Kiwirrkurra Indigenous Protected Area Western Australia

6–18 September 2015

Bush Blitz Species Discovery Program

Australian Government
Department of the Environment and Energy

bhpbilliton
Sustainable Communities

EARTHWATCH INSTITUTE

Australian Biological Resources Study

What is Bush Blitz?

Bush Blitz is a multi-million dollar partnership between the Australian Government, BHP Billiton Sustainable Communities and Earthwatch Australia to document plants and animals in selected properties across Australia.

This innovative partnership harnesses the expertise of many of Australia's top scientists from museums, herbaria, universities, and other institutions and organisations across the country.

Abbreviations

ABRS
Australian Biological Resources Study

ALA
Atlas of Living Australia

ANH
Australian National Herbarium

AVH
Australia's Virtual Herbarium

CDNTS
Central Desert Native Title Services

DPaW
Department of Parks and Wildlife

DWS
Desert Wildlife Services

EDJTR
Department of Economic Development, Jobs, Transport and Resources (Victoria)

EPBC Act
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

IBRA
Interim Biogeographic Regionalisation for Australia

IPA
Indigenous Protected Area

NTH
Northern Territory Herbarium

QM
Queensland Museum

UNSW
University of New South Wales

WAH
Western Australian Herbarium

WAM
Western Australian Museum

WCA
Wildlife Conservation Act 1950

Summary

Kiwirrkurra Indigenous Protected Area (IPA) was the focus of a Bush Blitz expedition between 6 and 18 September 2015. This IPA is located in the *tali* (sandhill) country of the Gibson and Great Sandy deserts, in Western Australia (WA). The entire area is Kiwirrkurra Native Title Determination and is managed by Pintupi traditional owners with assistance from Central Desert Native Title Services (CDNTS). The IPA takes its name from Kiwirrkurra, the only permanent settlement in the area and considered Australia's most remote community.

The Bush Blitz program provided an opportunity for scientists to undertake surveys in an area poorly known to western science. For invertebrates no background information was available–even for butterflies, which are one of the best-collected insect groups in Australia. The records obtained add significantly to knowledge of the distribution of species and are important for future biodiversity modelling in WA.

This Bush Blitz recorded 664 species, 375 of which had not been recorded previously in the IPA (13 vertebrates, 198 invertebrates and 164 plants). Forty-two of the species may be new to science (13 true bugs, 25 spiders, 1 snail and 3 plants), among them three new genera of spiders. Over 100 of the records are noticeable range extensions for plants and animals. Almost 600 voucher specimens were added to museum and herbarium collections. In many cases, they are the first specimens from the Gibson and Great Sandy deserts.

Traditional owners helped locate three species listed as threatened under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC) and the Western Australian *Wildlife Conservation Act 1950* (WCA): Bilby (*Macrotis lagotis*), Western Marsupial Mole (*Notoryctes caurinus*) and Great Desert Skink (*Liopholis kintorei*). It is likely that land management practices, particularly fire management and perhaps to a lesser extent hunting of feral cats, are benefiting threatened fauna. More study is needed to document the extent and size of populations of threatened fauna in the IPA.

Among the hundreds of invertebrate species recorded, some highlights included six major range extensions for butterflies; five major range extensions for snails; three spiders recorded for the first time in WA (*Australutica manifesta*, *Cryptoerithus nyetaut* and *Pseudasteron simile*) and additional records of five rare spiders (*Afraflacilla grayorum*, *Masasteron utae*, *Nomindra arenaria*, *Tamopsis nanutarrae* and *Wydundra uluru*).

The areas surveyed were of high quality, representing good examples of the vegetation of the Great Sandy Desert and Gibson Desert bioregions. Five plant taxa were recorded in WA for the first time, in addition to 17 significant range extensions. Nine species of conservation significance were identified, but none were threatened species—these findings reflect in part the relatively poor knowledge of plant distributions and abundances in the central deserts. Surveys for *Stackhousia* sp. Lake Mackay on gypsophilous soils are recommended to determine its true distribution and the size of individual populations, enabling assessment of its conservation status.

Introduced species noted included Camel (*Camelus dromedaries*), Cat (*Felis catus*), Fox (*Vulpes vulpes*), Rabbit (*Oryctolagus cuniculus*) and Mouse (*Mus musculus*). All are widely distributed throughout the arid zone. The Rutherglen Bug (*Nysius vinitor*), a pest of many crops, was the only invertebrate pest species collected.

Weed sightings were low and centred on areas of human disturbance and vehicle movement. While Buffel Grass (*Cenchrus ciliaris*) was a dominant species within Kiwirrkurra, the other three weeds noted were relatively minor at the sites where they were recorded. Mossman River Grass (*Cenchrus echinatus*) was the only species gazetted under Western Australia's *Biosecurity and Agricultural Management Act 2007*. Priority should be given to eradicating it from Kiwirrkurra where it is known from a single site. To keep the IPA free from major weed infestations, areas accessed by vehicles need to be monitored for weeds and incursions controlled. Road-grading procedures need review and drivers could be trained to prevent the further spread of weeds from Kiwirrkurra and Nyinmi.

Collaborative research was undertaken with traditional owners to document edible insects. Ten 'ethno species' of edible insects were collected, another four were named but not found. The collected material is undergoing DNA bar-coding to identify the scientific species. A Pintupi-English language booklet on Kiwirrkurra edible insects was prepared for use by the Kiwirrkurra community. It is hoped that the booklet will stimulate further interest in edible insects and encourage community members to collect the few species that were unable to be collected during the survey.

In addition to the specimens collected, strong cross-cultural exchange was enjoyed between the scientific team and traditional owners. As well as the transfer of knowledge on tracking animals and learning scientific trapping and processing methods, many wonderful stories were shared about traditional desert life and first experiences of meeting Australians of European heritage. Scientists greatly appreciated the chance to learn about Pintupi culture and community life.

Contents

Introduction

This is a report for the Bush Blitz program, which aims to improve our knowledge of Australia's biodiversity. Bush Blitz is an initiative of the Australian Government, through the Australian Biological Resources Study (ABRS), in partnership with BHP Billiton Sustainable Communities and Earthwatch Australia. Bush Blitz aims to:

- promote, publicise and demonstrate the importance of taxonomy through species discovery
- undertake a national species discovery program
- support the science of taxonomy in Australia through training of students and early career researchers, and by providing grants for species description and resolution of taxonomically problematic, nationally important groups
- promote partnerships between scientific institutions, government, industry and non-government organisations
- inform reserve managers and other stakeholders of the results of Bush Blitz projects.

The Kiwirrkurra IPA Bush Blitz

Bush Blitz provided an opportunity to undertake targeted biodiversity surveys of the Kiwirrkurra IPA, with the aim of discovering taxonomic novelties and providing baseline biodiversity data. Little biological survey work had been conducted in this IPA previously: gap-analysis modelling by CSIRO identified the IPA and surrounding region as one of the least known to western science in Australia.

The survey took place between 6 and 18 September 2015 and therefore the results are therefore representative of those taxa present/active in early spring. Daytime temperatures were warm to hot and overnight temperatures were moderately cool. There was a small amount of rain one night early in the survey, but overall the weather remained dry and the relative humidity was low. Temperature and humidity affect activity patterns for many animals, particularly reptiles. Many arid zone species are crepuscular or nocturnal so the cool evening conditions during the survey did not always encourage high animal activity. Low winter rainfall (2.2 mm from April to September 2015)[1] also meant that some species were found in low numbers, while others were absent or impossible to detect e.g. many plants, particularly annuals, bore no fertile stages and were therefore unsuitable as herbarium specimens. Despite less than ideal seasonal conditions for collecting, many significant specimens were obtained.

An important feature of this survey was the participation of traditional owners and IPA rangers. A wealth of undocumented Indigenous ecological knowledge about the IPA exists, due to the close and continuous connection of the traditional owners with their country. Tjamu Tjamu Aboriginal Corporation (Registered Native Title Body for traditional owners of Kiwirrkurra IPA) supports integrating scientific and Indigenous knowledge and fostering two-way learning opportunities between scientists and traditional owners—the survey provided a perfect opportunity to support this goal. Integration of traditional knowledge and scientific methods greatly increased the success of sampling. Without the

[1] BOM data from the nearest weather station at Kintore NT, accessed 12/05/2017 http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_startYear=&p_c=&p_stn_num=015664

involvement of traditional owners and their intimate knowledge of country a number of species would not have been recorded. This was particularly the case for all the threatened fauna.

To share the experience of the Bush Blitz with the Kiwirrkurra community, the survey team hosted a dinner for residents with a short film of highlights from the survey. Residents could also meet the scientists at work in the field laboratory and view the specimens during an 'open laboratory' event. The team also visited the local school and were interviewed live on Kiwirrkurra Community Radio.

The French company Mona Lisa Productions filmed the Bush Blitz for use in a European documentary series, *Planet Sand*. Bush Blitz and Tjamu Tjamu Aboriginal Corporation have permission to use the footage to promote their work.

Bush Blitz provided the logistical coordination and overall leadership for the survey. The Western Australian Museum (WAM) and the Western Australian Herbarium (WAH) were the host institutions, providing the core group of scientific personnel and accessioning the specimens into their collections. Experts from the following organisations conducted the field and laboratory work:

- Western Australian Museum
- Western Australian Herbarium
- Department of Parks and Wildlife (DPAW), Western Australia
- Northern Territory Herbarium (NTH)
- Australian National Herbarium (ANH)
- Queensland Museum (QM)
- La Trobe University
- University of New South Wales (UNSW)
- Desert Wildlife Services (DWS)

Acknowledgements

The ABRS acknowledges the traditional owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their culture and to their elders both past and present.

The Bush Blitz team comprised Mim Jambrecina, Brian Hawkins, Beth Tully and Jo Harding. They would like to acknowledge the traditional owners of the IPA and thank them for their support, enthusiasm and assistance in the field. Traditional owners who participated in the Bush Blitz were Roy Bennett, Lorna Brown, Sally Butler, William Gibson, Patrick Green, Patricia Jackson, Josephine Nangala, Yakari Napaltjari, Yalti Napangarti, Yukultji Napangarti, Maisie Ward, Payu West, Vivianne West and Jeremiah West.

The efforts of Kate Crossing and Andrew Drenen from CDNTS in facilitating access to country and two-way learning opportunities with the Kiwirrkurra people were greatly appreciated. Boyd Wright provided interpreter and translation services. Rob Whyte took many excellent macro-photographs of specimens and assisted with fieldwork. Helicopter pilots Dan Driscoll and Phillipe Lahore-Lahitte (Helispirit Pty Ltd) flew the teams safely. Robbie and Olive Bayliss kept everyone well fed.

This report is dedicated to Alan Yen, who contributed much to this Bush Blitz, and, sadly, passed away in March 2017.

Reserve overview[2]

Reserve name:

Kiwirrkurra Indigenous Protected Area

Area:

45, 867 km²

Land owner:

Tjamu Tjamu Aboriginal Corporation

Description

Kiwirrkurra IPA is located in the *tali* (sandhill) country of the Gibson and Great Sandy deserts, to the south-west of Lake McKay. It is approximately 1200 km east of Port Hedland and 700 km west of Alice Springs in WA. The entire area is Kiwirrkurra Native Title Determination. The IPA extends from the northern edge of Lake Mackay on the NT border, south to Lake Macdonald, and approximately 300 km to the west beyond Jupiter Well. It shares its southern boundary with Ngaanyatjarra IPA and most of its eastern boundary with the Southern Tanami IPA, the three forming an extensive network of reserves in the Central Desert. Kiwirrkurra is the only community within the Kiwirrkurra IPA and is permanently occupied; several outstations are used intermittently. Only one main access route traverses the IPA, the Gary Junction Road that connects Kintore to Kiwirrkurra and continues towards the Canning Stock Route.

