Macroinvertebrate reconnaissance sampling at Balijup Wetlands Spring 2014

Prepared by

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Waterways Assessment & Environmental Investigations

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Cover photo: Steve Janicke with volunteers, Suzanne, Mel and Julie sampling Balijup wetland Hordacre 08.

Acknowledgements

I acknowledge the assistance made by Basil Schur of Green Skills and Dr Nick Dunlop (Citizen Science for Ecological Monitoring Program) in coordinating the survey weekend and arranging access to the wetlands. I appreciate the discussion with Alan Hordacre on his memories of the wetlands and their condition. Thanks also to the Conservation Volunteers who assisted with the aquatic survey.

Thanks also to my husband Steve for his invaluable assistance in the field and helpful comments with the report.

Contents

Introduction

The Balijup wetlands are part of the suite of wetlands within the Forests to Stirlings area of the Gondwana Link Project. There are at least 13 wetlands on Balijup Farm, 7 km south east of Tenterden in the Great Southern Region, WA and numerous others on adjacent farms. These wetlands include perched ephemeral wetlands, whose water quality was very fresh and which may have contained a highly diverse ecosystem and also naturally saline wetlands that contain a diverse ecosystem of salt tolerant flora and fauna. Ferdowsian (2012a) suggests that the majority of the lakes lying lower in the landscape have been exposed to rising saline groundwater. The decline in water quality can lead to the degradation of the biodiversity values of both wetland systems. The residual and / or 'novel' biodiversity values associated with these systems had not been assessed.

Wetland Monitoring

Dr Nick Dunlop (Citizen Science for Ecological Monitoring Program) suggested that a benchmark survey of macro-invertebrates and waterbirds would be necessary to refine management objectives and the design of the long-term monitoring protocol for the wetland suite on Balijup Farm.

A reconnaissance survey of water quality and macroinvertebrates was conducted during the Balijup Citizen Science weekend of 22nd August to 24th August.

Wetlands sampled

Twelve wetlands were visited however Hordacre 03 was dry and eleven wetlands were surveyed for water quality and macroinvertebrates. Although macroinvertebrates were collected from all the wetlands visited, the macroinvertebrates have been identified from only five wetlands (See Table 1). The other samples were preserved and stored in 75% ethanol for potential identification at a later date.

Table 1: The wetland naming system for those sampled and their location (GDA 1994 MGA Zone 50).

Wetland name (Ferdowsian 2012 names)	GPS northing	GPS easting	Macroinvertebrates sampled and identified
Hordacre 03	544348	6191264	dry
Hordacre 06	544013	6191125	Sampled and Identified
Hordacre 07	544061	6191425	Sampled
Hordacre 08	544387	6192036	Sampled
Hordacre 09	543894	6191840	Sampled
Hordacre 10	543656	6192381	Sampled
Hordacre 11 (Hordacre/Cole 8)	546483	6191301	Sampled
Hordacre 12 (Hordacre/Cole 7)	546467	6190975	Sampled and Identified
Hordacre 13	545176	6190708	Sampled and Identified
Hordacre 15	545750	6190543	Sampled
Squire - Martagallup north	546657	6787299	Sampled
Squire - Martagallup south	546728	6187437	Sampled and Identified
Jefferies/Cole 06	547307	6191501	Sampled and Identified

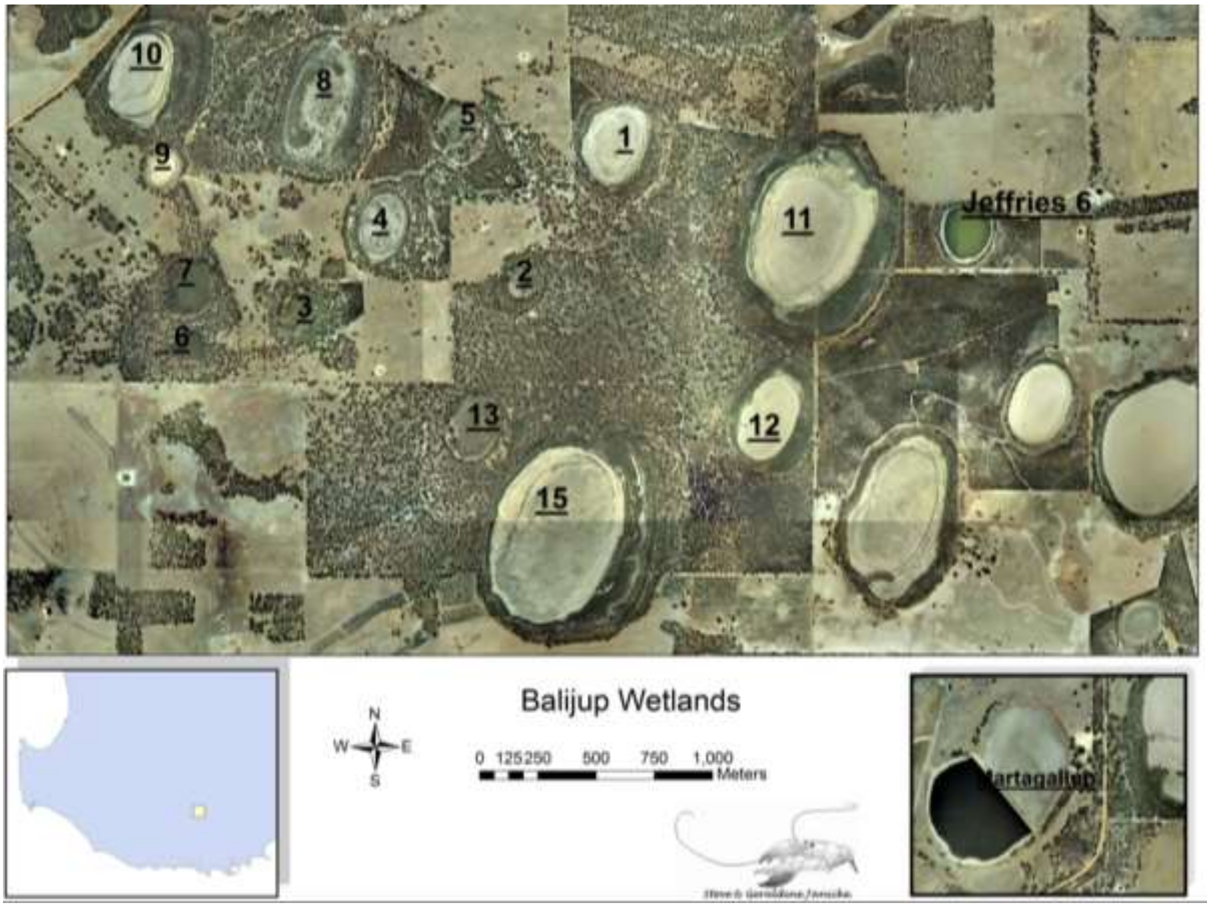


Figure 1: The wetland numbering identification used for Balijup (Hordacre).

Sampling methods

Water Quality

A Hydrolab multi-parameter water quality meter was borrowed from the Albany office of the Department of Water for measuring in-situ water quality. The instrument was calibrated the day before sampling. Parameters measured were:

- Conductivity (mS/cm)
- Salinity (ppt)
- pH
- DO % saturation
- DO (mg/L)
- Temp (°C)

Macroinvertebrates

A pond net with a 250 µm mesh was used to sweep through a 30 meter stretch of wetland and included all habitat zones (edge, open water, emergent vegetation). All samples were passed through appropriate sized sieves and placed in white trays for live picking (30 minutes, two persons). Picked macroinvertebrates were placed in labelled vials and preserved in 75% ethanol.

