if we subsequently discover that there were two closely related species - abundances can be estimated using the proportion of each in the 20 that was selected and applying this to the total number estimated. All specimens selected from the coarse and medium fractions should be bulked in one vial (**coarse portion**).

The exceptions are Chironomidae and Hydracarina - which should be kept separate as they will be sent to specialist taxonomists. Also, representatives of any microinvertebrates should be kept in a separate bulk sample. Taxa considered as microinvertebrates include:

Ostracoda

Copepoda
Cladocera
Rotifera
Protozoa

Any additional vials, as above, should be labelled and identified as **coarse fraction,** along with the site name, number and date sampled.

Step 2.

The fine fraction, being that which passes through the 2 mm sieve but is retained by the 250µm sieve will likely need to be subsampled. In some instances this fraction will be small (or contain few animals) and may be sorted in its entirety.

The recommended approach to subsampling is to use a jug splitter, as used for the Monitoring River Health Initiative. This splits the entire sample into half and then successive halves into quarters, eighths etc. The aim is to derive a subsample portion that contains a sufficient number of animals to still be representative of the whole of the fine fraction, but not to contain so many animals as to be impossible to sort. As a rule of thumb, the subsample fraction must contain at least 200 animals. Remove all animals from the subsample and place in a vial (**subsample fraction**), recording the size of the subsample on the label (i.e. 1/4, 1/8, 1/16 etc). If a subsample contains large numbers of a distinctive species, it is not necessary to remove every individual from the portion. If you are sure they are all one species, remove a representative sample (i.e. 20) and estimate the total number in the subsample and record this on the data sheet. Later on, the number estimated will be multiplied by the subsample portion, added to any individuals removed from the bulk portion and then converted to the abundance categories. As above, even if we subsequently discover that what appeared as one species is actually two closely related species - abundances can be estimated using the proportion of each in the 20 that was selected and applying this to the total number estimated.

Chironomidae and Hydracarina should be kept in separate vials as they will be sent to specialist taxonomists. Also, representatives of any microinvertebrates should be kept in a separate subsampled bulk sample. Taxa considered as microinvertebrates include:

Ostracoda
Copepoda
Cladocera
Rotifera
Protozoa

Any additional vials, as above, should be labelled and identified as **subsampled fractions** - recording the size of the subsample (i.e. 1/4, 1/8, 1/16 etc) along with the site name, number and date sampled.

Step 3.

After the subsampled portion (i.e. the 1/8) has been sorted, it may be discarded. However, the remaining 7/8$^{\text{ths}}$ must be retained, preserved in 70% alcohol for future reference. Before preserving the remaining 7/8$^{\text{ths}}$, it should be quickly scanned for any additional taxa that have not previously been recorded. Representatives should be placed in an additional vial labelled **fine fraction residue**. This will generally only include macroinvertebrates. Any singleton microinvertebrates will likely be in the dedicated samples for microinvertebrates collected with the 50µm mesh net and can be ignored.

Output:
For each sample, assuming it has been subsampled, there should be upto 12 vials:

Coarse Fraction
Macroinvertebrates
Chironomidae
Hydracarina
Microinvertebrates (unlikely given the coarse mesh sizes)

Subsampled Fraction
Macroinvertebrates
Chironomidae
Hydracarina
Microinvertebrates

Fine Fraction Residue
Macroinvertebrates
Chironomidae
Hydracarina
Microinvertebrates (ignore)

Example datasheet to be used with the above sampling protocol

Site Name		Site Number	
Date Sampled			
Comments :-			

Coarse Fraction			
Species abundance estimates	only for those species for which representatives were picked-out		
Species Name/Description	No.	Species Name/Description	No.
Fine Fraction Subsample		Size of Subsample =	
Species abundance estimates	only for those species for which representatives were picked-out		
Species Name/Description	No.	Species Name/Description	No.

Vial Checklist (✓ or no. vials in each component)		
Coarse Fraction	**Subsampled Fraction**	**Fine Fraction Residue**
Macroinvertebrates	Macroinvertebrates	Macroinvertebrates
Chironomidae	Chironomidae	Chironomidae
Hydracarina	Hydracarina	Hydracarina
Microcrustacea	Microcrustacea	Microcrustacea

Appendix 2. Physico-chemical and morphological data measured at each wetland on each sampling occasion ('.' indicates missing data)

