Biodiversity and Conservation Science

Julimar Claypan Aquatic Invertebrate Survey

David Cale

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Department of Biodiversity, Conservation and Attractions

GOVERNMENT OF WESTERN AUSTRALIA

Department of Biodiversity, Conservation and Attractions
Locked Bag 104
Bentley Delivery Centre WA 6983
Phone: (08) 9219 9000
Fax: (08) 9334 0498

www.dbca.wa.gov.au

Questions regarding the use of this material should be directed to:
Program Leader
Ecosystem Science Program
Department of Biodiversity, Conservation and Attractions
Locked Bag 104
Bentley Delivery Centre WA 6983
Phone: 92199868
Email: Adrian.pinder@dbca.wa.gov.au

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Summary

‘Julimar’ claypan situated in the Julimar State Forest lies within the hills on the eastern side of the northern extremity of the Darling Scarp, Western Australia. The wetland is an occurrence of a Threatened Ecological Community described as “claypans with shrubs over herbs”. The wetland is fresh and shallow, small (<1ha), covered in perennial vegetation, and ephemeral; filling either episodically or seasonally. The frequency and duration of inundation has not been documented. Its location in wandoo woodland east of the scarp is like that of other vegetated ephemeral claypans including Little Darkin Swamp for which a detailed ‘ecological characterisation’ has been conducted.

At least 87 species of aquatic invertebrates were collected at ‘Julimar’ claypan in October 2021. This richness is typical of higher quality freshwater wetlands in the southwest of Western Australia, and as high or higher than vegetated ephemeral claypans previously sampled. The fauna includes elements dependent on freshwater wetlands as well as typically widespread species that prefer freshwater wetlands. The fauna includes 5 of 7 species which have previously been identified as required biodiversity targets for the management of vegetated ephemeral claypans at Drummond Nature Reserve. The fauna included at least two species with restricted distributions; a snail *Glacidorbis occidentalis* and an undescribed ostracod *Lacrimicypris* n.sp..

The composition of the aquatic invertebrate fauna at ‘Julimar’ claypan is like that of a group of 5 other vegetated ephemeral claypans with which it was compared. The comparative wetlands were selected because they have previously been shown to differ in species composition from other high richness freshwater wetlands. Some species may have a high fidelity to vegetated ephemeral claypans or at least to freshwater clay-based wetlands in general.

1 Introduction

Vegetated ephemeral claypans may be characterised by a shallow basin with impervious clay-based substrate which is covered in low shrubs or trees and filled for a short period seasonally or, more rarely, episodically. This type of wetland is a subset (group 3) of the ephemeral clay-based wetlands described floristically by Gibson *et al* (2005). This wetland type occurs across much of the Southwest Botanical Province of Western Australia but is concentrated on the Swan Coastal Plain and in the Avon Wheatbelt regions. Vegetated ephemeral claypans were probably widespread across the western margin of the top of the Darling Scarp prior to European settlement. However, an estimated 70-95% of all clay-based wetlands have been cleared or altered (see Gibson *et al.*, 2005; Department of Parks and Wildlife, 2015) and clay-based wetlands are now listed as Threatened Ecological Communities (TEC) (Department of Parks and Wildlife, 2015) with conservation status ranging from 'Priority 1' to 'Endangered'.

While vegetated ephemeral claypans were identified, described and listed as a TEC based on floristics, it is emerging that they also share particularly diverse and distinct assemblages of aquatic invertebrates. Two vegetated ephemeral claypans at Drummond Nature Reserve were shown to support a species richness of 111 (74 and 89 for individual samples) species from 2 samples (Cale, 2005) which placed the fauna within the top decile for species richness at 207 wetlands surveyed in the Agricultural Zone Biodiversity survey (Pinder *et al.*, 2004). Further surveys at Drummond Nature Reserve indicated a total species richness of 160 species between 2004 and 2014 (Jones *et al.*, 2009; Pinder, Cale & Leung, 2011; Pinder *et al.*, 2013). Other vegetated ephemeral claypans including Goonaping (Cale & Pinder, 2020) Little Darkin Swamp (Shahrestani, 2017; Cale, 2020) Dobaderry (Pinder *et al.*, 2009) and Brixton St (Adrian Pinder and Kirsty Quinlan pers. Comm.) have reported similar levels of aquatic invertebrate diversity. An analysis of species composition across these vegetated ephemeral claypans identified a small suite of co-occurring species (Cale, 2020) which distinguished them from other high richness wetlands. Frequently, aquatic invertebrate species occurring in these vegetated ephemeral claypans have restricted ranges and particular habitat requirements ((Pinder *et al.*, 2013).

To further our understanding of the diversity of aquatic invertebrates in this habitat type, a vegetated ephemeral claypan in Julimar State Forest was sampled in October 2021. This 'Julimar' claypan lies at the north-western corner of the State Forest. It has an area of less than one hectare and is shallow at less than 40 cm when full. 'Julimar claypan' is listed as occurrence #100 (Id; JB20) of the TEC described as "claypans with shrubs over herbs" (Department of Parks and Wildlife 2015). This TEC has a conservation status of 'Priority 1'.

As far as known, aquatic invertebrates have not been sampled at this wetland previously. The aim of this study was to determine species richness and composition of aquatic invertebrates within the claypan and compare the fauna with other claypans.

2 Sampling and Analysis

Sampling of macroinvertebrates and *in situ* measurement of environmental and habitat variables occurred on 7/10/2021. Two sampling locations of different habitat structure were selected to maximize the collected species diversity. Site A (31°21'24.44"S 116°12'25.31"E) was located slightly east of the northern most point of the wetland. Site B (31°21'26.98"S 116°12'23.71"E) was diametrically opposite the first site; slightly west of the southern most point of the wetland.