For the 5 wetlands chosen for closer assessment, collected macroinvertebrates were identified in the laboratory to family (and in some cases species) level and analysed for species richness and compared against the water quality variables. The rest of the preserved samples have been stored for potential examination at a later date.

Water quality

Salinity

The salinity of a water body is usually measured by its electrical conductivity with units of milliSeimens per centimetre (mS/cm). This measure can be converted to the measure of grams per Litre (gm/L) which is the same as parts per thousand (ppt). The salinity levels recorded for the Balijup wetlands are mapped in Figure 2 and graphed in Figure 3. Salinity categories have been determined according to salinity tolerances of freshwater and saline tolerant macroinvertebrates (Pinder *et al,* 2005). Note: seawater is usually 35 ppt (52ms/cm).

- <3 ppt, freshwater
- 3 to 12 ppt, sub-saline or brackish
- 12 to 35 ppt, saline
- >35 ppt, hyper-saline.

Ferdowsian (2012) recorded three fresh water wetlands, (Hordacre 02, 03 & 13) and during this reconnaissance survey, only one wetland was considered fresh (Hordacre 13), while Hordacre 02 & 03 were dry. Although Ferdowsian (2012) recorded several wetlands saltier than seawater, during this survey four wetlands were recorded as saline (Hordacre 10, 11, 12, 15) and the rest were brackish. Hordacre 06 was borderline saline but is included in the brackish group in this report.

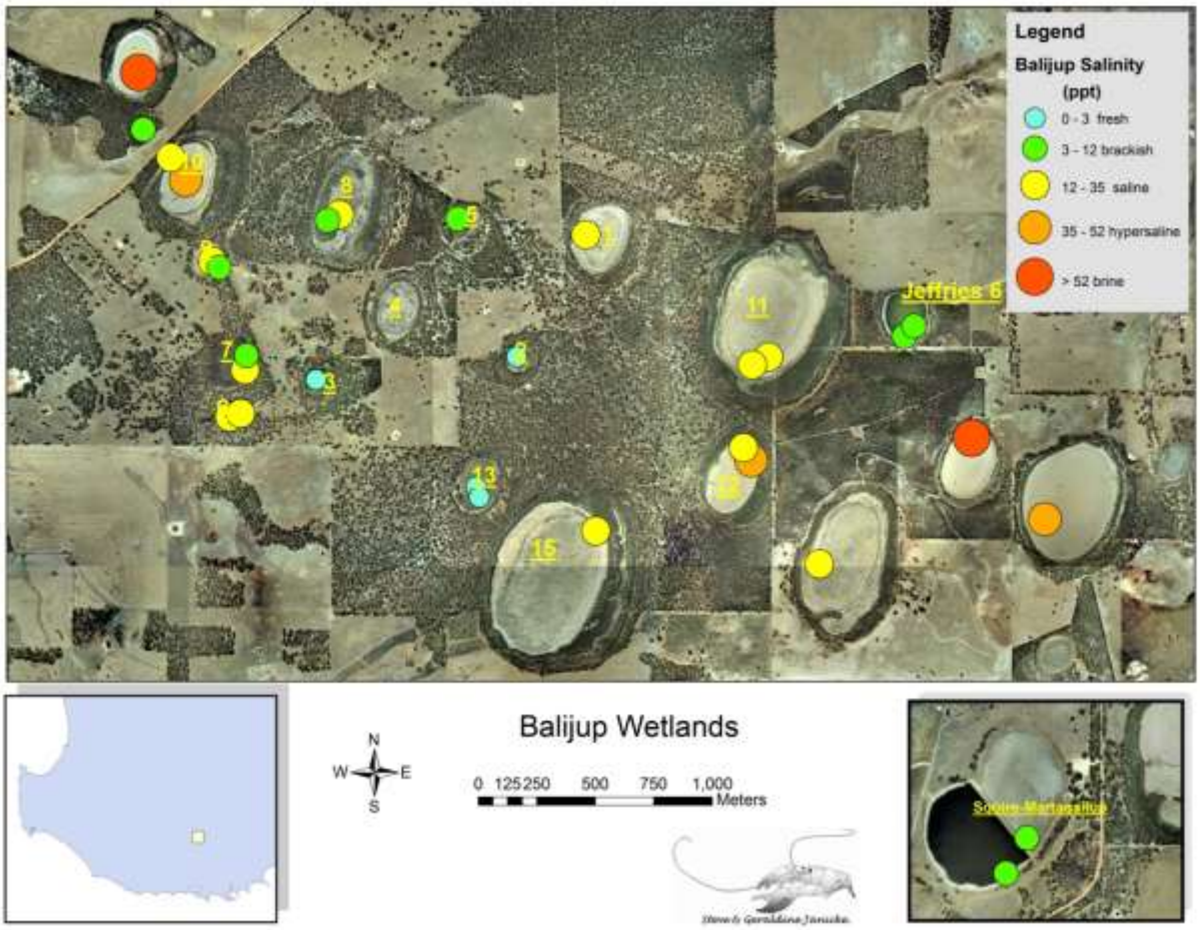


Figure 2: Salinity levels of the Balijup Wetlands as surveyed by Ferdowsian (16/11/2011) and this survey (22/8/2014).

It is not unusual for adjacent wetlands in the southwest of Western Australia to show highly variable salinity levels both geographically and over time (De Deckker (1983b), Davis *et al* (1993) Pinder *et al* (2004)). As wetlands dry out over summer, their salinity steadily increases (evapo-concentration) and may result in brine several times saltier than the sea. The differences of salinity between the two sampling occasions can be explained by the time of sampling. Ferdowsian sampled the wetlands in November and they would have experienced some evapo-concentration whereas this survey was conducted after high July rainfall (107mm in Kendenup).

Despite increasing secondary salinisation due to rising ground water levels, many wetlands in the southwest have always been saline and contain a rich endemic Crustacean fauna (Pinder *et al* (2002), De Deckker (1983 a & b), Kay *et al*(2002), Pinder *et al* (2005) and Pinder *et al* (2009).

