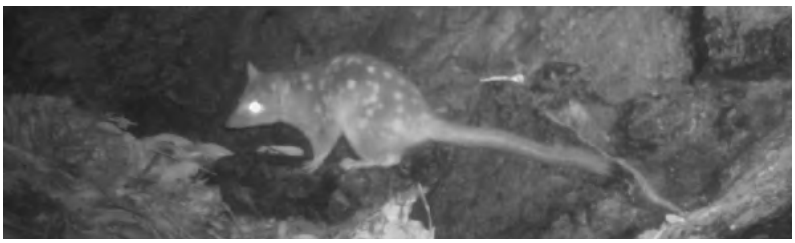
Biota Environmental Sciences

Pardoo and Ridley Desktop Study and Targeted Fauna Survey



Prepared for Atlas Iron Pty Ltd

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Biota Environmental Sciences

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Pardoo and Ridley Desktop Study and Targeted Fauna Survey

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1.0 Executive Summary

Atlas Iron Pty Ltd is investigating opportunities for the mining and processing of additional resources at its Pardoo and Ridley project areas (hereafter, the 'study area'), which cover 11,065 ha, approximately 57 km east of Port Hedland in the Pilbara region of Western Australia (WA). Biota Environmental Sciences Pty Ltd was commissioned to conduct a detailed terrestrial vertebrate and short-range endemic (SRE) invertebrate fauna survey and habitat assessment of the study area to support future environmental impact assessment of the project. The first phase of the detailed survey commenced in June 2022 but could not be completed due to heavy rainfall and was instead completed in November 2022. To provide more timely information on the potential occurrence of significant fauna in the study area, an additional targeted survey and desktop study was undertaken in July 2022.

The desktop study included a review of existing environmental data, such as land systems, surface geology and broad-scale vegetation mapping, and the compilation and review of fauna records from the locality. This was used to produce a potential species list for the locality and identify fauna species of significance and their habitats potentially occurring in the study area. For significant fauna species identified as potentially occurring, an assessment of the likelihood of occurrence was undertaken.

The targeted survey included survey effort for significant vertebrate fauna assessed as having a moderate to high likelihood of occurrence in the study area, and for SRE invertebrates. The targeted survey was undertaken from 5th to 13th July 2022, and survey effort comprised:

- 630 Elliott trap nights across four trapping sites;
- 42 nights of motion camera recording effort across nine sites;
- 16 nights of ultrasonic bat recording effort across eight sites;
- 13 nights of audible-range sound recording effort across four sites;
- 3 hours of targeted searching for vertebrate fauna across four sites; and
- 15.4 hours of targeted searching for SRE invertebrate fauna across 16 sites.

An additional 1,072 minutes of targeted searching for vertebrate fauna across 12 sites and 55 minutes of targeted searching for SRE invertebrate fauna across two sites was undertaken during the interrupted detailed survey undertaken from 28th May to 3rd June 2022.

Four broad fauna habitats were identified for the study area, though these are likely to be refined further following completion of the detailed survey:

- Rocky Hills;
- Alluvial Floodplains;
- Sandplains; and
- Major Drainage Lines.

A total of 349 vertebrate fauna species were identified from the locality (i.e. within 40 km of the study area) during the desktop study, including 40 mammals, 215 birds, 84 reptiles and 10 amphibians. Of these, 63 are listed as significant species under State or Commonwealth legislation or policy. Three of these significant species were recorded from the study area during the current survey, while a further five species have previously been recorded within the study area:

- Northern Quoll *Dasyurus hallucatus* (Endangered) – current survey and previously recorded;
- Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* Pilbara form (Vulnerable) – current survey;
- Ghost Bat *Macroderma gigas* (Vulnerable) – current survey;
- Pilbara Olive Python *Liasis olivaceus barroni* (Vulnerable) – previously recorded;
- Western Pebble-mound Mouse (Priority 4) – previously recorded;
- Brush-tailed Mulgara *Dasycercus blythi* (Priority 4) – previously recorded;

- Oriental Plover *Charadrius veredus* (Migratory) – previously recorded; and
- Peregrine Falcon *Falco peregrinus* (Other Specially Protected Fauna) – previously recorded.

A further five significant fauna species are considered to have a high likelihood of occurrence in the study area, while 16 are considered to have a moderate likelihood of occurrence ("may occur") within the study area. The species considered likely to occur in the study area but have not yet been recorded are:

- Pacific Swift *Apus pacificus* (Migratory);
- Glossy Ibis *Plegadis falcinellus* (Migratory);
- Little Curlew *Numenius minutus* (Migratory);
- Common Sandpiper *Actitis hypoleucos* (Migratory); and
- Oriental Pratincole *Glareola maldivarum* (Migratory).

A total of 18 invertebrate taxa from groups known to support SREs were identified from the locality during the desktop study, including eight mygalomorph spiders, one millipede and nine land snails. Eight of these taxa represent potential SREs, including six mygalomorph spiders, the sole millipede, and one of the land snails, while the remaining 10 taxa are not considered to be SREs.

Two potential SRE taxa have previously been recorded from within the study area:

- the mygalomorph spider Anaminae `MYGAAB`; and
- the millipede *Antichiropus simmonsi*.

Twenty specimens from groups known to support SREs were collected from the study area during the current survey. Based on molecular sequencing data, these specimens comprise six distinct lineages, all of which are considered likely to represent distinct species. Based on available reference data, none have been detected previously and the records from the study area currently represent the only known records of these species; thus, they represent potential SREs. These include:

- the mygalomorph spider *Idiosoma* H-182;
- the mygalomorph spider *Kwonkan* H-N168;
- the mygalomorph spider *Kwonkan* H-N169;
- the isopod Armadillidae H-ISA64;
- the isopod Armadillidae H-ISA64; and
- the land snail *Rhagada* H-SB020.

With the previous two taxa, which were not recorded during the current survey, the SRE fauna of the study area now stands at eight taxa.

2.0 Introduction

2.1 Project Background

Atlas Iron Pty Ltd (Atlas) is investigating opportunities for the mining and processing of additional resources at its Pardoo and Ridley project areas (hereafter, the 'study area'), located approximately 57 km east of Port Hedland in the Pilbara region of Western Australia (WA) (Figure 2.1). The study area covers approximately 11,065 ha and is intended to encompass any potential future mine and infrastructure associated with the proposal (mine pits, plant, tailings and waste dump).

Biota Environmental Sciences Pty Ltd (Biota) was commissioned to conduct a terrestrial fauna survey and habitat assessment for the study area (i.e. a desktop study followed by a two-phase seasonal detailed terrestrial vertebrate and short-range endemic (SRE) invertebrate fauna survey) to support future environmental impact assessment (EIA) of the project. The first phase of the detailed survey commenced in June 2022 but could not be completed due to heavy rainfall and was instead completed in November 2022. To provide more timely information on the potential occurrence of significant fauna in the study area, an additional targeted survey was undertaken in July 2022.

2.2 Study Scope and Objectives

The purpose of this study was to update the preliminary desktop study completed prior to the initial field survey, and to undertake a targeted fauna survey for significant vertebrate fauna and SRE invertebrate fauna in the study area.

The desktop study consolidated available and relevant existing data from databases and previous surveys in the locality to identify fauna species of significance and their habitats potentially occurring in the study area. The objective of the targeted survey was to provide updated information on the potential occurrence of significant fauna within the study area, through a single-phase targeted field survey and habitat assessment for significant fauna.

This report details the results of the updated desktop study and the targeted survey, and also includes data obtained during the interrupted first phase of the detailed survey for completeness.

Figure 2.1: Location of the study area.

3.0 Methodology

3.1 Desktop Study

3.1.1 Literature Review

The literature review comprised:

- a summary of the Interim Bioregionalisation for Australia (IBRA) region and subregion descriptions (DSEWPaC 2012);
- a summary of background information for the survey area, including land systems, surface geology, soils and broad vegetation mapping; and
- a review of published and unpublished reports from relevant biological surveys previously completed within the locality (40 km) of the study area (see below).

The following survey reports were identified and reviewed as part of the literature review:

1. Biota (2006) – Port Hedland Solar Saltfield Expansion Fauna Survey. Unpublished report prepared for Dampier Salt Ltd.
2. Bamford et al. (2010) – Fauna Assessment of the Pardoo 3 Mtpa DSO Project. Unpublished report for Atlas Iron Limited.
3. ENV (2011) – Port Hedland Regional Fauna Assessment. Unpublished report prepared for BHP Billiton Iron Ore Pty Ltd.

3.1.2 Database Searches

To inform the potential terrestrial vertebrate and SRE invertebrate fauna assemblage of the study area, the following databases were queried for fauna records within 40 km of the study area:

- NatureMap - a joint project of the Department of Biodiversity, Conservation and Attractions (DBCA) and the Western Australian Museum (WAM). This database represents the most comprehensive source of information on the distribution of Western Australia's flora and fauna, comprising records from the WA Threatened Fauna Database, Fauna Survey Returns Database (managed by the DBCA), the WAM Specimen Database, and the BirdLife Australia Atlas of Australian Birds. It is no longer publicly available, but data can be accessed by request through DBCA;
- DBCA Threatened and Priority Fauna and Ecological Communities database;
- The Atlas of Living Australia (https://www.ala.org.au/) - an open access database of Australian biodiversity data, including fauna records, from a range of sources, hosted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO);
- eBird (https://ebird.org/)- a citizen science database of bird records from around the globe, managed by Cornell University and moderated by local experts;
- The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool - a search tool to identify federally listed fauna species and any other Matters of National Environmental Significance (MNES) that are known to or may occur in the locality;
- WAM invertebrate databases – specifically arachnid, myriapod and mollusc records; and
- Biota's internal database of past surveys.

3.1.3 Likelihood of Occurrence Assessment

Results from the literature review and database searches were used to compile a list of terrestrial fauna species potentially occurring in the study area and identify any significant species with the potential to occur. Species listed as Marine under the EPBC Act were not considered as the study area does not encompass marine environs.

The likelihood of occurrence of significant species was then assessed using the rankings and criteria provided in Table 3.1. These criteria are used as guidance, and consideration was also given to:

- the documented distribution of the species;
- the proximity of the study area to known populations;
- the species' ecology; and
- level of survey effort in the locality.

Habitats were preliminarily defined according to vegetation units, landforms apparent on aerial imagery, and other existing information regarding the environment (see Section 3.2). Habitats were then refined following the field survey. The term 'close proximity' is defined as being within 20 km of the study area, while the broader 'locality' comprises the area up to 40 km from the study area.

Table 3.1: Ranking guidelines for assessing the likelihood that a species would occur in the study area.

Rank	Criteria
Recorded	1. The species has been previously recorded in the study area.
Likely to occur (High likelihood of occurrence in the study area)	1. There are existing records of the species in close proximity to the study area (within 20 km); and • the species is strongly linked to a specific habitat, which is present in the study area; or • the species has more general habitat preferences, and suitable habitat is present.
May occur (Moderate likelihood of occurrence in the study area)	1. There are existing records of the species from the locality (within 40 km), however • the species is strongly linked to a specific habitat, of which only a small amount is present in the study area; or • the species has more general habitat preferences, but only some suitable habitat is present. 2. There is suitable habitat in the study area, but the species is recorded infrequently in the locality.
Unlikely to occur (Low likelihood of occurrence in the study area)	1. The species is linked to a specific habitat, which is absent from the study area; or 2. Suitable habitat is present, however there are no existing records of the species from the locality despite reasonable previous search effort in suitable habitat; or 3. There is some suitable habitat in the study area, however the species is very infrequently recorded in the locality or the only records are historic (>40 years ago).
Would not occur (Negligible likelihood of occurrence in the study area)	1. The species is strongly linked to a specific habitat, which is absent from the study area; or 2. The species' range is very restricted and does not include the study area; or 3. The species is not considered extant in the locality.

3.1.4 Determining SRE Status

SRE invertebrate fauna are invertebrates that exhibit naturally small distributions (less than 10,000 km^2, per Harvey 2002). Certain taxonomic groups are pre-disposed to short-range endemism as a result of poor dispersal capabilities, confinement to disjunct habitats, slow reproduction and low fecundity (Harvey 2002, Ponder and Colgan 2002). These life history strategies render these groups vulnerable to localised extinction by relatively small-scale developments, such as mining and construction. Taxonomic groups that show high levels of short-range endemism include mygalomorph spiders, millipedes, pseudoscorpions, and both freshwater and terrestrial molluscs (EPA 2016a). Given the importance of short-range endemism to the conservation of biodiversity (EPA 2016a), the assessment of such invertebrate taxa is an important component of EIA.

The ability to assess impacts on SRE fauna is limited by knowledge of their biology, distribution and phylogeography, which are in many cases, poorly understood. The taxonomy of SRE invertebrate is patchy and incomplete, which makes determining the significance of potential SRE taxa

difficult. To determine the SRE status of putative species recorded from the survey, a range of criteria were used based on the current level of knowledge for each taxon (Table 3.2).

Table 3.2: Categories of SRE status and defining criteria.

SRE Status	Defining Criteria
Known SRE	• Species, morphotype or genetic type has a documented range of <10,000km^2. • Species, morphotype or genetic type is well collected, with numerous specimens typed and habitat preferences understood.
Potential SRE	• Species, morphotype or genetic type has a documented range of <10,000km^2 but is poorly sampled. • Specimen may not be formally described or assigned to a morphotype / genetic type. • Short-range endemism may be common in genus or family. • May have been collected from restricted, refugial or isolated habitats.
Unlikely to be an SRE	• Species, morphotype or genetic type has a documented range of <10,000km^2 but is poorly sampled. • Specimen may not be formally described or assigned to a morphotype / genetic type. • Short-range endemism is not common in the genus or family. • Specimen was not collected from restricted, refugial or isolated habitats. • Few other individuals of the taxon collected, but records separated by long distances (>100 km).
Not an SRE	• Specimen formally described or assigned to a morphotype / genetic type • Species, morphotype or genetic type has a documented range of >10,000 km^2.
Undetermined	• Taxa where there is insufficient taxonomic framework available to provide any informed comment on the species-level distribution of the fauna or, therefore, the risk of small-scale spatial restrictions.

3.1.4.1 Molecular Analysis

Molecular analysis of invertebrate specimens was undertaken to determine the number of species present, place them into local and regional context where possible and better assess their SRE status. Molecular analyses were undertaken by Helix Molecular Solutions Pty Ltd, for methodology refer to the accompanying report (Helix 2023; Appendix 4).

3.2 Fauna Habitat Mapping

Vertebrate fauna landscapes and landforms of the study area were identified based on Biota's fauna landscape approach (Biota 2013), which identifies functional landforms within a broader landscape. Preliminary mapping has been undertaken using existing spatial data for environmental features (e.g. land systems, broad-scale vegetation mapping) and aerial imagery, supported by on-ground habitat assessments. Fauna habitat mapping may be refined further following completion of the detailed survey phases.

3.3 Nomenclature

Taxonomy and nomenclature for mammals, reptiles and amphibians in this report follows that of the WAM taxonomic checklist, following EPA technical guidance (EPA 2020), which is revised and released every six months, or as necessary. Taxonomy and nomenclature for birds follows that of the International Ornithological Congress (IOC) World Bird List (Gill et al. 2022), as this is the global checklist that uses a taxonomic approach closest to that used by the WA Museum for other terrestrial vertebrate fauna groups. In 2021, the WAM updated their bird checklist to align more closely with the IOC list. Nomenclature for invertebrates follows that of the WA Museum.

3.4 Threatened Fauna Statutory Framework

Native fauna species that are rare, threatened with extinction, or have high conservation value, are specially protected by law under either or both of the State *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth EPBC Act 1999. The DBCA also maintains a list of Priority species that have not been assigned statutory protection under the BC Act. Appendix 1 details the categories of conservation significance recognised under these three frameworks.

3.5 Survey Timing and Weather

3.5.1 Survey Timing, Team and Permits

The targeted fauna survey was undertaken from the 5th to the 13th July 2022 by two Biota zoologists (Table 3.3). The survey was undertaken under DBCA Regulation 27 Licence No. BA27000650-2 and Section 40 authorisation no. TFA 2022-0065, both issued to Dr Sylvie Schmidt of Biota (see Appendix 2).

Table 3.3: Summary of personnel undertaking targeted survey.

Name	Position at Biota	Qualification	Years of Experience	Survey Role
Dan Kamien	Principal Zoologist	BSc. Hons	20	Field survey Desktop study
John Graff	Senior Zoologist	BSc. Hons	11	Field survey Data analysis and reporting

3.5.2 Weather and Seasonal Conditions

Weather data from the Bureau of Meteorology (BoM) Pardoo weather station (station no. 004028) were not available for the survey dates, so daily weather observations were taken from the BoM weather station at Port Hedland Airport (station no. 004032; Table 3.4). The Port Hedland Airport station is located approximately 50 km to the west of the study area.

Conditions in the year leading up to the survey were warmer and wetter than long-term averages (Figure 3.1). Average minimum temperatures were consistently higher than long-term medians throughout most of the previous year, and average maximum temperatures were distinctly higher over summer (Dec-Mar; Figure 3.1). Rainfall was higher than average in the year preceding the surveys, particularly during May and June. Mean rainfall was used rather than median rainfall as this more accurately reflected annual rainfall due to the patchy nature of rainfall in the region. In particular, the median annual rainfall is 310 mm, whereas the sum of the long-term monthly median rainfall totals is 134.9 mm, indicating that the median monthly rainfall totals are not reflecting the total annual median rainfall.

Table 3.4: Daily weather observations during survey.

Data taken from Bureau of Meteorology Port Hedland Airport weather station (station no. 004032; Bureau of Meteorology 2022).

Survey Phase	Date	Max Temp (°C)	Min Temp (°C)	Rainfall (mm)
Targeted	05/07/2022	24.2	7.8	0.0
	06/07/2022	25.3	7.8	0.0
	07/07/2022	27.4	7.4	0.0
	08/07/2022	28.0	8.5	0.0
	09/07/2022	26.4	9.2	0.0
	10/07/2022	26.7	9.0	0.0
	11/07/2022	27.2	9.3	0.0
	12/07/2022	28.2	10.8	0.0
	13/07/2022	28.2	13	0.0

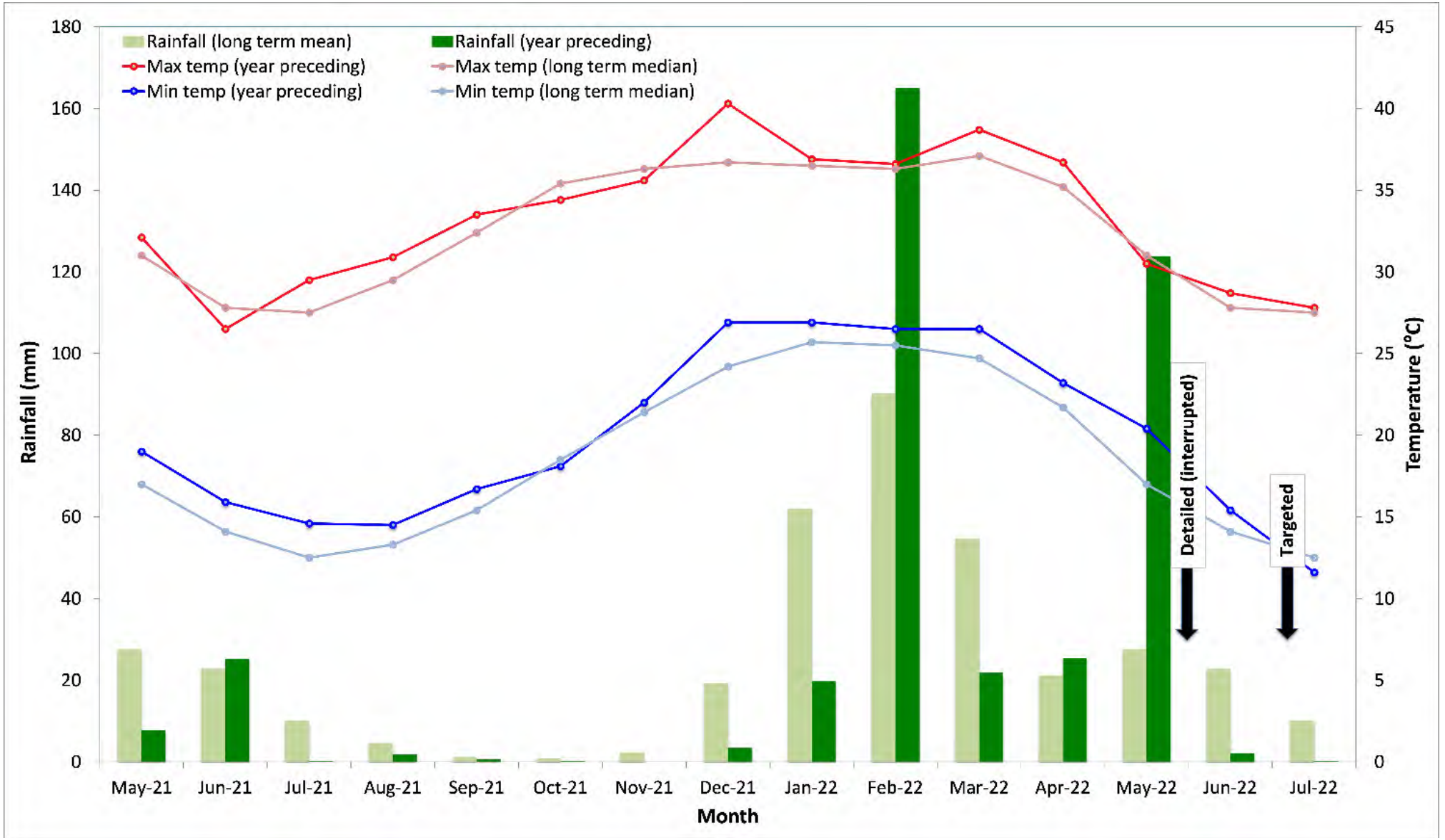

Figure 3.1: Rainfall and temperature data for the previous year compared to long-term averages.

Data taken from Bureau of Meteorology Port Hedland Airport weather station (station no. 004032).

3.6 Vertebrate Fauna Targeted Survey

Survey methodology and approach were undertaken with consideration of the following compliance and regulatory documents:

- Technical Guidance – Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016b);
- Technical Guidance – Terrestrial Fauna Surveys (EPA 2016c);
- Technical Guidance – Terrestrial Vertebrate Fauna Surveys (EPA 2020);
- Survey Guidelines for Australia's Threatened Birds (DEWHA 2010);
- Survey Guidelines for Australia's Threatened Mammals (DSEWPaC 2011);
- EPBC Act Policy Statement: EPBC Act Referral Guidelines for the Endangered Northern Quoll (Department of the Environment 2016); and
- Interim Guideline for Preliminary Surveys of Night Parrot (*Pezoporus occidentalis*) in Western Australia (DBCA 2017a).

3.6.1 Targeted Species

Vertebrate fauna species targeted during the survey were determined based on the results of the desktop study, identifying the most likely species to occur within the study area. Consideration was also given to the suitability of the targeted survey timing and methods for certain species; for example, limited search effort for Pilbara Olive Python was undertaken during the targeted survey because the timing for the detailed survey phases (November and March) is better suited for targeting that species. The significant species identified as potentially occurring, and survey methods employed for each species, are outlined in Table 3.5. In addition to the methods outlined below, an assessment of habitat suitability was undertaken for all species.

Table 3.5: Significant fauna survey methods.

Species	Common name	Survey methods
Mammals		
Dasyurus hallucatus	Northern Quoll	Elliott trapping, motion cameras, targeted searches
Macrotis lagotis	Bilby	Motion cameras, targeted searches
Rhinonicteris aurantia (Pilbara form)	Pilbara Leaf-nosed Bat	Ultrasonic sound recorders, targeted searches
Macroderma gigas	Ghost Bat	Ultrasonic sound recorders, targeted searches
Dasycercus blythi	Brush-tailed Mulgara	Motion cameras, targeted searches
Leggadina lakedownensis	Short-tailed Mouse	Not targeted during current survey
Pseudomys chapmani	Western Pebble-mound Mouse	Targeted searches, opportunistic observations
Birds		
Pezoporus occidentalis	Night Parrot	Audible-range sound recorders
Rostratula australis	Australian Painted Snipe	Targeted searches, opportunistic observations
Falco hypoleucos	Grey Falcon	
Apus pacificus	Pacific Swift	
Charadriidae/Scolopacidae spp.	Migratory shorebirds	
Laridae spp.	Migratory-listed terns	
Plegadis falcinellus	Glossy Ibis	
Hirundo rustica	Barn Swallow	
Motacilla tschutschensis	Eastern Yellow Wagtail	
Falco peregrinus	Peregrine Falcon	
Reptiles		
Liasis olivaceus barroni	Pilbara Olive Python	Targeted searches, opportunistic observations, motion cameras

3.6.1.1 Elliott Trapping

Four Elliott trapping sites were set up during the targeted survey in suitable habitat for Northern Quoll to target that species (Table 3.6; Figure 3.2). Traps were deployed for seven nights, unless closed earlier due to multiple captures of the same individual Northern Quoll(s), in accordance with the Northern Quoll referral guidelines (Department of the Environment 2016). Traps were baited with universal bait (peanut butter and oats).

Table 3.6: Elliott trapping site locations.

Site	Location		No. of traps	Nights open	Effort (trap nights)	Site photo
	Latitude	Longitude				
PDF15E	-20.33588	119.13809	25	4[1]	100	
PDF16E	-20.33611	119.09266	25	7	175	
PDF17E	-20.25632	119.13125	30	6[2]	180	
PDF18E	-20.27860	119.12868	25	7	175	
				Total	**630**	

[1] Site PDF15E closed after four nights due to repeat captures of multiple individual Northern Quolls.
[2] Site PDF17E closed after six nights due to five repeat captures of the same individual Northern Quoll.

3.6.1.2 Motion Cameras

Infrared motion cameras were deployed at nine locations within the study area during the targeted survey, totalling 42 trap nights (Table 3.7; Figure 3.3). Motion cameras were primarily

used to target mammal species of significance including Northern Quoll, Bilby, and Brush-tailed Mulgara. Cameras targeting Northern Quolls were placed in rocky areas, while those targeting Bilby and Brush-tailed Mulgara were placed in sandplain areas. Cameras were baited with a small amount of universal bait placed in front of the camera.

Table 3.7: Motion camera locations.

Site	Location		Target species	Effort (nights)
	Latitude	Longitude		
PDF01MC	-20.24347	119.1108	Northern Quoll	5
PDF02MC	-20.24972	119.15892	Northern Quoll	4
PDF03MC	-20.26974	119.12106	Northern Quoll	5
PDF04MC	-20.26984	119.12097	Northern Quoll	5
PDF05MC	-20.26811	119.10213	Northern Quoll	5
PDF06MC	-20.2905	119.10602	Northern Quoll	5
PDF07MC	-20.31064	119.09322	Bilby, Brush-tailed Mulgara	5
PDF08MC	-20.27941	119.12967	Northern Quoll	4
PDF09MC	-20.27409	119.05372	Bilby, Brush-tailed Mulgara	4
			Total	**42**

3.6.1.3 Ultrasonic Bat Recorders

SongMeter4BAT ultrasonic recording units were deployed at eight locations during the targeted survey to target Pilbara Leaf-nosed Bats and Ghost Bats, totalling 16 nights of survey effort (Table 3.8; Figure 3.3). The selectable filters and triggers, jumper and audio settings used followed the manufacturer's recommendations for bat detection (Wildlife Acoustics 2010). Units were deployed in a range of habitats, with particular focus on areas considered likely to attract bats, including near water sources, along flight corridors through and around vegetation, and in the vicinity of potential roosting habitat.

Bat call analysis was undertaken by Dan Kamien of Biota, using Kaleidoscope Pro software (version 5.4.6), following methods recommended by the Australasian Bat Society (2006), in conjunction with available reference data (Churchill 2008, McKenzie and Bullen 2009). Only sequences containing good quality search phase calls were considered for identification.

Table 3.8: Ultrasonic recording unit locations.

Site	Location		Target species	Effort (nights)
	Latitude	Longitude		
PDF01BAT	-20.27785	119.12895	Pilbara Leaf-nosed Bat, Ghost Bat	2
PDF02BAT	-20.24147	119.11173	Pilbara Leaf-nosed Bat, Ghost Bat	2
PDF03BAT	-20.24988	119.16014	Pilbara Leaf-nosed Bat, Ghost Bat	2
PDF04BAT	-20.27943	119.12971	Pilbara Leaf-nosed Bat, Ghost Bat	2
PDF05BAT	-20.28079	119.07975	Pilbara Leaf-nosed Bat, Ghost Bat	2
PDF06BAT	-20.3359	119.13793	Pilbara Leaf-nosed Bat, Ghost Bat	2
PDF07BAT	-20.25652	119.13163	Pilbara Leaf-nosed Bat, Ghost Bat	2
PDF08BAT	-20.33599	119.09244	Pilbara Leaf-nosed Bat, Ghost Bat	2
			Total	**16**

3.6.1.4 Audible-range Autonomous Recording Units

SM4Mini audible-range autonomous recording units (ARUs) were deployed targeting Night Parrots. ARUs were deployed at four locations (Table 3.9; Figure 3.3). Effort was concentrated in habitats closest to that known to be favoured by Night Parrots for roosting (i.e. tall old growth spinifex) and foraging (i.e. higher productivity areas of the plains habitats).

Call analysis was undertaken by John Graff of Biota, using Kaleidoscope Pro software (version 5.4.6), with a classifier built using Night Parrot calls recorded in WA. Potential matches were then assessed manually by visual inspection of spectra and listening to recordings.

Table 3.9: ARU locations.

Site	Location		Target species	Effort (nights)
	Latitude	Longitude		
PDF01A	-20.26724	119.10152	Night Parrot	5
PDF02A	-20.28091	119.07971	Night Parrot	4
PDF03A	-20.26251	119.12304	Night Parrot	2
PDF04A	-20.27507	119.10676	Night Parrot	2
			Total	**13**

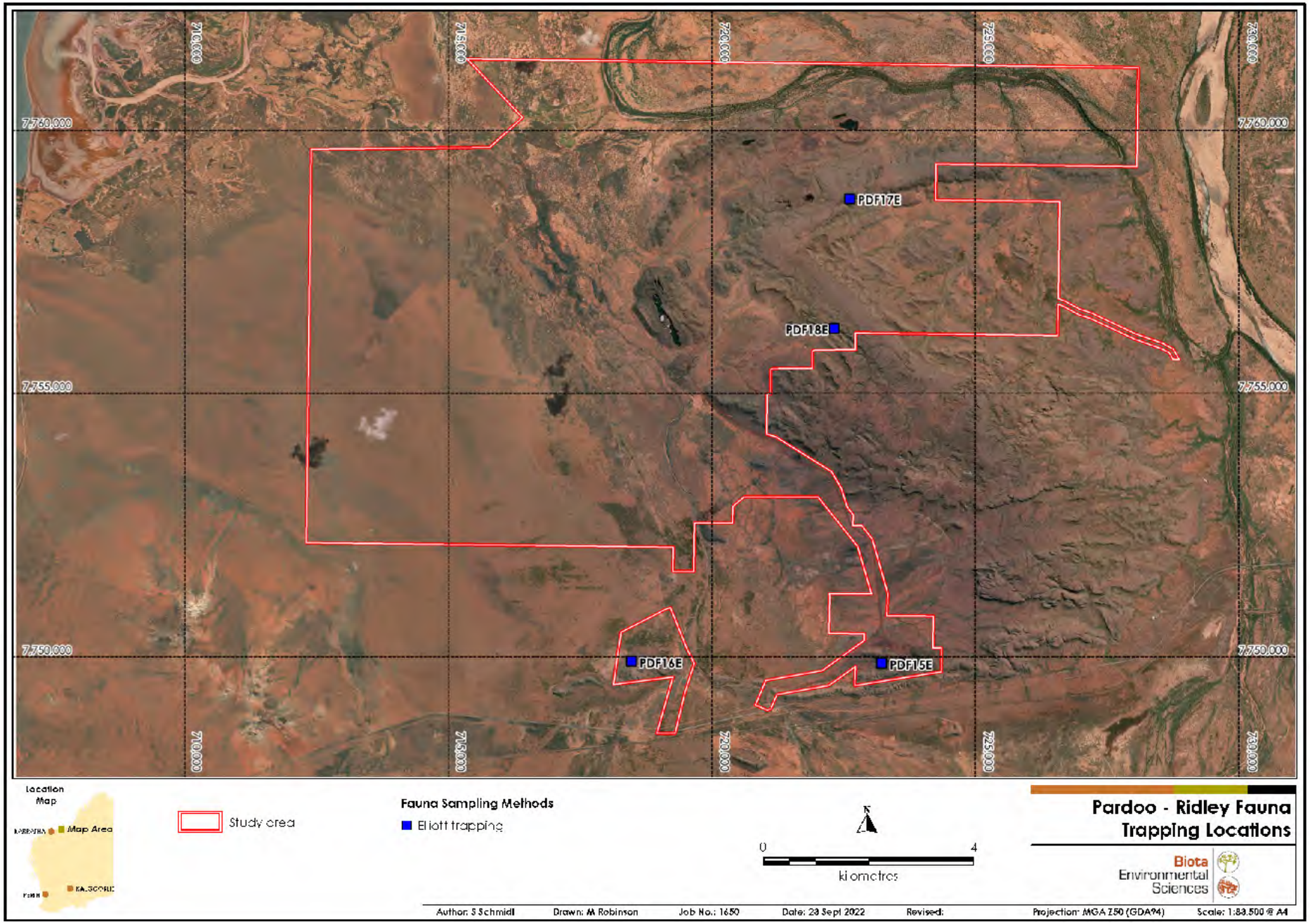

Figure 3.2: Elliott trapping locations.

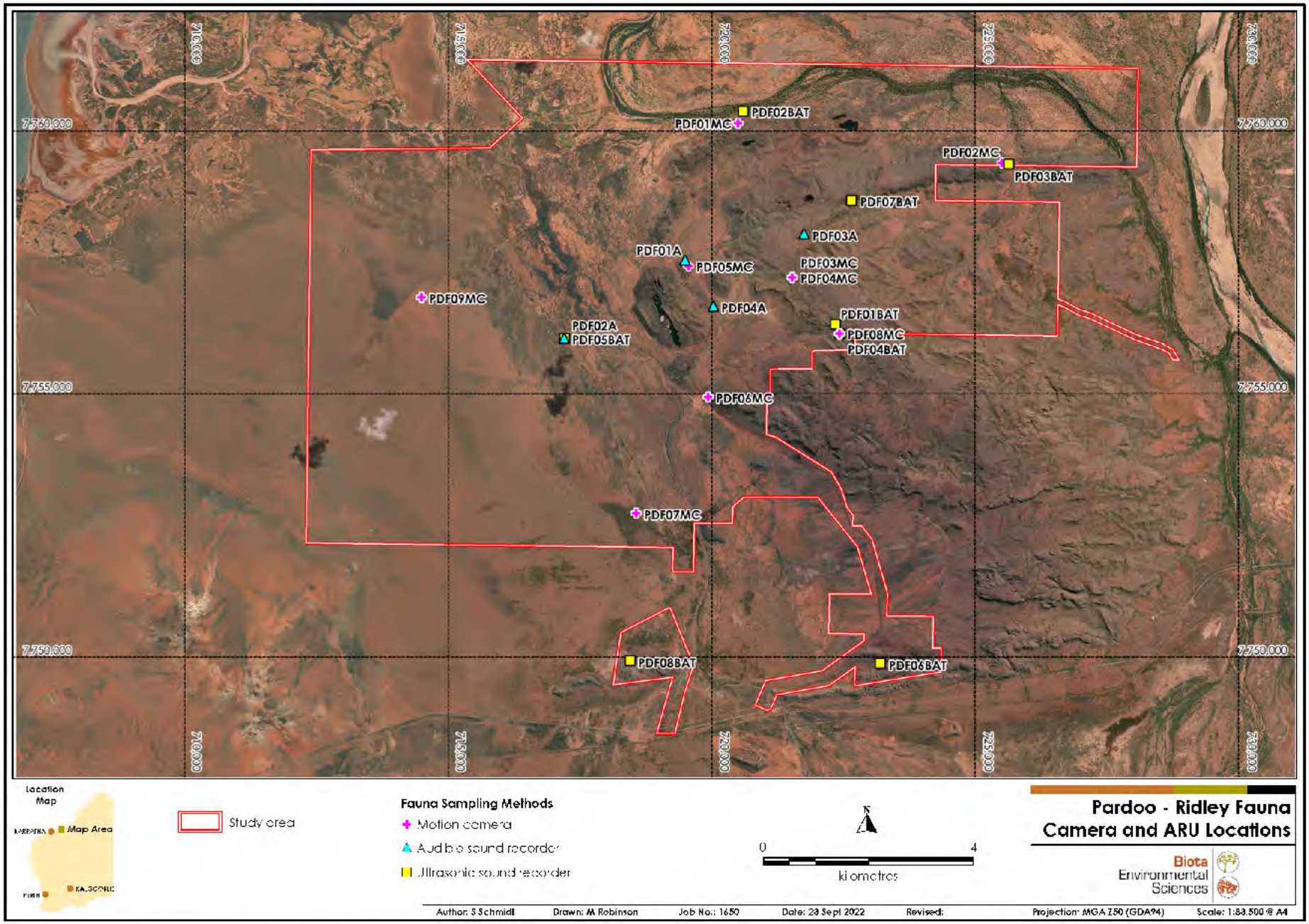

Figure 3.3: Motion camera, ultrasonic sound recorder and ARU locations.

3.6.1.5 Targeted Search Locations

Targeted searches for significant species (or evidence of them) were undertaken on foot at 16 locations in the study area during the targeted survey and the interrupted first phase of detailed survey (Table 3.10; Figure 3.4).

Table 3.10: Targeted search locations.