The habitat structure at each site was visually described using a hierarchical system with the area of cover of discernible formations as the first level and the area of cover of components of each formation as the second level. Described components were overstorey (*Melaleuca* spp), emergent sedges, floating plants and drape (sticks and senescing foliage at water surface), submergent macrophytes, woody debris (logs and sticks) and bare substrates. Bare substrates (unvegetated) were further described by the components: coarse particulate organic matter (CPOM, >4mm), fine particulate organic matter (FPOM) and inorganic substrate which was visually divided into clay and gravel.

At each site aquatic invertebrates were sampled in a benthic sample collected using a 250 µm mesh D-net to vigorously disturb substrates, and a plankton sample using a 110 µm mesh D-net in the water column and macrophytes. Both comprised a broken sampling path of approximately 50 m aimed at sampling all habitats within a path of about 200 m. Samples were preserved in General Laboratory Reagent (GLR) grade ethanol. Both invertebrate samples were sorted in the laboratory under a dissecting microscope to extract all species and to estimate their abundance on a log scale. Protista and Rotifera, which are typically collected in other studies (e.g., at Drummond; Cale 2005, Goonaping, Cale & Pinder 2020 and Little Darkin; Cale 2020) using this protocol, were not collected in this study. These two groups typically comprise a significant proportion of species richness, however, species composition varies greatly and over very short time frames, they require specialist taxonomists for identification and greatly add to the processing time of collected samples. The exclusion of these taxa was the main justification for using a 110 µm net in this study in contrast to the 53 µm net required in studies that included the Protista and Rotifera. Taxa collected from benthic and plankton samples were combined in the laboratory to provide the total sample species list for a site. Taxa were identified to the lowest level possible, usually species. Where taxa could not be identified to a described species they were attributed to a morphological species (morpho-species) specific to this survey. Some groups were not identified beyond a higher (e.g., Class) taxonomic level for example Turbellaria, Nematoda, oribatid and mesostigmatid mites.

The species composition of the macroinvertebrate community at Julimar claypan was compared with five wetlands previously described as vegetated ephemeral claypans (Cale 2020). Four of these wetlands are from wandoo and mixed woodlands of the western parts of the plateau at the top of the Darling Scarp. These are; Dobaderry swamp sampled in 2009 (Jones *et al.*, 2009), Goonaping swamp sampled repeatedly between 1998 -2006 (Cale & Pinder, 2020), Drummond claypans sampled by various authors (Cale, 2005; Jones *et al.*, 2009; Pinder *et al.*, 2011, 2013) and Little Darkin swamp sampled in 2020 (Cale, 2020). Brixton Street wetland was sampled in 2007 (Pinder and Quinlan DPAW unpublished data) and lies at the bottom of the Darling Scarp.

To compare community composition across this suite of wetlands it was necessary to ‘match’ presence/absence species lists so that spurious species were not added because of different levels of identification at each wetland. This required some combining or deletion of taxa until an equitable combined list was arrived at. All rotifer and protist taxa were removed from the analysis since they were not determined at Julimar. Individual sample species lists were used in the analysis to afford equal sampling effort in wetlands with one or two collected samples. A non-metric multidimensional scaling (NMDS) method was used to perform an ordination of the wetlands according to the dissimilarity (Bray Curtis) of composition between wetlands. This ordination was conducted using the metaMDS method in the vegan package (Oksanen et al., 2013) on the R statistical platform v.3.5.2 (R Development Core Team, 2019).

A YSI ProDSS meter was used to measure (*in situ*) electrical conductivity (ec), total dissolved solids (TDS), pH, dissolved oxygen (DO) and temperature (T) of wetland water at each site.

3 Results and Discussion

3.0 Site Characteristics

Julimar claypan is a slightly oval shaped basin 110 m wide and 150 m long (0.7 ha) with the long axis probably reflecting a drainage line. However, the local relief is very low with the margins of the basin the largest change in height. The wetland may sit on a small shelf roughly mid slope. While no surveying was done the land appears to slope up from the basin on all but the south-east side where the land appears flat but probably slopes down given that there is a clear fall in height over several hundred metres in this direction.

At the time of sampling the basin was approximately 70% wetted with 10 m between the lip of the basin and the wetted area. Maximum depth was approximately 35 cm, but most of the wetland was 20-30 cm deep. The wetland is presumed to dry each year but there is currently no information on how often the claypan fills or how long water persists on filling. Two Bureau of Meteorology weather stations; Bindoon 11 km southwest and Toodyay 32 km southeast of the wetland, recorded above average rainfall in the 4 months prior to sampling (Bureau of Meteorology, 2022). Rainfall was almost twice the median during July and approximately median in August – October. Consequently, the wetland probably had greater depth and had been inundated for longer than would occur in many years.

The wetland was very fresh with electrical conductivity of 99-101 µs/cm and <10 mg/L salts. Salinity is a major driver of community structure in aquatic communities in southern Western Australia (Davis *et al.*, 2003), however even with concentration as the wetland dries it is unlikely that salinity would be responsible for limiting invertebrate diversity in this wetland (Pinder *et al.*, 2005) since other factors such as temperature and depth would become at least as important.

Dissolved oxygen (DO) levels were relatively high but dependent on sample site. Levels were saturated (9.99 mg/L =118%) at site B where photosynthesis from dense stands of submergent plants was apparent. At site A, DO was lower (8.99 mg/L = 95.8%) probably because of the smaller area of submergent plants and the greater shading from overstorey vegetation. Water was circum-neutral (6.7-7.0) at both sites with the slight increase at site B (Table 1) probably influenced by sampling later in the day, and the differences in extent of photosynthesising submergent plants. Temperature was influenced by both water depth and shade with exposed shallows (<20 cm) 23.7 ^{o}C, exposed deeper water (30 cm) 20.9 ^{o}C and shaded deeper water (30 cm) 18.4 ^{o}C. There was no evidence of a thermocline with depth. Visually, water was clear with only slight colour and low turbidity, but no measurements were made for comparison with other wetlands.

Table 1 Water chemistry at the time of invertebrate sampling at both sites at Julimar claypan and at other vegetated ephemeral wetlands for comparison. Where a wetland has been sampled multiple times, median values are reported.

