Appendix B

Phoenix Targeted Spider Survey 2015

PHOENIX
ENVIRONMENTAL SCIENCES

Reconnaissance survey for the Shield-backed Trapdoor Spider (*Idiosoma nigrum*) for the Square Kilometre Array

Prepared for AECOM Pty Ltd

February 2015

Final Report

Reconnaissance survey for the Shield-backed Trapdoor Spider (*Idiosoma nigrum*) for the Square Kilometre Array

Prepared for AECOM Pty Ltd

Draft Report

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EXECUTIVE SUMMARY

The Square Kilometre Array (SKA) (the Project) is currently the largest international radio telescope project. Boolardy Station was selected as the site of the Australian SKA bid in 2007 and the Murchison Radio Observatory (MRO) was established in 2009. The Australian SKA Pathfinder (ASKAP) and Murchison Widefield Array (MWA) have since been constructed at the site.

In 2012, the announcement that Australia would jointly host the SKA with South Africa led to the commencement of the SKA-1 survey and the SKA-1 frequency array. During environmental surveys in proposed footprints of new infrastructure, a trapdoor spider burrow potentially belonging the Shield-backed Trapdoor Spider (*Idiosoma nigrum*) was identified, but the spider was not captured and its identity remained unconfirmed.

The Shield-backed Trapdoor Spider is listed as Vulnerable under the Federal Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and is on Schedule 1 of the Western Australian Wildlife Conservation Act 1950 (WC Act). Further investigations were therefore required to confirm the presence of the species on Boolardy Station (the 'study area') to establish if it requires consideration as part of the environmental impact assessment of the Project.

The survey scope was to:

- conduct a reconnaissance field survey to confirm if *I. nigrum* is present at the site where trapdoor spider burrows were originally observed
- determine the presence of *I. nigrum* at other locations with potential to support within the study area
- undertake genomic analyses (COI barcoding) to confirm morphological identification
- prepare a technical report outlining survey methods and results, i.e. the presence of *I. nigrum* in the study area.

The field survey was conducted on the 9th and 10th December 2014. A total of four sites were surveyed for *I. nigrum*.

Morphological and molecular identification confirmed the presence of *I. nigrum* at one site (IN01) characterised as sparse mulga woodland with rocky ground-cover; however, the species was absent at other sites of similar habitat (sites IN02 and IN03). Lacking a clear understanding of the local habitat preferences of *I. nigrum*, it is difficult to extrapolate the distribution of the species in the study area. Habitat mapping alone should not be used to infer the distribution of the species.

1 INTRODUCTION

In November 2014, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by AECOM Pty Ltd (AECOM) to undertake a targeted survey for the Shield-backed Trapdoor Spider (*Idiosoma nigrum*) for the Square Kilometre Array (SKA) ('the Project') to confirm its presence on Boolardy Station (the 'study area'). *Idiosoma nigrum* is listed as Vulnerable under the Federal Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and on Schedule 1 of the Western Australian Wildlife Conservation Act 1950 (WC Act).

1.1 BACKGROUND

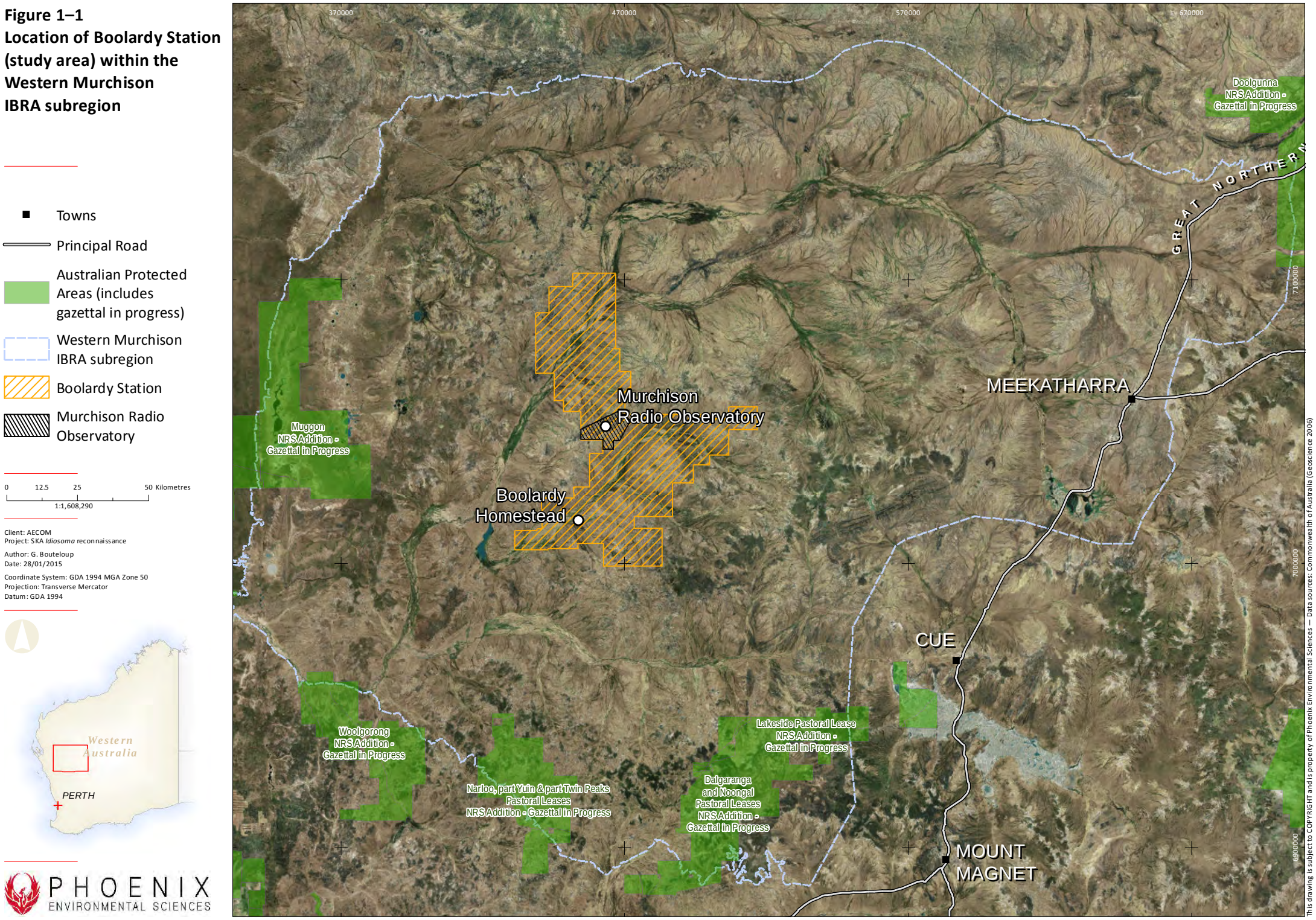
The SKA is currently the largest international radio telescope project. Boolardy Station (Figure 1-1) was selected as the home of the Australian SKA bid in 2007 and the Murchison Radio Observatory (MRO) was established in 2009. The Australian SKA Pathfinder (ASKAP) and Murchison Widefield Array (MWA) have since been constructed at the site. ASKAP has become part of the CSIRO's Australia Telescope National Facility (ATNF) which includes radio telescopes located at Parkes, Narrabri and Coonabarabran (Commonwealth of Australia 2015).