Site	Location		Date	Target species	Search effort	
	Latitude	Longitude			Search time (person mins)	Distance (km)
PDF01TS	-20.25697	119.13121	02/06/2022	Northern Quoll, Ghost Bat, Pilbara Olive Python	182	4.1
PDF02TS	-20.339869	119.13339	02/06/2022	Northern Quoll	29	0.8
PDF03TS	-20.333434	119.13694	02/06/2022	Northern Quoll	58	2.9
PDF04TS PDF02Bird	-20.23712	119.12604	03/06/2022	Grey Falcon, Peregrine Falcon, shorebirds	102	1.9
PDF05TS PDF03Bird	-20.243502	119.11162	03/06/2022	Northern Quoll, Grey Falcon, Peregrine Falcon, shorebirds	104	4.1
PDF06TS	-20.276554	119.13434	03/06/2022	Northern Quoll, Ghost Bat, Pilbara Olive Python	210	5.0
PDF07TS	-20.334533	119.09862	03/06/2022	Bilby, Brush-tailed Mulgara	75	1.2
PDF08TS	-20.306527	119.09223	03/06/2022	Bilby, Brush-tailed Mulgara	35	1.5
PDF09TS	-20.307389	119.09207	03/06/2022	Bilby, Brush-tailed Mulgara	32	0.8
PDF01BT	-20.334233	119.09875	03/06/2022	Bilby, Brush-tailed Mulgara	103	3.9
PDF02BT PDF02BT_Bird	-20.309077	119.08868	10/07/2022	Bilby, Brush-tailed Mulgara, Grey Falcon	67	2.7
PDF03BT	-20.26767	119.15782	11/07/2022	Bilby, Brush-tailed Mulgara	30	1.5
PDF04BT	-20.264936	119.15296	11/07/2022	Bilby, Brush-tailed Mulgara	38	1.1
PDF01Bird	-20.23709	119.12604	02/06/2022	Grey Falcon, Peregrine Falcon, shorebirds	104	1.5
PDF04Bird	-20.27391	119.10689	03/06/2022	Grey Falcon, Peregrine Falcon	38	0.6
PDF05Bird	-20.24313	119.09702	10/07/2022	Grey Falcon, Peregrine Falcon, shorebirds	50	2.6
				Total	**1,257**	**34**

3.7 SRE Invertebrate Fauna Targeted Survey

SRE survey methodology and approach were undertaken with consideration of the following compliance and regulatory documents:

- Technical Guidance – Sampling of Short-range Endemic Invertebrate Fauna (EPA 2016a).

3.7.1 SRE Search Sites

Searches for potential SRE invertebrates were undertaken at 16 sites during the targeted survey and at 2 sites the interrupted first phase of the detailed survey, which are included here given the targeted nature of the sampling (Table 3.11; Figure 3.5). Searches targeted habitats and microhabitats considered likely to support potential SRE invertebrate species. Search methods included visual searches for mygalomorph spider burrows, which were then excavated to obtain the specimen, and turning rocks and searching through leaf litter for snails, millipedes, pseudoscorpions and isopods.

Table 3.11: SRE search sites.

Site	Location		Date	Search effort		
	Latitude	Longitude		Search time (mins)	No. personnel	Search effort (person mins)
PDF01SRE_SS	-20.25675	119.13302	02/06/2022	15	2	30
PDF01SRE_PK	-20.27972	119.13093	03/06/2022	25	1	25
PDF01SRE_DK	-20.26828	119.12511	07/07/2022	63	1	63
PDF02SRE_DK	-20.26659	119.10106	07/07/2022	32	1	32
PDF03SRE_DK	-20.23529	119.14294	08/07/2022	111	2	222
PDF04SRE_DK	-20.27470	119.05428	08/07/2022	53	2	106
PDF05SRE_DK	-20.24974	119.15892	09/07/2022	37	2	74
PDF06SRE_DK	-20.24907	119.15850	09/07/2022	11	2	22
PDF07SRE_DK	-20.25138	119.14568	09/07/2022	18	2	36
PDF08SRE_DK	-20.26202	119.12269	09/07/2022	22	2	44
PDF09SRE_DK	-20.30913	119.08879	10/07/2022	55	1	55
PDF10SRE_DK	-20.27180	119.05858	10/07/2022	17	2	34
PDF11SRE_DK	-20.25594	119.08069	10/07/2022	16	2	32
PDF12SRE_DK	-20.24455	119.09633	10/07/2022	31	1	31
PDF13SRE_DK	-20.33599	119.08943	11/07/2022	24	1	24
PDF14SRE_DK	-20.26382	119.15256	11/07/2022	44	1	44
PDF15SRE_JG	-20.27652	119.10763	11/07/2022	31	2	62
PDF16SRE_JG	-20.29037	119.10466	11/07/2022	21	2	42
					Total	**978**

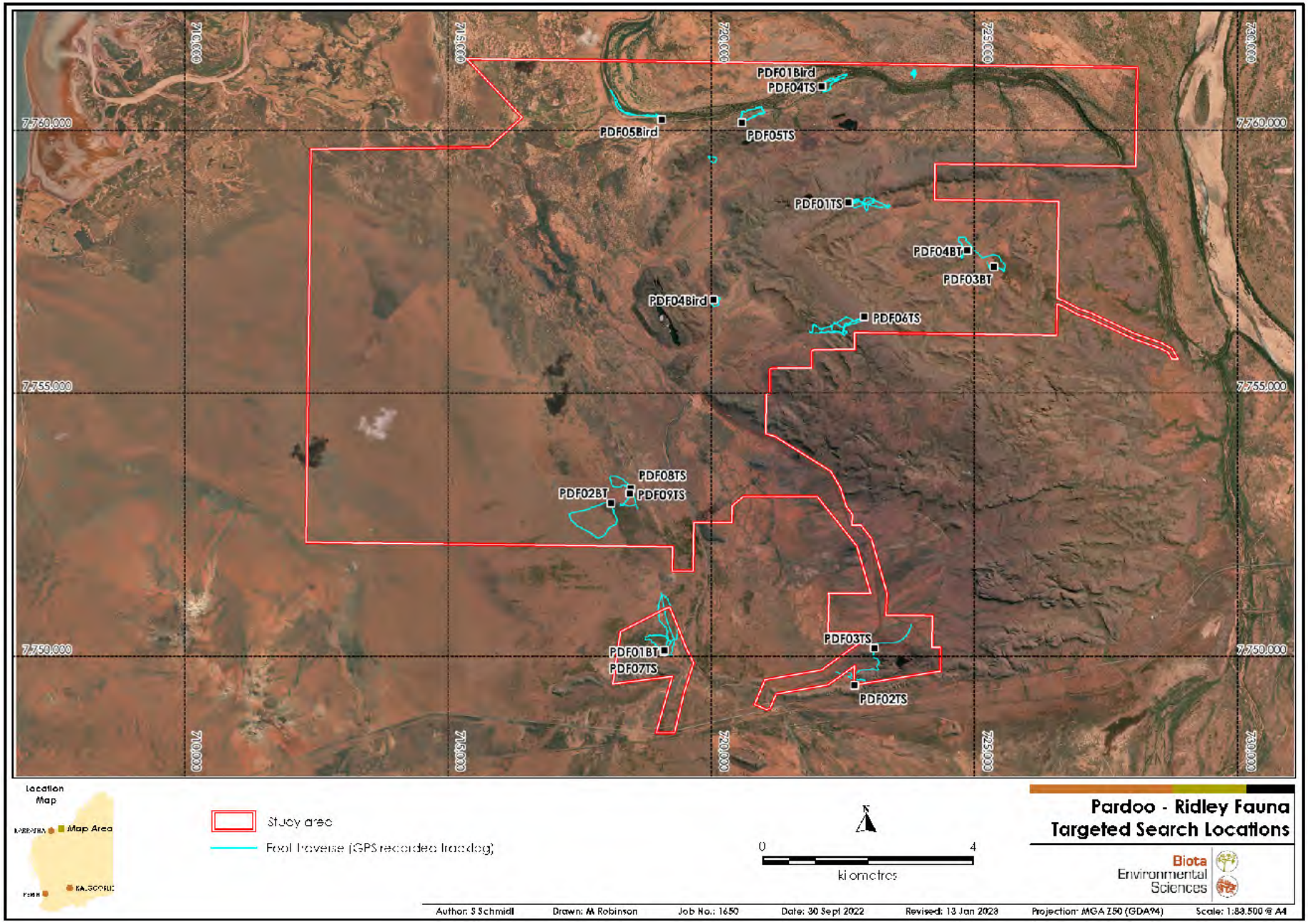

Figure 3.4: Targeted search locations.

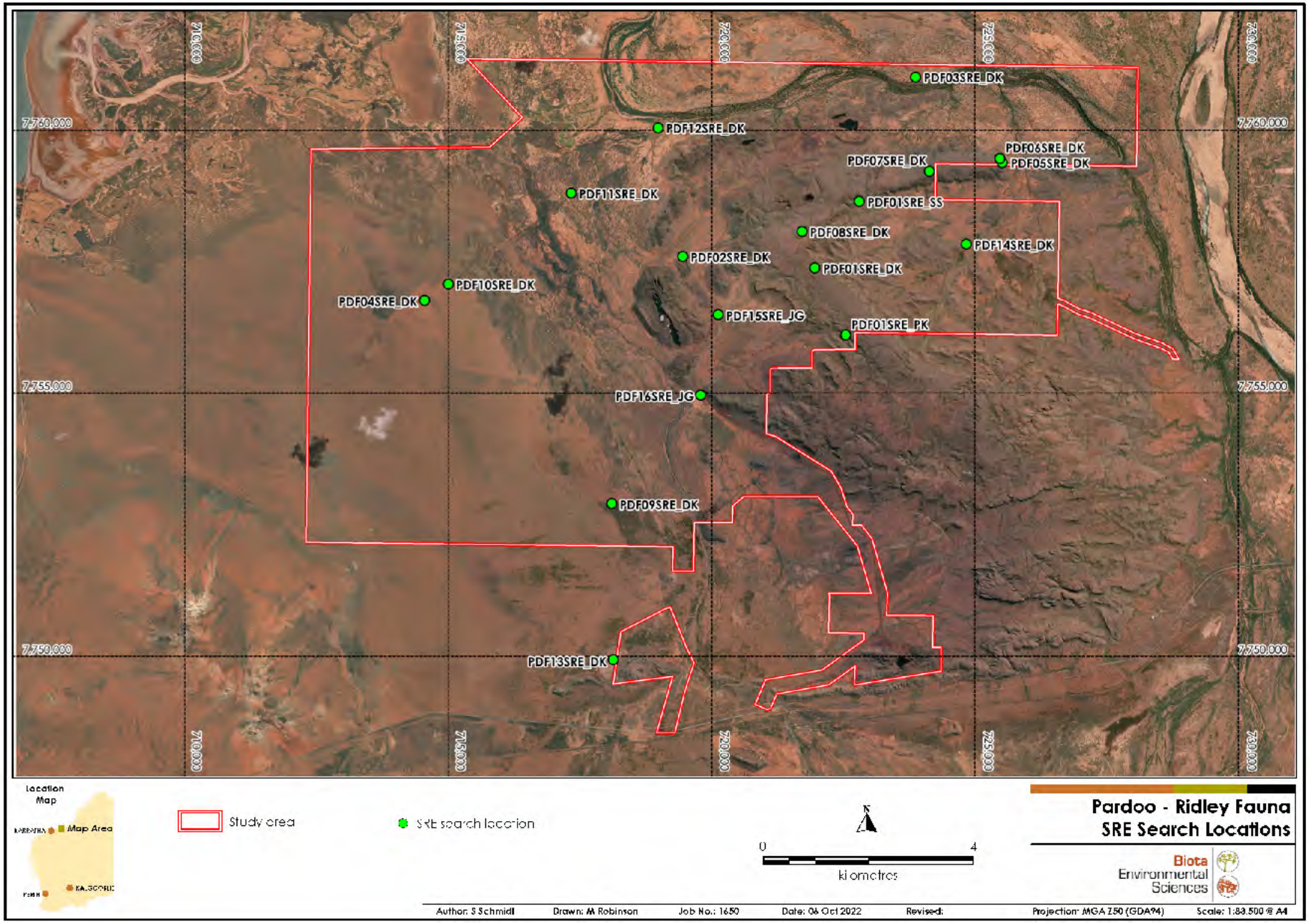

Figure 3.5: SRE search sites.

3.8 Survey Limitations

In accordance with EPA technical guidance for terrestrial fauna surveys (EPA 2020), potential survey limitations are addressed in Table 3.12.

Table 3.12: Potential constraints and limitations of the fauna survey.

Potential Constraint	Statement of Limitations
1. Availability of contextual information at a regional and local scale	There has been extensive survey effort in the Pilbara bioregion generally. Although only three recent fauna survey reports were found during the desktop study, a high volume of relatively recent (<20 years old) records were returned from database searches, including records from the study area. Overall, contextual information at local or regional scale is not considered to be a limitation for this survey.
2. Competency/ experience of the team carrying out the survey, including experience in the bioregion surveyed	Field personnel undertaking the survey were suitably qualified and experienced in detection/sampling, and identification of terrestrial vertebrate and SRE invertebrate fauna and habitat mapping/assessment (see Section 3.5.1), including extensive experience in the Pilbara bioregion. Competency and experience are not considered limitations for this survey.
3. Proportion of fauna recorded and/or collected, any identification issues	As this was a targeted survey, only specific significant vertebrate fauna species were targeted, so a relatively small proportion of the overall fauna assemblage was recorded, but this is not a limitation given the scope of the survey. All targeted vertebrate fauna were readily identifiable. Similarly, only specific habitats most likely to yield potential SRE invertebrate taxa were targeted as SRE sites, but this is not a limitation given the scope of the survey. SRE invertebrates are generally not identifiable to species level in the field, and this can be challenging even with detailed expert examination of specimens. Hence, detailed molecular analyses were conducted to provide species level identification, so identification of invertebrate fauna is not considered a limitation for this survey. While limited contextual data are available, which means additional sampling within the study area and in the wider locality is needed to determine whether taxa currently only known from the study area represent SRE species or have distributions >10,000 km^2, this is not considered a limitation for this survey given the scope of this survey.
4. Appropriate area fully surveyed (effort and extent)	The objective of this survey was to provide information on likely occurrence of significant vertebrate fauna and potential SRE invertebrate fauna within the study area in a more timely manner than was possible from the detailed survey. Hence, survey effort and extent was not considered to be a limitation given the objectives of this survey. However, given the size of the study area and the scope of the overall project, a seasonal two-phase detailed vertebrate and SRE invertebrate fauna survey is considered an appropriate level of survey and will be reported on separately.
5. Access restrictions	Access to small parts of the study area was affected by the potential presence of asbestos and active exploration operations. However, all major landforms and habitats within the study area were accessible, so access restrictions are not considered to be a limitation for this survey.
6. Survey timing, rainfall, season of survey	The targeted survey was undertaken in July, which is suitable timing for a number of significant fauna targeted, such as Northern Quoll. However, this timing is unsuitable for targeting many of the Migratory-listed bird species potentially occurring. Hence, survey timing is considered a limitation of the study to this point; this will be addressed when the two phases of detailed survey are completed at more suitable times for detecting most of the Migratory-listed bird species potentially occurring. Rainfall in the year preceding the survey was above average and is not considered to be a limitation for this survey from the perspective of prevailing environmental conditions.

Potential Constraint	Statement of Limitations
7. Disturbance that may have affected the results of survey such as fire, flood or clearing	Some parts of the study area have been cleared and excavated previously, and there is significant cattle damage to habitats, particularly along drainage lines. No short-term disturbances such as fires or floods affected the targeted survey.

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4.0 Existing Environment

4.1 IBRA Bioregion and Subregion

The study area lies within the Pilbara bioregion, one of 89 bioregions defined by the Interim Biogeographic Regionalisation for Australia (IBRA; DSEWPaC 2012). The Pilbara bioregion is divided into four subregions. The study area lies within the Roebourne subregion (PIL4), which is characterised by Kendrick and Stanley (2003) as follows:

- "Quaternary alluvial and older colluvial coastal and sub-coastal plains with a grass savannah of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia* species. Uplands are dominated by *Triodia* hummock grasslands. Ephemeral drainage lines support Eucalypt woodlands. Samphire, Sporobolus and mangal occur on marine alluvial flats and river deltas. Resistant linear ranges of basalts occur across the coastal plains, with minor exposures of granite. Islands are either Quaternary sand accumulations, or composed of basalt or limestone, or combinations of any of these three. Climate is arid (semi-desert) tropical with highly variable rainfall, falling mainly in summer. Cyclonic activity is significant, with several systems affecting the coast and hinterland annually. Subregional area is 2,008,983 ha."

4.2 Land Systems

Land systems mapping covering the study area has been prepared by van Vreeswyk et al. (2004). A total of 105 land systems have been mapped in the Pilbara bioregion, and the study area intersects seven of these land systems (Table 4.1; Figure 4.1). All seven land systems are widespread within the Pilbara bioregion, with only a negligible proportion of their total bioregional extent occurring in the study area (Table 4.1).

The dominant land systems of the study area are characterised by extensive spinifex plains on sandy and alluvial soils, rugged rocky hills (primarily associated with the Ord Range in the central to eastern parts of the study area), and the riverine systems along the Ridley River in the north of the study area.

Table 4.1: Land systems of the study area (van Vreeswyk et al. 2004).

Land System	Description	Extent in Study Area (ha)	Total Extent in Pilbara Bioregion (ha)	% of Bioregional Extent in Study Area
Uaroo (RGEUAR)	Broad sandy plains supporting shrubby hard and soft spinifex grasslands.	3,638	987,042	0.37
Capricorn (RGECPN)	Rugged sandstone hills and ridges; hard spinifex or stony short grass forb pasture in fair to good condition; no erosion.	2,811	698,526	0.40
Paradise (RGEPDS)	Alluvial plains supporting soft spinifex grasslands and tussock grasslands	2,157	148,124	1.46
Yamerina (RGEYAM)	Flood plains and deltaic deposits supporting tussock grasslands and grassy woodlands and minor halophytic shrublands.	1,111	119,391	0.93
Boolgeeda (RGEBGD)	Stony plains adjacent to hills.	890	961,637	0.09
River (RGERIV)	Active flood plains and major rivers supporting grassy eucalypt woodlands.	446	497,421	0.09
Mallina (RGEMAL)	Sandy surfaced alluvial plains supporting soft spinifex (and occasionally hard spinifex) grasslands.	11	335,753	<0.01

4.3 Vegetation

Beard (1975a, 1975b) described and mapped the vegetation of the Pilbara at a scale of 1:1,000,000. The study area is located on the Abydos Plain, which lies within the Fortescue Botanical District of the Eremaean Botanical Province, as defined by Beard (1975a, 1975b). The vegetation of this province is typically open, and frequently dominated by spinifex, acacias (wattles), and occasional eucalypts.

The study area intersects five vegetation units mapped by Beard (1975a, 1975b) (Table 4.2; Figure 4.2), all of which occur widely in the Pilbara region, with at most 1.58% of the total mapped extent of any unit occurring in the study area (Table 4.2). Vegetation associations 647 and 589 are widespread in the Roebourne subregion and association 93 is very common in the adjacent Chichester subregion (Kendrick and Stanley 2003), with none subject to major clearing.

Beard's (1975a, 1975b) vegetation mapping is broadscale and provides only limited information about the vegetation occurring in the study area. The broad vegetation in the study area is dominated by hummock grasslands on both plains and rocky hills, with riverine vegetation occurring in the north in association with the Ridley River.

A flora and vegetation survey was commissioned by Atlas as part of the Pardoo Direct Shipping Project (Woodman Environmental 2007), which overlaps the current study area. A total of 13 discrete vegetation units were documented (Woodman Environmental 2007).

Table 4.2: Beard vegetation units of the study area (Beard 1975a, 1975b, DPIRD 2018).

Vegetation Unit	Description	Extent in Study Area (ha)	Total Extent in Pilbara Bioregion (ha)	% of Bioregional Extent in Study Area
Abydos Plain 93	Hummock grasslands, shrub steppe; kanji over soft spinifex	4,557	432,909	1.05
Abydos Plain 589	Mosaic: Short bunch grassland - grass plain/hummock grasslands, grass steppe; soft spinifex	3,149	600,835	0.52
Abydos Plain 647	Hummock grasslands, dwarf-shrub steppe; *Acacia translucens* over soft spinifex	2,995	189,199	1.58
Abydos Plain 619	Medium riverine woodland of river red gum (*Eucalyptus camaldulensis*)	274	43,096	0.64
Abydos Plain – Chichester 93	Hummock grasslands, shrub steppe; kanji over soft spinifex	91	2,482,058	<0.01

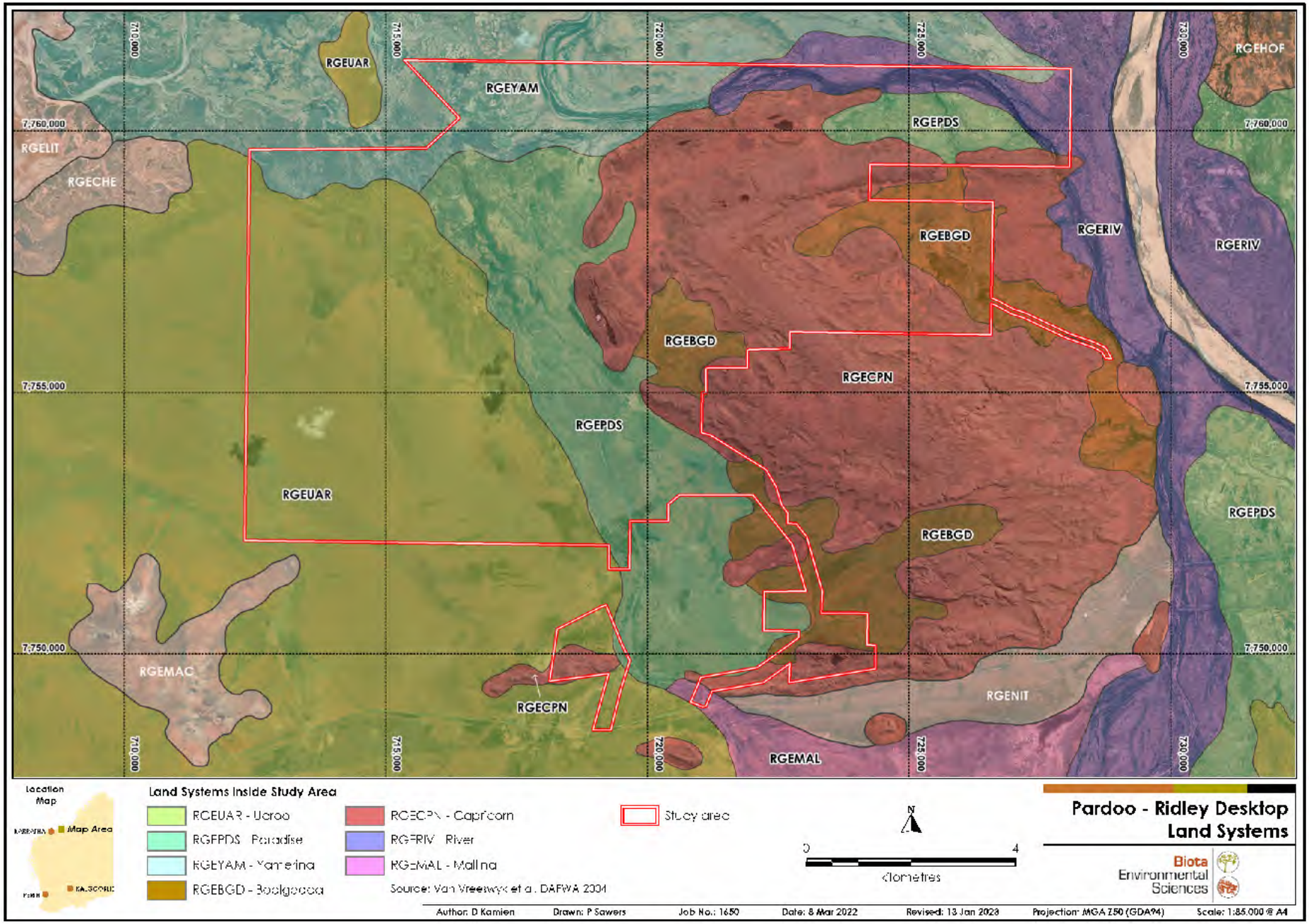

Figure 4.1: Land systems of the study area.

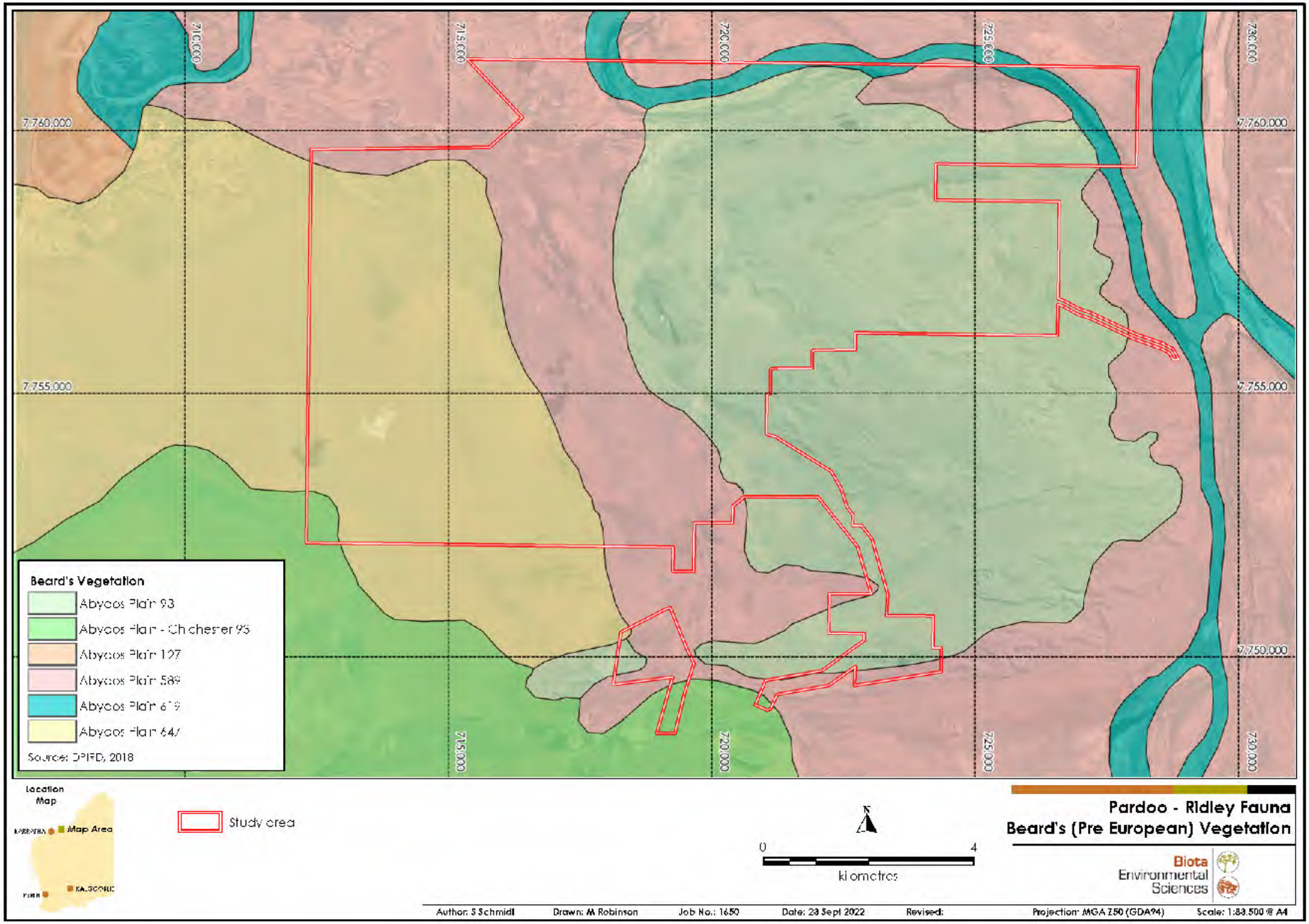

Figure 4.2: Beard vegetation units of the study area.

4.4 Geology and Soils

The study area intersects seven broad surface geology units (Geoscience Australia 2008), with three units collectively representing approximately 99% of the study area (Qa, 34%; Qrc, 33%; and Acg, 32%) (Table 4.3; Figure 4.3).

Four broad soil units occur within the study area (Agriculture Western Australia 1967), with three of the four units comprising 99% of the study area (OC61, 37%; Oc40, 36%; and AB19, 26%; Table 4.4; Figure 4.4).

Table 4.3: Geological units of the study area (Geoscience Australia 2008).

Geological Unit	Description	Extent in Study Area (ha)	Total Extent in Pilbara Bioregion (ha)	% of Bioregional Extent in Study Area
Qa - alluvium	Alluvial sediment - Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted	3,719.9	2,382,643	0.16
Qrc - colluvium	Colluvial sediment - Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite	3,687.1	4,317,860	0.09
Acg – Gorge Creek Group	Chert, banded iron formation, sandstone, conglomerate, felsic volcanic	3,488.6	78,773	4.43
Agi - Sisters Supersuite	Granite, monzogranite, granodiorite, felsic gneiss, tonalite	87.3	96,618	0.09
Agic - Chillerina Granodiorite	Hornblende-biotite granodiorite, K-feldspar-phyric monzogranite	73.7	6,931	1.06
Qdc - coastal dunes	Sand - aeolian, beach sediments, coastal sediment	7.8	101,854	0.01
JKsc - Callawa Formation	Sandstone, conglomerate, siltstone	0.2	3,884	0.01

Table 4.4: Soil units of the study area (Agriculture Western Australia 1967).

Geological Unit	Description	Extent in Study Area (ha)	Total Extent in Pilbara Bioregion (ha)	% of Bioregional Extent in Study Area
Oc61	Dissected pediments and steep residual hills with iron formations: chief soils are hard alkaline red soils, probably (Dr2.33). Associated are various (Um) and (Uc) soils on the residual hills.	4,054	77,057	5.26
Oc40	Alluvial plains, which are frequently badly surface-eroded, and levees associated with prior streams: chief soils are hard alkaline red soils (Dr2.33) and (Dr2.13), together with various sandy alkaline red soils including (Dr4.43) and (Dr4.33). There are small areas of sandy (Uc) soils on levees and prior stream channels, and also small areas of red dune soils (Uc5.11); and some sandy red earths (Gn). In places erosion has removed the sandy surfaces, and the resulting clay pans have sandy clay (Uf1.43) soils.	3,956	413,884	0.96
AB19	Extensive sandy plains: chief soils are red earthy sands (Uc5.21) with extensive areas of red earths (Gn2.12) and with some hard red soils (Dr) along creek lines. Similar to unit AB21 but without sandstone residuals.	2,905	69,033	4.21

Geological Unit	Description	Extent in Study Area (ha)	Total Extent in Pilbara Bioregion (ha)	% of Bioregional Extent in Study Area
My54	Broad very gently undulating plains with scattered rock outcrops occurring as mesas: chief soils are neutral and acid red earths (Gn2.12, Gn2.11) with some hard red soils (Dr) occurring on pediments of unit Oc61.	150	544,118	0.03

4.5 Threatened and Priority Ecological Communities

No Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) relevant to fauna were identified as occurring within the study area locality by the search of the DBCA Threatened and Priority Fauna and Ecological Communities database.

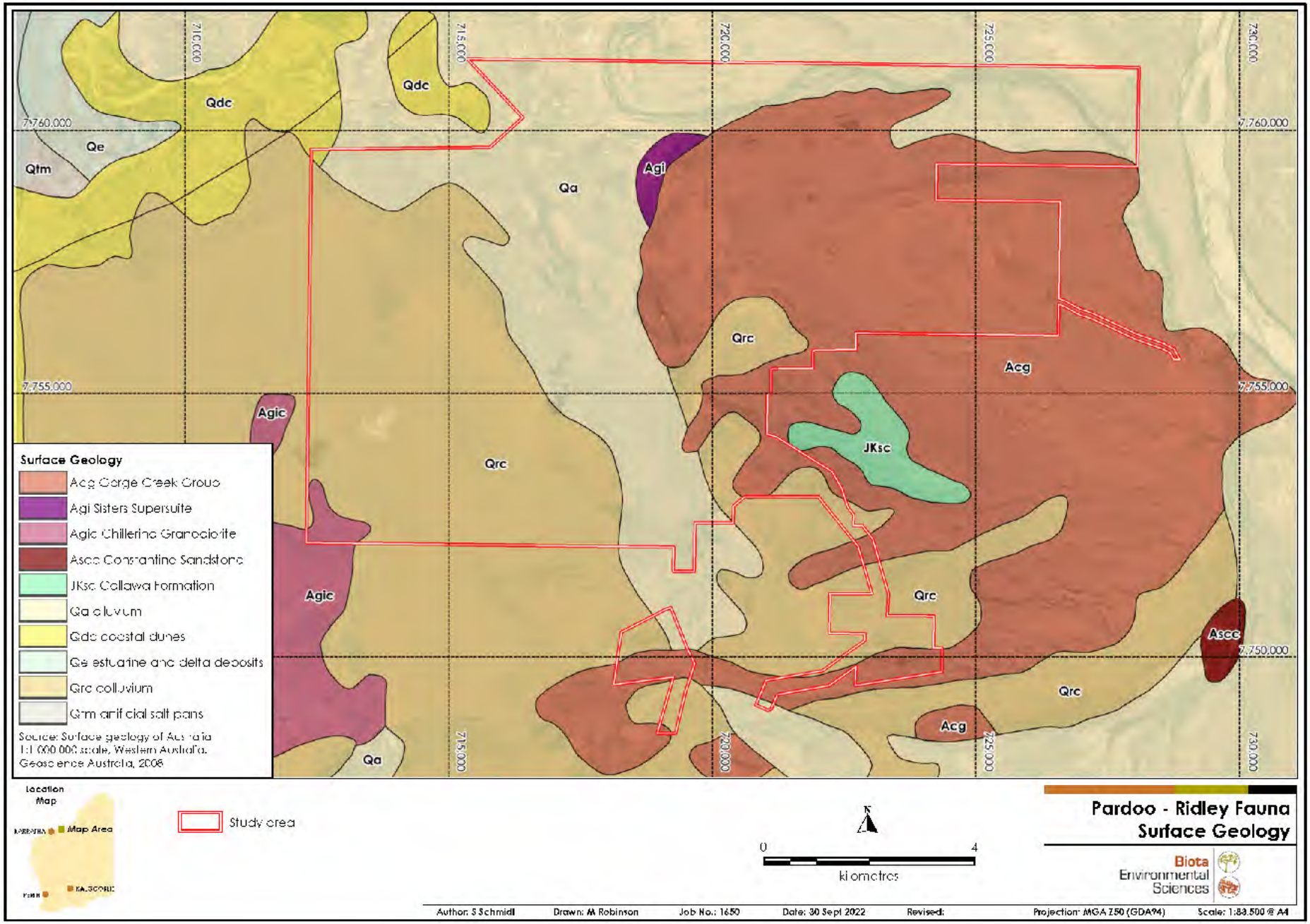

Figure 4.3: Surface geological units of the study area.

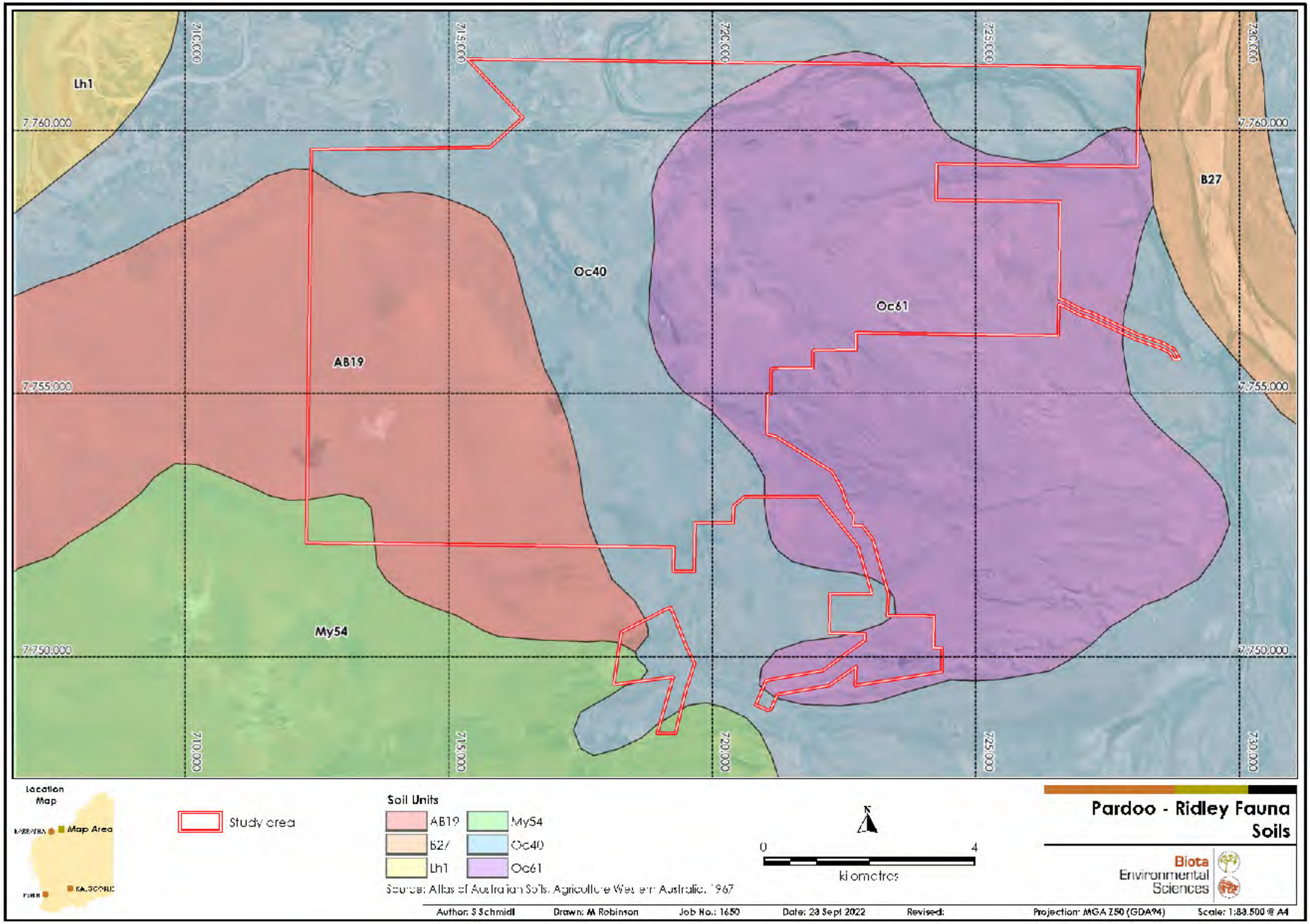

Figure 4.4: Soil units of the study area.