Wetland	Julimar claypan A	Julimar claypan B	Little Darkin Swamp	Dobaderry Swamp	Goonaping Swamp	Drummond NR
Date	7/10/2021	7/10/2021	7/10/2019	14/09/2007	1997- 2008	2010 - 2014
Depth (m)	0.3	0.2	0.41	0.3	0.2	0.25
Conductivity (µS/cm)	99	97 - 101	104.5	88.6	257	278.5
Field pH	6.96	6.70 - 6.75	7.84	6.81	7.175	6.375
Temperature (^{o}C)	18.4	20.9 - 23.7	18.8	18.8	22	19.2

Three habitat formations (Table 2) were apparent and formed approximately concentric zones across the wetland presumably in response to a combination of water depth and duration of inundation (see Shahrestani, 2017 chapter 2). There was a narrow band of shallows at the wetted margin that was characterised by depth 0 – 20 cm, sparse *Melaleuca viminea* over clumps of wiry semi-terrestrial sedges and patches of submergent macrophytes and bare substrates. At site B in particular a large proportion of the substrate in this formation was bare and suggestive of disturbance; it is possible this area has at some time been a vehicle track at the edge of the wetland.

Table 2 Habitat composition for the two invertebrate sampling paths.

	Site A			Site B		
Habitat	Shallows	Open	Melaleuca	Shallows	Open	Melaleuca
Proportion of site (%)	20	60	20	10	50	40
Median depth (cm)	10	25	30	10	25	35
% cover *Melaleuca* spp. overstorey	40		70	5		60
% cover emergent sedges	15	5	1		30	2
% cover submergent macrophytes	50	75	20	45	100	95
% cover floating macrophytes/drape		2	1		30	
% cover woody debris			5	5		5
% cover bare organic sediments				15		
% cover bare inorganic sediments	10	18	4	35		

Immediately inside the shallows was an area described as 'open' and characterised by depth 20-30 cm, an absence of overstorey, medium cover of sparse truly aquatic sedges and medium to dense cover of submergent macrophytes. The cover of submergents was greatest at site B where it was close to 100% by area and 75% by volume (Appendix 4, Plate 2) compared to <75% area and 25% volume at site A. The centre and presumably longest inundated region of the wetland supported a third formation described as *Melaleuca* thicket and characterised by depth >30 cm, medium to dense overstorey of *M. viminea*. over variable densities of emergent and submergent species and scattered woody debris. The amount of woody debris in this formation is underestimated in Table 2 because it made some regions at each site impenetrable to sampling and therefore not assessed as part of the sampling path.

The main habitat differences between sampling sites were the higher proportion of *Melaeuca* thicket and the higher % cover of both emergent and submergent macrophytes across the sampling path at site B.

3.1 Species richness

At least 87 taxa (Appendix 1) were collected at Julimar claypan. Five morpho-species specific to this survey were required to describe the fauna, i.e., 3 of 8 Ostracoda, 1 of 6 Chydoridae and 1 of 20 Diptera. These morpho-species contribute to analyses of species richness; however, they were not used in comparison of composition across different wetlands (see below). An additional 10 species were collected that matched morpho-species routinely used within the wetlands lab at DBCA (Pinder *et al.*, 2004, 2013; Pinder & Quinlan, 2015) and are consequently suitable for comparison with other wetlands surveyed by this group. Six taxa were not identified below family because the taxonomy is insufficiently developed (e.g., Nematoda, Turbellaria) or specimens were too immature (two dragonfly larvae) and nineteen were identified only to genus because the taxonomy could not be resolved with the available material (immature, wrong sex or taxonomy insufficiently developed). Identification of these higher taxonomic levels could include more than one species, resulting in an underestimation of total species richness in this study.

To place the richness of Julimar claypan in context, identical sampling effort (i.e. 2 sites) in the vegetated ephemeral claypan wetlands of Drummond Nature Reserve returned a richness of 82 taxa after excluding the Rotifera and Protista which were not collected in this study (see Cale, 2005). Similarly, 86 taxa, after excluding 57 taxa of Rotifera and Protista, were collected from 2 sites at Little Darkan Swamp (see Cale, 2020). Freshwater wetland types other than vegetated ephemeral claypans may also have similar richness. A freshwater wetland group (WG1) derived from an analysis of aquatic invertebrate faunas of 207 wetlands included in the biodiversity survey of the Western Australian agricultural zone (Pinder *et al.*, 2004) had an average richness of 65 ± 5 species. Similarly, the southern swamps group (WG9) which includes Lake Pleasant View had an average richness of 71 ± 5 species (Table 2 Pinder *et al.*, 2004).

The richness of individual samples at Julimar claypan was 73 and 82 species at sites A and B respectively. This is a similar sample richness to other vegetated ephemeral claypans (Fig. 1). Only Brixton recorded a higher sample richness, while Little Darkin has only slightly lower richness. At Goonaping and Drummond where samples have been collected over multiple years only occasional years with high water levels approach similar richness. Given the high rainfall before sampling at Julimar it is likely that the observed richness is above average for the site.