Conservation values

The IPA has an arid climate with hot summers (January mean max. 40°C, mean min. 26°C), mild winters (June/July mean max. 23° C, mean min. 11° C) and highly variable rainfall, averaging 306 mm per annum.[3] Rains mostly occur in the summer but are unreliable. The IPA occurs within the Great Sandy Desert and Gibson Desert bioregions and includes three IBRA subregions—Mackay, Lateritic Plain and Dune Field. The landscape is dominated by extensive spinifex-covered dunefields interspersed with laterised uplands and playas. The sand dunes typically are aligned in an east-west direction and are separated by red sandy swales approximately 1 km wide. Rattle-pod Grevillea (*Grevillea stenobotrya*) is the most common shrub on the dunes and good stands of Sandhill Bloodwood (*Eucalyptus chippendalei*) often occur on dune crests. The swales support open shrubland (primarily species of *Acacia*, *Grevillea* and *Hakea*) over spinifex. Desert Oaks (*Allocasuarina decaisneana*) are uncommon in this area and largely confined to the reticulated dunefields surrounding the drainage system south of Jupiter Well.

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[2] Information sourced from Department of Parks and Wildlife (WA) *Nature Map: mapping Western Australia's biodiversity* https://naturemap.dpaw.wa.gov.au/; Tjamu Tjamu 2014, *Kiwirrkurra IPA plan for country 2014 to 2019*. Report prepared by Tjamu Tjamu Aboriginal Corporation and Central Desert Native Title Services, Kiwirrkurra, WA; Paltridge, R. 2010, *Biological resources of the Kiwirrkurra region*. Report produced for the Ngaanyatjara Council. Desert Wildlife Services, Alice Springs, NT.

[3] BOM data based on Kintore weather station, accessed 12/05/2017 http://www.bom.gov.au/climate/data/?ref=ftr

Two large salt lakes are situated on the eastern boundary of the IPA—Lake Mackay and Lake Macdonald. A chain of much smaller salt lakes occurs along a palaeodrainage channel running south-west of Jupiter Well. A series of freshwater claypans occur in dune swales to the south and west of Lake Mackay.

Aboriginal people from this region were amongst the last in Australia to encounter white people, and many of the current traditional owners remember walking their country and living a traditional lifestyle up to the 1950s and '60s. Thus, they have an intimate knowledge of their country and they continue to pass this knowledge on to younger generations. The 1960s and '70s saw a gradual emptying of the landscape, with many people settling in Papunya. The Kiwirrkurra community was established in 1982. Although the country was mainly empty for the decades of the 1960s and '70s, there was at least one family group still living a traditional lifestyle in the area. In 1984 near Lake Mackay, this group met family members from Kiwirrkurra and nine agreed to come into the community. Three of those people still live in Kiwirrkurra today.

In September 2014, the traditional owners signed a declaration to manage their country as an IPA. Through this program, and with the support of other partners, they are combining their strong traditional land-management skills with western science to look after country, people and culture. This is often referred to as ‘two-way’ land management. The traditional owners have selected an IPA management team who are working with project staff from CDNTS to manage the IPA. Under their guidance, a ranger group undertakes activities such as burning country in a careful way to reduce wildfire risks, controlling feral animals and weeds, maintaining natural and human-managed water sources, monitoring of threatened species, and passing knowledge from elders to young people. Many Kiwirrkurra residents are still engaged in traditional land-use practices, including hunting, gathering of bush foods, patch burning, and fresh-water harvesting.

Methods

Taxonomic groups studied and personnel

A number of taxonomic groups were selected as targets for study. Table 1 lists the groups surveyed and the specialists who undertook the fieldwork.

Table 1 Taxonomic groups surveyed and personnel

Group	Common name	Expert	Affiliation
Vertebrates	Mammals, reptiles and frogs	Rachel Paltridge	Desert Wildlife Services
		Rebecca Bray	WAM
		Mark Cowan	DPAW
Lepidoptera	Butterflies	Matthew Williams	DPAW
Heteroptera	True bugs	Luciana Weiler	UNSW
		Ryan Shofner	
		Nikolai Tatarnic	WAM
Odonata	Damselflies and dragonflies	Nikolai Tatarnic	WAM
Arachnida	Spiders	Barbara Baehr	QM
Gastropoda	Snails and slugs	Corey Whisson	WAM
Edible insects	Edible insects	Alan Yen	EDJTR & La Trobe University
		Conrad Bilney	La Trobe University
Vascular plants	Vascular plants	Ryonen Butcher	WAH
		Rob Davis	
		Peter Jobson	NTH
		Dave Albrecht	ANH

The Bush Blitz team would also like to acknowledge the contributions of the following people:

- Norman McKenzie spent many hours analysing bat calls.
- Martin Baehr (Zoologische Staatssammlung Munich, Germany) identified the ground beetle (Carabidae) specimens.
- Brian Hanich (WAM) assisted with the identification of dragonflies and damselflies.
- Paige Maroni (WAM) databased and photographed all of the WAM Odonata and Heteroptera specimens.
- Gary Taylor confirmed the identification of the psyllid specimens.

- Robert Raven and Rob Whyte (QM), Volker Framenau (WAM) and Bernhard Huber (Alexander Koenig Zoological Research Museum, Germany) contributed to spider identifications within their areas of specialty. Mark Harvey (WAM) identified the pseudoscorpions collected.
- Lisa Kirkendale (WAM) contributed to reporting and molecular analysis of the snail specimens.
- Barbara Rye (identified *Newcastelia* spp.), Terry Macfarlane (identified *Corynotheca* spp.) and Kelly Shepherd (identified *Goodenia* and *Tecticornia* spp.) from WAH identified plant groups for which they are experts. Some specimens were also scanned and images sent to external specialists.

Site selection

All scientists surveyed two standard survey sites selected by Bush Blitz using modelling prepared by CSIRO. The first standard site was in dunefields to the north-east of Kiwirrkurra, the second in mulga woodland on a laterised plain to the south of the community. Each standard survey site was centred on a point (permanently marked), but the actual area surveyed varied between taxa. Standard methodologies were used to sample these sites. Bush Blitz staff also collected soil for detailed analyses of soil and soil biota (as part of the Biomes of Australian Soil Environments program) at these two sites.

The use of standard survey sites provides a unique opportunity to examine broad-spectrum biodiversity. Among other benefits, this will enable CSIRO to test assumptions (e.g. about relationships between the diversity of different taxa) that underpin many conservation decisions. It will also allow comparisons between sites, and help to establish a basis for future monitoring by reserve managers.

Aside from standard survey sites, site selection and collection methods were at the discretion of the individual scientists. Selection depended on access, suitability for trapping and time restrictions. Site locations were recorded using global positioning systems (GPS).

Survey techniques

A standard suite of survey techniques was used:

- **Terrestrial vertebrates** were surveyed within three areas selected to represent the IPA's geographic extent and habitats. The distance between survey areas was approximately 100 km. Six survey sites were established near Kiwirrkurra, four sites to the west near Nyinmi outstation and four sites around Murmur campsite adjacent to Lake Mackay. Survey sites were selected to represent the main habitats and significant environmental attributes such as presence of long unburnt spinifex or ephemeral damp areas. Most sites included a single trap line using a 50 to 60 m drift fence, six evenly spaced 20 L pits and six funnels set in pairs midway between the pits. Pits were not used at sites V8 and V9 owing to the rocky substrate. Instead, V8 had two 30 m drift lines with three pairs of funnels on each, while only Elliott traps were used at V9. For mammals, a single line of 25 medium-sized Elliott traps (type B) was placed at 10 to 15 m intervals at each site. Traps were baited with standard universal bait (a combination of oats and peanut butter).
- **Butterflies** were collected using standard butterfly sweep nets or recorded visually.
- **True bugs** were collected by beat-sampling flowering vegetation, litter sampling and as by-catch from pitfall traps.
- **Dragonfly and damselfly** specimens were collected using an aerial sweep net.

- **Spiders** were collected mainly by hand and as by-catch from vertebrate pitfall traps. Ten small pitfall traps filled with propylene glycol were used at eight sites.
- **Snails** were collected by hand from under peeled bark, woody debris and rocks. Since shells alone can be used to identify most snails, both live specimens and dead shells were taken. Each site was searched for 45 minutes. Samples of leaf litter (minimum 250 mL) were sieved in the field (1 mm and 0.5 mm mesh sizes) and inspected for micro-molluscs. When molluscs were found, a larger sample of leaf litter was taken (minimum 1 L) and sieved (1 mm and 0.5 mm mesh sizes). The coarser materials retained on the 1 mm sieve were inspected for molluscs and then discarded. Leaf litter samples from the 0.5 mm mesh were sorted under a dissecting microscope in the field laboratory.
- **Edible insects** (usually the larval stages of moths or beetles) were collected by traditional owners working closely with scientists. Collecting involved digging up soil using a digging stick and breaking off root fragments. When large numbers were found in one host plant species, the head capsule widths of specimens were measured. This was done in order to see if the number of instars could be calculated. The location where collections were made and the host plant of the grubs (larvae) was recorded. As insect taxonomy is usually based on adult morphological characters, it is generally not possible to determine the species based on the immature stages. The grubs retained for future study were killed and preserved in 100% ethanol for DNA extraction and sequencing to identify the species. Bush coconuts (gall-inducing scale insects) were also collected. Traditional owners explained the parts that were eaten. Some specimens were retained to weigh and measure, and to determine the nutritional value of the gall contents.
- **Vascular plants** were collected by hand. Only plants that were flowering or fruiting were taken. Specimens were generally pressed in the field to maximise quality. DNA samples were collected from targeted taxa (e.g. *Calandrinia*, *Lawrencia*, *Peplidium*, *Ptilotus*, *Stylidium*, *Tephrosia*; and groups in Asteraceae and Cyperaceae); flowers were placed into ethanol. By sampling the soil below plants, small seedlots of all available *Tephrosia* taxa were collected for taxonomic research.

Incidental observations of birds and psyllids (jumping plant lice) were recorded during the survey.

Identification

The specimens taken were identified using available literature and the holdings of museums and herbaria. Fauna specimens were deposited with WAM, with the exception of the true bugs which were deposited with UNSW. Flora collections were deposited with WAH, and duplicates of plant specimens with NTH and ANH. All specimen data are available through the Atlas of Living Australia (ALA).

Results

Location data for all collection or observational records are available to reserve managers. At least 375 species were new records for the reserve (some results are yet to be finalised), including 42 putative species new to science—these await formal description. Three threatened animal species were observed. Six exotic or pest animal species and four weed species were also recorded.

Table 2 provides a summary of the flora and fauna records for the IPA.

Table 2 Summary of flora and fauna records

Group	Common name	Number of species recorded	Species new to the reserves	Putative new species	Threatened species*	Exotic and pest species**
Mammalia	Mammals	23	8	0	2	5
Aves	Birds	61	0	0	0	0
Reptilia	Reptiles	47	5	0	1	0
Amphibia	Frogs and Toads	1	0	0	0	0
Lepidoptera	Butterflies	15	15	0	0	0
Lepidoptera	Moths	1	1	0	0	0
Coleoptera	Beetles	20	20	0	0	0
Heteroptera	True bugs	86	86	13	0	1
Sternorrhyncha	Psyllids	5	5	0	0	0
Odonata	Damselflies and Dragonflies	5	5	0	0	0
Arachnida	Spiders	61	61	25	0	0
Gastropoda	Snails and Slugs	5	5	1	0	0
Magnoliophyta	Flowering plants	329	159	3	0	4
Tracheophyta	Ferns	1	1	0	0	0
Bryophyta	Liverworts	4	4	0	0	0
Total		664	375	42	3	10

* Species listed as threatened under the Commonwealth EPBC Act or an equivalent listing under the WCA (WA).
** Includes native species that at times are pests or are exotic in this region.

Species lists

Lists of all species recorded during the survey are provided in Appendix A. Species lists were compiled using data from participating institutions.

Some specimens have been identified only to family or genus level. This is partly because identification of specimens is very time-consuming, with detailed microscopic examination needed in many cases. Also, some groups are 'orphans': currently no experts are working on them, or are available to work on them, and the taxonomic literature is out of date—species-level identification is not possible for these groups. Unidentified Bush Blitz specimens are held in institutional collections where they are available for future study. Collections hold many such specimens, among them species not yet described (i.e. unnamed species) as well as described species that have not been identified. For example, ANIC holds tens of thousands of unidentified specimens. Specimens often wait decades before the resources become available for their study. A key component of Bush Blitz is the funding of studies of specimens collected on Bush Blitz surveys.

Nomenclature and taxonomic concepts used in this report are consistent with the Australian Faunal Directory, Australian Plant Name Index, Australian Plant Census, and the Catalogue of Australian Liverworts and Hornworts.