5.0 Vertebrate Fauna

5.1 Desktop Study

Based on the database searches and results of previous surveys, 349 terrestrial vertebrate fauna species have been identified as occurring in the locality (Table 5.1; Appendix 3).

Table 5.1: Overview of the potential vertebrate fauna assemblage of the study area.

Fauna Group	No. of species	No. of significant species
Mammals – Native Terrestrial	20	6
Mammals – Introduced Terrestrial	7	0
Mammals – Bats	13	3
Birds	215	52
Reptiles	84	2
Amphibians	10	0
Total	**349**	**63**

Of these, 63 are State and/or Commonwealth listed significant fauna species. The locations of previous records of significant fauna species from the locality are mapped below in Figure 5.1 and Figure 5.2, where spatial data was available. A total of 29 significant species have been recorded from the study area, or are considered to have a moderate to high likelihood of occurrence in the study area (see Section 3.1.3); these species are discussed further in Sections 5.3 and 5.4.

5.2 Fauna Habitats

5.2.1 Habitat Mapping

Four fauna landscapes (broad fauna habitats) have been identified on the basis of the approach outlined in Section 3.2 (Table 5.2; Figure 5.3). Further discussion of these habitats with respect to significant fauna is included in Section 5.2.2.

Table 5.2: Broad fauna habitats present in the study area.

Broad fauna habitat	Landform(s)	Land System(s)	Area (ha)	Proportion (% of study area)
Rocky Hills	• Gully • Breakaway • Ridges	Capricorn	2,788.15	25.20
Alluvial Floodplain	• Alluvial plain • Minor drainage line • Stony plain	Paradise Uaroo Boolgeeda Malina	3,887.41	35.13
Sandplain	• Sandplain • Small areas of stony plain	Uaroo Boolgeeda	3,967.29	35.86
Major Drainage Line	• Major river • Floodplain	River Yamerina Boolgeeda	421.91	3.81

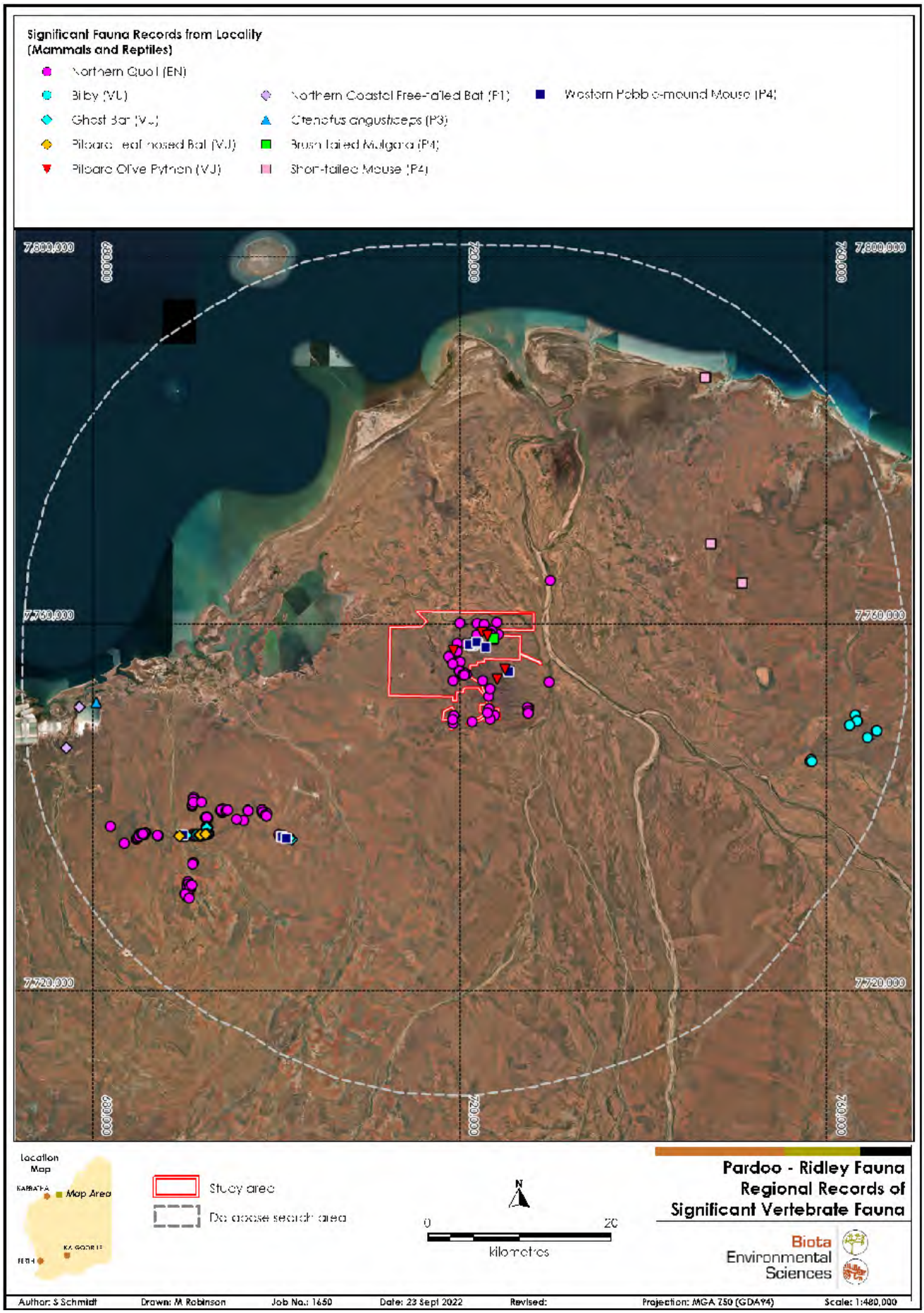

Figure 5.1: Previous records of significant mammal and reptile species from the locality.

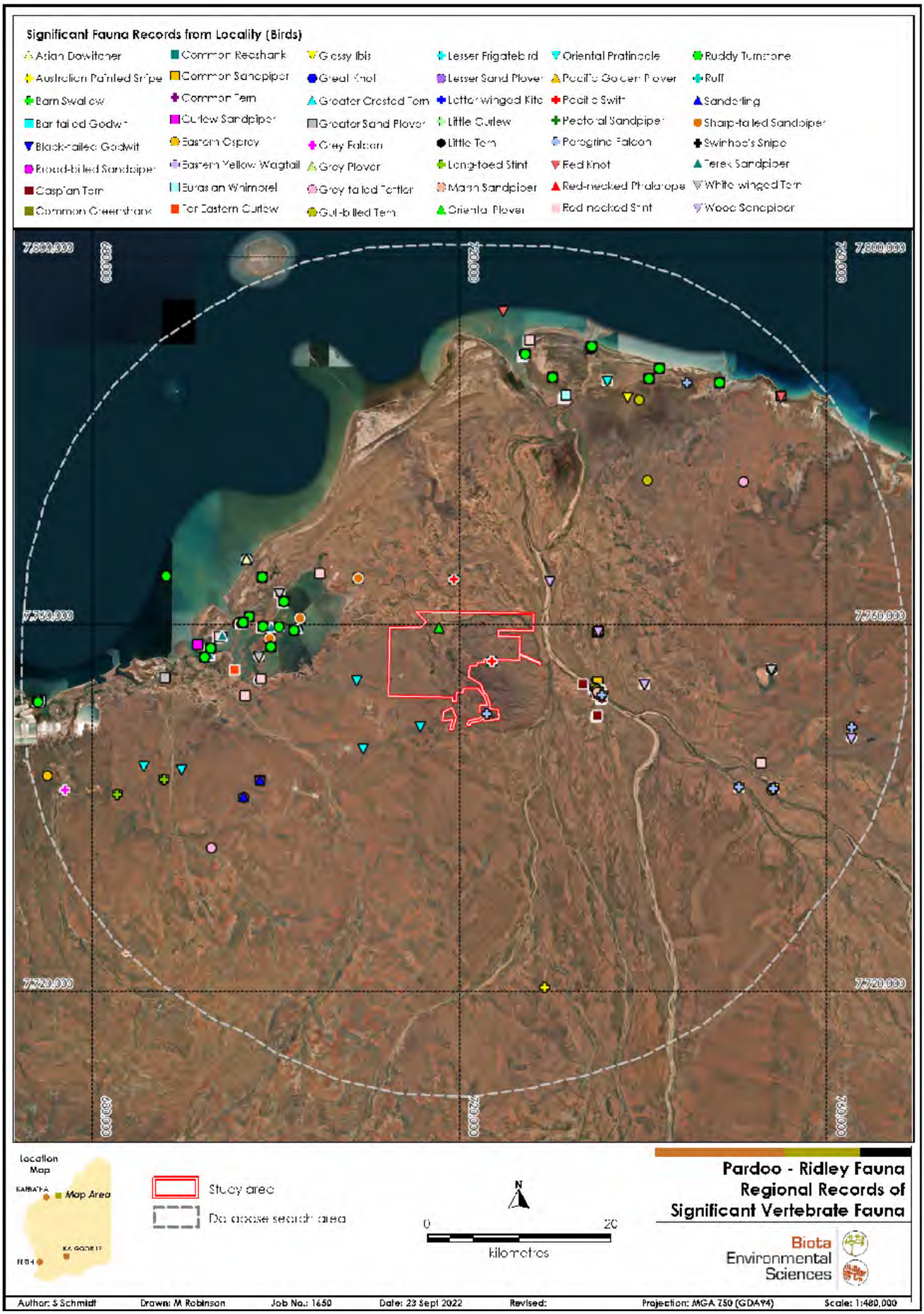

Figure 5.2: Previous records of significant bird species from the locality.

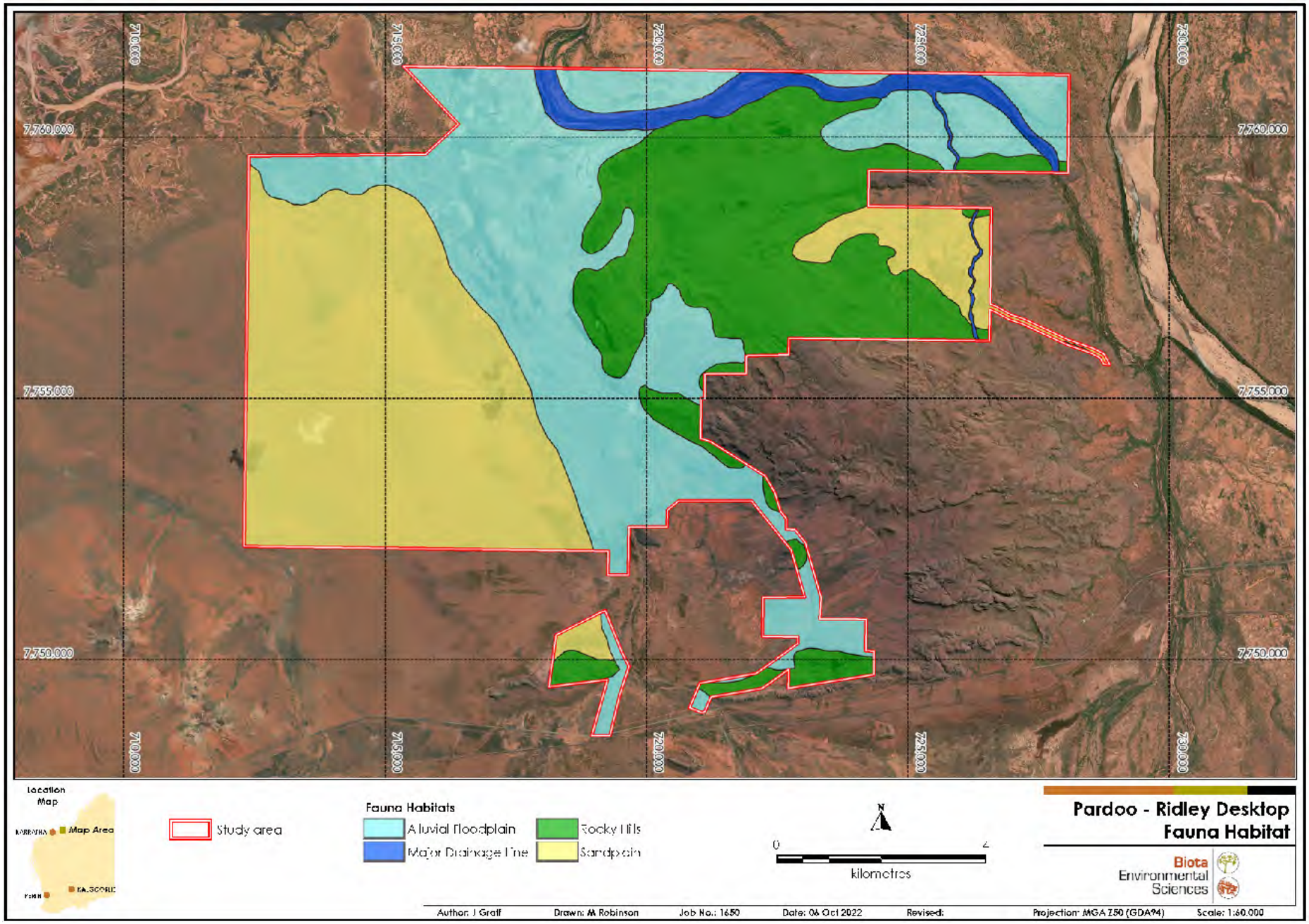

Figure 5.3: Fauna habitats of the study area.

5.2.2 Significant Species Habitat

Indicative preferred habitats for significant vertebrate fauna recorded in the study area, or considered to have a moderate to high likelihood of occurrence in the study area (see Table 5.8), are outlined below in Table 5.3. It should be noted that these habitats are broadly defined and reflect broad patterns in environmental variables and species occurrence, and thus for many species preferred habitat will be a subset of the broader habitat types indicated here.

Of the habitats identified within the study area, the Rocky Hills and Major Drainage Line habitats are important to the largest numbers of significant fauna species. However, the Sandplain and Alluvial Floodplain habitats are still likely to provide habitat for several significant species.

Table 5.3: Significant fauna indicative habitats.

Species	Common name	Indicative habitats in the study area[1]
Mammals		
Dasyurus hallucatus	Northern Quoll	Critical: Rocky Hills (recorded) Supporting: Major Drainage Lines
Macrotis lagotis	Bilby	Sandplain
Rhinonicteris aurantia (Pilbara form)	Pilbara Leaf-nosed Bat	Roosting: Rocky Hills (recorded) Foraging: Major Drainage Lines (recorded), Sandplains and Alluvial Floodplains in proximity to Rocky Hills
Macroderma gigas	Ghost Bat	Roosting: Rocky Hills (recorded) Foraging: All habitats
Dasycercus blythi	Brush-tailed Mulgara	Sandplain (recorded)
Leggadina lakedownensis	Short-tailed Mouse	Alluvial Floodplain
Pseudomys chapmani	Western Pebble-mound Mouse	Rocky Hills (recorded)
Birds		
Pezoporus occidentalis	Night Parrot	No high-quality habitat
Rostratula australis	Australian Painted Snipe	Major Drainage Lines
Falco hypoleucos	Grey Falcon	Primary: Rocky Hills, Major Drainage Lines Secondary: Sandplain, Alluvial Floodplain
Apus pacificus	Pacific Swift	Aerial over all habitats
Charadrius veredus	Oriental Plover	Major Drainage Lines, Alluvial Floodplains
Numenius minutus	Little Curlew	Major Drainage Lines, Alluvial Floodplains
Glareola maldivarum	Oriental Pratincole	Major Drainage Lines, Alluvial Floodplains, aerial over all habitats
Charadriidae/ Scolopacidae spp.	Other Migratory-listed shorebirds	Major Drainage Lines
Gelochelidon [*nilotica*] *macrotarsa*	Australian [Gull-billed] Tern	Major Drainage Lines, Alluvial Floodplains, Sandplains
Chlidonias leucopterus	White-winged Tern	Primary: Major Drainage Lines Secondary: Alluvial Floodplains, Sandplains
Plegadis falcinellus	Glossy Ibis	Major Drainage Lines
Hirundo rustica	Barn Swallow	Major Drainage Lines and Alluvial Floodplains most likely but possible in any of the habitats
Motacilla tschutschensis	Eastern Yellow Wagtail	Major Drainage Lines
Falco peregrinus	Peregrine Falcon	Primary: Rocky Hills, Major Drainage Lines Secondary: Sandplain, Alluvial Floodplain
Reptiles		
Liasis olivaceus barroni	Pilbara Olive Python	Primary: Rocky Hills Secondary: Major Drainage Lines

[1] Habitats are defined relatively broadly so for many species actual suitable habitat is likely to be a subset of the broad habitat types indicated here.

5.3 Significant Fauna Species Recorded

Three vertebrate species of significance were recorded during the current survey:

- Northern Quoll *Dasyurus hallucatus* (EPBC Act and BC Act Endangered);
- Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* Pilbara form (EPBC Act and BC Act Vulnerable); and
- Ghost Bat Macroderma gigas (EPBC Act and BC Act Vulnerable).

In addition, four further significant species have been recorded within the study area previously, based on the results of the desktop study and the interrupted detailed survey in June 2022:

- Pilbara Olive Python *Liasis olivaceus barroni* (EPBC Act and BC Act Vulnerable);
- Oriental Plover *Charadrius veredus* (EPBC Act and BC Act Migratory)[1];
- Peregrine Falcon *Falco peregrinus* (BC Act Other Specially Protected Fauna); and
- Brush-tailed Mulgara *Dasycercus blythi* (DBCA Priority 4); and
- Western Pebble-mound Mouse *Pseudomys chapmani* (DBCA Priority 4).

These species are discussed further below in Sections 5.3.1 to 5.3.8, and their recorded locations from the current survey and from previous surveys are mapped in Figure 5.4.

[1] DBCA Threatened Fauna Database record so not mapped in Figure 5.4 due to restrictions on presentation of data from this database at high resolutions.

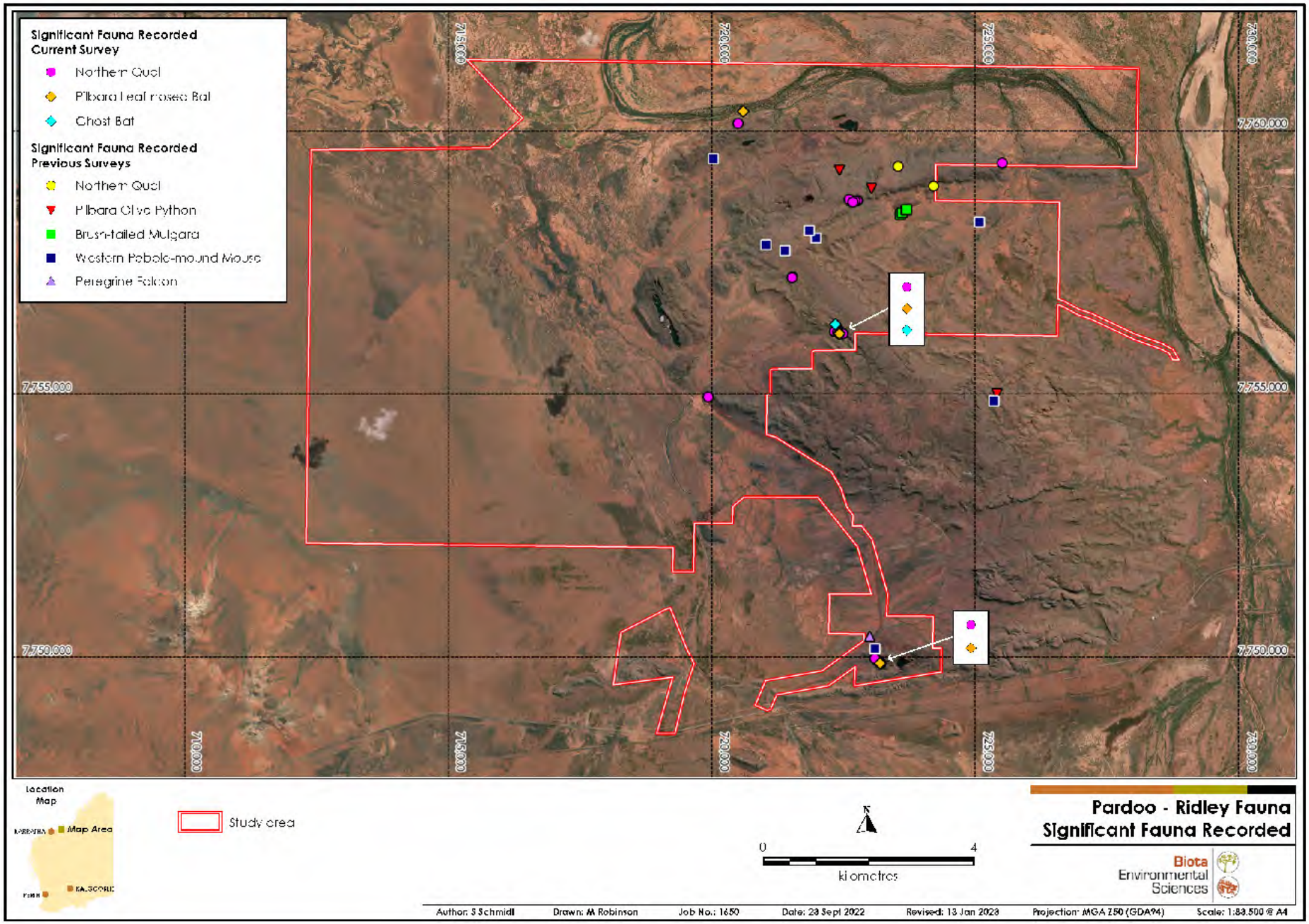

Figure 5.4: Significant fauna records from the study area.

5.3.1 Northern Quoll *Dasyurus hallucatus*

The Northern Quoll is listed as Endangered under both the EPBC Act and the BC Act. The species formerly occurred across much of northern Australia but is now restricted to six main areas. Two of these areas are in Western Australia: the northwest Kimberley and the Pilbara regions (Braithwaite and Griffiths 1994). Northern Quolls are most abundant in open, rocky habitats and also commonly utilise gorges, breakaways, and hills, particularly for denning (van Dyck and Strahan 2008). They also occur along drainage lines, where adjacent plains and vegetated areas provide habitats for foraging and dispersal of young (van Dyck and Strahan 2008). Populations fluctuate on both annual and inter-annual cycles, driven by both the reproductive biology of the species and longer-term cycles in response to regional stochastic processes such as rainfall, fire and related changes of prey populations (How et al. 2009).

Northern Quolls were recorded during the current survey from three of the four targeted Elliott trapping sites, and from a further six locations on motion cameras (Table 5.4; Figure 5.4; Plate 5.1). The trapping records involved a total of 10 individuals across the three sites, including five individuals at PDF15E, one individual at PDF17E and four individuals at PDF18E. Secondary evidence of the species was also recorded from the study area in 2007 and 2008 (Bamford et al. 2010; Figure 5.4), and there are numerous records from the locality in the DBCA Threatened Fauna database (DBCA 2022; Figure 5.1). All records from the current and previous surveys within the study area came from the Rocky Hills habitat type.

Table 5.4: Northern Quoll records from the study area during the current survey.

Site	Dates	Location		Notes
		Latitude	Longitude	
PDF15E	06/07/2022	-20.33552	119.13773	E08. Immature female
	06/07/2022	-20.33535	119.13732	E14. Immature female
	07/07/2022	-20.33535	119.13732	E14. Immature female, recapture.
	08/07/2022	-20.33588	119.13797	E02. Immature female, recapture.
	08/07/2022	-20.33575	119.13778	E05. Adult male.
	08/07/2022	-20.33565	119.13777	E06. Immature female.
	08/07/2022	-20.33505	119.13692	E20. Adult male.
	09/07/2022	-20.33587	119.13805	E01. Adult male, recapture.
	09/07/2022	-20.33584	119.13788	E04. Adult male, recapture.
	09/07/2022	-20.33531	119.13723	E15. Immature female, recapture.
	09/07/2022	-20.33508	119.13696	E19. Adult female.
PDF17E	07/07/2022	-20.25674	119.13185	E09. Immature female.
	08/07/2022	-20.25650	119.13265	E17. Immature female, recapture.
	09/07/2022	-20.25657	119.13228	E13. Immature female, recapture.
	10/07/2022	-20.25630	119.13119	E01. Immature female, recapture.
	12/07/2022	-20.25674	119.13185	E09. Immature female, recapture.
PDF18E	07/07/2022	-20.27920	119.13016	E17. Adult female.
	10/07/2022	-20.27894	119.12965	E10. Adult male.
	11/07/2022	-20.27908	119.12882	E06. Adult female.
	12/07/2022	-20.27897	119.12970	E11. Adult male.
	12/07/2022	-20.27912	119.12996	E15. Adult male, recapture.
	12/07/2022	-20.27942	119.13032	E20. Adult female, recapture.
	13/07/2022	-20.27914	119.12941	E09. Adult female, recapture
PDF01MC	06/07/2022	-20.24347	119.11080	At least three individuals.
	07/07/2022			
	08/07/2022			
PDF02MC	07/07/2022	-20.24972	119.15892	At least one individual.
	09/07/2022			
	11/07/2022			
PDF03MC	08/07/2022	-20.26974	119.12106	At least one individual.
	09/07/2022			

Site	Dates	Location		Notes
		Latitude	Longitude	
PDF04MC	07/07/2022	-20.26984	119.12097	Two individuals.
	08/07/2022			
	09/07/2022			
PDF06MC	08/07/2022	-20.2905	119.10602	One individual.
	10/07/2022			
PDF08MC	10/07/2022	-20.27941	119.12967	One individual.

Plate 5.1 **Northern Quoll motion camera images from the study area at PDF04MC (top) and PDF06MC (bottom).**

5.3.2 Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* Pilbara form

The Pilbara Leaf-nosed Bat is listed as Vulnerable under both the EPBC Act and BC Act. It is a sub-population of the Orange Leaf-nosed Bat that is endemic to the Pilbara and Ashburton regions of

Western Australia. The Pilbara population is isolated from the main tropical Orange Leaf-nosed Bat populations in the Kimberley, Northern Territory and Queensland by 400 km of unsuitable habitat in the Great Sandy Desert (Armstrong 2001). The Pilbara Leaf-nosed Bat is semi-desert adapted and has specific roosting requirements, requiring roost sites in caves or mine adits with stable, very hot (28 – 32°C) and very humid (96 – 100%) microclimates (Churchill 2008). Caves deep enough to create this environment are relatively uncommon in the Pilbara (van Dyck and Strahan 2008), which limits the availability of diurnal roosts for this species. Observed foraging habitat includes *Triodia* hummock grassland, sparse tree and shrub savannah, and riparian vegetation along drainage lines (Duncan et al. 1999).

Pilbara Leaf-nosed Bat calls were recorded on ultrasonic sound recorders from four locations within the study area during the current targeted survey (Table 5.5; Figure 5.4). Records were primarily from Rocky Hills habitat (three of four locations), with two of these locations near water pools. The fourth record was from Major Drainage Line habitat in the north of the study area. The relatively small number of calls and their timing (first calls over one hour after sunset, last over two hours before sunrise) suggests these records are likely to represent foraging individuals rather than close proximity to a roost site. No previous records for the study area were identified during the desktop study, with the nearest records identified being 25 km to the southwest of the study area (Figure 5.1).

Table 5.5: Pilbara Leaf-nosed Bat records from the study area during the current survey.

Site	Dates	Location		Notes
		Latitude	Longitude	
PDF01BAT	06/07/2022	-20.27785	119.12895	5 detections
	07/07/2022			8 detections
PDF02BAT	07/07/2022	-20.24147	119.11173	2 detections
PDF04BAT	09/07/2022	-20.27943	119.12971	8 detections
PDF06BAT	09/07/2022	-20.33590	119.13793	4 detections

5.3.3 Ghost Bat *Macroderma gigas*

The Ghost Bat is listed as Vulnerable under both the BC Act and EPBC Act. Ghost Bats previously occurred across most of inland and northern Australia, but are now restricted to the tropical and subtropical north of the continent (Churchill 2008). The distribution of the species is fragmented, with each population showing some genetic differentiation (Armstrong and Wilmer 2004). Ghost Bats occur in a broad range of habitats, with distribution influenced by the availability of suitable caves for roost sites, and are known to forage over areas up to 60 ha (Churchill 2008). Scat material from the Ghost Bat is quite distinctive and can be used to identify temporary roosts or feeding sites. Feeding sites are also usually readily identifiable based on the accumulation of discarded remains of prey animals (van Dyck and Strahan 2008).

Ghost Bat calls were recorded on an ultrasonic sound recorder at one location in Rocky Hills habitat within the study area (PDF01BAT), in a rocky gully adjacent to a small pool (Table 5.6; Figure 5.4). The small number of calls and timing (between 2350 and 0420) suggests these records are likely to represent foraging individual(s) rather than close proximity to a roost site. No previous records for the study area were identified during the desktop study, with the nearest record identified being approximately 18 km to the southwest of the study area (Figure 5.1).

Table 5.6: Ghost Bat records from the study area during the current survey.

Site	Dates	Location		Notes
		Latitude	Longitude	
PDF01BAT	06/07/2022	-20.27785	119.12895	2 detections
	08/07/2022			2 detections and 2 possible detections

5.3.4 Western Pebble-mound Mouse *Pseudomys chapmani*

The Western Pebble-mound Mouse is listed as a Priority 4 species by the DBCA. Previously described as endemic to the central and eastern parts of the Pilbara (Menkhorst and Knight

2011), it is now known to occur much more widely across the entire Pilbara region and into the Gascoyne (DBCA 2020), where it is commonly found on stony hillsides with hummock grasslands (Menkhorst and Knight 2011). The species is well known for the extensive mounds of small stones it constructs, which are the most obvious indication of the species' occurrence in an area. Mounds are most common on spurs and gentle slopes where suitably sized stones are present (van Dyck and Strahan 2008).

While the species was not recorded during the targeted survey, three inactive Western Pebble-mound Mouse mounds were recorded from the study area during the interrupted detailed survey in June (Table 5.7; Figure 5.4; e.g. Plate 5.2). A further five inactive mounds were reported from the study area in 2007 (Bamford et al. 2010; Figure 5.4).

Table 5.7: Western Pebble-mound Mouse records from the study area during the current survey.

Site	Dates	Location		Notes
		Latitude	Longitude	
PDF01TS_MG	02/06/2022	-20.3334	119.1369	Inactive mound
Opportunistic	02/06/2022	-20.2599	119.1549	Inactive mound
Opportunistic	03/06/2022	-20.2496	119.1064	Very old mound

Plate 5.2 Inactive Western Pebble-mound Mouse mound in the study area, June 2022.

5.3.5 Pilbara Olive Python *Liasis olivaceus barroni*

The Pilbara Olive Python is listed as Vulnerable under both the EPBC Act and BC Act. It is a distinct subspecies of the Olive Python (which is found across northern Australia). The distribution of the subspecies roughly coincides with the Pilbara bioregion, with important populations known to occur in four areas: Pannawonica, Millstream, Tom Price and the Burrup Peninsula (DSEWPaC 2012). Preferred habitat for the Pilbara Olive Python includes rocky areas such as gorges, escarpments, and rocky outcrops, typically close to pools (DAWE 2020). It seeks shelter in caves, beneath boulders, in pools and occasionally in trees overhanging water (Bush and Maryan 2011). Though it is often associated with ephemeral or permanent water, individuals have large home

ranges (between 88 ha and 449 ha) and may be recorded in rocky habitats some distance from water (Biota 2009).

The Pilbara Olive Python was not recorded from the study area during the current targeted survey, but three individuals were recorded from the study area during 2007 and 2008 (Bamford et al. 2010; Figure 5.4). There are also single records from 2007 and 2013 from the study area in the DBCA Threatened Fauna database (DBCA 2022; Figure 5.1). All records occur in association with Rocky Hills habitat.

5.3.6 Oriental Plover *Charadrius veredus*

The Oriental Plover is listed as Migratory under the BC Act and EPBC Act. The species breeds in Mongolia, northern China and southern Siberia, and is a non-breeding summer migrant to Australia, occurring primarily from September to April (Johnstone and Storr 1998). However, unlike most shorebird species, they are not tied to wetland and coastal habitats while in Australia. Their preferred foraging habitats are sparsely vegetated open areas, including short-grassed or bare plains, bare wetland margins, and recently burnt areas (Johnstone and Storr 1998). This also includes similar man-made habitats, such as sports fields and airfields. The species will also use tidal mudflats, beaches, sewage ponds and freshwater wetland areas, primarily while on migration, or for roosting during the heat of the day (Johnstone and Storr 1998, Menkhorst et al. 2017). They are mobile in response to conditions, and disperse across inland northern Australia during the wet season (Minton et al. 2013).

The Oriental Plover was not recorded from the study area during the current targeted survey, which is not unexpected given the timing of the survey. However, there is a historical record from 1978 of the species from the study area in the DBCA Threatened Fauna database, from plains in the northwest of the study area (DBCA 2022). There are also numerous records within 10-15 km of the study area to the west (Figure 5.2), and it is likely to be a regular visitor to sparsely vegetated plains and margins of major drainage lines in the study area from September to April.

5.3.7 Peregrine Falcon *Falco peregrinus*

The Peregrine Falcon is listed as Other Specially Protected Fauna under the BC Act. It occurs almost Australia-wide, but is largely absent from most deserts and the Nullarbor Plain (Johnstone and Storr 1998). The species inhabits a wide range of habitats including forests, woodlands, wetlands and open country (Pizzey and Knight 2007). Individuals maintain large home ranges of up to 30 km^2, and nest in recesses of cliff faces, tree hollows and along rivers (Johnstone and Storr 1998).

The species was not recorded from the study area during the current targeted survey, but a pair were observed in April 2007 near rocky hills in the south of the study area (Bamford et al. 2010; Figure 5.4). The Rocky Hills habitat in the study area provides potentially suitable breeding habitat for the species, as do taller trees along the Major Drainage Line habitat in the north of the study area. Foraging is likely to take place over all habitats in the study area, with features that attract aggregations of other birds, such as surface water sources, likely to be particularly attractive.

5.3.8 Brush-tailed Mulgara *Dasycercus blythi*

The Brush-tailed Mulgara is listed as a Priority 4 species by the DBCA. The species occurs from south-western Queensland across the Simpson, Tanami and Great Sandy Deserts of southern and central Northern Territory, through central Western Australia. It typically occurs in spinifex grasslands on sandplains and sandy swales between low dunes but is also known to inhabit gibber (rock and pebble covered flat plains). It is closely associated with gently sloping to flat topographic positions rather than steep-sided sand ridges (Pavey et al. 2011). Within Western Australia, the species has a widespread distribution including the Gascoyne, Murchison, Pilbara and some of the central deserts (Ric How, pers. comm., 2012).

The Brush-tailed Mulgara was not recorded during the current targeted survey, but six probable burrows were detected in April 2007 (Bamford et al. 2010), in an area of spinifex plain in the north-east of the survey area (Figure 5.4). There is also a sight record from the study area in 2007 in the DBCA Threatened Fauna database (DBCA 2022), 1-2 km southwest of the burrows. Suitable Sandplain habitat exists across the western and central-eastern parts of the study area.

5.4 Significant Species Potentially Occurring

In addition to the eight significant species confirmed as occurring in the study area, a further 21 significant fauna species have been assessed as having a moderate to high likelihood of occurrence (Table 5.8). Of these, five species are considered to have a high likelihood of occurrence ('Likely to occur') and 16 species are considered to have a moderate likelihood of occurrence ('May occur'). These species are discussed further below in Sections 5.4.2.1 to 5.4.2.9.

The remaining 35 significant species identified in the desktop study are considered to have low or negligible likelihood of occurrence (see Table 5.8).

Table 5.8: Likelihood of occurrence of significant fauna in the study area.