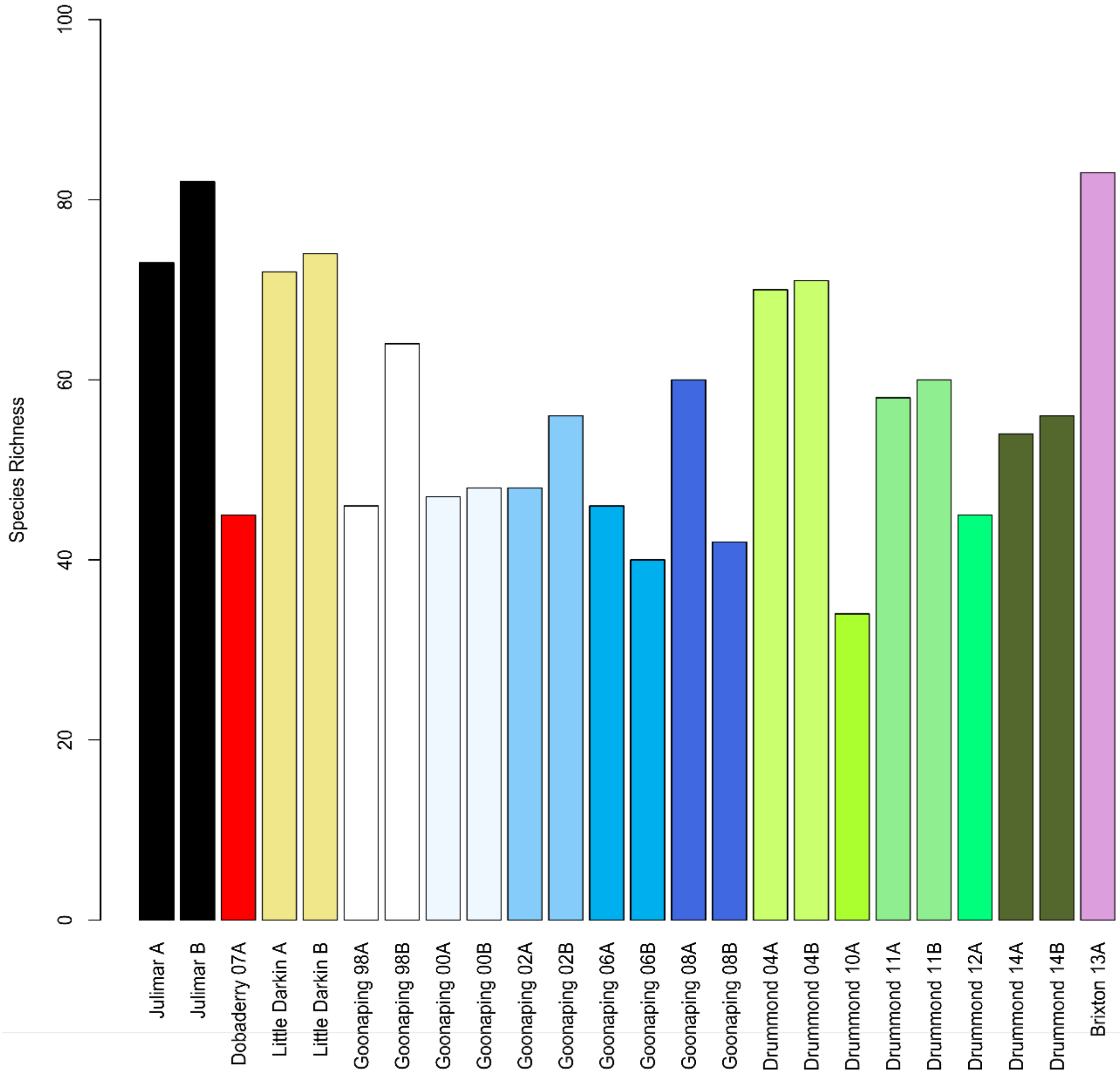


Figure 1 Species richness (excluding Protista and Rotifera) for individual samples at 'Julimar' claypan and five comparative vegetated ephemeral claypans.

Annual fluctuations in community composition and richness are typical of ephemeral wetlands as stochastic and climatic factors favour different species over others across years (e.g. Brendonck *et al.*, 2016) and result in an accumulation of species known from a site over time. In those claypans and vegetated swamps of the southwest land division that have been sampled over several years the annual richness has been 44-69% of total recorded richness (Table 3; Cale, 2020). The fauna at Julimar claypan is also likely to be more diverse over several years; possibly in the range 120-200 species.

The insects were the most species rich group within the wetland (Fig. 2) with 47 taxa (55% of fauna), followed by crustaceans with 27 taxa (31% of fauna). High richness of insects relative to crustaceans is common to other vegetated ephemeral claypans, including Drummond (Cale, 2005) and Goonaping (Cale & Pinder, 2020), but at Little Darkin the reverse was true (Cale, 2020). This division is relevant because insects generally have a greater dispersive capability because of winged adult stages. Consequently, insects may be more ubiquitously distributed. They are also better equipped to opportunistically colonise ephemeral wetlands, which, while supporting diversity also tends to increase the variability in community composition from year to year. Crustacean dispersal capabilities are often reliant on other species, such as waterfowl, to enable colonisation of wetlands. Alternatively, crustaceans rely on drought resistant stages (e.g., eggs, aestivating individuals) to persist. Reliance on resting stages tends toward fidelity to a wetland. It was beyond the scope of this survey to determine the relative importance of different methods of colonization of the wetland, but it may be an important driver of both richness and composition components of the fauna.

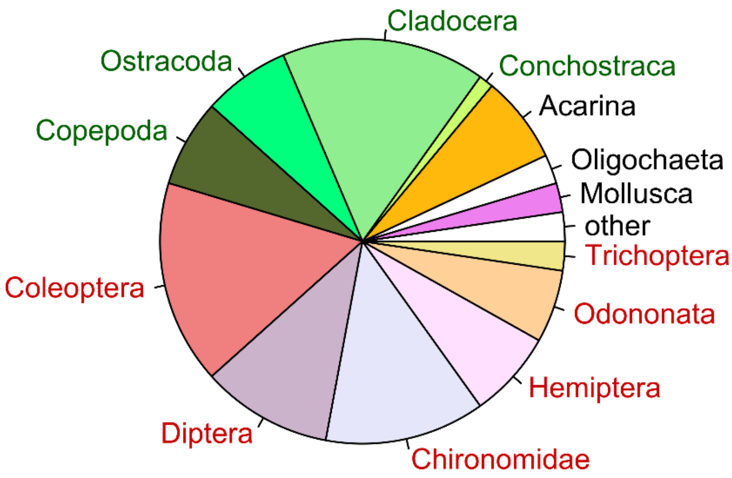
Among the insects Diptera (true flies) were represented by 20 taxa (23% of fauna), Coleoptera (beetles) by 14 taxa (16% of fauna), Hemiptera (boatmen and backswimmers) 6 taxa, Odonata (dragonflies and damselflies) 5 taxa and Trichoptera (caddisflies) 2 taxa. Diversity amongst the crustaceans was dominated by Cladocera (waterfleas) with14 taxa from 5 families, Copepoda and Ostracoda were represented by 6 and 10 species respectively and Conchostraca (clam shrimps) by a single species.