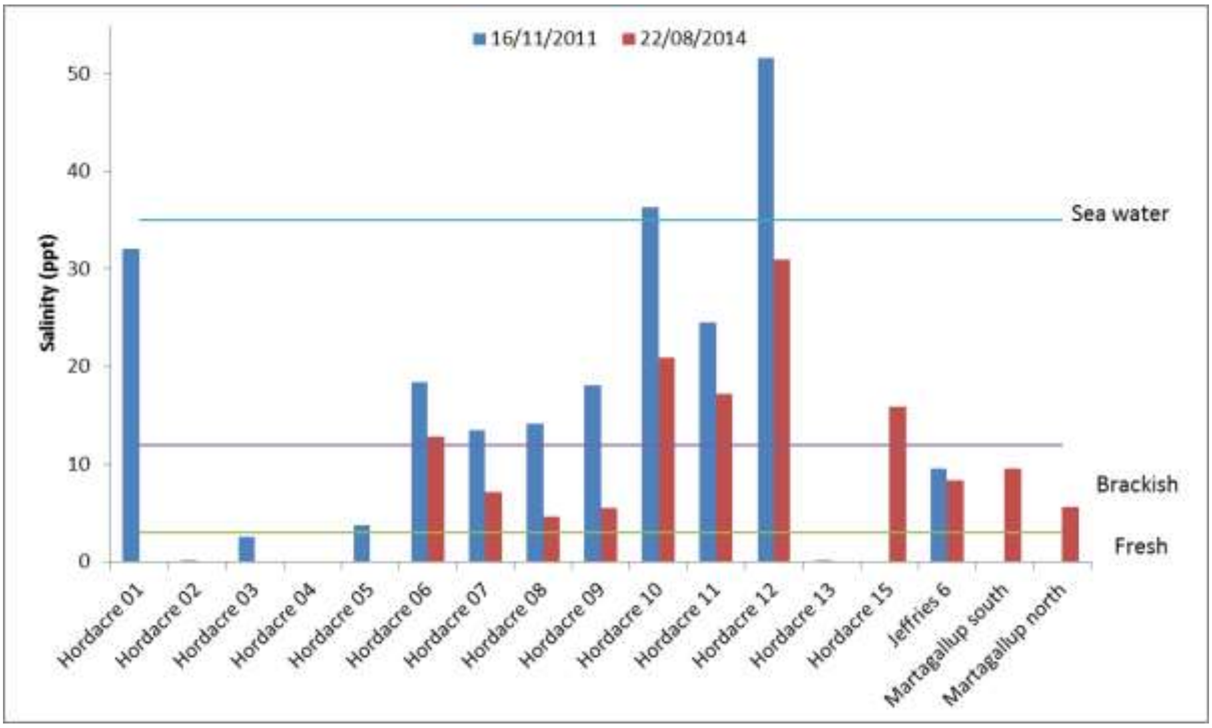


Figure 3: Salinity levels (ppt) for the wetland surveyed by Ferdowsian (16/11/2011) and this survey (22/8/2014).

pH

The pH of water is a measure of the concentration of hydrogen ions (H^+) in water on a log scale from 0 (extremely acidic) through 7 (neutral) to 14 (extremely alkaline). The term alkalinity is a measure of how much acid (H^+) is required to lower the pH to a specific level. This is usually measured in terms of neutralizing the bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions present in the water. In this survey, pH only was measured, not alkalinity and I will not use the term alkalinity to refer to alkaline water.

The freshwater wetlands at Balijup tend to be slightly acidic while the rest are alkaline. Ferdowsian (2012) recorded several highly alkaline wetlands (pH > 10) whereas in this survey, at a pH of 9.7 the most alkaline wetland was Hordacre 10 (See Figure 4). Pinder (2004) reported the majority of saline wetlands in the southwest of Western Australia were alkaline however only a few were recorded with a pH over 10. Pinder (2004) also reported that the composition of the majority of the wheatbelt wetlands with salinity greater than 3 ppt were all Na^+Cl^- dominated: normally $Cl^- > SO_4^{2-} > HCO_3^-$ (average milli-equivalent percentages 90.2 : 8.3 : 1.4) and $Na > Mg^{2+} > Ca^{2+} > K^+$ (average percentages 78.5 : 15.4 : 5.1 : 1.0).

Freshwater wetlands that are tea coloured (with tannins) are usually slightly acidic due to the organic acids in the water and the conversion of carbon dioxide (CO_2) to carbonic acid (HCO_3^-). With increasing salinity, suspended material is precipitated out of the water column and the water becomes alkaline. Sea water is alkaline with a pH of about 8.2. There are probably several reasons for the higher pH levels in some of the Balijup wetlands. One is that photosynthetic consumption of carbon dioxide (especially in algal blooms) can drive pH to high levels. This is because there is less carbonic acid formation when carbon dioxide is consumed, and therefore less dissociation of carbonic acid into hydrogen ions (OzCoasts 2014). Despite the higher salinity of the alkaline wetlands, there was a good growth of aquatic macrophytes (Lamprothamnium and Ruppia) which were actively photosynthesising, producing highly oxygenated water and consuming carbon dioxide. Pinder *et al* (2004) found particularly high macroinvertebrate richness in the more alkaline wetlands that were subsaline to moderately saline.

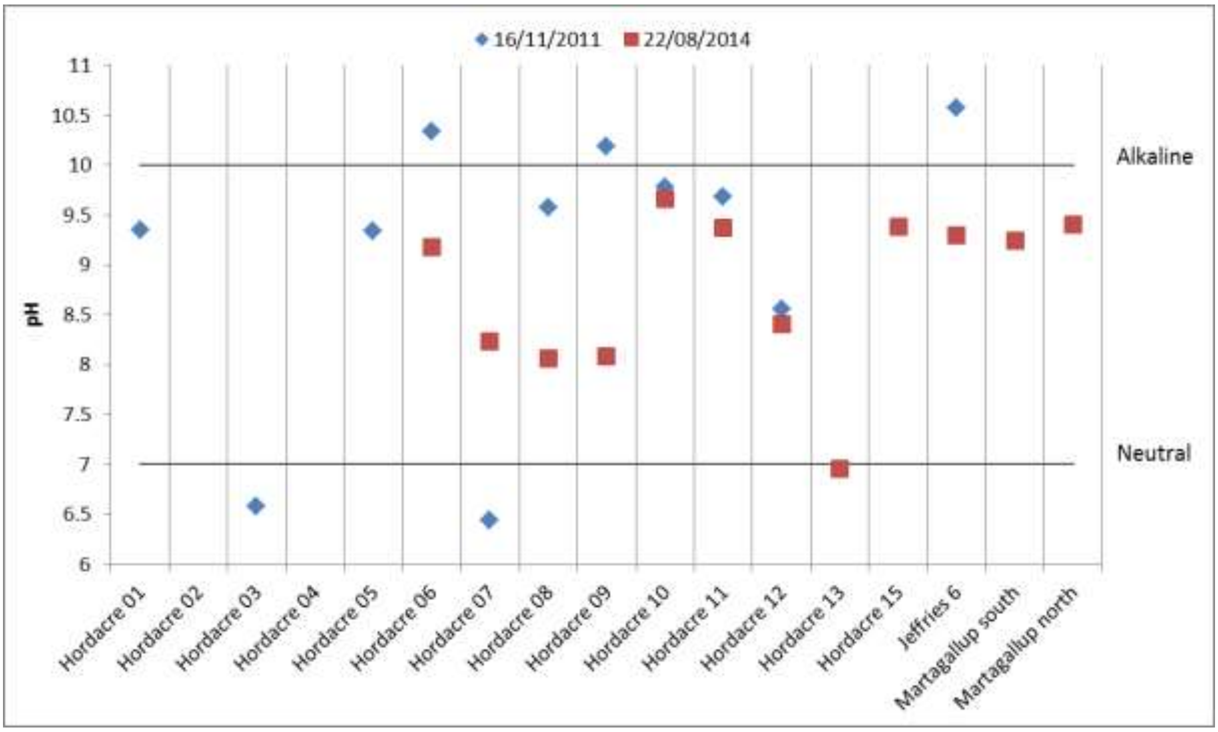


Figure 4: pH of wetlands at Balijup as recorded by Ferdowsian (16/11/2011) and in this survey (22/08/2014)

Dissolved Oxygen

Dissolved oxygen is expressed either in mg/L, or as percentage saturation. The amount of dissolved oxygen in water fluctuates naturally over 24 hours; colder water can carry more dissolved oxygen that warmer water. When in equilibrium with the atmosphere, at this maximum concentration the water is said to be saturated or at 100% saturation of dissolved oxygen. It is not unusual to see bubbles of oxygen attached to aquatic plants during the day as they photosynthesis releasing oxygen into the water. At night plants respire and consume oxygen. The breakdown of organic material also consumes oxygen.