Environmental surveys were undertaken as part of the site establishment activities at the MRO. Following the surveys, referrals were made to the Commonwealth and State environmental regulators under the EPBC Act and WA *Environmental Protection Act 1986* (EP Act). The Commonwealth determined that no further impact assessment was required. The WA Environmental Protection Authority returned a decision of 'not assessed' and a subsequent appeal of the decision by the Conservation Council of WA on the basis of soil conservation matters was dismissed (EPA 2009).

In 2012, the announcement that Australia would jointly host the SKA with South Africa led to the commencement of the SKA-1 survey and the SKA-1 frequency array. Environmental surveys for proposed footprints of new infrastructure beyond the initial MRO footprint have been undertaken in order to determine the potential environmental impacts and to prepare management approaches to minimise the level and scope of environmental assessment under State and Commonwealth regulators.

Recent fauna surveys identified a trapdoor spider burrow that potentially belonged to *I. nigrum*; however, specimens were not collected for positive identification. Further investigations were therefore required to confirm the identity of the spider and the presence of *I. nigrum* in the study area to potentially consider the species in the environmental impact assessment.

Figure 1–1
Location of Boolardy Station (study area) within the Western Murchison IBRA subregion



2 PROJECT SCOPE

The study area for the purpose of this report is defined by the boundary of Boolardy Station and contains the MRO (Figure 1-1). The reconnaissance survey initially focussed on the site in the south of the study area where trapdoor spiders were previously observed, here referred to as IN01 (see Figure 5-1).

2.1 SCOPE OF WORK AND SURVEY OBJECTIVES

The scope of this project was to:

- conduct a reconnaissance field survey to confirm the presence of *I. nigrum* at the site where trapdoor spider burrows were initially observed
- determine the presence of *I. nigrum* at other locations within the study area with potential to support the species
- undertake genomic analyses (COI barcoding) for up to ten specimens to confirm morphological identifications
- prepare maps showing records of *I. nigrum*
- prepare a technical report outlining survey methods and results, i.e. the presence of *I. nigrum* in the study area.

Where practicable, survey design, methodology and report-writing adhere to relevant principles and guidelines, including:

- Environmental Protection Authority (EPA) Position Statement No. 3: Terrestrial biological surveys as an element of biodiversity protection (EPA 2002)
- EPA Guidance Statement No. 56: Terrestrial fauna surveys for environmental impact assessment in Western Australia (EPA 2004).

The limitations of the survey with respect to Guidance Statement 56 (EPA 2004) are discussed in Section 6.2.

3 LEGISLATIVE CONTEXT

The protection of fauna in Western Australia is principally governed by three acts:

- Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)
- Wildlife Conservation Act 1950 (WC Act)
- Environmental Protection Act 1986 (EP Act).

3.1 COMMONWEALTH

Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of national environmental significance (NES), require approval from the Australian Government Minister for the Environment. The EPBC Act provides for the listing of threatened native fauna as matters of NES.

Conservation categories applicable to threatened fauna species under the EPBC Act are as follows:

- Extinct (EX)[1] – there is no reasonable doubt that the last individual has died
- Extinct in the Wild (EW) – taxa known to survive only in captivity
- Critically Endangered (CR) – taxa facing an extremely high risk of extinction in the wild in the immediate future
- Endangered (EN) – taxa facing a very high risk of extinction in the wild in the near future
- Vulnerable (VU) – taxa facing a high risk of extinction in the wild in the medium-term
- Conservation Dependent[1] – taxa whose survival depends upon ongoing conservation measures; without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.

Few terrestrial invertebrate taxa from WA are listed as matters of NES and those that are mostly include species that have experienced significant range contractions and population declines due to habitat loss, for example the Margaret River Marron (*Cherax tenuimanus*) (CR) and the Shield-backed Trapdoor Spider (*I. nigrum*) (VU) (Department of the Environment 2014a).