Site	No.	Date	Ca mg/l	Cl mg/l	K mg/l	Mg mg/l	Na mg/l	DO(%) Top	DO(%) Bottom
Poorginup Swamp	1	20/10/96	6.0	91.0	2.0	9.0	58.0	54	42
Poorginup Swamp	1	14/01/97	7.0	140.0	3.0	12.0	86.0	35	23
Poorginup Swamp	1	10/05/97	10.0	230.0	3.0	21.0	130.0	75	51
Tordit-Gurrup Lagoon	2	20/10/96	31.0	520.0	8.0	39.0	290.0	90	90
Tordit-Gurrup Lagoon	2	14/01/97	28.0	340.0	5.0	27.0	190.0	98	98
Tordit-Gurrup Lagoon	2	10/05/97	47.0	730.0	11.0	58.0	430.0	91	89
Yarnup Swamp	5	22/10/96	29.0	860.0	5.0	86.0	400.0	75	63
Yarnup Swamp	5	15/01/97	34.0	890.0	6.0	85.0	460.0	68	96
Yarnup Swamp	5	8/05/97	88.0	2800.0	17.0	270.0	1200.0	77	77
Bokarup Swamp	6	21/10/96	22.0	660.0	4.0	64.0	350.0	73	29
Bokarup Swamp	6	15/01/97	21.0	530.0	3.0	49.0	270.0	61	15
Bokarup Swamp	6	7/05/97	58.0	2100.0	10.0	170.0	1100.0	88	88
Cobertup Swamp	7	19/10/96	11.0	220.0	5.0	24.0	120.0	64	55
Cobertup Swamp	7	13/01/97	18.0	330.0	7.0	34.0	170.0	80	28
Cobertup Swamp	7	5/05/97	26.0	660.0	11.0	61.0	330.0	93	93
Noobijup Swamp	8	22/10/96	30.0	750.0	9.0	66.0	390.0	59	52
Noobijup Swamp	8	15/01/97	25.0	710.0	8.0	65.0	370.0	68	24
Noobijup Swamp	8	7/05/97	19.0	480.0	4.0	50.0	260.0	36	25
Kulunilup NR	11	5/08/97	63.0	1300.0	14.0	130.0	650.0	59	59
Kulunilup NR	11	22/10/97	25.0	470.0	5.0	48.0	230.0	90	70
Mulgarnup Swamp	12	17/10/96	21.0	620.0	7.0	44.0	340.0	51	48
Mulgarnup Swamp	12	16/01/97	30.0	860.0	11.0	61.0	480.0	35	18
Mulgarnup Swamp	12	6/05/97	35.0	1100.0	11.0	71.0	580.0	53	53
Byenup Lagoon	14	19/10/96	62.0	1400.0	12.0	130.0	690.0	80	78
Byenup Lagoon	14	14/01/97	48.0	550.0	6.0	58.0	290.0	127	135
Byenup Lagoon	14	9/05/97	160.0	2900.0	29.0	250.0	1400.0	99	99
N end of Byenup Lagoon	15	17/10/96	36.0	650.0	7.0	59.0	330.0	50	43
N end of Byenup Lagoon	15	16/01/97	74.0	1600.0	16.0	120.0	800.0	68	60
N end of Byenup Lagoon	15	6/05/97	170.0	3300.0	33.0	280.0	1600.0	101	101
Geordinup Swamp	16	18/10/96	30.0	730.0	4.0	79.0	340.0	65	49
Geordinup Swamp	16	14/01/97	65.0	1600.0	9.0	170.0	740.0	111	74
Geordinup Swamp	16	9/05/97	130.0	3500.0	20.0	370.0	1500.0	88	82
Western swamp in Kodjinup NR	18	20/10/96	16.0	650.0	7.0	45.0	360.0	47	22
Western swamp in Kodjinup NR	18	16/01/97	26.0	1100.0	11.0	74.0	620.0	41	33
Western swamp in Kodjinup NR	18	6/05/97	44.0	1900.0	15.0	120.0	1000.0	63	63
Galamup Swamp	19	18/10/96	8.0	130.0	7.0	12.0	88.0	58	48
Galamup Swamp	19	13/01/97	11.0	170.0	8.0	14.0	120.0	30	22
Galamup Swamp	19	5/05/97	19.0	460.0	15.0	31.0	320.0	56	56
Lake Unicup	24	5/08/97	140.0	3400.0	47.0	290.0	1700.0	100	105
Lake Unicup	24	21/10/97	40.0	890.0	12.0	78.0	460.0	102	99
Loc. 12676, S of E end of Pindicup Rd	29	21/10/96	12.0	270.0	4.0	24.0	160.0	43	31
Loc. 12676, S of E end of Pindicup Rd	29	15/01/97	12.0	210.0	3.0	19.0	130.0	95	9
Loc. 12676, S of E end of Pindicup Rd	29	7/05/97	12.0	530.0	5.0	42.0	310.0	58	58
Pindicup Lake	30	6/05/97	310.0	2600.0	63.0	340.0	2000.0	105	105
Pindicup Lake	30	20/10/97	140.0	2100.0	42.0	250.0	1300.0	110	112
Loc. 12686, SW of Unicup NR	31	21/10/96	120.0	11000.0	96.0	800.0	6900.0	89	84
Loc. 12686, SW of Unicup NR	31	16/01/97	130.0	12000.0	100.0	770.0	7400.0	90	90
Loc. 12686, SW of Unicup NR	31	6/05/97	180.0	17000.0	150.0	1100.0	9300.0	81	81
Loc. 12561, SE of Basil/Geordinup Rd	33	19/10/96	17.0	1100.0	22.0	48.0	750.0	97	97
Loc. 12561, SE of Basil/Geordinup Rd	33	15/01/97	38.0	3400.0	62.0	140.0	2100.0	94	96
Loc. 12561, SE of Basil/Geordinup Rd	33	9/05/97	96.0	19000.0	260.0	900.0	14000.0	85	85
NE Unicup NR	35	5/08/97	23.0	510.0	13.0	47.0	290.0	88	88
NE Unicup NR	35	21/10/97	19.0	460.0	9.0	42.0	250.0	91	70
S Kulunilup NR	37	22/10/97	12.0	230.0	4.0	24.0	110.0	90	50
W Kulunilup NR	38	22/10/97	2.0	160.0	5.0	4.0	110.0	125	125
NE Kodjinup NR	43	21/10/97	14.0	650.0	6.0	48.0	400.0	50	50
Myalgelup Road	44	23/10/97	.	.	.	.	.	.	.
SE Kodjinup NR	49	21/10/97	12.0	440.0	4.0	36.0	260.0	70	65
SW Kodjinup NR	50	21/10/97	24.0	890.0	5.0	69.0	520.0	30	22
Wimbalup Rd	52	23/10/97	8.0	170.0	2.0	15.0	91.0	.	.
SW Cowerup NR	53	23/10/97	16.0	590.0	6.0	47.0	330.0	.	.

Appendix 2. (cont.)

