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Cravens Peak Scientific Study Report

The Royal Geographical Society of Queensland Inc.
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The Royal Geographical Society of Queensland Inc. is a non-profit organization that promotes the study of Geography within educational, scientific, professional, commercial and broader general communities. Since its establishment in 1885, the Society has taken the lead in geographical education, exploration and research in Queensland.

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The Botanical Drawings in this publication are reproduced by kind permission of the artist, Gwenda White.

This publication has been prepared by Hayley Freemantle of RGSQ.

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Acknowledgements

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Scientific Advisory Committee

Mr Paul Feeney (convenor), Dr Alan Cribb, Mrs Joan Cribb, Em. Prof. John Holmes, Dr Bob Johnson, Mr Geoff Wharton, Mr David Carstens, Mrs Kath Berg and Mrs Hayley Freemantle. The Scientific Advisory Committee is the body, comprised of people suitably accredited to advise the Society on its Scientific Expedition programme. This Committee suggests possible locations for research attention, selects a site following survey reports, makes a selection of projects to be included in the expedition and oversees the refereeing of papers following the expedition. This work, much of it taking place twelve months or more prior to the actual field work, is very important for the overall success of the project. The success of each of the six expeditions conducted so far and the enthusiasm with which the reports have been received indicates the value of the work of this Committee.

Reviewers

Dr Stephen Balcombe, Dr Alex Kutt, Eric Vanderduys, Dr Geoff Montheith, Prof Angela Arthington, Dr Robert Raven, Dr Walter Boles, Dr Max Moulds, Dr Owen Seeman, John Thompson, Dr Michael Braby, Gregory Czechura, Harry Hines, Tony Bean and Dr Alex Cook provided valuable assistance in refereeing the papers published in this volume.

RGSQ Office Staff

Projects such as the expedition series rely very much on a competent ‘office’ back up. Our staff of Kath Berg and Keith Smith gave their unstinting support. Keith, as on previous expeditions, provided the sound financial basis on which the project ran. Helen Duckworth handled the day to day communication with researchers and the multitude of other detail involved in organising people, travel, permits and publicity. Her dedication to the job was very much appreciated. Many thanks go to Hayley Freemantle, our current Project Officer, for the organising of reviewers, reporting and publication of this study.

Australian Bush Heritage Fund

Our thanks to Australian Bush Heritage Fund for allowing the use of Cravens Peak. Although the site was originally selected on recommendation it proved to be ideal. To Julian Fennessy our thanks for guiding us through the approval process. The on site manager, Len Rule and his wife Jo, were a pleasure to work with. Nothing was too much trouble for them, offering both advice and physical assistance. Their friendliness contributed significantly to the comfortable atmosphere of the expedition.

Our thanks also to the managers of neighbouring properties, ‘Glenormiston’ to the North and ‘Carlo’ to the South. The expedition made significant use of a ‘Glenormiston’ track in accessing S Bend out-station. This diverted considerable traffic from the sand dune route making that track much safer for those who had no choice but to use it.

Financial contributions

The Society wishes to acknowledge the Department of Environment, Water, Heritage and the Arts. A grant was given to the Society for consultancy services that contributed to: “The Field survey and Data-basing of vascular plants, Vertebrates and Invertebrates at Cravens Peak, Queensland”.

Cravens Peak Scientific Study

Paul Feeney and Hayley Freemantle

The Royal Geographical Society of Queensland Inc.

The Cravens Peak Scientific Study was a project of the Royal Geographical Society of Queensland. The field work component took place from 27 March to 23 April 2007, where a multi-disciplinary team of scientists and assistants (Table 1) were on site to undertake fieldwork and surveys. Data collected during the scientific study will provide the Australian Bush Heritage Fund with onsite-inventories and valuable baseline data for undertaking on-going monitoring and further site surveys and fieldwork. Analysis of the data will assist the Australian Bush Heritage Fund in developing management plans to secure the conservation of Cravens Peak.

Background

The Royal Geographical Society of Queensland Inc. is a not for profit organisation that promotes the study in all aspect of Geography within scientific, professional, educational and broader general community. Since the Society's inception in 1885, it has supported geographical exploration, research and education in Queensland.

Since J.P Thomson, the Society's founder, pronounced his dream that "a society would grow in Queensland with the strength to supply geographical science, encourage exploration and contribute to the acquisition and dissemination of geographical knowledge about Queensland", the society has initiated a succession of noteworthy research activities which has provided beneficial information on the geography of Queensland, for perusal by many across the globe. Studies of the Lamington Plateau in the 1910s, the Great Barrier Reef in the 1920s, Carnarvon Ranges in the 1940s and 1950s.

The 1990s saw a renewed dedication by the Society to continue the legacy set before. The organisation of studies to the Northern part of the Cape York Peninsula, during the wet season in 1992, Musselbrook Reserve in 1995, North East Cay, Herald Cays in 1997, White Mountains National Park in 2000 and The Gulf of Carpentaria in 2002, verified the Society's responsibility to support geographical and environmental research and education in Queensland.

Origins

Following the successful completion of the Royal Geographical Society's five earlier scientific expeditions, the Scientific Advisory Committee, in its deliberations, decided that the next study should be in an area other than the north of the State. Although there is still a need for more work to be done in the tropical north it was felt that areas of the west and south-west should be considered.

In early 2006, Paul Feeney, Gerry Keates and Kevin Teys conducted a survey of potential sites in the South-West of Queensland. Specific attention was paid to Diamantina Lakes National Park, 'Ethabuka' – a property owned by Australian Bush Heritage Fund and 'Bulloo Downs' a privately owned and working cattle property. Each of these areas had both specific and general attractions. However, they also had significant difficulties for us.

While on 'Ethabuka' we were advised that Australian Bush Heritage Fund had just purchased another property to the north called 'Cravens Peak' which could be of interest to us. While we could not access the property, as the owners were still on it, we were able to see photographs of the facilities and discuss the property layout with 'Ethabuka' staff. The existing buildings on 'Cravens Peak' promised a better and more reliable prospect for a base area than any of the other sites. A map survey showed a greater diversity of land and habitat types than the other locations surveyed. It also showed a more comprehensive system of internal tracks although there were significant areas of sand hill country which could present significant safety issues with a number of people moving about the area.

The recommendation, which the Scientific Advisory Committee accepted, was that the expedition be conducted on 'Cravens Peak' as early as practicable after the wet season (if there was one) in 2007. The area had been in prolonged drought and the prospects of rain were not good.

Australian Bush Heritage Fund was most co-operative and keen to have the research work done. 'Cravens Peak' had been a working cattle property for many years. The research work would be carried out immediately after the property had been destocked. This would give Bush Heritage a baseline from which to determine how well their future habitat and species restoration programmes were working. As their philosophy is to revert the land to its original wilderness state such a baseline would form a very important part of their evaluation process.

Brief details of the location

Cravens Peak is located 23° 16'S 138° 10'E on the border between Queensland and the Northern Territory on the southern edge of the Toko Range. It is a former pastoral holding 135km south west of Boulia and was acquired by Australian Bush Heritage Fund in October 2005, as part of a broader proposal to extend the portion of regional ecosystems within the Mulligan River system. The 233,000 hectare conservation reserve is located on the northern end of the Simpson Desert across the boundary of the Simpson-Strezlecki Dunefields and Channel Country bioregions. Several wetlands of national significance are located on site. The Cravens Peak property is of considerable bio-geographic interest, with an exceptional number of small reptiles and mammal species on-site.

Preparation

On 11 Oct 2006 a small group left Brisbane to commence the preliminary work of preparing the homestead area to serve as an expedition base and principal accommodation area. In addition to an owners/managers house the facilities included two stockman's accommodation blocks each with five single rooms together with shower/toilet and laundry area. An old roadhouse from Boulia had been shifted to the property and was being used as a communal kitchen and mess area. Semi attached to this was the old shower/toilet block which was in a state of disrepair. There was a good water supply from a bore while electricity was generated from a diesel plant.

The team set about numerous tasks. The shower/toilet block was gutted and converted to a workroom for the researchers. This provided a draft free area with benches, power points and water. The electric wiring to the whole building had to be sorted out as numerous bits had been added or wires cut off as various facilities had been changed during the roadhouse days. The generator switch board was tidied up and simplified. In the accommodation areas numerous jobs from general cleaning to repairing toilets and general plumbing were carried out.

A general survey of the property was undertaken: Tracks suitable for constant use were identified, locations for 'outstations' were selected, water points were located and the areas of different soil, rock or vegetation type were recorded.

A plan was developed which would see the establishment of a base area with three outstations. This would give researchers four locations from which to operate with each location offering different environmental opportunities. The outstations would be set up to accommodate about six researchers who would be supported by two volunteer staff. The base area would accommodate the bulk of the volunteer staff and up to eight researchers. Communication between base and outstations would be by satellite phone.

During this time also a re-supply system was set up. This utilised an existing supply system out of Mt Isa to the nearest town of Boulia. Orders placed with suppliers in Mt Isa were trucked to Boulia then brought to Cravens Peak by volunteer drivers. Fuel for the expedition use was brought in to the property in the usual pre wet season dump.

One afternoon, towards the end of the fortnight that was allocated for this work, when the buildings were clean and a bit of fresh paint had been applied here and there the sky suddenly took on an unusual appearance. A strange coloured cloud appeared on the western horizon. This cloud grew and moved rapidly towards the homestead. It developed into a classic dust storm cloud – a moving wall of dust about 700m high and stretching the length of the western horizon. The storm hit late in the afternoon and raged for several hours. The winds were similar to those experienced in a cyclone, visibility was about one hundred metres and the air inside buildings was thick with dust. Next morning revealed a 5mm layer of the finest dust over every surface in every building. Vehicles which had been securely closed had dust inside them. There was no option but to begin cleaning again. This preliminary work put us in a good position to get the expedition on the ground as soon as possible after the next wet season.

The expedition

Advance party

Members of the advance party gathered at Boulia on the17th March 2007. We were greeted by the news that there had been heavy rain in the district and that the Donohue Highway west from Boulia was cut. There was also a message from Len Rule, manager at Cravens Peak, that he would meet us in Bedourie and guide us in through the Carlo road. This was a long way around but there was no option. Arriving at Bedourie we met Len and his wife Jo who had the news that Ruth Jones, one of the volunteers, had been bitten by a red-back spider and was airlifted to Mt Isa. She was accompanied by her husband, Howard. Things were not looking good.

We eventually left Bedourie about 4.30pm and headed into a beautiful sunset.

As we progressed it became obvious that there had been more rain in that area since Len and Jo had driven through. The trip became an extremely difficult driving exercise. The night was very dark with heavy cloud, the track was one long stretch of mud which was made more difficult to negotiate by the passage of heavily laden vehicles, some with full trailers. De-bogging vehicles and trailers down to their belly plates in knee deep mud at midnight after along day's driving was not pleasant. One trailer had to be abandoned but was recovered next day just before flood water cut the road. The group eventually reached Cravens Peak at about 2.30am very much in need of a belated St. Patrick's Day celebration.

The area had received very heavy rainfall since Christmas and there were patches of water still lying on the ground. The group set about unloading stores and in view of the changed circumstances, re-prioritising tasks.

The workload completed by this group in the following week was impressive. The kitchen was cleaned and rearranged with and additional stove, refrigerators and freezers installed. The electrical system was checked for safety and improved. The accommodation areas were cleaned and prepared for occupation. Many small repair tasks were completed. Ruth and Howard returned from Mt Isa, thankfully none the worse for their experience. The average age of the volunteer group was 70 years.

In addition to this work follow-up surveys were done on tracks and on the locations for out-stations. The tracks were in good condition with the usually loose sand on the tops of the dunes compacted by the rain. There was still considerable water in the swales, some of which resembled small lakes. These necessitated rough detours. Originally out-stations were planned for 12 Mile Bore in the West, Salty Bore in the central north-west and

Image 1. Getting started, Sue Pullman, Doreen Worth and Keith Hall

Image 2. Between Winton and Boulia, Sue Pullman

Meetuka Waterhole in the far north-west corner of the property. A combination of rain and distance made Meetuka un-workable so an alternative site, recommended by Len Rule was chosen at S Bend on the Mulligan River on the boundary with neighboring 'Glenormiston' station.

With the work of establishing the base area well in hand the establishment of the out-stations began. Salty Bore and S-Bend were set up just before a heavy storm hit the region. Fortunately all personnel were back in camp at the time. This storm was the beginning of a week of wet weather and coincided with the commencement of the research period.

Movement around the area was impossible. Scientists scheduled for an early start, together with more volunteer staff were held up in Boulia. Volunteers who were to leave Cravens Peak had to remain. The base facility, with accommodation, toilet and shower facilities for 12 people was now supporting 25. The septic systems were becoming a problem as the soil would not absorb any more moisture. It was impossible to erect tents as even the large shed had water over the floor.

Image 3. Cravens Peak, on the track

Image 4. Recovery of trailer, day 1. Brian McGrath, John Nowill, Kev Teys, Heather McGrath

As this wet period dragged on and it became obvious that even when the rain stopped it would still be some days before roads and tracks were dry enough to use some of the researchers in Boulia decided to head home. This was understandable as Boulia did not get any rain and valuable time was being wasted.

Despite the difficulties the volunteers kept busy and many small jobs were completed by sloshing through the mud in bare feet.

The research period

Sunday 1st April saw our first ration re-supply get through to Boulia and the arrival of those persons still waiting to come out.

The two out-stations had suffered somewhat with the wet and required considerable work to tidy them up. In the original plan Salty Bore was to be re-supplied with water carted from 12 Mile via an easy track. However, the rain had washed out the jump-up about two km from Salty so a tank had to be installed which was re-supplied from the homestead. S Bend, being located on a stony ridge, was also re-supplied from the homestead. The camp at 12 Mile Bore was established. Each out-station was staffed permanently by two volunteers who maintained the camp and prepared meals. As refrigeration capacity was at a minimum, re-supply was on a three day basis from the homestead camp.

The system, once the routine had been established, worked very well. Supplies which left Mt Isa in the morning were at Cravens Peak that night. The kitchen staff then worked very hard to sort goods into their various bundles while a

Image 5. Cravens Peak: S-Bend set up

Image 6. Racing home to beat the storm

Image 7. Cravens Peak: Salty Bore construction

Image 8. Cravens Peak rain

Image 9. Cravens Peak, after the rain

meal for each out-station was cooked. Next day the re-supply run delivered the rations together with a pre-cooked meal for that night.

In the early weeks the tracks were good following the rain. For the safe navigation of sand-dune tracks a timed one way system was established. With the number of vehicles using the area there was a high risk of vehicles traveling in opposite directions meeting at the top of a dune. As tracks dried out and the sand became softer a different driving technique was required and this risk increased. Proposed movements of researchers were also checked each evening for the next day and, if necessary, these movements were allocated track time. The movements of ration and water re-supply vehicles were also coordinated with research activities. The use of trailers was also banned as some of the dunes were such that they would have prevented the passage of a vehicle and trailer. Trailers stuck in such places would have had to be abandoned.

As with previous expeditions the research teams worked very hard and made good use of their field time. Those working with live animals were busy around the clock. Traps had to be constantly checked, records made quickly and animals released to ensure their survival.

Image 10. Cravens Peak dining room, a full house


Image 11. Cravens Peak: Toilet construction. Gerry Keates and Keith Hall


Image 12. Cravens Peak, a flooded shed, John Nowill and Tony Hillier


Image 13. Cravens Peak B-B-Q Dinner: Gwenda White, Doreen Worth and Col Portley

Image 14. Cravens Peak: Thorny Devil

Some researchers had more success with their findings than did others. But it is just as important to determine what is not in a region as to what is there. The details of the research work undertaken and the results to date form the main body of this report.

In addition to the research work the volunteer group continued with their efforts to improve the facilities. Routine maintenance, from toilet cleaning to structural repairs, continued at the homestead area. Further field water points were improved with repairs to motors and pumps. The bore at Salty was lifted and repaired while a solar system was installed at the homestead. This continued water supply would help make areas of Cravens Peak more readily accessible for future researchers.

Volunteers

As with previous expeditions the Cravens Peak project would not have been possible without the considerable time and effort of Society volunteers. These will be named separately but there are a few who deserve special mention. Kevin Teys, who has been on all six expeditions and Gerry Keates, who as been on five, were, as usual, instrumental in keeping things mechanical and electrical operating efficiently. In addition to their work on the actual expeditions these two members have formed part of the survey and advanced party teams for the expeditions. Their support and advice has been outstanding.

Former Society president, Doreen Worth, again was responsible for rationing and cooking, ably assisted by her daughter, Sue Pullman. Doreen and Sue have shouldered this responsibility on a number of Society ventures and through a combination of their catering skills and bright and happy natures have contributed significantly to developing the pleasant and contented nature of the expeditions.

The smooth operation of the base area was due to the effort and skills of Keith Hall. Though this was Keith's first expedition the type of work was not new to him and he controlled the complex task of coordinating the volunteer effort, ration runs, re-supply and the

Image 15. Cravens Peak: Plum Pudding feature and yards

Image 16. Cravens Peak: Water pooling in swales

Image 17. Cravens Peak: Feral camels

Image 18. Cravens Peak: 12 Mile out station

Image 19. Cravens Peak: Machine repairs, Ocean Bore. Kev Teys and Bruce Urquhart

Image 20. Cravens Peak: Ocean Bore flowing, Gerry Keates, James Hansen and Kev Teys

host of day to day necessities which spring up, with great efficiency. Keith also managed to get out and about including spending a night out with a small group which had a bogged vehicle which had to be abandoned till things dried out. A special mention of thanks to Gwenda White, whose "out-in-the-field" drawings, sketches and paintings enhance the pages in this volume.

References

Readers Digest, 1994 *Atlas of Australia*
http://www.ga.gov.au/map, maps online, Glenormiston, Cravens Peak.

Projects

The projects accepted for study are shown in Table 1 (page 16). Some scientists have done more than one paper. There are sixteen papers published in this volume.

Image 21. Cravens Peak: Sue working on the paving, while David Carstens watches

Image 22. Cravens Peak: Photographing animal skeletons trapped during the drought

Image 23. Cravens Peak: Lifting Salty Bore, Len Rule and Kev Teys

Image 24. Cravens Peak: Blossoms after the wet

Image 25. Cravens Peak: Old well boring machine, Jo Rule with Cameron

Image 26. Cravens Peak: Gathering information, Vanessa Bailey

Image 27. Cravens Peak: Sampling the water quality, Joan Powling

Image 28. Cravens Peak: Dragon

Image 29. Cravens Peak: Gecko and frog

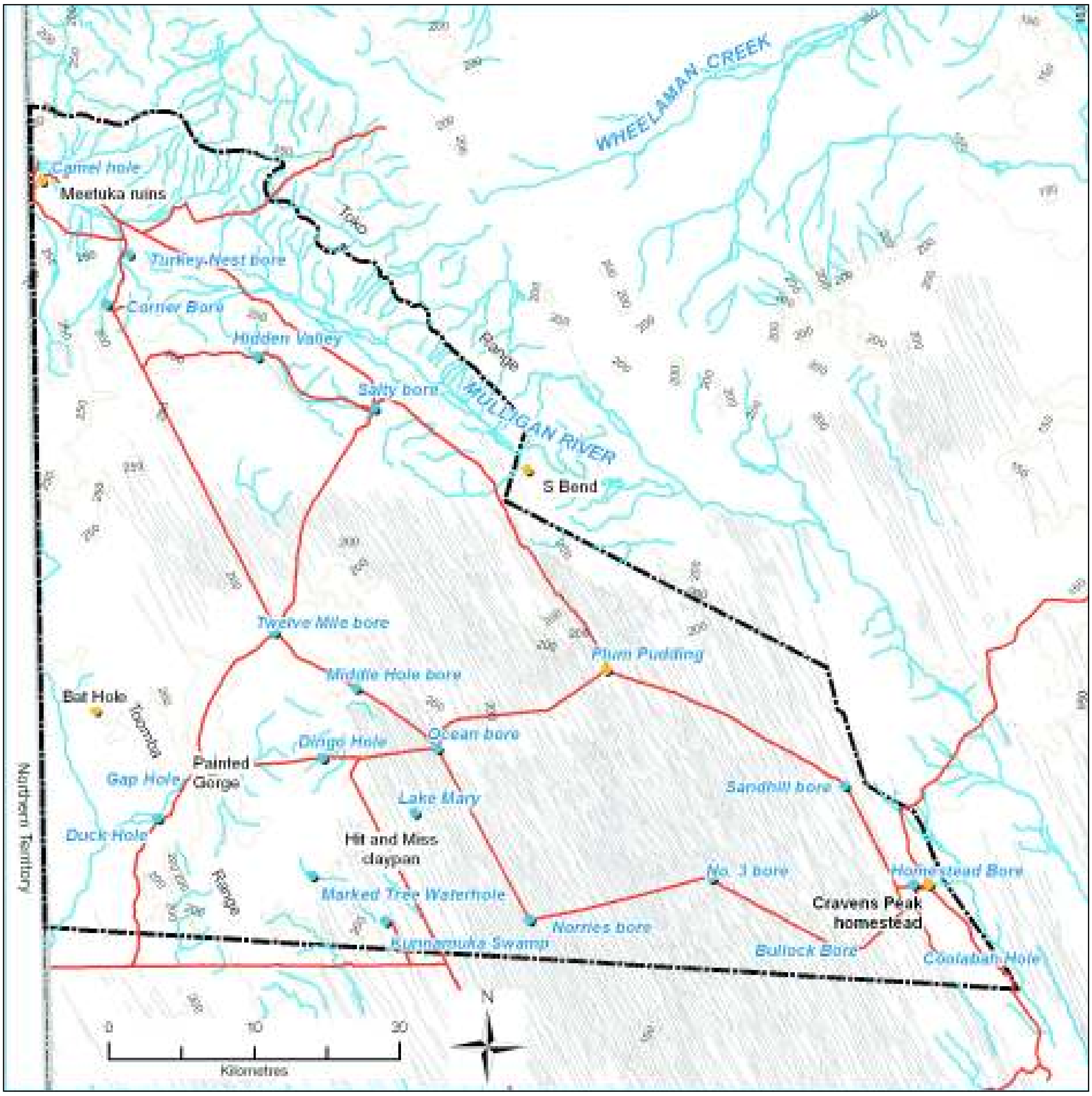
Image 30. Cravens Peak: Happy Hour at camp

Image 31. Cravens Peak: Sunset

Image 32. Cravens Peak: Packed for home

Table 1: Researchers, with their projects, in the Cravens Peak Scientific Study.

Project	Researcher	Institution
Aquatic ecosystem condition of the upper Mulligan River	Vanessa Bailey (Project Leader), Adam Kerezsy and Joan Powling assisted by Mick Brigden, Donald Cook, Angus Emmott and Alan Hoggett	Bio-diversity Planning EPA
Some observations on the temporal activity of nocturnal small vertebrates and large invertebrates in three habitats at Cravens Peak	Dr Dennis Black and Dr Peter Pridmore assisted by Marina Black and Run Hua Pridmore	Department of Environmental Management and Ecology La Trobe University
Botanical survey	Trevor Blake assisted by Beryl Blake	Private Researcher
Moths and Butterflies (Lepidoptera) of the Cravens Peak area	Ted Edwards and Michelle Glover	CSIRO, Entomology Canberra
Cicadas of the eastern segment of the Cravens Peak Reserve	Em. Prof. Tony Ewart	Queensland Museum
Collembolan diversity in different landscape units at Cravens Peak Reserve	Penny Greenslade	Department of Botany and Zoology Australia National University School of Science and Engineering University of Ballarat
A vertebrate fauna survey of Cravens peak, far western Queensland.	Ian Gynther ,Dr Alex Kutt, Harry Hines, Eric Vanderduys	CSIRO, Sustainable Ecosystems
Assemblage pattern in the vertebrate fauna of Cravens Peak Reserve	Dr Alex Kutt (Project Leader), Harry Hines, Ian Gynther and Eric Vanderduys	CSIRO, Sustainable Ecosystems Threatened Species Branch (EPA)
Baseline studies of aquatic and semi-aquatic Hemiptera of Cravens Peak area	Cate Lemann and Tom Weir	CSIRO Entomology, Canberra
Baseline studies of the Beetles (Coleoptera) of Cravens Peak Area	Cate Lemann and Tom Weir	CSIRO Entomology, Canberra
Observations on the biology of the Desert Spadefoot Toad/Frog (Notaden nichollsi) in South Western Queensland	Dr Peter Pridmore and Dr Dennis Black	Department of Environmental Management and Ecology La Trobe University
Biodiversity and biogeography of jumping spiders (Salticidax: Aranaea)	Dr Barry Richardson	Hon Fellow, ANIC CSIRO, Canberra
Vascular plants collected during the Cravens Peak Scientific Study	Megan Thomas and Gerry Turpin	Queensland Herbarium
A Vegetation communities and regional ecosystems survey and mapping of Cravens Peak	Gerry Turpin and Megan Thomas	Queensland Herbarium
Report on the geology of parts of the Cravens Peak area, Georgina Basin	Stuart Watt	Private Researcher
The Birds of the Bush Heritage, Cravens Peak Reserve	Dez Wells (Project Leader), assisted by Eric Anderson, Chris Armstrong, Evan Cleland, Diana O'Connor, Donalda Rogers and Grahame Rogers	Birds Australia South Queensland


WHEELAMAN CREEK
Camel hole
Meetuka ruins
Toko
Turkey-Nest bore
Corner Bore
Hidden Valley
Range
Salty bore
MULLIGAN RIVER
S Bend
Twelve Mile bore
Plum Pudding
Middle Hole bore
Bat Hole
Toomba
Ocean bore
Dingo Hole
Painted
Gorge
Gap Hole
Lake Mary
Sandhill bore
Duck Hole
Hit and Miss
claypan
Northern Territory
Range
No. 3 bore
Homestead Bore
Cravens Peak
homestead
Marked Tree Waterhole
Norries bore
Kurnamuka Swamp
Bullock Bore
Coolabah Hole
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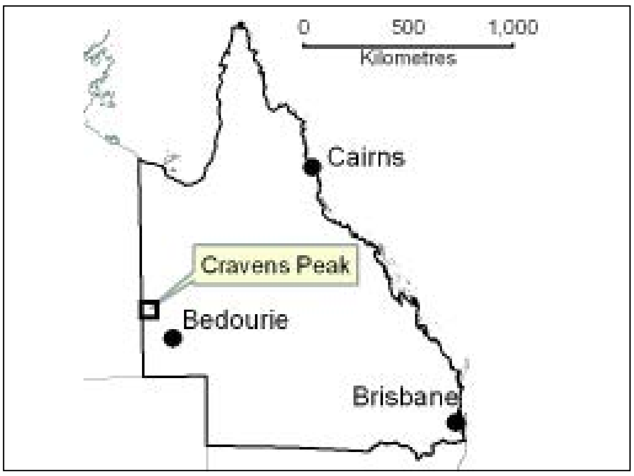
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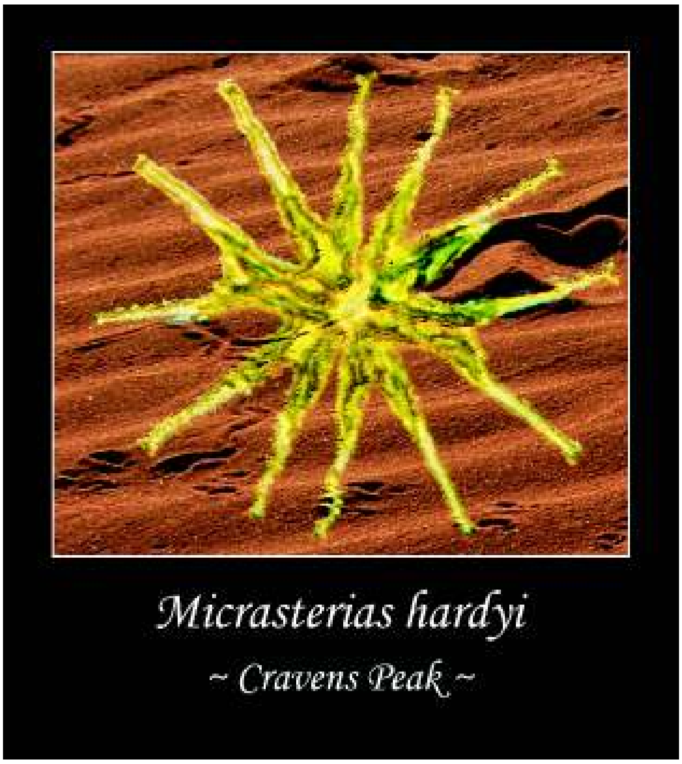
Kilometres
Cairns
Cravens Peak
Bedourie
Brisbane

Abutilon leucopetalum (Desert Chinese Lantern). Gwenda White

Cravens Peak Scientific Study
Aquatic survey April 2007



How to refer to this report

Each section was written by different authors, and should be quoted as such. Written April 2008

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Trip co-coordinator and report compiled by Vanessa Bailey.

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- Vanessa Bailey, Joan Powling, Adam Kereszy, Don Cook, Alun Hoggett, Mick Brigden.
- Queensland Royal Geographic Society for hosting the scientific survey
- Australian Bush Heritage Fund – Cravens Peak property for permitting survey

For logistic support

- the then or previously Queensland Environmental Protection Agency (now called the Department of Environment and Resource Management, DERM)
- Desert Channels Queensland
- Queensland Herbarium – confirmation of some plant identifications.

The study was greatly enhanced by the following people's expertise in taxonomy and they have been rewarded by the extension of the range for some of their plants and animals.