Discussion

Putative new species

Here we use the term 'putative new species' to mean an unnamed species that, as far as can be ascertained, was collected for the first time during this Bush Blitz. It is confirmed as a new species once it is named and its description published. Specimens collected during the Bush Blitz also include unidentified taxa that are already known from museum and herbarium collections—these are not counted as putative new species.

Fauna

Invertebrates

True bugs

Thirteen putative new species of true bug were collected during the survey.

Spiders

Spiders representing 25 putative new species and two putative new genera were collected. A number of these 'new' species belong to families of which the taxonomy is poorly resolved, necessitating broader study prior to identification or description of any new species. These include:

- two species of wishbone trapdoor spider (Nemesiidae); this family is only partly revised
- one species of false wolf spider (Miturgidae); this family includes 16 species from Australia, but a modern taxonomic treatment of *Miturga* is unavailable, therefore species level identification is impossible for most specimens
- two new species of goblin spider (Oonopidae), *Pelicinus* Kiw. nov.21 *and Pelicinus* Kiw. nov.24; Australian spiders in the genus *Pelicinus* have not been revised. So far, only *P. saaristoi* is known from WA.
- one new species of Phrurolithidae, which until recently were referred to a subfamily of the spiny-legged sac spiders (Liocrannidae).

Snails

The snail specimen identified as *Leichhardtia* sp. or ram's horn may be a new species. *Leichhardtia* is a monotypic genus based on *Leichhardtia sisurnius* which is found only in northern Australia, with a wide distribution across the Top End of the NT and WA northern coastal areas. The type locality for *L. sisurnius* is the Paterson Range in the eastern Pilbara Region; and populations are similar morphologically throughout its range. The species is found in lotic freshwaters that are discrete across the landscape and connectivity may be restricted. A high and consistent level of genetic distance (COI mtDNA) was observed between the IPA specimens and the only sequenced specimen of *Leichhardtia* collected from the Kimberley (GenBank). Further research is needed to substantiate these early findings, including sequencing of specimens from the type locality of *L. sisurnius*, and incorporation of additional markers and morphological data.

Table 3 Putative new invertebrate species

Family	Species
True bugs	
Miridae	*Bilbonotus* sp_BBKIW15Msp.012
Miridae	*Fronsetta* sp_BBKIW15_Msp.015
Miridae	Gn_Austromirini_001 sp_BBKIW15_Msp.020
Miridae	Gn_Austromirini_002 sp_BBKIW15_Msp.013
Miridae	Gn_Austromirini_002 sp_BBKIW15_Msp.014
Miridae	Gn-Austromirini_003 sp_BBKIW15_Msp.016
Miridae	Gn-Austromirini_004 sp_BBKIW15_Msp.018
Miridae	Gn_Austromirini_005 sp_BBKIW15_Msp.019
Miridae	Gn_Mirini_001 sp_BBKIW15_Msp.011
Miridae	Gn_Orthotylinae_001 sp_BBKIW15_Msp.029
Miridae	Gn_Orthotylini_001 sp_BBKIW15_Msp.021
Pentatomidae	*Kalkadoona* sp_BBKIW15_Msp.065
Pentatomidae	*Kalkadoona* sp_BBKIW15_Msp.066
Spiders	
Araneidae	*Araneus talipedatus* group n. sp. 41
Ctenidae	n. gen. 02 n. sp. 07
Gnaphosidae	*Eilica* n. sp. 13
Gnaphosidae	*Eilica* n. sp. 14
Gnaphosidae	*Eilica* n. sp. 29
Miturgidae	*Argoctenus* n. sp. 15
Miturgidae	*Argoctenus* n. sp. 11
Miturgidae	gen. 01 n. sp. 05
Miturgidae	gen. 01 n. sp. 34
Miturgidae	gen. 01 n. sp. 01
Miturgidae	*Miturga* n. sp. 03
Nemesiidae	*Kwonkan* n. sp. 26
Nemesiidae	*Kwonkan* n. sp. 30

Family	Species
Spiders (continued)	
Oonopidae	*Pelicinus* n. sp. 21
Oonopidae	*Pelicinus* n. sp. 24
Phrurolithidae	*Orthobula* n. sp. 20
Prodidomidae	*Wydundra* n. sp. 32
Salticidae	*Maratus kiwirrkurra* Baehr & Whyte 2016
Segestriidae	*Ariadna kiwirrkurra* Baehr & Whyte 2016
Zodariidae	*Australutica* n. sp. 02
Zodariidae	*Cavasteron* n. sp. 04
Zodariidae	*Cavasteron* n. sp. 31
Zodariidae	*Cavasteron* n. sp. 38
Zodariidae	*Cavasteron* n. sp. 28C
Zodariidae	*Minasteron* n. sp. 19
Snails	
Planorbidae	*Leichhardtia* sp.

Flora

Flowering plants

Three taxa in the genera *Acacia*, *Newcastelia* and *Triodia* were collected that could not be matched to any known species and are probably new. Additional material and further taxonomic study are required to confirm the status of each of these collections. Another 10 taxa show variation from the accepted morphology, with multiple collections of some (e.g. *Indigofera georgei* variant) showing consistent differences from the norm. It is clear that, after further study, at least some of the anomalous collections will require naming as new taxa. It is also likely that some of the anomalous collections may simply represent extra variation in recognised taxa, such as end-of-range variation, that will require expansion of taxonomic concepts and descriptions.

Table 3 Putative new flowering plant species

Family	Species	Comments
Flowering plants		
Fabaceae	*Acacia* n. sp. (DEA 14422)	Few collections, in bud only. Flowering and fruiting material is needed to complete the identification. Images viewed by Bruce Maslin who cannot place it based on combination of inflorescence form and phyllode morphology/venation.

Family	Species	Comments
Flowering plants (continued)		
Lamiaceae	*Newcastelia* n. sp. aff. *bracteosa* (DEA 14286)	Differs from *N. bracteosa* in its smaller leaves, which have the upper surface weakly bullate and only weakly dentritic to stellate-hairy, the hairs held ± against the leaf surface; greater separation of the flowers/young fruits into discrete units along the flowering spikes; little separation between the spike and the leaves. Collected in early fruit; more collections are needed.
Poaceae	*Triodia* n. sp. aff. *angusta* (DEA14502)	Leaf material sent to Matt Barrett for DNA analysis. Internal transcribed spacer sequence haplotypes are unique but very close to *T. angusta* haplotypes from the Great Sandy Desert, indicating a position in *T. angusta* rather than *T. longiceps*, although the sub-papillate epidermal cells on the leaf blades are more like *T. longiceps*. Several other isolated and morphologically-unusual populations of *T. angusta* are known from the Great Sandy Desert, disjunct from the core range of *T. angusta* in the Pilbara—these populations are possibly "relictual" on rockier substrates from the time of expansion of sandy deserts in the area. Further taxonomic and genetic examination of these collections is warranted.

Table 4 Complexes and anomalous collections that require further study

Family	Species	Comments
Flowering plants		
Chenopodiaceae	*Osteocarpum salsuginosum*	Variant approaching *Sclerolaena urceolata.*
Chenopodiaceae	*Sclerolaena crenata*	Leaves short and retain their hairs longer than usual; fruit a perfect match.
Chenopodiaceae	*Tecticornia halocnemoides* subsp. *longispicata*	Widespread and variable with a number of recognisable forms; this form does not match typical subsp. *longispicata* (which may be elevated to species rank in the future).

Family	Species	Comments
Flowering plants (continued)		
Fabaceae	*Indigofera georgei*	Shorter staminal tubes than proposed by Wilson & Rowe (2015) for *I. georgei* (i.e. ≥ 5 mm) and most specimens are consistently trifoliolate rather than 'usually five to seven, rarely three or nine'; range extension of approx. 100–150 km.
Fabaceae	*Tephrosia rosea*	*Tephrosia rosea* is a widespread and variable species extending from WA's Pilbara across the northern NT and north-western Qld; the complex comprises a number of named and phrase-named taxa (at different ranks). Small cuneate leaflet form; specimens of this form are segregated at WAH and by DNA, but not phrase-named pending revisionary work; flower colour variation noted, with most plants having typically purple flowers and a small population having pink-cream flowers.
Frankeniaceae	*Frankenia cordata*	Close to *F. cinerea* and possibly a form of that species; hairs similar to *F. cordata* but bases of leaves not very cordate.
Goodeniaceae	*Dampiera cinerea*	Swale plants noted to be smaller in all parts than dune plants; *Dampiera cinerea*, *D. atriplicina* and *D. conospermoides* require further study to assess extent of variation between the species.
Lamiaceae	*Dicrastylis exsuccosa*	Long-haired variant.
Solanaceae	*Solanum centrale*	Peduncles much shorter than normal form.

Threatened species

Australia is home to an estimated 580,000–680,000 species, most of which have not been described. Approximately 92% of Australian plants, 87% of mammals, 93% of reptiles and 45% of birds are endemic. Changes to the landscape resulting from human activity have put many of these unique species at risk. Over the last 200 years, many species have become extinct and many others are considered to be threatened, i.e. at risk of extinction.[4]

Fauna

Vertebrates

Traditional owners located three species listed as threatened under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC) or the Western Australian *Wildlife Conservation Act 1950* (WCA): Bilby (*Macrotis lagotis*), Western Marsupial Mole (*Notoryctes caurinus*) and Great Desert Skink (*Liopholis kintorei*).

More than 15 Bilby burrows, and numerous diggings and scats were documented. All of these were at a location known to traditional owners and within several kilometres of Kiwirrkurra. Cameras were used for eight nights at two burrows that showed signs of recent Bilby activity. A single Bilby was recorded on one evening; it was therefore impossible to assess abundance.

The Marsupial Mole is thought to be relatively common within sand dune habitats across much of the WA arid interior but is rarely seen. The only record during the survey was of a short track of less than a metre in the sand adjacent to Lake Mackay (site V15).

Great Desert Skinks were also recorded at a site known to traditional owners approximately 20 km east of the community. Within a relatively short time, at least four active burrow complexes were found, all with substantial latrines.

Land management practices, particularly fire management and perhaps to a lesser extent feral cat hunting, are probably benefiting threatened species. The Bilby and Great Desert Skink were detected close to the community, where fire scars were smaller and the heterogeneity of fire ages was greater than apparent further away. This type of fine fire mosaic is considered important in supporting viability of populations of many species.

More work is needed to document the extent and size of populations of threatened species in the IPA.

Table 5 lists the vertebrate threatened species that were collected or observed during the survey.

[4] Chapman, A. D. 2009, *Numbers of Living Species in Australia and the World*, 2nd edn. Australian Biological Resources Study, Canberra.

Table 5 Vertebrate threatened species

Family	Species	Common name	Status	Abundance
Mammals				
Notoryctidae	*Notoryctes caurinus*	Western Marsuipial Mole	Endangered—WCA	Likely to be common in sand dune systems; a single track was located by traditional owners.
Thylacomyidae	*Macrotis lagotis*	Bilby	Vulnerable—EPBC; Vulnerable—WCA	Sign was prevalent at only one location; images were obtained of one individual from a camera trap.
Reptiles				
Scincidae	*Liopholis kintorei*	Great Desert Skink, Tjakura	Vulnerable—EPBC; Vulnerable—WCA	Several active burrow complexes were observed.

Flora

Flowering plants

No threatened flora listed under the WCA were recorded; however, nine species of conservation significance in WA were identified. That none of the taxa collected are listed as threatened reflects in part the relatively poor knowledge of plant distributions and abundances in the central deserts, which makes it difficult to assess their conservation status.

The occurrence of *Atriplex flabelliformis* within the IPA could not be confirmed. This species appeared in AVH records for the IPA and is conservation-listed as Priority 3 in WA. A duplicate record (AD 96050029) occurs in the NT but the coordinates for the IPA specimen (MEL 0609762A) do not match the supplied state/territory name. As the collection was made from near the edge of Lake Mackay it is worth considering that the species may occur in the IPA near the NT border.

For *Stackhousia* sp. Lake Mackay, a survey of areas of gypsophilous soils would be useful to determine its true distribution range and the sizes of individual populations—data that would assist scientists to assess its conservation status.

Table 6 lists plant species of conservation significance and their abundance at the site at which they were collected.