Site	No.	Date	Temp Top	Temp Bottom	Cond. uS/cm	Salinity PPT	pH	Depth @ gauge	Depth @ Deepest	Alkal mg/L
Poorginup Swamp	1	20/10/96	18.5	15.0	388	0.19	6.20	0.62	0.77	15
Poorginup Swamp	1	14/01/97	18.8	18.2	570	0.29	5.64	0.42	0.57	20
Poorginup Swamp	1	10/05/97	14.1	11.6	835	0.42	6.04	0.15	0.30	18
Tordit-Gurrup Lagoon	2	20/10/96	18.2	18.2	2000	1.00	6.76	2.78	2.78	98
Tordit-Gurrup Lagoon	2	14/01/97	25.8	25.8	2260	1.13	7.63	2.56	2.56	110
Tordit-Gurrup Lagoon	2	10/05/97	13.3	13.3	2620	1.31	7.88	2.23	2.23	160
Yarnup Swamp	5	22/10/96	18.2	18.1	2800	1.40	5.78	1.02	1.02	43
Yarnup Swamp	5	15/01/97	28.2	25.1	5110	2.56	7.46	0.77	0.77	73
Yarnup Swamp	5	8/05/97	12.3	12.3	9080	4.54	7.28	0.53	0.53	110
Bokarup Swamp	6	21/10/96	19.9	17.9	2650	1.33	7.36	0.78	0.78	35
Bokarup Swamp	6	15/01/97	31.5	24.6	5450	2.73	7.44	0.53	0.53	95
Bokarup Swamp	6	7/05/97	12.4	12.4	10760	5.38	7.20	0.18	0.18	83
Cobertup Swamp	7	19/10/96	16.8	16.7	986	0.49	5.66	0.87	0.99	33
Cobertup Swamp	7	13/01/97	28.3	25.9	1610	0.81	6.79	0.54	0.66	63
Cobertup Swamp	7	5/05/97	16.4	16.4	2440	1.22	6.50	0.18	0.30	58
Noobijup Swamp	8	22/10/96	17.9	17.9	2550	1.28	6.40	1.12	1.23	45
Noobijup Swamp	8	15/01/97	27.8	27.8	3630	1.82	7.04	0.85	0.96	88
Noobijup Swamp	8	7/05/97	15.3	12.7	2910	1.46	6.68	0.69	0.80	73
Kulunilup NR	11	5/08/97	14.2	14.1	4400	2.20	6.95	0.27	2.00	70
Kulunilup NR	11	22/10/97	22.8	19.1	3700	1.85	7.01	0.74	2.47	58
Mulgarnup Swamp	12	17/10/96	13.8	13.7	2170	1.09	6.24	0.62	0.80	43
Mulgarnup Swamp	12	16/01/97	31.5	22.6	3460	1.73	6.33	0.32	0.50	70
Mulgarnup Swamp	12	6/05/97	15.9	15.9	6280	3.14	6.77	0.02	0.20	88
Byenup Lagoon	14	19/10/96	19.9	19.5	4380	2.19	8.01	2.52	2.52	140
Byenup Lagoon	14	14/01/97	26.8	26.4	7160	3.58	8.16	2.19	2.19	190
Byenup Lagoon	14	9/05/97	14.9	14.9	8730	4.37	8.60	1.89	1.89	240
N end of Byenup Lagoon	15	17/10/96	17.9	15.3	2160	1.08	6.13	0.69	0.81	68
N end of Byenup Lagoon	15	16/01/97	30.6	28.9	6060	3.03	6.77	0.41	0.53	140
N end of Byenup Lagoon	15	6/05/97	16.0	16.0	9830	4.92	7.50	0.18	0.30	200
Geordinup Swamp	16	18/10/96	18.3	17.2	2500	1.25	5.91	0.68	1.18	33
Geordinup Swamp	16	14/01/97	30.1	24.6	5910	2.96	7.26	0.36	0.86	75
Geordinup Swamp	16	9/05/97	13.3	13.3	9600	4.80	7.80	0.00	0.50	180
Western swamp in Kodjinup NR	18	20/10/96	20.8	16.5	2860	1.43	6.11	0.60	0.85	38
Western swamp in Kodjinup NR	18	16/01/97	26.1	22.1	3880	1.94	6.62	0.32	0.57	55
Western swamp in Kodjinup NR	18	6/05/97	13.2	13.2	5820	2.91	7.35	0.05	0.30	70
Galamup Swamp	19	18/10/96	21.6	17.2	572	0.29	5.86	0.52	0.77	15
Galamup Swamp	19	13/01/97	28.5	28.5	1165	0.58	6.53	0.26	0.51	95
Galamup Swamp	19	5/05/97	15.2	15.2	2260	1.13	6.49	-0.10	0.15	60
Lake Unicup	24	5/08/97	15.0	15.0	9720	4.86	8.10	1.28	1.28	120
Lake Unicup	24	21/10/97	19.7	19.4	6980	3.49	8.16	1.74	1.74	94
Loc. 12676, S of E end of Pindicup Rd	29	21/10/96	17.8	15.7	1446	0.72	7.90	0.80	1.54	45
Loc. 12676, S of E end of Pindicup Rd	29	15/01/97	30.0	23.9	1930	0.97	7.20	0.57	1.31	85
Loc. 12676, S of E end of Pindicup Rd	29	7/05/97	12.7	11.6	2910	1.46	6.55	0.08	0.82	100
Pindicup Lake	30	6/05/97	15.0	15.0	13670	6.84	8.54	0.17	0.40	180
Pindicup Lake	30	20/10/97	21.9	21.9	7190	3.60	8.59	0.57	0.57	170
Loc. 12686, SW of Unicup NR	31	21/10/96	19.3	19.9	34700	17.35	7.96	1.00	1.32	200
Loc. 12686, SW of Unicup NR	31	16/01/97	25.8	25.8	37600	18.80	8.33	0.75	1.07	240
Loc. 12686, SW of Unicup NR	31	6/05/97	12.6	12.6	46800	23.40	8.60	0.48	0.80	370
Loc. 12561, SE of Basil/Geordinup Rd	33	19/10/96	17.7	17.7	4050	2.03	9.94	0.65	0.92	83
Loc. 12561, SE of Basil/Geordinup Rd	33	15/01/97	25.8	25.8	12100	6.05	9.58	0.34	0.61	300
Loc. 12561, SE of Basil/Geordinup Rd	33	9/05/97	12.8	12.8	56100	28.05	9.01	-0.15	0.12	850
NE Unicup NR	35	5/08/97	15.0	13.9	2480	1.24	7.01	0.39	0.75	88
NE Unicup NR	35	21/10/97	25.0	18.3	1300	0.65	7.47	1.03	1.39	58
S Kulunilup NR	37	22/10/97	19.4	19.4	1630	0.82	6.25	0.25	0.25	18
W Kulunilup NR	38	22/10/97	29.4	29.4	610	0.31	7.04	0.10	0.10	13
NE Kodjinup NR	43	21/10/97	17.5	17.5	2700	1.35	7.35	0.20	0.20	160
Myalgelup Road	44	23/10/97	18.1	18.1	3170	1.59	6.14	0.30	0.58	13
SE Kodjinup NR	49	21/10/97	20.6	20.6	2050	1.03	6.91	0.20	0.20	53
SW Kodjinup NR	50	21/10/97	22.1	22.1	3100	1.55	7.07	0.25	0.25	63
Wimbalup Rd	52	23/10/97	20.4	20.4	640	0.32	6.50	0.20	0.30	25
SW Cowerup NR	53	23/10/97	20.9	20.9	2360	1.18	7.03	0.10	0.10	48

NB negative values for 'depth @ gauge' indicate water level was below the base of the gauge

Appendix 2 (cont.)