3.2 STATE

In Western Australia, the WC Act provides for the listing of native fauna (Threatened Fauna) species which are under identifiable threat of extinction. Threatened Fauna are assigned to one of four categories under the WC Act (Western Australian Government 2014):

- Schedule 1 (S1) – fauna that is rare or is likely to become extinct
- Schedule 2 (S2) – fauna presumed to be extinct
- Schedule 3 (S3) – Migratory birds protected under an international agreement
- Schedule 4 (S4) – other specially protected fauna.

Assessments for listing of fauna are based on the International Union for Conservation of Nature (IUCN) threat categories.

The Department of Parks and Wildlife (DPaW) administers the WC Act and also maintains a non-statutory list of Priority fauna species, most recently updated on 2 December 2014 (DPaW 2014). Priority species are still considered to be of conservation significance – that is they may be rare or threatened – but cannot be considered for listing under the WC Act until there is adequate understanding of their threat levels. Species on the Priority fauna lists are assigned to one of five priority (P) categories, P1 (highest) – P5 (lowest), based on level of knowledge/concern.

[1] Species listed as Extinct and Conservation Dependent are not matters of NES and therefore do not trigger the EPBC Act.

4 EXISTING ENVIRONMENT

4.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation of Australia (IBRA) defines 'bioregions' as large land areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems (Department of the Environment 2014b; Thackway & Cresswell 1995) . Their purpose is to record and categorise the large-scale geophysical patterns that occur across the Australian continent. The identified patterns in the landscape are linked to fauna and flora assemblages and processes at the ecosystem scale. They are a useful means for simplifying and reporting on more complex patterns of biodiversity (Thackway & Cresswell 1995).

Western Australia contains 26 IBRA bioregions and 53 subregions. By combining information for an IBRA region with information on protected areas within the region and its sub-regions, the level of protection of Australia's various landscapes can be established. IBRA is therefore a dynamic tool for monitoring progress towards building a comprehensive, adequate and representative reserve system (Department of the Environment 2014b) .

The Project is located approximately 148 km WNW of Cue within the Murchison bioregion (Figure 1-1). The Murchison bioregion is divided into two subregions: East Murchison subregion (MUR1) and Western Murchison subregion (MUR2). The Project falls within the Western Murchison subregion which forms part of the Yilgarn Craton (Desmond *et al.* 2001). The headwaters of the Murchison and Wooramel Rivers drain the subregion towards the coast. The subregion comprises low mulga woodlands on outcrops and Quarternary alluvial and elluvial plains, hummock grasslands on Quaternary sandplains, saltbush shrublands on calcareous soils and low *Halosarcia* shrublands on saline alluvial (Desmond *et al.* 2001).

4.2 CLIMATE AND WEATHER

The West Murchison subregion has an arid climate with an average annual rainfall of approximately 231 mm (BOM 2015).

The nearest active Bureau of Meteorology (BOM) weather station is located at Murchison (Latitude**:** 26.90°S Longitude**:** 115.96°E) approximately 71 km WSW of the study area. Murchison records the highest mean maximum monthly temperature (39.3°C) in January, the lowest mean minimum monthly temperature (6.2°C) in July and an average annual rainfall of 231 mm (BOM 2015) (Figure 4-1).

Rainfall and temperature during the three months preceding the field survey were generally above those of the long term averages (Figure 4-1); however, these conditions are an approximate indication of weather in the region and are not indicative of exact conditions on site.