Species Name	Common Name	Conservation Status		Preferred Habitat	Habitat Available in Study Area	Closest Records	Likelihood of Occurrence in Study Area
		State	C'wealth				
Mammals							
Dasyurus hallucatus	Northern Quoll	EN	EN	Rocky habitats, commonly utilising gorges, breakaways and hills. Also occurs near creek lines and drainage lines.	Yes	Recorded from nine locations in study area during current Targeted survey, and numerous previous records.	Recorded
Dasycercus blythi	Brush-tailed Mulgara	P4	–	Spinifex (*Triodia*) grasslands on sandplains, gibber plains.	Yes	Six probable burrows and a sight record from the study area in 2007.	Recorded
Pseudomys chapmani	Western Pebble-mound Mouse	P4	–	Typically on stony hillsides with hummock grasslands.	Yes	Three inactive mounds recorded from study area during interrupted survey in June, and five inactive mounds recorded from the study area previously in 2007.	Recorded
Rhinonicteris aurantia	Pilbara Leaf-nosed Bat	VU	VU	Occurrence influenced by the availability of suitable roost caves that offer high humidity and a stable temperature. Restricted to caves with semi-permanent or permanent water nearby, usually in rocky habitat. Foraging typically occurs over open grasslands in gorges, low hills and plains.	Yes	Calls recorded from four locations in study area during current Targeted survey.	Recorded
Macroderma gigas	Ghost Bat	VU	VU	Roost in caves, rock crevices and old mines, foraging in wide variety of habitats with distribution influenced by the availability of suitable caves for roost sites.	Yes	Calls recorded from one location in study area during current Targeted survey.	Recorded
Macrotis lagotis	Bilby	VU	VU	Primarily hummock grassland and *Acacia* shrubland, usually on sandplains.	Yes	Numerous records (most recent 2014) approximately 35 km ESE of study area on alluvial plain and sand plain.	May occur
Leggadina lakedownensis	Short-tailed Mouse	P4	–	In the Pilbara region, primarily known from cracking clay plains. Literature indicates a wider range of habitat preferences.	Yes	Closest records approximately 27 km to the north-east of study area from 2006.	May occur

Species Name	Common Name	Conservation Status		Preferred Habitat	Habitat Available in Study Area	Closest Records	Likelihood of Occurrence in Study Area
		State	C'wealth				
Ozimops cobourgianus	Northern Coastal Free-tailed Bat	P1	–	Mangrove specialist, restricted to mangrove forests, adjacent areas of monsoon forest and coastal woodland.	No	Approximately 35 km west of the study area in 2005, adjacent to mangrove habitat.	Unlikely to occur
Lagorchestes conspicillatus	Spectacled Hare-wallaby	P4	–	Tussock or hummock grasslands with sparse to moderately dense tree/shrub cover.	Marginal	Unpublished Biota records from previous Biota survey to the south-west, with that study area extending within 40 km of the current study area. However, records of this species are located at least 59 km from the current study area.	Unlikely to occur
Birds							
Charadrius veredus	Oriental Plover	MI	MI	Open plains, bare, rolling country, muddy or sandy wastes near inland swamps or intertidal mudflats; bare claypans, margins of coastal marshes; grassy airfields, sportsfields, lawns and coastal dune areas.	Yes	Recorded from plains in north-west of study area in 1978. Several more recent records within 20 km to the north-west.	Recorded
Falco peregrinus	Peregrine Falcon	OS	–	Found in most habitats. Prefers coastal and inland cliffs, or open woodlands near water.	Yes	Pair recorded over rocky hills in south of study area in 2007.	Recorded
Apus pacificus	Pacific Swift	MI	MI	Aerial over most habitats, particularly coastal and near coastal plains.	Yes	Recorded within 1 km of the study area in 2007.	Likely to occur
Numenius minutus	Little Curlew	MI	MI	Short grassland plains and bare country, roosts on sandy beaches and mudflats or margins of wetlands.	Yes	Approximately 20 km west of study area, most recently in 2014.	Likely to occur
Actitis hypoleucos	Common Sandpiper	MI	MI	Margins of coastal and inland wetlands, including mangroves/mangrove creeks, rocky shorelines, riverbanks, but less often intertidal flats.	Yes	Numerous records within 8 km to the south-east, most recently 2021.	Likely to occur

Species Name	Common Name	Conservation Status		Preferred Habitat	Habitat Available in Study Area	Closest Records	Likelihood of Occurrence in Study Area
		State	C'wealth				
Glareola maldivarum	Oriental Pratincole	MI	MI	Primarily forages on the wing over open country, roosts on bare ground near water (e.g. tidal flats, sandy beaches, margins of freshwater wetlands).	Yes	Within 1 km of the study area in 2007 and approximately 2.5 km to the south in 2013.	Likely to occur
Plegadis falcinellus	Glossy Ibis	MI	MI	Well-vegetated wetlands and floodplains, occasionally dry grasslands.	Yes	Multiple records within 8 km of the study area to the south-east, most recently in 2021.	Likely to occur
Rostratula australis	Australian Painted Snipe	EN	EN	Shallow, brackish or freshwater wetlands.	Yes	Approximately 30 km to the south of the study area.	May occur
Calidris acuminata	Sharp-tailed Sandpiper	MI	MI	Primarily shallow inland freshwater wetlands. Also found in mudflats, mangroves, rocky shores and beaches.	Limited	Numerous records approximately 10 - 15 km to the west of the study area, most recently in 2021, and approximately 8 km to the east along the De Grey River in 2015.	May occur
Calidris ferruginea	Curlew Sandpiper	CR[1]	CR; MI	Coastal and estuarine intertidal flats, adjacent sandy beaches and rocky shorelines; shallow fresh and brackish wetlands.	Limited	Numerous records approximately 10 - 15 km to the west of the study area, most recently in 2021.	May occur
Calidris subminuta	Long-toed Stint	MI	MI	Shallow freshwater or brackish wetlands and lakes, swamps, river floodplains, streams and lagoons.	Limited	Approximately 10 - 15 km to the west of the study area, most recently in 2021	May occur
Calidris ruficollis	Red-necked Stint	MI	MI	Intertidal mudflats, sandflats, estuaries, bays and lagoons.	Limited	Numerous records approximately 10 - 15 km to the west of the study area, most recently in 2021.	May occur
Calidris melanotos	Pectoral Sandpiper	MI	MI	Shallows and margins freshwater wetlands, occasionally coastal or estuarine intertidal flats.	Limited	Approximately 14 km to the west of the study area in 1998.	May occur
Tringa stagnatilis	Marsh Sandpiper	MI	MI	Shallow freshwater wetlands and wetland margins, less commonly intertidal mudflats.	Limited	Numerous records approximately 10 - 15 km to the west of the study area, most recently in 2021, and approximately 8 km to the east along the De Grey River in 2005.	May occur
Tringa glareola	Wood Sandpiper	MI	MI	Shallow freshwater wetlands and wetland margins.	Limited	Approximately 8 km to the east of the study area from 1977, more recent records (most recent 2020) within 9 km to the south-east along the De Grey River.	May occur

Species Name	Common Name	Conservation Status		Preferred Habitat	Habitat Available in Study Area	Closest Records	Likelihood of Occurrence in Study Area
		State	C'wealth				
Tringa nebularia	Common Greenshank	MI	MI	Coastal and estuarine intertidal flats, mangrove fringes, shallow freshwater wetlands and wetland margins, less commonly on sandy beaches.	Limited	Multiple records within 8 km of the study area to the south-east, most recently in 2021.	May occur
Gelochelidon [nilotica]	Gull-billed Tern	MI	MI	Australian: Coasts and estuaries, particularly in vicinity of intertidal flats, inland wetlands, grasslands and open country (sometimes far from water). Breeding primarily on large ephemeral wetlands inland. Common: coasts and estuaries, often in vicinity of tidal mudflats, near-coastal wetlands.	Yes	Approximately 9 km to the south-east of the study area from 2001 and 2006. More recent records (most recent 2021) approximately 14 km to the west of the study area.	May occur
Chlidonias leucopterus	White-winged Tern	MI	MI	Estuaries, sheltered seas, freshwater wetlands, sewage ponds, flooded samphire flats.	Limited	Multiple records approximately 10-15 km west of the study area, most recently in 2016.	May occur
Falco hypoleucos	Grey Falcon	VU	VU	Lightly wooded plains and tree-lined watercourses.	Yes	Approximately 35 km to the west of study area from 2013.	May occur
Hirundo rustica	Barn Swallow	MI	MI	Open country with low vegetation, often near water or manmade structures.	Yes	Approximately 8 km to the south-east of the study area in 2001.	May occur
Motacilla tschutschensis	Eastern Yellow Wagtail	MI	MI	Short grass and bare ground, margins of swamps and marshes, sewage ponds.	Yes	Approximately 11 km to the west of the study area from 1994.	May occur
Pluvialis fulva	Pacific Golden Plover	MI	MI	Intertidal mudflats, reef flats, adjacent sandy beaches, near-coastal grasslands and wetlands.	Marginal	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Pluvialis squatarola	Grey Plover	MI	MI	Coastal areas, inhabiting sheltered bays, estuaries and lagoons with mudflats and sandflats.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Charadrius mongolus	Lesser Sand Plover	EN[1]	EN; MI	Coastal and estuarine intertidal flats, sandy beaches.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Charadrius leschenaultii	Greater Sand Plover	VU[1]	VU; MI	Coastal and estuarine intertidal flats, sandy beaches, occasionally adjacent rocky shorelines.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur

Species Name	Common Name	Conservation Status		Preferred Habitat	Habitat Available in Study Area	Closest Records	Likelihood of Occurrence in Study Area
		State	C'wealth				
Numenius phaeopus	Eurasian Whimbrel	MI	MI	Coastal and estuarine intertidal flats, tidal creeks and mangroves, less commonly sandy beaches and rocky shorelines.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur.
Numenius madagascariensis	Far Eastern Curlew	CR[1]	CR; MI	Coastal and estuarine intertidal mudflats and sandflats, adjacent sandy beaches and mangrove fringes.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Limosa lapponica	Bar-tailed Godwit	CR[1,2]	CR[2]; MI	Coastal and estuarine intertidal flats, adjacent sandy beaches and rocky shorelines.	No	Numerous records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Limosa limosa	Black-tailed Godwit	MI	MI	Coastal and estuarine intertidal mudflats, shallow freshwater wetlands.	Marginal	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Arenaria interpres	Ruddy Turnstone	MI	MI	Coastal and estuarine intertidal flats, sandy beaches esp. with extensive tide wrack, rocky shorelines.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Calidris tenuirostris	Great Knot	CR[1]	CR; MI	Coastal and estuarine intertidal flats, adjacent sandy beaches and rocky shorelines.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Calidris canutus	Red Knot	EN[1]	EN; MI	Coastal and estuarine intertidal flats, adjacent sandy beaches and rocky shorelines.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2016.	Unlikely to occur
Calidris pugnax	Ruff	MI	MI	Shallow freshwater wetlands and wetland margins including sewage ponds. Elsewhere also uses wet grasslands and farmland, but generally rare on Intertidal flats.	Limited	Two records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Calidris falcinellus	Broad-billed Sandpiper	MI	MI	Coastal and estuarine intertidal flats, shallow margins of freshwater lakes.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Calidris alba	Sanderling	MI	MI	Sandy ocean beaches, less commonly tidal sand or reef flats.	No	Several records approximately 10 - 15 km to the west of the study area, most recently in 2017.	Unlikely to occur

Species Name	Common Name	Conservation Status		Preferred Habitat	Habitat Available in Study Area	Closest Records	Likelihood of Occurrence in Study Area
		State	C'wealth				
Limnodromus semipalmatus	Asian Dowitcher	MI	MI	Coastal and estuarine intertidal flats, adjacent sandy beaches.	No	Several records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Gallinago megala	Swinhoe's Snipe	MI	MI	Shallow, well-vegetated freshwater wetlands, damp grasslands.	Limited	Specimen collected in 1977 approximately 37 km east of the study area.	Unlikely to occur
Xenus cinereus	Terek Sandpiper	MI	MI	Coastal and estuarine intertidal flats, adjacent sandy beaches and rocky shorelines.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Phalaropus lobatus	Red-necked Phalarope	MI	MI	Primarily open seas in this region, when ashore favours natural salt lakes, artificial salt ponds/salt ponds, and sewage treatment ponds, sometimes freshwater wetlands.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Tringa brevipes	Grey-tailed Tattler	MI; P4	MI	Coastal and estuarine intertidal flats, less commonly sandy beaches, rocky shorelines, mangrove fringes, near-coastal wetlands.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Tringa totanus	Common Redshank	MI	MI	Most Australian records from coastal and estuarine tidal flats, or roosting on adjacent sandy beaches or rocky shorelines. Uses a broad range of wetland habitats overseas.	No	Approximately 12 km to the west of the study area from 1994.	Unlikely to occur
Hydroprogne caspia	Caspian Tern	MI	MI	Sheltered coasts, offshore islands, estuaries and large inland wetlands.	No	Numerous records approximately 8 - 10 km to the south-east (most recent 2007) and 10 - 15 km to the west (most recent 2021) of the study area.	Unlikely to occur

Species Name	Common Name	Conservation Status		Preferred Habitat	Habitat Available in Study Area	Closest Records	Likelihood of Occurrence in Study Area
		State	C'wealth				
Thalasseus bergii	Greater Crested Tern	MI	MI	Inshore seas, coasts, estuaries and tidal creeks, preferring clear waters.	No	Single record from survey centred on point within 1 km of the study area in 2007, though survey covered radius of 5 km from this point and habitat would be atypical for this species. Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Sternula albifrons	Little Tern	MI	MI	Sheltered seas, estuaries, mangrove creeks, sandy beaches and offshore islands.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021.	Unlikely to occur
Sterna hirundo	Common Tern	MI	MI	Sheltered seas, coasts, estuaries.	No	Several records approximately 10 - 15 km to the west of the study area, most recently in 2015.	Unlikely to occur
Fregata ariel	Lesser Frigatebird	MI	MI	Aerial over coasts and seas, breeding on offshore islands.	No	Two records approximately 13 km west of study area, most recently in 2016.	Unlikely to occur
Pandion cristatus	Eastern Osprey	MI	MI	Estuaries, coasts and offshore islands, less commonly large inland wetlands.	No	Multiple records approximately 10 - 15 km to the west of the study area, most recently in 2021, and several records approximately 8 km to the east along the De Grey River in 2002.	Unlikely to occur
Elanus scriptus	Letter-winged Kite	P4	–	Open country and grasslands in arid and semi-arid Australia.	Yes	Single record approximately 15 km west of study area. Rare irruptive visitor to the region generally.	Unlikely to occur
Pezoporus occidentalis	Night Parrot	CR	EN	Arid or semi-arid spinifex grasslands with large, established and unburnt hummocks. Foraging habitat includes areas of chenopods and high-productivity grasslands.	Marginal	No records within 40 km of study area, which is outside of current known distribution.	Unlikely to occur
Macronectes giganteus	Southern Giant Petrel	MI	MI	Oceanic species. Breeds in Antarctic and Subantarctic islands.	No	Nearest record located approximately 550 km SW of study area in Exmouth Gulf. Study area outside of documented distribution.	Would not occur

Species Name	Common Name	Conservation Status		Preferred Habitat	Habitat Available in Study Area	Closest Records	Likelihood of Occurrence in Study Area
		State	C'wealth				
Reptiles							
Liasis olivaceus barroni	Pilbara Olive Python	VU	VU	Gorges, escarpments, rocky outcrops and water holes where it may find suitable prey.	Yes	Recorded from the study area in 2007 and 2008, with a record in close proximity in 2022.	Recorded
Ctenotus angusticeps	Northwestern Coastal *Ctenotus*	P3	–	On mainland, coastal saltmarsh vegetation on mudflats, often near mangroves and with numerous crabholes.	Yes	Specimen from 32 km west of study area in 2012.	Unlikely to occur
Natator depressus	Flatback Turtle	VU	VU; MI	Tropical coastal and continental shelf waters, breeding on sandy beaches.	No	Record from coastline approximately 35 km to the west of the study area.	Would not occur

[1] The Migratory listing under the BC Act has been repealed for species also listed as Threatened, but note that these species still satisfy all other criteria for Migratory listing in addition to the criteria for their threatened listings.

[2] Subspecies *menzbieri* listed as Critically Endangered, subspecies *baueri* as Vulnerable – field identification can be problematic, but the majority of Bar-tailed Godwits in Western Australia belong to ssp. *menzbieri*.

5.4.1 Significant Species Likely to Occur

5.4.1.1 Pacific Swift *Apus pacificus*

The Pacific Swift (formerly known as Fork-tailed Swift) is listed as Migratory under the BC Act and the EPBC Act. It occurs as a non-breeding migrant across much of Australia from September to April, particularly in the northern half of the continent. In general, the species is most common closer to the coast, but does occur in inland areas. In Australia, the species is thought to be almost entirely aerial in habit, foraging for flying insects and even sleeping on the wing. It is highly mobile, often occurring in association with unsettled weather and low pressure systems (Johnstone and Storr 1998).

The Pacific Swift was not recorded during the current survey, and no previous records from the study area were identified in the desktop study. However, there is a record from 2007 in very close proximity to the study area (DBCA 2022; Figure 5.2), and the species regularly occurs across the Pilbara, particularly in coastal and near-coastal parts. The species is highly mobile, and likely to occur in airspace over the survey area sporadically between September and April.

5.4.1.2 Glossy Ibis *Plegadis falcinellus*

The Glossy Ibis is listed as Migratory under the BC Act and the EPBC Act. They are widely distributed globally but within Western Australia are primarily found in well-watered flatlands of the Kimberley and Swan Coastal Plain (Johnstone and Storr 1998). They are common in the Kimberley during and after the wet season, occasionally occurring in large numbers of up to 4,000 (Johnstone and Storr 1998). Preferred habitat includes shallow freshwater wetlands and adjacent flats, river pools, and flooded samphire (Johnstone and Storr 1998).

The Glossy Ibis was not recorded from the study area during the current survey, and no previous records from the study area were identified in the desktop study. There are over 15 previous records from the broader locality, with the nearest records within 8 km along the De Grey River (Cornell Lab of Ornithology 2022, DBCA 2022; Figure 5.2). Suitable habitat exists in the study area along the major drainage lines, so the species is likely to occur, though likely only as an occasional visitor.

5.4.1.3 Little Curlew *Numenius minutus*

The Little Curlew is listed as Migratory under the BC Act and EPBC Act. It is a common non-breeding summer migrant to northern Australia, primarily between mid-September and April, with very few overwintering (Menkhorst et al. 2017). It favours short grassland habitats, including natural short grasslands or recently burnt grasslands, airfields and sports grounds, and less commonly other open habitats such as drying river beds and tidal flats (Johnstone and Storr 1998). The species is generally more common in coastal areas but disperses further inland following widespread rainfall during the wet season.

The Little Curlew was not recorded from the study area during the current survey, and no previous records from the study area were identified in the desktop study. However, there are several records to the west of the study area, the nearest of which is approximately 10 km from the study area boundary (DBCA 2022; Figure 5.2). Suitable habitat for the species exists on sparsely vegetated Alluvial Floodplain habitat and the margins of Major Drainage Line habitat in the study area, and it is likely to occur as a sporadic foraging visitor from September to April.

5.4.1.4 Common Sandpiper *Actitis hypoleucos*

The Common Sandpiper listed as Migratory under the BC Act and EPBC Act. The species is a non-breeding migrant to Australia, occurring between July and May, with largest numbers present September to April. The species occurs along all coasts in Western Australia, as well as on many offshore islands, and inland areas where there is suitable habitat (Johnstone and Storr 1998). It uses a variety of habitats near water, including mangrove-lined creeks, rocky coastlines, river pools, sewage ponds, saltworks, dams, flooded claypan margins and drying swamps (Johnstone and Storr 1998, Menkhorst et al. 2017). However, it tends to avoid open intertidal mudflat areas favoured by many other shorebird species (Menkhorst et al. 2017).

The Common Sandpiper was not recorded from the study area during the current survey, and no previous records from the study area were identified in the desktop study. However, there are

numerous records from the broader locality, with the nearest records from within 8 km along the De Grey River (Cornell Lab of Ornithology 2022, DBCA 2022; Figure 5.2). Suitable habitat for the species exists along the Major Drainage Line habitat in the study area, so it is likely to occur as a non-breeding summer visitor.

5.4.1.5 Oriental Pratincole *Glareola maldivarum*

The Oriental Pratincole is listed as Migratory under the BC Act and the EPBC Act. The species is a non-breeding migrant to Australia and is typically present from October to May, with the largest numbers present from December to March (Johnstone and Storr 1998, Sitters et al. 2004). The Oriental Pratincole often uses broadly similar foraging habitats to the Oriental Plover, including short-grassed or bare plains, bare wetland margins. However, Oriental Pratincoles take most of their insect prey aerially (Johnstone and Storr 1998), and so will forage over a wider range of open habitat types, and occasionally over more wooded areas. Oriental Pratincole will also use tidal mudflats, beaches, sewage ponds and freshwater wetland areas, primarily for roosting during the heat of the day. They are mobile in response to conditions, and disperse across inland northern Australia during the wet season, occasionally gathering in exceptionally high numbers (Sitters et al. 2004).

No Oriental Pratincoles were recorded from the study area during the current targeted survey, which is unsurprising given the timing of the survey. A single record from the study area was identified in the desktop study (ALA 2022), but the location of this record had been generalised (precision reduced), with the actual location 2.5 km outside of the study area boundary (DBCA 2022). However, there are multiple records in close proximity to the survey area (DBCA 2022; Figure 5.2), and the species is likely to occur as visitor to the study area, primarily between December and March. Foraging is likely to occur aerially over all habitats within the study area, with roosting/loafing and ground foraging possible on sparsely vegetated Sandplain habitat.

5.4.2 Significant Species That May Occur

5.4.2.1 Bilby *Macrotis lagotis*

The Bilby is listed as Vulnerable under the EPBC Act and the BC Act. The species formerly occurred in a wide range of semi-arid and arid habitats across over 70% of the Australian mainland; however, it has declined markedly and now occupies less than 20% of its former range (Department of the Environment 2014). In Western Australia, there are disjunct populations in the Gibson Desert, south-western Kimberley, inland areas of the Pilbara and northern Great Sandy Desert (Friend 1990), and it has been reintroduced to parts of the southwest of WA. Extant populations occur in a variety of habitats, usually on landforms of low topographic relief and light to medium soils. In the Pilbara, the species prefers areas suitable for burrowing where the substrate comprises sand, soil, sandy clay or sandy gravel (DBCA 2017b), though it is also known from atypical stony gravelly areas (M. Dziminski, DBCA, pers. comm.). Additionally, the Bilby demonstrates strong association with particular species of *Acacia* that host root-dwelling larvae, which form a major food resource for the species in the Pilbara (DBCA 2017b).

No evidence of Bilby was detected during the current survey, and no previous records from the study area were identified in the desktop study. However, there is a cluster of records approximately 35 km to the east of the study area (DBCA 2022; Figure 5.1), and suitable habitat with *Acacia* shrubs on Sandplain habitat exists in the study area, so the species may occur.

5.4.2.2 Short-tailed Mouse *Leggadina lakedownensis*

The Short-tailed Mouse is listed as Priority 4 by the DBCA. Prior to 1997, only two specimens of this species had been collected, however the number of records of this species has increased substantially since this time (Cooper et al. 2003). In Western Australia, its distribution encompasses the Pilbara and Kimberley regions (Menkhorst and Knight 2011) although NatureMap records also place it within the Great Sandy Desert. Regional records suggest that the primary mainland habitat comprises areas of cracking clay and adjacent habitats. However, other sources provide a more diverse picture of habitat utilisation that includes areas of open tussock and hummock grassland, *Acacia* shrubland and savannah woodland, sandy soils as well as cracking clays (Morris et al. 2008) as well as hilltops (Dr Peter Kendrick, pers. comm.) and sandy coastal areas (Biota, pers. obs.). Population sizes appear to vary dramatically by season.

The Short-tailed Mouse was not recorded from the study area during the current survey, and no previous records from the study area were identified in the desktop study. However, potentially suitable habitat for the species exists on Alluvial Floodplains in the north and northwest of the study area, and the closest record is approximately 25 km northeast of the study area (DBCA 2022; Figure 5.1), so the species may occur.

5.4.2.3 Australian Painted Snipe *Rostratula australis*

The Australian Painted Snipe is listed as Endangered under the BC Act and the EPBC Act. It occurs sporadically through much of eastern and northern Australia, and is an occasional visitor to suitable habitat throughout the country (Menkhorst et al. 2017). In Western Australia, the species' stronghold appears to be the Kimberley, but there are scattered records throughout much of the state (Johnstone and Storr 1998, Cornell Lab of Ornithology 2022). The species breeds on temporary freshwater wetlands following flooding, favouring those with mosaic of shallow water, exposed ground/islands, and low dense cover (Garnett and Baker 2021). When not breeding, they disperse widely and may occur on a wide range of wetland habitat types, but still prefer sites with a mix of shallow water, low fringing vegetation and exposed mud (Menkhorst et al. 2017).

The Australian Painted Snipe was not recorded from the study area during the current survey, and no previous records from the study area were identified in the desktop study. The closest record identified in the desktop study is approximately 30 km to the south of the study area. However, the species is cryptic and easily overlooked, and potentially suitable habitat exists along drainage lines in the study area, so it may occur, though likely only as an occasional visitor.

5.4.2.4 Grey Falcon *Falco hypoleucos*

The Grey Falcon is listed as Vulnerable under both the BC Act and the EPBC Act. The species is sparsely distributed across much of arid inland Australia, including the Kimberley, occurring mainly on lightly wooded plains and along major watercourses (Johnstone et al. 2013). Breeding usually takes place in taller trees such as river red gums, or on isolated man-made structures such as communications towers.

The Grey Falcon was not recorded from the study area during the current survey, and no previous records from the study area were identified in the desktop study. The closest records are approximately 35 km to the west of the study area along Beebingarra Creek Figure 5.2. Potentially suitable breeding habitat exists along some sections of the Major Drainage Line habitat within the study area with taller trees, and all habitats in the study area represent suitable foraging habitat, with features that attract aggregations of other birds likely to be favoured, so the species may occur.

5.4.2.5 Other Migratory Shorebirds

Of the 32 species of shorebird listed as Migratory under the EPBC Act that were identified from the locality in the desktop study, 12 species have been recorded or are considered to have a moderate to high likelihood of occurrence in the study area. Those species recorded or considered likely to occur are discussed individually above (Section 5.3 and Section 5.4.1). A further eight species may occur, specifically:

- Curlew Sandpiper *Calidris ferruginea* – EPBC Act Critically Endangered and Migratory, BC Act Critically Endangered;
- Sharp-tailed Sandpiper *Calidris acuminata* – EPBC Act and BC Act Migratory;
- Long-toed Stint *Calidris subminuta* – EPBC Act and BC Act Migratory;
- Red-necked Stint *Calidris ruficollis* – EPBC Act and BC Act Migratory;
- Pectoral Sandpiper *Calidris melanotos* – EPBC Act and BC Act Migratory;
- Marsh Sandpiper *Tringa stagnatilis* – EPBC Act and BC Act Migratory;
- Wood Sandpiper *Tringa glareola* – EPBC Act and BC Act Migratory; and
- Common Greenshank *Tringa nebularia* – EPBC Act and BC Act Migratory.

These species are all non-breeding migrants to Australia, with the largest numbers present between September and April, though young birds of some species also overwinter. They all

regularly occur on shallow freshwater wetlands and may occur as non-breeding visitors along the Major Drainage Lline habitat in the study area, particularly along the more open areas in the northwest of the study area.

Other Migratory-listed shorebird species may visit occasionally but are either scarce in the region or prefer coastal and estuarine habitats rather than freshwater, so are considered unlikely to occur overall (see Table 5.8).

5.4.2.6 Australian [Gull-billed] Tern *Gelochelidon [nilotica] macrotarsa*

The Gull-billed Tern is listed as Migratory under both the BC Act and the EPBC Act. However, there are two populations of Gull-billed Tern in Australia; a resident population, *G.* [*nilotica*] *macrotarsa* and a migratory population *G. nilotica affinis*. Most authorities now recognise the resident Australian population as a distinct species, the Australian [Gull-billed] Tern, based on differences in plumage, structure, ecology and genetics (Rogers et al. 2005). The Australian [Gull-billed] Tern is still listed as Migratory under the EPBC Act due to a lag in updating the taxonomy of the species.

Australian [Gull-billed] Terns are nomadic and occur widely across Australia, including both coastal and inland areas, but generally remain within Australia. They breed colonially on inland wetlands, and forage over sheltered coastal and inland wetlands, and over open grassland and bare ground (Johnstone and Storr 1998). Numerous records of Gull-billed Terns from the broader locality were identified in the desktop study, though few differentiate between the two taxa. The nearest records are within 7 km along the De Grey River and are most likely referable to Australian [Gull-billed] Tern based on habitat (Cornell Lab of Ornithology 2022, DBCA 2022; Figure 5.2). Potentially suitable habitat for Australian [Gull-billed] Terns exist along some sections of drainage lines, and adjacent open plains in the study area, and the species may occur as a foraging visitor.

[Common] Gull-billed Terns (*Gelochelidon nilotica affinis*) are non-breeding migrants to Australia and use primarily coastal habitats. They may occasionally visit the study area from the coast, but are less likely to occur regularly.

5.4.2.7 White-winged Tern *Chlidonias leucopterus*

The White-winged Tern is listed as Migratory under the BC Act and the EPBC Act. The species breeds in Asia and is a summer migrant to Australia from October to April-May (Menkhorst et al. 2017). They can occur in suitable habitat across most of Australia but are more common in the north of the country. Preferred habitats include coastal and inland freshwater wetlands, estuaries, sheltered seas, salt lakes and samphire, as well as flooded grasslands (Johnstone and Storr 1998).

The White-winged Tern was not recorded from the study area during the current survey, and no previous records from the study area were identified in the desktop study. There are multiple records within 15 km of the study area, with the nearest approximately 11 km west of the study area (DBCA 2022; Figure 5.2). Potentially suitable habitat for White-winged Terns exists along the major drainage lines in the study area, so the species may occur as a summer migrant.

5.4.2.8 Barn Swallow *Hirundo rustica*

The Barn Swallow is listed as Migratory under both the BC and EPBC Acts. The species is a non-breeding migrant to Australia, where they occur in coastal areas of northern Australia between the Pilbara in Western Australia and northern Queensland. In Australia, they occur primarily over open habitats, particularly in areas such as wetlands where insect densities are high.

The Barn Swallow was not recorded from the study area during the current survey, and no previous records from the study area were identified in the desktop study. The closest record is approximately 8 km to the south-west of the study area from 2001 (DBCA 2022; Figure 5.2), and suitable habitat exists along the drainage lines and over open plains in the study area, so the species may occur as a non-breeding visitor.

5.4.2.9 Eastern Yellow Wagtail *Motacilla tschutschensis*

The Eastern Yellow Wagtail is listed as Migratory under both the EPBC and the BC Acts. It is a regular non-breeding summer migrant to northern Australia, primarily from late September to late April (Menkhorst et al. 2017). It favours open country, particularly short grasslands and open margins of water bodies, including human-modified environments such as sports fields and sewage ponds (Menkhorst et al. 2017).

The Eastern Yellow Wagtail was not recorded from the study area during the current survey, and no previous records from the study area were identified in the desktop study. The closest record of the species is approximately 11 km to the west of the study area (ALA 2022; Figure 5.2), and potentially suitable habitat exists in the survey area in more open sections of drainage lines, and less vegetated areas of the plains. Hence, the species may occur as a non-breeding migrant, primarily from October to April.

6.0 SRE Invertebrate Fauna

6.1 Desktop Study

A total of 18 taxa from groups known to support SREs were identified from the locality during the desktop study (Table 6.1; Figure 6.1). These include eight mygalomorph spiders, one millipede and nine land snails. Of these, 10 taxa are not considered to be SREs, based on the criteria outlined in Table 3.2. Eight taxa represent potential SREs, including six mygalomorph spiders, one millipede and one land snail (Table 6.1). Of these, two potential SRE taxa have previously been recorded from within the study area: the mygalomorph spider Anaminae `MYGAAB`, and the millipede *Antichiropus simmonsi* (Figure 6.1).

The results of the desktop study indicated that previous SRE sampling effort within the locality has been limited, with only a subset of habitats and land systems sampled.

Table 6.1: Potential SRE taxa returned from database searches.

Family	Taxon	Distribution	Data deficient	SRE Status	Source
Mygalomorph Spiders					
Actinopodidae	*Missulena rutraspina*	> 10,000 km^2	No	Not an SRE	WAM
Anamidae	*Anaminae `MYGAAB`	Undetermined	Yes	Potential SRE	WAM
	Aname ellenae	> 10,000 km^2	No	Not an SRE	WAM
	Aname sinuata	~ 8,000 km^2	Yes	Potential SRE	WAM
	Kwonkan `Yilgarnia`	Undetermined	Yes	Potential SRE	WAM
Barychelidae	*Synothele* `MYG115`	Undetermined	Yes	Potential SRE	WAM
Halonoproctidae	*Conothele* `MYG607`	Undetermined	Yes	Potential SRE	WAM
Idiopidae	*Idiosoma* `Aganippe`	Undetermined	Yes	Potential SRE	WAM
Millipedes					
Paradoxosomatidae	**Antichiropus simmonsi*	Restricted	Yes	Potential SRE	WAM
Land Snails					
Camaenidae	*Rhagada richardsonii*	> 10,000 km^2	No	Not an SRE	WAM & ALA
	Rhagada cf. *richardsonii*	> 10,000 km^2	No	Not an SRE	WAM & ALA
	Rhagada convita	> 10,000 km^2	No	Not an SRE	WAM
Helicodiscidae	*Stenopylis coarctata*	> 10,000 km^2	No	Not an SRE	WAM
Pupillidae	*Gastrocopta larapinta*	> 10,000 km^2	No	Not an SRE	WAM
	Gastrocopta mussoni	> 10,000 km^2	No	Not an SRE	WAM
	Pupoides beltianus	> 10,000 km^2	No	Not an SRE	WAM
	Pupoides lepidulus	> 10,000 km^2	No	Not an SRE	WAM
Succineidae	*Succinea* sp.	Undetermined	Yes	Potential SRE	WAM

*denotes taxon recorded in the study area.

Figure 6.1: Previous records of potential SRE invertebrates from the locality.

6.2 Targeted SRE Survey Results

Twenty potential SRE specimens were collected from the study area during the current survey, comprising nine mygalomorph spiders, five isopods and six land snails (Table 6.2; Figure 6.2).

Molecular sequencing indicated that these specimens represented six distinct lineages, including three mygalomorph spiders, two isopods and one land snail (Table 6.2). All six of these lineages are considered to represent distinct species, and have not been detected previously based on molecular data currently available for comparison (Helix 2023; Appendix 4). Based on their current known extents of occurrence, all six species are classified as potential SREs. However, SRE survey effort in the locality appears to be relatively limited, so further searches in the broader locality may extend the known distributions for some or all of these species, particularly those for which extensive areas of similar habitat extend contiguously from the collection locations in the study area.

Each of the species is discussed further in Sections 6.2.1 to 6.2.4 below.

Table 6.2: Potential SRE taxa recorded from the study area during the current survey.

Family	Preliminary Species ID	Molecular Species ID	Biota Specimen ID	No. of individuals	Collection date	Latitude	Longitude
Mygalomorph spiders							
Idiopidae	*Idiosoma* sp.	*Idiosoma* H-I82	M20220708_PDF03SRE_DK-01	1	08/07/2022	-20.23488	119.14253
			M20220708_PDF03SRE_DK-03	1	08/07/2022	-20.23437	119.14303
			M20220708_PDF03SRE_DK-02	1	08/07/2022	-20.23506	119.14248
Anamidae	*Kwonkan* sp.	*Kwonkan* H-N168	M20220710_PDF09SRE_DK-01	1	10/07/2022	-20.30913	119.08876
			M20220710_PDF09SRE_DK-03	1	10/07/2022	-20.30913	119.08877
			M20220710_PDF10SRE_DK-01	1	10/07/2022	-20.27181	119.05860
			M20220710_PDF10SRE_DK-02	1	10/07/2022	-20.27176	119.05856
		Kwonkan H-N169	M20220711_PDF14SRE_DK-01	1	11/07/2022	-20.26387	119.15252
	Anamidae sp.	No data	M20220710_PDF09SRE_DK-02	1	10/07/2022	-20.30913	119.08877
Land snails							
Camaenidae	Camaenidae sp.	*Rhagada* H-SB020	G20220602.PDF01SRE_SS-01	1	02/06/2022	-20.25677	119.13305
			G20220602.PDF01SRE_SS-02	1	02/06/2022	-20.25631	119.13490
			G20220603.PDF01SRE_PK-01	2	03/06/2022	-20.27970	119.13093
			SN20220709_PDF05SRE_DK-01	1	09/07/2022	-20.24980	119.15888
		No data		1			
Isopods							
Armadillidae	Armadillidae sp.	Armadillidae H-ISA64	I20220709_PDF05SRE_DK-01	2	09/07/2022	-20.24976	119.15896
		Armadillidae H-ISA65		1			
Unknown	No data	No data		1			
	No data	Not analysed		1			

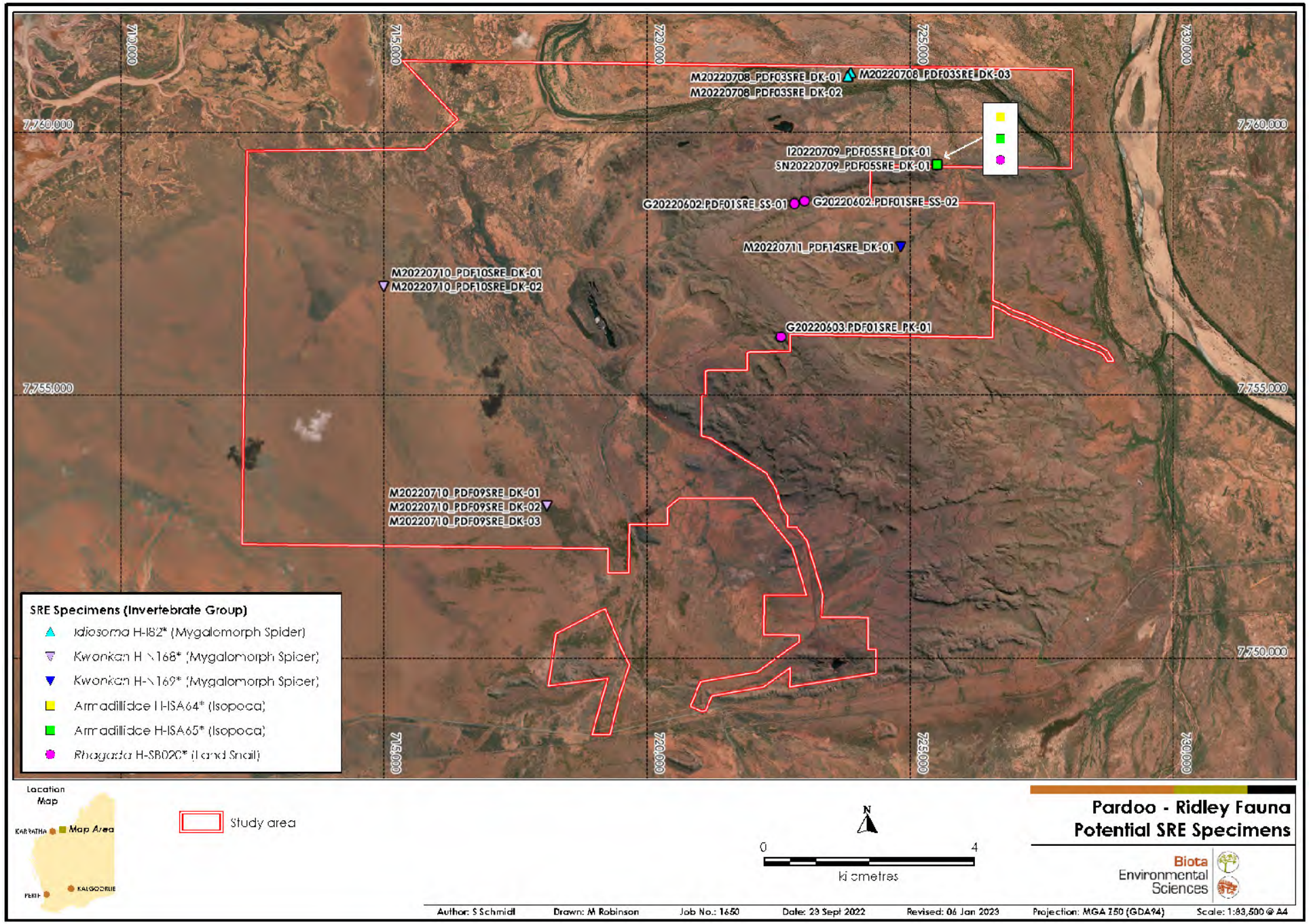

Figure 6.2: SRE invertebrate specimens collected from the study area during the current survey.