- Joan Powling, Consulting Freshwater Biologist, PO Box 235, Ivanhoe, Victoria 3079
- Dr Wendy Williams Rangeland Ecologist, The University of Queensland, Gatton, QLD 4343 (cyanobacteria and lichens)
- Dr David Eldridge Department of Environment and Climate Change, c/- School of Biological, Earth and Environmental Sciences, University of NSW, Sydney, 2052 (cyanobacteria and lichens)
- Dr Michelle Casanova, Wetlands Consultant, Lake Bolac (charophytes).
- Dr Russell Shiel, University of Adelaide (microfauna and zooplankton)
- Dr Brian Timms, Australian Museum, Sydney (branchiopod crustaceans)
- Dr Chris Watts, South Australian Museum (aquatic beetles)
- Cover Photograph: A. Hoggett & J. Powling, Digital Enhancement: J. Fitzherbert.

Arid zone aquatic ecosystems at Cravens Peak, in far western Queensland

Abstract In April 2007 a survey was undertaken to assess the condition of arid zone aquatic ecosystems at Cravens Peak, in far western Queensland. The Australian Bush Heritage property had good rain prior to the survey so that a range of ephemeral wetlands could be sampled. Parameters measured included water quality, riparian vegetation, algae, charophytes, zooplankton and microfauna, macro-invertebrates, and fish species. (Terrestrial biological crusts were surveyed as incidental records). Data collected can provide a snapshot baseline inventory for monitoring future change. Overall the variable environmental conditions at each site meant that a diverse range of species was collected. The degree of diversity, in all the groups of organisms observed in the Cravens Peak arid zone wetlands, was significant with several range extensions recorded for different groups eg charophytes, algae, macro-invertebrtes and lichens. No exotics were detected in all but one of the groups examined. Only two exotic plant species were recorded at one of the wetlands sites (S Bend), which was on the northern boundary of Cravens Peak and Glenormiston. The maintenance of ecological water flows to drive these 'boom' and 'bust' swamp, wetland and creek habitats is an important consideration for any future management plans.

Bailey, Vanessa

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Introduction

Cravens Peak, a 233,000 ha reserve, owned by Australian Bush Heritage Fund, is located on the border of the Northern Territory and far western Queensland. It is north of the Simpson Desert National Park, and adjoins Ethabuka (another Bush Heritage property). Situated approximately 135km south west of Boulia, it is remote and access is via a dirt road. The property has diverse range of landtypes from dunefields, swales, clay soil and gidgee communities to jump-up gorge country on the northern end. It is part of the Channel Country Bioregion –The Conservation Status of Queensland's Bioregionals Ecosystems. (The IBRA classification includes the Simpson-Strezlecki Dunefields Bioregion as being present on this property).

The southern part of Cravens Peak has expanses of red sand dune fields, swales and clay pans that can harbour ephemeral wetlands, which provide a significant refuge when inundated. The northern part consists of jump-up country with the Toomba and Toko Ranges and their spectacular landforms adjoining the sand dune landscapes, including rocky gorges, escarpments, mesas and gibber plains.

Site Descriptions

A range of natural aquatic ephemeral sites, from small dune swales and lakes to a riverine gorge, could be studied due to the opportunity of the recent rains, which followed an unusually wet summer for the region. Sampling was undertaken from mid to late April 2007. One of these natural sites, the Coolabah gidgee swamp (M2) had some augmentation due to man-made excavation to retain water longer. See site photos in Figures 1 to 9 from pages 25 to 29.

At S bend gorge a small, isolated off-channel rock pool (Site M6b, Figure 8, page 28) was sampled for algae and zooplankton/microfauna. Site M6 and/or M6a refers to the main channel surveyed at S Bend. (See Figures 8 and 9, on pages 28 and 29 respectively).

A site, not discussed in the macro-invertebrates, zooplankton/microfauna, or algae sections, is Ocean Bore due to its being a completely artificial site. It was sampled for fish but none were captured. The focus of our study was on natural aquatic systems.

Table 1. Site locations for Cravens Peak Aquatic Survey

Site ID	Site Name	Date visited	Latitude	Longitude
M1	Nardoo swamp	16/04/2007	-23.30398	138.55831
M2	Coolabah gidgee swamp	16/04/2007	-23.36799	138.59820
M3	Nardoo sundew canegrass swamp	16/04/2007	-23.28942	138.55125
M4	Little Lake Kunnamuka	18/04/2007	-23.33690	138.25147
M5	Big Lake Kunnamuka	19/04/2007	-23.34224	138.23107
M6	S Bend	20/04/2007	-23.06279	138.35293

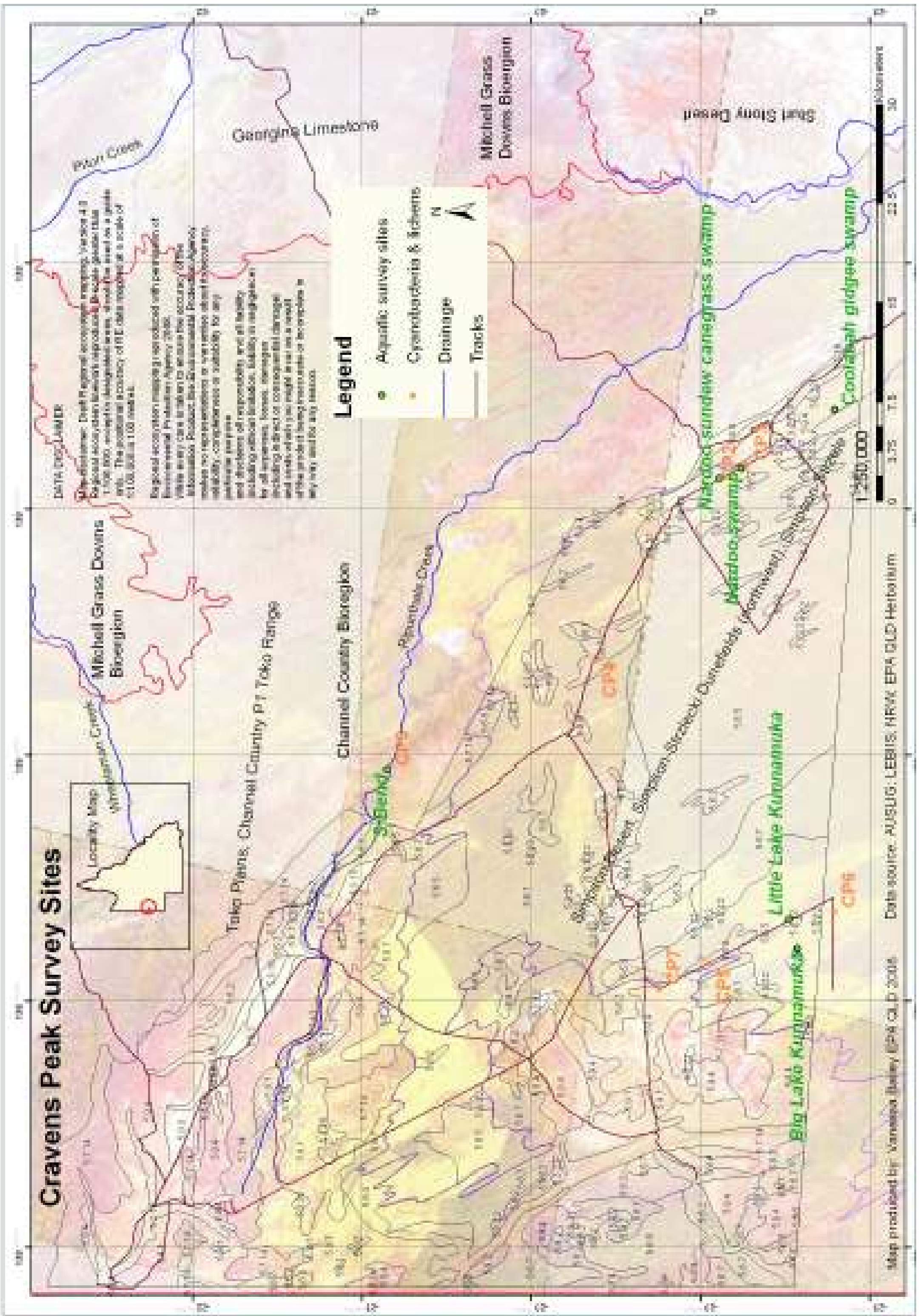
Map 1 (page 23) shows the named locations of the aquatic survey sites (marked in green), and the collections sites for the terrestrial cyanobacteria, and lichen samples (marked in orange as CP1- 8), on a satellite image. (CP1 is so close to sites CP2 & CP3 that the label does not show up due to label conflicts at this scale.) Map 2 (page 24) has all of the above locations but overlaid on a topographic image.

On both Map 1 (page 23) and Map 2 (page 24), Draft Regional ecosystems are marked in black outline with the unique vegetation code eg 5.3.22. The detailed key description for these vegetation codes and their status can be looked up on the Environmental Protection Agency (EPA) website: http://www.derm.qld.gov.au.

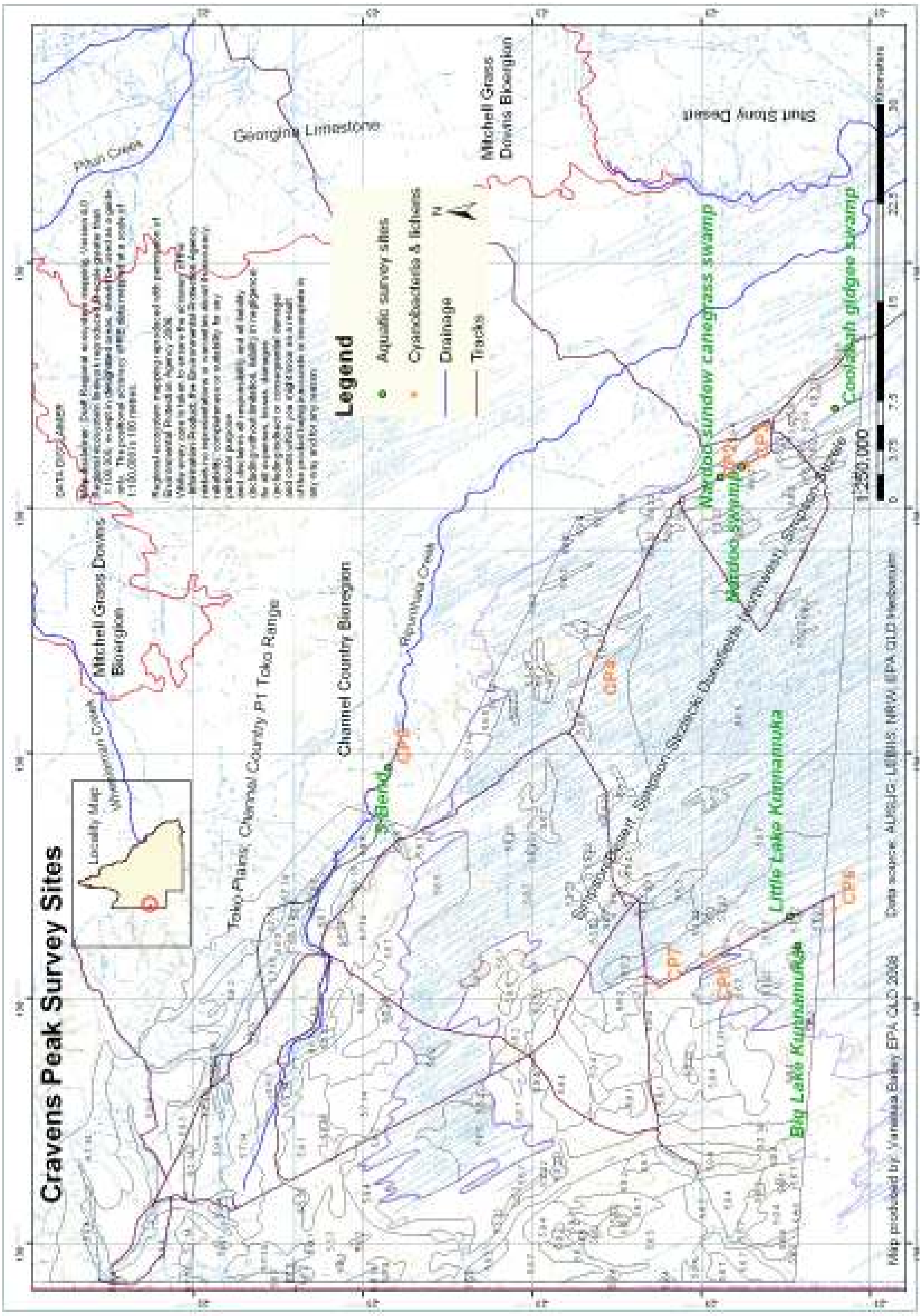
Individual reports

Various surveys were conducted as part of the general aquatic survey. They refer to site locations in Table 1 (page 22) and on Maps 1 and 2, pages 23 and 24 respectively, mentioned above.

These papers follow:



Cravens Peak Survey Site, Map 1



Cravens Peak Survey Site, Map 2

Figure 1. Site M1 - Nardoo swamp. Photo: V Bailey

Figure 2. Nardoo at site M1. Photo by A. Hoggett

Figure 3. Site M2 Coolabah gidgee swamp. Photo: V Bailey

Figure 4. Site M3 – Nardoo, Sundew. Photo: J Powling

Figure 5. Site M4 – Little Lake Kunnamuka. Photo: V Bailey

Figure 6. Site M5 – Big Lake Kunnamuka. Photo: V Bailey

Figure 7. Ocean bore, artificial site (fish sampling was done here). Photo: J Powling

Figure 8. S Bend site M6b. Photo : A. Hoggett

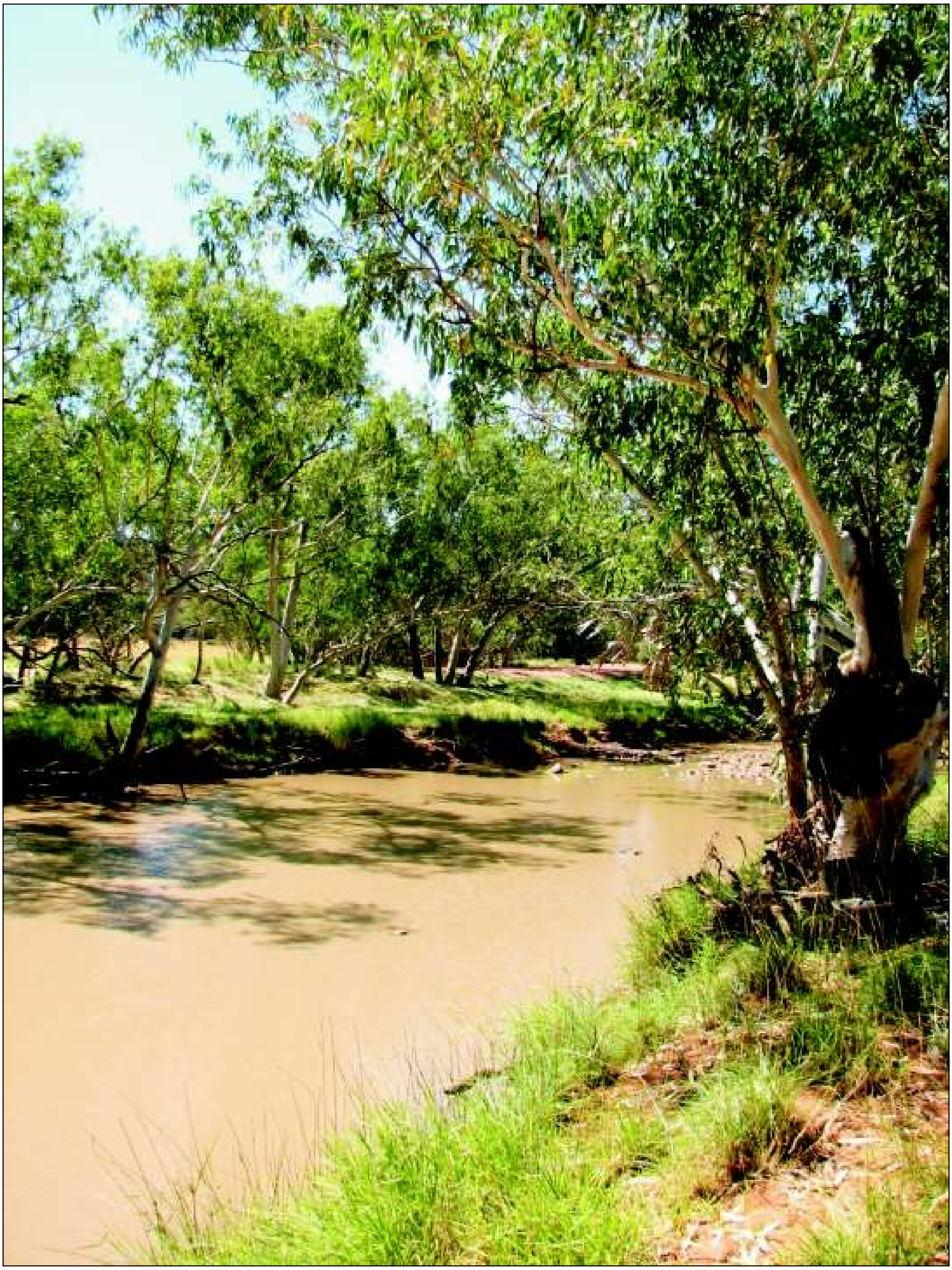


Figure 9. S Bend site M6a. Photo: V. Bailey

Report on Water Quality

Bailey, Vanessa

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Sample methods

At each site, the dominant microhabitat (vegetation and substrate type) was selected and on-site physico-chemical samples were recorded. Water quality sampling was done first to avoid contaminating the site area with disturbance from macro-invertebrate or other sampling. The composition of the bottom substrate was recorded afterwards, for example mud, sand, silt and sticks.

Primary physico-chemical measurements of electrical conductivity (EC µs/cm), pH, temperature (°C) and dissolved oxygen (mg/L) were made using calibrated WTW meters, and a secchi disc was used to estimate the turbidity or clarity of the water.

Water quality results were utilized in other sections of this study – charophytes, algae, zooplankton, microfauna, macro-invertebrates and fish.

Results and discussion

Conductivity was extremely low, as the natural sites were only recently rain-filled—all sites were fresh and under 100 µs/cm. (see Appendix 1, page 31).

The trend of water quality at Cravens Peak is in line with results from other sampling in the Lake Eyre Catchment. (Bailey 2001).

Temperature levels reflect the depths of individual sites, with the transient shallower lakes and soaks having the highest temperatures. The more permanent waterbodies (though still classed as semi-permanent as they dry out) have cooler temperatures as they are deeper.

The trend in many waterbodies, is that higher temperatures mean less capacity for dissolved oxygen in the water. However, in the warm, shallow, productive sites (M1, M2, M3, and M4), where there is increased algal activity and photosynthesis, high dissolved oxygen levels were recorded and peak in mid-afternoon. Where there is high algal activity dissolved oxygen levels can crash overnight as plants switch from producing oxygen to releasing carbon dioxide. (Measurements early in the morning will often show very low dissolved oxygen).

S Bend main channel (site M6 or M6a) had the lowest dissolved oxygen reading but this is in line with other measurements from waterholes in the Lake Eyre Catchment and is considered within healthy limits. This reading, taken at 1300 (1 pm) when algal activity and thus dissolved oxygen levels start to peak, actually indicates there is less algal activity compared to the shallower sites. From this we can conclude that dissolved oxygen would be more stable overnight, supporting the healthy fish population that was recorded in the survey. (see Fish section, page 70).

High turbidity affects light penetration and influences waterbody heating, by trapping sunlight in the top water layers, and assisting to stratify quite shallow waterholes. The natural colloidal clays are so fine that waterholes rarely settle out to become clear. Natural waterholes that become clear often have deposits of kopi (a naturally occurring form of gypsum rock). Other waterholes can become clear, once disconnected from floodwaters, as they have spring fed seepage and higher salinities.

The pH is naturally alkaline/basic within these river systems (Bailey 2001). All sites supported this trend. Deeper sites were either close to a neutral pH of 7, reflecting their rain-filled origin, and recent inundation. Shallower sites when they dry out become more concentrated. Some shallow sites measured were above pH 9 but were within expected alkaline ranges for these types and depths of wetlands.

These water quality results overall reflect and support the vast amount of reproduction observed in the algae, zooplankton, microfauna, and macro-invertebrate samples at these sites (M1 to M5), and the associated waterbird species feeding on this bounty. S Bend is a healthy riverine channel and supports a different range of aquatic species (including fish).

Recommendations

Water quality sampling in this case is spot sampling, and is expected to vary accordingly from year to year given the unpredictable and variable nature of the arid river systems. The idea is to capture a baseline at the individual sites and then look at the overall trends. Further monitoring that encompasses the other parameters examined in this aquatic survey (algae, macro-invertebrates etc) should be included as part of continuously assessing the overall aquatic system health, and its management requirements. To best capture the situation, monitoring should include a range of types of wetlands and allow for seasonal differences from being freshly inundated to when they are drying out.

References

Bailey, V. (2001). Western Streams Water Quality Monitoring Project. Qld Dept of Natural Resources and Mines, Brisbane.

Appendix 1. Cravens Peak Water Quality Results – Bailey (April 2007)

	M1	M2	M3	M4	M5	M6a	M6b
Site name	Nardoo swamp	Coolabah gidgee fridged swamp	Nardoo, sundew, canegrass swamp	Little Lake Kunnamuka	Big Lake Kunnamuka	S Bend – river channel	S Bend – off channel rock hole
GPS	-23.30398 138.55831	-23.36799 138.59820	-23.28942 138.55125	-23.33690 138.25147	-23.34224 138.23107	-23.06279 138.35293	not recorded
Date and time	16.04.2007 11.45	16.04.2007 16.30	16.04.2007 18.50	18.04.2007 11.00	19.04.2007 09.30	20.4.2007 13.00	not recorded
Site description	swale wetland (wet soak on vehicle track)	swale wetland artificially deepened	swale wetland	swale wetland	swale wetland	Rock gorge	off-river stranded pool
Microhabitat type	nardoo, joyweed, sesbania	joyweed, nardoo	Nardoo, sundew, canegrass	charophytes, lignum, coolibah, wattle	charophytes, lignum, coolibah, wattle	river red gum, silky brown top	river red gums, red mulga
Bottom	mud>clay	Mud> clay/ roots> stick litter/ sand	Sand> mud> stick litter/clay	Mud> sand> roots/clay	Mud> sand> stick, root,leaf litter/clay	Mud> clay> sand (loose rocks)	mud, sand and stones
Depth (m)	0.2	approx. 1m	0.6	0.1 edge (0.4m middle)	1.5	1	0.2
Bank slope (1-5)	flat	flat	flat	shallow/flat	1 (shallow)	acute	0.4
Sample depth (m)	0.2	0.2	0.3	0.2	0.5	0.5	not measured
Secchi disc (cm)	too shallow	6-8	4	6.5	14	10	not measured
Temp at 0.2m (°C)	27.0	31	28.5	26	23.3	23.8	not measured
Dissolved oxygen (mg/L)	8.3	12.4	9.3	9.1	7.6	4.8	not measured
Conductivity (µS/cm)	23	63	33.8	53	29.6	86	not measured
pH	6.9	9.4	9.0	7.5	7.4	7.4	nil
Current	nil	nil	nil	nil	nil	nil	calm
Wave action (1-5)	1	2 (0.2 ripples)	1	1	calm	2 (0.2)	20
Fetch (m)	100	100-150	approx. 200	approx. 2.5km	approx. 5km (?)	several km	1
Wind speed (1-4)	2	2	1	2	2	2	1
Sun (1-3)	1	1	1	1	1	1	

Cravens Peak Birds

Bailey, Vanessa[1] and Cook, Don[2]

[1]Principal Biodiversity Planning Officer, Environmental Protection Agency (now DERM), PO Box 202 Longreach Qld 4730
[2]at time of survey – Snr Principal Biodiversity Planning Officer, Environmental Protection Agency, Rockhampton

Sample methods

A list of birds at each wetland site was compiled. The sampling method included a walking survey along the fringes of the riparian area. The larger sites (Kunnamuka swamps, S Bend) were more comprehensively surveyed during the evening due to arrival time on site. Additional incidental records from throughout the day and following morning were included. (see Appendix 1, page 33).

Incidental records for birds and fauna have been included in separate tables as present on Cravens Peak (see Appendix 1, page 33, Appendix 2, page 34, and Figures 10 to 14 between pages 35 and 37).

Results and discussion

The presence of temporary water in the rain-filled dune swales, along with the riparian vegetation boom, and associated breeding of microfauna which feed the system, meant that a range of waterbirds were present eg glossy ibis were enjoying the bounty at site M1, nardoo swamp.

The most notable waterbird were the freckled ducks (*Stictonetta naevosa*), classed as rare under the Qld Nature Conservation Act (NCA) and recorded at Little Lake Kunnamuka (M4). (Within NSW it has a conservation status of vulnerable).

This swamp was much shallower than Big Kunnamuka (M5), and had freckled ducks prime habitat of lignum, preferred water depth and food such as algae, seeds and vegetative parts of aquatic grasses and sedges and small invertebrates. Breeding can occur anytime after suitable rains (variously given as March-April in Qld, June-September and October-February); with 5–14 eggs/clutch (usually 5–7) laid in screened, deep bowl-shaped nest up to 1m above water in edge of lignum well out from shore in swamp. (EPA WILDNET database 2008).

Known threats for this species are the destruction of its habitat, especially ephemeral breeding sites and drought refugia, through burning; drainage of wetlands for agriculture/ grazing and trampling by stock; and in more coastal areas, reduced water availability due to irrigation demands and illegal shooting. Feral animals such as pigs would also be a threat.

Recommendations for waterbird species include:

- the retention of protection of the seasonal wetlands and the natural composition and density of riparian and wetland vegetation (including weed monitoring and control)
- not implementing burning as a tool for lignum and river coobah/belalie vegetation control
- reduction of grazing pressure and trampling from stock and control of feral animals (pigs & camels)
- maintenance of ecological water flows to swamp, wetland and creek habitats
- monitoring of populations on refuge wetlands (especially in context of drought and climate change)

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EPA WILDNET database

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Appendix 1. Cravens Peak Bird Species List (Aquatic Survey) – Bailey & Cook (April 2007)

Common name	Bird species name	Site M1 Nardoo swamp	Site M2 Coolabah gidgee swamp	Site M3 Nardoo swamp	Site M4 Little Lake Kunnamuka	Site M5 Big Lake Kunnamuka	Site M6 S bend
Straw-necked ibis	*Threskiornis spinicollis*	x	x				
Glossy ibis	*Plegadis falcinellus*		x				
Bourke's parrot	*Neopsephotus bourkii*				x		
Quarrion / cockatiel	*Nymphicus hollandicus*	x	x	x	x	x	x
Budgerigar	*Melopsittacus undulatus*	x	x	x	x	x	x
Galah	*Eolophus roseicapillus*	x	x	x	x	x	x
Little corella	*Cacatua sanguinea*					x	x
Yellow-billed spoonbill	*Platalea flavipes*				x	x	
Freckled duck	*Stictonetta naevosa*				x		
Plumed whistling-duck	*Dendrocygna eytoni*		x				
Australian wood duck	*Chenonetta jubata*					x	
Hardhead / white-eyed duck	*Aythya australis*				x	x	
Pacific black duck	*Anas superciliosa*					x	
Hoary-headed grebe	*Poliocephalus poliocephalus*		x				
Australasian grebe	*Tachybaptus novaehollandiae*		x				
Grebe spp					x	x	
Pacific heron / white- face or white-necked heron	*Ardea pacifica*		x		x	x	
Nankeen night heron	*Nycticorax caledonicus*					x	x
Brown goshawk	*Accipiter fasciatus*						x
Spotted harrier	*Circus assimilis*		x			x	
Black kite	*Milvus migrans*	x	x	x	x	x	x
Whistling kite	*Haliastur sphenurus*	x					
Brown falcon	*Falco berigora*	x	x	x	x	x	x
Australian hobby/ Little Falcon	*Falco longipennis*				x	x	
Australian kestrel / nankeen kestrel	*Falco cenchroides*				x	x	
Brolga	*Grus rubicunda*				x		
Emu	*Dromaius novaehollandiae*		x		x	x	
Quail spp / little button-quail	*Turnix velox*					x	x
Black-faced cuckoo-shrike	*Coracina novaehollandiae*						x
Banded plover	*Charadrius bicinctus*				x	x	
Whiskered tern	*Chlidonias hybrida*				x	x	
Black-winged stilt	*Himantopus himantopus*		x				
Red-necked avocet	*Recurvirostra novaehollandiae*				x		
Crested pigeon	*Ocyphaps lophotes*	x	x	x	x	x	x
Diamond dove	*Geopelia cuneata*	x	x	x	x	x	x
Peaceful dove	*Geopelia striata*					x	x
Sacred kingfisher	*Todiramphus sanctus*						x

Continues on following page

continued from previous page

Common name	Bird species name	Site M1 Nardoo swamp	Site M2 Coolabah gidgee swamp	Site M3 Nardoo swamp	Site M4 Little Lake Kunnamuka	Site M5 Big Lake Kunnamuka	Site M6 S bend
Rainbow bee eater	*Merops ornatus*						x
White-plumed honeyeater	*Lichenostomus penicillatus*						x
Willie wagtail	*Rhipidura leucophrys*					x	x
Magpie-lark/mud lark/pee wee	*Grallina cyanoleuca*						x
Zebra finch	*Taeniopygia guttata*	x	x	x	x	x	x
Spiny-cheeked honeyeater	*Acanthagenys rufogularis*						x
Mistletoebird	*Dicaeum hirundinaceum*						x
Yellow-throated miner	*Manorina flavigula*				x	x	x
Red-winged parrot	*Aprosmictus erythropterus*						x

Bird incidental records

Common name	Bird species name	Site
Australian grey teal duck	*Anas gracilis*	Duck dam & Ocean bore
Owl spp		Scree above S bend
Brown falcon	*Falco berigora*	Duck dam
Australian bustard /plains turkey	*Ardeotis australis*	Dingo hole & Ocean bore Rd
Brown songlark	*Cincloramphus cruralis*	House dam
Crimson chat	*Epthianura tricolor*	Plum pudding & Ocean bore
Magpie-lark/mud lark/pee wee	*Grallina cyanoleuca*	Duck dam

Appendix 2. Cravens Peak fauna, amphibian and reptile incidental records – Bailey (April 2007)

Common name	Species name	Site	GPS
Sand goanna/Gould's goanna	*Varanus gouldii flavirufus*	CP1 – cyanobacteria collection On road to Nardoo swamp	-23.30639 138.55856
Desert spadefoot toad	*Notaden nichollsi*	At homestead Little Kunnamuka Big Kunnamuka	-23.33694 138.25149 -23.34225 138.23107
Perentie	*Varanus giganteus*	Gap hole	-23.24670 138.10056
Thorny devil	*Moloch horridus*	in Dunes on road to S bend and Salty	-23.12342 138.33385
Central bearded dragon	*Pogona vitticeps*	Scree on top of S bend Little Kunnamuka Big Kunnamuka	-23.33694 138.25149 -23.34225 138.23107
Central netted dragon	*Ctenophorus nuchalis*	All sites	
Ingram's brown snake	*Pseudonaja ingrami*	Rd near Glenormiston (specimen confirmed by Qld Museum)	-22.95439 138.84220

Figure 10. Brown Falcon (*Falco berigora*). Photo: V Bailey

Figure 11. Zebra Finch (*Taeniopygia guttata*). Photo: V Bailey

Figure 12. Central bearded dragon (*Pogona vitticeps*). Photo: A Hoggett

Figure 13. Desert spadefoot toad (*Notaden nichollsi*). Photo: V Bailey

Figure 14. Thorny Devil (*Moloch horridus*). Photo: V Bailey

Cravens Peak Plants

Bailey, Vanessa

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Plant sampling methods

At each site the dominant vegetation type was noted and general riparian plants were listed. (See Appendix 1: Cravens Peak Plants, page 39.)