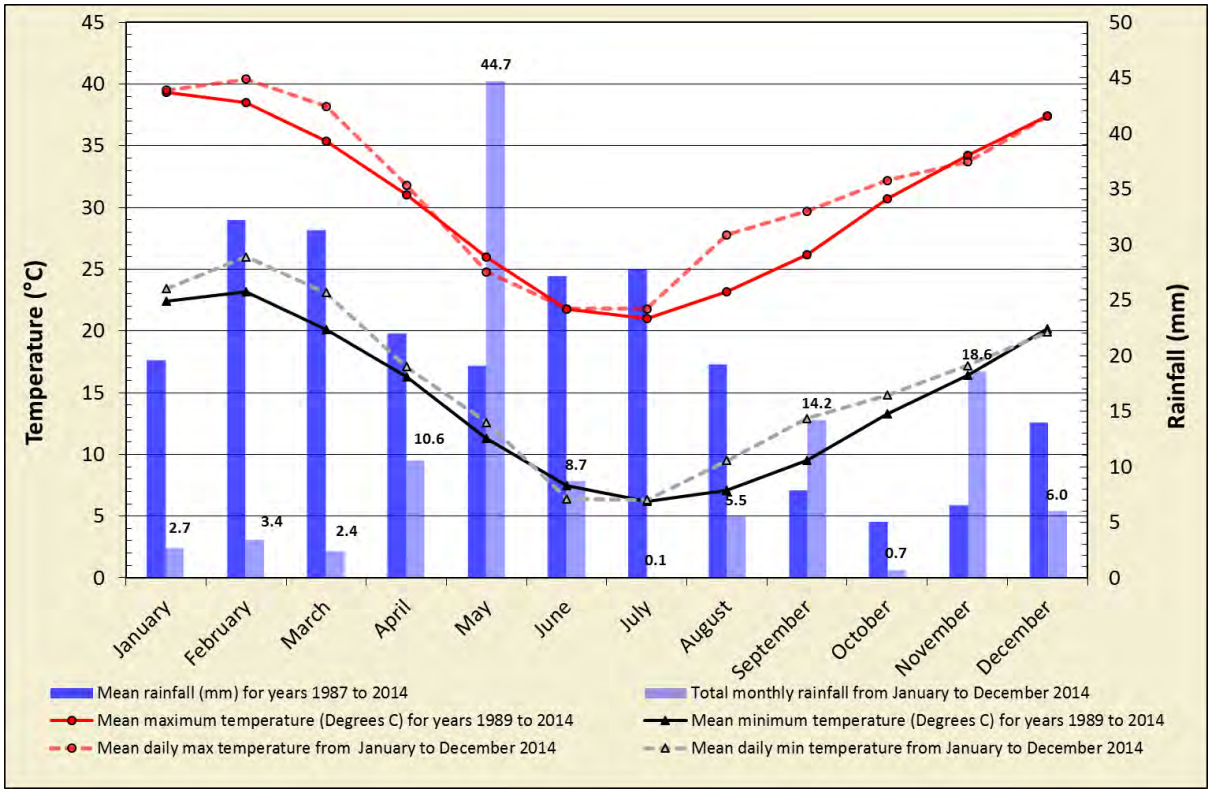


Figure 4-1 **Climate data (average monthly temperatures and rainfall records) and weather (temperature and rainfall preceding survey) for Murchison (BOM 2015)**

4.3 LAND USE

The main land uses of the Western Murchison subregion include grazing native pastures (92%), with lesser areas of Unallocated Crown Land (UCL) and Crown reserves (2.81%). Conservation lands constitute 0.06% of the subregion. There are considerable interests in nickel and gold mining (Desmond *et al.* 2001).

4.3.1 Conservation Reserves

Several reserves are proposed on former pastoral leases around Boolardy Station (Figure 1-1) and these may provide future refugial areas for threatened fauna and flora of the region. Within the context of this survey, *I. nigrum* has been found at proposed reserves on Lakeside and Dalgaranga and Noongal Pastoral Leases to the south of the study area (see Figure 6-2).

4.4 BIOLOGICAL CONTEXT

4.4.1 Biology of *Idiosoma nigrum*

Idiosoma nigrum (family Idiopidae) (Figure 4-2) is commonly known as the Shield-backed (or Black Rugose) Trapdoor Spider and was initially described from Wongan Hills in Western Australia (Main 1952). The species was subsequently recorded from many areas throughout the northern Avon Wheatbelt and Murchison regions of Western Australia. Land clearing, secondary salinisation and the introduction of feral animals such as goats, have substantially decreased its distribution in the past 50 years.

4.4.1.1 Distribution and habitat

Idiosoma nigrum is endemic to the semi-arid southwest and Murchison region, Western Australia (Main 2003). The species is a medium-sized to large trapdoor spider; females grow up to 30 mm in body length with dark brown to black colouration and a distinctive, rugose abdominal cuticle (Figure 4-2). The trapdoor of the burrow is constructed with a characteristic fan ('moustache') of twigs attached to the burrow rim (Figure 4-3). Burrow construction and decoration are similar to that of other idiopid genera such as *Anidiops* and *Aganippe*; however, the burrow of *I. nigrum* has a constriction in its upper part where spiders plug the burrow with their truncated abdomen (Main 2003).

Figure 4-2 Adult female of *Idiosoma nigrum*

Figure 4-3 *Idiosoma nigrum* burrow with trapdoor and 'moustache' twig-lining

The species was previously known from only as far north as Nerren Nerren Station. Recent biological surveys associated with mining projects in the Midwest and Murchison regions have extended the known distribution of this species north to Weld Range and Jack Hills, but also Albion Downs and Yeelirrie Stations.

Main (2003) reported that the species occurred "generally in eucalypt woodlands on heavy clay soils and occasionally in *Acacia*-dominated vegetation associations on granitic soils" within the larger Avon Wheatbelt region. In contrast, populations in the Midwest at Weld Range (estimated >10,000 individuals), Jack Hills (>13,000) and Karara Station (>20,000) appear to prefer habitat with open, low *Acacia* vegetation associations on sandy clay soils, commonly in association with creek/drainage lines often extending into nearby mesic slopes (Phoenix 2012, 2013). These Midwest populations are absent from areas with shallow or skeletal soil profiles and areas that are seasonally inundated. Proximity to drainage lines and aspect appear to be the major two predictors of *I. nigrum* presence in the Midwest region; however, neither on their own appear to be sufficient to guarantee its presence (Phoenix 2012, 2013).

4.4.1.2 Behaviour and life cycle

Idiosoma nigrum is believed to be one of the most arid-adapted Australian mygalomorph spider species (Main 2003). It has a heavily sclerotised abdomen, which acts to reduce water loss and is also believed to serve as a defensive mechanism against predators (Main 1952, 1957, 2003). Spiders plug the burrow below a constriction with their inflexible abdomen (i.e. with the abdomen facing the entrance). The abdomen fits the diameter of the burrow almost perfectly. They widen the opening of their burrows as they grow and therefore the diameter of the burrow entrance is directly related to age and sexual maturity of the inhabitant.

Idiosoma nigrum burrows have previously been reported to extend to 32 cm in total depth. In our studies, the deepest burrow measured to date is 37 cm (Phoenix 2012, 2013). Deeper excavations of more northerly populations may reflect dryer climatic conditions. Deeper burrows would provide greater control and stability of air temperature and relative humidity in more arid environments.

Individuals tend to cluster around the bases of trees apparently forming "meta-populations", i.e. spatially separate populations that have some, but limited, genetic exchange (Hanksi 1999). The size of subpopulations varies significantly from a few to dozens of individuals. Emergents tend to aggregate around female burrows. Further dispersion would be hazardous due to possible predation and therefore is presumably prompted only rarely, for example by a lack of space amongst other burrows (Main 2003). Genetic exchange between subpopulations may therefore largely be facilitated by the more active males in search for females.