Table 6 Plants of conservation significance

Family	Species	Common name	Status	Abundance
Celastraceae	*Stackhousia clementii*	Clementine	Priority 3	Occasional
Elatinaceae	*Elatine macrocalyx*		Priority 3	Frequent
Fabaceae	*Isotropis winneckei*		Priority 1	Infrequent
Fabaceae	*Rothia indica* subsp. *australis*		Priority 1	Rare
Goodeniaceae	*Dampiera atriplicina*		Priority 3	Locally frequent
Goodeniaceae	*Goodenia modesta*		Priority 3	Locally frequent
Phyllanthaceae	*Sauropus arenosus*		Priority 3	Occasional, 10–15 plants seen, more individuals usually found in post-fire areas
Scrophulariaceae	*Eremophila pallida*		Priority 2	Infrequent

* Species on the "Declared Rare and Priority Flora List" for Western Australia are categorised as poorly known and require further survey (P1 to P3) or are rare but adequately surveyed and not threatened (P4).

Exotic and pest species

Conservation reserves help to protect Australia's rare and threatened ecosystems and provide refuge for species at risk. Invasive species can have a major impact on already vulnerable species and ecosystems, as well as economic, environmental and social impacts. The inclusion of exotic and pest species records as part of this report is designed to provide land managers with baseline information to assist with further pest management programs.

Fauna

Vertebrates

Five introduced pest mammals were recorded: Camel (*Camelus dromedaries*), Cat (*Felis catus*), Fox (*Vulpes vulpes*), Rabbit (*Oryctolagus cuniculus*) and Mouse (*Mus musculus*). All are widely distributed throughout the arid zone, although foxes and rabbits are often more closely associated with particular parts of the landscape than the other three species.

Rabbits are often associated with heavier soils and succulent vegetation around salt lakes and ephemeral wetlands, and around large rock piles.

Almost all the foxes detected were on or near the small islands within Lake Mackay. Since they have a greater dependence on water, they are likely to occur in other parts of the landscape, but at a lower density.

Cats were detected in the same habitats as in other arid areas, with tracks frequently seen on the sandplains and dunes. They are likely to be present in all the major environments at a moderate but significant density. Away from water sources, they are likely to be in greater densities than foxes.

Camels were observed as individuals and small groups. Signs of camel (scats, tracks and browsing) were observed in many of the areas visited.

Mice were caught at all major trapping locations, but were most abundant around Lake Mackay. Mice occur in most habitats and are particularly successful after disturbances such as fire; they can undergo dramatic population increases when environmental conditions are good. The damage mice have done to populations of other small mammals through competition, predation and spread of disease is impossible to estimate but likely to be significant.

Table 7 lists the pest vertebrate species that were collected or observed in the IPA.

Table 7 Pest vertebrate species

Family	Species	Common name	Abundance
Camelidae	*Camelus dromedarius*	Dromedary, One-humped Camel	Relatively common with individuals seen on most days of the survey.
Canidae	*Vulpes vulpes*	Fox, Red Fox	Not able to determine abundance; tracks seen on and around the islands in Lake Mackay.
Felidae	*Felis catus*	Cat	Abundance probably typical for arid environments.
Leporidae	*Oryctolagus cuniculus*	Rabbit	Signs suggest it is abundant in certain habitats, particularly site V8 and in habitats adjacent to lakes and drainage systems.
Muridae	*Mus musculus*	House Mouse	Third most abundant mammal species with 18 individuals captured.

Invertebrates

The Rutherglen Bug (*Nysius vinitor*) was the only invertebrate pest species collected. This small native sap-sucking insect is a pest of many crops, e.g. sunflower, sorghum, canola and safflower. It breeds on a wide range of native and exotic plants, building up to large numbers in inland areas when winter and spring rainfall allows the growth of vegetation. In spring, as the host plants start to dry off, large numbers of bugs will move into cropping areas, dispersing on the winds of storm fronts. It can build up in such numbers as to seriously damaging fruit and vegetable crops.

Table 8 lists the pest and exotic invertebrate species that were collected in the reserves.

Table 8 Pest invertebrate species

Family	Species	Common name	Abundance
Lygaeidae	*Nysius vinitor*	Rutherglen Bug	–

Flora

Four alien (introduced) plant species and an additional species of uncertain status (*Cyperus hamulosus*) were collected.

Weed sightings were few and centred on areas of human disturbance and vehicle movement, i.e. Kiwirrkurra, Nyinmi outstation, and nearby roadsides. That few weeds were observed on the IPA is partly due to the absence of cattle and partly because collection sites were remote from Kiwirrkurra and mostly accessed by helicopter, thereby reducing the probability of encountering common roadside weeds. Other factors for low weed abundance and diversity include absence of history of feed being introduced for stock and the widespread occurance of low fertility soils.

Mossman River Grass (*Cenchrus echinatus*) was the only gazetted species, listed under WA's *Biosecurity and Agricultural Management Act* 2007. It is considered a widespread noxious weed in Australia and not permitted entry into WA. In the NT, Mossman River Grass is a Class B (growth and spread to be controlled throughout the Territory) and Class C (not to be introduced into the Territory) species.

While Buffel Grass (*Cenchrus ciliaris*) was a dominant species within Kiwirrkurra, other weeds were relatively minor at the sites where they were recorded.

Gallon's Curse (*Cenchrus biflorus*) is currently limited in distribution but is clearly being moved along roadsides by graders. Since the survey, reserve managers have noted that Gallon's Curse is spreading further along the roadside and is no longer contained within the Desert Oak habitat, though it is still common there.

Kapok Bush (*Aerva javanica*) is native to Africa and south-west and southern Asia. The species was introduced into Australia in the 1880s to revegetate degraded rangelands. It is now widespread across northern Australia and its spread continues by wind-borne seeds.

Until recently, *Cyperus hamulosus* was considered to be introduced from central Asia or Africa; however, there is now evidence from the NT to suggest that the central Australian populations (at least) are indigenous. The species is considered to be naturalised in WA, South Australia (SA) and Victoria, but its status is uncertain in the NT. Further research is required to resolve whether it is indigenous or alien to Australia.

In order to keep the IPA free from major weed infestations, regularly monitor sites susceptible to weed invasion (predominantly disturbed sites including Kiwirrkurra and outstations, road and track verges, also areas of higher soil moisture and/or fertility such as creeks and other drainage areas). Through monitoring, new weed incursions to the IPA can be identified. Early intervention and follow-up are critical to the success of any control program implemented. Review of road-grading procedures followed by training of grader drivers could limit the spread of weeds out from Kiwirrkurra and Nyinmi outstation. Priority should be given to eradication of Mossman River Grass from Kiwirrkurra where it is known from

a single site. Further consideration should be given to developing a control program for Buffel Grass as this species is well known in the region for it's ability to spread and compete with native species.

Tables 9 and 10 list the weeds that were collected or observed and their abundance within the IPA.

Table 9 Gazetted weeds

Family	Species	Common name	Abundance
Poaceae	*Cenchrus echinatus*	Mossman River Grass	Only seen in domestic gardens in Kiwirrkurra.

Table 10 Non-gazetted weeds

Family	Species	Common name	Abundance
Amaranthaceae	*Aerva javanica*	Kapok Bush	Common, collected previously from the IPA.
Cyperaceae	*Cyperus hamulosus*	–	Scattered and found on the margins of freshwater wetlands west-north-west of Lake Mackay; treated as a species of uncertain status in this report; first collection from the IPA.
Poaceae	*Cenchrus biflorus*	Gallon's Curse	Nyinmi outstation and along the Gary Junction Road east and west of Nyinmi; localised near buildings on the edge of the track and pull-off area; first collection from the IPA.
Poaceae	*Cenchrus ciliaris*	Buffel Grass	Abundant in disturbed areas around Kiwirrkurra where it was the dominant species, and abundant around dwellings at Nyinmi; also occurs as scattered patches along the Gary Junction Road, particularly west of Kiwirrkurra.

Range extensions

The IPA and surrounding region have received substantially less collecting effort than other parts of WA; many groups were collected from the Gibson Desert and the Great Sandy Desert for the first time. The records extend the known ranges of many taxa and fill gaps in knowledge for others. Helicopter access allowed collection from a wide range of sites.

Fauna

Vertebrates

Mammals, reptiles and frogs

None of the vertebrate species recorded represent range extensions since all species are widespread in the arid zone. However, while many vertebrates are ubiquitous and expected to occur in suitable habitats across the arid zone, verification of their occurrence and DNA tissue collection remain important for research in taxonomy and ecology—information that underpins biodiversity conservation planning.

Invertebrates

Butterflies

The collections of butterflies significantly extend the ranges of some species and fill gaps for others. There are no documented collections of butterflies from the IPA and relatively few from inland WA. The range extensions are consistent with the low collecting effort and poor understanding of butterfly distributions in the Central Desert region. The only comparable study recorded butterflies from sites several hundred kilometres to the south. Ten of the taxa collected were expected to occur in the region, while the remaining five all represent collections outside their known or expected ranges.

The most significant collection was of Copper Pencilled-blue (*Candalides cyprotus*), which extends the range of this species by approximately 900 km. Several specimens of this species, both male and female, were collected at two sites, indicating that resident breeding populations probably occur in the area as this is a non-migratory species. Copper Pencilled-blue occurs as two subspecies; *C. c. cyprotus* and *C. c. pallescens*. The specimens collected conform to the subspecies *cyprotus*. This subspecies is found across southern Australia, south of about 27° S latitude. An outlying, northern population was recorded at North West Cape. This record and that from near Queen Victoria Spring, 200 km east of Kalgoorlie, are the nearest known occurrences to the IPA. These are located about 1400 km to the west and 900 km to the south-west, respectively. The records from two sites in the IPA represent a substantial range extension.

Small Dusky-blue (*Candalides erinus*) has been recorded from north-western, northern and north-eastern Australia, from North West Cape in the west to almost as far south as Newcastle in the east. Most records are from coastal or near-coastal areas, with an outlying inland record from the Selwyn Range in eastern Queensland. The record from the IPA represents a range extension of about 600 km from nearest known occurrences, in the south-west and east of the Kimberley region.

Black-spotted Grass-blue (*Famegana alsulus*) is widespread across northern Australia, but with relatively few records from the inland. The record from Kiwirrkurra represents a range extension of around 500 km from Hermannsburg in the southern NT.

Spotted Dusky-blue (*Candalides delospila*) occurs widely but sporadically in the dry tropics of northern Australia. In WA it has been recorded from Balgo Hills, 300 km to the north.[5]

Lemon Migrant (*Catopsilia pomona*) occurs widely in northern Australia and is well known as a migratory species. The single sight record, probably of this species, represents a significant but unsurprising range extension. This record requires confirmation.

Common Grass-blue (*Zizina otis*) had not been recorded from the arid inland areas of WA, the eastern NT or north-west SA. The record from the IPA represents a range extension of around 500 km from the nearest record in central NT.

Table 11 Range extensions for butterflies documented during this Bush Blitz

Family	Species	Common name	Nearest previous record	Comments
Lycaenidae	*Candalides cyprotus*	Copper Pencilled-blue	900 km	–
Lycaenidae	*Candalides delospila*	Spotted Dusky-blue	300 km	–
Lycaenidae	*Candalides erinus*	Small Dusky-blue	600 km	–
Lycaenidae	*Famegana alsulus*	Black-spotted Grass-blue	500 km	Widespread across northern Australia, with relatively few records from the inland.
Lycaenidae	*Zizina otis*	Common Grass-blue	500 km	–
Pieridae	*Catopsilia pomona*	Lemon Migrant	–	This record requires confirmation.

Dragonflies and damselflies

Australian dragonflies are well known; however, a lack of targeted survey has resulted in limited data on distribution and biology.[6] There are no published reports of dragonflies in the Gibson Desert. The nearest invertebrate survey to include dragonflies was at Lake Gregory approximately 220 km north of the IPA, which recorded 11 species, though only five were identified formally to species. Only 21 species are listed for inland Australia, which includes all those collected during this survey. The ALA contains no records of dragonflies from the Gibson Desert, and only 31 records representing nine species from the Great Sandy Desert bioregion. All species collected during this survey, except for the Common Glider

[5] Braby, M.F. 2000, *The butterflies of Australia: their identification, biology and distribution*. CSIRO publishing, Collingwood, Victoria, Australia.