Riparian vegetation was recorded along the microhabitat stretch adjacent to where the macro-invertebrates, zooplankton and algae were sampled.

Plants and insects interactions – Little Lake Kunnamuka, Cravens Peak

Sundews

A Sundew is an annual herb that is a carnivorous plant (sometimes called insectivorous plant). It occurs on swampy areas, after rain. (See Figure 16, page 40.)

"Sundews lure, capture, and digest insects using stalks with tentacles on their leaf surface." The stalks are covered with a thick gluey substance composed of sugar residues. Insects are captured by the sundew to supplement its poor mineral nutrition from the soil. Various native species, differing greatly in size and form, can be found on every continent except Antartica. (Source Wikipedia; & QLD Environmental Protection Agency, WILDNET).

Eventually, through exhaustion or lack of oxygen, the insect which has been caught on the sundew, dies usually within a quarter of an hour. The nutrient soup is then absorbed through the leaf surface and can then be used to help fuel plant growth.

Eggfly Butterflies

"Eggfly butterflies are known for maternal care, with the females guarding leaves where eggs have been laid. Males are very territorial. The female hovers over a plant to check for ants which will eat her eggs. After selecting a plant without ants, she lays at least one but often two to five eggs on the undersides of the leaves." (See Figure 15, page 40.)

For more information:

•Plant: http://en.wikipedia.org/wiki/Sundew
•butterfly: http://en.wikipedia.org/wiki/Hypolimnas_bolina#Race_bolina

Discussion and recommendations

Queensland Herbarium is undertaking a review and is updating the draft Regional Ecosystem mapping that covers Cravens Peak.

A more comprehensive plant survey for terrestrial plant species was undertaken concurrently during April 2007 by a separate Queensland Herbarium field team, and is being provided separate to this document.

Recommendations for plant species include:

- further aquatic plant sampling and identification
- the retention of protection of the seasonal wetlands and the natural composition and density of riparian and wetland vegetation (including weed monitoring and control)
- not implementing burning as a tool for lignum and river coobah/belalie vegetation control
- reduction of grazing pressure and trampling from stock and control of feral animals (pigs)

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Queensland Environmental Protection Agency WILDNET database

Queensland Environmental Protection Agency – Queensland Herbarium – plant identification section

Wikipedia http://en.wikipedia.org

Appendix 1. Cravens Peak Plants – Bailey (April 2007)

Common name	Plant species name	Site M1 Nardoo swamp	Site M2 Coolabah gidgee swamp	Site M3 Nardoo sundew canegrass swamp	Site M4 Little Lake Kunnamuka	Site M5 Big Lake Kunnamuka	Site M6 S bend
Sundew	*Drascera indica*			x	x	x	
Blue bells	*Wahlenbergia* spp				x		
Nardoo	*Marsilea drummondii*	x	x	x	x	x	
Sandhill canegrass	*Zygochloa paradoxa*						
Daisy	*Brachyscome cilians*				x	x	
	Sporobolus sp				x		
Sedge	*Cyperus* sp		x		x	x	
Desert spurge	*Euphorbia tannensis*				x		
Poison morning glory	*Ipomoea muelleri*				x		x
Goodenia	*Goodenia* sp				x	x	
	Euphorbia sp				x		
Grey germander	*Teucrium racemosum*				x		
Simpson desert	*Eremophila macdonnellii*				x		
	Ptilotus polystachyus						
Saltbush	*Atriplex*						
Gidgee / gidyea	*Acacia georginae*	x	x				
Three awned wanderrie	*Eriachne aristidea*				x		
Sand indigo	*Indigofera psanmophila*				x		
Coolabah	*Eucalyptus coolabah*	x	x	x	x	x	
Desert oak	*Acacia coriacea* subsp. *Sericophylla* (Qld Herb confirming)				x	x	
Mulga	*Acacia aneura*					x	
	Tephrosea rosea						
Lignum	*Muehlenbeckia florulenta*				x	x	
Spinifex	*Triodia* sp			x	x		
Poached egg daisy	*Polycalymma stuartii*				x		
Joyweed	*Alternanthera nodiflora*	x	x			x	
Pea	*Sesbania*	x					
Mineritchie	*Acacia cyperophylla*						x
Wild tobacco	*Nicotiana megalosiphon*						x
Button grass	*Eremophila bowmanii*						x
Wiregrass	*Aristida* spp						x
River red gum	*Eucalyptus camaldulensis*						x
Limestone cassia	*Senna artemisioides* subsp. *oligophylla*						x
Silver cassia	*Senna artemisioides* subsp. *artemisioides*						x
Paddy melon	*Citrullus colocynthis*						x
Buffel grass	*Cenchrus ciliaris*						x
Chinese lantern	*Abutilon auritum*						x
Tick weed	*Cleome viscosa*						x
Silky brown top	*Eulalia aurea*						x
Grasses	*Chloris* spp						x

Figure 15. Eggfly Butterfly, female on the left and male on the right, caught on Sundew. Photo: V. Bailey

Figure 16. Carnivorous plant, Sundew. Photo: V. Bailey

Cravens Peak Charophytes

Casanova, Michelle[1] and Powling, Joan[2]

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Identified by Michelle Casanova

Introduction

Charophytes are large submerged green algae which occur in the shallow regions of lakes and wetlands. They are attached to the bottom by root-like organs and hence might appear at first glance to be flowering aquatic plants. Closer inspection reveals a glassy, almost translucent appearance and a distinctive arrangement of branchlets and orange or black reproductive organs. They are an important source of food for water birds and, in deeper water bodies, provide shelter for young fish. Epiphytic algae are often found on their branchlets, providing a further food source for grazing invertebrates such as protozoans, snails and small crustaceans.

Until the work by John Porter in the Paroo (Porter 2007) charophytes were rarely recorded from arid-zone wetlands. Two prior records exist: *Nitella tumida* and *N. partita* (Nordstedt 1891). It is likely that the opportunities for collecting charophytes have been limited (requiring collections when wetlands were wet and often inaccessible), and few people have had the time or skills to recognise or collect them. The Pilbara is the only other region outside eastern and south-western Australia where an extensive collection of charophytes has been made (Dept. of Environment & Conservation, WA). Charophytes are well adapted to temporary conditions. They possess thick-walled, desiccation resistant zygotes (called oospores) that allow them to persist in the seed bank of wetlands. The oospores are stimulated to germinate when the wetlands are inundated by rainfall or flood. Species can be identified on the basis of oospores alone (Casanova 2007, 2009), which is what has been done here.

Sample methods

Three samples were collected at Sites M4 and M5. Live plants were dug up, carefully washed and placed in a small plastic zip bag with just enough water to keep the specimen moist, then stored in a refrigerated box. A further sample was carefully washed in a shallow dish of clean water, mounted on a labelled white card, covered with greaseproof paper and pressed along with the other plant specimens. A third sample, of approximately 500 g of moist surface substrate (seed bank), was collected in the vicinity of the living plants, thoroughly dried out in the sun, then stored in plastic zip bags for later germination and identification of plants. Soil was not collected from Site M3 (see below, page 41).

Results and discussion

Charophytes were observed in situ at two sites sampled on Cravens Peak, Little Kunnamuka Swamp (Site M4) and Big Kunnamuka Swamp (Site M5). At both sites the charophytes were observed to be partially emergent in a discrete band in very shallow water around the shoreline (see Figure 17, page 42, Figure 18, page 42, and Appendix 1, page 43). Later examination of the algal trawls revealed a very small, delicate charophyte in the sample from the Nardoo/Sundew/Canegrass Swamp (Site M3). Collections at this site had taken place almost on dusk and the tiny plants were not observed during sampling.

Results of the seed bank rewetting trials indicate that the oospores of these species do not germinate in the first wetting period. The following identifications are therefore based on gross morphology and microscopic examination of the plants.

Site M3: Nardoo/Sundew/ Canegrass Swamp

The tiny fragment of charophyte accidentally found in the phytoplankton trawl has been identified as *Nitella* sp. aff. *sonderi*. It was identified as male (antheridia only) and described as dioecious, homeoclemous, bicellulate, 2-3 furcate with no mucus and no heads. There were 6 branchlets in a whorl. It is different to the *Nitella* sp. collected in the field at Site M5.

There are a number of species which appear to be related to *N. sonderi* and more taxonomic work is required on this group (Casanova,

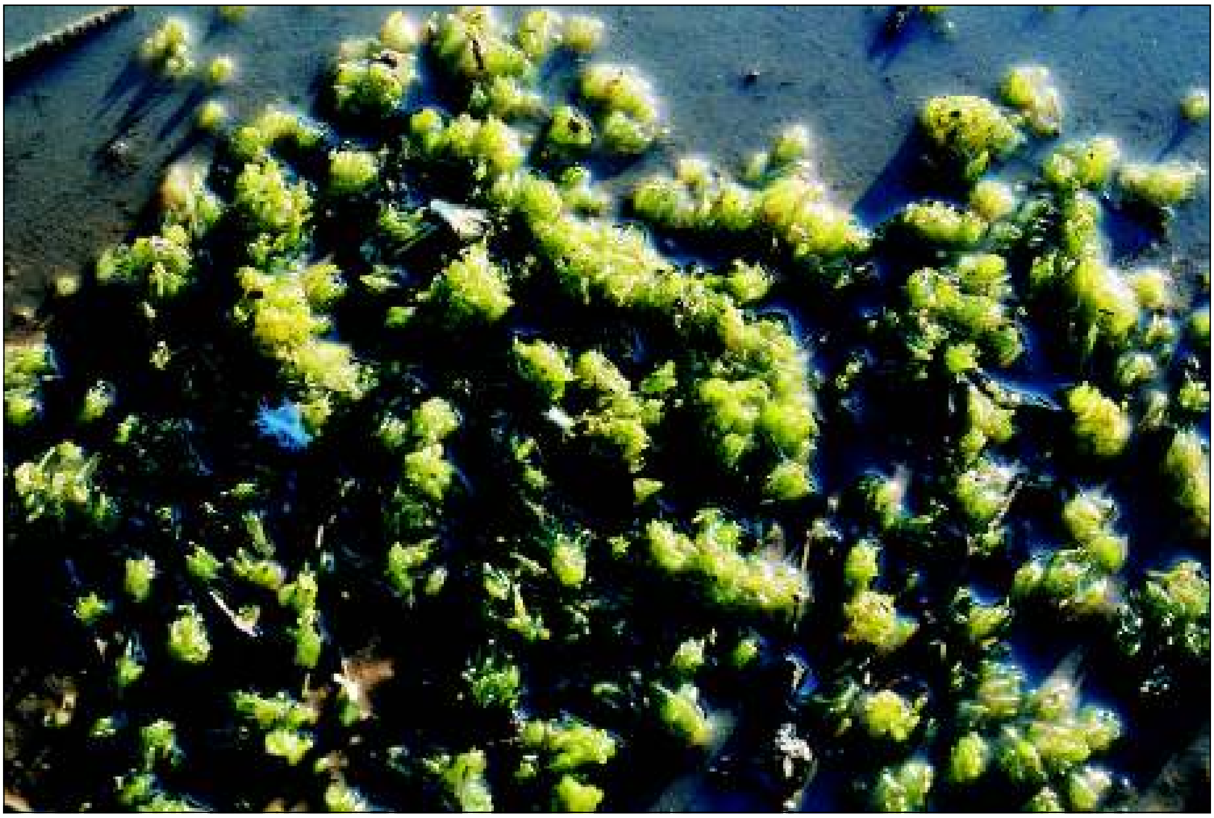

Figure 17. Charophytes at Little Lake Kunnamuka, Site M4. Photo: J. Powling

Figure 18. Charophytes at Little Lake Kunnamuka, Site M4. Photo: J. Powling

2007). If this plant is related, then this find places it at the northern extremity of its known range (Casanova, pers. comm.).

Site M4: Little Kunnamuka Swamp

The charophyte was identified as *Chara* sp. aff. *simplicissima*, also related to *Chara australis*. It is dioecious, has no cortex and the monopodial branchlets have distinctive single, inflated terminal cells (see Figure 19, page 44). The oospore has thick ridges instead of flanges, similar to the oospores illustrated in Caasnova (2005; fig. 9). Inflated branchlet segments are thought to be an adaptation to fluctuating salinity. They are frequently found in the genus *Lamprothamnium*.

This species has been collected previously in the Paroo Region by John Porter, University of New South Wales (pers. comm.) and appears to be restricted to permanent and temporary wetlands of the arid region of Australia.

Site M5: Big Kunnamuka Swamp

The charophyte was identified as *Nitella* sp. It appears to be related to the *Nitella pseudoflabellata* complex, which is closely related to *N. sonderi*. The oospores are similar to those of *N. sonderi* but not identical. They are a little less spiny and the plants are 3-4x furcate (see Figure 20, page 44), rather than 1-3x furcate, which suggests they are not *N. sonderi*. The *N. pseudoflabellata* complex in Australia is currently under revision, and contains at least five species (Casanova 2009).

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Appendix 1. Charophytes of the Cravens Peak Wetlands, April 2007

Taxon and Site	M1	M2	M3	M4	M5	M6a	M6b
Division Streptophyta							
Class CHAROPHYCEAE							
Order CHARALES							
Chara sp aff. *simplicissima*				+++			
Nitella sp. aff. *pseudoflabellata*					++		
Nitella sp. aff. *sonderi*			+				

Key: ++++ very common/abundant; +++ common; ++ occasional; + rare (sparse for charophytes)

Figure 19. Charophytes at Site M4. Photo: A. Hoggett

Figure 20. Charophytes at Site M5. Photo: A. Hoggett

Cravens Peak Algae

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Identified by Joan Powling

The freshwater algae of inland Australia are, generally, microscopic aquatic plants which are found floating or swimming in the open water of lakes, reservoirs and streams (planktonic), on sediments and soil (epipelic) or attached to submerged plants (epiphytic), rocks (epilithic) and microcrustaceans such as copepods (epizootic). They are one of the primary producer groups in the aquatic food chain.

Sample methods

Algal trawl samples were collected with a 35 micron mesh nylon plankton net, in a variety of ways depending on the characteristics of each sampling site. Samples were concentrated in the net to a minimal residual volume and preserved on site with Lugols Iodine immediately after collection and stored in the dark. Portions of all samples were kept live for examination on site with a Swift FM 31 Field Microscope (see Figure 21, below) and for further examination in Melbourne.

At Site M1 which was extremely shallow (5-10cm) the net was carefully swept for about 1 metre at a time through the submerged vegetation, mostly Nardoo, for a total trawl distance of approximately 10 metres.

At the deeper sites (Sites M2, M4 and M5), samples were collected at wading depth by three trawls of 5 metres from the water column within 10–15m of the shore; at site 6b the net was thrown three times from the edge of the pool.

Figure 21. Field microscope. Photo: A. Hoggett

In the Mulligan River (site M6a), the bed of which was shallow and stony, the net was again manipulated carefully in the deepest pools and an attempt made to approximate the same trawl distance as achieved at the other sites.

In addition to the trawls, samples of epipelic, epilithic and epiphytic algae were collected by various means (scrapes, pipette and forceps) and preserved immediately.

Physico-chemical measurements of electrical conductivity (EC), pH, temperature and dissolved oxygen were made with calibrated meters, and estimates of light penetration were made at wading depth using a Secchi Disc.

Examination of samples and identification of algal taxa

Most samples were examined on site with the Field Microscope (100–400x) soon after collection which allowed further sampling if necessary. It was also of interest to other team members to see brilliantly coloured algae and the feeding mechanism of rotifers at close quarters. Attempts to photograph organisms through the eyepiece of this microscope were successful using the super macro function of a Ricoh Caplio R4 digital camera (see Figures 22, page 46 and 23, page 46).

In Melbourne, samples were examined using a Wild M40 Inverted (Light) Microscope with a 10ml capacity sedimentation chamber. After a settlement period the entire chamber sample was examined at magnifications ranging from x100 to x400 and each of the recognised taxa recorded.

Algal taxa, other than the cyanobacteria (Cyanophyta) and diatoms (Bacillariophyta), were identified according to Ling and Tyler (2000) and Croasdale and Flint (1986, 1988). Reference was made to Baker and Fabbro (2002) for the cyanobacteria, and Gell et al. (1999) and Sonnemann et al. (2000) for the

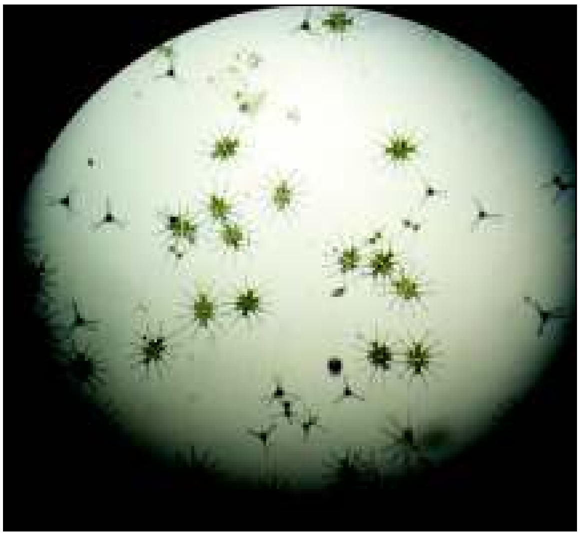

Figure 22. *Micrasterias hardyi* at Big Lake Kunnamuka Site M5. Photo: A. Hoggett

diatoms. The algae listed in the Appendix are classified according to the scheme used in Algae of Australia, ABRS (2007). Not all algae could be identified to species but photographic records and drawings were made. Algal counts were not performed.

Results and discussion

A total of 240 individual taxa was observed in samples collected from the five wetland sites, one riverine site and an off river pool on Cravens Peak (Table 1, page 47). All algal taxa recorded during the survey are listed in Appendix 1 (starting on page 51). The algal taxa collected at each site were characteristic of the type of site and its wetting history. Desmids were the most common group of algae observed; 88 of the 98 identifiable desmid taxa (90%) were found at only one site.

Site M1 (Nardoo Swamp), a wet soak on a vehicle track, which was rapidly drying out, was the most ephemeral of those sampled and contained the highest diversity of algal taxa (90) recorded during the study period. The collection was dominated by the Streptophyta, all of which were in the Order Zygnemales which includes the desmids. Desmids are a special group of green algae which have the ability to form reproductive spores which are resistant to desiccation. Several species secrete mucilage through pores and, in a phototactic response, enabling them to position themselves at the mud-water interface. When the wetland dries the mucilage and associated organisms contribute towards the stabilisation of sediments and soils. The most common desmids collected at this site were species of *Cosmarium*,

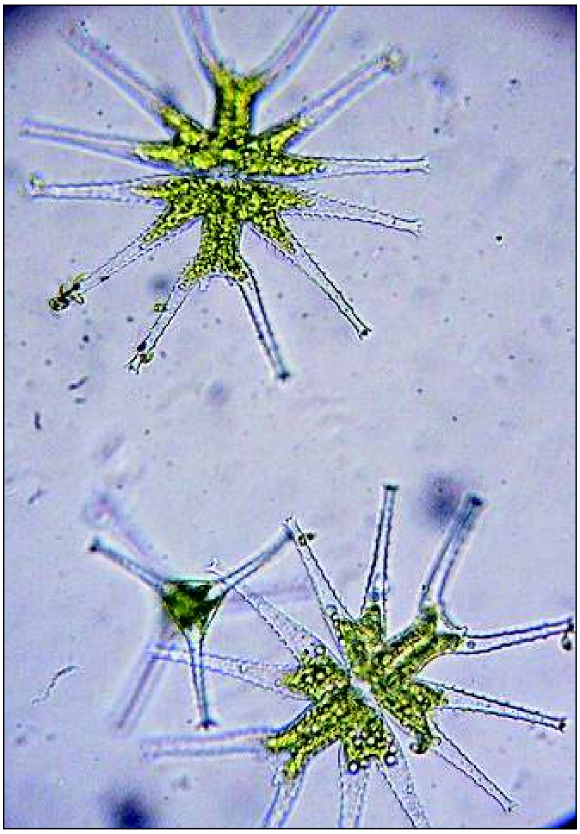

Figure 23. *Micrasterias hardyi* at Big Lake Kunnamuka Site M5. Photo: A. Hoggett

Staurastrum, *Staurodesmus* and the filamentous genera, *Spondylosium* and *Teilingia*.

The most common of the Chlorophyta (green algae) was the flagellate colony *Pandorina* which, with other members of the Order Volvocales, is often the first large alga to colonise rewetted areas, including those in other desert regions of Australia (Costelloe et al 2004). *Dictyosphaerium*, another early coloniser of freshly inundated sites such as newly constructed farm dams, was also common.

Site M2 (Coolabah, Gidgee Swamp), a coolibah/gidgee dune swale swamp with an abundant bird population, contained 46 taxa. Chlorophyta (green algae) were dominant, the most commonly recognised of which was the multi-celled alga *Pediastrum*. There were at least two species, one of which was rare by comparison with specimens collected in south-eastern Australia and the Lake Eyre Basin. *Pediastrum* is a partially benthic species which, when disturbed from its epipelic habitat, can maintain buoyancy by means of the 'holes' in its plate-shaped colony. More abundant than *Pediastrum* were several taxa of small green algae, either single-celled or in colonies, none of which could be identified satisfactorily.

Table 1: Distribution of algal taxa, by Division, for Cravens Peak Sites

Division	Site/no. of taxa							
	M1	M2	M3	M4	M5	M6a	M6b	all sites
Total	90	46	75	61	35	55	65	240
Cyanophyta	2	1	12	6	7	1	0	19
Heterokontophyta	9	8	8	12	7	15	12	28
(includes diatom taxa)	(7)	(6)	(6)	(11)	(7)	(12)	(7)	(20)
Cryptophyta	1	1	0	0	0	0	1	1
Dinophyta	6	0	4	2	0	4	5	10
Euglenophyta	1	7	0	10	0	16	13	25
Chlorophyta	24	28	21	18	11	12	22	54
Streptophyta	47	1	30	13	10	7	12	103
(includes charophytes)	(0)	(0)	(1)	(1)	(1)	(0)	(0)	(3)
(includes desmid taxa)	(47)	(1)	(28)	(12)	(9)	(6)	(12)	(98)

The green colony *Dictyosphaerium* (see Site M1) was very common as were several species of euglenid, a uni-flagellate group also found in freshly inundated water bodies, often with a raised level of organic nutrients and turbid water. Euglenids have light sensitive “eyespots” and, by means of their long single flagella, are capable of independent movement towards a zone of optimum light intensity necessary for their photosynthesis. They are competitive therefore in highly coloured and turbid waters and are typically found in and around the margins of farm dams with stock access and in lakes which carry high bird populations.

Site M3 (Nardoo/Sundew/Canegrass Swamp), a dune swale swamp in close proximity to Site M1, contained 76 taxa and was dominated by Streptophyta (desmids). Filamentous green algae were also very common and included species of *Oedogonium*. *Mougoetia* and the desmid, *Desmidium baileyi*. The most common desmids were *Staurastrum* and *Staurodesmus* and the comparatively large and flamboyant *Micrasterias mahabuleshwarensis*. Some of the filamentous algae and desmids were being attacked by fungal parasites of algae, chytrids, a phenomenon often observed as a wetland becomes stressed as it begins to dry.

More Cyanophyta (cyanobacteria or blue-green algae) were collected at this site than Sites M1 or M2. The most common of these were two filamentous genera of the Nostocales group, *Nostoc* sp. and *Cylindrospermum* sp., both of which are able to fix atmospheric nitrogen by means of specialised cells (hetrocysts or heterocytes). These organisms colonise the sediments and assist with the stabilisation of same by forming a tough crust which, when dried out, is resistant to wind and water movements. Each filament of *Cylindrospermum*, upon drying, produces a large number of resistant spores which have been observed in vitro to germinate readily upon rewetting.

Site M4, Little Kunnamuka Swamp (62 taxa), was characterised by a large amount of (mostly) decomposing green filamentous algae, *Oedogonium* sp., draped over the many emergent clumps of lignum in mid swamp (Figure 24, page 48) and also the first obviously visible evidence of charophytes on Cravens Peak. The water was moderately turbid and the trawl contained a great deal of organic detritus. Taxa from the Chlorophyta were predominant in the plankton, in particular small green needle-shaped algae (*Ankistrodesmus* spp.). Large desmids were also present. The latter group included *Pleurotaenium mamillatum* and a form of *Micrasterias mahabuleshwarensis* which differed subtly from the forms found at Sites M1 and M3. Some of the larger *Staurastrum* species were forming zygospores.

Several benthic diatoms were found at this site and the small *Nitzschia palea* was the most common of these. It is capable of movement and colonises sediments in shallow waters.

Site M5, Big Kunnamuka Swamp (35 taxa), was turbid in appearance and the sample contained less detrital material than that from Site M4. The resulting trawl was bright green due to the abundance of one particular desmid species, *Micrasterias hardyi*, first described from Melbourne’s Yan Yean Reservoir (West, 1909).

Figure 24. *Oedogonium* sp draped over lignum at Little Lake Kunnamuka, Site M4. Photo J. Powling

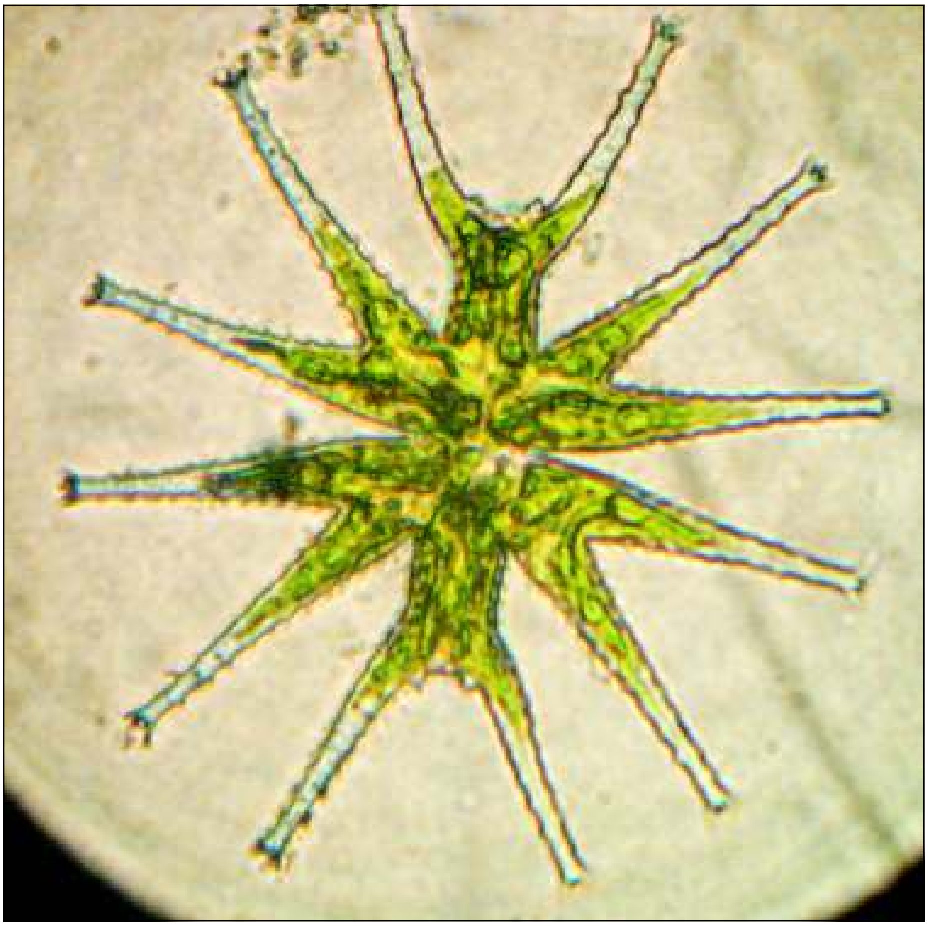

Figure 25. *Micrasterias hardyi* at Big Lake Kunnamuka Site M5. Photo: J. Powling

The plant was found to be particularly hardy in that a live sample, inadvertently kept for nearly 8 months in the dark, was examined again in November 2007, and found to contain bright green, very healthy, living cells (Figure 25, page 48). Some cells were still alive in April 2008.