During this survey all the wetlands had over 100% saturation of dissolved oxygen except for Hordacre 08 which was sampled early in the morning before normal photosynthesis started, replenishing the oxygen levels. The very high dissolved oxygen levels in most of the wetlands reflect either the healthy swards of aquatic plants or the presence of phytoplankton in the water column.

Chlorophyll *a* is the green pigment in plants that is responsible for photosynthesis and its measurement from the water column is an indicator of levels of phytoplankton. High levels of phytoplankton are an indicator of nutrient enrichment of the wetland and this parameter should be included in water quality monitoring.

Macroinvertebrates

Macroinvertebrates were collected from eleven wetlands however the samples of only five wetlands have been identified. The other samples have been preserved in 75% ethanol for potential identification at a later date.

Species commonly occurring in freshwater but tolerant of some salinity are referred to as halotolerant, while halophiles are those considered to show a strong preference for saline environments. The freshwater wetland, Hordacre 13 had the highest biodiversity with 28 species and the lowest abundance of individuals per species (Table 2). The species present were predominantly freshwater species with little tolerance of salinity.

The wetland with the lowest diversity was Hordacre 06, a saline and alkaline wetland. Six of the nine species present were indicator species for secondary saline impacted wetlands (Pinder *et al* 2004). These were the following crustaceans:

- *Mytilocypris ambiguosa*, a large seed shrimp
- *Diacypris spinosa*, a small seed shrimp
- Calanoid sp., a copepod
- Cyclopoid sp., a copepod
- *Daphniopsis pusilla*, an abundant water flea
- *Austrochiltonia subtenuis*, a scud or side swimmer.

These crustaceans were also found in the two brackish wetlands, Jefferies 06 and Squire-Martagallup. Since they are all microalgae and diatom feeders, it is suggested that nutrient (total nitrogen and total phosphorus) and chlorophyll *a* (a surrogate for microalgae) data be monitored from these wetlands to determine the potential impact of increased nutrient levels on wetland degradation.

The wetland Hordacre 12 was saline tending to hypersaline and contained several halophylic species of macroinvertebrate (Brine shrimp - *Parartemia cylindrifera,* Seed shrimp - *Australocypris bennetti,* Copepod - *Calamoecia* sp. pink metallic*,* Isopod - *Haloniscus searlei,*). These species were recorded by Pinder *et al* (2004) in wheatbelt wetlands that were the least impacted by secondary salinisation.

The south-west of Western Australia is a global hotspot for inland crustacean diversity with brine shrimp being one of the groups that contribute to this status. The brine shrimp genus *Parartemia*, is endemic to Australia, of which 14 of the 19 known species occur in Western Australia (Pinder *et al,* 2009). Pinder *et al* (2009) discussed the threatened status of the brine shrimp (*Parartemia* species) and suggested that although their tolerance to salinity can exceed 200 g/L (i.e. 5½ x seawater) for most species, they rarely colonise secondary salinised wetlands and some are disappearing from naturally saline lakes affected by altered hydrology.

The seed shrimp, *Australocypris bennetti* is described by Halse and McRae (2004) as occurring in two forms*,* an alkaline form and an acidophile but that both forms were recorded from natural seasonal saline lakes. De Deckker (1983b) comments that ***Haloniscus searlei,*** is also an endemic crustacean that is a common inhabitant of Australian salt lakes.

Alan Hordacre commented that he remembers brine shrimp (*Parartemia cylindrifera*) as always being present in wetland Hordacre 12 and Hordacre 10. The presence of these halophilic macroinvertebrates in Hordacre 12 indicates it is a naturally saline wetland that has had minimum impact from secondary salinisation. Consequently the saline wetlands are worth conserving along with the naturally freshwater wetlands (Hordacre 13).

The brackish and saline wetlands were dominated by crustaceans while the freshwater wetland was dominated by insects (See Figure 5).

Table 2: Macroinvertebrate species richness, abundance and uniqueness for five Balijup wetlands.

	Jefferies 06	Martagallup	Hordacre 12	Hordacre 06	Hordacre 13
Species richness	16	14	12	9	28
Average abundance per species	343	324	215	343	23
No. species found only in one wetland*	4	2	7	2	24

*** Note: species found only in one wetland may exist in the other wetlands that have had not had macroinvertebrates identified.**

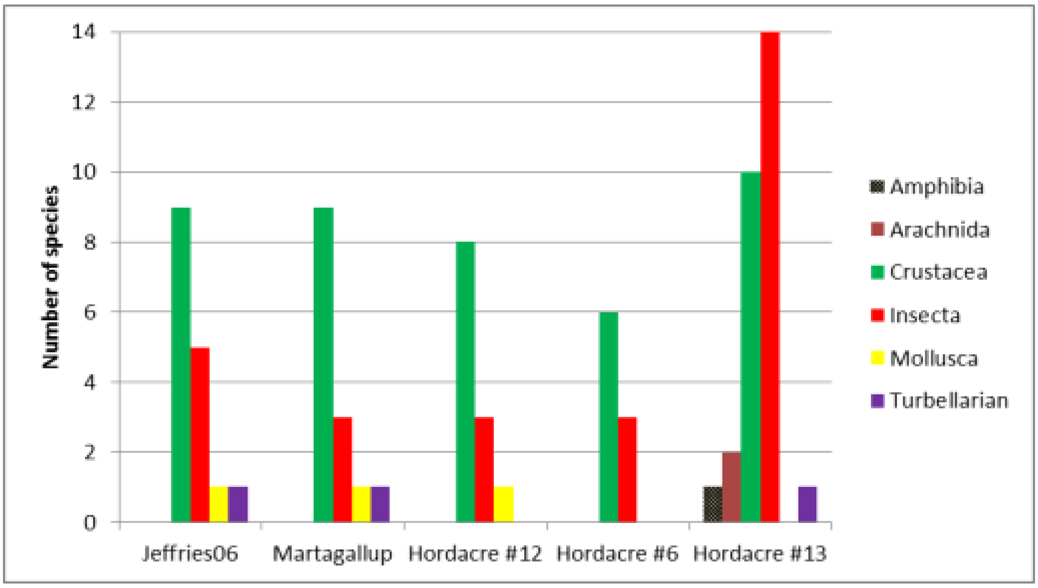


Figure 5: Macroinvertebrate groups recorded from five wetlands sampled in August 2014