Site	No.	Date	Colour TCU	N_NH3 mg/L	N_NO3 mg/L	Tot_N mg/L	P_SR mg/L	Tot_P mg/L	Turb NTU
Poorginup Swamp	1	20/10/96	180	0.05	0.02	1.70	0.005	0.010	1.9
Poorginup Swamp	1	14/01/97	390	0.02	0.02	1.70	0.010	0.010	1.1
Poorginup Swamp	1	10/05/97	350	0.02	0.03	1.40	0.005	0.005	3.8
Tordit-Gurrup Lagoon	2	20/10/96	68	0.28	0.03	1.80	0.005	0.005	1.6
Tordit-Gurrup Lagoon	2	14/01/97	81	0.14	0.04	1.80	0.010	0.010	0.9
Tordit-Gurrup Lagoon	2	10/05/97	38	0.20	0.01	2.00	0.005	0.005	0.9
Yarnup Swamp	5	22/10/96	38	0.03	0.02	0.94	0.005	0.005	0.9
Yarnup Swamp	5	15/01/97	66	0.02	0.01	0.81	0.005	0.005	0.7
Yarnup Swamp	5	8/05/97	43	0.02	0.01	0.96	0.005	0.005	1.6
Bokarup Swamp	6	21/10/96	160	0.07	0.01	1.20	0.005	0.010	1.6
Bokarup Swamp	6	15/01/97	270	0.49	0.01	1.50	0.010	0.010	1.0
Bokarup Swamp	6	7/05/97	130	0.61	0.01	2.00	0.005	0.010	1.1
Cobertup Swamp	7	19/10/96	120	0.03	0.03	1.00	0.005	0.005	1.3
Cobertup Swamp	7	13/01/97	180	0.01	0.02	2.00	0.005	0.005	1.0
Cobertup Swamp	7	5/05/97	30	0.01	0.01	0.79	0.005	0.005	1.4
Noobijup Swamp	8	22/10/96	31	0.03	0.01	1.60	0.005	0.005	1.2
Noobijup Swamp	8	15/01/97	90	0.02	0.01	1.50	0.005	0.005	1.1
Noobijup Swamp	8	7/05/97	120	0.03	0.00	1.80	0.005	0.005	1.2
Kulunilup NR	11	5/08/97	22	0.04	0.01	0.49	0.005	0.005	2.4
Kulunilup NR	11	22/10/97	28	0.01	0.01	0.44	0.005	0.005	2.3
Mulgarnup Swamp	12	17/10/96	310	0.06	0.02	1.70	0.050	0.005	2.7
Mulgarnup Swamp	12	16/01/97	530	0.03	0.02	1.90	0.005	0.005	1.0
Mulgarnup Swamp	12	6/05/97	460	0.31	0.01	2.20	0.005	0.005	1.5
Byenup Lagoon	14	19/10/96	21	0.08	0.01	1.80	0.005	0.005	2.0
Byenup Lagoon	14	14/01/97	42	0.28	0.01	1.90	0.010	0.010	1.2
Byenup Lagoon	14	9/05/97	31	0.08	0.01	2.70	0.005	0.005	2.0
N end of Byenup Lagoon	15	17/10/96	68	0.02	0.01	1.60	0.005	0.005	1.3
N end of Byenup Lagoon	15	16/01/97	140	0.22	0.02	2.70	0.005	0.005	1.3
N end of Byenup Lagoon	15	6/05/97	150	0.04	0.01	4.00	0.005	0.010	2.5
Geordinup Swamp	16	18/10/96	99	0.04	0.03	1.30	0.005	0.010	0.8
Geordinup Swamp	16	14/01/97	74	0.03	0.03	1.60	0.005	0.005	1.1
Geordinup Swamp	16	9/05/97	84	0.50	0.01	2.60	0.005	0.005	3.1
Western swamp in Kodjinup NR	18	20/10/96	210	0.05	0.02	1.40	0.005	0.010	0.4
Western swamp in Kodjinup NR	18	16/01/97	500	0.03	0.01	1.50	0.010	0.010	0.6
Western swamp in Kodjinup NR	18	6/05/97	260	0.02	0.03	1.30	0.005	0.005	0.6
Galamup Swamp	19	18/10/96	410	0.03	0.01	1.80	0.005	0.005	1.2
Galamup Swamp	19	13/01/97	1400	0.39	0.02	4.70	0.010	0.010	0.8
Galamup Swamp	19	5/05/97	2000	3.40	0.03	12.00	0.005	0.010	6.0
Lake Unicup	24	5/08/97	30	0.33	0.02	3.60	0.005	0.005	2.0
Lake Unicup	24	21/10/97	23	0.02	0.01	1.2	0.005	0.005	3.9
Loc. 12676, S of E end of Pindicup Rd	29	21/10/96	270	0.04	0.02	1.40	0.005	0.010	1.2
Loc. 12676, S of E end of Pindicup Rd	29	15/01/97	340	0.02	0.02	1.60	0.010	0.010	0.7
Loc. 12676, S of E end of Pindicup Rd	29	7/05/97	190	0.05	0.02	1.50	0.005	0.010	1.4
Pindicup Lake	30	6/05/97	33	0.03	0.02	1.70	0.005	0.005	1.4
Pindicup Lake	30	20/10/97	24	0.03	0.01	0.88	0.005	0.005	2.5
Loc. 12686, SW of Unicup NR	31	21/10/96	25	0.17	0.02	2.20	0.010	0.010	1.5
Loc. 12686, SW of Unicup NR	31	16/01/97	24	0.20	0.01	1.50	0.005	0.005	1.0
Loc. 12686, SW of Unicup NR	31	6/05/97	25	0.86	0.04	3.50	0.005	0.005	3.3
Loc. 12561, SE of Basil/Geordinup Rd	33	19/10/96	17	0.02	0.01	0.80	0.005	0.005	5.5
Loc. 12561, SE of Basil/Geordinup Rd	33	15/01/97	72	0.01	0.01	1.70	0.005	0.005	0.6
Loc. 12561, SE of Basil/Geordinup Rd	33	9/05/97	120	0.06	0.01	6.50	0.005	0.010	3.2
NE Unicup NR	35	5/08/97	110	0.01	0.01	2.20	0.005	0.010	1.4
NE Unicup NR	35	21/10/97	150	0.01	0.01	1.70	0.005	0.010	4.8
S Kulunilup NR	37	22/10/97	98	0.01	0.01	0.85	0.005	0.005	6.2
W Kulunilup NR	38	22/10/97	96	0.02	0.01	1.8	0.005	0.005	8.3
NE Kodjinup NR	43	21/10/97	380	0.01	0.01	1.5	0.005	0.005	6.1
Myalgelup Road	44	23/10/97	72	0.01	0.01	0.87	0.005	0.005	9.1
SE Kodjinup NR	49	21/10/97	480	0.03	0.01	1.4	0.005	0.01	3
SW Kodjinup NR	50	21/10/97	420	0.04	0.01	1.2	0.03	0.04	2.3
Wimbalup Rd	52	23/10/97	67	0.01	0.01	0.7	0.05	0.05	2.7
SW Cowerup NR	53	23/10/97	250	0.02	0.01	0.79	0.005	0.01	8.1

Appendix 2 (cont.)

Site	No.	Organics cms	open water %	reeds/ rushes %	Melaleuca %	Macrophyte %
Poorginup Swamp	1	133	35	50	15	0
Tordit-Gurrup Lagoon	2	85	45	54	1	20
Yarnup Swamp	5	97	10	89	1	10
Bokarup Swamp	6	150	35	64	1	0
Cobertup Swamp	7	130	0	99	1	0
Noobijup Swamp	8	60	0	99	1	0
Kulunilup NR	11	80	30	69	1	10
Mulgarnup Swamp	12	75	0	71	29	0
Byenup Lagoon	14	120	25	72	3	1
N end of Byenup Lagoon	15	120	0	90	10	0
Geordinup Swamp	16	150	15	84	1	0
Western swamp in Kodjinup NR	18	75	0	80	20	0
Galamup Swamp	19	105	0	99	1	0
Lake Unicup	24	15	95	4	1	90
Loc. 12676, S of E end of Pindicup Rd	29	3	50	17	25	0
Pindicup Lake	30	10	55	44	1	55
Loc. 12686, SW of Unicup NR	31	2	95	3	2	0
Loc. 12561, SE of Basil/Geordinup Rd	33	10	90	5	5	80
NE Unicup NR	35	2	50	30	10	40
S Kulunilup NR	37	1	1	5	94	0
W Kulunilup NR	38	1	3	90	10	1
NE Kodjinup NR	43	1	50	25	75	1
Myalgelup Road	44	1	5	1	99	0
SE Kodjinup NR	49	1	1	5	94	0
SW Kodjinup NR	50	5	10	45	95	0
Wimbalup Rd	52	1	5	1	99	0
SW Cowerup NR	53	1	5	1	99	0

NB (morphological data were measured on one occasion only at each wetland)

Appendix 3. Samples and species ordered according to salinity and possible salinity tolerance. Sample codes refer to sampling trip (1 = October 1996, 2 = January 1997, 3 = May 1997, 4 = October 1997) and site number (refer to Table 2). Species with a significant negative (-ve) or positive (+ve) correlation between abundance and salinity are indicated.