[6] Hawking, J. H., Theischinger, G. 2004, *Critical species of Odonata in Australia*. International Journal of Odonatology 7(2): 113–132.

(*Tramea loewii*), are represented in this list. The WAM collection does not reflect accurately the dragonfly diversity of WA and prior to this survey included no identified specimens from the Gibson or Great Sandy deserts.

True bugs

All true bug taxa are new records for the IPA and represent range extensions based on records held by the UNSW. Due to the lack of existing baseline data, these range extensions are not considered significant.

Spiders

No spiders were recorded from the IPA prior to this survey. Here three named species are recorded for the first time for WA: *Australutica manifesta* (known from SA and NT), *Cryptoerithus nyetaut* (known from only three localities in the NT) and *Pseudasteron simile* (a common species in NSW, NT, Qld). Additional records were obtained for five rare species: *Afraflacilla grayorum* (known from only four records from NSW, Qld and WA), *Masasteron utae* (known from seven records in the NT as well as in eastern WA), *Nomindra arenaria* (known from NT, Qld and WA), *Tamopsis nanutarrae* (a long spinneret bark spider known only from the type locality at the Ashburton River), *Wydundra uluru* (known from only six records in the NT and WA).

Snails

No previous surveys for molluscs in the Gibson Desert are known, thus, all the records from this Bush Blitz represent range extensions. Collecting of terrestrial and freshwater molluscs in WA has been mostly restricted to areas with easy access and as such, many remote areas of the State have not been collected from or properly surveyed. Consequently no information or relevant comparative material is available for these areas.

Adelaide Pupasnail (*Pupoides adelaidae*) records from this survey extend the known range inland considerably. This species has a wide geographic distribution that appears to extend from NSW and north-western VIC, across southern SA into the wheatbelt areas of WA and as far to the north-west as Morawa. It possibly also extends from Shark Bay north to North West Cape on the west coast of WA. The specimens collected during this survey extend the known range inland considerably. Further collecting of *P. adelaidae* might show it has a wider and more inland distribution.

Red Centre Pupasnail (*Pupoides beltianus*) specimens collected during this survey extend the known range of this species west and northward. This species was previously known from the Reynolds and Jervois Ranges in the NT, south to the Musgrave and Mann Ranges in SA, and west to the Barrow Ranges in WA, which are near the junction of the borders of WA, SA and the NT. It could extend across to the Pilbara region of WA.

Broad Sinistral Pupasnail (*Pupoides eremicolus*) specimens collected during this survey extend the known range of this species westward. This species has a known range in the southern part of the NT, with a few records from western Queensland.

Musson's Pupasnail (*Gastrocopta mussoni*) specimens collected during this survey extend the known range of this species to the west and east. This species is known from the northern and north-eastern parts of Queensland, southern (Central Australia) and northern parts of the NT and northern WA. It has also been recorded from the mid-west coast of WA and in SA. It was recorded recently from the Pilbara region of WA. The specimens collected during this survey extend the known range of this species to the west and east.

Flowering plants

Five flowering plant taxa known to occur in the NT were collected for the first time in WA. The names will be added to the WA plant census together with three other taxa held at interstate herbaria. Many specimens collected represent range extensions within the Gibson Desert and Great Sandy Desert bioregions, some being the first collections from these bioregions or within the Great Sandy Desert. Of the taxa already known from WA, there were 17 significant range extensions of 100–500 km. These range extensions reflect the relatively poor understanding of plant distributions in the Central Desert region and particularly for areas away from major roads. Many of the other plant taxa collected will also be range extensions of varying extents.

Table 12 Range extensions for flowering plants documented during this Bush Blitz

Family	Species	Nearest previous record	Comments
Asteraceae	*Calotis multicaulis*	>200 km	Second record for Gibson Desert; first record for Great Sandy Desert.
Asteraceae	*Centipeda racemosa*	–	Third record for WA.
Campanulaceae	*Isotoma petraea*	–	Second record for Great Sandy Desert in WA.
Campanulaceae	*Wahlenbergia caryophylloides*	>500 km	First record for Gibson Desert or Great Sandy Desert.
Chenopodiaceae	*Einadia nutans* subsp. *eremaea*	~200 km	First record for Gibson Desert or Great Sandy Desert (in WA).
Chenopodiaceae	*Sclerolaena fimbriolata*	~400 km	
Chenopodiaceae	*Sclerolaena parviflora*	>200 km	Second record for Gibson Desert; first record for Great Sandy Desert.
Cyperaceae	*Fimbristylis caespitosa*	~200 km	Southern limit in WA.
Elatinaceae	*Bergia occultipetala*	–	First record for WA and new species for WA plant census.
Euphorbiaceae	*Euphorbia biconvexa*	>200 km	First record for Great Sandy Desert in WA.
Fabaceae	*Gompholobium polyzygum*	Approx. 100–150 km	Second record for Great Sandy Desert in WA.
Fabaceae	*Indigofera linnaei*	Approx. 300 km (from WA records)	First record for Gibson Desert.
Fabaceae	*Senna artemisiodes* subsp. *alicia*	–	First record for WA and new species for WA plant census.

Family	Species	Nearest previous record	Comments
Fabaceae	*Swainsona tanamiensis*	>200 km	First record for Gibson Desert or Great Sandy Desert.
Gentianaceae	*Schenkia clementii*	>400 km	First record for Gibson Desert or Great Sandy Desert.
Goodeniaceae	*Dampiera dentata*	–	First record for Great Sandy Desert.
Goodeniaceae	*Goodenia halophila*	–	First record for WA and new name for WA plant census.
Juncaginaceae	*Triglochin hexagona*	>500 km (from WA records)	First record for Gibson Desert or Great Sandy Desert.
Lamiaceae	*Dicrastylis beveridgei*	Approx. 200 km	First record for Gibson Desert or Great Sandy Desert.
Malvaceae	*Sida* sp. Western Sand Dunes	–	First WA record for WAH (WA specimens held at DNA/NT); new name for WA plant census.
Malvaceae	*Triumfetta winneckeana*	–	First WA record for WAH (WA specimens held at DNA/NT).
Myrtaceae	*Corymbia deserticola* subsp. *mesogeotica*	–	Not collected during Bush Blitz; however, recognised as new name for WA plant census. Collection confirmed with D. Nicolle. Specimens for WAH collected by P.K. Latz and D.E. Albrecht from Kiwirrkurra IPA, June 2016.
Phrymaceae	*Peplidium* sp. Tanami	–	First record for WA and new species for WA plant census.
Plantaginaceae	*Stemodia florulenta*	>300 km	First record for GD or GSD.
Plantaginaceae	*Stemodia* sp. Tanami	–	Third record for WA.
Poaceae	*Eragrostis eriopoda* subsp. Sandy fireweed (P.K. Latz 12908)	–	New name for WA plant census; specimen to be lodged at CANB (WA specimens held at DNA/NT).

Family	Species	Nearest previous record	Comments
Poaceae	*Triodia latzii*	–	First record for WA; new name for WA plant census.
Poaceae	*Eriachne lanata*	>400 km	Eastern limit.
Sapindaceae	*Dodonaea viscosa* subsp. *mucronata*	>200 km	First record for GD or GSD.
Scrophulariaceae	*Eremophila forrestii* subsp. *forrestii*	Approx. 200 km	–

Other points of interest

Fauna

Vertebrates

One frog, 47 reptile and 18 native mammal species were recorded in the survey. Previously 49 species of reptile were recorded from the IPA; of the 47 species documented from this survey, almost 10% (5 species) were new records. A number of additional species were documented in the IPA that are not listed as new records since they are well known as inhabitants of the area, such as the Great Desert Skink (*Liopholis kintorei*), Centralian Blue-tongue (*Tiliqua multifasciata*), Northern Marsupial Mole (*Notoryctes caurinus*), kangaroos and large goannas. Analysis of species-accumulation data predicts that 58 reptiles and 64 mammals are likely to occur in the IPA.[7] Therefore, the survey detected around 83% to 91% of the predicted fauna across the habitats sampled. The overall confirmed species list for native reptiles, frogs and mammals is 64, two and 21, respectively.

The collection of 265 tissue samples across the range of species captured, along with 158 voucher specimens, were added to the WAM collections. This new material more than doubled tissue samples and almost doubled WAM's voucher collections from the region, providing material for future taxonomic work. Species lists for areas are important for conservation planning. Data detailing patterns in species assemblages across the landscape improve significantly our understanding of functional ecosystems. Further specimen collection and survey will add to tissue collections and for all species help to resolve finer scale patterns relating to environmental parameters.

A notable difference in species richness was observed between the two standard surveys sites (SS1 and SS2). The unburnt dune system (SS2) exhibited almost twice the species richness of the mulga woodland (SS1); 11 reptile and four mammal species were detected at SS2 and only six reptile and two mammal species were detected at SS1. The diversity of habitats associated with the dune site in comparison with the more uniform and simpler environment of the mulga woodland is likely to account for the significant difference in vertebrate richness.

[7] The Chao1 and Jacknife1 species accumulation indices for all reptiles and small mammal captures were used to predict species counts for the IPA.

Mammals

Recorded mammals included seven marsupials, three rodents, seven bats and one echidna. New records for the IPA included the Fat-tailed Pseudantechinus (*Pseudantechinus macdonnellensis*) and seven bats, the bats representing three separate families.

Acoustic sampling for bats was undertaken at three locations: one night at site V9, three nights at Nyinmi and one night at Murmur. Six species were recorded at Nyinmi, four species at site V9 and only one at Murmur, again probably reflecting the complexity of the habitat associated with each of the areas. The development of the newer generation of sophisticated ultrasonic recorders such as the SM2Bat, along with availability of call libraries and methodology, now make aspects of field sampling of bats comparatively straightforward, although analysis of the resulting data files still requires much effort.

The Fat-tailed False Antechinus was locally abundant in the rock pile sampled at site V8, and although only caught once at V9 is probably abundant there considering the type and extent of rocky habitat. Six of the seven females trapped were carrying pouch young.

Reptiles

The survey documented eight dragons, 11 geckos, four legless lizards, 15 skinks, five goannas and five snakes. Five species of reptile were new records for the IPA: two snakes, two legless lizards and a gecko. Only two of the newly recorded reptile species were detected through trapping, with the remainder all single observations. The Smooth Knob-tail Gecko (*Nephrurus levis*) was caught on seven occasions at sites around Kiwirrkurra and Nyinmi, while the Hooded Scaly-foot (*Pygopus nigriceps*) was caught only once, near Lake Mackay. Several groups recorded during the survey may be the focus of future taxonomic revisions, specifically species of the gecko genera *Gehyra* and *Diplodactylus*.

Invertebrates

The terrestrial invertebrate fauna of inland Australia is estimated to comprise at least 250,000 species. Research on Australian invertebrates has increased significantly over the last 20 years, but it is estimated that less than 15% of species have been described formally. Surveys of the IPA prior to this Bush Blitz tended to focus on vertebrates, and thus little was known about the invertebrates.

Butterflies

Fifteen species of butterfly were collected. The number and abundance of species observed far exceeded expectations. The time of year and collecting conditions were close to ideal for collecting butterflies in this region. The results suggest that inland areas, during suitable conditions, are far richer in butterfly species than previously thought. The sites situated on red sand dunes (SSS2 and WP930) produced the greatest diversity of butterflies: this habitat type should be targeted on future surveys.

Most butterflies breed on a single or narrow range of plant species; the distribution of butterflies therefore depends upon the distribution of the host plants. Copper Pencilled-blue breeds on several plant species,[8] but only one known host Needlewood (*Hakea leucoptera*) occurs in the IPA. Small Dusky-blue is recorded to breed on three species of *Cassytha*; one of these, *C. capillaris*, was newly recorded for the region during the survey. *Cassytha capillaris* is also the only recorded host plant for Spotted Dusky-blue. Notably, Small Dusky-blue and Spotted Dusky-blue were recorded together at the same site

[8]Braby, M.F., 2016. *The complete field guide to butterflies of Australia*. 2nd edn. CSIRO publishing, Clayton South, Victoria, Australia.