Males are rarely seen in burrows. During autumn and winter months they wander in search of females. Males of the species have characteristic grooves on the abdomen and comparatively longer legs than females. Leg elongation in males is observed in many ground-dwelling spiders as longer legs provide greater mobility and therefore may increase fertilisation success (Framenau 2005).

Mating occurs within the female burrow and the male typically dies after mating, usually from exposure or predation (Main 2003). The female lays her eggs in spring and the spiderlings hatch in the early- to mid-summer in the Avon Wheatbelt populations (Main 2003). The young are believed to remain in the burrow until autumn or winter when the first rains provide more favourable digging conditions. Spiderlings must establish a burrow on the first night they leave their mother's burrow or they are likely to die of heat exposure the following day.

Idiosoma nigrum is believed to be a very long-lived species. Individuals may take five or six years to mature and female life span may be more than 12 years after maturity (Main 2003).

5 METHODS

5.1 FIELD SURVEY

The field survey was conducted on the 9th and 10th of December 2014. Four sites with habitat qualities potentially supporting populations of *I. nigrum*, in particular within *Acacia* woodland, were surveyed (Table 5-1; Figure 5-1; Appendix 1). The first site (IN01) represented the location where trapdoor spiders had previously been observed during fauna surveys by AECOM. Site IN04 was the only site within the MRO that showed potential to support *I. nigrum*.

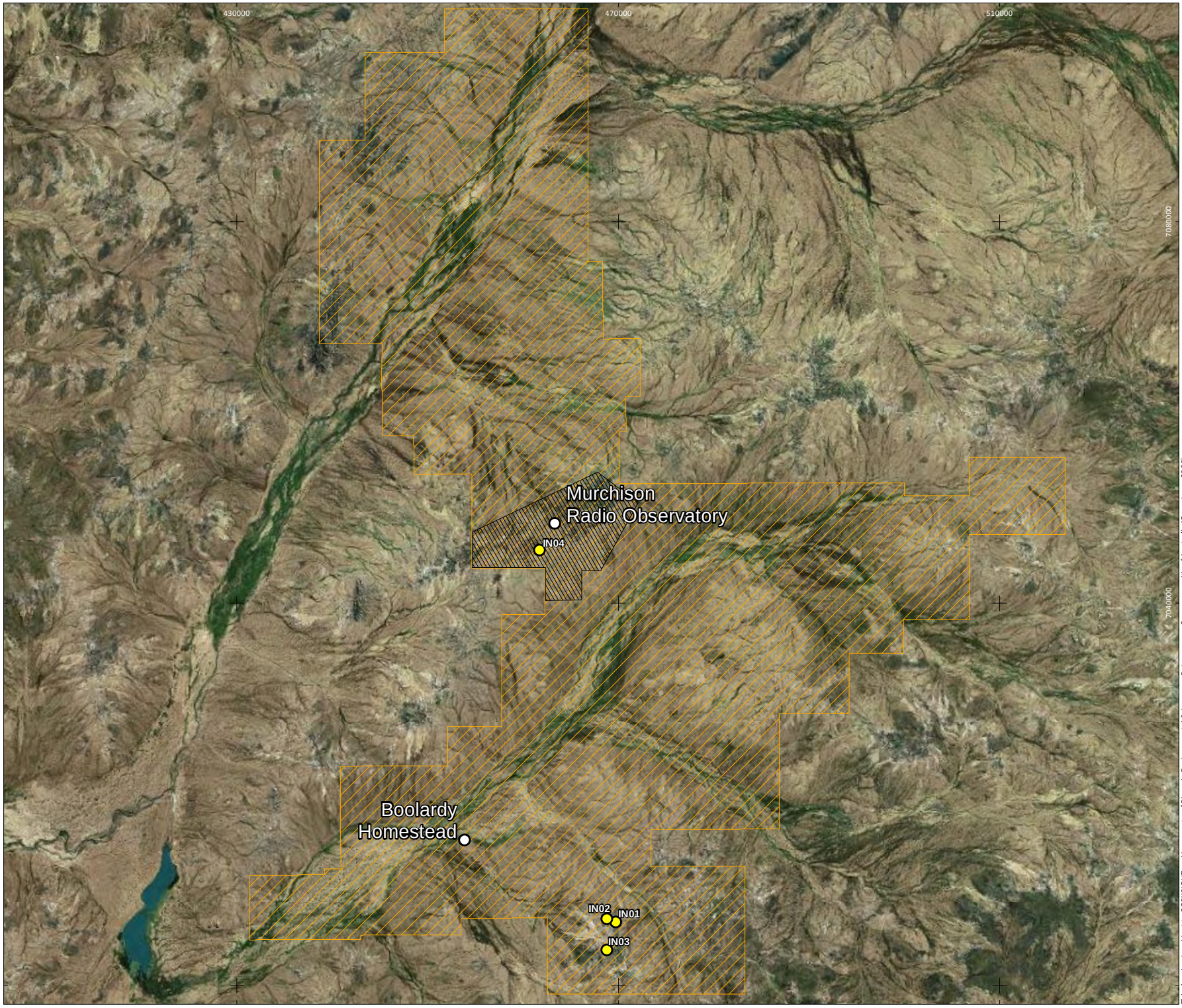
Table 5-1 Geographic coordinates and habitat type of *Idiosoma nigrum* survey sites

Site	Latitude (GDA94)	Longitude (GDA94)	Easting (Zone 50)	Northing (Zone 50)	Habitat type
IN01	-27.062899	116.695334	469789	7006561	Open mulga woodland
IN02	-27.059550	116.686119	468874	7006930	
IN03	-27.089167	116.685833	468854	7003649	
IN04	-26.710833	116.615833	461787	7045534	

Potential *I. nigrum* burrows were examined for evidence of current occupancy, including freshness of silk at the entrance and condition of the twig lining of the burrow. Suitable burrows were carefully excavated and the spiders extracted. Each spider was preserved in cool (approximately 10°C) > 95% Ethanol. On return to the camp site (Boolardy Homestead), the third right leg was separated from each specimen for DNA fixation. Specimens were refrigerated overnight at approximately 2°C.