Pinder *et al.* (2004) described a series of 10 aquatic invertebrate assemblages from the Western Australian agricultural zone (Wheatbelt) based on their co-occurrence in wetlands with similar conditions of water chemistry and/or habitat. Species of six of these assemblages were present at Julimar claypan, however a large proportion of the fauna, 42 taxa (48%), could not be ascribed to an assemblage because they were not present in the initial analysis (i.e. Pinder *et al.*, 2004). Assemblages A (7 taxa), E (23 taxa) and F (12 taxa) accounted for 95% of the taxa ascribed to assemblages. Additionally, an assemblage (C) associated with freshwater wetlands in northern parts of the Wheatbelt and one typical of riverine wetlands (J) were also present and represented by one species each.

The assemblages present describe a fauna of mostly ubiquitously distributed species that prefer freshwater wetlands. Assemblage E is dominated by insects many with high dispersal characteristics and a tolerance of a broad range of sub-saline salinities. Assemblages A and F have a narrower tolerance of salinity and are typical of freshwater wetlands of the higher rainfall south-west and coastal districts. The absence of species of assemblage D, another freshwater assemblage, is principally because the Rotifera which dominate this assemblage were not collected. No assemblages associated with saline or hypersaline wetlands were collected.

The proportion of each assemblage at Julimar claypan is broadly like that of the other vegetated ephemeral claypans compared here. Assemblages A, E and F generally accounted for most of the species attributed to an assemblage. Assemblage A was typically less rich than assemblages E or F which were of similar proportional richness and liable to change dominance where the wetland was sampled multiple times. Less rich assemblages (B, C, D, H, I and J) displayed more variable richness both across the suite of wetlands and overtime (where a wetland was repeatedly sampled). Assemblages B, I and J were only represented by more than 1 species at Drummond (frequently) and on one occasion at Goonaping.

A)



B)

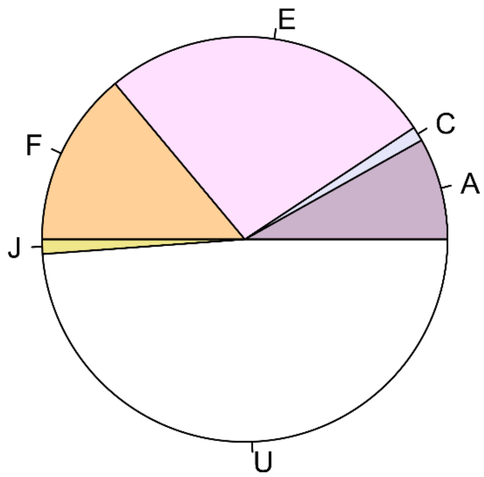


Figure 2 Proportional composition of the aquatic invertebrate fauna at 'Julimar' claypan. A) by taxonomic group, B) by assemblage (sensu Pinder et al 2004).

3.2 Community Composition

The faunas of 5 vegetated ephemeral claypans were compared with the Julimar claypan fauna. The compared wetlands have previously been shown to have similar faunas that are distinct from other freshwater wetland types (Cale, 2020). To match species and sampling effort across the 6 wetlands all Rotifera and Protisa (115 taxa) were removed and a further 18 taxa were removed when merged to higher taxonomic levels. After editing, species richness for each sample in the comparative analysis was 89-98 % of the actual richness without Rotifera and Protista (Appendix 2).

Community composition was compared across wetlands using an ordination[1] (non-metric multidimensional scaling - NMDS). Three dimensions were required to reduce the stress[2] of the ordination to an acceptable value (0.12). This ordination (Fig. 3) reveals two comparative features of community composition across the suite of wetlands. Firstly, where more than one sample was collected at a wetland those samples remain closely grouped even when those samples were taken in different years; defining the wetland and indicating that the fauna at each wetland is distinct. Secondly, because differences in composition are of similar scale between all wetland pairs including Julimar, it is reasonable to suggest Julimar is part of this predefined group. So, despite a distinctive fauna at each wetland, they are as a group distinct from other wetland types at least as determined by Cale (2020).

The fauna at Dobaderry is the least like Julimar and is different from other wetlands except Drummond and Goonaping. This dissimilarity of fauna is strongly influenced by the low species richness (45) of the sample at Dobaderry. The 2010 sample at Drummond was different from Julimar and other Drummond samples for the same reasons of low richness (33) and shared few species with the Julimar samples. In 2010 a widespread drought across the wheatbelt resulted in a poor filling and early drying of the Drummond wetlands. It seems likely that low richness at these wetlands, including Dobaderry, reflects a 'harsher' year.

Of the 239 taxa included in the comparison of community composition, 31 'high occurrence' species occurred in at least half the samples and may represent species typical of vegetated ephemeral claypans, at least in the locality of the 5 wetlands investigated. While typical of, these species do not define vegetated ephemeral claypans since they also occur in other wetland types. At Julimar claypan 27 of the high occurrence species were collected. This represents one third of the wetland's analysed richness. Seven of the high occurrence species have previously been identified as closely associated with seasonal clay-based wetlands in particular, and as useful target species in the management of the vegetated ephemeral claypans of Drummond Nature Reserve (Pinder *et al.*, 2011; Department of Environment and Conservation, 2011). *Lynceus* sp. (a clam shrimp more recently confirmed as *L. tatei*) and *Latonopsis brehmi*, *a* 'waterflea', were recorded at both sites in Julimar

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[1] A pairwise ordering of samples in multiple dimensions, so that similar samples are near each other, and dissimilar samples are farther apart.

[2] The distortion across multiple dimensions required to get the 'best fit' for all pairwise distances between samples.