6.2.1 *Idiosoma* H-182

The three idiopid specimens collected from the study area during the current survey belong to this new species of *Idiosoma* (Helix 2023; Appendix 4). All three were collected from the same search site in the north of the study area from the alluvial floodplain broad habitat type (Figure 6.2). Specimens were located in clay lid burrows without adornments (Plate 6.1), located on bare areas of ground amongst tall open *Acacia* shrubland on alluvial floodplain (Plate 6.2).

Plate 6.1 *Idiosoma* H-182 burrow morphology.

Plate 6.2 Habitat from which *Idiosoma* H-182 specimens were collected in July 2022.

6.2.2 *Kwonkan* H-N168 and *Kwonkan* H-169

The Anamidae specimens collected from the study area were found to belong to the two new species *Kwonkan* H-168 (four specimens) and *Kwonkan* H-169 (one specimen), with molecular sequence data not able to be extracted from the sixth (Helix 2023; Appendix 4). All specimens

were collected from sock burrows (Plate 6.3) in sandplain habitat vegetated with spinifex (*Triodia* sp./spp.) with patches of low *Acacia* shrubs, particularly *A. stellaticeps*, in some areas (Figure 6.2; Plate 6.4). Burrows were located in open bare sandy areas and were observed in high densities in some areas.

The two species showed similar burrow morphology and were recorded in similar habitats but may be allopatric based on the limited data available to date. The four *Kwonkan* H-168 specimens were all recorded from sandplains west of Ord Range in the centre of the study area, while the single specimen of *Kwonkan* H-169 was recorded from similar habitat east of the Ord Range (Figure 6.2). This could suggest that the rocky hills of the Ord Range may be a barrier to dispersal between suitable sandplain habitats for these species.

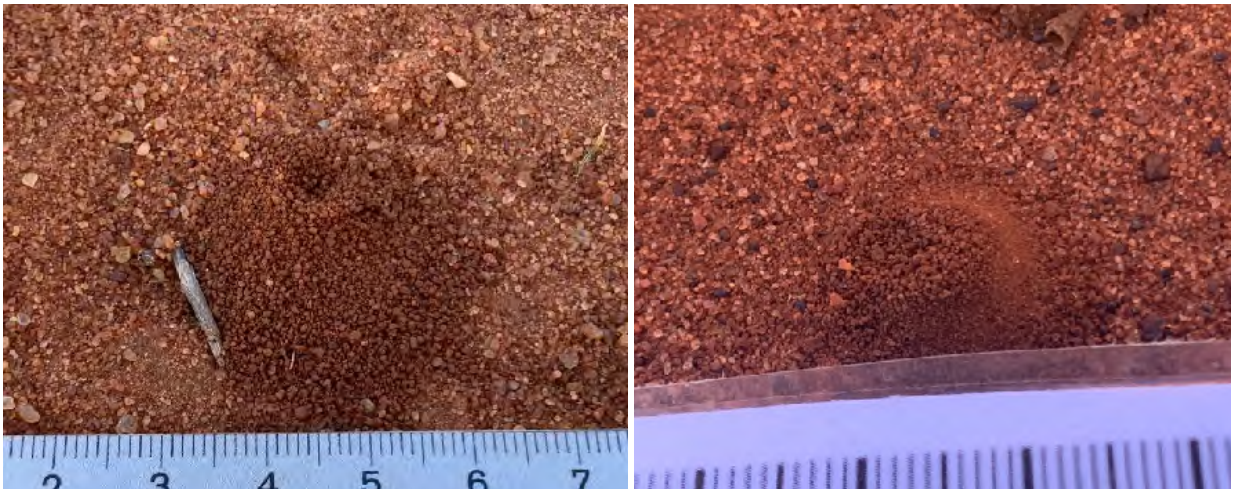

Plate 6.3 *Kwonkan* H-N168 (left) and *Kwonkan* H-N169 (right) burrow morphology.

Plate 6.4 Example sandplain habitat from which the *Kwonkan* specimens were collected in July 2022.

6.2.3 Armadillidae H-ISA64 and Armadillidae H-ISA65

Five isopod specimens were collected from the study area during the current survey, of which three were successfully sequenced. These three specimens were found to belong to the two new species Armadillidae H-ISA64 (two specimens) and Armadillidae H-ISA65 (one specimen), occurring sympatrically within the study area (Helix 2023; Appendix 4). Placement of the specimens within a specific genus is problematic and would require expert morphological examination in addition to molecular analysis, but the species Armadillidae H-ISA64 potentially sits within the genus *Buddelundia* (Helix 2023; Appendix 4).

All specimens were collected from a single location in the northeast of the study area, on the edge of the Rocky Hills broad habitat type (Figure 6.2). Specimens were collected from sheltered microhabitats, such as under rocks and in crevices filled with leaf litter, around a large rocky outcrop vegetated with a large fig (*Ficus* sp.; Plate 6.5).

Plate 6.5 Habitat from which the Armadillidae H-ISA64 and Armadillidae H-ISA65 specimens were collected in July 2022.

6.2.4 *Rhagada* H-SB020

Five land snail specimens were collected from the study area during the current survey, of which four were successfully sequenced and were found to belong to this new lineage, likely representing a new species (Helix 2023; Appendix 4). Specimens were collected from sheltered microhabitats at four locations within the rocky hills broad habitat type (Plate 6.6).

The specimens collected exhibit a small banded shell morphology (Plate 6.7) morphologically similar to other small banded *Rhagada* clades in the Pilbara (Helix 2023; Appendix 4). However, the new lineage differs from all other sequences available by over 7.8%, indicating it likely represents a new species within this morphotype, though further sampling and additional reference data are required to confirm this (Helix 2023; Appendix 4).

Plate 6.6 Example habitat from which the *Rhagada* H-SB020 specimens were collected in June 2022.

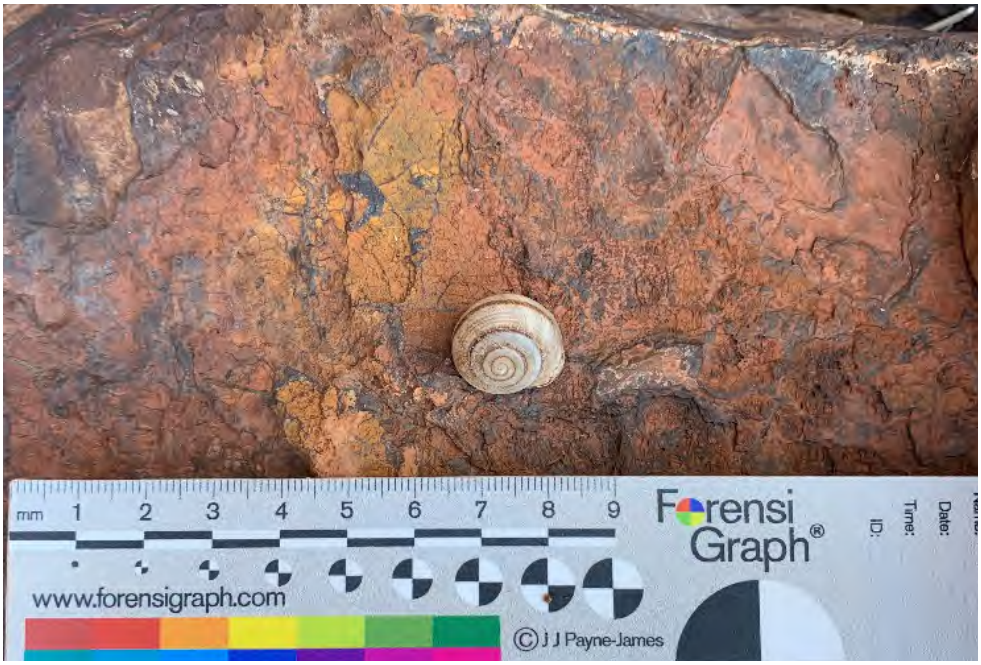

Plate 6.7 *Rhagada* H-SB020 specimen collected from the study area in June 2022.

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7.0 Conclusions

A total of 349 vertebrate fauna species were identified from the locality (i.e. within 40 km of the study area) during the desktop study, including 40 mammals, 215 birds, 84 reptiles and 10 amphibians. Of these, 63 are listed as significant species under State or Commonwealth legislation. Four of these significant species were recorded from the study area during the current survey, while a further four species have previously been recorded within the study area:

- Northern Quoll *Dasyurus hallucatus* (Endangered) – current survey and previously recorded;
- Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* Pilbara form (Vulnerable) – current survey;
- Ghost Bat *Macroderma gigas* (Vulnerable) – current survey;
- Western Pebble-mound Mouse (DBCA Priority 4) – current survey and previously recorded;
- Pilbara Olive Python *Liasis olivaceus barroni* (Vulnerable) – previously recorded;
- Oriental Plover *Charadrius veredus* (Migratory) – previously recorded;
- Peregrine Falcon *Falco peregrinus* (Other Specially Protected Fauna) – previously recorded; and
- Brush-tailed Mulgara *Dasycercus blythi* (DBCA Priority 4) – previously recorded.

A further five significant fauna species are considered to have a high likelihood of occurrence in the study area, while 16 are considered to have a moderate likelihood of occurrence ("may occur") within the study area. The species considered likely to occur in the study area but have not yet been recorded are:

- Pacific Swift *Apus pacificus* (Migratory);
- Glossy Ibis *Plegadis falcinellus* (Migratory);
- Little Curlew *Numenius minutus* (Migratory);
- Common Sandpiper *Actitis hypoleucos* (Migratory); and
- Oriental Pratincole *Glareola maldivarum* (Migratory).

A total of 18 taxa from groups known to support SREs were identified from the locality during the desktop study. Of these, ten taxa are not considered to be SREs, eight taxa represent potential SREs. Two potential SRE species have previously been recorded from the study area:

- the mygalomorph spider Anaminae `MYGAAB`; and
- the millipede *Antichiropus simmonsi*.

Neither of these taxa were recorded during the current survey but six new potential SRE species were collected from the study area during the current survey:

- the mygalomorph spider *Idiosoma* H-182;
- the mygalomorph spider *Kwonkan* H-N168;
- the mygalomorph spider *Kwonkan* H-N169;
- the isopod Armadillidae H-ISA64;
- the isopod Armadillidae H-ISA64; and
- the land snail *Rhagada* H-SB020.

The records from the study area currently represent the only known records of these species, and thus they represent potential SREs, bringing the potential SRE fauna of the study area to eight taxa in total.

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Appendix 1

Significant Fauna Species Listing Definitions

Commonwealth *EPBC Act 1999*

Fauna species of national environmental significance are listed under the Commonwealth *EPBC Act*, and may be classified as 'critically endangered', 'endangered', 'vulnerable' or 'lower risk', which are consistent with IUCN categories.

Critically Endangered (CR): a taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

Endangered (EN): a taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future.

Vulnerable (VU): a taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

Lower Risk (LR): a taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:

1. **Conservation Dependent (CD).** Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
2. **Near Threatened (NT).** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. **Least Concern (LC).** Taxa which do not qualify for Conservation Dependent or Near Threatened.

Migratory species (MI) are also protected under the *EPBC Act* as species of national environmental significance. Migratory species are those animals that migrate to Australia and its external territories, or pass through or over Australian waters during their annual migrations. The list of migratory species consists of those species listed under the following international conventions:

1. Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention);
2. China-Australia Migratory Bird Agreement (CAMBA);
3. Japan-Australia Migratory Bird Agreement (JAMBA); and,
4. Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

Marine species (MA) are also protected under the *EPBC Act*, and are listed to ensure the long-term conservation of the species. Marine species include all Australian sea snakes, seals, crocodiles, dugongs, marine turtles, seahorses and seabirds that naturally occur in the Commonwealth marine area. These species have not been considered in this report as the study area does not encompass marine environs.

Western Australian *Biodiversity Conservation Act 2016*

The Wildlife Conservation (Specially Protected Fauna) Notice 2018 has been transitioned under regulations 170, 171 and 172 of the Biodiversity Conservation Regulations 2018 to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the Biodiversity Conservation Act 2016:

Threatened Species

- **Critically Endangered (CR):** Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines.
- **Endangered (EN):** Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines".

- **Vulnerable (VU):** Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines".

Extinct Species

- **Extinct Species (EX):** Species where "there is no reasonable doubt that the last member of the species has died"
- **Extinct in the wild (EW):** Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form"

Specially Protected Species

- **Migratory (MI):** Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth, excluding those already listed as Threatened under the criteria outlined above. Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program
- **Species of special conservation interest (conservation dependent fauna) (CD):** Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened.
- **Other specially protected fauna (OS):** Fauna otherwise in need of special protection to ensure their conservation

Department of Biodiversity, Conservation and Attractions Priority Listing

The DBCA maintains a list of Priority species that have not been assigned statutory protection under the *Biodiversity Conservation Act 2016*. Species on this list are considered to be of conservation priority because there is insufficient information to make an assessment of their conservation status or they are considered to be rare but not threatened and are in need of monitoring. Under this list, species are classified according to four Priority categories:

Priority 1: Poorly known species
Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.

Priority 2: Poorly known species
Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.

Priority 3: Poorly known species
Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

Priority 4: Rare, Near Threatened and other species in need of monitoring
(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands.

(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable, but are not listed as Conservation Dependent.

(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Appendix 2

Fauna Licences

Department of Biodiversity, Conservation and Attractions

GOVERNMENT OF WESTERN AUSTRALIA

FAUNA TAKING (BIOLOGICAL ASSESSMENT) LICENCE

Regulation 27, Biodiversity Conservation Regulations 2018

Licence Number: BA27000650-2

Licence Holder: Dr Sylvie Schmidt
Biota Environmental Sciences
Level 1 / 228 Carr Place
Leederville WA 6007

Date of Issue: 24/05/2022

Date Valid From: 23/05/2022
Date of Expiry: 31/05/2023

LICENSED ACTIVITIES

Subject to the terms and conditions on this licence, the licence holder may –

1. Take and disturb fauna for detailed fauna survey for Atlas Iron Pty Ltd to determine the fauna assemblage of the study area and the presence of conservation significant species to inform project planning and environmental impact assessment processes. Systematic trapping sites will comprise remote sensing cameras, ultrasonic bat detectors, acoustic recorders, spotlighting, dry pitfall trapping transects consisting of a single row of ten pitfall traps arranged as alternating 20 litre buckets and 150 mm diameter x 600 mm deep PVC tubes, spaced at approximately 9 m intervals and connected with a 90 m length of 300 mm high fly wire fence). One pair of funnel traps will be set at each end. Five Elliott box traps and one cage will also be deployed at the sites at approx. 20 m intervals parallel to the trapping fence, exact locations dependent on suitably shelter being available. Vertebrate fauna trapped may be temporarily held for the purposes of confirming identifications prior to release at capture site. Short range endemic (SRE) invertebrate survey to be undertaken using hand foraging with any specimens will lodged with WA Museum following any morphological and sequencing work. All proposed activities to be conducted in accordance with DBCA Standard Operating Procedures (SOPs) for fauna survey and monitoring techniques.

LOCATIONS

1. Pardoo And Ridley project areas located approximately 55 kilometres east of Port Hedland.

AUTHORISED PERSONS

The following persons or persons of the specified class may assist in carrying out the licensed activities:

1. Michael Greenham
2. Daniel Kamien
3. Roxanne De Vos
4. Joshua Keen
5. Nathan Beerkens
6. Peter Kendrick
7. Robert Hooper
8. Victoria Ford
9. John Graff

CONDITIONS

1. Fauna must not be taken on CALM land, (as defined in the Conservation and Land Management Regulations 2002*),* unless authorised by a written notice of a lawful authority issued under regulations 4 and 8 of the Conservation and Land Management Regulations 2002.
2. If persons, other than the licence holder, are authorised to carry out/assist in carrying out the activities under the licence, the licence holder must ensure those persons have read and understand the licence terms and conditions.
3. The written authorisation of the person in possession or occupation of the land accessed and upon which fauna is taken, as required under regulation 101(2) and referred to in "Additional information" below, must:
   a) state location details (including lot or location number, street/road, suburb and local government authority);
   b) state land owner or occupier name, and contact phone number;
   c) specify the time period that the authorisation is valid for;
   d) be signed and dated; and
   e) be attached to this licence at all times.
4. This licence, and any written authorisation or lawful authority which authorises the take of fauna on specified locations must be carried at all times while conducting licensed activities and be produced on demand by a wildlife officer.
5. If a species of fauna listed as a threatened species under Section 19 of the *Biodiversity Conservation Act 2016* is inadvertently captured, that species is to be released immediately at the point of capture. If the fauna is injured or deceased, the licence holder shall contact the DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au) for advice on treatment or disposal. Details of any capture of threatened fauna must be included in the "Return of Fauna Taken."
6. The licence holder must not:
   a) release any fauna in any area where it does not naturally occur;
   b) transfer fauna to any other person or authority (other than the Western Australian Museum) unless approved in writing by the CEO; or
   c) dispose of the remains of fauna in any manner likely to interfere the natural or present day distribution of the species.
7. The licence holder must not take and remove more than ten specimens of any one protected species of fauna from any location less than 20km apart. Where exceptional circumstances make it necessary to take a larger number of specimens from a particular location in order to obtain adequate statistical data, the collector must proceed with circumspection and justify their actions to the Director General in advance.
8. All holotypes and syntypes and a half share of paratypes of species or subspecies permitted to be permanently taken under this licence must be donated to the Western Australian Museum. Duplicates (one pair in each case) of any species collected, which represents a significant extension of geographic range must be offered to the Western Australian Museum.
9. All specimens and material retained under the authority of this licence must be offered to the Western Australian Museum for loan, for inclusion in its collection, or on request be made available to other persons involved in relevant scientific studies.
10. The licence holder must create, compile and maintain records and information as required in a DBCA approved "Return of Fauna Taken" of all fauna taking activities as they occur.
11. A DBCA approved "Return of Fauna Taken" must be completed in full (including nil taking details) and submitted to DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au) prior to the end of each annual period of the licence (from the valid from date) (refer to "Additional Information" section below).

Danny Stefoni
LICENSING OFFICER
WILDLIFE PROTECTION BRANCH

Delegate of CEO

ADDITIONAL INFORMATION

1. It is an offence to take any species of fauna listed as a threatened species under Section 19 of the *Biodiversity Conservation Act 2016* unless the person is authorised under Section 40. The penalty ranges between $300 000 and $500 000; Section 150 Biodiversity Conservation Act 2016.
2. Regulation 82 empowers the CEO to add, substitute or delete a term or condition of a licence or to correct errors. Such power may be exercised on application of a licence holder or by the CEO's own initiative. If an amendment to a licence term or condition is required, please contact the CEO or the Licensing Section on wildlifelicensing@dbca.wa.gov.au in the first instance. The licence holder, if adversely affected by a condition imposed in this licence, may apply to the State Administrative Tribunal for review of the decision of the CEO to impose that condition on a licence: regulation 89(2) Biodiversity Conservation Regulations 2018.
3. A person must not contravene a condition of a licence. The penalty for an offence involving the contravention of a condition of a licence is a fine of $10 000: regulation 84 of the Biodiversity Conservation Regulations 2018.
4. It is an offence for persons authorised by this licence to enter land that is not in their possession or under their control without first having the *prior* written authorisation of the current owner or occupier of the land to:

   a) enter the land; and

   b) carry out the activity authorised by this licence.

   The penalty for this offence is a fine of $5 000: regulation 101(2) of the Biodiversity Conservation Regulations 2018.
5. The licence holder must be able to produce for inspection upon request any information or records required by regulation 85(2) of the Biodiversity Conservation Regulations 2018 Penalty $10 000. It is an offence to knowingly include false or misleading information or make statements in records: regulation 85(3) of the Biodiversity Conservation Regulations 2018 Penalty $10 000. It is an offence to include any information or make any statement in a return that the licence holder knows to be false or misleading in a material particular: regulation 86 (2) of the Biodiversity Conservation Regulations 2018 Penalty $10 000.
6. The approved DBCA "Return of Fauna Taken" data file can be downloaded from the DBCA webpage (https://www.dpaw.wa.gov.au/plants-and-animals/licences-and-authorities).
7. The issuing of a licence under the Biodiversity Conservation Regulations 2018 does not constitute an animal ethics approval or a licence to use animals for scientific purposes as required under the *Animal Welfare Act 2002,* Animal Welfare (Scientific Purposes) Regulations 2003. It is the responsibility of a

licence applicant / licence holder to ensure that they comply with the requirements of all applicable legislation. Enquiries relating to the Animal Welfare Act licences and animal ethics approvals are to be directed to the Department of Primary Industries and Regional Development (https://www.agric.wa.gov.au/animalwelfare).

8. Threatened fauna can only be taken under a *Biodiversity Conservation Act 2016* Section 40 authorisation, Occurrences of threatened species must be reported to the CEO. For more information please see https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals.

9. Any interaction involving Nationally Listed Threatened Fauna that may be invasive and/or harmful to the fauna may require approval from the Commonwealth Department of the Environment and Energy http://www.environment.gov.au/about-us/business-us/permits-assessments-licences. Interaction with such species is controlled by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and Environment Protection and Biodiversity Conservation Regulations 2000 as well as the *Biodiversity Conservation Act 2016* and Biodiversity Conservation Regulations 2018.

GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

AUTHORISATION TO TAKE OR DISTURB THREATENED SPECIES

Section 40 of the Biodiversity Conservation Act 2016

AUTHORISATION DETAILS

Authorisation type: Fauna

Authorisation number: TFA 2022-0065

Authorisation duration: From date signed by Minister's delegate below until 31 May 2023.

AUTHORISATION HOLDER

Sylvie Schmidt
Biota Environmental Sciences
Level 1/228 Carr Place
Leederville WA 6007

AREA TO WHICH THIS AUTHORISATION APPLIES

Pardoo and Ridley project areas located approximately 55 kilometres east of Port Hedland. Pilbara Region.

AUTHORISED ACTIVITY

Purpose of taking/disturbance:

Detailed terrestrial fauna survey to determine the fauna assemblage of the study area and the presence of conservation significant species. Findings will inform project planning and environmental impact assessment processes.

Threatened species authorised to be taken/disturbed (including conservation status):

Pezoporus occidentalis, Night parrot (Critically Endangered)

Dasyurus hallucatus, Northern quoll (Endangered)

Liasis olivaceus barroni, Pilbara olive python (Vulnerable)

Macrotis lagotis, Bilby (Vulnerable)

Quantity of threatened species authorised to be taken/disturbed:

Any number of individual animals of the above listed threatened fauna species may potentially be captured and released during the trapping program and/or disturbed by the research activities.

Authorised taking/disturbance methodology:

Take northern quolls through the deployment of 14 cage traps and 170 Elliot traps placed in shaded areas under low vegetation for 7 nights.

Take Pilbara olive pythons through the deployment of 56 funnel traps and opportunistic hand capture at trap sites for 7 nights.

All traps will be covered with hessian, checked within 3 hours of sunrise and again in the afternoon. Traps will be closed if extreme weather is forecast including temperatures >35°C and heavy rain. Captured fauna will be released immediately at the capture site without further processing.

Disturb threatened fauna through the deployment of 20 remote sensor cameras baited with consumable lure. Cameras will be deployed for up to 12 nights.

Disturb night parrots through the deployment of 6 acoustic call recorders in suitable habitat for a minimum of 7 nights.

All activities will be conducted in accordance with DBCA Standard Operating Procedures (SOPs) for fauna survey and monitoring techniques.

ADDITIONAL AUTHORISED PERSONS

Michael Greenham	Joshua Keen	Robert Hooper
Daniel Kamien	Nathan Beerkens	Victoria Ford
Roxanne De Vos	Peter Kendrick	John Graff

Additional personnel who are suitably qualified and experienced in the authorised activities working under the direction of the Authorisation holder.

Field assistants assisting with the authorised activities working under the direct supervision of the Authorisation holder or suitably qualified and experienced named additional authorised person.

CONDITIONS

1. The written authorisation of the person in possession or occupation of the land accessed and upon which threatened fauna is taken or disturbed must:
   a) state location details (including lot or location number, street/road, suburb and local government authority);
   b) state land owner or occupier name, and contact phone number;
   c) specify the time period that the authorisation is valid for;
   d) be signed and dated; and
   e) be attached to this Authorisation to take or disturb threatened species at all times.
2. This Authorisation to take or disturb threatened species, and any other written authorisation or lawful authority which authorises the take or disturbance of fauna on specified locations for the authorised activities must be carried at all times while conducting authorised activities and be produced on demand by a wildlife officer.
3. Additional authorised persons who are not suitably qualified and experienced in the authorised activities, and field assistants assisting with the authorised activities, must be working under direct supervision of experienced and competent named authorised persons.
4. Any inadvertently captured species of non-target threatened fauna or non-threatened fauna (threatened fauna as defined in *Biodiversity Conservation Act 2016* Section 19) is to be released immediately at the point of capture. Details of such fauna must be included in the fauna taking/disturbance return as required under this Authorisation.

5. The Authorisation holder, unless specified in the authorised activities, must not:
   a) release any threatened fauna in any area where it does not naturally occur;
   b) transfer threatened fauna to any other person or authority (other than the Western Australian Museum) unless the fauna is injured or abandoned fauna (condition 6); or
   c) dispose of the remains of threatened fauna in any manner likely to confuse the natural or present-day distribution of the species.
6. All threatened fauna injuries, unexpected deaths, unplanned euthanasia, and abandoned young or eggs, must be reported by the Authorisation holder to the DBCA Wildlife Protection Branch, Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au) to notify of the incident and for advice on treatment or disposal. All deceased threatened fauna must be offered to the Western Australian Museum.
7. All holotypes and syntypes and a half share of paratypes of species or subspecies permitted to be permanently taken under this Authorisation must be donated to the Western Australian Museum. Duplicates (one pair in each case) of any species collected, which represents a significant extension of geographic range must be offered to the Western Australian Museum.
8. To prevent any unnecessary collecting in this State, all specimens and material taken and retained under this Authorisation, that remain at the conclusion of the activities, must be offered to the Western Australian Museum for loan, for inclusion in its collection, or made available to other persons involved in relevant scientific studies if so required.
9. The Authorisation holder must create, compile and maintain records and information as required in a DBCA approved "Return of Fauna Taken/Disturbed" of all fauna taking/disturbance activities as they occur.
10. A DBCA approved "Return of Fauna Taken/Disturbed" must be completed in full (including nil taking/disturbance details) and submitted to DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au) prior to the end of the Authorisation duration and, if the Authorisation duration is greater than 12 months, prior to the end of each annual period of the Authorisation (from the date signed by the Minister's delegate) (refer to "Additional Information" section below). Where a licence to take or disturb fauna is issued in conjunction with this Authorisation to take or disturb threatened species, a combined "Return of Fauna Taken/Disturbed" may be completed and submitted.
11. A written report detailing the undertaken authorised activities, outcome, unintended incidents, injuries and mortalities of threatened fauna, implemented monitoring, mitigation and management, and explaining the records and information as required in a DBCA approved "Return of Fauna Taken/Disturbed" must be submitted, in addition to a "Return of Fauna Taken/Disturbed" to DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au).

ADDITIONAL INFORMATION

1. Before undertaking the authorised activity, permission must be obtained from: (a) the owner or occupier of private land; or (b) the Department or Authority controlling Crown land, on which the Threatened Fauna occur. This includes obtaining the written endorsement from Department of Biodiversity, Conservation and Attractions (DBCA) if the authorised activity is proposed for land managed by DBCA.

2. This Authorisation to take or disturb threatened species does not constitute lawful authority issued under regulations 4 and 8 of the *Conservation and Land Management Regulations 2002*. Contact the applicable Department District Officer for further information.
3. The approved DBCA "Return of Fauna Taken/Disturbed" template can be obtained from DBCA Wildlife Licensing Section (wildlifelicensing@dbca.wa.gov.au).
4. Any interaction involving nationally listed threatened fauna that may be harmful to the fauna and/or invasive may require approval from the Commonwealth Department of the Environment and Energy (http://www.environment.gov.au/biodiversity/threatened/permits). Interaction with such species is controlled by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and *Environment Protection and Biodiversity Conservation Regulations 2000*.
5. It is the responsibility of the Authorisation holder to ensure that they comply with the requirements of all applicable legislation.
6. An Authorisation to take or disturb threatened species does not constitute an animal ethics approval or a licence to use animals for scientific purposes as required under the *Animal Welfare Act 2002, Animal Welfare (Scientific Purposes) Regulations 2003*. Enquiries relating to the Animal Welfare Act scientific purposes licence and animal ethics committee approvals are to be directed to the Western Australian Department of Primary Industries and Regional Development (https://www.agric.wa.gov.au/animalwelfare).

.....Margaret Byrne.....

Dr Margaret Byrne

Executive Director of Biodiversity and Conservation Science

AS DELEGATE OF THE MINISTER

DATE: ...18../...5...../2022

Appendix 3

Regional Fauna List

Mammals

FAMILY/Species	Common Name	Conservation Status		DBCA[1]	ALA	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth							
Tachyglossidae										
Tachyglossus aculeatus	Short-beaked Echidna			●	●			●		●
Dasyuridae										
Dasycercus blythi[2]	Brush-tailed Mulgara[2]	P4		●				●		
Dasykaluta rosamondae	Kaluta			●	●		●			●
Dasyurus hallucatus	Northern Quoll	EN	EN	●	●	●		●		●
Ningaui timealeyi	Pilbara Ningaui			●	●					●
Pseudantechinus woolleyae	Woolley's Pseudantechinus			●	●					
Sminthopsis macroura	Stripe-faced Dunnart			●	●					
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart			●	●		●			●
Thylacomyidae										
Macrotis lagotis	Bilby, Dalgyte	VU	VU	●		●				●
Macropodidae										
Lagorchestes conspicillatus	Spectacled Hare-wallaby	P4								●
Osphranter robustus[3]	Euro, Biggada			●	●		●	●		●
Osphranter rufus[3]	Red Kangaroo, Marlu			●	●			●		●
Petrogale rothschildi	Rothschild's Rock-wallaby			●						
Muridae										
Leggadina lakedownensis	Short-tailed Mouse	P4		●	●					
Mus musculus	House Mouse*			●	●		●	●		●
Notomys alexis	Spinifex Hopping-mouse			●			●			●
Pseudomys chapmani	Western Pebble-mound Mouse	P4		●				●		●
Pseudomys delicatulus	Delicate Mouse									●
Pseudomys desertor	Desert Mouse			●	●		●	●		●
Pseudomys hermannsburgensis	Sandy Inland Mouse			●	●					●

FAMILY/Species	Common Name	Conservation Status		DBCA[1]	ALA	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth							
Zyzomys argurus	Common Rock-rat			●	●					●
Leporidae										
Oryctolagus cuniculus	Rabbit*							●		
Pteropodidae										
Pteropus scapulatus	Little Red Flying-fox			●	●					●
Hipposideridae										
Rhinonicteris aurantia (Pilbara form)	Pilbara Leaf-nosed Bat	VU	VU	●		●				●
Megadermatidae										
Macroderma gigas	Ghost Bat	VU	VU	●		●				
Emballonuridae										
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat								●	●
Taphozous georgianus	Common Sheath-tailed Bat			●				●	●	●
Molossidae										
Austronomus australis[4]	White-striped Free-tailed Bat									●
Chaerephon jobensis	Greater Northern Free-tailed Bat									●
Ozimops cobourgianus[5]	Northern Coastal Free-tailed Bat	P1		●			●			
Ozimops lumsdenae[6]	Northern Free-tailed Bat									●
Vespertilionidae										
Chalinolobus gouldii	Gould's Wattled Bat			●					●	●
Nyctophilus geoffroyi	Lesser Long-eared Bat									●
Scotorepens greyii	Little Broad-nosed Bat			●					●	●
Vespadelus finlaysoni	Finlayson's Cave-bat			●			●		●	●
Canidae										
Canis familiaris[7]	Dog/Dingo*			●			●	●	●	●
Vulpes vulpes	Red Fox*			●			●	●		

FAMILY/Species	Common Name	Conservation Status		DBCA[1]	ALA	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth							
Felidae										
Felis catus	Cat*			●				●	●	●
Camelidae										
Camelus dromedarius	Dromedary, Camel*									●
Bovidae										
Bos primigenius taurus[8]	European Cattle*			●						

* Introduced
[1] Includes the NatureMap and Threatened and Priority Fauna databases.
[2] Some previous records attributed to *D. cristicauda* (Crest-tailed Mulgara; formerly Mulgara)
[3] Previously placed in genus *Macropus*, some previous records listed as such.
[4] Previously placed in genus *Tadarida*, some previous records listed as such.
[5] Previously included as a subspecies of *Mormopterus loriae* (*M. l. cobourgianus*), some previous records listed as such.
[6] Previously included within *Mormopterus beccarii*, some previous records listed as such.
[7] Previously treated as *C. lupus familiaris* (Dog) and *C. lupus dingo* or *C. dingo* (Dingo), some previous records listed as such.
[8] Previously treated as distinct species *B. taurus*, most previous records listed as such.