(WP930), so it is likely that they breed on the *C. capillaris* nearby. None of the recorded host plants of Black-spotted Grass-blue were recorded in the IPA, but three species of *Indigofera* (*I. georgei*, *I. linaei*, and *I. monophylla*) were recorded during the survey and one of these could be the host.

Beetles

Twenty ground beetle (Carabidae) species were collected at different locations in the IPA and mostly caught in the vertebrate traps. Sixteen are un-named and need further taxonomic work. Species in the following genera are now recorded from the IPA: *Carenum* (five species), *Conopterum* (one species), *Euryscaphus* (two species), *Neocarenum* (five species), *Nototarus* (one species) and *Scaraphites* (two species).

Dragonflies and damselflies

Dragonflies and damselflies (Odonata) are easily recognised by their large membranous wings (held out to the sides in dragonflies, folded over the abdomen at rest in damselflies), large eyes and elongate bodies. Spending most of their lives as water-dwelling nymphs, they are primarily aquatic insects. As adults, they remain closely associated with water, around which they hunt, defend territories, mate and lay eggs. They are voracious predators as both larvae and as adults. There has been increasing interest in the study of Odonata as indicators of global climate change and more generally as indicators of aquatic ecosystem health. Dragonfly distributions shift in response to changes in climate; they and other aquatic insects are also highly susceptible to changes in water quality.[9]

During this survey, five dragonfly species were collected from two of the 26 sites visited. Dragonflies were collected from Jupiter Well in the far west of the IPA and from a large, ephemeral freshwater lake system in the north-east corner; the majority of dragonfly specimens were collected from the latter locality. Such low diversity is probably due to restricted sampling time at each site, and seasonal variation; the survey was conducted during a dry year. Future surveys would benefit from collecting during the wetter seasons and from spending more time at sites such as the ephemeral lake system where most of the specimens were collected.

Psyllids

Although psyllids were not one of the target groups, a small number of these small sap-sucking insects were collected opportunistically. Four species referred to the genus *Acizzia* were collected from six different host plant species; however, *Tephrosia* "rosea" is a doubtful host plant since only one psyllid specimen was collected from it and this could simply have been blown on to this plant. Over 400 psyllid species are recorded for Australia, most found on myrtaceous and mimosaceous plant species; it is expected that many species are yet to be collected and described in Australia.

True bugs

The true bugs of Australia comprise about 2500 named species (Australian Faunal Directory) and recent surveys during the first phase of the Bush Blitz programme recorded 1391 species, of which 391 are new to science. The predicted total true bug fauna of Australia is about 6500 species.[10]

This current survey of true bugs documented 85 species from 19 families; the greatest species richness was in the family Miridae (51 species). Specimens were collected from 27 localities. It impossible to

[9]Theischinger, G., Endersby, I. 2009, *Identification Guide to the Australian Odonata*. Department of Environment, Climate Change and Water NSW.

[10]Cassis, G., Laffan, S. 2012, *Heteroptera integration and spatial analysis*. Unpublished report prepared for the ABRS, Canberra. School of Biological, Earth and Environmental Sciences, University of New South Wales.

characterise the true bug fauna of the IPA given the paucity of available information from much of inland WA where sampling has been inadequate.

Spiders

Sixty-one species from 21 families were collected. All of the described species have distributions beyond the IPA. Most of the spiders collected hunt actively, so it was not surprising that they were caught in vertebrate pitfall traps. Corinnids, hersiliids and prodidomids are daylight hunters, active mostly in the early mornings, whereas lamponids, lycosids, miturgids, nemesiids, and zodariids are nocturnal hunters that hide in burrows or under spinifex during the day.

The identities of 17 species could not be determined due to a lack of modern taxonomic revisions and no available expert. No recent comprehensive revisions exist for the Australian orb-weaver spiders (Araneidae), wandering spiders (Ctenidae), ground spiders (Gnaphosidae), wolf spiders (Lycosidae), racing stripe spiders (Miturgidae), wishbone spiders (Nemesiidae), goblin spiders (Oonodpiae), lynx spider (Oxyopidae), Phrurolithidae, jumping spiders (Salticidae), tube-web spiders (Segestriidae) and long-jawed spider (Tetragnathidae); therefore, it is unsurprising that most of the un-named species belong to these families. More than 70% of the spiders collected from the IPA are new or un-named.

The IPA has at least four un-named species of ground spiders. This group of free hunting nocturnal spiders is species-rich; they hide during the day in sand or under spinifex. Few species of ground spiders have been the subject of modern taxonomic revision.

Wolf spiders are one of the most diverse spider families in Australia. The taxonomy of this family is only partly revised. The six species collected are difficult to identify; unfortunately, no specialist is available for the identifications.

One species of lynx spider was collected from the IPA. In Australia 19 species of lynx spider are known, but most are difficult to identify because there is no recently published modern revision.

The collection of long spinneret ground spiders (Prodidomidae) yielded five described species in five genera. *Molycria vokes* is widely distributed in WA and SA. *Myandra bicincta* is very common throughout Australia.

Salticidae, the Jumping spiders are the most species-rich and diverse of all spider families in Australia. Because of their remarkable diversity, it is impossible to treat all the jumping spiders of the IPA in this report.

The tube-web spiders caused great excitement, as it was not immediately obvious to which family they belonged. Tube-web spiders are six-eyed haplogyne spiders recognised by the position of their legs. When resting, three pairs of legs are directed forward alongside the spider's body. Tube-web spiders are poorly resolved taxonomically. Only six species are described for Australia, in two genera. Only females have been described so far; the seven specimens collected from the IPA are the first males ever taken and these were described as *Ariadna kiwirrkurra* Baehr & Whyte 2016. Most descriptions date from 1873–1911 with one species described in 1954.

The freshwater lakes of the IPA support at least one species of long-jawed spider. This family have extremely elongate jaws, at least in the subfamily Tetragnathinae; the jaws are used for interlock during mating, possibly to avoid the male being sexually cannibalised by the female.

The collection of ant spiders (Zodariidae) yielded seven described species, referred to seven genera. Zodariidae are mostly night-active hunters in litter or sand. Most of them mimic ant behaviour and live with ants while preying on them.

Pseudoscorpiones

Although pseudoscorpions were not a target taxa for this survey, an un-named species was collected in each of the genera *Austrohorus* and *Indolpium* (Olpiidae), from three locations in the IPA.

Snails

Only five species of snail were recorded from the IPA; the low species diversity was expected, given the geographic location, infrequent and low rainfall, high temperatures and few prominent ranges and hills. Thirty-two sites were visited over 10 days, with snails collected at 14 of these. Helicopters provided access to remote sites across the vast area of the IPA; however, a maximum of only two sites per day could be visited by helicopter.

Land snails in arid environments tend to be found in areas with rock piles, good amounts of shade (e.g. fig trees) and seasonally wet spots. Selection of sites was focussed first on areas of elevated topography (i.e. ranges, hills, outcrops), targeting south-facing gullies or depressions where the presence of water, shade and mixed vegetation was expected to be greatest. The topography of the IPA generally decreases going east to west, and this appears to be accompanied by a decrease in the occurrence of tall trees and vegetation, particularly fig trees. Traditional knowledge was invaluable in locating habitats suited to snails, and as the survey progressed the focus shifted to wetlands, calcrete areas and fig trees.

The land snail fauna of the central deserts of Australia is known to include an extensive radiation of the land snail family Camaenidae and a suite of small-sized, less diverse families broadly termed 'non-camaenids'. A single relict species of the mostly southern Gondwanan genus *Bothriembryon* is known from the Red Centre. Freshwater snails are also found and can be either air-breathers (pulmonates) or have a modified gill.

Future surveys during periods of higher rainfall when snails are active may record additional species, particularly along gullies and the south-facing slopes of prominent ranges and hills. Locating and sampling other fig trees within the IPA could turn up land snails in the families Bothriembryontidae and Camaenidae. Likewise, other freshwater and terrestrial snails could be found by sampling more extensively at ephemeral lakes, particularly after rain.

Flora

Flowering plants

In general, the areas surveyed were all of high quality, representing good examples of the vegetation of the Great Sandy Desert and Gibson Desert bioregions. Botanists collected 334 plant taxa from 48 families; 170 of these (54%) were new records for the IPA (159 of these being formally named and 11 being phrase-named). In total 435 vascular plant taxa are now recorded from the IPA, most vouchered in an Australian herbarium. The five most speciose groups collected were Fabaceae (55 taxa in 15 genera), Poaceae (32 taxa in 12 genera), Chenopodiaceae (28 taxa in 13 genera), Malvaceae (25 taxa in nine genera) and Goodeniaceae (21 taxa in six genera).

Close to 600 plant collections were made on this survey, greatly improving information on the flora of the IPA, and the Gibson and Great Sandy deserts. The list of species from the IPA is far from complete as several habitats (e.g. rocky ranges in the east) were not surveyed and conditions during the survey were

poor for annuals. Also, for identification reasons and specimen lodgement standards, only fertile specimens (i.e. those with flowers or fruits) were collected during this trip—a much greater number of species were observed.

Much less collecting has been done in the central deserts than other areas Figure 1. Based on AVH records, previous collections within the IPA were concentrated along the Gary Junction Road and areas around Kiwirrkurra, Buck Hills, Dovers Hills, Pollock Hills and north-western Lake Mackay, including the Marruwa outstation area Figure 2. Collections were mostly opportunistic, usually with just a handful of specimens collected in any one year Figure 3.

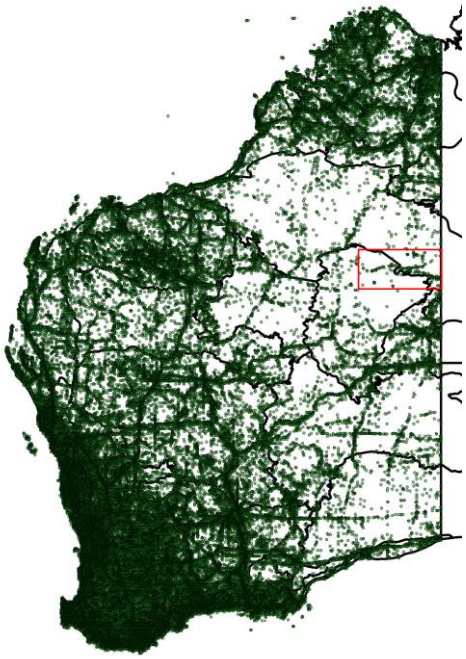


Figure 1 Map of WA showing the location of the IPA (red rectangle) and all vascular plant specimen records in AVH. IBRA boundaries are shown in black, with the IPA straddling the boundary between the Gibson Desert (SW corner) and Great Sandy Desert (NE corner) bioregions.

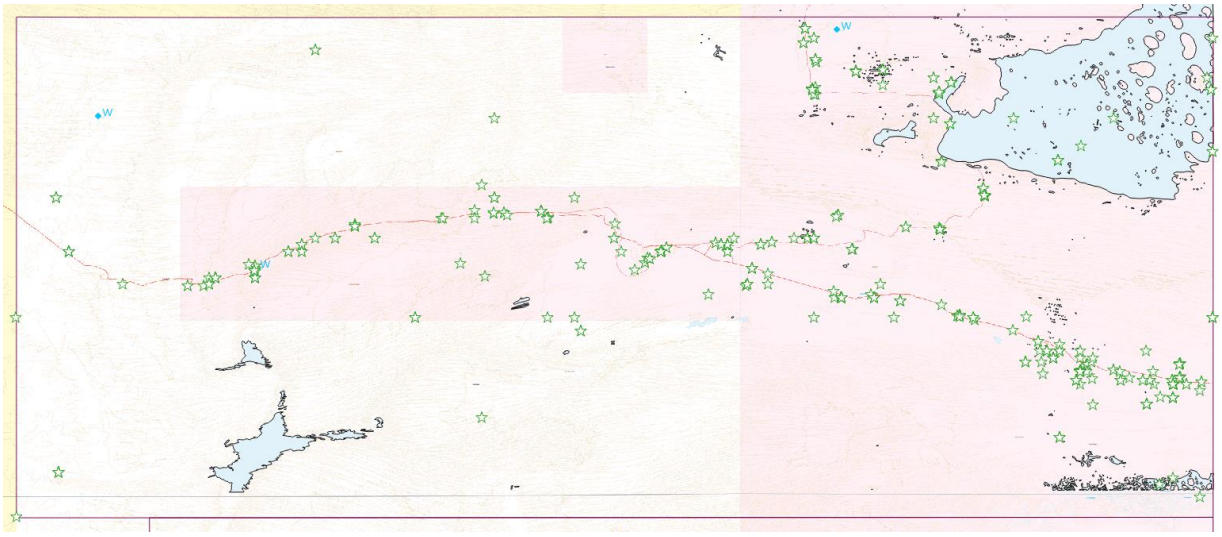


Figure 2 Map of vascular plant collection records in the IPA prior to the Bush Blitz, data from AVH.