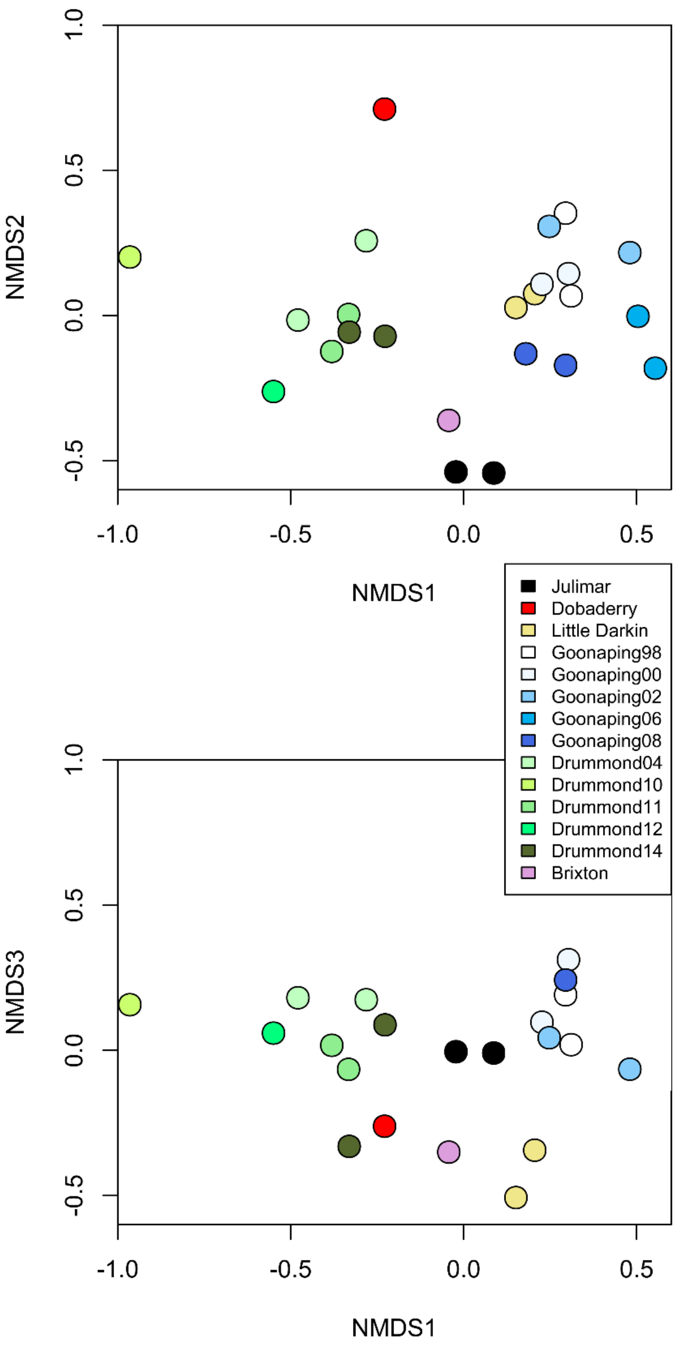

Figure 3 An ordination of community composition (presence/absence) of individual samples at Julimar claypan and a series of comparison wetlands (see methods for descriptions). Goonaping and Drummond samples include a suffix representing the year of sampling between 1998 and 2014. (NMDS, stress = 0.12).

and for all samples at other wetlands except the 2010 drought affected sample from Drummond. Both species were collected at both sites in Julimar in moderate - high abundance. A further three species: *Promochlonyx australiensis* (ghost midge), *Calamoecia attenuata* (cyclopoid) and *Bennelongia 'australis* lineage' (seed shrimp), were present in all wetlands although absent from some samples. *P. australiensis* was found at low abundance and only one site in Julimar, the other two species were at high abundance at both sites. The *Bennelongia 'australis'* lineage at Julimar was identified as *B. gwelupensis* but species level identification of this lineage has not been undertaken for specimens at other sites. The beetle *Paroster couragei* has been identified to species (male specimens required) at Goonaping and Drummond and to genus at Little Darkin, but not recorded at Julimar, Dobaderry or Brixton. Another beetle, *Berosus approximans*, was absent from Julimar and Dobaderry, but present in at least some samples of each of the other wetlands.

Twelve other high occurrence species were collected from all wetlands except Dobaderry. Most of these species do not have a close association to vegetated ephemeral claypans their presence reflecting broad distributions and generalist habitat requirements, they included: *Austrolestes analis*, *Megaporus* sp, *Procladius* sp. ('normal claws') and several higher taxa that are likely to represent multiple species. A smaller sub-group including *Ainudrilus nharna*, *Corynoneura* sp V49, *Ilyodromus* spp. *Cypretta baylyi*, *Simocephalus elizabethae* and *Microcyclops varicans* prefer freshwater wetlands and may have a greater fidelity to vegetated ephemeral claypans.

At Drummond Nature Reserve thirteen species were identified which are rare or known from only a few similar wetlands ((Pinder *et al.*, 2013). Two of these species, *Glacidorbis occidentalis* and the giant ostracod morpho-species *Lacrimicypris* n.sp., were collected at Julimar. The operculate snail *G. occidentalis* was believed to be restricted to intermittent streams in the south-west Jarrah forest (Bunn & Stoddart, 1983; Bunn, Davies & Edward, 1989). However, it is emerging that this species is a frequent component of the fauna in ephemeral vegetated claypans (e.g. Pinder *et al.*, 2011; Cale, 2020), where the intermittent nature of the wetland undoubtedly reflects similarity in habitat to intermittent Jarrah forest streams. This very small gastropod (<1.5mm diameter) has an operculum which can close off the shell to minimise dehydration during drought and is believed to enable aestivation within stream sediments (Bunn *et al.*, 1989). Interestingly, Carey et al. (2023) failed to detect this species at Bunn *et al*'s stream sites and implicated climate change and stream drying. The taxonomic identity of *Glacidorbis* collected at Drummond Nature Reserve have been shown to be sufficiently similar to Jarrah forest populations, at the molecular level, to be considered conspecific (Dolman, Whisson & Kirkendale, 2015). There is currently no reason to suspect the animals present at Julimar, and other vegetated ephemeral claypans, are not also of this species. Similarly, the undescribed *Lacrimicypris* is likely to have some fidelity to vegetated ephemeral claypans. This species was the largest ostracod at Julimar and occurred at high relative abundances (100-1000/sample) in both samples. It is only found to date in clay-based wetlands including Brixton Street wetland, Ellen Brook and Twin swamps on the Swan Coastal Plain, Arro swamp on the Geraldton Sandplain and Drummond NR and Julimar claypan to the east of the Darling Scarp.