Collection of *I. nigrum* during this survey was made under Regulation 17 Licence SF010095. All material collected during the survey will be lodged with the WA Museum.

Figure 5–1
Idiosoma nigrum **survey locations**



5.2 TAXONOMY AND NOMENCLATURE

5.2.1 Morphological species identification

Idiosoma nigrum possesses a highly diagnostic dark, thickened and ridged abdominal morphology that enables positive identification in the field of virtually all life stages (Figure 4-2). Field identifications were made by Dr Erich S. Volschenk confirmed in the laboratory by Dr Volker W. Framenau.

5.2.2 Molecular species identification

The identification of species based on comparisons between DNA sequences is referred to as DNA barcoding. Any gene can be used for barcoding purposes; however, the primary gene targeted by researchers is Cytochrome Oxidase Subunit I (COI or COXI), the 'Barcoding Gene' (Hebert *et al.* 2003). Hebert *et al.* (2003) examined the percentage differences of over 130,000 species pairs. That study found a mean divergence of 11.3% between species pairs and with the majority of species showing 8% or more sequence divergence. Approximately 1460 'other orders' of Arthropoda were found to have an average sequence divergence of 10.1% and more than 50% had divergences greater than 8%. For this reason 8% sequence difference is usually used as the threshold for discrimination of species, although a number of studies on invertebrates show that caution must be applied when using a 'one-size-fits-all' approach (Bond 2004; Boyer *et al.* 2007; Köhler & Johnson 2012). A recent large scale study on WA mygalomorph spiders, including species in the family Idiopidae, used 9.5 % sequence divergence to delineate species (2014).

5.2.2.1 DNA extraction

COI was sequenced for six specimens identified as *I. nigrum* on the basis of morphological examination, including the three specimens collected during the survey from site IN01 and three specimens previously collected by Phoenix at Jack Hills (Table 5-2).

Genomic DNA was extracted at the molecular laboratory of the University of Western Australia using the Qiagen DNeasy Blood & Tissue Kit (Valencia, CA, USA). Extraction was achieved by incubating leg muscle tissue in lysis buffer overnight at 56˚C. Initial test PCR's using four primer combinations were run to determine which primers could amplify the gene consistently across all species. The forward primer LCO1490 and the reverse primer HCO2198 (Folmer *et al.* 1994) were ultimately chosen to amplify approximately 700 nucleotides of COI.

5.2.2.2 Sequence analysis

The COI sequences obtained from the specimens from Boolardy Station and Jack Hills were submitted to the WA Museum for comparison with those of *I. nigrum* lodged at the WA Museum.

Table 5-2 Specimens sequenced in this study

Species	Phoenix database number	WA Museum registration[2]	Location	Latitude (GDA94)	Longitude (GDA94)
Idiosoma nigrum	17895	TBA	Boolardy Station (IN01)	-27.062899	116.695334
	17896	TBA			
	17899	TBA			
	9296	TBA	Jack Hills	-26.048112	117.253619
	9293	TBA			
	9295	TBA			

5.3 SURVEY PERSONNEL

Phoenix personnel involved in the survey are presented in (Table 5-3).

Table 5-3 Project team

Name	Qualifications	Role/s
Dr Erich S. Volschenk	B.Sc. (Zool.) (Hons), Ph.D. (Zool.)	Field survey, reporting, genomic analyses, GIS
Dr Volker W. Framenau	M.Sc. (Cons. Biol.), Ph.D. (Zool.)	Project manager, taxonomy, report review
Ms Anna Leung	B.Sc. (Env. Sci.) (Hons)	Field survey, report writing
Mr Guillaume Bouteloup	Advanced Diploma (Land and Conservation Management)	GIS

[2] The Taxonomic Services Unit of the WA Museum was closed for submission when this report was compiled.