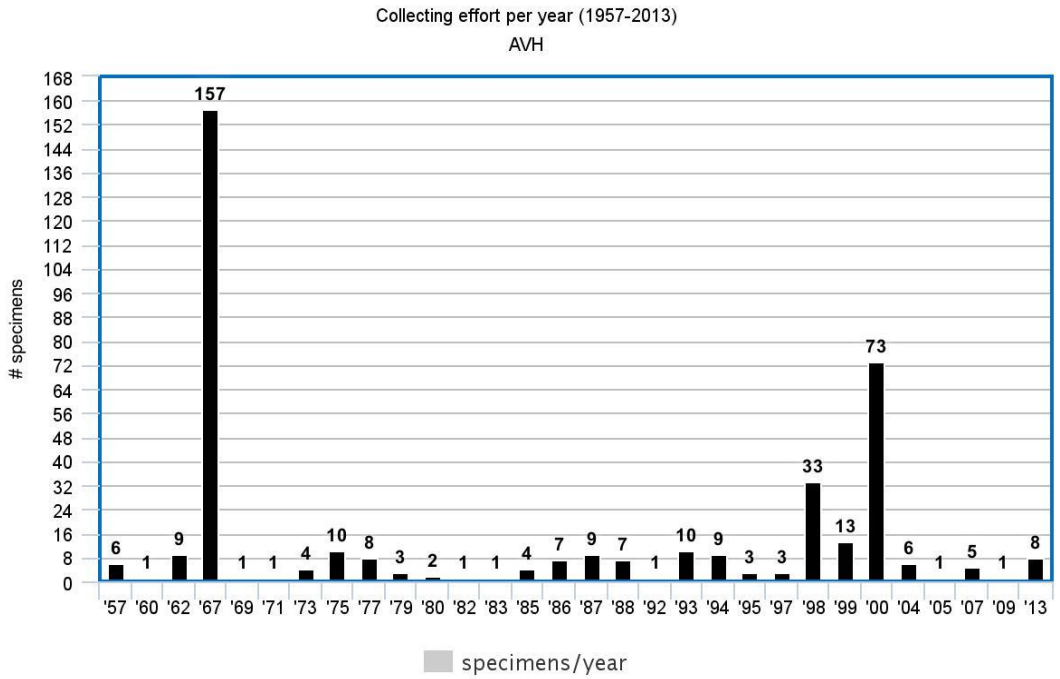


Figure 3 Collecting effort for vascular plants within the IPA prior to the Bush Blitz, based on AVH data (with duplicate specimens removed) for which collecting year was supplied (nine collections not graphed).

Site selection was based on CSIRO Gap Analysis combined with other factors. Gap Analysis and environmental modelling identified a number of target areas within the IPA, suggesting survey locations that sampled thoroughly the full range of biophysical characteristics (i.e. soil characteristics, elevation, temperature, moisture) on the property. These were ranked by a prediction of likelihood of discovering new species. Prior to arrival at the site, the area was explored using Google Earth and GIS imagery, including maps of tenure, base geology, soil categories, vegetation and fire history provided by Bush Blitz. Discussions were held with field botanists with experience in the region to identify landforms and habitats that should be targeted. Since the area away from main access routes had been poorly collected, as broad a range of habitats and vegetation communities as possible were selected for field sampling. Particular attention was given to areas of differing geologies, with complex geological mosaics, geologies known to have endemic taxa (e.g. gypsums), good water-holding properties (clay pans, soaks, wetland areas) and peculiar habitats. Preliminary sites were chosen to maximise the chance of finding significant specimens (i.e. novelties and range extensions).

Conditions in early September were dry and many taxa had finished flowering. Given the dry conditions, areas around wetlands and moist clay pans were the most productive for general collecting, and were targeted more than would have been the case earlier in the season when flowering would have been more widespread.

Seemingly uniform landscape elements (dunes and swales) were found to vary in species composition due to their mosaic vegetation structure—adjacent dunes did not necessarily support identical species. The influences of microclimate and fire history were apparent. Dune sites burnt within the previous five years were observed to have high species diversity with more taxa flowering in the swales where moisture had been retained.

Traditional patch burning has created a vegetation mosaic in the dunefield. Extensive broad-scale patch burning is no longer practised; activities are now localised and concentrated around Kiwirrkurra. Research shows that the changed fire practice between 1953 and 1994 has resulted in approximately the same total area burnt, but fewer individual burnt patches; the patches are also much larger, having been increased tenfold in size. These changes have affected local refugia and species diversity.

Future surveys during higher rainfall years would allow collection of more species, particularly annuals.

Liverworts

Seven liverwort specimens were collected representing at least four species of *Riccia* (Ricciaceae). Although all of these are widespread across Australia, none had been collected previously within the IPA.

Edible insects project

An important goal of this Bush Blitz was to document edible insects. This research was a priority identified by traditional owners and was undertaken with their close collaboration. Ten 'ethno species' of edible insects were collected and four others were named by traditional owners but not found. The material collected is undergoing DNA bar-coding to identify the scientific species. A Pintupi-English language booklet on edible insects was prepared for use within the community. It is hoped that the booklet will stimulate further interest in edible insects and encourage community members to collect the few species that were not collected during the survey.

Nearly 2,000 species of insects have been used as food for humans in Africa, Asia, North, Central and South America, and in Australia.[11] With food globalisation trends, there has been a tendency to drop insects from the diet in many of the insect-eating countries. Impending global food shortages have resulted in the United Nations Food and Agriculture Organisation advocating increased use of insects as food and interest has been renewed in the traditional use of insects as food. Besides nutritional and possibly other health benefits, cultural benefits are also associated with the use of insect foods in many ethnic groups. Consequently, there has been interest in recording information on use of insects as food in different cultures so that the information is available for use by future generations.

Edible insects are an important component of the traditional diet of desert-dwelling Aborigines. Insects were an important food source in many parts of Australia, being available throughout most of the year[12] and considered healthy, especially for childhood development[13]. The few analyses on the nutritional value of edible Australian insects indicate high levels of important nutrients.[14] Approximately 60 species of insects were eaten[15] although this figure is probably an underestimate because there have not been thorough inventories of insect foods at a broad regional level in Australia. Records of Aboriginal use of insects as food have generally been fragmentary, isolated observations, often made because the early

[11] Jongema, Y. 2015, *List of edible insects of the world*. Wageningen University, Wageningen, the Netherlands. http://www.wageningenur.nl/en/Expertise-Services/Chair-groups/Plant-Sciences/Laboratory-of-Entomology/Edible-insects/Worldwide-species-list.htm

[12] Tindale, N.B. 1953, On some Australian Cossidae including the moth of the witjuti (witchety) grub. *Transcript of the Royal Society of South. Australia*. 76:56–65; Latz, P. 1995, *Bushfires and Bushtucker*. IAD Press, Alice Springs.

[13] Tindale, N.B. 1981, Desert aborigines and the southern coastal peoples: Some comparisons. In Keast, A. (ed). *Ecological Biogeography of Australia*. Dr. W. Junk Publishers, The Hague, pp. 1853–1884.

[14] Cherikoff, V., Brand, J.C.,Truswell, A.S. 1987, The nutritional composition of Australian aboriginal bushfoods. II. Animal foods. *Food Technology in Australia* 37(5): 208–211.

[15] Yen, A.L. 2015a, Insects as food and feed in the Asia Pacific region: historical perspectives and future directions. *Journal of Insects as Food and Feed* 1(1): 33–55.

European observers were biased against insects as a food and considered it a form of 'primitiveness' or a starvation food.

The edible insects in Australia are unique in that most of the species are the wood-feeding larvae of moths and beetles.[16] These larvae have been given common names such as 'witchetty grubs' or 'bardi grubs'. The loose manner of application of these names, the lack of confirmed species identifications, and the possibility that many more species are yet to be identified, has resulted in 'the witchetty grub conundrum'.[17] The larval stages are usually eaten, but insect identification is based on adults. People generally have not taken the next step to identify the larvae to species; consequently, it is often uncertain what species are being eaten. This lack of certainty about the species identity can have implications for managing the environment and for ensuring that edible insects are harvested in a sustainable manner.[18]

Prior to this survey, there was one only reference to edible insects for the area, from the north-western side of Lake Mackay. Thomson (1975) describes a Pintupi woman digging up edible grubs from Desert Grevillea (*Grevillea pterosperma*).[19] He identified it as larvae of a cerambycid beetle *Cnemoplates edulis*. Meyer-Rochow (1975) lists some of the Pintupi insect foods as termites, grasshoppers, leafhoppers and other plant bugs, larvae (and sometimes adults) of beetles and moths, honey ants, and native honey.[20] Cane and Stanley (1985) name two edible insects used by Pintupi near Kintore: coconut apples (scale insect galls on Desert Bloodwood) and witchetty grubs from the trunk of Desert Poplars.[21] From further west, Veth and Walsh (1988) list 18 species of plants that provide either grubs or galls for Martujarra in the Little Sandy Desert.[22] They do not distinguish which plant species were the source of grubs and which of galls, but it is likely that most of the plant species have edible grubs. The Pintupi/Luritja Dictionary lists 13 words to indicate types of witchetty grubs.

In some Aboriginal languages, edible grubs are given names that indicate that they are an edible grub followed or preceded by the name of the plant species that it is the source. For example, the edible grub found in Witchetty Bush (*Acacia kempeana*) is called *maku ilykuwara* in Pitjantjatjara and *atnyematye* in Arrernte. In the Pintupi language, the word *maku* indicates edible insect. However, traditional owners of the IPA did not use this term in association with a plant name to identify any particular ethno species.

Traditional owners identified 15 plant species that are sources of edible grubs or insect products Table 13. During the fieldwork, edible insects were associated with 10 plant species; eight of these were edible grubs (larvae), one was a scale insect gall, and the last were lerps—the sugary coverings of nymphs of a sap-sucking insect (psyllids). Either the remaining plant species lacked edible insects at the time of searching or the plant species was not located.

[16]Yen, A.L. 2015b, Conservation of Lepidoptera used as human food and medicine. *Current Opinion in Insect Science* 12: 102–108.
[17]Bilney, C., Lawler, S., Yen, A.L. *Opening a can of witchetty grubs*. Manuscript in preparation.
[18]Yen, A.L. 2012, Edible insects and management of country. *Ecological Management & Restoration* 13(1): 97–99.
[19]Thomson, D. 1975. *Bindibu Country*. Thomas Nelson: Melbourne.
[20]Meyer-Rochow, V.B. 1975, Local taxonomy and terminology for some terrestrial arthropods in five different ethnic groups of Papua New Guinea and Central Australia. *Journal of the Royal Society of Western Australia* 58(1): 15–30.
[21]Cane, S., Stanley, O. 1985, *Land use and resources in desert homelands*. Australian National University Northern Australia Research Unit Monograph, Darwin.
[22]Veth, P.M., Walsh, F.J. 1988, The concept of "staple" plant foods in the Western Desert region of Western Australia. *Australian Aboriginal Studies* 188(2): 19–25.