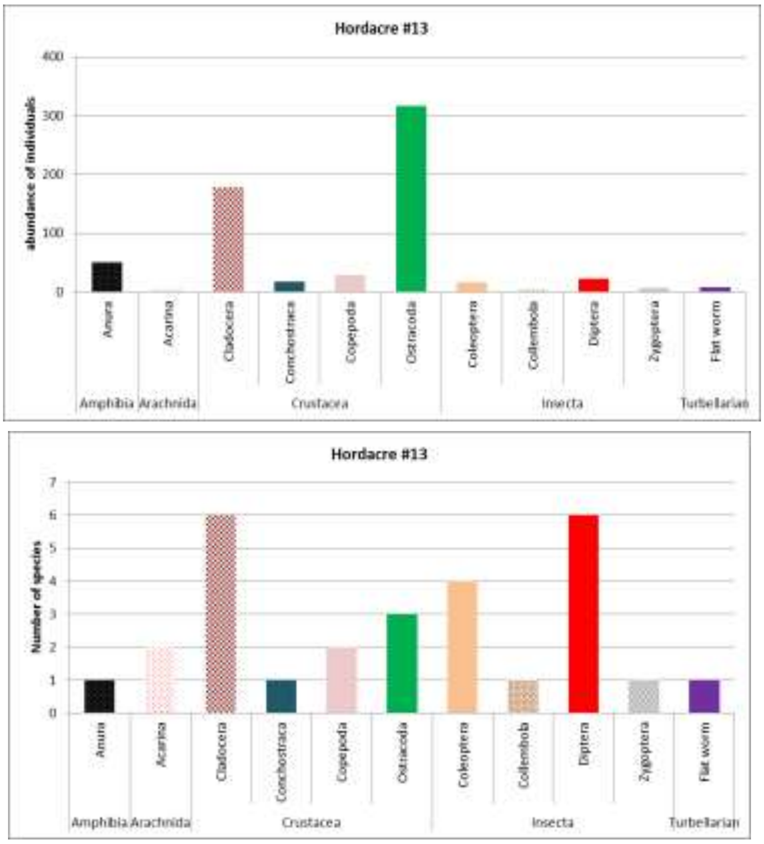
Steve & Geraldine Janicke

Fresh Water Wetlands

Hordacre 13

Figure 6: Steve Janicke explaining water quality measurements to a conservation volunteer at Balijup wetland Hordacre 13.

Hordacre 13 a short lived ephemeral wetland with healthy sedges and Myrtaceous scrub (*Melaleuca lateritia*, *M. viminea* fringing, some *M. raphiophylla* and *M. densa*) (Figure 6). It appears to be heavily used by kangaroos and the kangaroo scat density seems to be enriching the water with nutrients judging by the presence of dark green filamentous algae.



The water was very fresh (0.05ppt), slightly acidic (pH 6.96) and very well oxygenated (143 % saturation). Very high saturation levels of oxygen are common during the day in waters containing algae or aquatic plants as they are pumping oxygen into the water as part of the process of photosynthesis.

This wetland had the highest number of species (species richness) of the wetlands sampled with 28 species collected.

Insects were the dominant group with 14 species and Crustaceans were the next dominant group with 10 species (see Figure 7). Of these 28 species, only 4 were found in other wetlands. These were a water flea *Daphniopsis pusilla*, a large seed shrimp Mytilocypris ambiguosa and two groups of copepods. There was a low abundance of individuals per species collected and this is typical of healthy freshwater wetlands.

Figure 7: Macroinvertebrate species richness and abundance of individuals for Hordacre 13

Hordacre 02

This wetland was reported as being dry at the time of the survey and was not visited.

Hordacre 03

Figure 8: Balijup wetland Hordacre 03 was dry at the time of this survey.

Hordacre 03 was dry at the time of this survey (Figure 8). This wetland was fresh when sampled by Ferdowsian (2012) and has always been fresh according to Alan Hordacre. A species of Cotula (Yellow buttons) was growing around some of the edges of the wetland and may be an early warning sign of groundwater close to the surface.

Brackish tending to Saline wetlands

Hordacre 06

Figure 9: Hordacre 06, a brackish tending to saline wetland with dead *Melaleuca lateritia* in the centre.

Hordacre 06 is a brackish, tending to saline, wetland with dead Robin Red Breast bush (*Melaleuca lateritia)* in the centre. Alan Hordacre commented that the wetland had once been beautiful. Meadows of the aquatic plants, *Ruppia* sp. and *Lamprothamnium* sp. dominated the wetland however there were bare patches with orange soil which could have been discharge zones. Cotula around the edge also indicated discharge zones where the groundwater was near the surface.

Hordacre 06 had the lowest macroinvertebrate diversity with six of the nine species present indicator species for secondary salinised wetlands (Pinder *et al* 2005). These were crustaceans which were also found in the two other brackish wetlands, Jefferies 06 and Squire-Martagallup. Since they are all microalgae and diatom feeders, it will be necessary to monitor nutrient and chlorophyll *a* (a surrogate for microalgae) levels from the wetlands to determine the potential impact of increased nutrients on wetland degradation. The wetland was dominated by crustaceans with high abundance of the ostracods, *Mytilocypris ambiguosa* and *Diacypris spinosa* (Figure 10).

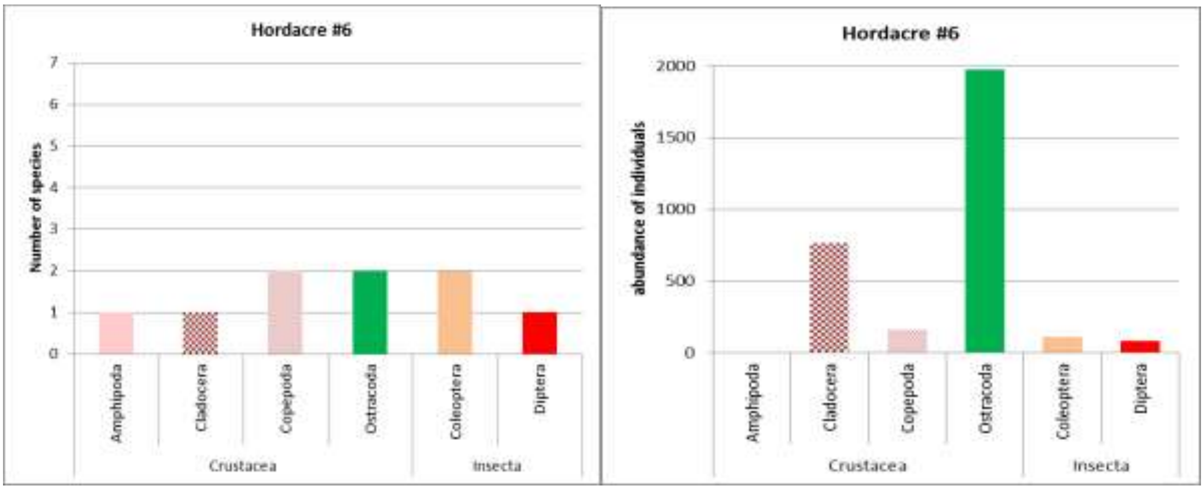


Figure 10: Macroinvertebrate species richness and abundance of individuals for Hordacre 06.

Hordacre 07

Figure 11: Hordacre 07 is a brackish wetland with dead *Melaleuca lateritia* in the centre similar to Hordacre 06.

Hordacre 07 is similar to Hordacre 06 with dense swards of the aquatic plant *Ruppia* sp. Scattered among the dead Robin Red Breast bushes (*Melaleuca lateritia)* were water ribbons (*Triglochin* sp.). Thick green filamentous algae occurred in a five meter band around the edge of the wetland and may indicate nutrient enrichment. Future monitoring of the wetlands should include total Nitrogen and total Phosphorus levels of the water.