Anabaena circinalis was of common occurrence in the trawl sample. This was the only Cravens Peak site at which a potentially toxic species of cyanobacteria was found. Other algae common in the trawl were small, green single cells and colonies which could not be identified satisfactorily.

Site M6a, the Mulligan River at S Bend, was the only riverine site sampled and 55 taxa were recorded in the collection. The filamentous stream diatom, *Aulacoseira granulata* (formerly *Melosira granulata*), was common in the net sample as were several members of the euglenid group (*Euglena*, *Phacus*, *Strombomonas* and *Trachelomonas*). *Aulacoseira granulata* is a cosmopolitan riverine diatom and is the most common species in the River Murray, the River Thames and the River Nile among other major river systems world-wide.

Several species of benthic diatoms such as *Nitzschia palea* and a large desmid, *Closterium acerosum* were found in the sample scraped from a rock in mid-stream. Some of the *Closterium* cells were forming spores.

Site M6b, a temporary pool cut off from the main river at S Bend, was the second most diverse site sampled and contained more flagellates than any other site (23 of the 65 taxa present). The water was clear rather than turbid and very dark in colour, a factor conducive to the dominance of the flagellates which exhibit independent movement to achieve their optimum light requirements for photosynthesis. The chrysophyte *Mallomonas* was particularly common as were the euglenids, several dinoflagellates, the large green colonies of *Pandorina* and *Eudorina*, small green unidentified bi-flagellates, and the cryptomonad, *Cryptomonas*. Small green algae were also common (many unidentified).

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Appendix 1. Algae of the Cravens Peak Wetlands, April 2007

Key to relative abundance: ++++ very common/abundant; +++ common; ++ occasional; + rare

Taxon	Site						
	M1	M2	M3	M4	M5	M6a	M6b
PROKARYOTES							
Division Cyanophyta							
Class CYANOPHYCEAE							
Order CHROOCOCCALES							
Aphanocapsa cf. *delicatissima*				+			
Aphanothece sp.			+		+		
Microcystis cf. *incerta*			+				
Microcystis sp.					+		
Merismopedia sp.				+			
unidentified chroococcales colonies			+	+	++		
Order NOSTOCALES							
Anabaena circinalis					++		
Anabaena cf. *oscillarioides*			+				
Anabaena sp. (straight trichome)			+		+		
Cylindrospermum cf. *licheniforme*			+++		+		
Gloeotrichia cf. *raciborskii*			++				
Nostoc cf. *linckia*			+				
unidentified sheathed nostocales			+				
Order OSCILLATORIALES							
Planktothrix sp.			+	+	+	+	
Trichodesmium sp.	+	+		+			
Trichodesmium cf. *iwanoffianum*			++				
unidentified Oscillatoriales (2µ)				+			
unidentified Oscillatoriales (4µ)			+				
unidentified sheathed Oscillatoriales	+						
EUKARYOTES							
Division Heterokontophyta							
Class CHRYSOPHYCEAE							
Order CHROMULINALES							
Dinobryon sp. 1 (solitary lorica)	+						
Mallomonas sp.				+		+	+++
Class XANTHOPHYCEAE							
Order MISCHOCOCCALES							
Centritractus sp.							+
Ophiocytium sp.			+				+
Heterococcus sp.			+				
Pseudostaurastrum hastatum		++				+	+
Tetraedriella sp.		+				+	+

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Taxon	Site						
	M1	M2	M3	M4	M5	M6a	M6b
Tetraedriella spinigera	+						
Class BACILLARIOPHYCEAE (diatoms)							
Fragilaria sp. 1	+			+	++		
Fragilaria sp. 2					+		
Synedra nana			++			++	
Eunotia sp. 1				+	+	++	
Eunotia sp. 2				+	+	+	
Gyrosigma sp.				+		+	
Navicula sp. 1	+	++	++	++	+	++	+
Navicula sp. 2		+					
Pinnularia sp.	+	++		+	++	+	+
Stauroneis sp.				+			
Nitzschia sp. 1 (210-220µ)	++	+	++	++	+	++	+
Nitzschia sp. 2 (60-70µ)	+			+		+	
Nitzschia cf. *linearis*			++	+			
Nitzschia palea			+	+++		+++	++
Nitzschia sigma	+						
Gomphonema sp.							+
Class COSCINODISCOPHYCEAE							
Aulacoseira granulata						++++	++
Cyclotella sp.		+					+
unidentified pennate diatom	+		+			+	
unidentified filamentous diatom		+				++	
Division Cryptophyta							
Class CRYPTOPHYCEAE							
Order CRYPTOMONADALES							
Cryptomonas sp.	++	+					+
Division Dinophyta							
Class DINOPHYCEAE							
Order PERIDINIALES							
Glenodinium sp.	++						
Peridiniopsis cf. *elpatiewskyi*	++		+			+	++
Peridinium sp. small and plated (20-30µ)	++					+	+++
Peridinium sp. small and smooth (20µ)	+						
Peridinium cf. *africanum*	++						
Peridinium gutwinski			+			+	++
Peridinium cf. *volzii* var. *vancouverense*			+				
Peridinium sp. (54µ)			+				+
unidentified naked dinoflagellate (28µ)	+			+		+	++
unidentified dinoflagellate (small)				++			
Division Euglenophyta							

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Taxon	Site						
	M1	**M2**	**M3**	**M4**	**M5**	**M6a**	**M6b**
Class EUGLENOPHYCEAE							
Order EUGLENALES							
Euglena sp. 1 (60µ)	++			++		++	++
Euglena acus						+	
Euglena oxyuris						++	++
Euglena polymorpha							+
Euglena spirogyra						+	
Euglena texta							++
Euglena tripteris						+	
Lepocinclis sp.							++
Phacus curvicauda						+	++
Phacus longicauda						++	
Phacus pleuronectes						+	
Strombomonas sp. 1 (68µ)						++	
Strombomonas sp. 2 (54µ)						+	
Strombomonas cf. *concertina*							+
Strombomonas girardiana							++
Strombomonas cf. *maxima*						++	
Strombomonas cf. *napiformis* var. *brevicollis*						+	++
Strombomonas cf. *verrucosa*		++					
Trachelomonas armata							+
Trachelomonas cf. *coronata*		+					+
Trachelomonas hispida		+				+	++
Trachelomonas oblonga var. *australica*		+				++	
Trachelomonas cf. *similis*		+				++	
Trachelomonas volvocina		++				+	++
unidentified uniflagellate (10µ)		++					
Division Chlorophyta							
Class CHLOROPHYCEAE							
Order CHLOROCOCCALES							
Sphaerocystis sp.	+		++	++			++
Ankyra sp.						+	
Ankyra cf. *lanceolata*		++	+				+
Treubaria triappendiculata		++					+
Pediastrum cf. *angulosum*				+			
Pediastrum duplex	+	+++	+		+	+	+
Pediastrum duplex var. *cohaerens*			+	+	++		
Pediastrum duplex var. *gracillimum*	++		++	++		++	++
Pediastrum duplex var. *gracillimum* forma		++					
Pediastrum tetras							++
Dictyosphaerium sp.	+++	+++	+++		++		

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Taxon	**Site**						
	M1	**M2**	**M3**	**M4**	**M5**	**M6a**	**M6b**
Lagerheimia sp.		+					
Nephrocytium cf. *limneticum*	++		++				
Oocystis sp.			+	+	++		
Oocystis cf. *eremosphaera*	+			+			
Oocystis cf. *irregularis*		++					
Oocystis cf. *lacustris*	++	+					+
Ankistrodesmus sp.		+		++			
Ankistrodesmus falcatus	+	+	+	+++	++		
Ankistrodesmus fusiformis	+		++	+++		+	++
Kirchneriella sp.	+	+	++				+
Kirchneriella obesa				+			
Monoraphidium sp.			+				
Monoraphidium cf. *mirabile*		+++		++			
Actinastrum hantzschii	+	++				+	
Actinastrum hantzschii var. *subtile*							+
Coelastrum sp.		+			+	+	++
Coelastrum cf. *microporum*	++						
Crucigenia quadrata		+		+			+
Crucigeniella rectangularis		+				+	++
Scenedesmus sp. 1 (8µ)		+			+		
Scenedesmus acuminatus	+	++				+	
Scenedesmus bijuga var. *alternans*	+		+				+
Scenedesmus cf. *brasiliensis*	+						
Scenedesmus dimorphus		++				+	
Scenedesmus cf. *disciformis*			+				
Scenedesmus quadricauda	+	+	+			+	+
Scenedesmus quadricauda var. *inermis*		+					++
Scenedesmus cf. *quadrispina*							++
Tetrallantos lagerheimii		++		++			+
Order VOLVOCALES							
Coccomonas cf. *orbicularis*	+						
Pteromonas sp.						+	
Wislouchiella planctonica		++					
Gonium sociale		+					
Pandorina sp.	+++	+		++		+	++
Eudorina sp.	++	+	++	+	+		+
small green flagellates (20µ)	++	+++					++
Order CHAETOPHORALES							
Draparnaldia cf. *mutabilis*			+				
Stigeoclonium sp.	+				+		
Class ULVOPHYCEAE							

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Taxon	Site						
	M1	M2	M3	M4	M5	M6a	M6b
Order CODIOLALES							
Planctonema lauterbornii	++			++	++		+
Ulothrix sp.	+						
Class OEDOGONIOPHYCEAE							
Order OEDOGONIALES							
Bulbochaete sp.			+				
Oedogonium sp. 1 (14µ)	+++	++	++	+++	++		
Oedogonium sp. 2 (8µ)			+				
Oedogonium undulatum			++	+			
Division Streptophyta							
Class ZYGNEMOPHYCEAE							
Order ZYGNEMALES							
Mougeotia sp.			+++				
Spirogyra sp.						++	
Spirotaenia sp.			+				
Penium cylindrus				+			
Closterium sp. 1 (40µ)	+						
Closterium sp. 1 (180µ)				+			
Closterium acerosum	+		+	+		+++	
Closterium aciculare					++		
Closterium closterioides var. *intermedium*			+				
Closterium cf. *Cynthia*				+			
Closterium dianae					+		
Closterium tumidulum forma						+	
Closterium cf. *venus*		+					
Order DESMIDIALES							
Pleurotaenium cf. *mamillatum*				++			
Actinotaenium cf. *cucurbita*	++						
Cosmarium sp. 1 (undulate, punctate, 18µ)	+						
Cosmarium sp. 2 (28µ) cf. *pseudophaseolus*	+						
Cosmarium sp. 3 (small 'triangular' cell)			+				
Cosmarium sp. 4 (14µ) cf. *angulosum* forma				+			
Cosmarium sp. 5 (small, smooth, 22µ)						+	++
Cosmarium sp. 6 (26µ) cf. *excavatum*	+						
Cosmarium sp. 7 (30µ) cf. *pseudoprotuberans*	+						
Cosmarium sp. 8 (28µ) cf. *subcrenatum*	+						
Cosmarium sp. 9 (68µ) cf. *securiforme* forma			++				
Cosmarium blyttii var. *blyttii*			+				
Cosmarium contractum var. *contractum*	+						
Cosmarium contractum var. *ellipsoideum*	++						+
Cosmarium contractum var. *minutum*	++						

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Taxon	Site						
	M1	**M2**	**M3**	**M4**	**M5**	**M6a**	**M6b**
Cosmarium depressum var. *achondrum*	+						
Cosmarium depressum var. *minutum*	+						
Cosmarium granatum						+	
Cosmarium impressulum	+						
Cosmarium laeve var. *laeve*	+						
Cosmarium magnificum			+	++	+		+
Cosmarium moniliforme	++						
Cosmarium moniliforme var. *indentatum*							+
Cosmarium obsoletum forma	+						
Cosmarium obsoletum var. *obsoletum*	+						
Cosmarium obsoletum var. *sitvense*			+				
Cosmarium punctulatum var. *punctulatum*			+				
Cosmarium punctulatum var. *subpunctulatum*	+						
Cosmarium quadrifarium	+						
Cosmarium quadrum				+			
Cosmarium quadrum var. *minus*	+						
Cosmarium cf. *sportella*				+			
Cosmarium subspeciosum forma	+						
Euastrum sp. 1 (30µ)	+						
Euastrum sp. 2 (22-27µ)	+						
Euastrum sp. 3 (50µ)				+			
Euastrum denticulatum forma 1	+						
Euastrum denticulatum forma 2			+				
Euastrum denticulatum var. quadrifarium			+				
Euastrum spinulosum	++						
Euastrum turgidum forma							++
Micrasterias hardyi					++++		
Micrasterias mahabuleshwarensis			+++				
M. Mahabuleshwarensis var. *ampullacea*	++						
M. mahabuleshwarensis var. *mahabuleshwarensis*				+++			
Staurastrum sp. 1 (24µ bi-radiate) cf. *americanum*						+	+
Staurastrum sp. 2 (30µ) five-radiate forma	+						
Staurastrum bibrachiatum	+		+				
Staurastrum ensiferum			++				
Staurastrum muticum			+++				
Staurastrum orbiculare var. *protractum*	++						
Staurastrum pingue				+++	+++		
Staurastrum pinnatum	+						
Staurastrum playfairi					++		+++
Staurastrum playfairi 3-radiate forma			+				

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continued from previous page

Taxon	Site						
	M1	M2	M3	M4	M5	M6a	M6b
Staurastrum protectum	+		+				++
Staurastrum pseudosebaldi	+						
Staurastrum sexangulare 4-radiate forma			+++				
Staurastrum smithii			+				
Staurastrum tetracerum						+	
Staurastrum tohopokaligense (short processes)	+++				+		+
Staurastrum tohopokaligense (long processes)			+++				
Staurastrum victoriense			+++				
Staurodesmus sp. 1 (40µ) no spines	+						+
Staurodesmus sp. 2 (20µ) cf. *connatus*	++						
Staurodesmus sp. 3 (56µ) bi-radiate			+				
Staurodesmus apiculatus	+						
Staurodesmus cuspidatus					+		
Staurodesmus cuspidatus var. *curvatus*			++				
Staurodesmus dejectus forma	+						
Staurodesmus dejectus large form (48µ)			+				
Staurodesmus dickiei forma	++		++				
Staurodesmus leptodermus	+						
Staurodesmus mamillatus			++				
Staurodesmus mucronatus var. *subtriangularis*	+++						
Cosmocladium sp.	+						
Desmidium aptogonum					+		
Desmidium baileyi			+++				
Hyalotheca undulata	+						
Phymatodocis sp.			+				
Spondylosium nitens	+++						
Spondylosium panduriforme fa. *limneticum*	++						
Spondylosium cf. *planum*							+
Teilingia excavata forma 1	+++						
Teilingia excavata forma 2							+
unidentified filamentous desmid (16µ)	++						
MISCELLANEOUS (unidentified)							
green filament		++			++	+	
green filament (very long cells, 5µ w)	++						
branched green filament			+		++		
green colony (oval cells)	++	+		++	++		++
small green colonies (various)		++++	++	+++	+++		
single green cells (various)		+++			+++		

Cravens Peak zooplankton and microfauna

Powling, Joan[1] identified by Shiel, Russell[2]

[1]Consulting Freshwater Biologist, Ivanhoe Victoria
[2]Dr Russell Shiel, University of Adelaide (microfauna and zooplankton)

Zooplankton and microfauna are microscopic invertebrate animals. The zooplankton are found in the open water and the microfauna in the sediments or attached to submerged vegetation and other substrates. Protozoans, rotifers and microcrustaceans are found in both groups and occupy all niches in the aquatic food chain as detritivores, bacteriovores, herbivores and carnivores.

Sampling methods

Trawl samples were collected in exactly the same manner as the algae, concentrated in the net to a minimal residual volume and preserved on site with ethyl alcohol.

Samples were sent to R. J. Shiel at the University of Adelaide for identification of protista, rotifera, cladocera, copepoda, ostracoda and any macro-invertebrates which happened to be caught in the net.

Results and discussion

The number of identifiable taxa in each of the major groups is shown for each site in Table 1 (page 59). All zooplankton and microfauna recorded during the survey are listed in Appendix 1 (starting on page 61).

Excluding the juvenile copeods and indeterminate records, there were 68 taxa collected from the seven sites during the survey period. Three rotifers, three cladocerans and three calanoid copepods are noted to be endemic to Australia (R. Shiel, pers. comm.).

Site M1, (16 taxa), contained three protists, nine rotifers, one chydorid cladoceran, the cyclopoid copepod *Mesocyclops* sp., cyclopoid copepodites and nauplii and a juvenile ostracod. It was the only site at which a bivalve was recorded, a juvenile, cf. *Corbiculina* sp.; a micro-turbellarian was also found in the sample. The most common zooplankter in the trawl was the cyclopoid *Mesocyclops* sp.

Site M2, (13 taxa), contained an abundance of the protist *Difflugia gramen*, five planktonic rotifers of which *Brachionus lyratus* was most common by far, three cladocerans, three copepods (two calanoids and one cyclopoid) and one ostracod. Five of the taxa are Australian endemic species viz. two of the rotifers, *Brachionus lyratus* and *Keratella slacki*, two cladocerans, *Daphnia* cf. *projecta* and *Macrothrix* cf. *breviseta* and the calanoid copepod, *Calamoecia lucasi*.

Site M3, (30 taxa), contained four protists including *Difflugia gramen*, ten rotifers, nine cladocerans (the most at any site and including four chydorids), four copepods and two ostracods. There were two endemic taxa, the cladoceran *Latonopsis brehmi* and the calanoid copepod *Calamoecia ultima*. A gastrotrich was also found in the algal trawl sample.

Site M4, (14 taxa), contained two protists, five rotifers, one cladoceran and three calanoid copepods. Also recorded were an unidentified cyclopoid and an ostracod from the algal trawl. It was the only site at which a nematode and a spicule of a freshwater sponge, *Spongilla alba*, was collected. Early literature (Williams 1980) has this species recorded only from Queensland.

Site M5, (20 taxa), contained seven protists, six rotifers including a planktonic carnivore *Asplanchna* sp. and the colonial *Lacinularia ismaeloviensis* (Figure 26, page 60), five cladocerans, the calanoid copepod *Boeckella triarticulata* and an indeterminate juvenile ostracod. A species of *Difflugia* was the most common of the protists and the most common rotifer was the endemic species *Keratella australis*.

Site M6a, the only riverine sample (25 taxa), contained six protists, five planktonic rotifers, three cladocerans and three copepods. The microfauna collection was dominated by the protist *Difflugia gramen* and the empty tubes of a rotifer, *Floscularia ringens*, a detritivore which constructs its home out of its own faecal pellets (Figure 27, page 60). By comparison, species of *Difflugia* use sand grains, diatom frustules and other siliceous material for construction of their tests (cases) while *Netzelia tuberculata*, also recorded at site M5, extracts silica from the water for this purpose.

Site M6b, the isolated off-river pool (12 taxa), contained three protists, seven rotifers, one cladoceran and one copepod. The rotifers were by far the most common of the zooplankton, especially *Trichocerca similis* which was

Table 1: Distribution of Zooplankton and Microfauna Taxa by Site

Group	Site							
	M1	M2	M3	M4	M5	M6a	M6b	all sites
Total	16	13	30	14	20	25	12	68
Protista	3	1	4	2	7	6	3	10
Rotifera	9	5	10	5	6	12	7	33
Cladocera	1	3	9	1	5	4	1	13
Copepoda	1	3	4	3	1	3	1	6
Ostracoda	1	1	2	1	1	0	0	2
other	1	0	1	2	0	0	0	4

abundant. Also common were *Polyarthra dolichoptera*, *Keratella procurva* and *Anuraeopsis fissa*.

Protists and rotifers are usually the first animals to emerge from flooded sediments (Shiel et al, 1998) to feed on the immediately available abundance of bacteria, minute single-celled algae and detrital particles.

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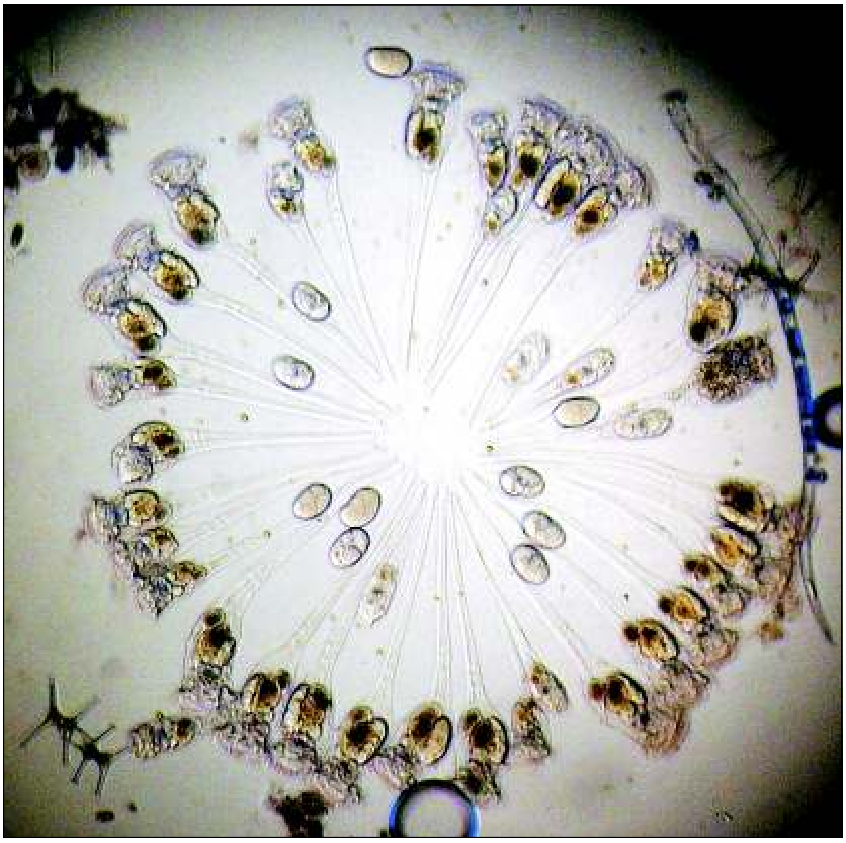

Figure 26. *Lacinularia ismaeloviensis* at Big Lake Kunnamuka Site M5. Photo: A. Hoggett

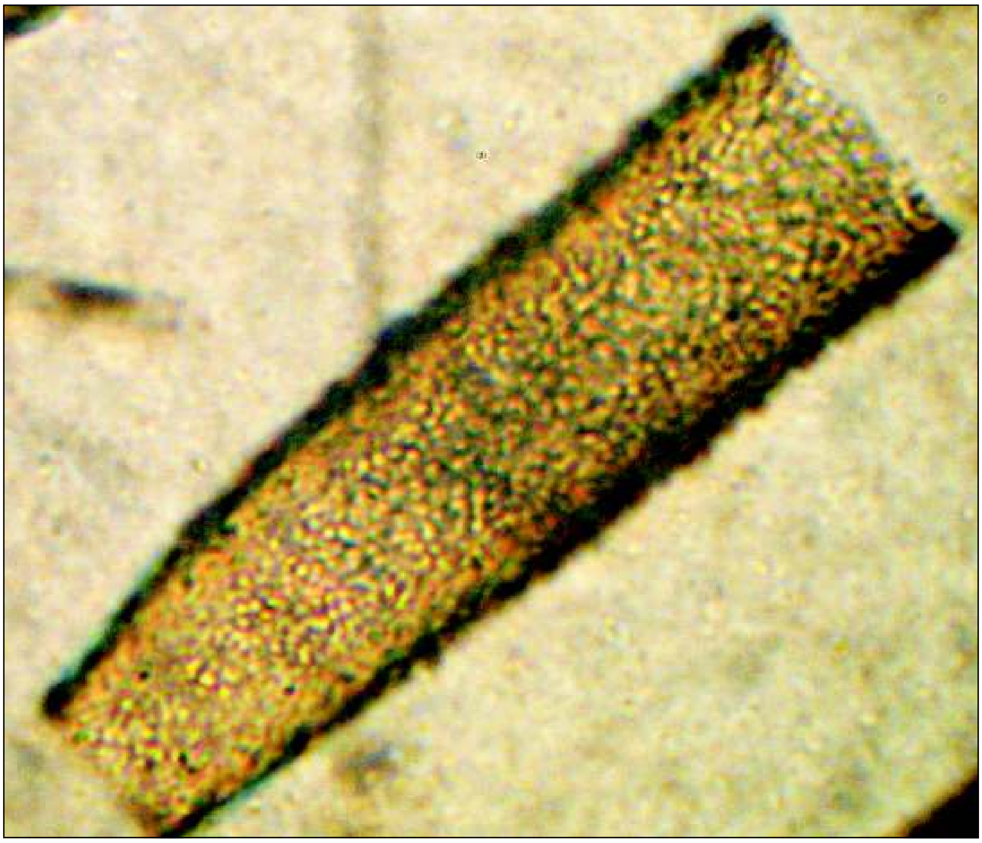

Figure 27. *Floscularia ringens* at S Bend Site 6a. Photo: J. Powling

Appendix 1. Zooplankton and Microfauna, Cravens Peak Wetland Study, April 2007

Key to relative abundance: ++++ very common/abundant; +++ common; ++ occasional; + rare

Taxon	Site						
	M1	M2	M3	M4	M5	M6a	M6b
Phylum PROTISTA							
Class Amoeba							
unidentified Amoeba					+		
Class Rhizopoda							
Arcella sp.	+				+	+	+
Centropyxis aculeata Ehrenberg, 1830					+		
Difflugia cf. *elegans*			+				
Difflugia gramen Penard, 1902		++++	++			+++	+
Difflugia sp.	+			++	+++	++	
Netzelia tuberculata (Wallich, 1864)					+	+	
Euglypha filifera Penard, 1890					++	+	
Euglypha sp.	+		++	+			+
Lesquereusia sp.					+		
Class Ciliata							
Vorticella sp.			+			+	
Phylum PORIFERA							
cf. *Spongilla alba*				+			
Phylum PLATYHELMINTHES							
Class Turbellaria							
micro-turbellarian	+						
Phylum GASTROTRICHA							
unidentified gastrotrich			+				
Phylum ROTIFERA							
Class Bdelloidea							
unidentified bdelloid rotifer	+						
Class Monogononta							
Floscularia ringens Linné, 1758						+++	
Lacinularia ismaeloviensis Poggenpol, 1872					+		
Asplanchna sp.					+		
Anuraeopsis fissa (Gosse, 1851)						+	++
Anuraeopsis sp.			+			+	
Brachionus angularis Gosse, 1851						+	+
Brachionus lyratus Shephard, 1911		+++				+	
Keratella australis Berzins, 1963					+++		
Keratella procurva (Thorpe, 1891)							++
Keratella slacki (Berzins, 1963)		++				+	

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Taxon	**Site**						
	M1	**M2**	**M3**	**M4**	**M5**	**M6a**	**M6b**
Plationus patulus (Müller, 1786)						+	
Conochilus sp.			+			+	
Lophocharis sp.				+			
Euchlanis dilatata (Ehrenberg, 1832)	+		+				
Ascomorpha sp.				+		++	
Hexarthra mira (Hudson, 1871)					++		
Lecane curvicornis (Murray, 1913)	+					+	
Lecane hastate (Murray, 1913)			+				
Lecane luna (Müller, 1776)	+						
Lecane lunaris (Ehrenberg, 1832)			++				
Lecane signifera (Jennings, 1896)			++				
Lecane sp.	+	+	+				
Cephalodella cf. *gibba* (Ehrenberg, 1832)	+						
Notommata copeus Ehrenberg, 1834			+				
Scaridium sp.	+						
Polyarthra dolichoptera (Idelson, 1925)	+	+	++			+++	+++
Trichocerca pusilla (Jennings, 1903)				+			+
Trichocerca rattus (Müller, 1776)					+		
Trichocerca similis (Wierzejski, 1893)			++		++	+	++++
Trichocerca sp.	+			+			
Filinia cf. *longiseta* (Ehrenberg, 1834)		+		+			+
Phylum NEMATODA							
unidentified nematode				+			
Phylum ARTHROPODA							
Subphylum Crustacea							
Class Branchiopoda							
Order Diplostraca							
Suborder Cladocera							
Alona rigidicaudis Smirnov, 1971			+				
Armatalona macrocopa (Sars, 1895)	+		+				
Chydorus sp.			+				
Ephemeroporus barroisi (Richard, 1894)			+				
Leydigia sp.					+		
Ceriodaphnia cornuta Sars, 1885			+	+	+	++	
Daphnia cf. *projecta* Hebert, 1977		+					
Macrothrix capensis (Sars, 1916)			+				
Macrothrix cf. *breviseta* Smirnov, 1976		+					
Macrothrix sp.						+	+
Neothrix sp.					+		

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Taxon	Site						
	M1	**M2**	**M3**	**M4**	**M5**	**M6a**	**M6b**
Moina micrura Kurz, 1874			+		+	+	
Moina sp.		+					
Diaphanosoma excisum Sars, 1885			+		+	+	
Latonopsis brehmi Petkovski, 1973			+				
Class Maxillopoda							
Subclass Copepoda							
Order Calanoida							
Boeckella triarticulata (Thomson, 1883)		+	++	+	+		
Boeckella sp.			++	+		+	
Calamoecia lucasi Brady, 1906		++					
Calamoecia ultima (Brehm, 1960)			++				
Calamoecia sp.				+			
calanoid copepodites		+					
calanoid nauplii		++					
Order Cyclopoida							
Mesocyclops sp.	+++	++	+			++	++
Thermocyclops sp.						++	
unidentified cyclopoid				+	+		
cyclopoid copepodites	+	+		+	+	++	+
cyclopoid nauplii	+	++		+	+	++	+
Class Ostracoda							
cf. *Cyprinotus*			+				
cf. *Cypretta*		+	+				
unidentified ostracods	+		+	+	+		

Cravens Peak macro-invertebrates

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[2]Principal Biodiversity Planning Officer, Environmental Protection Agency (now DERM), PO Box 202 Longreach Qld 4730

Identified by Brian Timms[1] and Chris Watts[2]

[1]Australian Museum, Sydney (branchiopod crustaceans)
[2]South Australian Museum (aquatic beetles)

Introduction

Macro-invertebrates are small aquatic animals without backbones such as insects, snails, worms, shrimps, crabs and yabbies that can be seen with the naked eye. They consume plant and animal material and, in turn, are a source of food for fish and waterbirds.