Other notable species at Julimar included two ostracod species of the family Lymnocytheridae that could not be resolved beyond family and several unresolved ostracod species of the genus *Ilyodromus*. Species of *Ilyodromus* are also present at Drummond, Little Darkin, Goonaping and Brixton. There is considerable difficulty in comparing morphology amongst *Ilyodromus* species (Shearn *et al.*, 2014) and more work is required to establish which of the 11 morpho-species used in this study (Table 3) are distinct or synonyms and which species are shared by which wetlands. Consequently, they were merged to *Ilyodromus* spp. in this study, with potentially a considerable loss of information. The snail *Glyptophysa* sp. was found in all 5 comparison wetlands but not Julimar. Glyptophysa sp. has a widespread distribution but was replaced by the snail *Isidorella* sp. at Julimar. Pinder *et al.* (2004) found *Isidorella* snails associated with a group of claypan wetlands in the wheatbelt.

3.3 Concluding Remarks

The habitat for aquatic invertebrates at Julimar is structurally and chemically like that of other vegetated ephemeral claypans. Shallow water, zonation into areas with and without medium shrub overstorey, submergent and emergent macrophyte habitats and fine clay and organic substrates are common amongst this type of wetland. The wetlands investigated are circum-neutral and fresh and while the period of inundation has only been studied at Drummond Nature Reserve, and Little Darkin Swamp (Sharestani, 2017) they are all intermittent.

Julimar supported a diverse aquatic invertebrate fauna comparable to or richer than other vegetated ephemeral claypans. It is not clear from a single survey whether the high observed richness reflects an exceptional year in 2021 or is typical. While most of the Julimar aquatic invertebrate fauna comprises widespread species, the combination of species present, and the fact that several species appear to be characteristic of vegetated ephemeral claypans in the region, indicates that Julimar can be classified with these wetlands. Two species, an operculate snail and a 'giant' ostracod, are believed to be restricted to a few wetlands which include some of the vegetated ephemeral claypans. There is sufficient similarity of composition, including a suite of 31 frequently shared species, between the wetlands compared here to suggest they form a natural wetland type. However, there are also a large group of species at each wetland that are not shared even after several years of sampling. These species contribute to the distinctiveness of each wetland and suggest that protecting a range of such wetlands is required to conserve the total fauna. However, at Julimar unshared species are generally widespread common species, in contrast to, for example, Drummond where a significant number of species are believed to have restricted distributions. Further research into the distribution of species found in vegetated ephemeral claypans and their role in supporting the functioning of the claypan is needed in support of decisions about the conservation of the fauna of this wetland type.

The fauna at Julimar was slightly dominated by species with broader tolerance to salinity and toward insects with greater dispersal ability. There is no evidence that salinity is a limiting factor for the community at Julimar or that salinisation is a threatening process. The insect dominance is more likely a response to harsher conditions within the wetland or the dynamics of seasonal colonization. The hydroperiod of the wetland has not been determined, nor has the dynamics of colonization from Julimar claypan and surrounding wetlands, but both factors can be strong determinants of community composition.

Appendices

Appendix 1 'Julimar' claypan Species (log abundance) by Sample Matrix

LowestIDNC	Taxon	SiteA	SiteB	Assemblage
Platyhelminthes (flatworms)				
IF999999	Turbellaria	1	1	
Nematoda (round worms)				
II999999	Nematoda	1	1	
Mollusca (snails)				
KG070399	*Isidorella* sp.	2	3	F
KG090102	*Glacidorbis occidentalis*	3	3	
Oligochaeta (earthworms)				
LO052101	*Ainudrilus nharna*	3	2	
LO150101	*Pristina longiseta*	1	2	
Acarina (water mites)				
MM120101	*Limnesia dentifera*		1	E
MM170101	*Acercella falcipes*		1	E
MM170303	*Piona murleyi*		1	A
MM2301C4	*Arrenurus* cf *novaehollandiae*	1	1	
MM9999A1	Oribatida sp.	1	1	
MM9999A2	Mesostigmata	1	1	
Conchostraca (clam shrimps)				
OF040101	*Lynceus tatei*	2	2	
Cladocera (waterfleas)				
OG010106	*Diaphanosoma unguiculatum*	3	3	
OG010201	*Latonopsis brehmi*	3	3	F
OG030212	*Alona rigidicaudis*	2	2	E
OG030299	*Alona sp.*		2	
OG0317A6	*Leberis diaphanus*	3	3	
OG032701	*Rak labrosus*	3	3	A
OG033401	*Armatalona macrocopa*	3	2	
OG034101	*Flavalona setigera*	2	2	