Table 13 List of plant species within the IPA that have edible insects or insect products

Host Plant	Common name	Pintupi name	Insect type
Acacia adsurgens	Whipstick Wattle	murraputar	maku
Acacia aff. *dictyophleba*	Spear Tree	mulyati	maku
Acacia hilliana	Hill's Tabletop Wattle	yantarrma	maku
Acacia ligulata	Dune or Sandhill Wattle	watarrka	maku
Acacia melleodora	Scented Wax or Waxy Wattle	ngaltjirri, minytju, lukurrpa, lungkunypa	maku
Acacia murrayana	Colony Wattle	nyurrimpa, nyurrinpa, pitapitalpa	maku
Codonocarpus cotinifolius	Desert Poplar	kanturangu	maku
Corymbia opaca	Desert Bloodwood	arrkinki?, tjuta, tjutapati	bush coconut (scale insect gall)
Corymbia aparrerinja	Ghost Gum	itata?	maku
Eucalyptus camaldulensis	River Red Gum	itara	maku and aparalyi (lerp)
Hakea macrocarpa	Dogwood	mulupuku	maku
Indigofera georgii		punyanyi	maku
Salsola australis	Roly Poly	tjilkalangkatarra	maku
Senna notabilis	Cockroach Bush	kulpita, anamara	maku
Thinicola incana		altjirri, ngalytjirri	maku

Edible insects need to be collected collaboratively, with scientists and traditional owners working together. The latter are required to locate, collect and identify by local name the insects as a food. Scientists are needed to preserve specimens correctly for scientific identification. Documenting traditional knowledge about any type of food involves working closely with members of the community who know what they are looking for, how to collect it, and whether it is edible or not. Scientists could have dug up large white grubs from many different plant species, but not know if they are used as a food source by the local communities. Collecting involved going out with different members of the community to locations where they know the source plants are found. Community members explained what they looked for when searching for edible insects. As most species are wood-dwelling, either in the trunk or roots of their host plant, the signs of grubs included fresh holes in the timber, sawdust, cracks on the surface of the ground caused by swollen roots, pupal cases sticking out of the ground, fresh insect droppings and sick looking or dying trees. Collecting involved digging up the ground and breaking off root fragments using a digging stick; the larvae were pulled out of the root and stored in a container or threaded with a stick. Larvae left in a piece of excised root can remain live and fresh for some period (exact length of period unknown). Digging sticks in the past were wooden, but metal ones are now

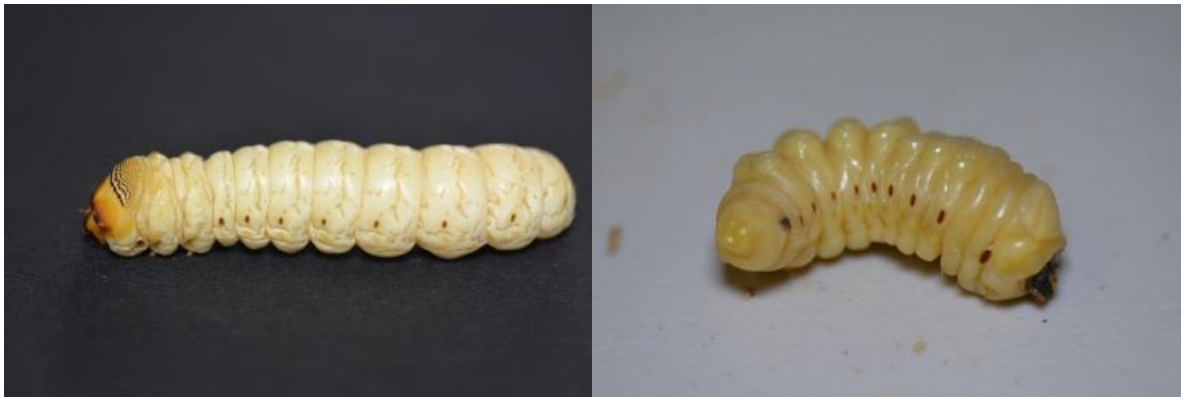
preferred. Larvae in the trunks were dug out using a small axe. The larvae were either cooked lightly in hot ashes or occasionally eaten raw.

Left to right: digging for edible grubs; maku in an exposed root; maku collection; maku on a skewer; cooking maku Photo Alan Yen © Copyright, La Trobe University

Sixty-two individual edible larvae were collected and kept for identification. The specimens represented the range of grubs of different appearance. Many more grubs were found, but the remainder were happily consumed. The number of grubs retained from each plant species is shown in Table 14. Interestingly, nearly one third of the individuals retained are beetle larvae while the rest are moth larvae (caterpillars). Species' identification could only be achieved through DNA bar-coding and this is currently in progress. A supplementary report will be submitted when the DNA results become available. Morphologically, the moth larvae seemed to belong to the family Cossidae. Most of the beetles seem to be from the family Cerambycidae. Not all the grubs were identified positively by community members as edible; this is the case with Spear Tree (*Acacia* aff. *dictyophleba*).

Table 14 The edible larvae retained for DNA analysis

Host plant species	Common name	Number of specimens	Ordinal identities of larvae
Acacia aff. *dictyophleba*	Spear Tree	5	1 beetle, 1 moth
Acacia hilliana	Hill's Tabletop Wattle	7	7 moth
Acacia ligulata	Dune or Sandhill Wattle	6	6 moth
Acacia melleodora	Scented Wax or Waxy Wattle	26	2 beetle, 24 moth
Acacia murrayana	Colony Wattle	5	1 beetle, 4 moth
Codonocarpus cotinifolius	Desert Poplar	5	5 beetle
Salsola australis	Roly Poly	2	2 beetle
Thinicola incana	–	6	6 beetle



Maku—cossid moth larva on the left, beetle larva on the right, photo Alan Yen © Copyright, La Trobe University

The number of instars witchetty grubs undergo is unknown. For most immature insects, the head capsule increases by a factor of 1.2 at each moult to the next instar. The head capsules of 44 larvae of the cossid moth species from the Waxy Wattle (*Acacia melleodora*) were measured in an attempt to determine the number of instars Figure 4. The widths were all large (ranging from 4.2–6.8 mm); it will be necessary to measure some early instars at another time of the year to complete this exercise.

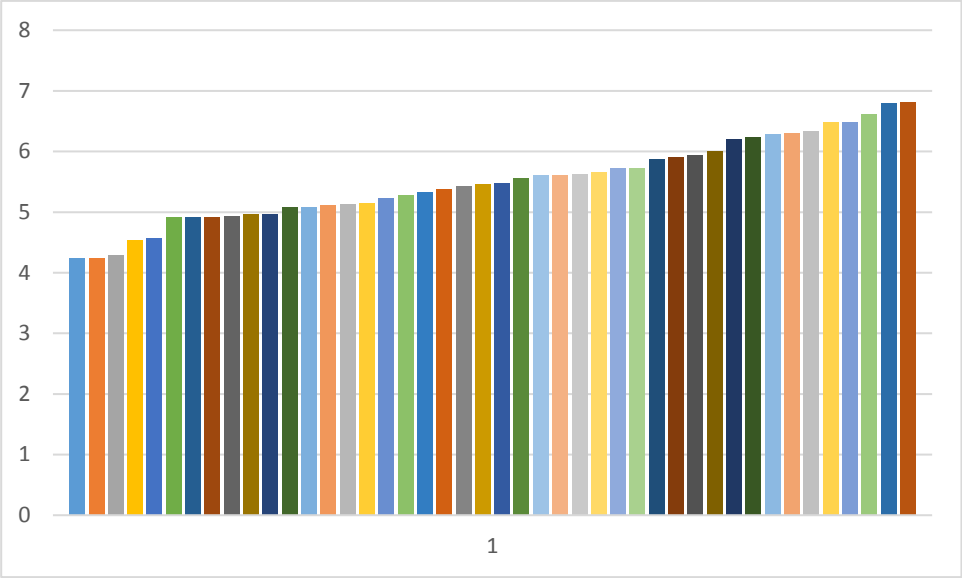


Figure 4 Head capsule widths of species of maku from *Acacia melleodora*

Bush coconuts, also called bloodwood apples, are galls induced by *Cystococcus pomiformis* a species of scale insect. The gall is initiated by a single female that enlarges as it grows within the gall. The female produces winged males first, followed later by a batch of wingless females. When the founder female dies, the young females attach themselves to a winged male that then emerges out of the gall. Three components of the gall are used as food: the founder female (most preferred food), followed by the young males and females, and the white 'coconut' flesh. Thirty-seven bush coconuts of varying sizes (35.1–95.8 mm diameter, 25–161 g in weight) were collected and measured; a subsample are being analysed for the nutritional value of the contents.

Left to right: bush coconut; scale insect; immature scale insects, photo Alan Yen © Copyright, La Trobe University

Lerps are shelters developed by psyllid nymphs using their sugary anal exudations derived from feeding by sucking sap from eucalypts. One *Glycaspis* sp. was found on River Red Gum (*Eucalyptus camaldulensis*). The lerps are collected and either eaten immediately or compressed into a ball and stored for use later.

Lerps, photo Alan Yen © Copyright, La Trobe University

Few studies have been based purely on all insect foods of Australian Aborigines. One study is underway with the Kaytetye community near Barrow Creek, and this study in the IPA may be the second. The value of the IPA study, besides documenting traditional information of the community, is that it will also identify important regional differences in the edible insect fauna. There is great geographical variation in habitats and plant species, so we cannot expect similar edible insect species across Australia. The IPA does not have honey ants or native honey, an immediate difference from many other regions. Witchetty Bush is a widespread plant from which Aborigines collect witchetty grubs; yet it is very rare in IPA.

The inventory prepared from the Bush Blitz and the subsequent bar-coding will assist any future efforts to document the availability of edible insects (over space and time) and any issues involved with caring for country that impact on sustainability. It could also strengthen culture because eventually we might find that some communities will have species of edible insects that are not found anywhere else.

The next step is to find the known species of edible grubs that have not yet been collected for DNA bar-coding. The distribution of a community booklet has already had an impact. In December 2015, grubs were collected from *Indigofera georgii* by a member of the community and these are available now for DNA analysis. The emphasis has been on insects with a close association with plants, and we still need to find out whether any other groups of insects (e.g. termites, grasshoppers) are or were eaten. The community booklet will be updated once more of the 'uncollected' species are found. The whole project will be documented in a peer-reviewed scientific paper with relevant community members as co-authors. Already a short note on the bush coconut is being drafted.

Although the nutritional and health benefits of edible insects has only been touched on by nutritionists and health workers, the increased global interest in the benefits of traditional foods makes it important that traditional information is recorded before it is lost for use by future generations.

Glossary

Exotic species: a species occurring outside its normal range.

Crepuscular: an animal that is active primarily during twilight, on moonlit nights or during overcast days.

Host plant: a species of plant that is used by larvae of insects as a place to feed and develop.

Nocturnal: an animal that is active primarily during the night and sleeps during the day.

Pest species: a species that has the potential to have a negative environmental, social or economic impact.

Putative new species: an unnamed species that, as far as can be ascertained, was collected for the first time during the Bush Blitz.

Range extension: increase in the known distribution or area of occurrence of a species.

Species range: the geographic area within which a particular species can be found.

Taxon (plural taxa): a member of any particular taxonomic group (e.g. a species, genus, family).

Taxonomy: the categorisation and naming of species. The science of identifying and naming species, as well as grouping them based on their relatedness.

Threatened: fauna or flora that are listed under Section 178 of the EPBC Act in any one of the following categories—extinct, extinct in the wild, critically endangered, endangered, vulnerable, conservation dependent.

Type locality: the location where the holotype or syntypes (type specimen(s)) was/were found.

Type specimens (holotype, syntypes): the specimen, or set of specimens, on which the description and name of a new species is based.

Undescribed taxon: a taxon (usually a species) that has not yet been formally described or named.

Vascular plants: a lineage of plants that possess well-developed veins (vascular tissue) in their stems, roots and leaves. Vascular plants include the majority of familiar land plants: flowering plants, ferns, conifers, cycads and fern allies, but not mosses, liverworts or algae.

Notes

All publications are available online at:
www.bushblitz.org.au

PUBLISHER ABRS, Canberra
EDITOR ABRS
LAYOUT Biotext
DESIGN TEMPLATE Biotext

Contributors

Bush Blitz is coordinated by the Australian Biological Resources Study (ABRS), which is part of the Australian Government Department of the Environment and Energy. The program is a partnership between the Australian Government, BHP Billiton Sustainable Communities and Earthwatch Australia.

Research agencies involved in this Bush Blitz were the Western Australian Museum, Western Australian Herbarium, Department of Parks and Wildlife (WA), Northern Territory Herbarium, Australian National Herbarium, Queensland Museum, La Trobe University, University of New South Wales and Desert Wildlife Services.

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Kiwirrkurra Indigenous Protected Area

Western Australia

6–18 September 2015

Australian Government
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