Macro-invertebrates are an important indicator of ecosystem health. Changes in macro-invertebrate community composition occur with differing environmental conditions. Water from local rain and flooding rivers dispersing over flood plains or between dunes can produce very different responses. A combination of factors such as the presence or absence of fish, the vegetation type, nature of the substrate, depth and quality of the water, create individual ecosystems. Large numbers of a predatory macro-invertebrate species will impact on zooplankton and algae whereas if macro-invertebrate numbers are low there is less food available for larger animals such as fish and waterbirds.

Sampling method

At each site a dominant microhabitat (vegetation and substrate type) was selected and samples were collected from depths between 0.5m to 0.9m. A triangular frame (30 cm sides), mounted on a broomstick with a 250 µm mesh, was used to sweep for samples over approximately a 5m² area for 20 seconds. The samples were collected walking backwards, using a sweeping technique through emergent and submerged macrophytes/vegetation, and bouncing the net along the substrate to disturb any benthic fauna/macro-invertebrates.

Once collected, the excess water and silt was drained off through the net with some dunking and the sample was transferred into a 500ml jar with 90% ethanol. (Experience from previous surveys indicated that a higher concentration of ethanol was needed in this region due to higher temperatures, evaporation and faster deterioration).

The actual netting technique does have some limitations and it would have missed some animals such as mussels and crabs, but these were often observed and recorded as incidental catches in the fish bait traps or when sampling the substrata (mud, clay, rock base).

Some identification of larger bugs, and crabs was done on site, and the preserved samples were sent to Brian Timms at the Australian Museum, Sydney for identification of branchiopod crustacea (Timms, 2004, 2009). The aquatic beetles were identified by Chris Watts of the South Australian Museum (Watts, 2002).

Results and discussion

The macro-invertebrates collected during the Survey period are listed in Appendix 1, page 67. 26 taxa are listed including the bivalve mollusc found in the zooplankton trawl at Site M1 and two incidental catches, the giant water bug (*Lethocerus insulanus*) (Figure 28, page 66) and freshwater crab (*Austrothelphusa transversa*) (Figure 29, page 66) at Site M6a in the Mulligan River.

Site M1, the very shallow soak on a vehicle track and covered in Nardoo (*Marsilea* cf. *mutica*), was host to a flock of glossy ibis (*Plegadis falcinellus*). The only bivalve from the study area, cf. *Corbiculina*, was recorded here at Site M1, caught in the plankton trawl net along with a single branchiopod, *Branchinella* sp. There was one dytiscid, two hydrophilids and an oribatid mite.

At Site M2, the branchiopod, *Caenestheriella packardi* (little red clam shrimp) was recorded, also an indeterminate species of gastropod, the only one found in the study. Corixids, notonectids, one dytiscid and two hydrophilids were also present.

Site M3 contained three branchiopods, *Branchinella* ?*affinis* (fairy shrimp), a new species of *Eocyzicus* (Yellow Clam Shrimp) and

Limnadia sp. (clear clam shrimp). There were two dipterans (one a chironomid and one non-chironomid), a notonectid, one dytiscid and an unidentified conchostracan.

The new species of *Eocyzicus* is the same as the ones collected from the Paroo system, from around Alice Springs and also in the northern goldfields and Esperance regions of Western Australia (Timms, 2009) and its range has therefore been extended by this collection from Cravens Peak.

Site M4 also contained three branchiopods, the new species of *Eocyzicus* as found at Site M3, *Caenestheriella packardi* (little red clam shrimp) and *Branchinella australiensis*. There was one notonectid, one dytiscid and a zygopteran.

One dytiscid and two hydrophilid beetles were the only macro-invertebrates collected at Site M5.

No macro-invertebrates were collected in the Mulligan River sample at S Bend, Site M6, but a giant water bug, *Lethocerus insulanus*, and a freshwater crab, *Austrothelphusa* (previously *Holthuisana*) *transversa* was caught in the fish sampling gear. A dead freshwater crab was found stranded on the bank of a river tributary, near site M6b at S Bend.

Austrothelphusa is widespread in arid and semi-arid regions of Australia which experience annual flooding. They withstand the dry periods by burrowing into the clay, sometimes to a depth of one metre, and sealing the opening to their burrows with a plug of mud. *Lethocerus insulanus* is a very large (up to 75mm long) predator of arthropods and small fish. It hangs upside down in submerged vegetation and hunts by stealth, grasping its prey and sucking their body contents. It can also inflict a nasty bite on human water samplers (personal experience, Site M5 – Big Kunnamuka Swamp).

Branchinella ?*affinis* is a filter feeder and is most commonly found in turbid waters in the arid region of Australia (Timms, 2002); *Limnadia* is also restricted to the arid regions whereas *Branchinella australiensis* and *Caenestheriella packardi* are found throughout most of mainland Australia, except Tasmania. With the exception of *Enochrus elongatus* at Site M5, all the dytiscid and hydrophilid beetles recorded from the Cravens Peak sites are widespread and common in Australian arid zone waters; nine of the ten taxa were recorded from one site only.

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Figure 28. Giant water bug (*Lethocerus insulanus*) at S Bend Beetle (Site M6). Photo: V. Bailey

Figure 29. Freshwater Crab (*Austrothelphusa transversa*) at Site M6a. Photo: V. Bailey

Appendix 1. Macro-invertebrates, Cravens Peak Wetland Study, April 2007

Key: + present in any one of samples collected

Taxon	Site						
	M1	M2	M3	M4	M5	M6a	M6b
Phylum MOLLUSCA:							
Class Bivalvia cf. *Corbiculina*	+						
Class Gastropoda		+					
Class Arachnida: Oribatidae (mite)	+						
Class Crustacea: Anostraca							
Branchinella cf. *affinis*			+				
Branchinella australiensis				+			
Branchinella sp.	+						
Class Crustacea: Conchostraca							
Caenestheriella packardi		+		+			
Eocyzicus sp. nova			+	+			
Limnadia sp.			+				
Class Crustacea: Decapoda							
Austrothelphusa (Holthuisana) transversa						+	+
Class Insecta							
Hemiptera: Corixidae	+	+					
Hemiptera: Belostomidae							
Lethocerus insulanus						+	
Hemiptera: Notonectidae		+	+	+			
Diptera: Chironomidae			+				
Diptera: non-Chironomidae			+				
Coleoptera: Dytiscidae							
Allodessus bistrigatus	+						
Antiporus gilberti				+			
Eretes australis			+				
Megaporus howittii					+		
Necterosoma penicillatum		+					
Coleoptera: Hydrophilidae							
Berosus munitipennis		+					
Berosus nutans	+	+					
Enochrus elongatus					+		
Enochrus maculiceps					+		
Limnoxenus zealandicus	+						
Odonata: Zygoptera				+			

General discussion on wetland survey – charophytes, algae, zooplankton and microfauna and macro-invertebrates

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The timing of the wetlands survey of Cravens Peak was entirely fortuitous in that rain had fallen in the previous fortnight and had also fallen in the Channel Country early in the year. The findings of this survey are essentially a snapshot of life on one day in each of the six wetlands in April 2007.

Recently inundated areas contain assemblages of invertebrate animals whose composition will depend not only on the physical, chemical and biological constituents of the water and the timing and extent of hatching from the egg bank but also on the extent of predation by other, larger, invertebrate species and the higher vertebrate animals such as fish and water birds. Less is known of the algae.

Bacteria appear first after wetting and drive the various chemical and biological transformations at the soil/water interface. Oxygen levels fluctuate and plant nutrients are released. The tiny picoplankton (0.2-2µ), most of which are single celled flagellates including motile algal zoospores, and the nanoplankton (2-20µ) are the first algae to emerge. The bacteria, algae and detrital particles are readily grazed by the emerging microfauna and zooplankton and the larger macroinvertebrates such as the filter feeding branchiopod crustaceans.

Later in the wetting cycle the algal assemblages probably become more stable, particularly those of the larger forms such as desmids, filamentous green algae and the larger flagellates which, in the absence of large herbivores, are less readily grazed. The changes in species composition in a flooding/drying cycle are more likely to be driven by changes in light penetration through disturbance of sediments or in water chemistry as a site dries up, concentrating the nutrients.

Until very recently, algae had not been much studied in ephemeral wetland habitats of the arid region of Australia. Most attention has been given to invertebrate animals, including zooplankton and microfauna (Shiel et al, 1998), the larger branchiopod crustaceans (Timms, 2002, 2004, 2009) and the charophytes (Casanova et al, 2003). All these groups, with their fascinating life histories, contain species which are characteristic of the arid zone because of their ability to produce resting eggs or resistant spores which may lie dormant for many years in between flooding events.

The degree of diversity in all four groups of organisms observed in the Cravens Peak wetlands was significant but not surprising when other studies of the semi-arid regions of Australia are considered. Variability between sites was high and has been observed in floodplain studies elsewhere (Shiel et al, 1998). It has been suggested (*op. cit.*) that rotifers have successfully adapted to unpredictability and that the heterogeneity of their dispersion is related to that of their habitats. The wetland habitats sampled on Cravens Peak were all slightly different one from the other, as were the terrestrial habitats between one dune swale community and the next. Sites M4 and M5, the two Kunnamuka Swamps, might well have been expected to exhibit some similarity but their micro-flora and fauna were strikingly different in composition and relative abundance.

The diversity of desmid species, in particular, was striking in this study and there was a high degree of variability between sites viz. 90% of identifiable desmid taxa were recorded from single sites. The ability of desmids to withstand desiccation has not achieved any prominence in the literature but it was observed in the ARIDFLO study of the Lake Eyre Basin (Costelloe et al, 2004) that when the waters of the Diamantina River began to flow towards Lake Eyre in March 2000 the ephemeral sites, such as wash-outs over roads, contained a diversity of organisms which was quite unexpected. Desmids are also found in ephemeral gnamma holes on granite inselbergs in the wheat belt of Western Australia (J. Powling unpublished data), along with conchostrocans and other animals which produce resistant eggs.

At Cravens Peak, the most ephemeral site, M1, in a flooded vehicle track, had the highest diversity of desmids in the study (47 taxa). Close examination of samples from this and Site M3 (30 taxa) showed that several desmids, *Micrasterias mahabuleshwarensis*, *Staurastrum tohopokaligense* and *Phymatodocis*, and the green filament *Oedogonium* sp. were beginning to form spores. Site M1 was dry only days after the sample was collected.

Since 2000, results of the algal components of two large scale studies in the arid or semi-arid region, ARIDFLO in the Lake Eyre Basin (LEB) and the WA Department of Conservation survey of the Pilbara region, have demonstrated a very high diversity of desmids in newly flooded wetlands and temporary pools. In the Western District of Victoria, a low-lying former sheep paddock, dry and dusty after four years of drought, produced an assemblage of 53 algae including 20 desmid species after rain in August 2007 (M. Casanova & J. Powling, unpublished data).

Big Kunnamuka Swamp (Site M5) produced the two unexpected findings of the study. The first was the abundance of the desmid *Micrasterias hardyi*, the type locality for which is Yan Yean Reservoir (West, 1909), Melbourne's first water supply storage built in 1857. *M. hardyi* could perhaps be considered a bit of a "weed" because it is not found in traditional desmid habitats, rather it has been common in the past in regulated impoundments such as municipal water storages in many parts of Victoria (J. Powling, unpublished data). There are no published records to suggest that. *M. hardyi* has been reported from waters north of the Snowy Mountains in New South Wales where it was recorded in Lake Jindabyne in 1968 (Tyler, 1970). This find extends the range of this plant considerably.

Site M5 also was the only site on Cravens Peak at which the potentially toxic cyanobacteria *Anabaena circinalis* was collected although it was found to be abundant in a sample collected from the Georgina River crossing on the road to Boulia.

Recommendations

As the property has removed its domestic stock, other impacts to consider would be damage from camels and feral pigs which appear seasonally when the wetlands are most bountiful. Management would need to consider appropriate feral animal and weed control, along with careful consideration on where and when domestic stock may be used for vegetation management.

The wetlands have been found to be a great repository of algal species, some of which are probably not yet recorded for Queensland. Greater sampling diligence of more microhabitats, based on the experience of the recent survey, will surely uncover more algae and sampling earlier in a flood cycle may well uncover more branchiopod crustaceans and micro-fauna. The range for several species may well have been extended by this study and there is certainly scope for more studies of the aquatic biota of this region, including on nearby Ethabuka, another recent Bush Heritage acquisition.

An interesting exercise would be to compare the DNA of the *Micrasterias hardyi* of the arid region with the southern population. It will certainly withstand the long distance involved in sample transport were it to be found in Big Kunnamuka Swamp on a future visit.

It is recommended that further wetlands surveys be planned in the future to gather more baseline information and monitor these diverse arid zone ecosystems.

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Cravens Peak Fish Survey April 2007, Mulligan River Catchment, far western Queensland

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Abstract A survey of freshwater fish was undertaken in the Mulligan River Catchment on Cravens Peak station between April 19 and 21, 2007. Three sites were utilised, including one ephemeral dune lake, one artificial bore and one river channel site at S-Bend Gorge. Fish were not present in either the ephemeral dune lake or the artificial bore. As the main river channel at S-Bend Gorge was characterised by a series of waterholes, this site was sampled twice (ie: 2 waterholes rather than 1) and the results were pooled in order to better represent the overall fish community. Water quality parameters such as temperature, dissolved oxygen, conductivity, pH and turbidity were measured at each site, and a total of 327 fish comprising 5 species were sampled, measured and returned to the water alive.

Introduction

The fish communities of the Mulligan River Catchment in far western Queensland are currently unknown and no records exist at the Queensland Museum (Jeff Johnson, personal communication).

Although surveys and targeted studies have been completed in other areas of the Queensland Lake Eyre Basin (Bailey and Long 2001; Arthington et. al. 2005), current knowledge of the ecology of aquatic systems in western Queensland should be considered fragmentary.

The fish fauna of the Mulligan River is likely to be a subset of the species from the nearby Georgina River and the wider Lake Eyre Basin in Queensland. Like the Georgina, Diamantina and Cooper/Thomson/Barcoo Catchments, the Mulligan is an intermittent river experiencing a highly variable flow regime. Unlike these more eastern catchments of the Queensland Lake Eyre Basin, the Mulligan River lacks deep cracking clays (termed 'channel country') and should be considered a true desert river, especially given its geographical location bordering the Simpson Desert.

Targeted studies of specific areas throughout the Mulligan catchment are likely to improve the accuracy of knowledge of fish populations and their distribution within the Queensland Lake Eyre Basin. Completion of these surveys (such as the work presented here) also has the potential to lay a foundation upon which to conduct more specific research concerning fish life histories in the central Australian arid zone, particularly with regard to breeding and recruitment of fish species in a hydrologically highly variable system.

Methods

Study area

Cravens Peak is situated approximately 150 kilometres south-west of Boulia in western Queensland. In April 2007, the Mulligan River (more correctly a series of waterholes) contained comparatively high water levels due to recent flooding and elevated flows in the catchment (Scott Hamilton, Ethabuka Station, personal communication).

For the purposes of the fish survey, three sites were chosen where water existed with sufficient depth to suggest there was a possibility of fish being present. The first fish survey site, or Site M5 (for the purpose of the rest of the aquatic sampling – macroinvertebrates, zooplankton, algae, birds, plants) was Big Kunnamuka Swamp (23.34225;138.23107), a recently-filled ephemeral lake between two dunes in the Simpson Desert, on the southern part of Cravens Peak. The second site was an artifical bore (Ocean Bore: 23.2335;138.2619) and the third site (site M6) was the Mulligan

Table 1. Water quality parameters at Cravens Peak, April 2007

Site name	Length (m)	Width (m)	Maximum depth (m)	Temperature (degrees celsius)	Dissolved oxygen (%)	Conductivity (microsiemens)	pH	Turbidity (cm)
Big Kunnamuka Swamp	1000+	1000	0.6	24.3	81.7	56.5	6.9	10
Ocean Bore	10	10	3+	28.5	109.2	2850	7	80
S-Bend gorge	500	10	1.5	24	38	120.8	7	6

River itself close to its headwaters in the Toko Gorge (S-Bend Gorge: 23.06279; 138.35293).

Sampling methods

Water quality parameters such as temperature, dissolved oxygen, conductivity, pH and turbidity were tested at each site, and estimations relating to length, width and depth of each river section or waterhole were also recorded.

Fish were sampled using a combination of small (2mm) and large-meshed (13mm) fyke nets set overnight and by a 5 minute larval trawl comprising a funnel-shaped 500 micron mesh trawl net manually dragged through the water column. Small bait traps (400 x 250 x 250mm) with a 30mm entry hole were also utilized.

Due to differences in depth and size of the waterholes at each site, the methods could not be easily standardised. The following summary lists the sampling equipment used at each site:

- Big Kunnamuka Swamp: 10 small fyke nets and one larval trawl,
- Ocean Bore: 5 bait traps and one larval trawl,
- S-Bend Gorge: 2 large fyke nets, 2 small fyke nets and one larval trawl.

All fish were held in water-filled buckets upon the emptying of nets. Fish were then identified, measured (standard length in millimetres) and returned to the water alive. All sampling work was carried out under a scientific research permit (General Fisheries Permit No: PRM03315D) and under a Griffith University Animal Ethics Agreement.

Results

Water quality results are summarised in Table 1, page 71.

In general, water quality results were consistent with the recent flooding in the Mulligan catchment, with conductivity (salinity) levels comparatively low at both Big Kunnamuka Swamp and S-Bend Gorge. Salinity was far higher at Ocean Bore, an expected result given the nature of the site. Turbidity was also low at Ocean Bore compared to the other two sites, and again, this is a likely result as Ocean Bore is fed from groundwater as opposed to run-off.

Fish results are summarised in Table 2, page 71.

No fish were sampled at either Big Kunnamuka Swamp or Ocean Bore.

A total of 327 individual fish were sampled comprising five species at S-Bend Gorge. All species have previously been recorded from the Lake Eyre Basin (Wager and Unmack 2000), however all can be considered range extensions in the Mulligan River due to the absence of prior surveys. The most commonly sampled species at Cravens Peak was spangled perch,

Table 2. Fish species occurring at S-Bend Gorge in April 2007, including numbers of individuals sampled.

Species	Common name	Numbers sampled at S-Bend Gorge
Nematolosa erebi	Bony bream	43
Porochilus argenteus	Silver tandan	4
Leiopotherapon unicolor	Spangled perch	183
*Melanotaenia splendida tatei**	Desert rainbowfish	53
Ambassis sp.	Glassfish	44

*Rainbowfish sampled at S-Bend Gorge are likely to be a local colour variant – see discussion.

Figure 30. Bony Bream. Photo: A. Kerezsy

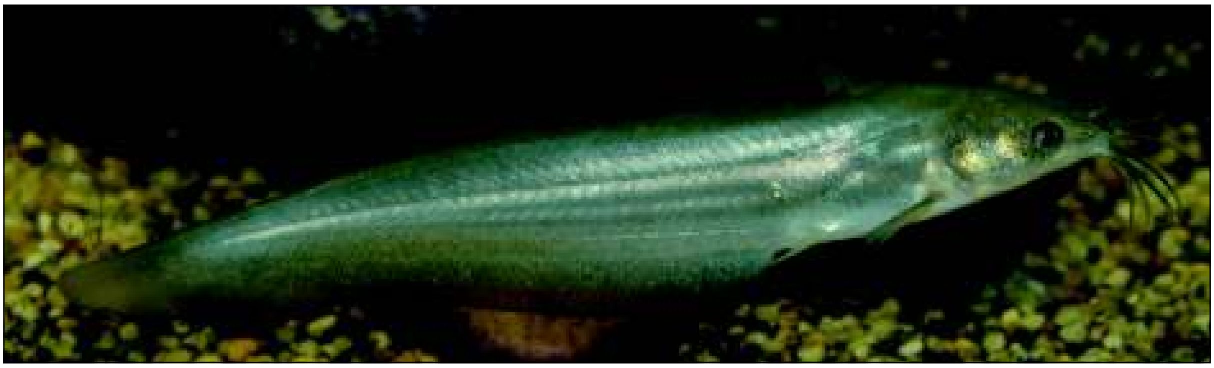

Figure 31. Moonfish. Photo: A. Kerezsy

Figure 32. Spangled perch. Photo: M. Brigden

Figure 33. Glass fish. Photo: A. Emmott

Figure 34. Desert rainbow fish barcoo. Photo: A. Kerezsy

Figure 35. Desert rainbow fish S-bend. Photo: A. Kerezsy

Leiopotherapon unicolor (see Figure 32, page 72).

There was considerable variation in the lengths of sampled fish (Table 3, page 74), indicating that recruitment of several species may have occurred during - or immediately after - the period of flooding and elevated flows in the Mulligan River which preceded the survey.

Discussion, conclusion and recommendations

The fish species sampled at Cravens Peak in April 2007 were species previously identified as present in the Queensland Lake Eyre Basin (see Figures 30 – 32, page 72, and Figures 33 – 35, page 73). The comparatively low number of species (5) sampled at Cravens Peak reflects the comparative lack of aquatic habitat existing on the property. S-Bend Gorge, and the Toko Range itself, is likely to be the only area on Craven's Peak with waterholes that do not dry up relatively soon after flows or flooding. It seems likely that within the S-Bend/Toko area there may be permanent waterholes that possibly maintain remnant populations of the five species sampled, thus facilitating recruitment and colonisation of downstream waterholes following flow and/or flood events.

Alternatively, fish may colonise the Mulligan from the south (Eyre Creek), however this would only be possible in major floods.

Table 3. Length ranges of sampled fish at Craven's Peak in April, 2007 – S Bend Site 6.

Species	Range of lengths sampled (standard length in mm)
Bony bream	50 - 80
Silver tandan	90 - 100
Spangled perch	32 - 193
Rainbowfish	35 - 75
Glassfish	32 - 53

It is recommended that follow-up surveys be completed in the S-Bend Gorge and the Toko Range in different seasonal conditions and under different hydrological conditions in order to understand the hydrology and ecology of this area more fully.

The rainbowfish sampled at S-Bend Gorge exhibited vivid colouration compared with rainbowfish from other catchments in the Queensland Lake Eyre Basin. This result is not uncommon for members of this family (Atherinidae), and local colour variants are often evident for these species (Allen et al. 2002; Helen Larson, NT Museum, personal communication). The presence of rainbowfish at S-Bend Gorge with different colouration to rainbowfish from other catchments within the Queensland Lake Eyre Basin could therefore suggest that the population of the upper Mulligan River exists in isolation.

The results from the current survey indicate that all fish species sampled at S-Bend Gorge either occur in breeding populations, or that juvenile migration to the area may have recently occurred, as juveniles of all species were sampled. Prior studies in both the South Australian Lake Eyre Basin (Puckridge 1999) and in Cooper Creek (Arthington et al. 2005) have suggested that in dryland river systems with unpredictable flow and flooding cycles, the breeding of some species may be advantaged by elevated flows or a series of floods.

It is suggested that a follow-up survey during another season and perhaps at a similar time of year following a drier summer be undertaken in order to yield more detailed information regarding possible linkages between fish recruitment (breeding) and elevated flows.

Fish were not sampled at either Big Kunnamuka Swamp or Ocean Bore. These results are not surprising given the isolation of both sites from permanent water. It seems likely that Big Kunnamuka Swamp filled following high rainfall in late summer 2007, however its geographical location (ie: between sand dunes) prevented colonisation by either fish or aquatic crustaceans.

In summary, results from this survey indicate that the Mulligan River at Cravens Peak appears to provide suitable habitat for at least 5 species of native Australian fish, and that the rainbowfish present may represent a local colour variant. No alien fish species were found in April 2007.

Acknowledgements

Adam Kerezsy thanks Janet Pritchard and Vanessa Bailey for inviting/allowing him to work on the Cravens Peak project and the Royal Geographical Society of Queensland for co-ordinating the April 2007 survey. Adam also thanks Mick Brigden for his help throughout April 2007, and Angus Emmott for his continued support and detailed knowledge of the natural history of western Queensland. Adam and Mick both thank Ness, Alun, Don and Joan for their company during the survey.

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Cravens Peak microbiotic crusts

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Introduction

Microbiotic crusts are found in almost all biomes worldwide and exist in habitat niches often too harsh for terrestrial vegetation. They can occur in the form of thin films of one or two species of cyanobacteria or algae, to a complex of lichens, cyanobacteria, mosses, liverworts, fungi and bacteria (Belnap et al., 2001; Budel, 2003).

Lichens, cyanobacteria and soil or rock micro-organisms are an important part of arid landscape flora providing biodiversity and maintaining a functional role that includes soil retention and stabilisation, nutrient inputs and the long-term chemical weathering of rocks (Büdel, 2003). These ancient micro-organisms perform oxygenic photosynthesis and precede early plant life. They have evolved over time, morphogenetically adapting to survive extended periods of desiccation (in a dry state), extremes in temperatures and the damaging effects of ultraviolet irradiation (Mann, 2001).

Cyanobacteria often pioneer the soil environment with the capacity to move between the soil surface or take sub-surface refuge depending on conditions, and in doing so they create mucilaginous secretions that bind the soil particles (Belnap et al., 2001). Many cyanobacteria and cyanolichens also fix atmospheric nitrogen in a form available to plants and when it rains it is flushed into the soil providing a source of nutrients in these nutrient-scarce environments (Evans and Lange, 2001).

Microbiotic soil crusts create small patches that improve resource capture – an important function of patchy landscapes (West, 1990). In this report we have provided a representation of these microbiotic crusts that inhabit the soil and rock environments of Cravens Peak Reserve, Queensland. Collections were made in 2007 from a selection of dune soils and rocky outcrops. (See Figures 36 – 44 on page 77.)

Lichens

Microlichens were commonly found in suitable microenvironments on rock surfaces but were strongly integrated with cyanobacteria and micro-fungi. We recorded 5 species of lichens (see Appendix 1, page 82).

Biogeographically, the records of lichens from these regions in Queensland are new and most of the lichens identified represent range extensions, including at least one new species that is thought to be a new record for Queensland. However, at this stage confirmation to a species level will require some further work.

Once identifications are verified the specimens will be lodged and held in the Queensland Herbarium (BRI). In some cases there were cyanobacteria overgrowing lichens, typical in regions where summer rains occur favouring the faster growing cyanobacteria. In this environment lichens were not found on soil and would not be expected to survive on the relatively unstable soil surfaces subject to summer rain at high temperatures (Rogers, 1977). (See Figure 45, page 79, Figure 46, page 79, Figure 47, page 80, Figure 48, page 80.)

Cyanobacteria and microfungi

The red-sand dune soils (Kandosols; Isbell, 2002) including slopes and swales were found to contain thin biofilms of cyanobacteria mostly consisting of two species (see Appendix 1, page 82). The most dominant was a *Phormidium* – (see Figure 49, page 81 and Figure 50, page 81) like Oscillatoria that has not been previously described in Australia. Formal identification requires culturing, complete morphological descriptions and DNA sequencing.

These cyanobacteria appear to be an important component of the dune ecosystems in this region with their web-like structures just below the surface (e.g. Lange et al., 1992). The long

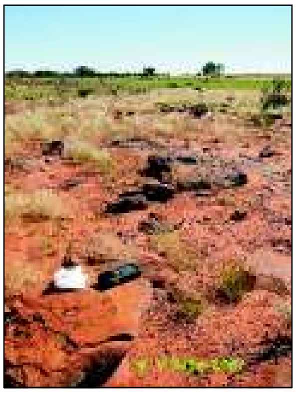
Figure 36. Site CP1. Photo: V. Bailey


Figure 37. Site CP2. Photo: V. Bailey


Figure 38. Site CP3. Photo: V. Bailey


Figure 39. Site CP4. Photo: V. Bailey


Figure 40. Site CP 5. Photo: V. Bailey

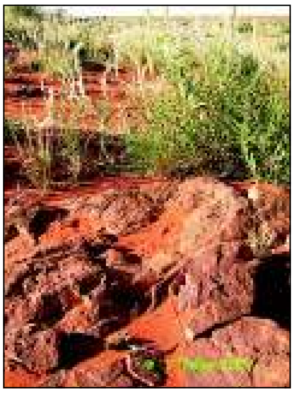
Figure 41. Site CP6. Photo: V. Bailey


Figure 42. Site CP7 close up. Photo: V. Bailey

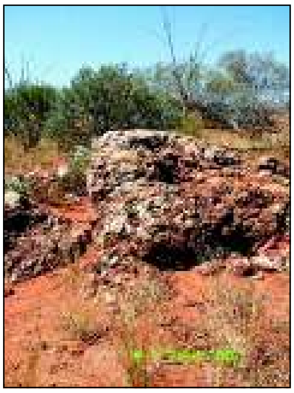
Figure 43. Site CP7. Photo: V. Bailey


Figure 44. Site CP8. Photo: V. Bailey

entangled filaments would aid in the prevention of soil loss and contribute to soil nutrients.

The other cyanobacteria soil species was *Scytonema* cf. *hofman-bangii* C. Argardh ex Bornet et Flahault 1887 which occurs commonly in arid environments including on a widespread basis in Australian soils (Willliams and Büdel, unpublished data).