Steve & Geraldine Janicke

Hordacre 08

Figure 12: Hordacre 08, a wetland with healthy regeneration of *Melaleuca cuticularis* trees and dense swards of the aquatic plant *Ruppia* sp..

Hordacre 08 is a brackish wetland surrounded by thick groves of healthy *Melaleuca cuticularis* trees and saplings and with dense swards of the aquatic plant *Ruppia* in the open water. The *Ruppia* provides food for many wetland birds and ducks as well as for macroinvertebrate grazers. There were many dead *Gahnia triffida* tussocks seen around the edge that may have died from waterlogging as this species is salt tolerant but not tolerant of extended waterlogging. Alan commented that he thought this wetland had always been brackish. It should be noted that brackish in terms of the human perception of taste is a salinity 1.5 and 5 ppt. The category of brackish used in this report is in terms of macroinvertebrate tolerance.

Hordacre 09

Figure 13: Hordacre 09, wetland covered in Samphire.

Ferdowsian (2012) recorded this wetland with as saline (18 ppt) and highly alkaline (pH 10.3) however during this survey, it was brackish at 5.5 ppt and less alkaline than seawater. This highlights the variability of water quality parameters in saline systems as discussed in the Comments section below.

Alan Hordacre commented that this wetland used to be fresh with red flowering Melaleucas (*Melaleuca lateritia*) growing in it 20 years ago. Today the whole wetland is covered in Samphire. Dense filamentous algae were present in the water potentially indicating nutrient enrichment.

Jefferies/Cole 6.

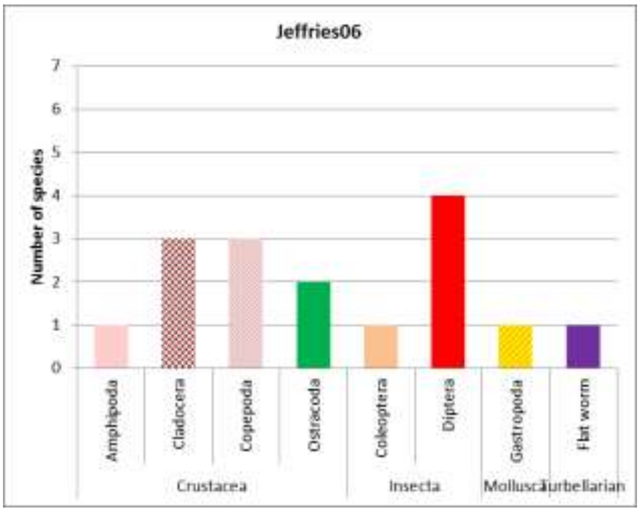
Figure 14: Cole/Jefferies 06 wetland with Geraldine sampling for macroinvertebrates (upper image), Steve collecting water quality data (lower image) and Basil Schur and volunteers watching on, taking photographs and recording the data.

This wetland was highly alkaline with a pH (10.57) when surveyed by Ferdowsian (2012) and was used as a test project to attempt lowering the pH of the lake by adding some organic material onto the lake bed. Consequently, in April 2014, 23 dry big square bales of straw (about 10350 Kg) were spread out over the wetland area. At the time of this survey the pH was much lower at 9.3. However since the two other highly alkaline wetlands had also a much lower pH during this survey (Table 3), the effectiveness of adding organic material in lowering pH cannot be determined.

Table 3: pH of three alkaline wetlands in the Balijup suite sampled in November 2011 and August 2014.

	Ferdowsian, 16/11/2011	This survey, 23/8/2014
Cole/Jefferies 06	10.57	9.3
Hordacre 06	10.34	9.18
Hordacre 09	10.19	8.08

Adding straw (and manure as recommended by Ferdowsian 2012) would add nutrients and a different food source to the wetland and would be expected to have an impact its the aquatic ecology. Jefferies 06 shared the same indicator species for secondary salinised wetlands as were in Hordacre 06 and Martagallup. However it also had several species of Diptera midge larvae (including *Chironomus occidentalis* which is a nuisance midge of the eutrophic wetlands on the Swan Coastal Plain (Davis *et al* 1993)) and a much very high abundance of the cladoceran, *Daphniopsis pusilla*, a micro-algae eater (Figure 15).



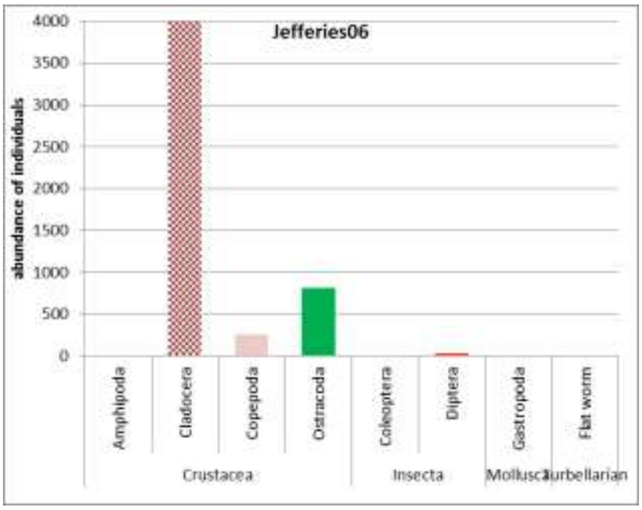


Figure 15: Macroinvertebrate species richness and abundance of individuals for Jefferies 06

Squire - Martagallup south

Figure 16: Squire – Martagallup wetland, south of the bund

Squire - Martagallup wetland was devoid of riparian vegetation, has recently been fenced and is part of an extensive revegetation program. The lake bed was a fine whitish silty clay and at the site of sampling had a thin growth of the aquatic plant *Ruppia.* Swans and many other birds were using the wetland at the time of this survey.

Figure 17: The author standing alongside a clump of *Baumea articulata* on the edge of the bund separating the two halves of the wetland.

On the bund between the two wetlands halves and along the edge of the northern half were several clumps of the sedge *Baumea articulata* which has a preference for fresh water and is often found at the sites of freshwater springs (Figure 17).

The northern half of the wetland was sampled for water quality and was slightly fresher than the southern half of the wetland (See Table 4.).

Table 4: Salinity and pH for the two halves of Squire - Martagallup wetland.

	Salinity (ppt)	pH
Squire - Martagallup south	9.6	9.24
Squire - Martagallup north	5.6	9.4

Squire - Martagallup south shared the same indicator species for secondary salinised wetlands as were in Hordacre 06 and Jefferies 06. However it also contained the halophylic ostracod, *Platycypris bauerii.* Squire - Martagallup south had a high abundance of the cladoceran *Daphniopsis pusilla*, a micro-algae which may indicate nutrient enrichment of the wetland. Sampling for total Nitrogen and total Phosphorus levels and chlorophyll *a* (a surrogate for microalgae) would be required to determine this.