LowestIDNC	Taxon	SiteA	SiteB	Assemblage
OG0402A0	*Daphnia* cf. *carinata* (SAP)	1		
OG040505	*Simocephalus elizabethae*	2	2	F
OG050105	*Ilyocryptus spinifer*	3	3	
OG060201	*Macrothrix breviseta*		3	E
OG0602B0	*Macrothrix* cf. *rosea* (SAP)	3	3	E
OG090301	*Neothrix armata*	3	3	F
Ostracoda (seed shrimps)				
OH019999	Limnocytheridae	2	3	
OH070101	*Candonopsis tenuis*		3	A
OH080316	*Bennelongia* (australis lineage) *gwelupensis*	3	3	
OH080501	*Cypretta baylyi*	3	3	E
OH082199	*Cypricercus* sp.	3	4	
OH081999	*Ilyodromus* spp.	3	3	
OH0825A0	*Lacrimicypris* n.sp.	3	3	
Copepoda (copepods)				
OJ110101	*Boeckella triarticulata* s.l.	4	4	E
OJ110118	*Boeckella robusta*	4	4	F
OJ110203	*Calamoecia attenuata*	3	4	A
OJ1102A1	*Calamoecia* sp. 342 (ampulla variant) (CB)	3	4	E
OJ310101	*Microcyclops varicans*	3	3	F
OJ310703	*Mesocyclops brooksi*	3	3	F
Coleoptera (beetles)				
QC060199	*Haliplus* sp.		1	
QC090499	*Hyphydrus* sp.	1	2	
QC091002	*Limbodessus shuckhardi*		1	
QC091101	*Allodessus bistrigatus*	1	1	E
QC091699	*Antiporus* sp.		1	
QC091805	*Sternopriscus multimaculatus*	1	4	E
QC092099	*Necterosoma* sp.		1	
QC092103	*Megaporus howittii*	2		E
QC092199	*Megaporus* sp.		1	
QC092399	*Rhantus* sp.		1	

LowestIDNC	Taxon	SiteA	SiteB	Assemblage
QC092799	*Copelatus* sp.	1	1	
QC093401	*Onychohydrus scutellaris*	1	1	F
QC110499	*Berosus* sp.	1	2	
QC111899	*Hydrophilus* sp.	1	1	
QC209999	Scirtidae	2	2	
QCAN9999	Curculionidae	1	3	
Diptera (flies)				
QD019999	Tipulidae	1	1	
QD0199A4	Tipulidae type E (SAP)		1	A
QD050201	*Promochlonyx australiensis*	1		F
QD070101	*Anopheles annulipes* s.l.	2	2	E
QD0919A3	*Monohelea* sp. 4 (SAP)	1		
QD0927A0	*Atrichopogon* sp. 2 (SAP)	1		A
QD092999	*Dasyhelea* sp.	1		E
QD3699A1	Dolichopodidae sp. B (SAP)	1		E
QD7899A6	Ephydridae sp. 2 (SAP)	1		E
QD899999	Muscidae	1	1	
QDAE08A2	*Procladius* sp. (normal claws)	2	2	
QDAE1102	*Ablabesmyia notabilis*	1	2	E
QDAE1201	*Paramerina levidensis*	2	2	F
QDAF06A2	*Corynoneura* sp. (V49) (SAP)	2	2	
QDAF2801	*Limnophyes vestitus* (V41)	2	2	
QDAF99A0	*Gymnometriocnemus* sp.=ortho sp A (?VSC11) (SAP)	2	2	E
QDAF99C0	Orthocladiinae SO3 sp. C (V31) (SAP)	3	2	G
QDAI01A0	*Harrisius* sp. A (SAP)		1	J
QDAI2199	*Microchironomus* sp.	1	1	
QDAI2201	*Cladopelma curtivalva*	1	1	E
QDAI25A0	*Parachironomus* sp. 1 (VSCL35) (SAP)	1	1	C
Hemiptera (striders,backswimmers and boatmen)				
QH560101	*Microvelia* (*Pacificovelia*) *oceanica*	1	1	F
QH600201	*Saldula brevicornis*	1	1	
QH650204	*Sigara truncatipala*		1	A

LowestIDNC	Taxon	SiteA	SiteB	Assemblage
QH650399	*Agraptocorixa* sp.	1	1	
QH650502	*Micronecta robusta*	1	2	E
QH670402	*Anisops hyperion*		3	E
QH670499	*Anisops* sp.	2		
Odonata (damselflies, dragonflies)				
QO029999	Coenagrionidae		1	
QO050101	*Austrolestes analis*	2	2	F
QO121204	*Anax papuensis*	1	2	
QO179999	Libellulidae		1	
QO300102	*Hemicordulia tau*	1	2	E
Trichoptera (caddisflies)				
QT250799	*Oecetis* sp.	1	1	
QT251103	*Triplectides australis*	2	1	E

Appendix 2 The richness (R) of wetland samples before and after combining species for NMDS ordination. All Rotifera and Protista taxa were removed before this level of editing.

		R post edit	R pre edit	% R used in analysis
Wetland	Sample			
Julimar	VCP00121A	69	72	96
	VCP00121B	77	80	96
Dobaderry	ABP04107A	42	45	93
Little Darkin	LDS00119A	66	72	92
	LDS00119B	68	74	92
Goonaping	SPM01398A	44	46	96
	SPM01398B	61	64	95
	SPM01300A	46	47	98
	SPM01300B	47	48	98
	SPM01302A	46	48	96
	SPM01302B	53	56	95
	SPM01306A	44	46	96
	SPM01306B	39	40	98
	SPM01308A	55	60	92
	SPM01308B	39	42	93
Drummond	DNR00104A	68	70	97
	DNR00204A	68	71	96
	SPM03010A	33	34	97
	SPM03011A	54	58	93
	SPM03011B	55	60	92
	SPM03012A	44	45	98
	SPM03014A	48	54	89
	SPM03014B	50	56	89
Brixton	WST007131	77	83	93

Appendix 3 Number of species of the ostracod *Ilyodromus* in each of the compared vegetated ephemeral claypan wetlands

	Named species	Morphospecies
Julimar		3
Little Darkin		4
Dobaderry	1	
Goonaping		3
Drummond	1	
Brixton	1	1

Appendix 4 'Julimar' claypan sampling site photographs

Plate 1

Site A - Left to right, top row: Site A, shallow habitat

middle row: open habitat, Melaleuca habitat

bottom row: shallow habitat substrate, open habitat substrate

Appendix 4 (cont)

Plate 2

Site B - Left to right, top row: Site B left, Site B right

middle row: shallow habitat substrate, open habitat

bottom row: Melaleuca habitat, open habitat substrate

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