Cyanobacteria on the rock surfaces were predominately epilithic (surface colonies) with just one or two species occurring together with the microfungi *Lichenothelia* sp. (See Figure 51, page 81.) (e.g. CP 1, 5 & 8). Little is known about the role of microfungi in these arid environments and as a component of microbiotic crusts (Büdel, 2003). These rocks generally had smooth surfaces with few microhabitats available for a diversity of biota. Desert varnish was a common feature of these rocks – a dark coloured surface that is derived through the precipitation of manganese or iron resulting from bacterial activity (Gadd, 2007). The cyanobacteria *Chroococcidiopsis* sp. is found across many Australian rock surfaces and dominated these samples (see Figure 46, page 79).

Sample CP 7 (see Figures 42 and 43, pages 77 and 77 respectively) had well developed microbiotic rock crusts as it contained a variety of microhabitats that typically favoured colonisation by lichens, cyanobacteria and microfungi both epilithically and endolithically (in cracks and crevasses and the natural fissures).

Summary and recommendations

Microbiotic crusts at Cravens Peak Reserve significantly contribute to terrestrial biodiversity of an arid ecosystem and are important to conserve. This is achieved by the limitation of vehicular traffic to specified tracks, exclusion of domestic stock and specified walking tracks in fragile areas.

Further more detailed surveys would be beneficial to provide greater insights and more complete records of biodiversity.

Identification of the new cyanobacteria (*Phormidium* sp.) to a species level will most likely take place as part of a current Australia-wide biogeographical project being carried out by Williams and Büdel.

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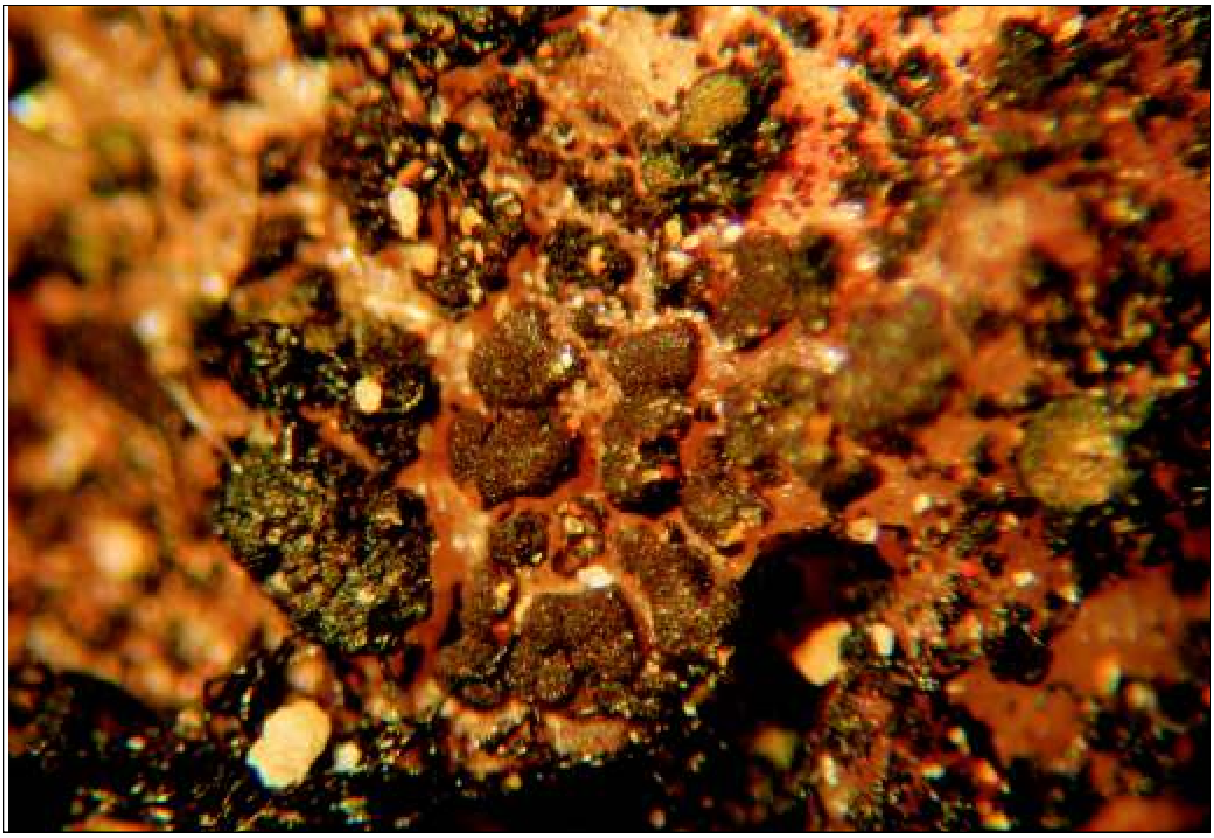

Figure 45. Site CP7a *Peltula*. Photo: W. Williams

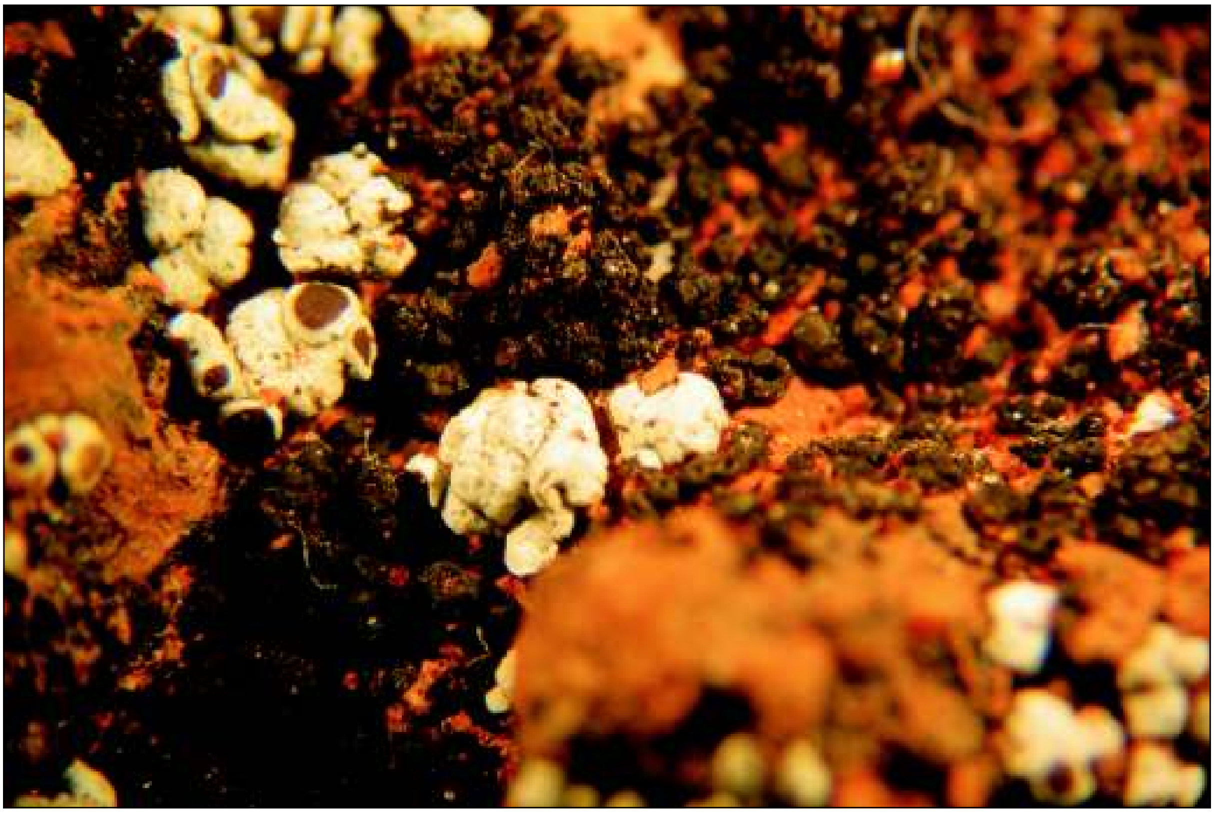

Figure 46. Site CP7b Lecanoraceae and *Chroococcidiopsis*. Photo: W. Williams

Figure 47. Site CP7c *Acarospora* sp. Photo: W. Williams

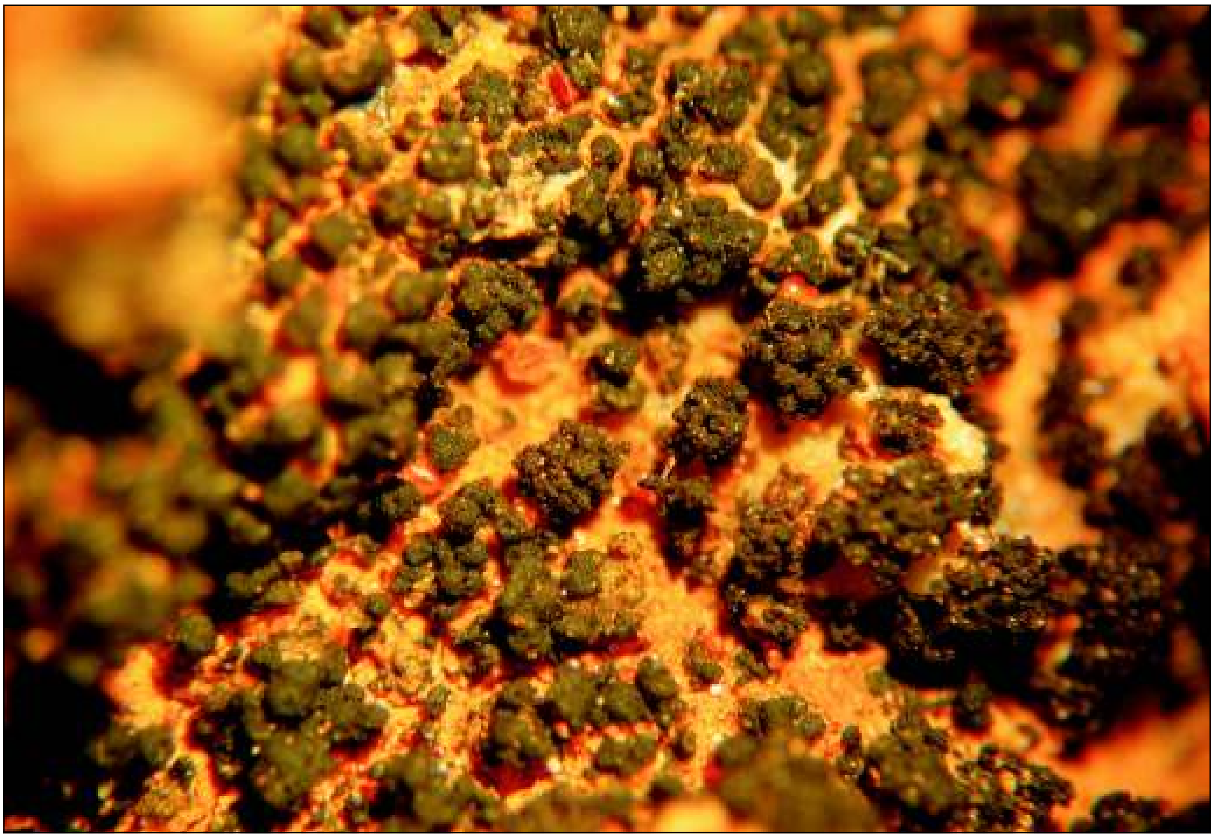

Figure 48. Site CP7d *Cyanolichen.* Photo: W. Williams

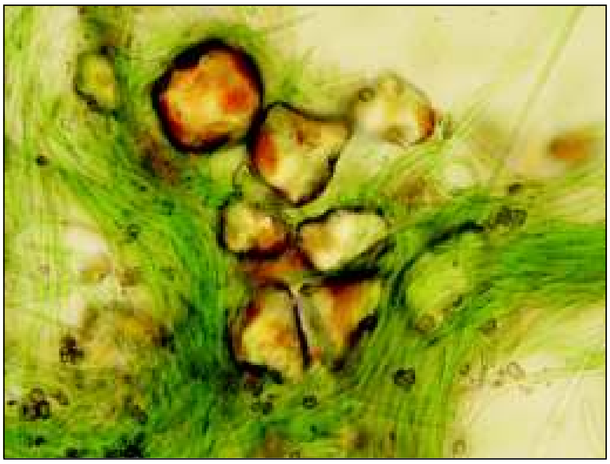

Figure 49. Site CP3 *Scytonema hofman-bangii* (400 x magnification). Photo: B Budel

Figure 50. Site CP2 *Phormidium* sp. Photo: W. Williams

Figure 51. Site CP7 *Lichenothelia* sp. Photo: W. Williams

Appendix 1. Cravens Peak Terrestrial Cyanobacteria, Micro-fungi and Rock Lichens (April 2007)

Collected by V Bailey and identified by WJ Williams and DJ Eldridge.

Location	Dune Swale (rock) CP1	Dune slope (sand) CP2	Lower slope (sand) CP3	Soil CP4	Shotline CP5	Dune rock crest Kunnamuka CP6	Rock CP7	S bend CP8
GPS Coordinates	S -23.30639 E 138.55856	S -23.3064 E 138.56101	S -23.30776 E 138.56101	S -23.20420 E 138.42736	S -23.28297 E 138.22164	S -23.36706 E 138.25658	S -23.24800 E 138.20424	S -23.06279 E 138.35293
Cyanobacteria								
Phormidium sp.		+	+	+	+			
Chroococcus sp.	+				+	+		
Chroococcidiopsis sp.	+				+		+	+
Scytonema hofman-bangii			+		+			
Scytonema sp.			+				+	
Lichens								
Lecanoraceae sp.							+	
Acarospora sp.							+	
Peltula sp. 1							+	
Peltula sp. 2							+	
Cyanolichen (unidentified)							+	
Micro-fungi								
Lichenothelia sp.					+	+	+	+
Desert Varnish	+				+			+

Some observations on the temporal activity of nocturnal small vertebrates and large invertebrates in three habitats at Cravens Peak Station in south-western Queensland

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Abstract The terrestrial nocturnal fauna of small vertebrates and large invertebrates was surveyed at Cravens Peak Station in April 2007. The primary aim was to determine if relationships could be detected between the nocturnal activity patterns of different species. Animals were surveyed prior to and after midnight in three habitats (sand dunes, plains and rocky uplands) using three sampling techniques (Elliot trapping, pitfall trapping and strip transect spotlighting). Four vertebrate species were common at the time of the study, two of which seemed to confine their activity to the first half of the night (*Lerista labialis* and *Sminthopsis macroura*), and two of which were active throughout the night (*Notaden nichollsi* and *Gehyra variegata*). Invertebrate diversity was slightly greater at the family level in all habitats in the first half of the nights sampled, but only greater in the first half of the night at the levels of order and morphospecies in two of the three habitats. The total invertebrate abundances were greater in the first half than in the second half in the two habitats most fully surveyed. Ants were the most abundant group of invertebrates recorded, and the dominant ant species varied between habitats. Surprisingly, no termites were recorded despite literature reports that all four of the common vertebrates recorded at Cravens Peak include them as a significant component of their diets.

Introduction

Cravens Peak Station is a former cattle run of over 233,000 hectares in south-west Queensland which was purchased by the Australian Bush Heritage Fund in 2005. The centre of the property lies at approximately 138°15’00" East and 23°15’00" South, the western boundary adjoining the Queensland-Northern Territory border. As with other parts of the Australian arid zone the climate is warm to very warm during the day (see Results, this report, page 87) and dry for much of the year (Pridmore and Black, this volume, page 277). Accordingly for much of the year small animals (vertebrates and invertebrates) risk desiccation and/or overheating if they are active during daylight hours. They cope with these conditions with various physiological, morphological and behavioural adaptations, and many are nocturnally active (Edney 1966; Davey 1983).

The Bush Heritage website (www.bush-heritage.asn.au) gives an overview of the landscape, vegetation and wildlife at Cravens Peak. Some 21 plant communities are represented in a landscape that varies from dunes and open plains to sandstone ridges, providing many different kinds of habitat for the abundant and diverse fauna. This diversity lends itself to investigations like the present study, making it relatively easy to concurrently assess activity trends across a wide range of taxa in different habitats.

Aside from the fact that they are usually not active during daylight hours, little is known about activity patterns within communities of terrestrial nocturnal animals. Many factors might potentially influence nocturnal activity patterns, such as thermal requirements, food availability, competitive interactions, or relative prey vulnerability relating to environmental conditions. In this study, it was anticipated that most nocturnally-active invertebrates would exhibit greater activity (and so be more evident) during the early evening, when air and ground temperatures are higher and better suited to their ectothermic physiology than would be the case in the pre-dawn morning. Furthermore, we conjectured that nocturnally-active small reptiles and amphibians would also be more active in the earlier hours of darkness; this is partly because of their ectothermy, but additionally because their diets consist mainly of large invertebrates. Predictions regarding the likely intensity of nocturnal activity in small nocturnally-active mammals are complicated by dietary considerations. We anticipated that invertebrate-feeding small mammals (e.g. dasyurid marsupials) would exhibit greater activity earlier in the night since this would allow them greater access to prey, while essentially herbivorous small mammals (e.g. native and introduced murid rodents) would show no obvious period of elevated activity during the night since access to dietary items for each species should not vary between sunset and sunrise.

Our primary aim was to document the patterns of nocturnal activity of large invertebrates and small vertebrates in three different terrestrial habitats in the western part of Cravens Peak Station. We hoped to assess the extent to which the abundances of nocturnally-active large invertebrates changed during the hours of darkness and to see whether these were coinciding with changes in the abundances of small vertebrates that are active over this same period. Secondary aims were to compare diversity between the three habitats sampled and to assess the effectiveness of a new survey method (strip spotlighting transects for small vertebrate and large invertebrate species).

Study sites

The locations of our base camp at 12 Mile Bore (138°09’09" E, 23°09’38" S) and of our study sites in the three habitats investigated are shown in Figure 1, page 85. Since we had to visit our sites several times on the nights they were surveyed we attempted to locate our study sites as close to our base camp as possible. The outcome was that sites were located at or less than twelve kilometres from that camp. Locations of the sites and site descriptions are presented in the Appendix. The study was conducted from 09/04/07 to 20/04/07. Upland sites were sampled on the evenings of the 11th, 14th and 17th (and the early mornings of the following day), dunes sites on the 12th/13th, 15th/16th and 18th/19th, and plains sites on the 13th/14th, 16th/17th and 19th/20th.

Methods

After arriving in the area and assessing what investigations were physically possible within the time constraints, we decided to restrict the collection of data to two periods during the night (approximately between 7:00 pm and 1:00 am and between 1:00 and 7:00 am). Three major habitat types (dunes, plains and foothill outcrops) were subsequently sampled.

Two different methods of assessing animal diversity and activity were used: (i) trapping (pitfall and Elliot traps), and (ii) spotlighting.

(i) Trapping

Pitfall trapping was undertaken in the dunes and plains habitats using three trap lines in each habitat (i.e. 3 x 2 = 6 trap lines total). This method was unsuitable for use in the foothill outcrops because of the rocky nature of the substrate. Each trap line consisted of six pitfall traps (20 litre buckets) set at approximately three metre intervals along a 21 metre long drift fence (Figure 2, page 86). The fences were composed of plastic damp-proofing material about 30 cm high which was set into the ground to a depth of about five cm. Each fence was supported by wooden garden stakes and stainless steel rods. Buckets were dug into the ground along each fence such that their rims were several centimetres below ground level, and the fences straddled the middle of the tops of the buckets. Small holes were punched in the bottom of the buckets to prevent water accumulating and small platforms (about 10 cm square and approximately 8 cm tall) were placed in the bottom of the buckets in an attempt to keep potential prey safe from any predators that might be present in the same bucket. Crumpled paper was also included as a potential refuge. Pitfall traps were opened around dusk every third night for a total of three nights sampling in each of the two habitats. They were inspected and cleared twice during the night at approximately six hourly intervals. Pitfall lines were closed during daylight hours (with the exception of one day – see note below at the end of the

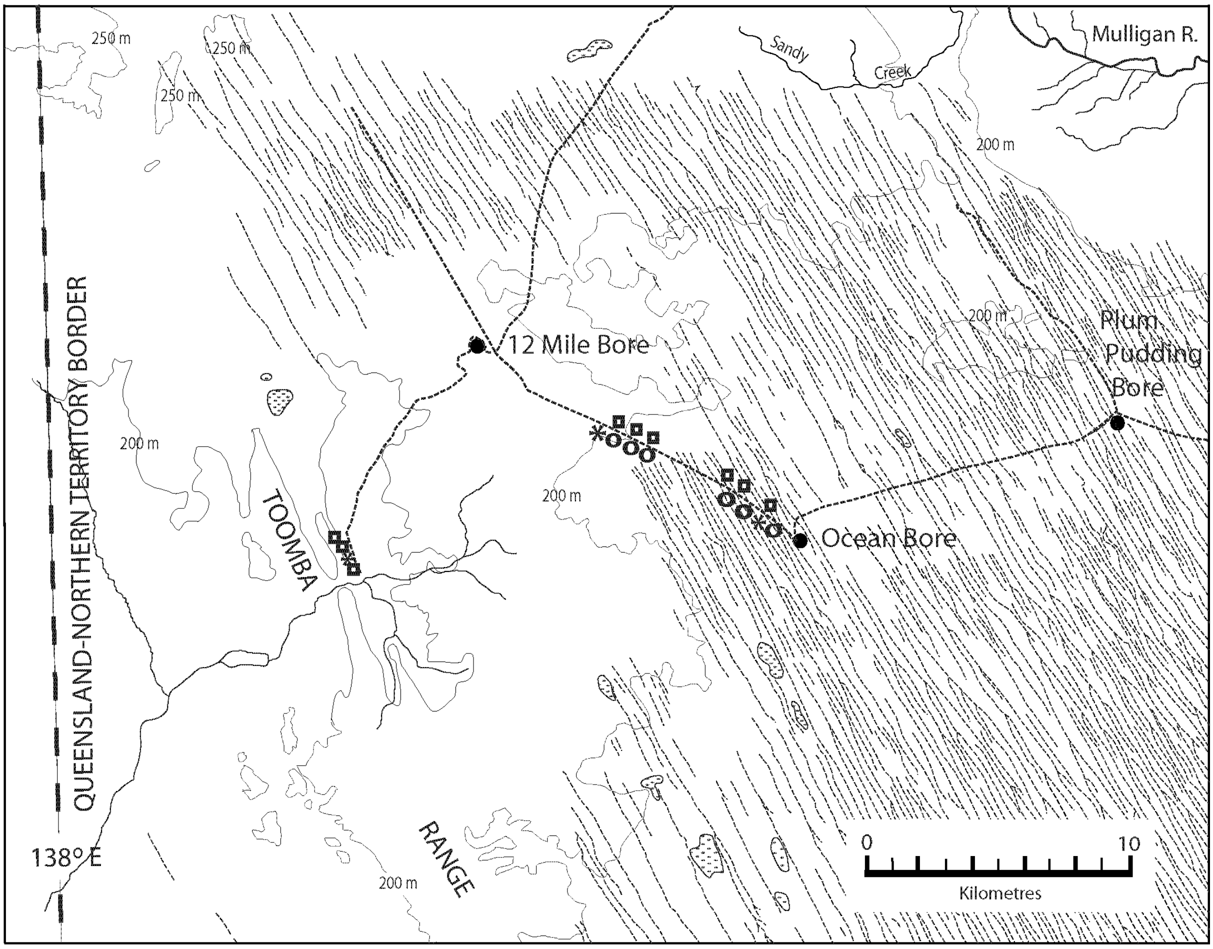

Figure 1. Locations of base camp (12 Mile Bore) and study sites. Squares indicate Elliot trap lines, open circles pitfall lines, and asterisks spotlighting strip-transects.

Results) and individual traps invaded by ants were either not opened at dusk or closed when inspected at midnight.

Elliot traps (three lines of 10 traps for each habitat, for a total of 30/habitat) were opened for three nights in each of the three habitats at three day intervals, for a total of 270 trap nights. Traps (Figure 2, page 86) were placed at approximately five metre intervals in a line. Bait consisted of peanut butter, honey and oats combined into small balls. Traps were wrapped in plastic to keep the interiors dry, and bedding material (wood wool) was provided for warmth. The trap lines were opened at dusk, then examined and cleared towards the end of the first time interval (7:00 pm – 1:00 am) and again towards the end of the second time interval (1:00 am – 7:00 am). Traps were kept closed throughout the day.

(ii) Spotlighting

One spotlight transect was located in each of the three habitats (Figure 2, page 86). Each transect was a 100 metre long strip that was six metres wide. The sides were marked at regular intervals with flags of yellow plastic tape supported by vertical lengths of wire. A measuring tape extended along the middle of the transect and provided reference points. Walkable tracks along either side of the six metre strip allowed animals to be spotted without physical interference from the observers. Spotlighting was carried out for three nights in each habitat (at three-nightly intervals in each). On a given night this involved two sessions approximately four hours apart, one before midnight (roughly between 10:00 pm and 11:00 pm) and one after (between 2:00 am and 3:00 am). The same two observers were involved for each session, each progressing along different sides of the strip at a similar pace with a hand held 50 watt spotlight and battery pack. All large invertebrates and small vertebrates spotted were recorded, and their positions along the transect noted. The sessions lasted anywhere from 20 minutes to half an hour, depending on the variable demands of data recording, and each transect strip was walked twice by each observer, once up

Figure 2. A = a pitfall trap line in plains habitat; B = the spotlight transect in rocky upland; C = an Elliot trap line being checked by one of the authors (P. Pridmore) in sand dunes.

and once back for a total of 200 metres each. Individual observers were responsible for recording only the animals sighted within the three metres on their side of the strip, and observers changed sides for the run back.

References used for identification purposes were: Cogger (2000) and Wilson and Swan (2003) for amphibians and reptiles; Strahan (1995) for mammals; Naumann (1991), Lawrence and Britton (1994) and Rentz (1996) for insects; Harvey and Yen (1989), Koch (1977) and Brunet (1996) for other arthropod groups. Animals were generally identified to family in the field, but where handling was not involved, (such as along the spotlight transects) samples were taken for identification at the base camp when doubt existed.

Results

Large invertebrates belonging to 13 orders and 25 families were found in our pitfall traps or on our spotlight transects (Table 1, page 88). Members of nine of these orders and 18 of these families were encountered in the sand dunes. In the plains habitat we encountered 12 of these orders (several represented by single specimens) and again 18 families. In the uplands four orders and seven families were encountered; however, it must be kept in mind that only one of the two invertebrate survey methods was used in that habitat. Nocturnal vertebrates belonging to a total of four orders and five families were recorded. In both the dunes and the plains habitats we found members of three of these orders belonging to three families, whereas in the upland habitat only one order and one family of nocturnal vertebrate was recorded.

Most of the invertebrates in Table 1 (page 88) have only been identified to family level and were sorted to morphospecies, whereas vertebrates were identified to species. Not listed in the vertebrates are the one dragon specimen trapped (*Ctenophorus isolepis*) and a single individual of one skink species (*Ctenotus pantherinus*) that was found. Both were most likely trapped shortly after dusk when the pitfalls were first opened, and are not considered to be normal components of the nocturnal fauna.

The four common nocturnal native vertebrate species recorded by the three methods employed are depicted in Figure 3 (page 89). Elliot trapping effort was not productive, being only successful in trapping one *Sminthopsis macroura* in the plains; this species was otherwise only found in pitfall traps in the dunes. Pitfall trapping was generally the most productive method for surveying both vertebrates and invertebrates. Trends evident in the spotlighting data generally follow those generated by the pitfall trapping data, so the results for these two methods have been combined for the data presented in Table 1 (page 88).

Two of the common vertebrate species were collected only in the first half of the night (*Lerista labialis* and *S. macroura*) while two were collected or observed throughout the night (*Notaden nichollsi* and *Gehyra variegata*). Two other species of geckoes (*Diplodactylus conspisillatus* and *Lucasium damaeum*) were trapped or sighted on only one occasion, as was the one house mouse (*Mus musculus*) encountered.

Invertebrate diversity was slightly greater at the family level in all habitats in the first half of the nights sampled, but only greater in the first half of the night at the levels of order and morphospecies in two of the three habitats. The total invertebrate abundances were greater in the first half than in the second half in the two habitats fully surveyed. The data for abundances are misleading, as on a number of occasions some pitfalls had to be closed due to the presence of large numbers of the dominant ant species. This was especially a problem in the sand dunes habitat where sometimes only half of the buckets could be left open. The number of buckets open in particular pitfall lines at particular times is given in Table 1 of Pridmore and Black, this volume, page 279.

In combination, the data from both censusing techniques indicate that orthopterans of various sorts, beetles and ants were the insect groups most frequently encountered (Table 1, page 88). Arachnids were poorly represented overall, with scorpions and wolf spiders the only groups commonly collected. The only mygalomorph spider sighted was a large therophosid observed in a burrow several metres from the edge of the plains spotlighting transect.

Invertebrate family diversity and species richness were greater in the dunes habitat than in the plains before midnight, but the reverse was true after midnight. Vertebrate abundances were much greater in the dunes over both time periods, invertebrate abundances greater in the plains. Uplands data represent only spotlighting results, so cannot be directly compared with those of the other habitats.

Temperature data were also recorded during the course of the work and are presented in Figure 4 (page 90). Temperatures at dusk were about 35°C during the course of this study, and on average about 18°C at dawn, leading to a difference of approximately 17°C between dusk and dawn, with a fairly rapid drop between 6:00 pm and midnight.

During one day the sand dune pitfall traps were deliberately left open (April 16th) to determine if *L. labialis* was active during the day as well as pre-midnight. No *L. labialis* were collected on this day, but some other expedition participants (B. Richardson and party) reported an observation of this species starting to actively move through the upper layers of sand at sunset one evening.