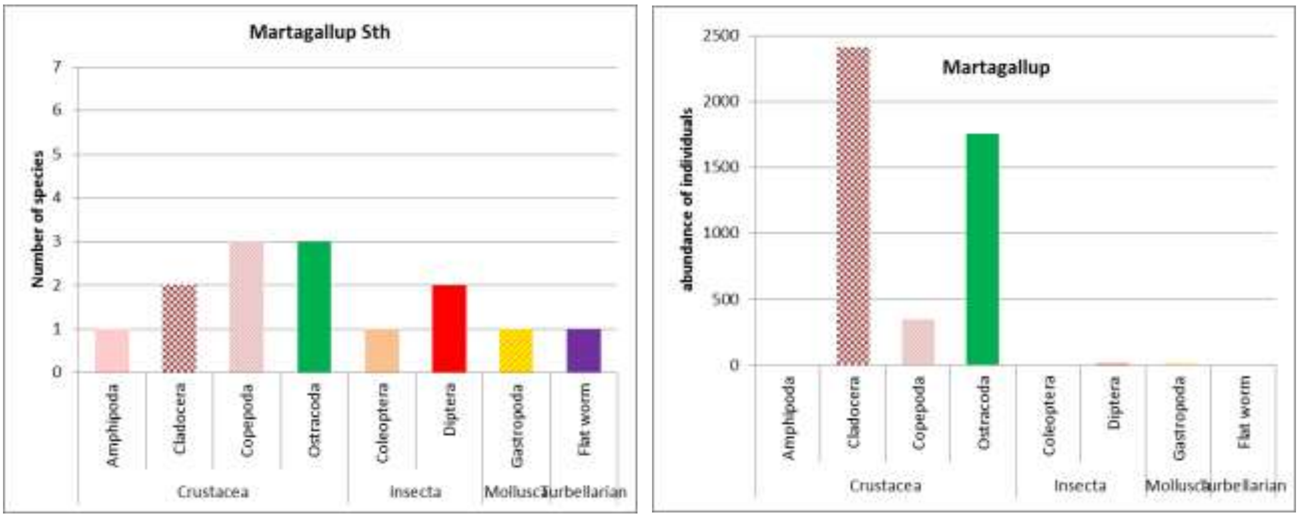


Figure 18: Macroinvertebrate species richness and abundance of individuals for Squire - Martagallup wetland south of the bund.

Fully saline wetlands

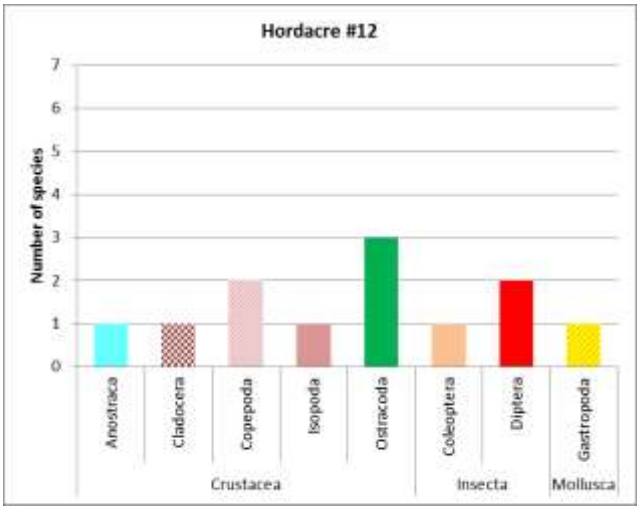
Hordacre 12

Figure 19: Balijup wetland, Hordacre 12 showing the soft white silty sandy clay bed.

The wetland Hordacre 12 is referred to as *Hordacre/ Cole 7* by Ferdowsian (2012). Hordacre 12 was the most saline wetland sampled in this survey (31 ppt) and was recorded as being saltier than the sea (52 ppt) by Ferdowsian. It is fringed by Samphire and *Melaleuca cuticularis* trees.

Despite being saline tending to hypersaline the wetland contained several halophylic species of macroinvertebrate (Brine shrimp - *Parartemia cylindrifera,* Seed shrimp - *Australocypris bennetti,* Copepod - *Calamoecia* sp. pink metallic*,* Isopod - *Haloniscus searlei,*). As mentioned earlier, these species were recorded by Pinder *et al* (2005) in wheatbelt wetlands that were least impacted by secondary salinisation. Although the brine shrimp species, *Parartemia cylindrifera* is common in southern Australia, their status is being threatened by secondary salinisation (Pinder *et al*, 2005). Alan Hordacre commented that he remembers brine shrimp (*Parartemia cylindrifera*) as always being present in wetland Hordacre 12 and Hordacre 10.

The presence of these halophilic macroinvertebrates in Hordacre 12 indicates it is a naturally saline wetland that has had minimum impact from secondary salinisation. Consequently the saline wetland is worth conserving. As with other saline wetlands, crustaceans dominated the macroinvertebrate fauna and copepods were the most abundant species (Figure 20).



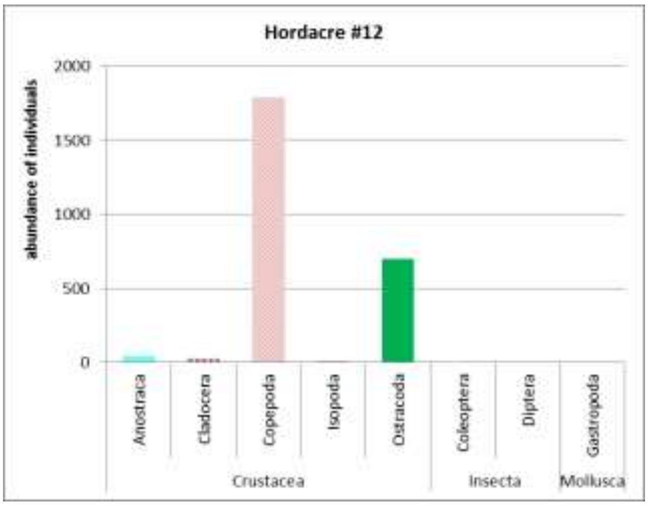


Figure 20: Macroinvertebrate species richness and abundance of individuals for Hordacre 12.

Hordacre 10

Figure 21: Balijup wetland, Hordacre 10 showing Steve Janicke returning from collecting water quality data and the fringe of dead Melaleuca cuticularis trees.

Hordacre 10 was saline tending to hypersaline and was fringed by Samphire and dead *Melaleuca cuticularis* trees (see Figure 21). The aquatic plant *Ruppia* was growing thinly over the wetland bed. There was an eight meter fringe of decomposing filamentous algae at the sampling site which could indicate nutrient enrichment of the wetland. Sampling for total Nitrogen and total Phosphorus levels and chlorophyll *a* (a surrogate for microalgae) would be required to determine this.

Alan Hordacre commented that the wetland was flooded for several years and this is when the fringing *M. cuticularis* trees died. This is most likely the cause of their death as they do not like long periods of water logging but can withstand high levels of salinity. It is unlikely that high pH levels would adversely impact these trees.

Alan Hordacre also commented that it had always been salty and he remembers seeing brine shrimp in it. Although the macroinvertebrate sample from the wetland have not been identified, brine shrimp were collected.

Hordacre 11

Figure 22: Balijup wetland, Hordacre 11 showing Geraldine Janicke collecting a macroinvertebrate sample and the fringing Samphire.

Hordacre 11 is referred to as *Hordacre/Jefferies/Cole 8* by Ferdowsian (2012). This saline wetland had a thin scattering of the aquatic plant *Ruppia* growing across its bed. I suspect that it has always been a saline wetland and the death of the *Melaleuca cuticularis* trees around the fringe is due to higher water levels and water logging sometime in the past as it was in Hordacre 10.