Birds

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Casuariidae											
Dromaius novaehollandiae	Emu			●	●	●		●	●		●
Anatidae											
Dendrocygna eytoni	Plumed Whistling Duck			●	●	●				●	
Cygnus atratus	Black Swan			●	●	●					
Malacorhynchus membranaceus	Pink-eared Duck			●	●						
Chenonetta jubata	Maned Duck			●	●	●					
Anas superciliosa	Pacific Black Duck			●	●	●			●		●
Anas gracilis	Grey Teal			●	●	●			●	●	
Aythya australis	Hardhead			●	●	●					
Phasianidae											
Coturnix ypsilophora	Brown Quail			●	●	●			●		●
Coturnix pectoralis	Stubble Quail			●	●						
Caprimulgidae											
Eurostopodus argus	Spotted Nightjar			●	●	●			●		●
Podargidae											
Podargus strigoides	Tawny Frogmouth			●	●	●					
Aegothelidae											
Aegotheles cristatus	Australian Owlet-nightjar			●	●	●			●		●
Apodidae											
Apus pacificus	Pacific Swift[2]	MI	MI	●	●						
Otididae											
Ardeotis australis	Australian Bustard			●	●	●		●		●	●
Cuculidae											
Centropus phasianinus	Pheasant Coucal			●	●	●					

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Chrysococcyx basalis	Horsfield's Bronze Cuckoo			●	●	●			●	●	
Chrysococcyx osculans	Black-eared Cuckoo			●			●	●			
Cacomantis pallidus	Pallid Cuckoo			●	●	●			●		●
Cuculus optatus	Oriental Cuckoo	MI	MI				●				
Columbidae											
Columba livia	Rock Dove [Feral Pigeon]			●		●				●	
Phaps chalcoptera	Common Bronzewing				●	●				●	
Phaps histrionica	Flock Bronzewing			●	●						
Ocyphaps lophotes	Crested Pigeon			●	●	●		●		●	●
Geophaps plumifera	Spinifex Pigeon			●	●	●			●		●
Geopelia cuneata	Diamond Dove			●	●	●		●	●		●
Geopelia placida	Peaceful Dove			●	●	●		●	●	●	
Geopelia humeralis	Bar-shouldered Dove			●	●	●					
Rallidae											
Hypotaenidia philippensis	Buff-banded Rail			●	●	●					
Fulica atra	Eurasian Coot			●	●	●					
Gruidae											
Antigone rubicunda	Brolga			●	●	●			●		
Podicipedidae											
Tachybaptus novaehollandiae	Australasian Grebe			●	●					●	
Poliocephalus poliocephalus	Hoary-headed Grebe			●	●	●					
Podiceps cristatus	Great Crested Grebe				●						
Turnicidae											
Turnix pyrrhothorax	Red-chested Buttonquail			●	●						
Turnix velox	Little Buttonquail			●	●	●		●	●		●
Burhinidae											
Burhinus grallarius	Bush Stone-curlew			●	●					●	

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Esacus magnirostris	Beach Stone-curlew			●	●	●					
Haematopodidae											
Haematopus longirostris	Pied Oystercatcher			●	●	●					
Haematopus fuliginosus	Sooty Oystercatcher			●	●	●					
Recurvirostridae											
Himantopus leucocephalus[3]	Pied Stilt[3]			●	●	●	●			●	
Cladorhynchus leucocephalus	Banded Stilt			●	●	●				●	
Recurvirostra novaehollandiae	Red-necked Avocet			●	●	●	●				
Charadriidae											
Vanellus tricolor	Banded Lapwing									●	●
Vanellus miles	Masked Lapwing			●	●	●					
Erythrogonys cinctus	Red-kneed Dotterel			●	●	●				●	
Pluvialis fulva	Pacific Golden Plover	MI	MI	●	●	●	●				
Pluvialis squatarola	Grey Plover	MI	MI	●	●	●	●				
Charadrius ruficapillus	Red-capped Plover			●	●	●	●	●		●	
Charadrius mongolus	Lesser Sand Plover	EN^	EN; MI	●	●	●	●				
Charadrius leschenaultii	Greater Sand Plover	VU^	VU; MI	●	●	●	●				
Charadrius veredus	Oriental Plover	MI	MI	●	●	●	●	●			
Elseyornis melanops	Black-fronted Dotterel			●	●	●			●	●	
Rostratulidae											
Rostratula australis[4]	Australian Painted Snipe[4]	EN	EN		●		●				
Scolopacidae											
Numenius phaeopus	Eurasian Whimbrel[5]	MI	MI	●	●	●	●				
Numenius minutus	Little Curlew	MI	MI	●	●		●				
Numenius madagascariensis	Far Eastern Curlew[6]	CR^	CR; MI	●	●	●	●				
Limosa lapponica	Bar-tailed Godwit	CR^,[7]	CR[7]; MI	●	●	●	●				
Limosa limosa	Black-tailed Godwit	MI	MI	●	●	●					

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Arenaria interpres	Ruddy Turnstone	MI	MI	●	●	●	●				
Calidris tenuirostris	Great Knot	CR^	CR; MI	●	●	●	●				
Calidris canutus	Red Knot	EN^	EN; MI	●	●	●	●				
Calidris pugnax	Ruff	MI	MI	●		●					
Calidris falcinellus	Broad-billed Sandpiper	MI	MI	●	●	●	●				
Calidris acuminata	Sharp-tailed Sandpiper	MI	MI	●	●	●	●				
Calidris ferruginea	Curlew Sandpiper	CR^	CR; MI	●	●	●	●				
Calidris subminuta	Long-toed Stint	MI	MI	●	●	●					
Calidris ruficollis	Red-necked Stint	MI	MI	●	●	●	●			●	
Calidris alba	Sanderling	MI	MI	●	●	●					
Calidris melanotos	Pectoral Sandpiper	MI	MI	●	●		●				
Limnodromus semipalmatus	Asian Dowitcher	MI	MI	●	●	●	●				
Gallinago megala	Swinhoe's Snipe	MI	MI	●							
Xenus cinereus	Terek Sandpiper	MI	MI	●	●	●	●				
Phalaropus lobatus	Red-necked Phalarope	MI	MI	●	●	●	●				
Actitis hypoleucos	Common Sandpiper	MI	MI	●	●	●	●				
Tringa brevipes	Grey-tailed Tattler	MI; P4	MI	●	●	●	●				
Tringa totanus	Common Redshank	MI	MI		●	●					
Tringa stagnatilis	Marsh Sandpiper	MI	MI	●	●	●	●				
Tringa glareola	Wood Sandpiper	MI	MI	●	●	●					
Tringa nebularia	Common Greenshank	MI	MI	●	●	●	●				
Glareolidae											
Stiltia isabella	Australian Pratincole			●	●	●					
Glareola maldivarum	Oriental Pratincole	MI	MI	●	●	●	●				
Laridae											
Chroicocephalus novaehollandiae	Silver Gull			●	●	●				●	

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Gelochelidon [nilotica][7]	Gull-billed Tern[7]	MI	MI	●	●	●				●	
Hydroprogne caspia	Caspian Tern	MI	MI	●	●	●				●	
Thalasseus bergii	Greater Crested Tern	MI	MI	●	●	●					
Thalasseus bengalensis	Lesser Crested Tern			●	●	●					
Sternula albifrons	Little Tern	MI	MI	●	●	●	●				
Sterna hirundo	Common Tern	MI	MI	●	●	●					
Chlidonias hybrida	Whiskered Tern			●	●	●					
Chlidonias leucopterus	White-winged Tern[8]	MI	MI	●	●	●					
Ciconiidae											
Ephippiorhynchus asiaticus	Black-necked Stork			●	●	●				●	●
Fregatidae											
Fregata ariel	Lesser Frigatebird	MI	MI	●	●	●	●				
Anhingidae											
Anhinga novaehollandiae[9]	Australasian Darter[9]			●	●	●					
Phalacrocoracidae											
Microcarbo melanoleucos	Little Pied Cormorant			●	●	●					
Phalacrocorax varius	Australian Pied Cormorant			●	●	●				●	
Phalacrocorax sulcirostris	Little Black Cormorant			●	●	●					
Phalacrocorax carbo	Great Cormorant			●	●	●					
Threskiornithidae											
Threskiornis molucca	Australian White Ibis			●	●	●					
Threskiornis spinicollis	Straw-necked Ibis			●	●	●				●	
Plegadis falcinellus	Glossy Ibis	MI	MI	●	●	●					
Platalea regia	Royal Spoonbill			●	●	●					
Platalea flavipes	Yellow-billed Spoonbill			●	●	●					
Ardeidae											
Ixobrychus flavicollis	Black Bittern				●						

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Nycticorax caledonicus	Nankeen Night Heron			●	●	●					
Butorides striata	Striated Heron			●	●	●				●	
Bubulcus coromandus	Eastern Cattle Egret				●	●				●	
Ardea pacifica	White-necked Heron			●	●	●				●	
Ardea alba	Great Egret			●	●	●			●		
Ardea intermedia	Intermediate Egret			●	●	●					
Egretta novaehollandiae	White-faced Heron			●	●	●			●		
Egretta garzetta	Little Egret			●	●	●					●
Egretta sacra	Pacific Reef Heron			●	●	●					
Pelecanidae											
Pelecanus conspicillatus	Australian Pelican			●	●	●				●	●
Pandionidae											
Pandion cristatus[10]	Eastern Osprey[10]	MI	MI	●	●	●		●		●	
Accipitridae											
Elanus axillaris[11]	Black-shouldered Kite			●	●	●			●		●
Elanus scriptus	Letter-winged Kite	P4			●	●					
Hamirostra melanosternon	Black-breasted Buzzard			●	●	●					
Hieraaetus morphnoides	Little Eagle			●	●	●			●	●	
Aquila audax	Wedge-tailed Eagle			●	●	●			●		
Accipiter fasciatus	Brown Goshawk			●	●	●			●		
Accipiter cirrocephalus	Collared Sparrowhawk			●	●	●					
Circus approximans	Swamp Harrier			●	●	●				●	
Circus assimilis	Spotted Harrier			●	●	●			●	●	●
Milvus migrans	Black Kite			●	●	●			●	●	
Haliastur sphenurus	Whistling Kite			●	●	●			●	●	●
Haliastur indus	Brahminy Kite			●	●	●		●		●	
Haliaeetus leucogaster	White-bellied Sea Eagle			●	●	●				●	

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Tytonidae											
Tyto javanica[12]	Eastern Barn Owl[12]				●	●					●
Strigidae											
Ninox connivens	Barking Owl			●	●	●					
Ninox boobook[13]	Australian Boobook[13]			●	●	●					
Alcedinidae											
Dacelo leachii	Blue-winged Kookaburra			●	●	●			●	●	●
Todiramphus sordidus[14]	Torresian Kingfisher[14]				●	●					
Todiramphus sanctus	Sacred Kingfisher			●	●	●			●	●	
Todiramphus pyrrhopygius	Red-backed Kingfisher			●	●	●			●	●	●
Meropidae											
Merops ornatus	Rainbow Bee-eater			●	●	●	●	●	●	●	●
Falconidae											
Falco cenchroides	Nankeen Kestrel			●	●	●		●	●	●	●
Falco longipennis	Australian Hobby			●	●	●			●	●	
Falco berigora	Brown Falcon			●	●	●			●	●	●
Falco hypoleucos	Grey Falcon	VU	VU	●			●				
Falco peregrinus	Peregrine Falcon	OS		●	●				●		
Cacatuidae											
Nymphicus hollandicus	Cockatiel			●	●	●			●	●	●
Eolophus roseicapilla	Galah			●	●	●			●	●	●
Cacatua sanguinea	Little Corella			●	●	●				●	●
Psittaculidae											
Barnardius zonarius	Australian Ringneck			●	●	●			●	●	
Pezoporus occidentalis	Night Parrot	CR	EN				●				
Melopsittacus undulatus	Budgerigar			●	●	●			●	●	●
Ptilonorhynchidae											

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Chlamydera guttata[15]	Western Bowerbird[15]			●	●	●					
Climacteridae											
Climacteris melanurus	Black-tailed Treecreeper			●	●	●			●		
Maluridae											
Malurus assimilis[16]	Purple-backed Fairywren[16]			●	●	●		●		●	●
Malurus leucopterus	White-winged Fairywren			●	●	●		●	●	●	
Stipiturus ruficeps	Rufous-crowned Emu-wren			●							
Amytornis whitei[17]	Rufous Grasswren[17]			●							
Meliphagidae											
Epthianura tricolor	Crimson Chat			●	●	●					
Epthianura aurifrons	Orange Chat			●	●	●		●			
Certhionyx variegatus	Pied Honeyeater			●		●					●
Sugomel niger	Black Honeyeater			●		●					
Philemon citreogularis	Little Friarbird			●							
Lichmera indistincta	Brown Honeyeater			●	●	●			●	●	●
Melithreptus gularis	Black-chinned Honeyeater			●	●	●					
Gavicalis virescens	Singing Honeyeater			●	●	●		●	●	●	●
Ptilotula keartlandi	Grey-headed Honeyeater			●	●	●					●
Ptilotula penicillata	White-plumed Honeyeater			●	●	●		●	●	●	●
Acanthagenys rufogularis	Spiny-cheeked Honeyeater			●							
Manorina flavigula	Yellow-throated Miner			●	●	●			●	●	●
Pardalotidae											
Pardalotus rubricatus	Red-browed Pardalote			●	●	●		●	●	●	
Pardalotus striatus	Striated Pardalote			●	●	●					
Acanthizidae											
Smicrornis brevirostris	Weebill			●	●						●
Gerygone fusca	Western Gerygone			●	●	●					

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Gerygone tenebrosa	Dusky Gerygone			●	●	●					
Pomatostomidae											
Pomatostomus temporalis	Grey-crowned Babbler			●	●	●			●		●
Artamidae											
Artamus leucorynchus	White-breasted Woodswallow			●	●	●		●		●	
Artamus personatus	Masked Woodswallow			●	●	●			●		
Artamus cinereus	Black-faced Woodswallow			●	●	●		●	●	●	●
Artamus minor	Little Woodswallow			●	●	●			●		
Gymnorhina tibicen	Australian Magpie			●	●						
Cracticus torquatus	Grey Butcherbird			●	●						
Cracticus nigrogularis	Pied Butcherbird			●	●	●			●	●	
Campephagidae											
Coracina novaehollandiae	Black-faced Cuckooshrike			●	●	●		●	●	●	●
Lalage tricolor[18]	White-winged Triller			●	●	●		●	●	●	●
Neosittidae											
Daphoenositta chrysoptera	Varied Sittella			●							
Oreoicidae											
Oreoica gutturalis	Crested Bellbird			●	●	●					
Pachycephalidae											
Pachycephala melanura	Mangrove Golden Whistler			●	●	●					
Pachycephala rufiventris	Rufous Whistler			●	●	●		●			
Pachycephala lanioides	White-breasted Whistler			●	●	●					
Colluricincla harmonica	Grey Shrikethrush			●	●	●				●	
Rhipiduridae											
Rhipidura leucophrys	Willie Wagtail			●	●	●			●	●	●
Rhipidura albiscapa	Grey Fantail			●	●	●					
Rhipidura phasiana	Mangrove Fantail[19]			●	●	●					

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Monarchidae											
Grallina cyanoleuca	Magpie-lark			●	●	●		●	●	●	●
Corvidae											
Corvus orru	Torresian Crow			●	●	●		●	●	●	
Corvus bennetti	Little Crow			●	●						●
Petroicidae											
Melanodryas cucullata	Hooded Robin			●	●						
Peneothello pulverulenta	Mangrove Robin			●		●					
Petroica goodenovii	Red-capped Robin			●	●						
Alaudidae											
Mirafra javanica	Horsfield's Bush Lark			●	●	●		●	●		
Hirundinidae											
Cheramoeca leucosterna	White-backed Swallow			●	●					●	
Hirundo neoxena	Welcome Swallow			●	●	●					
Hirundo rustica	Barn Swallow	MI	MI	●	●		●				
Petrochelidon ariel	Fairy Martin			●	●	●				●	
Petrochelidon nigricans	Tree Martin			●	●	●			●	●	
Acrocephalidae											
Acrocephalus australis[20]	Australian Reed Warbler[20]			●	●						
Locustellidae											
Poodytes carteri	Spinifexbird			●		●			●	●	●
Cincloramphus cruralis	Brown Songlark			●	●	●				●	
Cincloramphus mathewsi	Rufous Songlark			●	●	●		●	●	●	
Zosteropidae											
Zosterops luteus	Canary White-eye[21]			●	●	●		●		●	
Dicaeidae											
Dicaeum hirundinaceum	Mistletoebird			●	●						

FAMILY/Species	Common Name	Conservation status		DBCA [1]	ALA	eBird	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth								
Estrildidae											
Heteromunia pectoralis	Pictorella Mannikin			●							
Emblema pictum	Painted Finch			●	●	●			●		
Bathilda ruficauda	Star Finch			●	●	●					
Taeniopygia castanotis[22]	Australian Zebra Finch[22]			●	●	●		●	●	●	●
Motacillidae											
Motacilla tschutschensis[23]	Eastern Yellow Wagtail[23]	MI	MI		●	●	●				
Motacilla cinerea	Grey Wagtail	MI	MI				●				
Anthus australis[24]	Australian Pipit[24]			●	●	●		●	●		●

The following species have not been included: Southern Giant Petrel (obligate marine species in Australia), Eurasian Wigeon (vagrant to Australia), Grey-fronted Honeyeater (egular occurrence not proven in Pilbara region; photographs of putative individuals thus far all referrable to Grey-headed Honeyeater), Rainbow Lorikeet (aviary escapee or data error), Australian Raven (significantly outside range, likely misidentification or data error), and Western Thornbill (significantly outside range, likely misidentification or data error)

^ The Migratory listing under the BC Act has been repealed for species also listed as Threatened, but note that these species still satisfy all other criteria for Migratory listing in addition to the criteria for their threatened listings.

[1] Includes the NatureMap and Threatened and Priority Fauna databases.
[2] Previously referred to as Fork-tailed Swift, prior to taxonomic revision separating several species from *A. pacificus*.
[3] Previously treated as a subspecies of Black-winged Stilt (*H. himantopus*).
[4] Previously treated as a subspecies of (Greater) Painted Snipe (*R. benghalensis*).
[5] Previously referred to as Whimbrel, prior to revision of Hudsonian Whimbrel as separate species.
[6] Also known as Eastern Curlew.
[7] Two taxa in Australia, now treated as two species by many authorities, Australian [Gull-billed] Tern (*G. [nilotica] macrotarsa*) and [Common] Gull-billed Tern (*G. nilotica affinis*). Retained together here as many previous records do not indicate the taxon involved.
[8] Also known as White-winged Black Tern
[9] Previously treated as subspecies of [Oriental] Darter *A. melanogaster*.
[10] Previously treated as subspecies of [Western] Osprey *P. haliaetus*. May revert to this taxonomic treatment in near future.
[11] Previously included within *E. caerulus* (now known as Black-winged Kite).
[12] Previously treated as subspecies of Barn Owl *T. alba*.
[13] Previously treated as Southern Boobook (*N. novaeseelandiae*) and Southern Boobook (*N. boobook*) prior to taxonomic revisions.
[14] Previously treated as subspecies of Collared Kingfisher (*T. chloris*).
[15] Treated as subspecies of Spotted Bowerbird (*C. maculata*) by some authorities.
[16] Previously treated as subspecies of Variegated Fairywren (*M. lamberti*).
[17] Previously treated as subspecies of Striated Grasswren (*A. striatus*).

[18] Previouly treated as subspecies of *L. sueurii*.
[19] Also known as Mangrove Grey Fantail.
[20] Previously treated as subspecies of Clamorous Reed Warbler *A. clamosus*.
[21] Also known as Yellow White-eye.
[22] Previously treated as subspecies of [Sunda] Zebra Finch *T. guttata*.
[23] Previously treated as subspecies of [Western] Yellow Wagtail *M. flava*.
[24] Previously treated as subspecies of Richard's Pipit *A. richardi* then Australasian Pipit *A. novaeseelandiae*.

Reptiles

FAMILY/Species	Common Name	Conservation status		DBCA[1]	ALA	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth							
Chelidae										
Chelodina steindachneri	Flat-shelled Turtle				●					
Carphodactylidae										
Nephrurus levis				●	●		●			
Diplodactylidae										
Diplodactylus laevis[2]	Desert Fat-tailed Gecko[2]			●	●		●	●		●
Lucasium stenodactylus[3]	Western Sandplain Gecko[3]			●	●		●			●
Lucasium woodwardi[3]	Pilbara Ground Gecko[3]			●						
Rhynchoedura ornata	Western Beaked Gecko			●	●		●			●
Strophurus ciliaris							●			
Strophurus elderi				●	●					
Strophurus jeanae				●	●		●			
Gekkonidae										
Gehyra incognita[4]	Northern Pilbara Cryptic Gehyra[4]				●					●
Gehyra macra[5]	Large Pilbara Rock Gehyra[5]									●
Gehyra media[5]	Medium Pilbara Spotted Rock Gehyra[5]				●					
Gehyra montium[4]					●					●
Gehyra pilbara				●	●		●			
Gehyra punctata[5]				●	●			●	●	●
Gehyra purpurascens[4]				●			●			
Gehyra variegata[4]				●	●		●	●	●	
Heteronotia binoei	Bynoe's Gecko			●	●		●	●	●	●
Heteronotia spelea	Pilbara Cave Gecko			●						
Pygopodidae										

FAMILY/Species	Common Name	Conservation status		DBCA[1]	ALA	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth							
Delma borea				●	●					
Delma butleri[6]				●	●		●		●	
Delma nasuta				●	●					
Delma pax				●	●		●			●
Delma tincta				●	●		●	●		●
Lialis burtonis				●	●			●		●
Pygopus nigriceps				●	●					●
Agamidae										
Ctenophorus caudicinctus	Ring-tailed Dragon			●	●			●	●	●
Ctenophorus isolepis	Military Dragon			●	●		●	●	●	●
Ctenophorus nuchalis	Central Netted Dragon			●	●		●	●	●	●
Diporiphora pindan	Pindan Dragon			●	●					
Diporiphora vescus[7]	Northern Pilbara Tree Dragon[7]			●	●					●
Gowidon longirostris[8]	Long-nosed Dragon[8]			●	●		●	●	●	●
Pogona minor				●	●					●
Scincidae										
Carlia munda									●	
Carlia triacantha				●	●		●			●
Ctenotus angusticeps		P3		●						
Ctenotus duricola				●	●					●
Ctenotus grandis				●	●		●			●
Ctenotus hanloni				●	●					
Ctenotus helenae[9]				●	●					●
Ctenotus pantherinus	Leopard Ctenotus			●	●		●	●	●	●
Ctenotus piankai				●			●			●
Ctenotus saxatilis	Rock Ctenotus			●			●	●	●	●

FAMILY/Species	Common Name	Conservation status		DBCA[1]	ALA	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth							
Ctenotus serventyi				●	●		●			
Egernia epsisolus[10]	Eastern Pilbara Spiny-tailed Skink[10]							●	●	●
Eremiascincus musivus	Mosaic Desert Skink			●	●				●	●
Eremiascincus pallidus[11]	Western Narrow-banded Skink[11]			●	●		●			
Eremiascincus richardsonii	Broad-banded Sand Swimmer			●	●					
Lerista bipes				●	●		●		●	●
Lerista clara				●	●		●			
Lerista jacksoni				●	●		●	●		
Lerista muelleri				●						
Menetia greyii				●	●		●			●
Morethia ruficauda				●	●				●	●
Notoscincus ornatus				●	●					
Proablepharus reginae				●	●					●
Tiliqua multifasciata	Central Blue-tongue			●	●		●			●
Varanidae										
Varanus acanthurus	Spiny-tailed Goanna			●	●		●	●	●	●
Varanus brevicauda	Short-tailed Pygmy Goanna			●	●		●			●
Varanus eremius	Pygmy Desert Goanna			●	●		●			●
Varanus giganteus	Perentie			●						
Varanus gouldii	Bungarra or Sand Goanna			●			●			●
Varanus panoptes	Yellow-spotted Goanna				●					
Varanus pilbarensis	Northern Pilbara Rock Goanna			●				●		
Varanus tristis	Racehorse Goanna				●					
Typhlopidae										
Anilios ammodytes				●	●					●
Anilios grypus				●	●					●

FAMILY/Species	Common Name	Conservation status		DBCA[1]	ALA	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth							
Anilios pilbarensis				●	●					
Pythonidae										
Antaresia childreni[12]	Children's Python[12]			●	●			●		●
Antaresia perthensis	Pygmy Python			●	●			●		
Aspidites melanocephalus	Black-headed Python								●	
Aspidites ramsayi	Woma								●	
Liasis olivaceus barroni	Pilbara Olive Python	VU	VU	●		●	●	●		
Elapidae										
Acanthophis pyrrhus	Desert Death Adder				●			●		
Brachyurophis approximans				●	●					
Demansia psammophis	Yellow-faced Whipsnake				●			●		●
Demansia rufescens	Rufous Whipsnake									●
Furina ornata	Moon Snake			●	●				●	●
Pseudechis australis	Mulga Snake			●	●		●			●
Pseudonaja mengdeni[13]	Western Brown Snake[13]			●	●			●	●	
Pseudonaja modesta	Ringed Brown Snake			●	●					●
Simoselaps anomalus	Desert Banded Snake				●		●			●
Suta punctata	Spotted Snake			●	●			●		
Ephalophis greyae				●						

Note: Flatback Turtle (*Natator depressus*) not included as is a marine species

[1] Includes the NatureMap and Threatened and Priority Fauna databases.
[2] Previously included within *D. conspicillatus*, animals in this area likely all referrable to *D. laevis*.
[3] Previously treated as a subspecies of *L. stenodactylus*, most or all individuals in locality likely referrable to *L. woodwardi*, but in proximity to the limit of *L. stenodactylus* published range so this species may also occur and has been retained in this list.
[4] Following revision of *G. variegata*, *G. montium* and *G. purpurescens* group, records from locality likely referrable to *G. incognita* and *G. montium*, but *G. variegate* and *G. purpurescens* retained in list as distribution limits do approach locality.
[5] All previously included within *G. punctata*, records from locality likely all referrable to *G. macra* or *G. media*, but *G. punctata* retained in list as distribution limit does approach locality.
[6] Includes *D. haroldi*.

[7] Previously included within *D. valens*.
[8] Previously placed in genera *Amphibolurus* and *Lophognathus*.
[9] Sometimes treated as conspecific with *C. inornatus*.
[10] Previously included within *E. depressa*.
[11] Previously included within *E. fasciolatus*.
[12] Previously treated as a distinct species, Stimson's Python *A. stimsoni*.
[13] Previously included within Northern Brown Snake *P. nuchalis*.

Amphibians

FAMILY/Species	Common Name	Conservation status		DBCA[1]	ALA	EPBC	Biota (2006)	Bamford et al. (2010)	ENV (2011)	Biota unpub.
		State	C'wealth							
Hylidae										
Cyclorana australis	Giant Frog			●	●		●	●		
Cyclorana maini	Sheep Frog			●	●			●		
Pelodryadidae										
Litoria caerulea	Green Tree Frog								●	
Litoria rubella	Little Red Tree Frog							●	●	●
Limnodynastidae										
Neobatrachus aquilonius	Northern Burrowing Frog			●	●					
Notaden nichollsi	Desert Spadefoot			●	●		●	●		
Platyplectrum spenceri	Centralian Burrowing Frog			●	●		●			●
Myobatrachidae										
Uperoleia glandulosa	Glandular Toadlet			●	●					
Uperoleia micromeles	Tanami Toadlet			●	●					
Uperoleia talpa	Ratcheting Toadlet			●	●					

[1] Includes the NatureMap and Threatened and Priority Fauna databases

Appendix 4

SRE Molecular Report (Helix 2023)

Helix
Molecular
Solutions

Molecular Systematics of the Pardoo and Ridley Short-range Endemic Invertebrates

Prepared for Biota Environmental Sciences

January 2023

Author: Dr Karen Cullen
Dr Zoë Hamilton

Quality Checking History

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Molecular Systematics of the Pardoo and Ridley SRE Invertebrates

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1.0 Executive Summary

Biota Environmental Sciences has conducted a targeted short-range endemic (SRE) invertebrate fauna search of the Pardoo and Ridley survey area, which yielded nine Mygalomorphae spider specimens, four terrestrial isopod specimens, and six camaenid land snails based on morphological character traits.

The infraorder Mygalomorphae, which includes trapdoor spiders and their kin, are frequently identified as SREs, as are many species of Camaenidae land snails and terrestrial Isopoda. Biota Environmental Sciences engaged Helix Molecular Solutions to perform DNA extractions, sequencing of the mitochondrial cytochrome oxidase subunit I gene (COI) and analyses of the specimens from the Pardoo and Ridley survey area. The objective of this was to gain information on the number of potential species and their apparent distributions, based on the molecular genetic data available for comparison. Mygalomorphae spider specimens belonging to the family Idiopidae were also sequenced for Cytochrome b (CYB) to provide confident phylogenetic placement in this group.

Mygalomorphae - family Idiopidae and Anamidae
The nine specimens identified as Mygalomorphae were collected from four sampling locations within the survey area. Two specimens that were originally identified as belonging to the family Halonoproctidae and one specimen as Anamidae, were later reassigned to the family Idiopidae following preliminary analysis and were sequenced for both COI and CYB gene regions. The three idiopid specimens were analysed along with 201 reference specimens (Helix database n=102 and GenBank n=99) for COI, and 191 reference specimens (Helix database n=36 and GenBank n=155) for CYB. All three specimens are confirmed to belong within the genus *Idiosoma* (previously *Aganippe*) and represent one distinct lineage *Idiosoma* **H-I82*** that has not previously been detected.

Of the remaining six specimens that were identified as anamids, five were successfully sequenced and analysed along with 702 reference specimens (Helix database n=251 and GenBank n=451). All five specimens are confirmed to belong within the genus *Kwonkan*, with two distinct lineages identified (*Kwonkan* **H-N168*** and *Kwonkan* **H=N169*),** both of which were newly detected.

Isopoda– family Armadillidae
Four specimens of terrestrial isopod belonging to the family Armadillidae were collected from one location within the survey area. Of these, three specimens yielded successful COI sequences and were analysed along with 108 reference specimens (Helix database n=68 and GenBank n=40). Two new lineages were detected (Armadillidae **H-ISA64*** and Armadillidae **H-ISA65*),** which are likely to represent two different genera. The lineage Armadillidae **H-ISA64*** possibly belongs within the genus *Buddelundia* based on available reference specimens on GenBank, while Armadillidae **H-ISA65*** could not be confidently assigned to a known genus. Further taxonomic and genetic analysis is needed to determine confident phylogenetic placement within this group.

Gastropoda – family Camaenidae
The six specimens identified as Camaenidae were collected from two sampling locations within the survey area. Of these, five yielded COI sequences and were analysed along with 146 reference specimens (Helix database n=25; and GenBank n=121). All five specimens were confirmed to belong within the genus *Rhagada* and represent one distinct lineage *Rhagada* **H-SB020***that has not previously been detected.

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2.0 Background and Objectives

Biota Environmental sciences engaged Helix Molecular Solutions to undertake DNA extractions of terrestrial invertebrate fauna collected from a targeted short-range endemic (SRE) survey within the Pardoo and Ridley survey Area. Specimens were to be sequenced for variation at the mitochondrial cytochrome oxidase subunit I gene (COI), and for any mygalomorph spider specimens belonging to the family Idiopidae or Halonoproctidae, an additional inhouse primer set for the mitochondrial cytochrome b gene (CYB) was to be used. Analysis was undertaken to elucidate the taxonomic/phylogenetic relationships amongst the potential SRE invertebrate fauna.

A total of 19 invertebrate fauna specimens from six sites were collected within the Pardoo/Ridley survey area in the Pilbara. Nine specimens of invertebrate fauna belonging to two families of mygalomorph spider (Araneae: Mygalomorphae: Anamidae and Idiopidae), four specimens belonging to an unknown family of terrestrial Isopoda (slaters), and six specimens belonging to one land snail family (Gastropoda: Camaenidae) were submitted to Helix Molecular Solutions for DNA extraction and sequencing. Successful molecular sequences were then assessed to determine the number of taxa present, and their apparent distribution based on comparisons with available molecular genetic data.

This report provides a synopsis of the relationships between successfully sequenced specimens, including the number of putative species, based on the available molecular sequence data from the Helix database and GenBank.

3.0 Methods

The 19 specimens, comprising four taxonomic groups based on morphology (Halonoproctidae, Anamidae, Camaenidae and Isopoda), were collected from six sampling locations. The specimens were sequenced for variation at COI using primers LCOI and HCO2 (Folmer et al., 1994). Halonoproctidae specimens were also sequenced for variation at CYB using an additional inhouse primer set. The primers used for CYB were 'CYBJ10612_id_f1' and 'CYB_Id_r1' from Rix et al. (2017a).

Three specimens (RV05, RV11 and RV15) were not sequenced successfully and could therefore not be assigned to a lineage. Sequence failure could be due to degradation of the DNA, primer mis-matches, or contamination by other DNA in the sample. Two other specimens originally identified as Halonoproctidae (RV01 and RV02) and one originally identified as Anamidae (RV03), were reassigned to the family Idiopidae after preliminary genetic analyses.

The COI sequences from the 16 successfully sequenced specimens were edited using Geneious version 6.1.8 (https://www.geneious.com) performed within MEGA version 5.05 (Tamura et al., 2011) using the built-in alignment tool using CLUSTAL W (Thompson et al., 1994) using default parameters. DNA nucleotide sequences were translated into protein sequences to ensure that the amplified sequences corresponded to the target mtDNA. The translated protein sequences were then checked for the presence of stop codons, to ensure that pseudogenes had not been amplified. Pseudogenes have a DNA sequence that is similar to the functional gene (e.g. COI) however, they do not code for a functioning protein despite the shared ancestry with the functional gene. The presence of pseudogenes can complicate molecular analyses, producing odd results. DNA sequences were translated into proteins with ExPASy using the invertebrate genetic code. All sequences analysed were of high quality with no evidence of heterogeneous peaks. All resulting sequences were 'BLAST'ed (Basic Local Alignment Search Tool) with the NCBI (National Centre for Biotechnology Information). This program compares DNA nucleotide sequences with a library of sequences and identifies sequences within the database that resemble the query sequences above a certain threshold. Genetic distances between unique genetic sequences (haplotypes) were measured using uncorrected p-distances (total percentage of nucleotides different between sequences). Un-corrected p-distances do not account for mutational saturation, which results from back mutations, and therefore provide a conservative estimate of genetic distance. To account for polymorphism within lineages, the net genetic diversity of Nei (1987) was calculated to give a 'corrected' distance between lineages.

For phylogenetic analysis, likelihood ratio tests using the Bayesian Information Criterion were calculated in MEGA 11 (Tamura et al., 2021) to determine the best-fit model of evolution. The phylogenetic analyses were conducted in Geneious Prime version 2022.2.2 (https://www.geneious.com) using the best-fit model of evolution calculated for each family (Table 1). Maximum likelihood (ML) analyses with 100 rapid bootstrap replicates, were performed in RAxML (Randomised Accelerated Maximum Likelihood) version 8.2.11 (Stamatakis, 2014), using default settings.

For the purposes of this report, lineages were defined as haplotypes or groups of haplotypes differing from other such groups by >3% sequence divergence. This cut-off was selected based on bar-coding data, which indicates that intra-specific variation rarely exceeds 3% (Hebert et al., 2003b). Species were determined based on taxonomic group, molecular and morphological data available, and previously published literature for each taxonomic group. For most groups Helix species names have been updated for the

current report to reflect new knowledge and current Helix nomenclature. This update includes the prefix 'H-'.

Table 1. Best-fit model of evolution for each of the taxonomic groups and families analysed.
Abbreviations: GTR: General Time Reversible; HKY: Hasegawa-Kishino-Yano; G: Gamma; I: Invariant sites.

Analysis Group	Family/Genus	Best Model	Gamma Value
Mygalomorphae	Idiopidae (COI)	GTR + G + I	0.60
Mygalomorphae	Idiopidae (CYB)	GTR + G + I	0.71
Mygalomorphae	Anamidae/*Kwonkan*	GTR + G + I	0.64
Isopoda	Armadillidae	GTR + G + I	0.63
Pulmonata	Camaenidae/*Rhagada*	HYK + G + I	1.04

4.0 Results

A total of 6 distinct species (6 lineages) belonging to four families were detected from the 16 analysed specimens collected from the Pardoo study area (Table 2). All species detected were new and had not been detected previously, according to the molecular data currently available for comparison (Table 2).

Table 2. Invertebrate specimens used in the present study (n=19), and the genetic lineage/species to which they were assigned. Shaded cells represent samples that failed to sequence. Molecular lineages in bold text and marked with '*' represent newly detected species.

Specimen ID	Site	Lat dec	Long dec	Family	Helix ID	Species ID	Lineages	Molecular Sp. ID
M20220708_PDF03SRE_DK-01	PDF03SRE_DK	-20.23488252	119.1425268	~~Halonoproctidae~~ Idiopidae	RV01	*Idiosoma* sp.	**L01**	***Idiosoma* H-I82***
M20220708_PDF03SRE_DK-03	PDF03SRE_DK	-20.2343725	119.1430298	~~Halonoproctidae~~ Idiopidae	RV02	*Idiosoma* sp.	**L01**	***Idiosoma* H-I82***
M20220708_PDF03SRE_DK-02	PDF03SRE_DK	-20.23505471	119.1424826	~~Anamidae~~ Idiopidae	RV03	*Idiosoma* sp.	**L01**	***Idiosoma* H-I82***
M20220710_PDF09SRE_DK-01	PDF09SRE_DK	-20.30912824	119.0887644	Anamidae	RV04	*Kwonkan* sp.	**L01**	***Kwonkan* H-N168***
M20220710_PDF09SRE_DK-02	PDF09SRE_DK	-20.30912808	119.08877	Anamidae	RV05	No Data	No Data	No Data
M20220710_PDF09SRE_DK-03	PDF09SRE_DK	-20.30912638	119.0887671	Anamidae	RV06	*Kwonkan* sp.	**L01**	***Kwonkan* H-N168***
M20220710_PDF10SRE_DK-01	PDF10SRE_DK	-20.27180891	119.058596	Anamidae	RV07	*Kwonkan* sp.	**L01**	***Kwonkan* H-N168***
M20220710_PDF10SRE_DK-02	PDF10SRE_DK	-20.27176195	119.0585594	Anamidae	RV08	*Kwonkan* sp.	**L01**	***Kwonkan* H-N168***
M20220711_PDF14SRE_DK-01	PDF14SRE_DK	-20.26386618	119.152517	Anamidae	RV09	*Kwonkan* sp.	**L02**	***Kwonkan* H-N169***
I20220709_PDF05SRE_DK-01	PDF05SRE_DK	-20.24976073	119.1589644	Armadillidae	RV10	Armadillidae sp.	**L01**	***Buddelunia* H-ISA64***
I20220709_PDF05SRE_DK-01	PDF05SRE_DK	-20.24976073	119.1589644	No Data	RV11	No Data	No Data	No Data
I20220709_PDF05SRE_DK-01	PDF05SRE_DK	-20.24976073	119.1589644	Armadillidae	RV12	Armadillidae sp.	**L02**	**Armadillidae H-ISA65***
I20220709_PDF05SRE_DK-01	PDF05SRE_DK	-20.24976073	119.1589644	Armadillidae	RV13	Armadillidae sp.	**L01**	***Buddelunia* H-ISA64***
SN20220709_PDF05SRE_DK-01	PDF05SRE_DK	-20.24980278	119.1588754	Camaenidae	RV14	*Rhagada* sp.	**L01**	***Rhagada* H-SB020***
SN20220709_PDF05SRE_DK-01	PDF05SRE_DK	-20.24980278	119.1588754	Camaenidae	RV15	No Data	No Data	No Data
G20220602.PDF01SRE_SS-02	PDF01SRE_SS	-20.25630684	119.13490199	Camaenidae	RV16	*Rhagada* sp.	**L01**	***Rhagada* H-SB020***
G20220602.PDF01SRE_SS-01	PDF01SRE_SS	-20.25677212	119.13304503	Camaenidae	RV17	*Rhagada* sp.	**L01**	***Rhagada* H-SB020***
G20220603.PDF01SRE_PK-01	PDF01SRE_PK	-20.27970470	119.13093050	Camaenidae	RV18	*Rhagada* sp.	**L01**	***Rhagada* H-SB020***
G20220603.PDF01SRE_PK-01	PDF01SRE_PK	-20.27970470	119.13093050	Camaenidae	RV19	*Rhagada* sp.	**L01**	***Rhagada* H-SB020***

4.1 Mygalomorphae

The infraorder of Arachnida, Mygalomorphae, includes trapdoor spiders and their kin, which are frequently identified as SREs (e.g. Harvey et al., 2011; Castalanelli et al., 2014). This ancient group has a worldwide distribution that includes tarantulas, trapdoor spiders and funnel-web spiders (Opatova et al., 2020). Identification of species has traditionally been performed using morphological techniques, however, only males can be used in identification, as both females and juveniles lack the diagnostic characters used to delineate morphospecies, and furthermore there is a large backlog of undescribed taxa.