Table 1. Taxa of nocturnally active animals recorded from western Cravens Peak Station and their activity periods. Numbers listed in the final six columns are abundances by time period and habitat. The dominant ant morphospecies (family Formicidae) were not counted and are not included in abundance values; their presence is indicated with a "+". Numbers in brackets are mean values for the three nights sampled.

Class	Order	Family	Species	Morpho-species		Dunes		Plains		Uplands	
				PM total	AM total	PM total	AM total	PM total	AM total	PM total	AM total
Insecta	Thysanura	Lepismatidae		1	1	2	2	6	1	0	0
	Blattodea	Blattidae		2	1	4	1	1	0	0	0
	Mantodea	Mantidae		0	1	0	0	0	1	0	0
	Orthoptera	Gryllacrididae		1	0	2	0	0	0	4	0
		Tettiogoniidae		1	0	0	0	1	0	0	0
		Gryllidae		2	2	11	1	0	5	2	5
		Acrididae		1	1	4	0	5	4	3	1
	Phasmatodea	Phasmatidae		0	1	0	0	0	1	0	0
	Hemiptera	Miridae		1	1	4	1	2	3	0	0
		Nabidae		1	1	0	0	1	1	0	0
	Neuroptera	Mantispidae		1	0	0	0	1	0	0	0
	Coleoptera	Carabidae		2	1	17	7	11	9	5	4
		Scarabaeidae		1	1	5	2	0	0	0	0
		Staphylinidae		1	1	1	1	1	0	0	0
		Elateridae		1	1	1	1	0	0	1	0
		Tenebrionidae		1	1	1	0	1	2	0	0
		Chrysomelidae		1	0	1	0	0	0	0	0
		Curculionidae		1	1	1	1	0	0	0	0
	Hymenoptera	Formicidae		8	8	41+	48+	126+	95+	3+	3+
		unknown wasp		1	0	2	0	0	0	0	0
Arachnida	Araneae	Lycosidae		1	1	20	9	15	21	0	1
		Araneidae		1	0	0	0	1	0	0	0
	Scorpionida	Urodacidae		1	1	9	2	10	6	0	0
	Pseudoscorpionida			0	1	0	0	0	1	0	0
Chilopoda	Scolopendromorpha			0	1	0	2	0	0	0	0
Amphibia	Anura	Myobatrachidae	*Notaden nichollsi*			20	19	11	1	0	0
Reptilia	Squamata	Scincidae	*Lerista labialis*			7	0	0	0	0	0
		Gekkonidae	*Diplodactylus conspicillatus*			0	0	1	0	0	0
			Gehyra variegata			0	0	0	0	6	4
			Lucasium damaeum			0	0	1	0	0	0
Mammalia	Marsupialia	Dasyuridae	*Sminthopsis macroura*			3	0	1	0	0	0
	Rodentia	Muridae	*Mus musculus*			0	0	0	1	0	0
Total orders						11 (9.0)	10 (6.0)	12 (9.0)	12 (7.0)	4 (3.7)	4 (3.0)
Total families						20 (13.3)	14 (8.3)	18 (12.0)	15 (9.3)	7 (5.3)	6 (3.0)
Total morphospecies						28 (17.0)	18 (10.0)	19 (17.3)	22 (13.7)	11 (6.3)	8 (3.7)
Total vertebrate abundance						30 (10.0)	19 (6.3)	14 (4.7)	2 (0.7)	6 (2.0)	4 (1.3)
Total invertebrate abundance						126 (42.0)	78 (26.0)	182 (60.7)	150 (50.0)	18 (6.0)	18 (6.0)

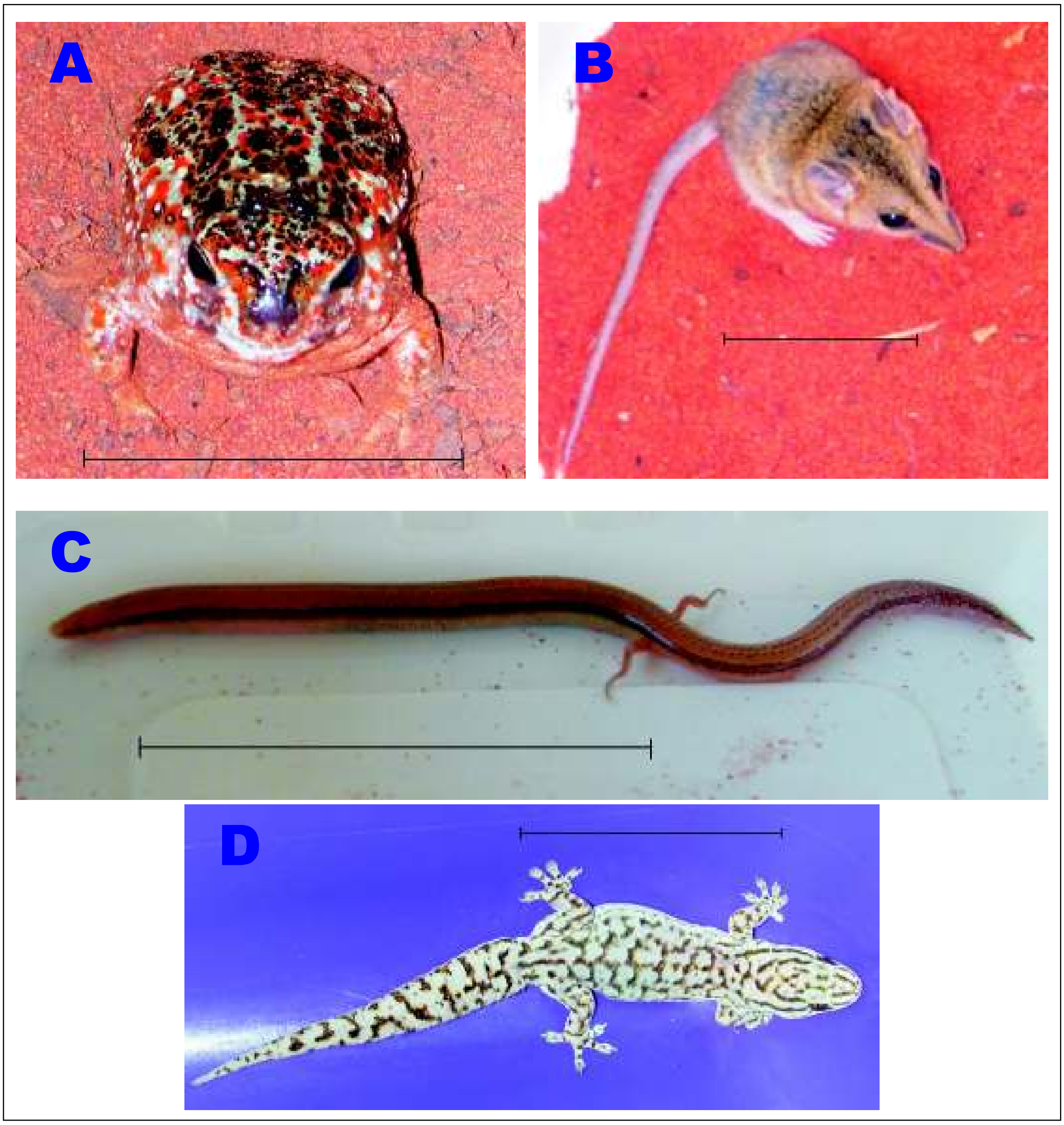

Figure 3. Nocturnally active native vertebrate species recorded in the study.
A = *Notaden nichollsi*; B = *Sminthopsis macroura*; C = *Lerista labialis*; D = *Gehyra variegata*. The scale bar equals approximately five centimetres.

Discussion

We set out to investigate whether there is correspondence in activity patterns between nocturnally-active small vertebrates and their potential invertebrate prey at Cravens Peak. Our results suggest that most surface-active arthropods were more active pre-midnight than in the early morning. These levels of activity are most likely related to both ground and air temperatures, given that these animals are ectothermic. Minimum temperatures for arthropod activity are extremely variable, which is not surprising given that the group is so diverse. They are clearly successful with their myriad adaptations to arid environments (Edney 1966; Cloudsley-Thompson 1968; Davey 1983). Minimum active temperatures for many insects appear to be about 15° C (Chapman 1969), unless they have specific adaptations for extreme cold. The drop in activity that we witnessed as night temperatures approached this point suggests that very few invertebrates at Cravens Peak would have been

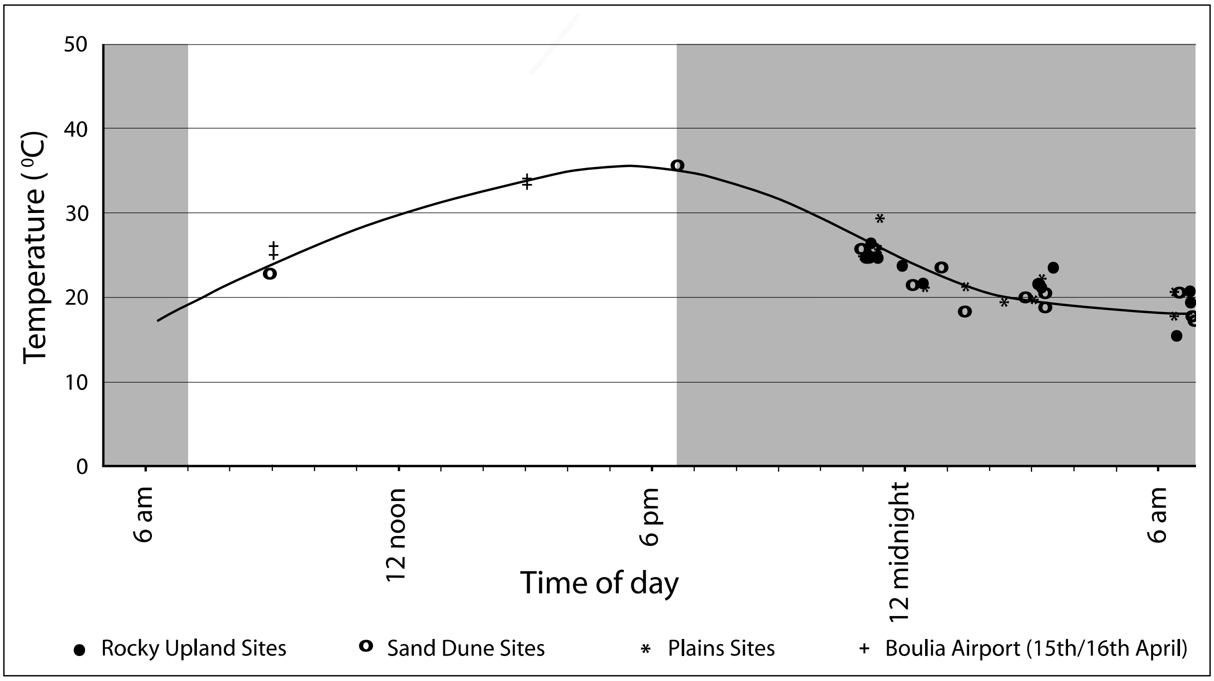

Figure 4. Temperature data for the 9th—20th of April 2007 at the study sites. Data for Boulia airport from the Australian Bureau of Meteorology website.

active below that point. The 17° difference that occurred between dusk and dawn is 3° – 4° greater than the average range for this time of year reported by Pianka (1986) for two arid regions slightly further south in central Western Australia.

Two of the 'common' small vertebrates that were collected had activity periods that coincided with the greater invertebrate activity. The thermal range over which *L. labialis* is active has not been previously reported, and the results from our study suggest the possibility that evening activity may be associated with prey availability. Another possible explanation for the pre-midnight activity might simply be the higher temperatures of the surface sand in the early evening. We cannot, therefore, be certain that there is a causal link between the activity patterns of this skink and the arthropods. Greenville and Dickman (2004) report a similar activity pattern for this species. The other small vertebrate that was active pre-midnight was *S. macroura*, an insectivore that is broad in its food preferences (Australian Museum 1995). Since it is an endotherm that could potentially be active throughout the night, its activity pattern may well be strongly linked with invertebrate availability.

The other two 'common' small vertebrates recorded (*N. nichollsi* and *G. variegata*) were active throughout the night. In *Notaden* activity patterns associated with maintaining water balance may be difficult to disassociate from foraging activity; they may need to be active whenever physical parameters are suitable (see Pridmore and Black, this volume, page 277). The maintenance of water balance is likely to be less demanding for the gecko, so that the activity of *G. variegata* is likely to reflect air temperature and/or prey availability. In a study of *G. variegata* carried out in the Pilliga scrub of northern NSW (Bustard 1968) it was found that this species suspended foraging activity below temperatures of 18° C. During the present study the post-midnight temperatures recorded in the rocky upland habitat, where this species was active, remained well above this temperature (21.5° – 23.4°). Bustard recorded that the diet of this species consists mainly of beetles, spiders and termites. At Cravens Peak this gecko was still active at the cooler time of night even though there would seem to have been lower availability of food when compared with late evening.

A secondary aim was to determine if there are some obvious differences between the faunas of the three habitats sampled. Concerning the four common vertebrates recorded, the anuran was restricted to the more pliable substrates of the sand dunes and plains, as was the dasyurid marsupial. In both species this might reflect ease of burrowing. The skink *L. labialis* is primarily subterranean, requiring loose sand for locomotion, and was therefore confined to sandy habitat. According to Bustard (1968) the gecko is mainly arboreal, but will forage on the ground. The rocky uplands with their scattered *Acacia* shrub cover obviously provided suitable habitat for this species. It is more difficult to compare the invertebrate faunas of the three habitats, particularly since the primary survey technique (i.e. pitfall traps) could not be used in the rocky uplands. The most striking difference was that the dominant ant species varied between habitats. The latter may well vary in their food quality and/or defensive capabilities, both of which would be important to their potential as prey. Clearly this needs further investigation. Although invertebrate species richness and diversity were not substantially different between the dunes and the plains, abundances appear to have been greater on the plains, mainly as a result of the greater numbers of moderately common ant species. Whether this is related to the much lower numbers of vertebrate predators at the plains sites is unclear. The numbers of invertebrate predators (carabid beetles, some ants, wolf spiders and scorpions) were similar on the dunes and plains sites, and did not vary much during the night. This suggests that relative food availability for them had little effect on their activity patterns, whereas the opposite might be true in the case of *Sminthopsis*.

A third aim was to trial a modified survey technique involving spotlighting along transects. Pitfall trapping is an effective and commonly used method for terrestrial invertebrate survey, particularly in open habitats (New 1998; Brennan et al. 2005), but the rocky upland habitat included in our study unfortunately did not lend itself to this technique. As an alternative, we trialled a modified strip-transect survey method in the rocky upland, as well as in the other two habitats. This approach has several limitations (Ogutu et al. 2006), so the data collected probably do not represent an overview of the common nocturnally-active terrestrial animals, but more a brief snapshot. The data generated confirm this; pitfall trapping in the dunes and plains sites was a much more effective survey method. Nonetheless, the transect surveys in the uplands did provide some data which would otherwise not have been available.

The limited time available may be responsible for our failure to record termites as an obvious component of the invertebrate fauna at Cravens Peak. The literature suggests that they may feature as an important proportion of the diet of all four of the common nocturnal small vertebrates that we found there (Greenville and Dickman 2004; Menkhorst and Knight 2001). Pianka (1986) reports that most of the other lizard species that we recorded from the 12 Mile Bore region (e.g. the skinks *Ctenotus ariadnae*, *C. dux*, *C. helenae*, *C. pantherinus*and the geckoes *Diplodactylus conspisillatus* and *Lucasium damaeum*) also include termites in their diets to greater or lesser degrees. Abensperg-Traun (1994) and Abensperg-Traun and Steven (1997) document a higher proportion of termite specialists in lizards and mammals in the arid zone than in mesic regions, and partly attribute this to the greater palatability of termites compared to adult ants. They also point out that the peculiarities of climate in arid regions sometimes limits termite availability. It is clear that future studies of a similar nature undertaken in the Cravens Peak area should document the diets of the common vertebrates and that invertebrate survey techniques more appropriate for termites should be employed.

Given the potential number of additional small native nocturnal vertebrate species that may occur at Cravens Peak (see the earlier survey of Gibson and Cole 1988 and the fauna list compiled by Dickman and provided to expedition participants), the six recorded during the course of this study seems relatively low, with two of these only being recorded on a single occasion. This may reflect the relatively short period of sampling, the relative effectiveness of the survey methods used, the environmental conditions prevailing at the time of the expedition, or even the lunar cycle at the time (which may differentially affect the behaviour of the species surveyed). Similar studies in the Northern Territory, South Australia and Western Australia (James 1994; Moseby and Read 2001; Thompson et al. 2005) suggest that common species are detected very quickly using pitfall traps, so perhaps our data do reflect the small nocturnal vertebrates that were common at Cravens Peak under the specific environmental conditions prevailing at the time of our study.

Our initial efforts at documenting nocturnal activity patterns at Craven's Peak should be treated as such. The aims were perhaps too ambitious, but the limited data collected suggest that there may indeed be associations between the nocturnal activity periods of particular small vertebrate species and their potential invertebrate prey. Further investigations along these lines are warranted, coupled with dietary analyses. Related to this, the moisture and temperature requirements of the species involved and the influence of moon phase on behaviour need to be documented in detail in the context of these possible associations.

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Appendix 1. Localities and descriptions of study sites

	Sand dune sites	Plains sites	Upland sites
Latitude/longitude (midpoint of sites)	23°13'03" S/ 138°14'35" E	23°11'22" S/ 138°11'49" E	23°14'32" S/ 138°06'15" E
Elevation	183—188 metres	196—205 metres	201—208 metres
Description	Flat to slightly undulating dune tops (average height 9 m); no trees except for one dune with two, shrub layer scattered and mostly dead, ground layer a few forbs but mostly grasses dominated by *Triodia basedowii*	Flat, one site with a few very shallow, dry water courses; no trees (bloodwoods 20—40 m away), scattered shrubs, mostly *Acacia murrayana* with some *Eremophila* and *Grevillea*, ground layer mostly non-*Triodia* grasses	Mostly flat mesas 20—30 m wide, but one site narrower and varying about 8 m in altitude along its length; no trees, shrub layer scattered *Acacia murrayana*, ground layer scattered grasses, herbs and small chenopods
Ground cover	10-30% vegetation, 70-90% bare sand	40-60% vegetation, 40-60% red sandy soil	30—50% vegetation, 50—70% flat rocks of variable shape and size (5 cm—3m)

Eremophila longifolia (Berrigan, long leaf eremophila). Gwenda White

Cravens Peak: A Botanical Survey

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Introduction

The following plant list is based on field identifications made by Trevor Blake during the Cravens Peak Scientific Study and is published as such. The literature listed at the end of this paper was consulted in making these identifications.

Family	Species	Location	Habitat
Acanthaceae	*Dipteracanthus corynothecus*	R	Rocky watercourse banks
Aizoaceae	*Glinus lotoides*	G	Clay creek flats
	Glinus oppositifolius	C,A	Dunes slopes & sandplains
Amaranthaceae	*Alternanthera nodiflora*	A,Q	Flats common
	Ptilotus exaltatus	E,I	Rocky hillsides & sandplains
	Ptilotus latifolius	H	Dunes & slopes
	Ptilotus leucocoma	F	Rocky hillsides & tops
	Ptilotus macrocephalus	R,E	Rocky hillsides
	Ptilotus obovatus	I	Rocky hillsides
	Ptilotus polystachyus var. *polystachyus*	D,N,A,S	Widespread, common
	Ptilotus sessilifolius	G	Sandy plains by creek
Amaryllidaceae	*Crinum flaccidum*	I, J	Creek banks, floodplains
Apiaceae	*Trachymene glaucifolia*	A	Grassy plain, periodically wet
Asclepiadaceae	*Sarcostemma viminale* ssp. *australe*	E,I,O	Clays, stony country
Asteraceae	*Calotis denticulata*	J	S Bend Gorge & flats
	Calotis porphyroglossa	I,P	Clays, floodplain
	Dichromochlamys dentatifolia	I	Stony hills
	Gnephosis arachnoidea	G,K,Q	Sandy plains
	Minuria denticulata	A,J	Clays, open plains
	Streptoglossa odora	O	Rocky plains
Boraginaceae	*Halgania* aff. *cyanea*	L,U	Swales
	Trichodesma zeylanicum	R,G	Rocky hillsides & sandplains
Byttneriaceae	*Keraudrenia nephrosperma*	L,U	Swales
	Rulingia loxophylla	L,U	Swales
Caesalpiniaceae	*Senna artemisioides* ssp. *helmsii*	G	Sandy plains
	Senna artemisioides ssp. *zygophylla*	D,N	Sandy soils & rocky soils on gorge floor
	Senna glutinosa ssp. *pruinosa*	W	Dunes tops
	Senna helmsii	S,J,U,N	Stony slopes & sandy creek banks
	Senna notabilis	C,A	Ac. georginae plains
	Senna oligoclada	I,J,N,Q,R,G	Widespread, rocky & sandy soils
Capparaceae	*Apophyllum anomalum*	T	Swales
	Capparis lasiantha	T	Swales & clays
Caryophyllaceae	*Polycarpaea spirostylis*	O	Sandy, gravelly plains

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Family	Species	Location	Habitat
Chenopodiaceae	*Dysphania kalpari*	R	Plains, drains & watercourses
	Enchylaena tomentosa	E	Rocky hillsides
	Rhagodia spinescens	G	Sandy flats
	Salsola kali	O	Gravelly sands
	Sclerolaena bicornis	S,N	S Bend gorge, sandy & rocky sites
	Sclerolaena cornishiana	B,L	Dunes slopes & sandplains
	Sclerolaena cuneata	O	Stony flats & rises
	Sclerolaena diacantha	M	Sandy swales
	Sclerolaena eriacantha	Q	Stony rises & hillsides
	Sclerolaena muricata	E,N,O	Rocky hillsides & gullies
Chloanthaceae	*Newcastelia spodiotricha*	N,T,U	Dune slopes, sparse
Convolvulaceae	*Convolvulus angustissimus* ssp. *angustissimus*	H,G,A,J	Roadsides, sandy flats & plains
	Evolvulus alsinoides var. *decumbens*	D,H,K,P	Floodplain
	Ipomoea muelleri	J,G	Floodplain & stony soils
Curcurbitaceae	*Cucumis melo* ssp. *agrestis*	J	S Bend gorge
	Cucumis myriocarpus	J, E	Disturbed sands & clays
Cyperaceae	*Cyperus alternifolius*	N,J	Wet areas gorge flats
	Cyperus difformis	P	Wet sands by water
	Cyperus gymnocaulos	P	Wet sands by water
	Fimbristylis dichotoma	G,K,Q,	Swales
Droseraceae	*Drosera indica*	P	Wet sands by water
Euphorbiaceae	*Euphorbia tannensis* ssp. *eremophila*	F	Stony & sandy flats
	Phyllanthus maderaspatensis	J	Gorge flats
Fabaceae	*Aeschynomene indica*	J	Gorge flats
	Crotalaria cunninghamii	A,V	Common on dunes
	Crotalaria dissitiflora ssp. *dissitiflora*	R	Clays by roads & edges of claypans
	Crotalaria eremaea	C,D,L,A	Dune swales & clays of floodplains
	Cullen cinereum	A,P	Colonies on floodplain
	Indigofera colutea	A	Sandy soil, grassy plain
	Indigofera linifolia	D,A	Sands, disturbed areas, roadsides
	Indigofera linnaei	D,P,R	Floodplain & disturbed areas
	Swainsona affinis	K,L,Q	Floodplain
	Swainsona burkei	N	Moister sands
	Templetonia egena	A	Sandy plains
	Tephrosia brachyodon	I,S	Dune slopes & swales
	Tephrosia sphaerospora	D	Dune slopes & swales
	Tephrosia supina	F	Rocky hillsides
Frankeniaceae	*Frankenia serpyllifolia*	N	Creek bed

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Family	Species	Location	Habitat
Goodeniaceae	*Goodenia fascicularis*	D,P	Moist sandy flats
	Goodenia lunata	L	Deep sands, swales
	Goodenia vilmoriniae	F	Sandy flats by hills
	Lechenaultia divaricata	F,L,G	Sandy plains
	Scaevola ovalifolia	U	Stony rises & floodplains
	Scaevola parvifolia	L,U	Sandy plains
	Scaevola spinescens	O	Stony rises
Lamiaceae	*Teucrium racemosum*	A	Inundated flats
Loranthaceae	*Amyema maidenii*	J	Host Ac. cyperophylla
	Amyema quandang var. *quandang*	Widespread	Host Ac. georginae
	Lysiana subfalcata	G,T	Host Euc. pachyphylla
Malvaceae	*Abutilon leucopetalum*	A	Rocky hillsides
	Gossypium australe	R	Flats by roadside
	Gossypium sturtianum	N,R	Flats by roadside & gorge area
	Hibiscus sturtii var. *sturtii*	L,U	Wet areas swales, flats, water courses
	Malvastrum americanum	R	Streambanks
	Sida cunninghamii	F,M	Stony soils
	Sida fibulifera	I	Sandy gravelly soils
	Sida filiformis	P	Rocky hillsides
	Sida platycalyx	H	Sands swales & slopes
	Sida rohlenae	A	Sandy soils
	Sida trichopoda	D	Sandy swales & flats
Marsileaceae	*Marsilea drummondii*	A,P,Q,R,N	Common, inundated areas
Meliaceae	*Owenia acidula*	A,Q,G	Sandy triodia plains
Mimosaceae	*Acacia ancistrocarpa*	A,L	Swales & dune sides
	Acacia aneura	F,S,Q	Rock slopes & red stony sands
	Acacia bivenosa	A,L,N	Dunes & sandplains
	Acacia brachystachya	E,I	Rocky hillsides
	Acacia cambagei	Widespread	Watercourses & flats
	Acacia coriacea ssp. *sericophylla*	A,N	Painted Gorge
	Acacia cyperophylla	E,J	Stony watercourses
	Acacia dictyophleba	A,F,W,G	Dune sides, grassy plains
	Acacia farnesiana	J	S Bend Gorge
	Acacia georginae	Widespread,	floodplains
	Acacia ligulata	D,S,O	Dune slopes
	Acacia murrayana	D,A,G	Dune sides & swales
	Acacia orthocarpa	F	Rocky slopes gorge area
	Acacia retivenia	B,A	Dunes & swales
	Acacia stenophylla	J	S Bend Gorge
	Acacia stowardii	L,M,N,Q	Sandy swales
	Neptunia dimorphantha	J	Claysoils,sandy areas

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Family	Species	Location	Habitat
Myoporaceae	*Eremophila duttonii*	D	Sands & slopes
	Eremophila freelingii	E,I,J,N,O	Rocky slopes gorge area
	Eremophila latrobei	E,K,Q,S,J,N	Widespread rocky soils/sand
	Eremophila longifolia	N,Q,J	Widespread,dunes plains, gullies
	Eremophila macdonnellii	I,K	3 forms, sands to rocky slopes
	Eremophila maculata ssp. *maculata*	Q,T	Sandy plains & swales
	Eremophila obovata ssp. *obovata*	D,L,U	Widespread sandy flats & moist areas
Myrtaceae	*Corymbia terminalis*	S,W	Sandy plains
	Eucalyptus camaldulensis	G,J	Creek banks, floodplains
	Eucalyptus coolabah	A,Q,J,N.T	Plains & inundated areas
	Eucalyptus gamophylla	G,T,U	Sandy plains
	Eucalyptus pachyphylla	G,Q,T,U,W	Sandy plains & swales
Poaceae	*Aristida contorta*	D	Widespread rocky soils/sand
	Aristida holathera	Q	Sandy plains & by drainage chan.
	Aristida inaequiglumis	G	Sandy alluvial plains
	Astrebla lappacea	I	Very stony hillsides
	Astrebla squarrosa	I	Stony hillsides
	Dactyloctenium radulans	C	Common disturbed areas
	Enneapogon avenaceus	C,D,F,H	Sandy plains
	Enneapogon polyphyllus	I	Rocky hillsides
	Eragrostis tenellula	R	Sandy flats
	Eulalia aurea	R	Clayey sands & floodplains
	Paraneurachne muelleri	L	Sandy plains
	Perotis rara	D	Dune slopes & swales
	Sarga timorense	P	Sandy swales
	Setaria surgens	D	Sandy soils
	Sporobolus actinocladus	I,J	Rocky slopes
	Sporobolus australasicus	J	Floodplain & gorge floor
	Triodia basedowii	D	Rocky slopes
	Triodia pungens	F,A,W,G	Sands common
Polygonaceae	*Acetosa vesicaria*	I	Sandy flats, stony hills
	Muehlenbeckia florulenta	R	Floodplain
Portulacaceae	*Calandrinia balonensis*	A,L,Q,T	Widespread sandy flats
	Calandrinia polyandra	L	Sandy plains
	Portulaca intraterranea	E,I	Stony rises
	Portulaca oleracea	O	Clays, stony country
Proteaceae	*Grevillea juncifolia*	T,G	Sandy plains
	Grevillea stenobotrya	A,Q,T,G	Dune areas
	Grevillea striata	A,O,T	Sandy plains & dune slopes
	Hakea eyreana	A,D,S,N,T,G	Sandy plains & dune slopes
	Hakea lorea	A,Q	Sandy plains & dune slopes
Rubiaceae	*Asperula gemella*	Q	Dune slopes
	Dentella pulvinata	P	Moist floodplains
Santalaceae	*Santalum lanceolatum*	G	Sands, rocky hills

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Family	Species	Location	Habitat
Sapindaceae	*Atalaya hemiglauca*	A,G,Q,J,U,O	Widespread flats, swales to dunes
	Dodonaea viscosa ssp. *angustissima*	T	Disturbed sandy areas & dunes
Scrophulariaceae	*Mimulus prostratus*	R	Moist floodplains
	Mimulus repens	P	Moist floodplains
Solanaceae	*Duboisia hopwoodii*	H	Dune areas
	Nicotiana megalosiphon	G,J	Rocky sites
	Solanum esuriale	A	Clayey flats & floodplains
	Solanum quadriloculatum	B,O	Dune slopes
Violaceae	*Hybanthus aurantiacus*	I,O	Wet areas swales, flats, water courses
Zygophyllaceae	*Nitraria billardierei*	V	Stony rises
	Tribulopis angustifolia	D,G,N	Dunes slopes & sandplains
	Tribulus astrocarpus	I.K	Sandy creek beds
	Tribulus hystrix	F	Dunes & slopes
	Tribulus terrestris	D	Disturbed sands

Location	Coordinates		Habitat
A	23° 15' 32"	138° 32' 01"	Grassy plain
B	23° 15' 41"	138° 32'18"	Dune and slopes
C	23° 19' 29"	138° 34' 21"	*Acacia georginae* plains
D	23° 19' 19"	138° 34' 03"	Dunes and slopes
E	23° 03' 50"	138° 17' 48"	Rocky gully and stony hilltops
F	23° 03'	138° 21'	S Bend rocky hills camp area
G	23° 04' 27"	138° 18' 16"	Red gum creek and flats
H	23° 04' 33"	138° 18' 18"	Dunes
I	23° 01' 23"	138° 12' 28"	Salty Bore: Very stony hills and flats
J	23° 03' 57"	138° 21' 07"	S Bend gorge and flats
K	23° 01' 32"	138° 14' 56"	Stony rises east of Salty Bore
L	23° 05' 44"	138° 10' 29"	Dunes and swales
M	23° 12' 44"	138° 07' 58"	Swale, Plum Pudding to Ocean Bore
N	23° 10' 23"	138° 08' 15"	Painted gorge
O	23° 14' 38"	138° 07' 53"	Stony rises, 12 ml. to Salty Bore
P	23° 15' 29"	138° 31' 55"	Flood plain
Q	23° 12' 06"	138° 25' 20"	Wet flats
R			H/S to gate. *Acacia georginae* flats
S	23° 10' 57"	138° 11' 04"	Sandy Plains, Ocean Bore to 12 ml.
T			Dunes and swales to 12 ml. from S Bend T/O
U	23° 04' 23"	138° 11' 15"	12 ml. to Salty Bore, Dunes and swales
V	23° 14' 19"	138° 12' 39"	Dune top above stony rises
W	23° 13' 48"	138° 28' 45"	Dune top

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Butterflies and Moths (Lepidoptera) of Cravens Peak Bush Heritage Reserve

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Abstract The butterfly species recorded from Cravens Peak are listed and the moth families, and in some cases subfamilies, are listed and the number of species recorded is given. The conditions of the survey and methods used are discussed. Brief comments are provided on some species of particular interest that were recorded and some notable features of the moth fauna highlighted. A few moth groups that were not recorded are discussed and possible reasons for their absence are suggested.