site	1-1	2-1	1-19	4-38	4-52	3-1	1-7	2-19	4-35	1-29	2-7	4-37	2-29	1-2	4-49	1-15	1-12	2-2	3-19	4-53	3-7	3-35	1-16	1-8	3-2	1-6	4-43	1-5	1-18	3-8	3-29	4-50	4-44	2-12	2-8	4-11	2-18	1-33	1-14	3-11	2-5	2-6	3-18	2-16	2-15	3-12	4-24	2-14	4-30	3-14	3-5	3-16	3-24	3-15	3-6	2-33	3-30	1-31	2-31	3-31	3-33	
salinity	0.19	0.29	0.29	0.31	0.32	0.42	0.49	0.58	0.65	0.72	0.81	0.82	0.97	1.00	1.03	1.08	1.09	1.13	1.13	1.18	1.22	1.24	1.25	1.28	1.31	1.33	1.35	1.40	1.43	1.46	1.46	1.55	1.59	1.73	1.82	1.85	1.94	2.03	2.19	2.20	2.56	2.73	2.91	2.96	3.03	3.14	3.49	3.58	3.60	4.37	4.54	4.80	4.86	4.92	5.38	6.05	6.84	17.35	18.80	23.40	28.05	Correlation
Paramerina levidensis (Skuse)	*	*	*	.	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	.	*	*	*	*	*	*	*	*	*	*	*	*	.	*	*	.	*	*	.	*	*	.	*	.	*	.	.	.	*	.	.	.	.	.	.	-ve
Chironomus aff alternans (Walker)	*	*	*	.	.	*	.	*	*	*	*	*	*	*	*	.	*	*	*	*	.	*	*	*	.	.	*	*	*	*	*	*	*	*	.	*	*	*	*	*	*	*	*	*	*	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	-ve
Tanytarsus sp(VBM1)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	.	*	.	*	*	*	*	*	*	.	.	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	.	*	*	*	*	*	*	*	*	*	.	*	*	*	*	*	*	.	.	.	-ve
Limnophyes pullulus (Skuse)	*	*	.	*	*	*	*	.	*	*	*	*	.	.	*	*	*	.	*	.	.	.	*	*	*	.	*	*	*	.	.	*	*	*	.	*	.	*	*	.	*	.	.	.	*	*	*	*	.	*	.	.	*	*	.	.	.	.	.	.	.	-ve
Planorbidae spB1	.	*	*	*	*	*	.	*	.	.	.	.	*	*	*	*	*	*	.	*	.	.	*	*	.	.	.	*	*	*	*	*	*	*	*	*	*	.	*	.	*	*	*	*	*	*	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	-ve
Dicrotendipes sp. V47	.	*	.	.	*	*	.	.	*	*	.	*	*	*	*	.	.	*	*	*	*	*	*	*	*	.	*	*	*	*	*	*	*	*	*	*	*	.	*	.	*	.	*	*	.	*	*	.	.	.	*	*	.	*	*	.	.	.	.	.	.	-ve
Notonecta sp	*	*	*	*	.	*	*	*	*	*	*	.	*	.	.	*	*	.	.	*	.	*	.	.	.	.	*	.	*	.	*	*	.	*	.	.	*	*	*	.	.	.	*	*	*	*	.	*	*	.	.	.	.	*	.	*	*	.	.	.	.	-ve
Chironomini Genus (VSCL35)	.	*	.	.	*	*	.	.	*	*	*	*	.	.	.	*	*	*	.	*	.	*	*	*	.	.	.	*	*	*	*	.	.	.	*	.	*	.	.	*	*	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-ve
HYDROPHILIDAE spH1	.	*	.	*	*	.	.	*	*	.	*	*	*	*	.	.	.	.	.	*	.	.	*	.	.	.	*	.	.	.	.	*	*	*	*	*	*	.	*	.	*	*	.	*	.	.	.	*	.	.	.	.	.	.	.	*	.	.	.	.	.	-
Perthia acutitelson	.	*	*	.	.	.	*	*	.	.	*	.	*	.	.	*	*	.	.	*	.	.	*	*	.	.	.	*	*	.	*	*	*	.	.	.	*	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Sternopriscus multimaculatus	*	.	*	.	*	*	*	*	.	.	*	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	*	*	.	.	*	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hyphydrus elegans	.	*	.	.	.	.	.	.	*	*	*	.	*	*	*	*	.	.	.	*	.	*	.	.	.	*	.	.	*	.	*	.	*	*	.	*	*	*	*	.	*	*	*	*	.	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	-
Limnesia longigenitalis	*	*	*	.	*	*	.	.	.	.	.	*	*	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Tanytarsus sp(VSCL5)	.	.	*	.	*	.	*	.	.	*	.	*	.	.	*	.	.	*	.	*	.	.	*	.	.	.	*	*	*	.	.	.	*	.	.	*	.	.	.	*	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Alotanypus dalyupensis Freeman	.	*	*	.	*	*	.	.	.	*	*	.	*	.	.	.	.	.	*	*	.	.	*	*	.	.	*	*	*	*	*	*	*	*	.	.	*	.	.	*	*	.	*	*	*	*	.	*	.	.	*	*	*	.	*	.	.	.	.	.	.	-
Pentaneurini Genus C	*	*	*	.	*	*	.	.	.	.	*	*	.	.	*	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	-
Veliidae sp1	.	*	*	.	.	.	.	.	*	.	*	.	*	.	.	*	*	.	.	.	.	.	*	*	.	.	.	*	.	.	.	.	.	*	*	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Dicrotendipes ?conjunctus	*	.	*	.	.	.	.	*	*	*	*	.	*	.	.	.	*	*	*	*	.	*	.	*	*	.	.	*	*	*	*	.	.	*	*	.	*	*	.	*	*	*	*	*	*	.	*	*	.	*	*	*	*	*	.	*	*	.	.	.	.	-
Austrolestes analis	.	.	*	*	.	.	*	.	.	.	.	.	*	.	*	*	*	.	.	*	.	.	.	.	.	.	*	.	*	.	.	*	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
HYDROPHILIDAE sp1 (255602)	.	*	.	*	.	.	.	.	*	.	*	*	*	*	*	*	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	*	*	*	*	.	.	*	*	.	.	*	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	-
Procordulia affinis	.	.	.	.	.	*	*	*	.	.	*	.	*	*	*	*	*	*	.	.	.	.	*	*	.	.	.	*	.	*	.	.	.	*	*	*	.	.	.	.	*	*	.	*	*	*	.	.	.	.	*	*	.	.	*	*	.	.	.	.	.	-
Perthia branchialis	*	*	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	*	*	*	.	.	.	.	.	*	.	*	*	.	*	.	*	*	*	*	.	.	.	*	*	*	.	*	.	.	.	*	.	*	.	.	.	*	.	*	.	.	.	.	-
Hirudinae spB1	.	.	*	.	*	.	*	.	.	*	.	.	*	*	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Leptoceridae spH	*	*	.	.	*	.	.	.	.	.	.	*	.	.	.	*	*	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	*	*	.	.	*	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Cherax preisii	*	.	*	.	.	.	.	*	.	*	.	.	*	.	*	*	.	.	.	*	.	.	.	.	.	.	*	*	.	.	.	*	*	*	.	.	.	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	-
Antiporus sp (L)	*	.	*	.	.	.	*	.	*	.	.	.	.	.	.	*	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	-
Sternopriscus minimus	.	*	*	.	*	.	.	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	*	*	*	*	.	.	.	*	*	*	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	-
ceratopogonidae	*	.	.	.	.	.	*	.	*	*	*	*	.	*	.	*	*	*	.	.	.	.	*	*	*	.	*	*	.	*	*	.	*	*	*	*	*	*	.	.	.	.	.	*	*	.	.	.	*	*	.	.	*	*	.	.	*	.	*	.	.	-
Culicidae sp2	.	.	*	*	.	.	.	*	.	*	.	.	*	.	.	*	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Kiefferulus martini Freeman	.	.	.	.	*	*	.	.	*	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Limnochares australica	*	*	.	.	.	.	*	.	.	*	.	.	.	*	.	*	.	*	.	.	.	.	*	*	.	.	.	.	*	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	*	.	.	*	*	.	.	*	.	*	.	.	.	.	.	.	.	-
Coleoptera C1	.	.	.	*	.	.	.	.	.	.	*	.	*	*	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Corixidae sp1	*	.	*	.	.	.	*	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Arrenurus tasmanicus	*	*	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Cybister sp (L)	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	*	.	.	*	.	.	.	.	.	*	.	.	.	*	.	.	*	*	.	*	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	-