Mygalomorph spider systematics has received a great deal of attention over the last decade as integrative molecular approaches have revolutionised our understanding of speciation, classification and biogeography in these iconic arachnids (Rix et al., 2018). The morphological conservatism of the Mygalomorphae has been highlighted in these conceptual developments, which is often seemingly at odds with the very high levels of mitochondrial divergence observed in most taxa (Rix *et al*., 2018). Multi-locus approaches have revealed higher levels of diversity than anticipated (Rix et al., 2018). DNA barcoding with the use of COI has become a rapid, objective method aiding mygalomorph species identifications and their distributions, and is recognised as providing important information that regulatory authorities can use to assess the environmental impacts of large-scale developments (Rix et al., 2008; Castalanelli et al., 2014). Extensive molecular work has been conducted on the trapdoor spider fauna of Western Australia (Helix, 2009a and b; 2010; 2011 a - l; 2012a – i; 2013a and b; 2014a – d; 2015a – e; 2018, 2019, 2020, 2021 and 2022). The resulting dataset provides a molecular framework that can be used to provide regional context for localised sampling.

4.1.1 Family Idiopidae

The spiny trapdoor spiders (Idiopidae) encompass the Australasian endemic subfamily Arbanitinae (Rix et al., 2017a-c). The family has a distribution consistent with the former Gondwanan land masses, and they are largely undescribed at the species level and have a confusing taxonomic history at the generic level (Rix et al., 2017a). Taxonomic revisions using molecular data in this family have highlighted the need for a multi-gene approach for some species (Wilson et al., 2019). Previous discussions with Dr Mike Rix (Queensland Museum) principal author of the *Gaius* revision (Rix et al., 2018), which was based on a multi-gene approach, have resulted in the decision to sequence both COI and CYB as a standard for Idiopidae specimens. Initially the three specimens from Pardoo were assigned to the family Halonoproctidae (RV01, RV02) and Anamidae (RV03). However, following preliminary molecular analysis, they were reassigned to the family Idiopidae (Table 2).

Reference Specimens and Outgroups

All three specimens were successfully sequenced at COI and CYB gene regions. The COI sequenced specimens from Pardoo were analysed along with a total of 201 reference specimens sequenced for COI from both the Helix database (n=102) and GenBank (n=99, including outgroups *Centruroides vittatus* (EU404114) and *Mesobuthus martensii* (JF700146)). The representative haplotypes of the CYB idiopid specimens were analysed along with 191 reference specimens from both the Helix database (n=36) and GenBank (n=155), which included outgroups *Mesobuthus cyprius* (DQ323712) and *Mesobuthus gibbosus* (DQ323730).

Phylogenetic Analyses

For all three idiopid specimens collected from the Pardoo survey Area, a 687 base-pair (bp) fragment of COI, in addition to a 719 bp fragment of CYB were isolated.

Phylogenetic analysis of the COI and CYB molecular data detected one unique lineage among the three survey specimens, with haplotypes showing minimal sequence divergence (Figure 1). Maximum Likelihood analysis of the survey specimens with 201 COI and 191 CYB reference specimens indicate that the survey specimens did not have a close affinity to any previously recorded species, based on currently available molecular data. However, the placement of the survey specimens (RV01 – RV03) within the phylogenetic tree, indicate that they are a novel species of *Idiosoma* (previously referred to as *Aganippe*, Rix et al., 2017a), and that they are related to specimens of *Idiosoma* found within the Australian arid zone.

Differentiation within and between lineages

Analysis of the COI molecular data from the Pardoo study area detected one unique lineage, with haplotypes showing between 0.1 and 0.7% pairwise sequence divergence from each other (Table 3, Table 5). Similarly, for CYB, one distinct lineage was detected with haplotypes differing between 0.1 and 0.4% sequence divergence from each other (Table 4; Table 6).

The new lineage/species of *Idiosoma* **H-I82*** (specimens RV01-RV03) is genetically distinct, with the closest specimens from the Helix database showing 11.5 -12.2% sequence divergence (BW17_IBU) and 13.3% (AD505 IBJ) sequence divergence from the survey specimens (Table 5, Figure 1). Cytochrome B sequences from the same reference specimens were unavailable on Genbank and hence the divergence at CYB could not be directly compared. Based on the specimens available for comparison, the closest specimens for CYB from GenBank showed 18.8% sequence divergence (KY295451.1 *Aganippe* sp. WAM T131974), and 19.1% sequence divergence (KY295443.1 *Aganippe* sp. WAM T101994; Table 6, Figure 2).

Conclusions

The three Idiopid specimens (RV01 – RV03) from the Pardoo study sampling site PDF03SRE_DK (Table 2, **Error! Reference source not found.**) belong to a new species ***Idiosoma* H-I82***, owing to the high levels of genetic divergence between the survey specimens and all reference sequences available.

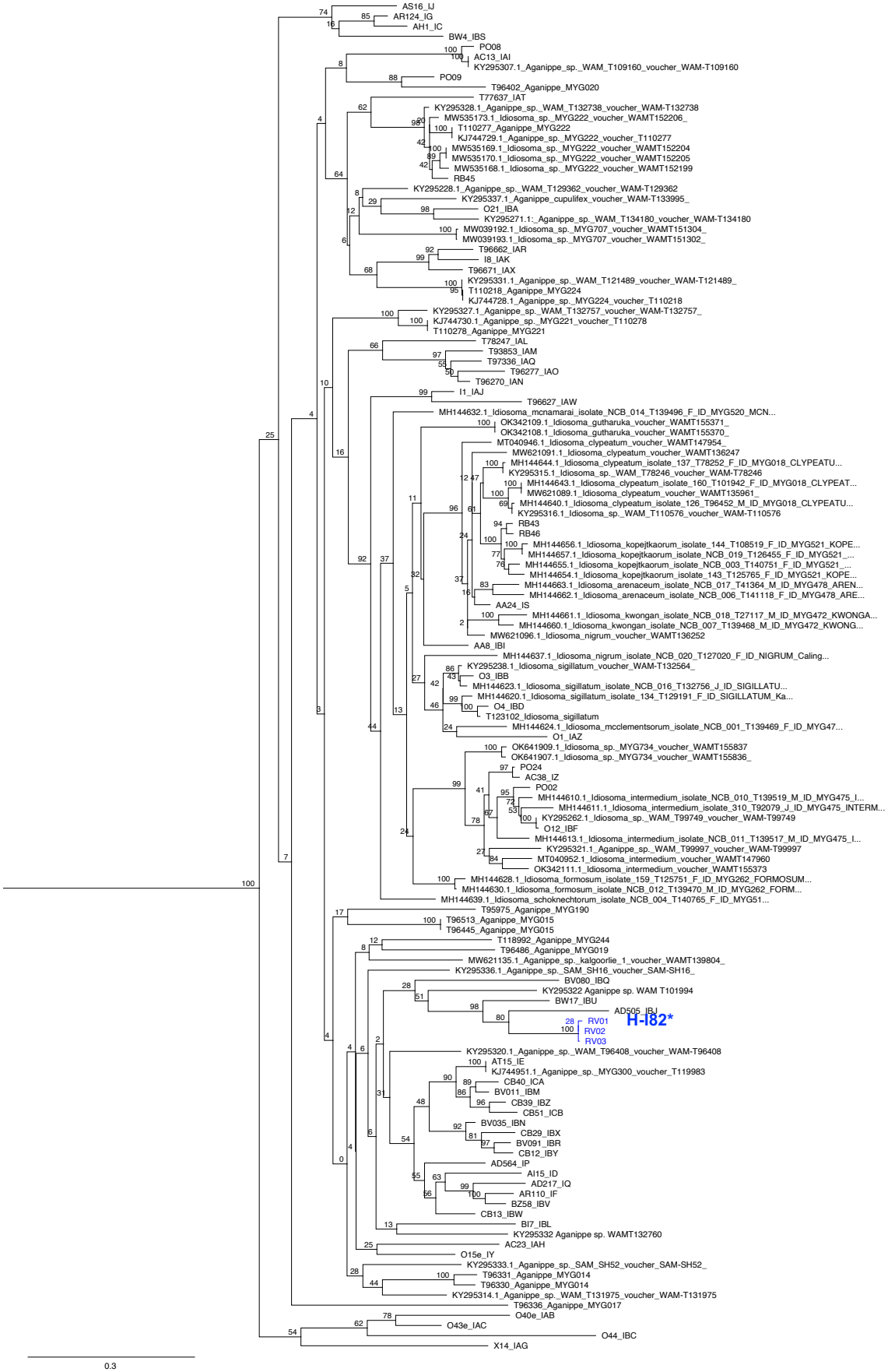

Figure 1. **Maximum Likelihood analysis of Idiopidae COI mtDNA sequences, showing the placement of the specimens ('RV' prefix) of one species clade (coloured in blue), within the taxonomic framework of the family Idiopidae, including 132 reference specimens (original analysis included 201 reference specimens). Numbers on nodes indicate nodal support by means of maximum likelihood (ML) bootstrap values. Scale indicates inferred evolutionary distance (substitutions/site).**

Figure 2. **Maximum Likelihood analysis of Idiopidae CYB mtDNA sequences, showing the placement of the specimens ('RV' prefix) of one species clade (coloured in blue), within the taxonomic framework of the family Idiopidae, including 84 reference specimens (original analysis included 191 reference specimens). Numbers on nodes indicate nodal support by means of maximum likelihood (ML) bootstrap values. Scale indicates inferred evolutionary distance (substitutions/site).**

Table 3. **Genetic p-distance (below) and the associated standard error (above - blue text) between the three COI sequenced Idiopidae specimens from this study ('RV' prefix).**

	RV01	RV02	RV03
RV01		0.0029	0.0032
RV02	0.0058		0.0015
RV03	0.0073	0.0015	

Table 4. **Genetic p-distance (below) and the associated standard error (above - blue text) between the three CYB sequenced Idiopidae specimens from this study ('RV' prefix).**

	RV03	RV01	RV02
RV03		0.0024	0.0020
RV01	0.0042		0.0014
RV02	0.0028	0.0014	

Table 5. **Pardoo ('RV' prefix) Idiopidae COI p-distance and the associated standard error from reference specimens showing less than 15% sequence divergence. Lineages in bold text represent lineages detected during the current survey.**

Pardoo specimen	Reference Specimen	P-Distance	Std. Err
RV02	**RV03**	0.0015	0.0015
RV03	**RV02**	0.0015	0.0015
RV01	**RV02**	0.0058	0.0029
RV02	**RV01**	0.0058	0.0029
RV01	**RV03**	0.0073	0.0032
RV03	**RV01**	0.0073	0.0032
RV02	BW17 IBU	0.1150	0.0155
RV03	BW17 IBU	0.1174	0.0156
RV01	BW17 IBU	0.1221	0.0159
RV01	AD505 IBJ	0.1334	0.0135
RV02	AD505 IBJ	0.1334	0.0135
RV03	AD505 IBJ	0.1334	0.0135
RV01	O4 IBD	0.1364	0.0156
RV02	O4 IBD	0.1364	0.0156
RV03	O4 IBD	0.1384	0.0157
RV02	T123102 *Idiosoma sigillatum*	0.1479	0.0137
RV01	T78247 IAL	0.1485	0.0171
RV02	T78247 IAL	0.1485	0.0171
RV03	T78247 IAL	0.1485	0.0171
RV01	O3 IBB	0.1492	0.0160
RV01	T123102 *Idiosoma sigillatum*	0.1494	0.0137
RV03	T123102 *Idiosoma sigillatum*	0.1494	0.0137

Table 6. Pardoo ('RV' prefix) Idiopidae CYB p-distance and the associated standard error from reference specimens showing less than 20% sequence divergence. Lineages in bold text represent lineages detected during the current survey.

Pardoo specimen	Reference Specimen	P-Distance	Std. Err
RV01 Cytb	**RV02 Cytb**	0.0014	0.0014
RV02 Cytb	**RV01 Cytb**	0.0014	0.0014
RV03 Cytb	**RV02 Cytb**	0.0028	0.0020
RV02 Cytb	**RV03 Cytb**	0.0028	0.0020
RV03 Cytb	**RV01 Cytb**	0.0042	0.0024
RV01 Cytb	**RV03 Cytb**	0.0042	0.0024
RV02 Cytb	KY295451.1 Aganippe sp. WAM T131974	0.1884	0.0151
RV01 Cytb	KY295451.1 Aganippe sp. WAM T131974	0.1899	0.0151
RV03 Cytb	KY295451.1 Aganippe sp. WAM T131974	0.1914	0.0152
RV02 Cytb	KY295443.1 Aganippe sp. WAM T101994	0.1924	0.0151
RV01 Cytb	KY295443.1 Aganippe sp. WAM T101994	0.1939	0.0151
RV03 Cytb	KY295443.1 Aganippe sp. WAM T101994	0.1953	0.0151

4.1.2 Family Anamidae

The family Anamidae (previously Nemesiidae) is one of the most diverse and speciose mygalomorph families in Australia (Castalanelli et al., 2014; 2017; 2020). It is considered the most dominant trapdoor spider family in Australia (Castalanelli et al., 2020) and currently includes ten genera (*Aname*, L. Koch, 1873, *Chenistonia* Hogg, 1901, *Hesperonatalius*, Castalanelli et al., 2017, *Kwonkan* (including *Yilgarnia* and *Anamae turrigera*), Main, 1983, *Namea*, Raven, 1984, *Proshermacha*, Simon, 1908, *Swolnpes*, Main and Framenau, 2009, *Teyl*, Main 1975, *Teyloides*, Main 1985 and *Stanwellia,* Castalanelli et al., 2014; 2017; 2020). The most speciose of these genera, *Aname*, is found across most of Australia and is currently represented by 48 described species (World Spider Catalogue 2022).

Reference Specimens and Outgroups

Seven specimens collected from four sampling locations were initially identified as belonging to the family Anamidae. Of these, one (RV03) was reassigned to Idiopidae and another (RV05) failed to produce a sequence. The remaining five COI sequences were initially analysed along with 702 reference specimens from both the Helix database (n=251) and GenBank (n=451). All five Pardoo specimens (RV04, RV06 – RV09) were identified as belonging to the genus *Kwonkan* and a subsequent analysis was undertaken with a reduced dataset of 106 reference specimens from Helix (n=49) and GenBank (n=57) to simplify the phylogenetic tree (Figure 3). However, the full dataset was examined for relationships to reference specimens. Both *Anamidae* trees were rooted using two outgroups, *Centuroides vittatus* (Genbank Accession #EU404114) and *Mesobuthus martensii* (GenBank Accession #JF00146).

Phylogenetic Analyses

A 687 base-pair (pb) fragment of COI was isolated for each of the five individuals from the current survey, resulting in five unique haplotypes. The five specimens were spread amongst two distinct lineages (based on the 3% sequence divergence criterion), all of which are confirmed to sit within the family Anamidae and the genus *Kwonkan* (Table 2, Figure 3). One new species of *Kwonkan* detected is represented by four Pardoo specimens (RV04, RV06 – RV08) and the second species of *Kwonkan* by one specimen

(RV09). These two species form a well-supported clade with reference specimen NGC_N129_CW5 (see Figure 3).

Differentiation within and between species/lineages

The five specimens of Anamidae collected from the Pardoo survey area show between 0.3% and 10.6% sequence divergence from one another (Table 7). Phylogenetic analyses suggest that two species are present in the study area. Specimens belonging to *Kwonkan* sp. **H-N168*** (RV04, RV06 – RV08) show between 0.2% and 2.8% intra-specific pairwise genetic divergence and differed from *Kwonkan* sp. **H-N-169*** (RV09) between 9.3% and 10.6%. The Pardoo specimens differed from the closest reference specimen, NGC-N129_CW5, by between 8.1% and 9.1% (**H-N-168***) and 10.8% (**H-N-169***) pairwise genetic divergence (Table 11).

Conclusion

Two lineages of *Kwonkan* have been detected from the Pardoo survey area, likely corresponding to two distinct species. Both species detected during the current survey are likely to be new (*Kwonkan* **H-N168*** and *K.* **H-N169***), as they differed from the nearest reference specimens by >9%. None of the new *Kwonkan* species were found in sympatry, with *K.* **H-N168*** collected from two locations (PDF09SRE_DK, and PDF10SRE_DK), separated geographically by approximately 5 km, and *K.* **H-N169*** collected from one location (PDF14SRE_DK), approximately 8-10 km from the *K.* **H-N168*** collecting locations. The closest reference species detected was NGC_N129_CW5, which was previously collected approximately 215 km west of the study area, just north of Wickham.

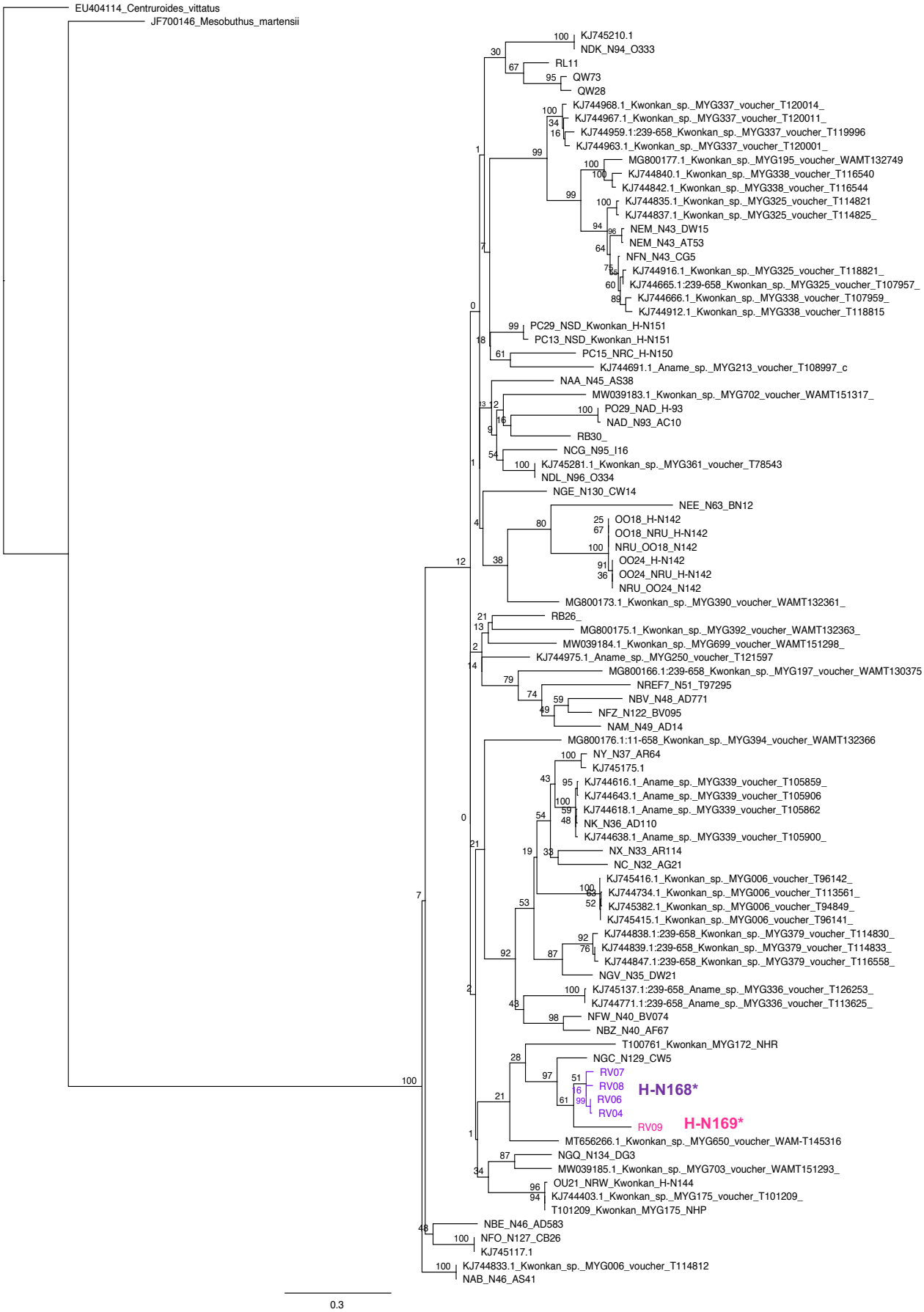

Figure 3. **Maximum Likelihood analysis of Anamidae COI mtDNA sequences, showing the placement of the 5 haplotypes ('RV' prefix) and two species designations (coloured in pink and purple), within a collapsed taxonomic framework of the family Anamidae, including 88 reference specimens (initial analysis included 702 reference specimens). Numbers on nodes indicate nodal support by means of maximum likelihood (ML) bootstrap values. Scale indicates inferred evolutionary distance (substitutions/site).**

Table 7. **Genetic p-distance (below) and the associated standard error (above - blue text) between the 5 Anamidae specimens from this study ('RV' prefix).**

	RV09	RV07	RV08	RV04	RV06
RV09		0.0118	0.0111	0.0116	0.0115
RV07	0.1063		0.0063	0.0061	0.0058
RV08	0.0932	0.0277		0.0059	0.0056
RV04	0.1033	0.0262	0.0247		0.0021
RV06	0.1004	0.0233	0.0218	0.0029	

4.2 Isopoda

4.2.1 Family Armadillidae

The family Armadillidae (Crustacea: Oniscidea) dominates the terrestrial isopod fauna of much of arid and semi-arid Western Australia. However, very few species have been formally described despite the large diversity of armadillids recorded. The taxonomy of the Armadillidae has been challenging, with different interpretations and nomenclatural problems (Taiti, 2014, Taiti et al. 1998), making placement of new species within the correct genera highly problematic.

A systematic study of Armadillidae with description of the new species together with integrated genetic analysis is needed to provide a clearer understanding of the biogeography of isopods in WA (Judd and Perina, 2013).

Three of the four individuals of Isopoda specimens from site PDF05SRE_DK were successfully sequenced (Table 2) and identified as belonging to the family Armadillidae from preliminary analyses. One specimen (RV11) failed to sequence and could not be assigned to a lineage.

Reference Specimens and Outgroups

The three specimens from the study area were analysed along with 108 reference specimens from both the Helix database (n=68) and GenBank (n=40) to confirm family placement. A subsequent analysis was undertaken with a reduced dataset of 92 reference specimens from Helix (n=52) and GenBank (n=40) to simplify the phylogenetic tree (Figure 4). However, the full dataset was examined for relationships to reference specimens. Both Armadillidae phylogenetic trees were rooted using the outgroup *Centuroides acuminata* (Genbank Accession #DQ838027.2).

Phylogenetic Analyses

There were two lineages detected amongst the three specimens sequenced, both of which had not been detected previously, according to the molecular sequence data currently available for comparison. The two distinct lineages, which represent two new species (**H-ISA64*** and **H-ISA65***), are confirmed to sit within the family Armadillidae (Table 2. Invertebrate specimens used in the present study (n=19), and the genetic lineage/species to which they were assigned. Shaded cells represent samples that failed to sequence. Molecular lineages in bold text and marked with '*' represent newly detected species. , Figure 4). As discussed above, placement of specimens within a particular genus of Armadillidae can be problematic due to taxonomic limitations. However, one new species (**H-ISA64***), represented by two specimens from Pardoo (RV10 and RV13), potentially sits within the genus *Buddelundia* based on reference specimens from GenBank. The other species (**H-ISA65***), is represented by one specimen (RV12), but could not be assigned to a known genus (Figure 4).

Differentiation within and between species/lineages

The three specimens of Armadillidae collected from the survey area show between 0.0% and 21.8% sequence divergence from one another (Table 8). Phylogenetic analyses confirm that two species are present in the study area. Specimens belonging to *Buddelunia* sp. **H-ISA64*** (RV10/RV13) showed 0.0% intra-specific (within species) pairwise genetic distance and differed from Armadillidae sp. **H-ISA65*** (RV12) by 21.8%. The closest reference specimens to *Buddelunia* sp. **H-ISA64*** were GenBank sequences ON923815 and ON923816 (*Buddelundia* sp. Biologic-ISOP049), with a pairwise genetic

distance of 14%. Armadillidae sp. **ISA65*** (RV12) did not closely align with any reference specimens, with the closest specimen being *Spherillo dorsalis* (GenBank AB861897), with a pairwise genetic distance of 18.4% (Table 9).

Conclusion

Two lineages of Armadillidae have been detected from the Pardoo survey area, corresponding to two distinct species. Both species detected during the survey are considered new (*Buddelunia* sp. **H-ISA64*** and Armadillidae sp. **H-ISA65***) and differ from the nearest reference specimens by >14% (Table 9). Both species were detected from the same site (PDF05SRE_DK). The closest reference specimens to *Buddelunia* sp. **H-ISA64*** were collected from the Pilbara, approximately 10 km west of Paraburdoo. Both morphological examinations together with molecular analysis would be required to more confidently determine the placement of the specimens within the correct genera.

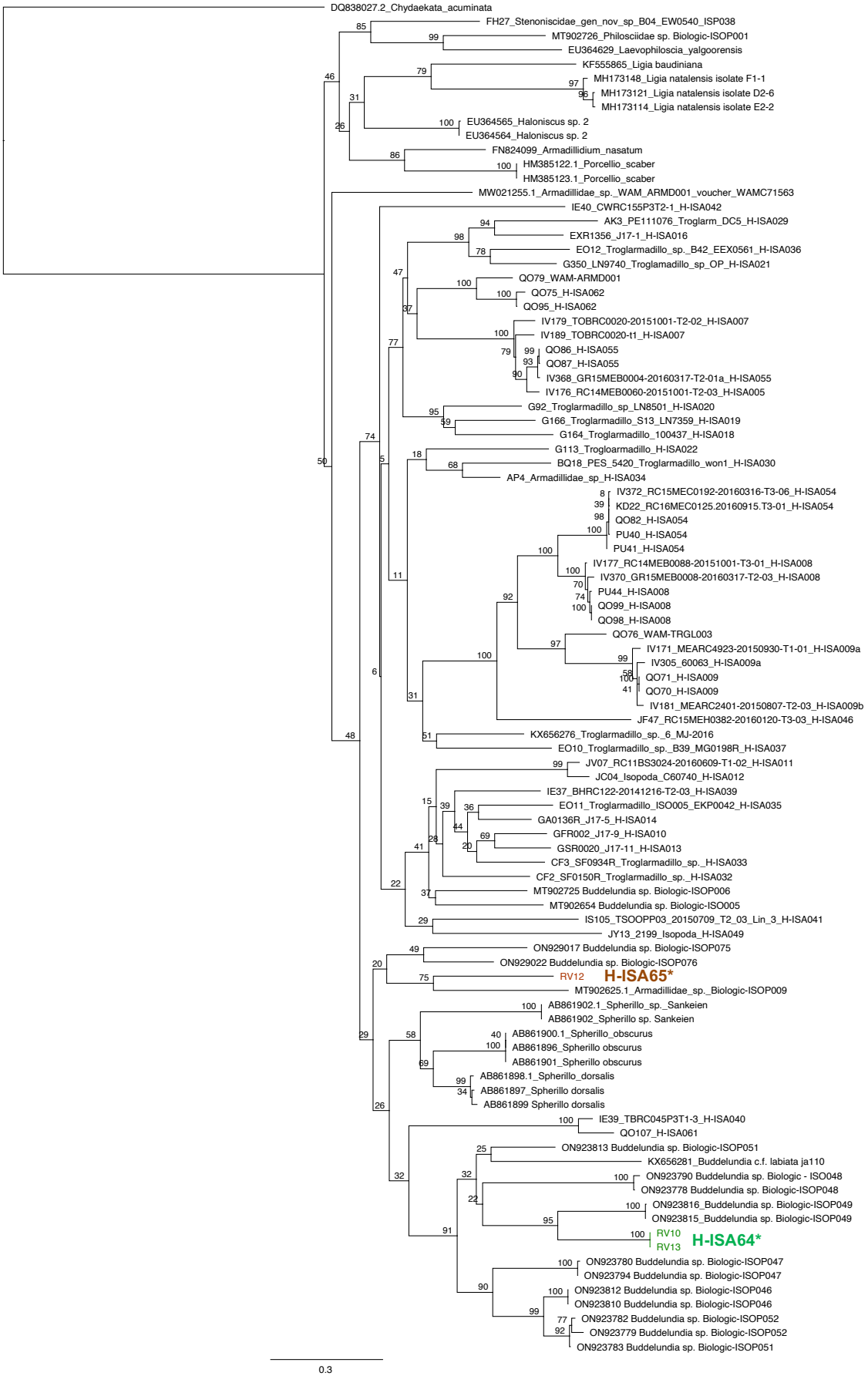

Figure 4. **Maximum Likelihood analysis of Isopoda COI mtDNA sequences, showing the placement of the two haplotypes ('RV' prefix) and two species designations (coloured brown and green), within the taxonomic framework of the family Armadillidae, including 92 reference specimens. Numbers on nodes indicate nodal support by means of maximum likelihood (ML) bootstrap values. Scale indicates inferred evolutionary distance (substitutions/site).**

Table 8. **Genetic p-distance (below) and the associated standard error (above - blue text) between the three Armadillidae specimens from this study ('RV' prefix).**

	RV10	RV13	RV12
RV10		0.0000	0.0158
RV13	0.0000		0.0158
RV12	0.2183	0.2183	

Table 9. **Genetic p-distance and the associated standard error from reference specimens showing less than 20% sequence divergence from the Pardoo Armadillidae specimens ('RV' prefix). Lineages in bold text represent lineages detected during the current survey. Un-corrected p-distances do not account for mutational saturation, which results from back mutations, and therefore provide a conservative estimate of genetic distance.**

Pardoo Specimen	Reference Specimen	P-Distance	Std. Err
RV10	**RV13**	0.0000	0.0000
RV13	**RV10**	0.0000	0.0000
RV10/RV13	ON923815 Buddelundia sp. Biologic-ISOP049	0.1400	0.0135
RV10/RV13	ON923816 Buddelundia sp. Biologic-ISOP049	0.1400	0.0135
RV10/RV13	KX656281 Buddelundia c.f. labiata ja110	0.1618	0.0149
RV10/RV13	ON929017 Buddelundia sp. Biologic-ISOP075	0.1793	0.0150
RV12	AB861897 Spherillo dorsalis	0.1837	0.0156
RV10/RV13	ON923813 Buddelundia sp. Biologic-ISOP051	0.1869	0.0152
RV12	AB861898.1 Spherillo dorsalis	0.1870	0.0157
RV12	ON929022 Buddelundia sp. Biologic-ISOP076	0.1884	0.0152
RV12	MT902625.1 Armadillidae sp. Biologic-ISOP009	0.1887	0.0153
RV10/RV13	ON929022 Buddelundia sp. Biologic-ISOP076	0.1900	0.0153
RV12	AB861899 Spherillo dorsalis	0.1902	0.0158
RV10/RV13	AP4 Armadillidae sp H-ISA034	0.1924	0.0151
RV10/RV13	AB861899 Spherillo dorsalis	0.1951	0.0160
RV10/RV13	G350 LN9740 Troglamadillo sp OP H-ISA021	0.1953	0.0152
RV10/RV13	AB861897 Spherillo dorsalis	0.1984	0.0161
RV10/RV13	G166 Troglarmadillo S13 LN7359 H-ISA019	0.1985	0.0152
RV10/RV13	EXR1356 J17-1 H-ISA016	0.1997	0.0158
RV10/RV13	AB861898.1 Spherillo dorsalis	0.2000	0.0161

4.3 Gastropoda

4.3.1 Family Camaenidae

The camaenid land snail genus *Rhagada* is the most species-rich genus of land snails in Western Australia's semi-arid Pilbara region, where it shows both morphological conservatism within and among species over large distances (Solem, 1997; Johnson *et al*., 2012; Hamilton & Johnson, 2015), as well as extreme morphological diversification of shell traits over relatively small areas (Stankowski, 2011, 2013, 2015; Stankowski and Johnson, 2014; Johnson et al., 2015). Due to these contrasting patterns of morphological variation, presence of distinct cryptic taxa and the occurrence of narrow hybrid zones between distinct taxa (Hamilton and Johnson, 2015), a combination of DNA barcoding with COI, in addition to morphological taxonomy, is required to resolve species in this complex group.

Reference Specimens and Outgroups

The six gastropod specimens morphologically identified as Camaenidae were collected from two sites within the survey area (Table 2). Five of the specimens yielded successful COI sequences and were analysed along with 146 reference specimens from both the Helix database (n=25) and GenBank (n=121). A subsequent analysis with a reduced dataset was undertaken to simplify the tree resulting in 77 reference specimens (Helix n= 6, GenBank n=71;
Figure 5). The phylogenetic trees were rooted using the camaenid land snail *Baudinella* sp. (WAM S37063).

Phylogenetic Analyses

There were five unique haplotypes amongst the five individuals sequenced from the current survey. The five haplotypes were considered to belong to the same lineage (based on the 3% sequence divergence criterion;
Figure 5; Table 10). Phylogenetic analyses also confirm that the five specimens belong to the genus *Rhagada* and cluster with other species of *Rhagada* known from the Pilbara region. Furthermore, the lineage they form clusters amongst other species with the same general shell morphology. However, based on the reference sequences currently available for comparison, the Pardoo specimens did not align closely with any previously known or described species (
Figure 5).

Differentiation within and between lineages

The Pardoo specimens are putatively assigned to a new *Rhagada* species (*Rhagada* **H-SB020*)**. Intra-specific divergence between the specimens from this study were low and ranged from 0.15% – 1.9%, with a mean intra-specific divergence of 1.4%. The closest reference specimens to *Rhagada* **H-SB020*** were specimens of *Rhagada 'radleyi'* (GenBank JQ362687, JQ362685 and JQ362686), which differ from the Pardoo specimens by between 7.8% and 8.6%.

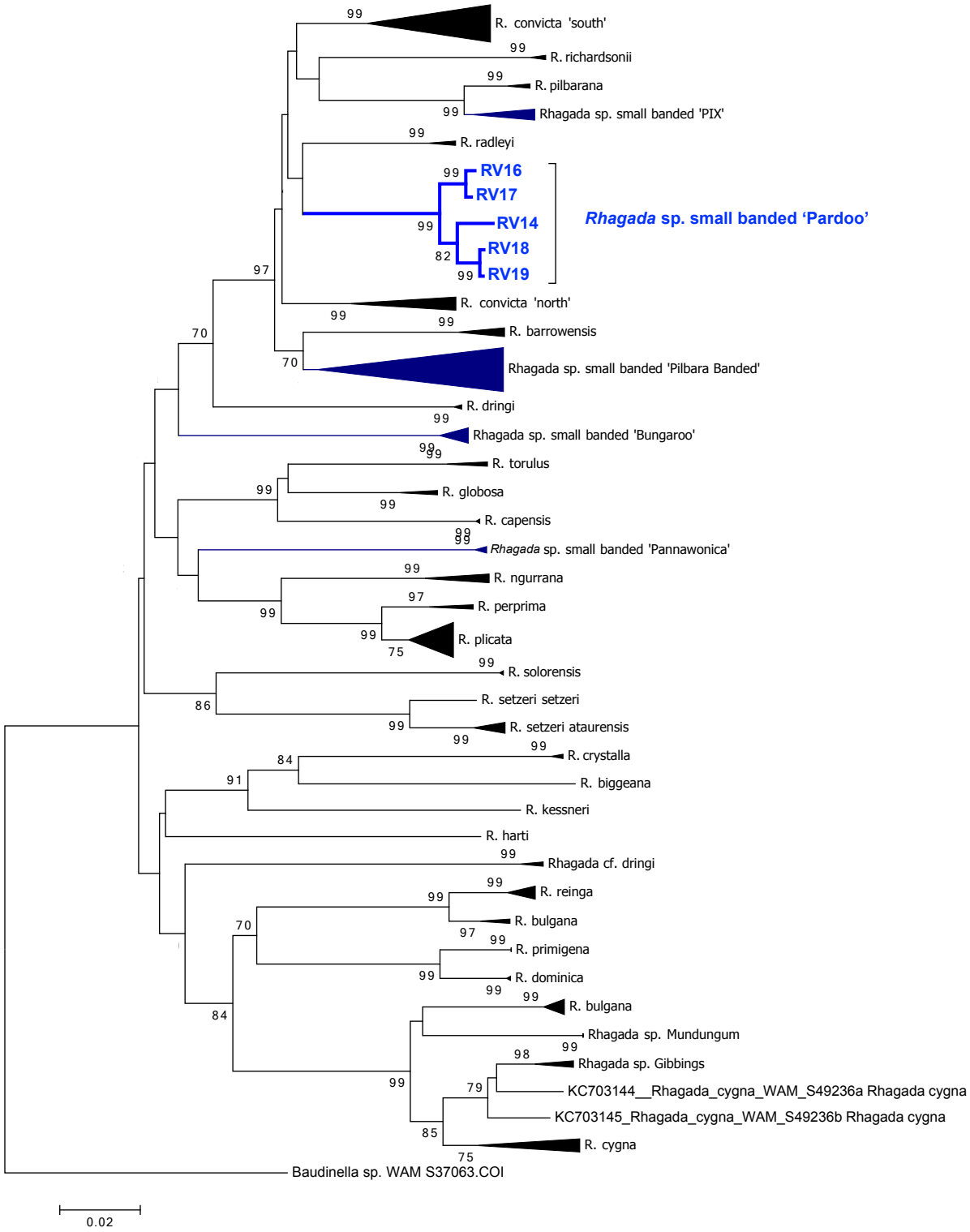

Figure 5. Maximum Likelihood analysis of Camaenidae COI mtDNA sequences, showing the placement of the Pardoo survey specimens ('RV' prefix), within a reduced taxonomic framework of the genus *Rhagada*, including 62 reference specimens. Other lineages of *Rhagada* sharing the same small banded morphotype are depicted in navy. Numbers on nodes indicate nodal support by means of maximum likelihood (ML) bootstrap values. Scale indicates inferred evolutionary distance (substitutions/site).