Hordacre 15

Figure 23: The saline wetland Hordacre 15 with an insert showing empty shells from the snail *Coxiella* which had been washed up in drifts on the edge of the wetland.

This wetland had a healthy fringe of Samphire and *Melaleuca cuticularis* trees and a scattering of the aquatic plant *Ruppia* growing across the wetland bed. The salinity and pH of the wetland were similar to Hordacre 10 and Hordacre 11.

Comments regarding monitoring.

I am not sure that the high alkaline levels recorded for the various saline wetlands are a concern with regard to the health of the aquatic and riparian vegetation and the aquatic fauna. Of greater concern would be nutrient enrichment from fertiliser run off and movement through the groundwater. Hence I would be very wary of adding organic matter, especially manure, to the wetlands. This might alter the pH of the wetland for a short period of time however the added food source and increased nutrients would alter the delicate aquatic ecology of the wetland and could adversely impact the endemic species present.

Monitoring the water quality of saline wetlands is very difficult since they have a natural cycle of drying out (with increasing salinity levels) and refilling with episodic heavy rains (when they become fresher again). Hence endeavouring to maintain salinity levels has little meaning. The salinity levels measured yearly in September would be impacted more by seasonal or un-seasonal rainfall than by groundwater impacts. Similarly, pH values could vary more by season than from groundwater impacts. However macroinvertebrates are adapted to these seasonal variations and are a more reliable indicator of degradation due to secondary salinisation and nutrient enrichment.

The survey of 230 wetlands in the wheatbelt of Western Australia was conducted by Pinder *et al* (2005) to provide a framework for setting conservation priorities. Their work has revealed various macroinvertebrate species that are ‘indicator’ species for naturally saline and secondarily salinised wetlands. Utilising these indicator species has already shown that the wetland Hordacre 12 is still a relatively natural saline wetland whilst Jefferies 06 contained species common to nutrient enriched wetlands.

Monitoring fringing riparian vegetation health can also be difficult to interpret since *Melaleuca cuticularis* can regenerate in dense forests, as seen in parts of the fringe of Hordacre 08 and then die all together due to unseasonal long high water levels as noted for Hordacre 10.

Decline in the freshwater ecosystems is simpler to monitor since a rise in salinity is critical and decline in riparian vegetation more indicative of degradation.

Appendix 1 Water Quality

Wetland name	Date sampled	Average depth of sampling site (m)	Conductivity (mS/cm)	Salinity (ppt)	pH	DO % saturation	DO (mg/L)	Turbidity	Temp (°C)
Squire - Martagallup south	22/08/2014	0.15	16.4	9.6	9.24	133.4	12.84	slightly milky	14.5
Squire - Martagallup north	22/08/2014	0.1	9.2	5.6	9.4	174.5	16.6	slightly milky	15.9
Jefferies/Cole 06	22/08/2014	0.4	14.4	8.4	9.3	155	14.4	light tannins	16.7
Hordacre 03	22/08/2014	0	dry						
Hordacre 06	22/08/2014	0.3	21.63	12.81	9.18	154.5	15.03	clear	13.05
Hordacre 07	22/08/2014	0.2	12.55	7.2	8.23	109.4	11.38	clear	11.56
Hordacre 08	22/08/2014	0.2	8.22	4.62	8.06	48.6	5.28	clear	10.3
Hordacre 09	22/08/2014	0.1	9.787	5.53	8.08	118.6	11.43	moderate tannins	15.55
Hordacre 10	22/08/2014	0.1	33.33	20.94	9.66	120	11.3	slightly milky	12.24
Hordacre 11	22/08/2014	0.3	27.97	17.17	9.37	132	11.3	clear	18
Hordacre 12	22/08/2014	0.1	47	30.99	8.4	124.9	9.77	clear	18.2
Hordacre 13	22/08/2014	0.1	1.252	0.05	6.96	143.5	13.21		19
Hordacre 15	22/08/2014	0.1	26.04	15.88	9.38	153.7	13.2		18.7

Appendix 2 Macroinvertebrate species

				Jefferies 06	Martagallup	Hordacre 12	Hordacre 06	Hordacre 13
Amphibia								
	Anura	Pseudophryne sp. tadpoles	Tadpole					50
Arachnida								
	Acarina	Pionid mite sp. 1	Mites					3
		Pionid mite sp. 2	Mites					2
Crustacea								
	Amphipoda	Austrochiltonia subtenuis	Scud	3	1		3	
	Anostraca	Parartemia cylindrifera	Brine shrimp			44		
	Cladocera	Chydorid sp. 1	Water fleas					100
		Chydorid sp. 2	Water fleas					50
		Chydorid sp. 3	Water fleas					9
		Ceriodaphnia ?quadrangular	Water fleas	12				
		Daphnia sp.	Water fleas		2			
		Daphniopsis pusilla	Water fleas	4327	2409	31	763	8
		Daphniid sp. white long	Water fleas					8
		Scapholoberis sp.	Water fleas					3
		Macrothricid sp.	Water fleas	15				
	Conchostraca	Lynceus tatei	Clam shrimp					18
	Copepoda	Calamoecia sp. pink metalic	Copopods			1753		
		Calanoid sp.	Copopods	36	308		1	23
		Cyclopoid sp.	Copopods	183	24	37	161	5
		Harpacticoid sp.	Copopods	40	14			
	Isopoda	Haloniscus searlei	Water slater			12		
	Ostracoda	Australocypris bennetti	Seed shrimps			72		
		Cypretta sp.	Seed shrimps					299
		Cypricersus sp. affin	Seed shrimps			572		
		Diacypris spinosa	Seed shrimps	737	1393		1635	
		Mytilocyprid sp. white	Seed shrimps			52		

				Jefferies 06	Martagallup	Hordacre 12	Hordacre 06	Hordacre 13
		Mytilocypris ambiguosa	Seed shrimps	75	297		337	3
		Platycypris bauerii	Seed shrimps		65			
		Unknown white bean sp.	Seed shrimps					15
Insecta								
	Coleoptera	Allodessus sp.	Diving beetle					1
		Hyderodes crassus	Diving beetle					10
		Necterosoma penicilatus	Diving beetle	8	5	2	102	
		Paracymus sp.	Diving beetle					1
		Haliplus sp.	Crawling beetle					4
		Berosus discolor	Scavenger beetle				8	
	Collembola	Hypogastrurid. sp.	Collembola					3
	Diptera	Ceratopog sp.	Biting midge					1
		Promochlonyx australiensis	Phantom midge					15
		Chironomus alternans	Non-biting midge	4	3			
		Chironomus occidentalis	Non-biting midge	23				
		Cladopelma curtivalva	Non-biting midge			1		
		Kiefferellis intertinctus	Non-biting midge					1
		Parachironomus sp.	Non-biting midge	1				
		Tanytarsus barbitarsus	Non-biting midge	4	8	1		
		Pentaneurini sp.	Non-biting midge					4
		Aedes camptorrhincus	Mosquito				81	
		Aedes stricklandii	Mosquito					1
		Culex latus	Mosquito					1
	Zygoptera	Austrolestes analis	Damsel fly					7
Mollusca								
	Gastropoda	Coxiella sp.	Snail	8	2	3		
Turbellarian								
		Flatworm sp. large brown						8
		Flatworm sp. small white		4	2			

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