site	1-1	2-1	1-19	4-38	4-52	3-1	1-7	2-19	4-35	1-29	2-7	4-37	2-29	1-2	4-49	1-15	1-12	2-2	3-19	4-53	3-7	3-35	1-16	1-8	3-2	1-6	4-43	1-5	1-18	3-8	3-29	4-50	4-44	2-12	2-8	4-11	2-18	1-33	1-14	3-11	2-5	2-6	3-18	2-16	2-15	3-12	4-24	2-14	4-30	3-14	3-5	3-16	3-24	3-15	3-6	2-33	3-30	1-31	2-31	3-31	3-33	
salinity	0.19	0.29	0.29	0.31	0.32	0.42	0.49	0.58	0.65	0.72	0.81	0.82	0.97	1.00	1.03	1.08	1.09	1.13	1.13	1.18	1.22	1.24	1.25	1.28	1.31	1.33	1.35	1.40	1.43	1.46	1.46	1.55	1.59	1.73	1.82	1.85	1.94	2.03	2.19	2.20	2.56	2.73	2.91	2.96	3.03	3.14	3.49	3.58	3.60	4.37	4.54	4.80	4.86	4.92	5.38	6.05	6.84	17.35	18.80	23.40	28.05	Correlation
Aeshna brevistyla	.	*	.	.	.	.	*	*	*	.	*	.	*	.	.	.	*	.	*	.	*	*	*	.	.	*	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	*	.	.	.	.	-
Antiporus femoralis	.	.	*	.	.	.	.	.	.	.	.	.	.	*	*	*	.	*	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Uvarus pictus	*	.	.	.	*	.	.	.	.	.	.	.	.	*	.	*	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Curculionidae spB	.	.	.	.	*	.	*	.	.	*	.	.	.	*	.	.	*	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	-
HYDROPHILIDAE spL1 (L)	*	.	.	*	*	.	.	.	*	*	.	*	.	*	*	*	.	.	.	*	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	-
Coleoptera C9	*	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
HYDROPHILIDAE spH2	.	*	.	*	*	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	*	.	.	*	*	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	-
Hellythira sp2	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	*	.	.	.	*	.	.	.	.	*	*	.	.	.	*	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	-
Corynonewra sp	.	.	.	*	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Haliplus gibbus/fuscatus	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	*	.	.	.	*	.	.	*	.	.	.	*	.	*	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	-
HYDRAENIDAE sp1	*	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Homeodytes sp (L)	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Sternopriscus sp (L)	.	.	.	*	*	.	*	*	.	.	*	*	.	.	.	.	.	.	.	*	.	*	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	-
Antiporus sp(A)	*	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Megaporus sp (L)	.	.	.	*	.	.	.	.	*	*	.	*	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	.	-
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Eylais sp.	.	.	.	*	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Oniscoidea sp1	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Argiolestes pusillus	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Ecnomus sp	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	-
Ecnomina sentosa	.	*	*	.	.	.	*	.	.	.	.	.	.	.	.	*	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	-
Hydrodroma sp.	.	.	.	.	.	.	.	.	*	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Pleidae sp	.	.	.	.	.	.	.	.	*	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Leptoceridae sp1	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Xanthagrion erythroneurum	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	-
Palaemonetes australis	*	.	.	.	*	.	.	.	.	.	.	.	.	*	*	.	*	*	.	*	.	.	*	.	*	.	.	.	*	.	.	.	*	.	.	*	.	.	*	*	.	*	.	*	*	*	*	*	.	*	.	*	*	*	*	.	.	.	.	.	.	-
HALIPLIDAE sp (L)	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Rhantus suturalis	.	.	.	.	*	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Anisops sp1	.	.	.	*	.	.	*	*	*	*	.	.	*	.	*	.	.	.	*	*	.	*	.	.	.	.	*	.	*	.	*	*	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	*	*	.	.	*	.	-
Cloeon sp	.	.	.	.	.	.	.	.	*	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	*	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	-
Coleoptera C4	.	.	.	*	*	.	.	.	*	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	*	.	.	.	.	*	.	*	.	.	.	.	*	.	.	.	.	*	.	*	.	.	.	.	.	-
Ferrisia petterdi	.	.	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	-
Hemiptera sp2	*	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Larri laffa	*	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Austrolestes io	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Lancetes sp (L)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hyphydrus sp (L)	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-

site	1-1	2-1	1-19	4-38	4-52	3-1	1-7	2-19	4-35	1-29	2-7	4-37	2-29	1-2	4-49	1-15	1-12	2-2	3-19	4-53	3-7	3-35	1-16	1-8	3-3	1-6	4-43	1-5	1-18	3-8	3-29	4-50	4-44	2-12	2-8	4-11	2-18	1-33	1-14	3-11	2-5	2-6	3-18	2-16	2-15	3-12	4-24	2-14	4-30	3-14	3-5	3-16	3-24	3-15	3-6	2-33	3-30	1-31	2-31	3-31	3-33	
salinity	0.19	0.29	0.29	0.31	0.32	0.42	0.49	0.58	0.65	0.72	0.81	0.82	0.97	1.00	1.03	1.08	1.09	1.13	1.13	1.18	1.22	1.24	1.25	1.28	1.31	1.33	1.35	1.40	1.43	1.46	1.46	1.55	1.59	1.73	1.82	1.85	1.94	2.03	2.19	2.20	2.56	2.73	2.91	2.96	3.03	3.14	3.49	3.58	3.60	4.37	4.54	4.80	4.86	4.92	5.38	6.05	6.84	17.35	18.80	23.40	28.05	Correlation
Forcipomyiinae sp1	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hemianax papuensis	.	.	.	.	.	.	.	.	.	*	.	.	*	.	.	*	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	-
Tasmanocoenis tillyardi	.	.	.	.	.	.	.	.	*	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	-
?Paralymnophyes sp	.	.	.	*	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Allodessus bistrigatus	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Lymnidae sp1	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Orthocladiinae (VSC11)	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Lancetes lanceolatus (A)	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	-
Corixidae sp2	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hellythira sp1	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	-
Macrogyrus sp	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Limnichidae sp (A)	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
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Liodessus dispar	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hydrovatus sp	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Austroagrion coeruleum	.	.	.	.	.	.	.	*	*	*	*	.	*	*	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	*	*	.	.	.	*	*	.	.	.	.	-
Lancetes sp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Cladotanytarsus sp (VBM4)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Orthocladiinae (V43)	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Oecetis sp	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	*	.	.	*	.	.	*	.	.	*	.	.	.	*	*	.	.	.	*	.	.	.	.	.	.	.	*	.	*	.	*	.	.	.	*	*	.	.	.	.	-
Arrenurus forpicatoides	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Curculionidae spA	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hydrachna sp.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
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Empididae sp1	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Peza sp. 1	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	-
Leptoceridae sp1	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Orthocladinae ?genus	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Leptoceridae sp2	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	*	.	.	.	*	.	.	*	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	*	.	.	.	.	.	*	*	.	.	.	.	-
Hydaticus sp (L)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
?Micronecta sp1	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	*	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	*	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	-
Tipulidae	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Coleoptera C10	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hyderodes crassus	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Culicidae sp1	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Notoperata tenax	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Platynectes sp	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-