Conclusion

Five specimens of *Rhagada* comprising a unique phylogenetic lineage, (**H-SB020***), were detected from the Pardoo survey area from two locations. The lineage differs from all reference sequences currently available for comparison by >7.8% (Table 12). Examination of shell characters, along with its phylogenetic relationship and placement within all reference *Rhagada* specimens from the Pilbara, suggest that the lineage may represent a newly recorded species of small banded *Rhagada*. Reference sequences of *Rhagada* from the Pilbara are relatively comprehensive due to targeted sampling and research in the region (Hamilton, 2021, Hamilton and Johnson 2015, Johnson et al., 2012, Johnson et al., 2016, Stankowski, 2011, Stankowski 2013, Stankowski 2015, Stankowski and Johnson 2014) lending confidence to our interpretation.

Previous detailed investigation of the molecular variation amongst similar small banded morphotypes in the Pilbara found four major clades from the inland Pilbara that are morphologically indistinguishable, referred to as 'Bungaroo', 'Pannawonica', 'PIX' and 'Pilbara Banded' (Hamilton, 2021). Mean pairwise sequence divergence between these four clades ranged from 11.1% to 17.5% (Hamilton, 2021). However, one of these clades, the 'Pilbara Banded' clade, had extensive molecular variation, with thirteen subclades showing mean inter-clade divergences >5% (Hamilton, 2021). These are perhaps indicative of species-level differences, though the taxonomic significance of these subclades still requires further investigation. Levels of sequence divergence within described Pilbara *Rhagada* species assessed by Hamilton (2021) all showed less than 7% sequence divergence; again lending support to the view that *Rhagada* **H-SB020*** from Pardoo may represent a new species.

Broad-scale morphological conservatism (such as with the small banded shell types discussed here) within the mainland species of *Rhagada* is thought to be due to their relatively homogenous environments over large distances (Johnson et al., 2012), rather than simply due to common ancestry. This interpretation is strengthened by the finding of independent evolution of the small, banded morphotype in phylogenetic lineages ('PIX' and 'Pilbara Banded') that share the rocky inland habitat, contrasting with the sandy habitats of the larger, more globose coastal species. The general pattern of homogeneity in shell form over large distances in mainland *Rhagada* species (Solem, 1997; Johnson et al., 2012) is exhibited by the small banded morphotype, which spans some 240 km. However, hybridisation between *Rhagada* species has also been documented (Hamilton and Johnson, 2015) and its influence on the relationship between shell morphology and the topology of the phylogenetic tree cannot be dismissed when considering patterns of morphological adaptation and ancestry.

Given the above, it appears that *Rhagada* **H-SB020*** from the Pardoo study area, whilst apparently sharing morphological shell characters with a number of lineages, represents a new species. Final determination of its taxonomic rank would require additional sampling and further comparisons to additional reference data.

Table 10. **Genetic p-distance (below) and the associated standard error (above - blue text) between the five Camaenidae specimens from this study ('RV' prefix). Un-corrected p-distances do not account for mutational saturation, which results from back mutations, and therefore provide a conservative estimate of genetic distance.**

	RV16	RV17	RV14	RV18	RV19
RV16		0.00206	0.00522	0.00502	0.00481
RV17	0.00292		0.00522	0.00502	0.00481
RV14	0.01901	0.01901		0.00481	0.00459
RV18	0.01754	0.01754	0.01608		0.00146
RV19	0.01608	0.01608	0.01462	0.00146	

5.0 Summary

COI is widely considered to show suitable variation to distinguish species (Hebert et al., 2003a) and the use of this gene can be extremely effective for DNA barcoding in taxa where clear differentiation exists between intra and interspecific levels of divergence (e.g. Hebert et al., 2004a; 2004b). In a comparison of COI sequences for over 13,000 pairs of taxa, Hebert et al., (2003b) found a mean of 11.1% sequence divergence between distinct species. Nearly 80% of these comparisons found that species pairs differed from one another by >8% sequence divergence.

Despite its merits in barcoding, a taxon-by-taxon approach, examining the amount of phylogenetic variation within and between taxa is the most widely accepted method of delineating species and their distributions, especially in areas where rapidly expanding development outpaces taxonomic treatment of unresolved taxa.

In summary, we detected a total of six lineages from four families (Idiopidae n=1, Anamidae n=2, Armadillidae n=2, and Camaenidae n=1) amongst the 19 sequenced specimens from the Pardoo survey area. These lineages likely correspond to six distinct new species. Based on reference data currently available for comparison, these species have not been detected previously and are therefore currently only known from the survey area. The potential distributions of these species outside the survey area cannot be determined without further systematic collections.

6.0 References

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Appendix 1

Genetic p-distance between Pardoo specimens and reference specimens

Table 11. Genetic p-distance and the associated standard error from reference specimens showing less than 15% sequence divergence from the Pardoo survey Anamidae specimens ('RV' prefix). Lineages in bold text represent lineages detected during the current survey.

Pardoo Specimen	Reference specimens	P-Distance	Std. Err
RV04	RV06	0.0029	0.0021
RV06	RV04	0.0029	0.0021
RV08	RV06	0.0218	0.0056
RV06	RV08	0.0218	0.0056
RV07	RV06	0.0233	0.0058
RV06	RV07	0.0233	0.0058
RV08	RV04	0.0247	0.0059
RV04	RV08	0.0247	0.0059
RV07	RV04	0.0262	0.0061
RV04	RV07	0.0262	0.0061
RV07	RV08	0.0277	0.0063
RV08	RV07	0.0277	0.0063
RV07	NGC N129 CW5	0.0809	0.0135
RV06	NGC N129 CW5	0.0833	0.0137
RV04	NGC N129 CW5	0.0858	0.0139
RV08	NGC N129 CW5	0.0907	0.0142
RV09	RV08	0.0932	0.0111
RV08	RV09	0.0932	0.0111
RV09	RV06	0.1004	0.0115
RV06	RV09	0.1004	0.0115
RV09	RV04	0.1033	0.0116
RV04	RV09	0.1033	0.0116
RV09	RV07	0.1063	0.0118
RV07	RV09	0.1063	0.0118
RV09	NGC N129 CW5	0.1078	0.0154
RV08	RL11	0.1119	0.0154
RV06	RL11	0.1143	0.0155
RV04	RL11	0.1167	0.0157
RV07	RL11	0.1167	0.0157
RV08	PC28 NSD Kwonkan H-N151	0.1169	0.0157
RV08	PC29 NSD Kwonkan H-N151	0.1169	0.0157
RV07	PC28 NSD Kwonkan H-N151	0.1169	0.0157
RV07	PC29 NSD Kwonkan H-N151	0.1169	0.0157
RV07	PC12 NSD Kwonkan H-N151	0.1190	0.0158
RV08	PC12 NSD Kwonkan H-N151	0.1190	0.0158
RV07	PC27 NSD Kwonkan H-N151	0.1193	0.0158
RV07	PC30 NSD Kwonkan H-N151	0.1193	0.0158
RV08	PC17 NSD Kwonkan H-N151	0.1193	0.0158
RV08	PC27 NSD Kwonkan H-N151	0.1193	0.0158
RV08	PC30 NSD Kwonkan H-N151	0.1193	0.0158
RV07	PC13 NSD Kwonkan H-N151	0.1217	0.0160
RV08	PC13 NSD Kwonkan H-N151	0.1217	0.0160
RV08	MT656266.1 Kwonkan sp. MYG650 voucher WAM-T145316	0.1218	0.0128
RV08	KJ745210.1 Kwonkan sp. MYG343 voucher T57563	0.1220	0.0160
RV07	PC17 NSD Kwonkan H-N151	0.1241	0.0161
RV08	NDK N94 O333	0.1241	0.0161
RV06	MT656266.1 Kwonkan sp. MYG650 voucher WAM-T145316	0.1248	0.0129

Pardoo Specimen	Reference specimens	P-Distance	Std. Err
RV06	PC28 NSD Kwonkan H-N151	0.1265	0.0162
RV06	PC29 NSD Kwonkan H-N151	0.1265	0.0162
RV08	OU21 NRW Kwonkan H-N144	0.1265	0.0162
RV07	KJ745210.1 Kwonkan sp. MYG343 voucher T57563	0.1268	0.0163
RV04	MT656266.1 Kwonkan sp. MYG650 voucher WAM-T145316	0.1279	0.0130
RV07	MT656266.1 Kwonkan sp. MYG650 voucher WAM-T145316	0.1279	0.0130
RV06	PC12 NSD Kwonkan H-N151	0.1286	0.0163
RV06	QW28	0.1286	0.0163
RV04	PC28 NSD Kwonkan H-N151	0.1289	0.0164
RV04	PC29 NSD Kwonkan H-N151	0.1289	0.0164
RV06	PC17 NSD Kwonkan H-N151	0.1289	0.0164
RV06	PC27 NSD Kwonkan H-N151	0.1289	0.0164
RV06	PC30 NSD Kwonkan H-N151	0.1289	0.0164
RV07	KJ744975.1 Aname sp. MYG250 voucher T121597	0.1289	0.0164
RV07	NDK N94 O333	0.1289	0.0164
RV08	KJ744975.1 Aname sp. MYG250 voucher T121597	0.1289	0.0164
RV04	PC12 NSD Kwonkan H-N151	0.1310	0.0165
RV04	QW28	0.1310	0.0165
RV04	RB26 H-N159	0.1310	0.0130
RV06	RB26 H-N159	0.1310	0.0130
RV07	QW28	0.1310	0.0165
RV08	QW28	0.1310	0.0165
RV04	PC17 NSD Kwonkan H-N151	0.1313	0.0165
RV04	PC27 NSD Kwonkan H-N151	0.1313	0.0165
RV04	PC30 NSD Kwonkan H-N151	0.1313	0.0165
RV06	OU21 NRW Kwonkan H-N144	0.1313	0.0165
RV06	PC13 NSD Kwonkan H-N151	0.1313	0.0165
RV08	T101209 Kwonkan MYG175 NHP	0.1313	0.0165
RV06	KJ745210.1 Kwonkan sp. MYG343 voucher T57563	0.1316	0.0165
RV09	KJ745210.1 Kwonkan sp. MYG343 voucher T57563	0.1316	0.0165
RV06	QW73	0.1324	0.0131
RV08	KJ744839.1:239-658 Kwonkan sp. MYG379 voucher T114833	0.1333	0.0166
RV08	KJ744841.1:239-658 Kwonkan sp. MYG379 voucher T116542	0.1333	0.0166
RV04	OU21 NRW Kwonkan H-N144	0.1337	0.0166
RV04	PC13 NSD Kwonkan H-N151	0.1337	0.0166
RV06	NDK N94 O333	0.1337	0.0166
RV09	NDK N94 O333	0.1337	0.0166
RV09	PC17 NSD Kwonkan H-N151	0.1337	0.0166
RV09	PC27 NSD Kwonkan H-N151	0.1337	0.0166
RV04	KJ745210.1 Kwonkan sp. MYG343 voucher T57563	0.1340	0.0167
RV08	KJ744964.1 Kwonkan sp. MYG337 voucher T120003	0.1343	0.0167
RV04	QW73	0.1354	0.0132
RV08	KJ744838.1:239-658 Kwonkan sp. MYG379 voucher T114830	0.1357	0.0167
RV08	KJ744847.1:239-658 Kwonkan sp. MYG379 voucher T116558	0.1357	0.0167
RV04	NDK N94 O333	0.1360	0.0167
RV06	KJ744975.1 Aname sp. MYG250 voucher T121597	0.1360	0.0167
RV06	T101209 Kwonkan MYG175 NHP	0.1360	0.0167
RV07	KJ745281.1 Kwonkan sp. MYG361 voucher T78543	0.1360	0.0167
RV07	NDL N96 O334	0.1360	0.0167
RV07	OU21 NRW Kwonkan H-N144	0.1360	0.0167

Pardoo Specimen	Reference specimens	P-Distance	Std. Err
RV07	T101209 Kwonkan MYG175 NHP	0.1360	0.0167
RV09	PC28 NSD Kwonkan H-N151	0.1360	0.0167
RV09	PC29 NSD Kwonkan H-N151	0.1360	0.0167
RV06	PC15 NRC H-N150	0.1364	0.0168
RV08	KJ744963.1 Kwonkan sp. MYG337 voucher T120001	0.1368	0.0134
RV07	RB26 H-N159	0.1369	0.0133
RV08	RB26 H-N159	0.1369	0.0133
RV09	PC12 NSD Kwonkan H-N151	0.1381	0.0168
RV06	KJ744963.1 Kwonkan sp. MYG337 voucher T120001	0.1383	0.0135
RV08	KJ744962.1 Kwonkan sp. MYG337 voucher T120000	0.1383	0.0135
RV08	KJ744967.1 Kwonkan sp. MYG337 voucher T120011	0.1383	0.0135
RV04	KJ744975.1 Aname sp. MYG250 voucher T121597	0.1384	0.0169
RV04	T101209 Kwonkan MYG175 NHP	0.1384	0.0169
RV08	KJ745281.1 Kwonkan sp. MYG361 voucher T78543	0.1384	0.0169
RV08	NDL N96 O334	0.1384	0.0169
RV09	PC30 NSD Kwonkan H-N151	0.1384	0.0169
RV07	T100761 Kwonkan MYG172 NHR	0.1384	0.0169
RV04	PC15 NRC H-N150	0.1388	0.0169
RV06	KJ744964.1 Kwonkan sp. MYG337 voucher T120003	0.1391	0.0169
RV07	KJ744964.1 Kwonkan sp. MYG337 voucher T120003	0.1391	0.0169
RV07	QW73	0.1399	0.0134
RV08	QW73	0.1399	0.0134
RV08	NGQ N134 DG3	0.1400	0.0173
RV08	NCG N95 I16	0.1401	0.0171
RV08	KJ744959.1:239-658 Kwonkan sp. MYG337 voucher T119996	0.1405	0.0170
RV08	T100761 Kwonkan MYG172 NHR	0.1408	0.0170
RV06	T100761 Kwonkan MYG172 NHR	0.1408	0.0170
RV09	PC13 NSD Kwonkan H-N151	0.1408	0.0170
RV08	PC15 NRC H-N150	0.1411	0.0170
RV04	KJ744963.1 Kwonkan sp. MYG337 voucher T120001	0.1413	0.0136
RV06	KJ744967.1 Kwonkan sp. MYG337 voucher T120011	0.1413	0.0136
RV08	MW039184.1 Kwonkan sp. MYG699 voucher WAMT151298	0.1413	0.0136
RV04	KJ744964.1 Kwonkan sp. MYG337 voucher T120003	0.1415	0.0171
RV08	MW039185.1 Kwonkan sp. MYG703 voucher WAMT151293	0.1424	0.0137
RV07	NGQ N134 DG3	0.1425	0.0175
RV07	NAD N93 AC10	0.1432	0.0171
RV04	T100761 Kwonkan MYG172 NHR	0.1432	0.0171
RV08	KJ744832.1 Kwonkan sp. MYG379 voucher T114811	0.1432	0.0171
RV06	MW039185.1 Kwonkan sp. MYG703 voucher WAMT151293	0.1440	0.0138
RV06	KJ744962.1 Kwonkan sp. MYG337 voucher T120000	0.1444	0.0137
RV08	KJ744612.1 Aname sp. MYG339 voucher T105852	0.1444	0.0137
RV08	KJ744615.1 Aname sp. MYG339 voucher T105858	0.1444	0.0137
RV08	KJ744616.1 Aname sp. MYG339 voucher T105859	0.1444	0.0137
RV04	KJ744967.1 Kwonkan sp. MYG337 voucher T120011	0.1444	0.0137
RV08	KJ744968.1 Kwonkan sp. MYG337 voucher T120014	0.1446	0.0137
RV07	NCG N95 I16	0.1449	0.0173
RV04	KJ744959.1:239-658 Kwonkan sp. MYG337 voucher T119996	0.1452	0.0172
RV08	KJ744771.1:239-658 Aname sp. MYG336 voucher T113625	0.1452	0.0172
RV06	KJ745281.1 Kwonkan sp. MYG361 voucher T78543	0.1456	0.0172
RV06	NDL N96 O334	0.1456	0.0172

Pardoo Specimen	Reference specimens	P-Distance	Std. Err
RV07	NBV N48 AD771	0.1456	0.0172
RV08	KJ744403.1 Kwonkan sp. MYG175 voucher T101209	0.1459	0.0138
RV08	MG800175.1 Kwonkan sp. MYG392 voucher WAMT132363	0.1459	0.0138
RV08	KJ744635.1 Aname sp. MYG339 voucher T105893	0.1459	0.0138
RV08	KJ744637.1 Aname sp. MYG339 voucher T105899	0.1459	0.0138
RV08	KJ744638.1 Aname sp. MYG339 voucher T105900	0.1459	0.0138
RV08	KJ744643.1 Aname sp. MYG339 voucher T105906	0.1459	0.0138
RV07	PC15 NRC H-N150	0.1459	0.0173
RV06	KJ744968.1 Kwonkan sp. MYG337 voucher T120014	0.1461	0.0138
RV07	MW039185.1 Kwonkan sp. MYG703 voucher WAMT151293	0.1471	0.0139
RV04	MW039185.1 Kwonkan sp. MYG703 voucher WAMT151293	0.1471	0.0139
RV04	KJ744962.1 Kwonkan sp. MYG337 voucher T120000	0.1474	0.0138
RV04	MW039184.1 Kwonkan sp. MYG699 voucher WAMT151298	0.1474	0.0138
RV06	KJ744403.1 Kwonkan sp. MYG175 voucher T101209	0.1474	0.0138
RV06	MW039184.1 Kwonkan sp. MYG699 voucher WAMT151298	0.1474	0.0138
RV07	KJ744963.1 Kwonkan sp. MYG337 voucher T120001	0.1474	0.0138
RV07	MG800175.1 Kwonkan sp. MYG392 voucher WAMT132363	0.1474	0.0138
RV08	KJ744618.1 Aname sp. MYG339 voucher T105862	0.1474	0.0138
RV06	NGQ N134 DG3	0.1475	0.0177
RV06	KJ744959.1:239-658 Kwonkan sp. MYG337 voucher T119996	0.1476	0.0173
RV07	KJ744959.1:239-658 Kwonkan sp. MYG337 voucher T119996	0.1476	0.0173
RV08	KJ745137.1:239-658 Aname sp. MYG336 voucher T126253	0.1476	0.0173
RV09	KJ744847.1:239-658 Kwonkan sp. MYG379 voucher T116558	0.1476	0.0173
RV07	NFO N127 CB26	0.1480	0.0173
RV08	NFO N127 CB26	0.1480	0.0173
RV08	KJ744625.1 Aname sp. MYG339 voucher T105873	0.1480	0.0173
RV08	NC N32 AG21	0.1480	0.0173
RV04	KJ745281.1 Kwonkan sp. MYG361 voucher T78543	0.1480	0.0173
RV04	NDL N96 O334	0.1480	0.0173
RV07	NBE N46 AD583	0.1480	0.0173
RV08	NAD N93 AC10	0.1480	0.0173
RV07	KJ745117.1 Aname sp. MYG335 voucher T125329	0.1483	0.0174
RV08	KJ745117.1 Aname sp. MYG335 voucher T125329	0.1483	0.0174
RV07	RB30 H-N160	0.1488	0.0137
RV09	RB26 H-N159	0.1488	0.0137
RV04	KJ744403.1 Kwonkan sp. MYG175 voucher T101209	0.1489	0.0139
RV07	KJ744403.1 Kwonkan sp. MYG175 voucher T101209	0.1489	0.0139
RV07	KJ744962.1 Kwonkan sp. MYG337 voucher T120000	0.1489	0.0139
RV07	KJ744967.1 Kwonkan sp. MYG337 voucher T120011	0.1489	0.0139
RV07	MW039184.1 Kwonkan sp. MYG699 voucher WAMT151298	0.1489	0.0139
RV04	KJ744968.1 Kwonkan sp. MYG337 voucher T120014	0.1492	0.0139

Table 12. Genetic p-distance and the associated standard error from reference specimens showing less than 15% sequence divergence from the Pardoo Camaenidae specimens ('RV' prefix). Lineages in bold text represent lineages detected during the current survey.

Pardoo Specimen	Reference specimens	P-Distance	Std. Err
RV18	RV19	0.00146	0.00146
RV16	RV17	0.00292	0.00206
RV14	RV19	0.01462	0.00459
RV14	RV18	0.01608	0.00481
RV16	RV19	0.01608	0.00481
RV17	RV19	0.01608	0.00481
RV16	RV18	0.01754	0.00502
RV17	RV18	0.01754	0.00502
RV16	RV14	0.01901	0.00522
RV17	RV14	0.01901	0.00522
RV17	JQ362687 Rhagada radleyi isolate R861	0.07798	0.01049
RV16	JQ362687 Rhagada radleyi isolate R861	0.08104	0.01067
RV17	JQ362685 Rhagada radleyi isolate R962	0.08257	0.01076
RV16	JQ362685 Rhagada radleyi isolate R962	0.08563	0.01094
RV16	JQ362695 Rhagada convicta isolate R824	0.08563	0.01094
RV17	JQ362695 Rhagada convicta isolate R824	0.08563	0.01094
RV14	JQ362678 Rhagada convicta isolate R16	0.08576	0.01096
RV19	JQ362678 Rhagada convicta isolate R16	0.08576	0.01096
RV14	MN551637 Rhagada sp. WAM S88449	0.08702	0.01101
RV14	JQ362687 Rhagada radleyi isolate R861	0.08716	0.01103
RV18	JQ362678 Rhagada convicta isolate R16	0.08729	0.01105
RV19	JQ362687 Rhagada radleyi isolate R861	0.08869	0.01112
RV14	KC703165 Rhagada convicta AM C.463519a	0.09008	0.01119
RV16	JQ362696 Rhagada convicta isolate R825	0.09008	0.01119
RV17	JQ362696 Rhagada convicta isolate R825	0.09008	0.01119
RV18	KC703165 Rhagada convicta AM C.463519a	0.09008	0.01119
RV19	MN551637 Rhagada sp. WAM S88449	0.09008	0.01119
RV14	JQ362685 Rhagada radleyi isolate R962	0.09021	0.01120
RV18	JQ362687 Rhagada radleyi isolate R861	0.09021	0.01120
RV19	JQ362685 Rhagada radleyi isolate R962	0.09021	0.01120
RV16	JQ362678 Rhagada convicta isolate R16	0.09035	0.01122
RV17	JQ362678 Rhagada convicta isolate R16	0.09035	0.01122
RV16	MN433264 Rhagada sp. OV81	0.09064	0.01098
RV17	MN433264 Rhagada sp. OV81	0.09064	0.01098
RV14	JQ362677 Rhagada convicta isolate R15	0.09160	0.01127
RV16	MN551637 Rhagada sp. WAM S88449	0.09160	0.01127
RV17	MN551637 Rhagada sp. WAM S88449	0.09160	0.01127
RV18	MN551637 Rhagada sp. WAM S88449	0.09160	0.01127
RV19	JQ362677 Rhagada convicta isolate R15	0.09160	0.01127
RV19	KC703165 Rhagada convicta AM C.463519a	0.09160	0.01127
RV18	JQ362695 Rhagada convicta isolate R824	0.09174	0.01129
RV16	JQ362689 Rhagada convicta isolate R1039	0.09174	0.01129
RV17	JQ362689 Rhagada convicta isolate R1039	0.09174	0.01129
RV18	JQ362685 Rhagada radleyi isolate R962	0.09174	0.01129
RV16	RT56	0.09211	0.01106
RV16	RT57	0.09211	0.01106
RV16	RT58	0.09211	0.01106
RV17	RT56	0.09211	0.01106
RV17	RT57	0.09211	0.01106
RV17	RT58	0.09211	0.01106
RV14	KC703121 Rhagada convicta AM C.463515	0.09313	0.01136

Pardoo Specimen	Reference specimens	P-Distance	Std. Err
RV16	JQ362690 Rhagada convicta isolate R1040	0.09313	0.01136
RV17	JQ362690 Rhagada convicta isolate R1040	0.09313	0.01136
RV18	JQ362677 Rhagada convicta isolate R15	0.09313	0.01136
RV14	JQ362695 Rhagada convicta isolate R824	0.09327	0.01137
RV19	JQ362695 Rhagada convicta isolate R824	0.09327	0.01137
RV16	RT45	0.09357	0.01114
RV17	RT45	0.09357	0.01114
RV16	KC703165 Rhagada convicta AM C.463519a	0.09466	0.01144
RV17	KC703165 Rhagada convicta AM C.463519a	0.09466	0.01144
RV14	MF498934 Rhagada sp. Pilbara Banded isolate ID37	0.09480	0.01145
RV14	MF498935 Rhagada sp. Pilbara Banded isolate ID38	0.09480	0.01145
RV14	MF498951 Rhagada sp. Pilbara Banded isolate ID68	0.09480	0.01145
RV16	MF498934 Rhagada sp. Pilbara Banded isolate ID37	0.09480	0.01145
RV16	MF498935 Rhagada sp. Pilbara Banded isolate ID38	0.09480	0.01145
RV16	MF498951 Rhagada sp. Pilbara Banded isolate ID68	0.09480	0.01145
RV17	MF498934 Rhagada sp. Pilbara Banded isolate ID37	0.09480	0.01145
RV17	MF498935 Rhagada sp. Pilbara Banded isolate ID38	0.09480	0.01145
RV17	MF498951 Rhagada sp. Pilbara Banded isolate ID68	0.09480	0.01145
RV16	MF499043 Rhagada sp. Pilbara Banded isolate R1832	0.09480	0.01145
RV17	MF499043 Rhagada sp. Pilbara Banded isolate R1832	0.09480	0.01145
RV19	MN433264 Rhagada sp. OV81	0.09503	0.01121
RV19	MN433274 Rhagada sp. OV100	0.09503	0.01121
RV16	JQ362677 Rhagada convicta isolate R15	0.09618	0.01152
RV17	JQ362677 Rhagada convicta isolate R15	0.09618	0.01152
RV18	JQ362696 Rhagada convicta isolate R825	0.09618	0.01152
RV19	MF499043 Rhagada sp. Pilbara Banded isolate R1832	0.09633	0.01154
RV16	MN433274 Rhagada sp. OV100	0.09649	0.01129
RV17	MN433274 Rhagada sp. OV100	0.09649	0.01129
RV18	MN433264 Rhagada sp. OV81	0.09649	0.01129
RV18	MN433274 Rhagada sp. OV100	0.09649	0.01129
RV14	JQ362696 Rhagada convicta isolate R825	0.09771	0.01160
RV16	KC703121 Rhagada convicta AM C.463515	0.09771	0.01160
RV17	KC703121 Rhagada convicta AM C.463515	0.09771	0.01160
RV17	KC703157 Rhagada convicta voucher AM C.463524a	0.09771	0.01160
RV19	JQ362696 Rhagada convicta isolate R825	0.09771	0.01160
RV19	KC703121 Rhagada convicta AM C.463515	0.09771	0.01160
RV19	MF498934 Rhagada sp. Pilbara Banded isolate ID37	0.09786	0.01162
RV19	MF498935 Rhagada sp. Pilbara Banded isolate ID38	0.09786	0.01162
RV19	MF498951 Rhagada sp. Pilbara Banded isolate ID68	0.09786	0.01162
RV18	MF499043 Rhagada sp. Pilbara Banded isolate R1832	0.09786	0.01162
RV14	KC617889 Rhagada sp. barrowensis isolate R838	0.09789	0.01153
RV18	KC617889 Rhagada sp. barrowensis isolate R838	0.09789	0.01153
RV16	MN433269 Rhagada sp. OV92	0.09795	0.01137
RV16	MN433284 Rhagada sp. OV125	0.09795	0.01137
RV16	RT50	0.09795	0.01137
RV16	RT52	0.09795	0.01137
RV17	MN433269 Rhagada sp. OV92	0.09795	0.01137
RV17	MN433284 Rhagada sp. OV125	0.09795	0.01137
RV17	RT50	0.09795	0.01137
RV17	RT52	0.09795	0.01137
RV18	RT56	0.09795	0.01137
RV18	RT57	0.09795	0.01137
RV18	RT58	0.09795	0.01137
RV19	MN433281 Rhagada sp. OV120	0.09795	0.01137

Pardoo Specimen	Reference specimens	P-Distance	Std. Err
RV19	MN433282 Rhagada sp. OV121	0.09795	0.01137
RV19	MN433291 Rhagada sp. OV143	0.09795	0.01137
RV18	KC703121 Rhagada convicta AM C.463515	0.09924	0.01168
RV19	KC703157 Rhagada convicta voucher AM C.463524a	0.09924	0.01168
RV18	MF498934 Rhagada sp. Pilbara Banded isolate ID37	0.09939	0.01170
RV18	MF498935 Rhagada sp. Pilbara Banded isolate ID38	0.09939	0.01170
RV18	MF498951 Rhagada sp. Pilbara Banded isolate ID68	0.09939	0.01170
RV19	KC617889 Rhagada sp. barrowensis isolate R838	0.09940	0.01161
RV14	RT56	0.09942	0.01144
RV14	RT57	0.09942	0.01144
RV14	RT58	0.09942	0.01144
RV16	MN433282 Rhagada sp. OV121	0.09942	0.01144
RV16	MN433291 Rhagada sp. OV143	0.09942	0.01144
RV17	MN433282 Rhagada sp. OV121	0.09942	0.01144
RV17	MN433291 Rhagada sp. OV143	0.09942	0.01144
RV18	MN433281 Rhagada sp. OV120	0.09942	0.01144
RV18	MN433282 Rhagada sp. OV121	0.09942	0.01144
RV18	MN433291 Rhagada sp. OV143	0.09942	0.01144
RV18	RT45	0.09942	0.01144
RV19	MN433269 Rhagada sp. OV92	0.09942	0.01144
RV19	MN433284 Rhagada sp. OV125	0.09942	0.01144
RV19	RT56	0.09942	0.01144
RV19	RT57	0.09942	0.01144
RV19	RT58	0.09942	0.01144
RV16	KC703157 Rhagada convicta voucher AM C.463524a	0.10076	0.01176
RV18	KC703157 Rhagada convicta voucher AM C.463524a	0.10076	0.01176
RV16	KM405444 Rhagada convicta isolate R1061	0.10087	0.01256
RV16	KM405447 Rhagada convicta isolate R1110	0.10087	0.01256
RV17	KM405444 Rhagada convicta isolate R1061	0.10087	0.01256
RV17	KM405447 Rhagada convicta isolate R1110	0.10087	0.01256
RV16	KM405446 Rhagada convicta isolate R1106	0.10087	0.01256
RV17	KM405446 Rhagada convicta isolate R1106	0.10087	0.01256
RV14	MN433264 Rhagada sp. OV81	0.10088	0.01152
RV14	MN433282 Rhagada sp. OV121	0.10088	0.01152
RV14	RT45	0.10088	0.01152
RV16	MN433288 Rhagada sp. OV131	0.10088	0.01152
RV17	MN433288 Rhagada sp. OV131	0.10088	0.01152
RV18	MN433269 Rhagada sp. OV92	0.10088	0.01152
RV18	MN433284 Rhagada sp. OV125	0.10088	0.01152
RV19	MN433276 Rhagada sp. OV105	0.10088	0.01152
RV19	MN433278 Rhagada sp. OV110	0.10088	0.01152
RV19	RT45	0.10088	0.01152
RV18	JQ362689 Rhagada convicta isolate R1039	0.10092	0.01178
RV18	JQ362690 Rhagada convicta isolate R1040	0.10229	0.01184
RV16	MN433276 Rhagada sp. OV105	0.10234	0.01159
RV16	MN433278 Rhagada sp. OV110	0.10234	0.01159
RV16	MN433281 Rhagada sp. OV120	0.10234	0.01159
RV17	MN433276 Rhagada sp. OV105	0.10234	0.01159
RV17	MN433278 Rhagada sp. OV110	0.10234	0.01159
RV17	MN433281 Rhagada sp. OV120	0.10234	0.01159
RV18	MN433276 Rhagada sp. OV105	0.10234	0.01159
RV18	MN433278 Rhagada sp. OV110	0.10234	0.01159
RV19	MN433279 Rhagada sp. OV113	0.10234	0.01159
RV16	KC617889 Rhagada sp. barrowensis isolate R838	0.10241	0.01177

Pardoo Specimen	Reference specimens	P-Distance	Std. Err
RV17	KC617889 Rhagada sp. barrowensis isolate R838	0.10241	0.01177
RV14	JQ362689 Rhagada convicta isolate R1039	0.10245	0.01186
RV14	MF499043 Rhagada sp. Pilbara Banded isolate R1832	0.10245	0.01186
RV19	JQ362689 Rhagada convicta isolate R1039	0.10245	0.01186
RV14	KC617888 Rhagada sp. barrowensis isolate R837	0.10256	0.01178
RV18	KC617888 Rhagada sp. barrowensis isolate R837	0.10256	0.01178
RV16	KM405445 Rhagada convicta isolate R1102	0.10261	0.01265
RV17	KM405445 Rhagada convicta isolate R1102	0.10261	0.01265
RV14	MN433274 Rhagada sp. OV100	0.10380	0.01166
RV14	MN433281 Rhagada sp. OV120	0.10380	0.01166
RV14	MN433288 Rhagada sp. OV131	0.10380	0.01166
RV16	MN433279 Rhagada sp. OV113	0.10380	0.01166
RV17	MN433279 Rhagada sp. OV113	0.10380	0.01166
RV18	MN433279 Rhagada sp. OV113	0.10380	0.01166
RV18	RT50	0.10380	0.01166
RV18	RT52	0.10380	0.01166
RV14	JQ362690 Rhagada convicta isolate R1040	0.10382	0.01192
RV19	JQ362690 Rhagada convicta isolate R1040	0.10382	0.01192
RV19	KC617888 Rhagada sp. barrowensis isolate R837	0.10407	0.01186
RV18	KM405447 Rhagada convicta isolate R1110	0.10435	0.01275
RV18	KM405446 Rhagada convicta isolate R1106	0.10435	0.01275
RV14	MN433269 Rhagada sp. OV92	0.10526	0.01173
RV14	MN433284 Rhagada sp. OV125	0.10526	0.01173
RV14	RT50	0.10526	0.01173
RV14	RT52	0.10526	0.01173
RV19	RT50	0.10526	0.01173
RV19	RT52	0.10526	0.01173
RV14	KC703157 Rhagada convicta voucher AM C.463524a	0.10534	0.01200
RV16	KM405443 Rhagada convicta isolate R1045	0.10609	0.01284
RV17	KM405443 Rhagada convicta isolate R1045	0.10609	0.01284
RV18	KM405445 Rhagada convicta isolate R1102	0.10609	0.01284
RV19	KM405447 Rhagada convicta isolate R1110	0.10609	0.01284
RV19	KM405446 Rhagada convicta isolate R1106	0.10609	0.01284
RV14	MN433291 Rhagada sp. OV143	0.10673	0.01181
RV19	MN433288 Rhagada sp. OV131	0.10673	0.01181
RV16	JQ362692 Rhagada convicta isolate R822	0.10687	0.01207
RV17	JQ362692 Rhagada convicta isolate R822	0.10687	0.01207
RV18	JQ362692 Rhagada convicta isolate R822	0.10687	0.01207
RV16	KC617888 Rhagada sp. barrowensis isolate R837	0.10709	0.01201
RV17	KC617888 Rhagada sp. barrowensis isolate R837	0.10709	0.01201
RV16	JQ362691 Rhagada convicta isolate R821	0.10769	0.01216
RV17	JQ362691 Rhagada convicta isolate R821	0.10769	0.01216
RV18	JQ362691 Rhagada convicta isolate R821	0.10769	0.01216
RV18	KM405444 Rhagada convicta isolate R1061	0.10783	0.01293
RV19	KM405445 Rhagada convicta isolate R1102	0.10783	0.01293
RV18	MN433288 Rhagada sp. OV131	0.10819	0.01188
RV14	JQ362692 Rhagada convicta isolate R822	0.10840	0.01215
RV19	JQ362692 Rhagada convicta isolate R822	0.10840	0.01215
RV14	JQ362691 Rhagada convicta isolate R821	0.10923	0.01223
RV19	JQ362691 Rhagada convicta isolate R821	0.10923	0.01223
RV14	KM405444 Rhagada convicta isolate R1061	0.10957	0.01303
RV14	KM405447 Rhagada convicta isolate R1110	0.10957	0.01303
RV19	KM405444 Rhagada convicta isolate R1061	0.10957	0.01303
RV14	KM405446 Rhagada convicta isolate R1106	0.10957	0.01303

Pardoo Specimen	Reference specimens	P-Distance	Std. Err
RV14	MN433276 Rhagada sp. OV105	0.10965	0.01195
RV14	MN433278 Rhagada sp. OV110	0.10965	0.01195
RV14	MN433279 Rhagada sp. OV113	0.11111	0.01202
RV14	KM405445 Rhagada convicta isolate R1102	0.11130	0.01312
RV18	KM405443 Rhagada convicta isolate R1045	0.11304	0.01321
RV14	KM405443 Rhagada convicta isolate R1045	0.11478	0.01329
RV19	KM405443 Rhagada convicta isolate R1045	0.11478	0.01329