6 RESULTS

6.1 FIELD SURVEY

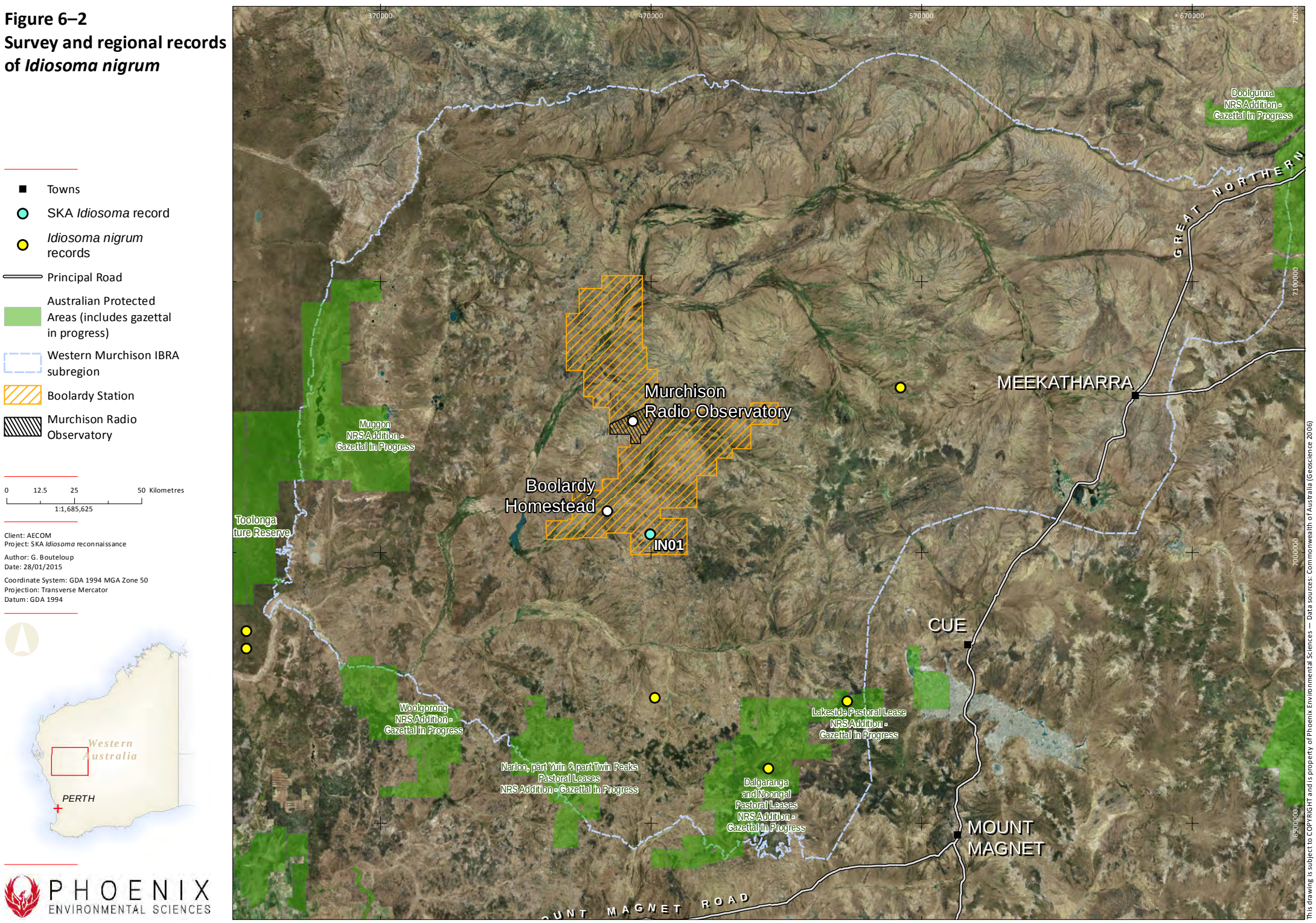
A total of five trapdoor spiders were collected during the survey (Table 6-1), including three specimens of *I. nigrum*— all from site IN01 (Figure 6-1; Figure 6-2) —and two juvenile specimens in the genus *Anidiops*.

Table 6-1 Trapdoor spiders (family Idiopidae) recorded during the survey

Family	Species (Family)	No. of specimens	Habitat	Sites
Idiopidae (true trapdoor spiders)	*Idiosoma nigrum*	3	Sparse mulga thicket	IN01
	Anidiops sp. indet.	1	Sparse mulga thicket	IN01
		1	Sparse mulga thicket	IN03

Figure 6-1 *Idiosoma nigrum* habitat at site IN01

Figure 6–2
Survey and regional records of *Idiosoma nigrum*



6.1.1 Molecular analyses

The molecular analyses revealed the three specimens from the survey to be conspecific with 0% COI sequence divergence. These specimens differed from the three additional specimens of *I. nigrum* from Jack Hills by between 5.9 % and 6.4% COI divergence suggesting these to be conspecific as they fall under the divergence threshold of 9.5 % (Castalanelli *et al.* 2014).

Analyses undertaken by the WA Museum indicated that all six sequences matched their sequences of *I. nigrum*; however, the species has notably polymorphic COI sequences with 5% sequence divergence within the lineage (G. Dolman, email to E.S. Volschenk, 16 January 2015).

6.2 SURVEY LIMITATIONS

Guidance Statement 56 (EPA 2004) identified potential limitations that may be encountered during terrestrial fauna surveys. With respect to this guidance statement, no major limitations were identified for the survey at Boolardy Station Table 6-2

Table 6-2 Survey limitations based on EPA Guidance Statement 56 (EPA 2004)

Limitations	Limitation for this survey?	Comments
Competency/experience of survey personnel, including taxonomy	No	The field team and report authors have extensive experience in targeted fauna surveys, incl. for *I. nigrum*, and include taxonomic experts of international standing. All identifications were confirmed with molecular tools.
Scope and completeness - were all planned survey methods implemented successfully, was the study area fully surveyed	No	Suitable collecting methods were used. The survey was a reconnaissance survey and appropriate sites were surveyed.
Proportion of fauna identified, recorded and/or collected.	No	The survey was a targeted survey for *I. nigrum*, which was collected. Specimens of an additional idiopid spider (*Gaius* sp.) were collected and identified.
Availability of adequate contextual information	No	All available COI sequence data (i.e. WA Museum) was included in the molecular analyses and confirmed the identity of the species.
Timing, weather, season, cycle	No	The targeted I. nigrum survey is not dependent on a particular season. Seasonal conditions during the survey match the long-term average.
Disturbances which affected the results of the survey	No	No disturbances occurring during the period of the field survey are considered to have impacted the results.
Remoteness and/or access problems	No	All targeted sites were accessible by 4WD vehicle.