site	1-1	2-1	1-19	4-38	4-52	3-1	1-7	2-19	4-35	1-29	2-7	4-37	2-29	1-2	4-49	1-15	1-12	2-2	3-19	4-53	3-7
salinity	0.19	0.29	0.29	0.31	0.32	0.42	0.49	0.58	0.65	0.72	0.81	0.82	0.97	1.00	1.03	1.08	1.09	1.13	1.13	1.18	1.22
GYRINIDAE sp1 (L)	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.
Tanypodinae ?genus (VBM7)	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phreatoisidae sp1	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Conchostraca sp1	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Glacidorbis sp	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
HYDROPHILIDAE spL4	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Orthocladiinae sp (VSCL7)	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.
Austrogomphus collaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.
Leptoceridae sp4	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudohydryphantes doegi	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hemiptera sp3	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hydrazoa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*
Synthemis macrostigma	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hirudinae sp3	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.
Oxus australicus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*
Orthocladinae (V44)	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hirudinae sp4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paramerina sp (VBM3)	.	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.
Orthetrum caledonicum	.	.	.	.	.	.	.	.	*	*	.	.	*	.	.	.	.	.	.	.	.
Corixidae sp4	.	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	.	.	.
Scirtidae	*	*	.	.	.	.	*	*	.	.	.	.	.	.	.	*	*	.	.	.	.
Hemicordulia tau	.	.	.	.	.	.	.	.	*	*	.	.	*	.	.	.	.	.	.	.	.
Hirudinae sp5	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.
Larsia ?albiceps	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.
Arrenurus balladoniensis	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.
Austrolestes psche	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.
Tanytarsus sp (VSCL9)	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.
Cladopelma curtivalva Kieffer	.	.	.	.	*	*	.	.	.	*	*	*	*	*	.	.	.	*	*	*	*
Harrisius sp (VBM5)	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Sternopriscus marginatus	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Liodessus ?inornatus	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.
Sternopriscus sp. nov.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Laccotrephes tristis	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.
Arrenurus sp.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.
Austrothemis nigrescens	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	*
Amphipoda sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.
Tillia sp. 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.

site	3-35	1-16	1-8	3-2	1-6	4-43	1-5	1-18	3-8	3-29	4-50	4-44	2-12	2-8	4-11	2-18	1-33	1-14	3-11	2-5
salinity	1.24	1.25	1.28	1.31	1.33	1.35	1.40	1.43	1.46	1.46	1.55	1.59	1.73	1.82	1.85	1.94	2.03	2.19	2.20	2.56
GYRINIDAE sp1 (L)	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	.
Tanypodinae ?genus (VBM7)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phreatoisidae sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Conchostraca sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Glacidorbis sp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
HYDROPHILIDAE spL4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Orthocladiinae sp (VSCL7)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.
Austrogomphus collaris	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leptoceridae sp4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudohydryphantes doegi	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hemiptera sp3	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.
Hydrazoa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Synthemis macrostigma	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hirudinae sp3	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Oxus australicus	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.
Orthocladinae (V44)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hirudinae sp4	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Paramerina sp (VBM3)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Orthetrum caledonicum	*	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.
Corixidae sp4	.	.	.	.	.	.	.	*	*	*	.	*	.	.	.	*	.	.	.	.
Scirtidae	.	*	.	.	.	.	.	*	.	.	.	.	*	.	.	*	.	*	.	.
Hemicordulia tau	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Hirudinae sp5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Larsia ?albiceps	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arrenurus balladoniensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Austrolestes psche	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tanytarsus sp (VSCL9)	*	.	.	.	.	.	.	.	.	*	.	.	.	.	*	.	.	.	*	*
Cladopelma curtivalva Kieffer	*	.	.	*	.	*	*	.	.	*	.	.	.	.	.	*	.	*	*	*
Harrisius sp (VBM5)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sternopriscus marginatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Liodessus ?inornatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.
Sternopriscus sp. nov.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.
Laccotrephes tristis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arrenurus sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Austrothemis nigrescens	.	*	*	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	.	.
Amphipoda sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tillia sp. 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

site	2-6	3-18	2-16	2-15	3-12	4-24	2-14	4-30	3-14	3-5	3-16	3-24	3-15	3-6	2-33	3-30	1-31	2-31	3-31	3-33	
salinity	2.73	2.91	2.96	3.03	3.14	3.49	3.58	3.60	4.37	4.54	4.80	4.86	4.92	5.38	6.05	6.84	17.35	18.80	23.40	28.05	Correlation
GYRINIDAE sp1 (L)	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Tanypodinae ?genus (VBM7)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Phreatoisidae sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Conchostraca sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Glacidorbis sp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
HYDROPHILIDAE spL4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Orthocladiinae sp (VSCL7)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Austrogomphus collaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Leptoceridae sp4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Pseudohydryphantes doegi	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hemiptera sp3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hydrazoa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Synthemis macrostigma	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hirudinae sp3	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	-
Oxus australicus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Orthocladinae (V44)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hirudinae sp4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Paramerina sp (VBM3)	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	-
Orthetrum caledonicum	*	.	.	.	.	*	.	*	.	.	.	.	.	.	*	*	.	.	.	.	-
Corixidae sp4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	-
Scirtidae	*	.	*	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	.	.	-
Hemicordulia tau	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	-
Hirudinae sp5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Larsia ?albiceps	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Arrenurus balladoniensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Austrolestes psche	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Tanytarsus sp (VSCL9)	.	.	.	.	.	.	*	.	.	*	*	.	.	.	.	.	.	.	.	.	-
Cladopelma curtivalva Kieffer	.	*	*	*	*	*	.	.	.	*	*	*	*	*	.	*	.	*	*	.	-
Harrisius sp (VBM5)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Sternopriscus marginatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Liodessus ?inornatus	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Sternopriscus sp. nov.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	-
Laccotrephes tristis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Arrenurus sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Austrothemis nigrescens	.	.	.	.	.	.	.	*	*	*	*	.	.	.	.	*	.	.	.	.	-
Amphipoda sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Tillia sp. 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-

site	1-1	2-1	1-19	4-38	4-52	3-1	1-7	2-19	4-35	1-29	2-7	4-37	2-29	1-2	4-49	1-15	1-12	2-2	3-19	4-53	3-7	3-35	1-16	1-8	3-2	1-6	4-43	1-5	1-18	3-8	3-29	4-50	4-44	2-12	2-8	4-11	2-18	1-33	1-14	3-11	2-5	2-6	3-18	2-16	2-15	3-12	4-24	2-14	4-30	3-14	3-5	3-16	3-24	3-15	3-6	2-33	3-30	1-31	2-31	3-31	3-33	
salinity	0.19	0.29	0.29	0.31	0.32	0.42	0.49	0.58	0.65	0.72	0.81	0.82	0.97	1.00	1.03	1.08	1.09	1.13	1.13	1.18	1.22	1.24	1.25	1.28	1.31	1.33	1.35	1.40	1.43	1.46	1.46	1.55	1.59	1.73	1.82	1.85	1.94	2.03	2.19	2.20	2.56	2.73	2.91	2.96	3.03	3.14	3.49	3.58	3.60	4.37	4.54	4.80	4.86	4.92	5.38	6.05	6.84	17.35	18.80	23.40	28.05	Correlation
Coleoptera C5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Curculionidae spC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Megaporus solidus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Limnichidae sp (L)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Ishnura aurora	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Culicidae sp5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hydryphantes sp. 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Copelatus sp(L)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Berosus ?discolor	.	.	.	.	*	.	.	.	.	.	.	.	.	*	*	.	.	.	.	*	.	.	*	.	.	.	*	.	*	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	.	-
Culicidae sp4	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	-
Cricotopus ?albitibia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Cladotanytarsus sp (VBM6)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Ephydridae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
HYDROPHILIDAE sp (L)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Culicidae sp3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Acritoptila globosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Tanytarsini ?genus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Curculionidae sp(L)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Notonectidae sp6	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	-
Cryptochironomus griseidorsum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Thienemanniella sp (V19)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Piona murleyi	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Spongilla sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Arrenurus australicus ?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Orthocladiinae (VSCL38)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	*	.	.	*	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	-
Triplectides spB	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Copelatus ater	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Planorbidae sp2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	*	*	.	*	.	.	.	.	.	.	.	-
Coleoptera C3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Orthocladinae (V31)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Polypedilum sp (VSCL8)	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	*	*	.	*	.	.	*	.	.	.	.	.	.	.	.	-
Xenochironomus sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
?Viviparidae spB2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	-
Gerridae sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Corixidae sp5	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	*	.	.	.	.	.	.	.	-
Corixidae sp3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Kiefferulus intertinctus Skuse	.	.	*	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	*	.	*	.	.	.	*	*	.	.	.	.	.	.	.	.	*	*	*	.	*	*	.	.	.	.	.	-