7 DISCUSSION

The scope of this survey was to confirm the presence of *I. nigrum* in the study area. The survey recovered three specimens at a single site (IN01), and both morphological and molecular identification confirmed the presence of *I. nigrum* on Boolardy Station.

The current understanding of the biology of *I. nigrum* suggests the species to be fairly plastic in its habitat requirements as long as some *Eucalyptus* or *Acacia* vegetation is present. Site IN01 was characterised by slight south-sloping topology, sparse mulga woodland and a rocky ground cover. Similarly, most populations of *I. nigrum* at Weld Range where found on the southern side of the range, always within the boundaries of drainage lines and underneath *Acacia* vegetation (Ecologia 2009b; Phoenix 2012). At Jack Hills, only a little more than half of all spider burrows were found at southern-facing drainage-lines, whereas about 45 % of the *I. nigrum* burrows were found at the foot of the hills near these drainage lines (Ecologia 2009a). In contrast, within the larger Avon Wheatbelt with low topographic profile, the species was found in eucalypt woodlands on heavy clay soils, but also in *Acacia*-dominated vegetation on granitic soils (Main 2003). Overall, Midwest populations of *I. nigrum* at Weld Range, Jack Hills and Karara Station appear to prefer habitats with open, low *Acacia* vegetation on sandy clay soils, commonly near drainage lines often extending into nearby, southern-facing mesic slopes (Phoenix 2011, 2012, 2013).

Lacking a clear understanding of the local habitat preferences of *I. nigrum*, it is difficult to extrapolate the distribution of the species at Boolardy Station without further targeted surveys. The absence of the species from site IN02 and IN03, both with very similar habitat qualities to IN01, confirms that habitat mapping alone cannot be used to infer the distribution of the species in the study area. However, it should be considered that the burrows of *I. nigrum* can be extremely cryptic and it is possible that burrows were overlooked at sites IN02 and IN03. In contrast, the ground surface at site IN04 was less complex with fewer rocks, making it less likely that burrows were missed at that site.

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Appendix 1: Survey site descriptions

Site number: IN01

Coordinates (WGS84): -27.062899 N, 116.695334 E; **UTM,** 7006561 N, 469789 E, Zone 50

Habitat

Type: *Acacia* (mulga) woodland

Geography: topography, footslope; slope, gentle

Vegetation: tree count within 10 m, 4; dominant tree, *Acacia* sp. (mulga); shrub count within 10 m, 3; herb count within 10 m, 0; grass absent

Soil: texture, sandy loam; colour, red-orange; surface type, fine-coarse gravel, loose soil,

Rockiness: rock abundance, common: 30–50% cover; rock type/s, ferrous and non-ferrous

Litter: leaf litter distribution, concentrated under shrubs/trees; leaf litter depth, < 1 cm; wood litter distribution, abundant

Disturbance and fire: weeds, 0; fire history, none evident; other disturbance/s, none evident

Site number: IN02

Coordinates (WGS84): -27.059550N, 116.686119E; **UTM,** 7006930 N, 468874 E, Zone 50

Habitat

Type: *Acacia* (mulga) woodland

Geography: topography, foot slope, minor drainage; slope, gentle

Vegetation: tree count within 10 m, 4; dominant tree, *Acacia* sp. (mulga); shrub count within 10 m, 2; herb count within 10 m, 0; grass absent

Soil: texture, sandy loam; colour, red-orange; surface type, fine-coarse gravel, loose soil,

Rockiness: rock abundance, common: 30–50% cover; rock type/s, ferrous and non-ferrous

Litter: leaf litter distribution, concentrated under shrubs/trees; leaf litter depth, < 1 cm; wood litter distribution, abundant

Disturbance and fire: weeds, 0; fire history, none evident; other disturbance/s, none evident

Site number: IN03

Coordinates (WGS84): -27.089167 N, 116.685833 E; **UTM,** 7003649 N, 468854 E, Zone 50

Habitat

Type: *Acacia* (mulga) woodland

Geography: topography, foot slope, minor drainage; slope, gentle

Vegetation: tree count within 10 m, 4; dominant tree, *Acacia* sp. (mulga) and *Eucalyptus* sp.; shrub count within 10 m, 3; herb count within 10 m, 0; grass absent

Soil: texture, sandy loam; colour, red-orange; surface type, fine-coarse gravel, loose soil,

Rockiness: rock abundance, uncommon: 15–30% cover; rock type/s, ferrous and non-ferrous

Litter: leaf litter distribution, concentrated under shrubs/trees; leaf litter depth, < 1 cm; wood litter distribution, sparse

Disturbance and fire: weeds, 0; fire history, none evident; other disturbance/s, none evident

[No image available]

Site number: IN04

Coordinates (WGS84): -23.15966 N, 118.97034 E; **UTM,** 7437441 N, 701712 E, Zone 50K

Habitat

Type: *Acacia* (mulga) woodland

Geography: topography, mid slope; slope, gentle

Vegetation: tree count within 10 m, 4; dominant tree, *Acacia* sp. (mulga); shrub count within 10 m, 3; herb count within 10 m, 0; grass absent

Soil: texture, sandy loam; colour, red-orange; surface type, fine-coarse gravel, loose soil,

Rockiness: rock abundance, common: 30–50% cover; rock type/s, non-ferrous

Litter: leaf litter distribution, concentrated under shrubs/trees; leaf litter depth, <1 cm; wood litter distribution, sparse

Disturbance and fire: weeds, 0; fire history, none evident; other disturbance/s, none evident