site	1-1	2-1	1-19	4-38	4-52	3-1	1-7	2-19	4-35	1-29	2-7	4-37	2-29	1-2	4-49	1-15	1-12	2-2	3-19	4-53	3-7	3-35	1-16	1-8	3-2	1-6	4-43	1-5	1-18	3-8	3-29	4-50	4-44	2-12	2-8	4-11	2-18	1-33	1-14	3-11	2-5	2-6	3-18	2-16	2-15	3-12	4-24	2-14	4-30	3-14	3-5	3-16	3-24	3-15	3-6	2-33	3-30	1-31	2-31	3-31	3-33	
salinity	0.19	0.29	0.29	0.31	0.32	0.42	0.49	0.58	0.65	0.72	0.81	0.82	0.97	1.00	1.03	1.08	1.09	1.13	1.13	1.18	1.22	1.24	1.25	1.28	1.31	1.33	1.35	1.40	1.43	1.46	1.46	1.55	1.59	1.73	1.82	1.85	1.94	2.03	2.19	2.20	2.56	2.73	2.91	2.96	3.03	3.14	3.49	3.58	3.60	4.37	4.54	4.80	4.86	4.92	5.38	6.05	6.84	17.35	18.80	23.40	28.05	Correlation
Biodessini sp (L)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
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Koenikea verrucosa	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	-
Tanytarsus sp (VSCL18)	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	-
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Diplacodes bipunctata	.	.	.	.	.	.	.	.	*	.	*	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	-
Cherax quinquecarinatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Halacaridae sp.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	-
HYDROPHILIDAE spH3	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	-
Veliidae sp4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	-
Tipulidae spb1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Gerridae sp2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Hellythira sp3	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	-
HYDROPHILIDAE spL2 (L)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	-
Procladius paluicola	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	-
Oxus sp. 1	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	-
Oecetis sp2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	*	.	.	.	.	.	.	.	.	.	.	.	-
Stratiomyidae sp	.	.	.	.	.	.	.	.	*	.	.	.	*	*	.	*	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	*	*	.	*	*	.	.	*	.	.	.	.	.	*	.	*	.	.	*	.	.	-
Muscidae sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	-
Chironomus occidentalis Skuse	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	*	.	*	.	.	.	.	.	.	-
Oecetis sp3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	-
Sciomyzidae sp1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	-
Polypedilum nubifer (Skuse)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	-
Ephydridae sp2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	-
Hirudinae sp2	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	-
Berosus munitipennis	*	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*	*	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	*	.	-
Notilina ?fulva	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	*	.	.	.	.	-
Oligochaetae V1	*	*	*	.	*	*	*	.	.	.	*	*	.	.	.	*	.	*	*	.	*	*	.	*	*	.	.	.	.	.	.	.	.	*	*	*	.	.	*	*	.	.	*	*	*	*	.	.	*	*	*	*	*	*	*	.	*	*	.	*	.	-
Procladius sp(VBM2)	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	*	.	.	*	*	.	.	.	.	*	*	.	.	*	.	*	.	.	*	.	*	*	.	.	-
Necterosoma sp (L)	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	.	-
Procladius villosimanus Kieffer	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	*	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	*	.	*	.	.	.	*	.	*	.	.	*	.	-
Tabanidae spB1	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	.	.	.	*	*	*	.	.	-
Austrolestes annulosus	.	.	.	.	.	.	.	*	*	.	.	.	*	.	.	.	.	.	*	.	.	*	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	*	.	*	.	*	+ve
?Pyralidae sp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	*	.	.	.	.	*	+ve
Gastropoda V2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.	+ve
Berosus sp (L)	.	.	.	*	*	.	.	.	*	.	.	.	*	.	.	.	.	.	.	*	.	*	.	.	.	*	*	*	.	.	.	.	.	.	.	.	.	*	*	.	*	*	.	*	.	.	.	*	*	*	*	.	.	*	*	*	*	*	*	*	*	+ve
Tanytarsus ?barbitarsus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	+ve

site	1-1	2-1	1-19	4-38	4-52	3-1	1-7	2-19	4-35	1-29	2-7	4-37	2-29	1-2	4-49	1-15	1-12	2-2	3-19	4-53	3-7
salinity	0.19	0.29	0.29	0.31	0.32	0.42	0.49	0.58	0.65	0.72	0.81	0.82	0.97	1.00	1.03	1.08	1.09	1.13	1.13	1.18	1.22
Ceinidae sp2	.	.	.	.	.	.	.	.	*	*	.	.	*	*	.	*	*	*	.	.	.
Necterosoma darwini	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Viviparidae sp2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leptoceridae sp3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oniscoidea spV2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

site	3-35	1-16	1-8	3-2	1-6	4-43	1-5	1-18	3-8	3-29	4-50	4-44	2-12	2-8	4-11	2-18	1-33	1-14	3-11	2-5
salinity	1.24	1.25	1.28	1.31	1.33	1.35	1.40	1.43	1.46	1.46	1.55	1.59	1.73	1.82	1.85	1.94	2.03	2.19	2.20	2.56
Ceinidae sp2	*	*	.	*	.	.	*	*	.	*	.	.	*	.	*	*	*	*	*	*
Necterosoma darwini	.	.	.	.	.	.	.	.	.	*	.	.	.	.	.	.	.	.	.	*
Viviparidae sp2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	.	.
Leptoceridae sp3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oniscoidea spV2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

site	2-6	3-18	2-16	2-15	3-12	4-24	2-14	4-30	3-14	3-5	3-16	3-24	3-15	3-6	2-33	3-30	1-31	2-31	3-31	3-33	
salinity	2.73	2.91	2.96	3.03	3.14	3.49	3.58	3.60	4.37	4.54	4.80	4.86	4.92	5.38	6.05	6.84	17.35	18.80	23.40	28.05	Correlation
Ceinidae sp2	*	*	*	*	*	*	*	*	*	*	*	*	*	.	*	*	*	*	*	*	+ve
Necterosoma darwini	.	*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	*	.	+ve
Viviparidae sp2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	.	*	*	*	+ve
Leptoceridae sp3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	*	*	+ve
Oniscoidea spV2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*	.	*	*	*	*	+ve