Introduction

The purpose of the survey was to collect and prepare specimens of moths and butterflies for identification to family level and to provide baseline data to help characterise the current moth fauna. The opportunity was taken to also collect selected moths for DNA sampling and subsequent analysis. Cravens Peak, on the north-eastern margin of the Simpson Desert and the western margin of the Channel Country, is an ideal place to survey the fauna of both regions.

The nearest site to the survey area for which the butterflies have been listed is the Selwyn Range, about 250 km to the northeast of Cravens Peak (Woodger, 1990, 1991a, 1991b, 1997). Woodger recorded 31 species from the Selwyn Range. Some butterflies were recorded from the far north-east of South Australia by Grund & Hunt (2001).

No moth collecting had previously been done in the area. Previous collections have been made at several locations on the Birdsville Track by Murray Upton in September 1972 and between Longreach and Dajarra in May 1973 by E.D. Edwards. The closest previous collecting sites were at Illungnarra Waterhole (22° 18'S 137° 52'E) on the Plenty Highway just over the NT border west of "Tobermory" and on the Donohue Highway on "Herbert Downs" (23° 02'S 139° 18'E) both in October 1978 and again the collections were made by E. D. Edwards. All these samples were single night collections and not surveys. There are no published records of any of these collections but the material was available for comparison with the Cravens Peak collections in the ANIC.

Moths and butterflies of the Channel Country and Simpson Desert have remained until now almost completely unstudied; this survey is the first to provide published information on the moths and butterflies.

Methods

The survey was conducted over two weeks from 10 to 23 April 2007.

Moths were collected by attracting them to light at night. The light was run by a generator and was suspended from a pole in front of a white sheet strung between two poles. Moths were collected when they alighted on the sheet near the light.

Light collecting was carried out in a place as sheltered from the wind as possible. The open nature of the plant communities present meant that shelter from wind was often difficult to find and collecting was confined to thickets in creek lines, in swales or behind mallee eucalypts in the lee of sand hills and behind occasional patches of denser vegetation in depressions.

The homestead and out-camps were naturally situated where water was available in rivers or bores. Before the property became a reserve these bores provided water for stock and concentrated stock in their vicinity. This meant that grazing was heaviest round the watering points and the vegetation most damaged near these locations. Collecting took place as far away from the camps as possible in order to collect in vegetation in the best condition available.

Because rain had fallen immediately before the collecting period very large numbers of small bugs (water bugs, spinifex bugs, plant hoppers, rutherglen bugs), midges and crickets were attracted to the light. These insects made collecting very uncomfortable; either a net had to be worn over the face impairing vision or ears had to be blocked and eyes protected as far as possible. The large numbers of bugs and of a few very common moths also meant that searching the sheet for different species was laborious and that many moths were battered or damaged before they could be extracted from the scrambling mass of insects on the sheet. Others were deterred from alighting on the sheet by the mêlée or left the sheet after a short, continually disturbed, visit.

Because of the very large numbers of non-target insects attracted the usual collecting methods were modified in several ways. The lowest-power light available was run, a 160 watt blended lamp (a mercury vapour bulb with an incandescent filament acting as a choke) rather than a 250 watt MV lamp plus separate choke which we have used on previous surveys. A single lamp was run because, had two (a more usual number) been run, then the mêlée round the light would have damaged any moths coming to the unattended light beyond recovery before they were collected. The light was run from 7.00 pm (dusk) until 10 pm. Collecting ceased at 10 pm because of the vast build up of bugs, midges and crickets and a fall off in the numbers of new moths coming to the light. However, had collecting continued all night further species would have been recorded although only a few relative to the catch early in the night.

Moths were killed in bottles containing cyanide or preserved alive for DNA analysis. Moths killed in cyanide were pinned the next morning and in the case of micro moths were partially spread in small plastic boxes and then allowed to dry.

Moths kept alive were anaesthetised in cyanide but removed before they died and the abdomen excised and placed in absolute ethanol for subsequent DNA analysis. The moths were then pinned and killed in cyanide as voucher specimens. Cyanide was used to anaesthetise the moths because the usual method of cooling in a refrigerator was impracticable under the hot conditions and the limited power available for the vehicle fridges. These specimens will constitute a very useful DNA resource for future study both in CSIRO Entomology, in the international Consortium for the Barcode of Life initiative (University of Guelph, Canada) and the Tree of Life project (University of Maryland, USA).

The specimens collected are available for study in the Australian National Insect Collection (ANIC).

Collection Sites

Collection sites are shown in Table 1 (page 103).

Results

Butterflies

Few butterflies were collected during the survey and the records listed in Table 2 (page 104) are mostly observations. A total of 16 species was recorded, some of which represent considerable range extensions on previously known distributions.

Moths

A rough estimate of the number of micro moths collected was 1700. A rough estimate of the number of macro moths collected was 660. A total of 376 species was collected and the number of species in each family is shown in Table 3 (page 105).

Parts of several hundred specimens were preserved in 100% ethanol for future DNA analysis. The remainder of these specimens were preserved dry for identification and as voucher material. These specimens represent a wide range of moth taxa.

Comments

Butterflies

There is no doubt that few of the butterflies would have been seen without the timely rainfall experienced by Cravens Peak before the survey. This is true of butterflies because they have not adapted well to the arid areas of Australia and so a high proportion of the butterflies that do occur in the area tend to be opportunists. The moths on the other hand have adapted well to arid Australia and the proportion of opportunists which responds after rain is lower. A more thorough butterfly survey could be expected to yield quite a few more species. Perusal of the distribution maps in Braby (2000) will show that several of the butterflies are recorded from the north-eastern edge of the Simpson Desert for the first time.

Eurema herla (Macleay) (Pieridae) was collected at S Bend on the Mulligan River in a shady place beside the river. The site represents

Table 1. Collection Sites at Cravens Peak

Date	Location	Coordinates	Altitude	Description
10-Apr-07	Near Salty Bore	23°01.218'S 138° 13.664'E	204 m (670 feet)	Rocky drainage line with *Acacia georginae*, *Eremophila* spp.
11-Apr-07	Near Salty Bore	23° 02.194'S 138° 12.736'E	216 m (710 feet)	Dry creek bed with *Acacia georginae*, *A. cyperophylla*, *Eremophila* spp.
12-Apr-07	Near Salty Bore	23° 01.660'S 138° 13.611'E	204 m (670 feet)	Dry creek bed with *Acacia georginae*, *Eremophila* spp.
13-Apr-07	Near Salty Bore	23° 01.996'S 138° 12.994'E	210 m (690 feet)	Dry creek bed with *Acacia georginae*, *A. cyperophylla*, *Eremophila* spp.
14-Apr-07	S bend in Mulligan River where it traverses Toko Range	23° 03.842'S 138° 21.335'E	171 m (560 feet)	River bank, *Eucalyptus camaldulensis*, *Acacia georginae*, *A. cyperophylla*, *Eremophila* spp., grasses, herbs
15-Apr-07	near 2-pickets	23° 05.549'S 138° 18.843'E	192 m (630 feet)	Sandhill and swale, *Acacia georginae*, *Eucalyptus pachyphylla*, *Triodia* sp., grasses, herbs
16-Apr-07	near 2-pickets	23° 04.512'S 138° 18.453'E	192 m (630 feet)	Level sands near sandhills, *Corymbia terminalis*, *Atalaya hemiglauca*, *Senna artemisioides*. *Eremophila* spp., *Zygochloa paradoxa*, other grasses and herbs
17-Apr-07	near 12 mile Bore	23° 11.053'S 138° 11.275'E	201 m (660 feet)	Green depression, *Corymbia terminalis*, *Senna artemisioides*, *Acacia georginae*, *Eremophila* spp., *Hakea eyreana*, grasses, herbs
18-Apr-07	The Gap, Toomba Range	23° 14.817'S 138° 06.091'E	186 m (610 feet)	Dry creek bed traversing gap in rocky hills, Very mixed vegetation with *Eucalyptus camaldulensis*, *Senna artemisioides*, *Acacia georginae*, *Eremophila* spp., *Hakea eyreana*, *Grevillea striata*, numerous grasses and herbs
19-Apr-07	North of 12 mile Bore	23° 07.078'S 138° 10.231'E	201 m (660 feet)	Sandhill and swale, *Eucalyptus gamophylla*, *Calandrinia balonensis*, *Triodia* sp, sparse grasses and herbs
20-Apr-07	The Gap, Toomba Range	23° 14.842'S 138° 05.858'E	186 m (610 feet)	Dry creek bed traversing gap in rocky hills, Very mixed vegetation with *Eucalyptus camaldulensis*, *Senna artemisioides*, *Acacia georginae*, *Eremophila* spp., *Hakea eyreana*, *Grevillea striata*, numerous grasses and herbs
22-Apr-07	South of Sandhill Bore	23° 16.997'S 138° 32.785'E	152 m (500 feet)	Sandhill and moist depression, *Acacia georginae*, *Eremophila* spp., *Triodia*, *Marsilea* sp. Grasses, herbs
23-Apr-07	Two km N of Cravens Peak Homestead	23° 18.308'S 138° 32.785'E	143 m (470 feet)	Sandy creek-line in flat plain, *Corymbia terminalis*, *Acacia georginae*, *Senna artemisioides*, *Eremophila* spp., grasses, herbs

the edge of its range, the nearest recorded locality being the Selwyn Range. It is possible that it is a permanent resident in favoured sites at Cravens Peak.

The small lycaenid, *Zizula hylax attenuata* (Lucas), was collected near the homestead. The record from Cravens Peak is way outside its recorded distribution although not really surprising as it is known from the Queensland coast and from the Alice Springs area. Clearly it is better established in the arid zone than previously believed.

Another small lycaenid, *Famegana alsulus alsulus* (Herrich-Schäffer), was very common at Cravens Peak. It has also rarely been recorded from the arid zone but it is clearly well established in the Channel Country and northern Simpson Desert. The nearest previous record is from the Selwyn Range (Braby, 2000).

No Hesperiidae (skipper butterflies) were recorded. There are several species (for example *Croitana arenaria* Edwards, *Taractrocera anisomorpha* (Lower) and *Taractrocera ina* (Waterhouse) which should

Table 2. Larvae observed on *Cullen* sp. (Fabaceae), *Neptunia* sp., *Senna* spp. (Fabaceae)

Family	Species	Location	General behaviour	Larval Foodplants
Papilionidae	*Papilio demoleus*	Common at all sites	Mobile and migratory	Larvae observed on *Cullen* sp. (Fabaceae)
Pieridae	*Catopsilia pyranthe*	Homestead, single record only	Mobile and migratory	*Senna* spp. (Fabaceae)
Pieridae	*Eurema smilax*	Common at all sites	Mobile and migratory	*Neptunia* sp., *Senna* spp. (Fabaceae)
Pieridae	*Eurema herla*	S Bend on Mulligan River	Sedentary	*Senna* spp. (Fabaceae)
Pieridae	*Belenois java*	S Bend & Homestead	Mobile and migratory	*Capparis* spp. (Brassicaceae)
Nymphalidae	*Danaus chrysippus*	Observed at all sites	Mobile and migratory	*Marsdenia* sp., *Sarcostemma* sp. (Apocynaceae)
Nymphalidae	*Junonia villida*	Observed at all sites	Mobile and migratory	Many foodplants
Nymphalidae	*Hypolimnas bolina*	Common at all sites	Mobile and migratory	Many foodplants
Lycaenidae	*Jalmenus icilius*	Near 2-pickets, the Gap and Homestead	Sedentary	Larvae observed on *Senna artemisioides* (Fabaceae)
Lycaenidae	*Theclinesthes miskini*	Near 2-pickets and Homestead	Sedentary	Adults flying around *Atalaya hemiglauca* (Sapindaceae) and *Acacia georginae* (Fabaceae)
Lycaenidae	*Theclinesthes serpentata*	The Gap	Sedentary	Adult flying around *Rhagodia* sp. (Chenopodiaceae)
Lycaenidae	*Nacaduba biocellata*	Common at all sites	Sedentary	Adults flying around *Acacia* spp. (Fabaceae)
Lycaenidae	*Lampides boeticus*	Common at most sites	Mobile and dispersive	Adults visiting *Crotalaria* spp. (Fabaceae)
Lycaenidae	*Famegana alsulus*	Very common at all sites	Sedentary	Fabaceae
Lycaenidae	*Zizina labradus*	Very common at all sites	Sedentary	Fabaceae
Lycaenidae	*Zizula hylax*	Near Homestead	Sedentary	*Hygrophila* sp., *Ruellia* sp. (Acanthaceae)

be present and all of these feed as larvae on grasses. Populations of surviving species could be very low indeed and they do not respond rapidly to rain and it may take several good seasons for them to build up in numbers.

Mistletoes were scarce on *Acacia georginae* but one, probably *Amyema quandang* (Loranthaceae) (it was not in flower), was present. Several mistletoes were also present on mallee eucalypts. The lycaenid (blue) butterfly *Ogyris amaryllis meridionalis* (Bethune-Baker) whose larvae feed on mistletoes is found throughout the arid zone but none were observed at Cravens Peak in spite of some effort to watch for them flying around mistletoe.

The small lycaenid (blue) butterfly, *Zizeeria karsandra* (Moore), was not taken. It could be expected in the area and its larval food plant *Tribullus* sp., (Zygophyllaceae) was common. Small blue butterflies are difficult to distinguish in flight and only a few samples were taken so this species could easily have been missed. This species may be more dispersive than the other small lycaenids as it is found commonly in arid southern New South Wales in some years but is mostly absent. It is a regular inhabitant of much of Queensland and northern Australia.

Another small blue lycaenid, *Theclinesthes albocincta* (Waterhouse), could be expected although it was not recorded from the area. The

Table 3. List of Moth Families recorded from Cravens Peak

Family	Subfamily	Number of species
Nepticulidae		1
Opostegidae		2
Psychidae		5
Tineidae		7
Galacticidae		2
Gracillariidae		3
Yponomeutidae		1
Plutellidae		1
Oecophoridae		62 (16.5%)
	Oecophorinae	50
	Xyloryctinae	11
	Stenomatinae	1
Hypertrophidae		8
Coleophoridae		5
Ethmiidae		2
Cosmopterigidae		39
Gelechiidae		30
Scythrididae		19
Lecithoceridae		1
Cossidae		3
Tortricidae		9
Limacodidae		4
Cyclotornidae		2
Alucitidae		1
Pterophoridae		1
Pyralidae		51 (13.5%)
	Galleriinae	1
	Epipaschiinae	1
	Endotrichinae	1
	Phycitinae	21
	Crambinae	4
	Scopariinae	6
	Schoenobiinae	1
	Odontiinae	1
	Glaphyrinae	1
	Pyraustinae	14

Family	Subfamily	Number of species
Geometridae		17 (4.5%)
	Ennominae	5
	Oenochrominae	6
	Geometrinae	1
	Sterrhinae	3
	Larentiinae	2
Uraniidae		
	Epipleminae	1
Lasiocampidae		4
Anthelidae		5
Sphingidae		6
Notodontidae		
	Notodontinae	1
	Thaumetopoeinae	1
Lymantriidae		1
Arctiidae		1
Aganaidae		1
Nolidae		7
Noctuidae		72 (19%)
	Hypeninae	1
	Catocalinae	25
	Plusiinae	1
	Euteliinae	1
	Bagisarinae	2
	Acontiinae	15
	Agaristinae	1
	Amphipyrinae	6
	Hadeninae	2
	Noctuinae	5
	Stirriinae	3
	Heliothinae	10
Total		**376**

larvae of this species feed on *Adriana* sp. (Euphorbiaceae) which grows on the crests of sand hills. The food plant is known from the area but has a very patchy distribution and none of the sand hills searched had *Adriana* sp. growing on them. The butterfly is sedentary and would not be found away from the food plant.

Moths

The total of 376 species collected at Cravens Peak compares with 518 from Musselbrook which is a seasonally wetter environment with a greater and more reliable wet season rainfall and with 786 for White Mountains with more diverse vegetation and much higher and more reliable rainfall. The figures are vaguely comparable because they were all made using roughly the same collecting effort, techniques and at the same time of year. However comparisons of the proportions of different families will be more meaningful than comparisons of absolute numbers of species. These figures may be compared with a survey of the Edgar Ranges, about 150 km SE of Broome, WA, where 517 species were collected (Common & Edwards, 1981). In some families at Cravens Peak, the rain prior to the survey would have boosted the numbers significantly but less so than with the butterflies. This is because a higher proportion of the butterflies are mobile and migratory. Some moth families, like the Sphingidae and Noctuidae, have a significant proportion of mobile species but most would be permanent residents and relatively sedentary. The boost in numbers of most moths due to the rains, therefore, probably resulted from emergence of adults from local pupae rather than immigration. It is also likely that the diversity and numbers of moths were reduced by the previous history of overgrazing and drought on the Cravens Peak property but given several years of good rainfall numbers could largely recover in step with the recovery of the vegetation. The diversity may increase through the spread of species from adjoining less damaged properties as the vegetation recovers. Certainly there is a significant surviving fauna on which to base a recovery, now that Cravens Peak is managed by the Australian Bush Heritage Fund for conservation purposes. This survey, although not quantitative in terms of numbers of specimens, will represent useful base-line information by which the future recovery of biodiversity may be measured.

The arid nature of the climate is reflected in the moth fauna by the higher percentage of some groups than is found in moister localities. The genus *Homadaula* in the family Galacticidae is widely represented in the arid zone and a few species enter the seasonally dry monsoon habitats. There are four described species and at least another four known; two were taken at Cravens Peak. The larvae are known to web phyllodes of *Acacia*. The genus *Paratheta* in the Scythrididae is also particularly well represented in the Australian arid zone and one species is known with larvae which form galls on Galvanised Burr, *Sclerolaena* sp. (Chenopodiaceae). Other species probably feed on other chenopodiaceous plants. There are three described species in the genus but the estimate of the Cravens Peak fauna is about 19 species which is an indication of how little is known of the genus. The genus *Coleophora* in the Coleophoridae has some species also associated with Chenopodiaceae and they are also well represented, by Australian standards, at Cravens Peak. The Noctuidae subfamilies Stirriinae and Heliothinae were also well represented. These are usually flower or seed feeders on Asteraceae, Malvaceae or Poaceae, all families well represented at Cravens Peak and which responded rapidly to the rain by prolific flowering and seeding.

Some species collected are widespread in the arid zone of Australia but because there has been very limited collecting in the interior some, well known from the NT or WA, were previously unknown from Qld. A notable example is the species *Dinophalus cyanorrhoea* (Lower) (Geometridae) originally described from Alice Springs but since found also in arid WA (Common & Edwards, 1981). The larvae of this species will almost certainly be found on Proteaceae, probably *Grevillea* or *Hakea*. Another example is *Macrobathra* sp (Cosmopterigidae), which will be mentioned later, whose larvae produce terminal galls in stems of *Senna*.

Gracillariidae

In Australia there is a group of giant Gracillariidae which form terminal galls in the stems of *Eremophila* (Myoporaceae) (Zborowski & Edwards, 2007 p. 32). Several species were collected at Cravens Peak which marks the northern-most distribution of this group of moths. The genus and species in this group are undescribed and unstudied.

Oecophoridae

This family usually dominates the moth fauna in Australia except in the moist tropical rainforests of northern Cape York Peninsula. At Cravens Peak, where it made up 16.5% of the catch, it was only exceeded by the number of Noctuidae (19%). The dominance of Oecophoridae is usually so marked that collecting them is taken for granted and the first night of the survey when none appeared elicited surprise and concern about the results to be expected from the survey. Subsequent nights redressed the imbalance. It is usual for many new species of Oecophoridae to be taken in any survey of poorly known areas and Cravens Peak was no exception with some interesting novelties. The Cravens Peak Oecophoridae were dominated by species of mostly a white colour. This corresponds with a similar bias in the collection from Herbert Downs in 1978 but at a very different season (October). This contrasts markedly with a predominance of yellow species collected from around Alice Springs also in October. There is no available explanation of why this should be.

Two species of the genus *Notodryas* sp. (four described species and 15 undescribed, endemic to Australia) were collected. These are tiny moths with much reduced hindwing venation with one of the known species associated with *Eucalyptus* as the larval food plant (Common, 1997). Both species are undescribed but one of them was known previously from a single specimen from Tibooburra, NSW. Both are silvery white with pale brown markings.

The well known *Trisyntopa euryspoda* Lower whose larvae feed in parrots nests was taken at only one site, not far from a stand of large *Eucalyptus* in a depression which may have provided a nesting site for some of the larger parrots. The question arose whether the moth may be associated with the budgerigar but adults were not found in many of the places where budgerigars were breeding. With budgerigar breeding so dependent on irregular rains it is possible they are not a suitable host for the moth. Much more work on the host range of the moth is needed (Edwards et al., 2007).

Gelechiidae

Australia has a large arid zone fauna of the genus *Pexicopia* in the subfamily Pexicopiinae. These were first studied by Ian Common following field work in south-western Qld and north-western NSW when 16 species were recognized (Common, 1958). At Cravens Peak nine species were collected. The larvae of these moths feed on the fruit of Malvaceae, usually herbs and shrubs, which are plentiful in the arid zone.

Cosmopterigidae

The Cosmopterigidae were dominated by the very large genus *Macrobathra* which is very well represented in the arid zone. At Cravens Peak, 15 species were collected. The larvae feed on *Acacia* (Fabaceae) and *Senna* (Fabaceae) and clearly each species of food plant is host to multiple species of moths. The small group of species in *Macrobathra* which cause terminal shoot galls on *Senna* was represented by one species, a new record from Queensland, which was previously known from WA and the NT. None of the *Senna* group has been described.

Tortricidae

A single specimen of the newly described genus *Ixonympha* (Horak, 2006) was collected in sand hills. This genus is known to feed as larvae on the newly deployed seed of mistletoes (that is, seed after it has passed through the gut of a bird and been deposited on a branch). These endemic moths are widespread in Australia and are known from one described and two undescribed species. At the collection site the mallee eucalypts growing on the slopes of the sand hills were infested with several species of mistletoe, including *Lysiana* sp.

Cyclotornidae

Two large species were taken at the Gap. One of these belongs to the straw-coloured group of species, of which none have been described, but which is found widely across northern Australia. This is probably a new one and occurs in a much more arid and southerly environment than any previously known species. The Cyclotornidae are endemic to Australia and carnivorous with a fascinating and complex biology involving external parasitism on leaf hoppers and predation of ant larvae.

Lymantriidae

The genus *Leptocneria* has always been an enigma. It contains two species, *L. reducta* (Walker) which is found widely in northern Australia south to southern NSW (Zborowski & Edwards, 2007) and *L. binotata*, Butler found in more tropical and often semi arid areas. It is a fairly isolated genus endemic to Australia. The known larval food plant of *L. reducta* is the white cedar, *Melia azedarach* (Meliaceae), which is a tree widespread from the Middle East to southern NSW and is found in rainforest margins and monsoon forests but is also planted widely for shade in the semi arid zone. The moth has also been reported as feeding on the related red cedar, *Toona ciliata*, which is also a widespread tree but confined to rainforests. The inconsistency of an endemic moth genus feeding only on very widespread plants, almost certainly not of Australian origin, has always been a puzzle. At Cravens Peak two female *L. reducta* were collected one night in sand hill country near 2-Pickets (23°05.549'S 138°8.834'E). That two moths were taken rather than one, suggests they were not strays. Moreover, females are much less agile than males so their origin was probably quite near 2-Pickets. There was certainly no *Melia azedarach* growing for many kilometres of 2-Pickets but there was a stand of *Owenia acidula* (Meliaceae) growing nearby, although a quick search failed to find signs of larval occupation. Nevertheless it seems very likely that *Owenia* is the native food plant of *Leptocneria* and that the moths transferred to *Melia azedarach* and *Toona ciliata* when those plant species became widespread in Australia.

The larvae of *L. reducta* are clothed in long hairs which cause urtication in humans. The larvae of *L. binotata* have been discovered in Darwin feeding on the neem tree, *Melia indica*, by P. Whelan and they are also urticating.

Castniidae

Unlike the surveys of Musselbrook (Edwards, 1998) and White Mountains (Edwards, 2004) no species of the day-flying Castniidae were collected or observed in spite of some searching. Nevertheless one of the family's preferred food plants, the grass *Chrysopogon fallax* (Poaceae), was present along creek lines and conspicuous because of its rapid seeding after the rain. No species of Castniidae is known from the Channel Country or Simpson Desert but with suitable food plant present one may eventually be found.

Pyralidae

The subfamily Midilinae is represented in the drier parts of Qld by several genera but particularly by *Styphlolepis*. These are large, heavy bodied moths the larvae of which all bore in the trunks or roots of *Capparis* (Brassicaceae). While *Capparis* is present at Cravens Peak (particularly at the Gap where several trees were examined) it seemed too sparse to support *Styphlolepis* and indeed no specimens were taken. However, trees at the Gap did show signs of very old tunnelling in the dead trunks so *Styphlolepis* may once have been present and may still persist in unsurveyed places.

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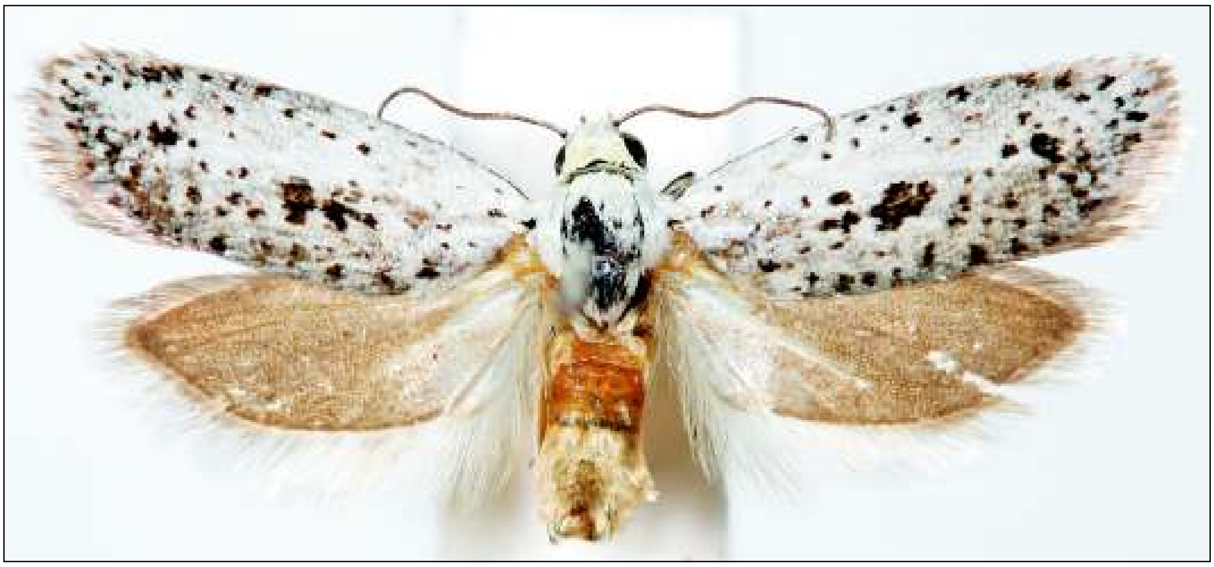
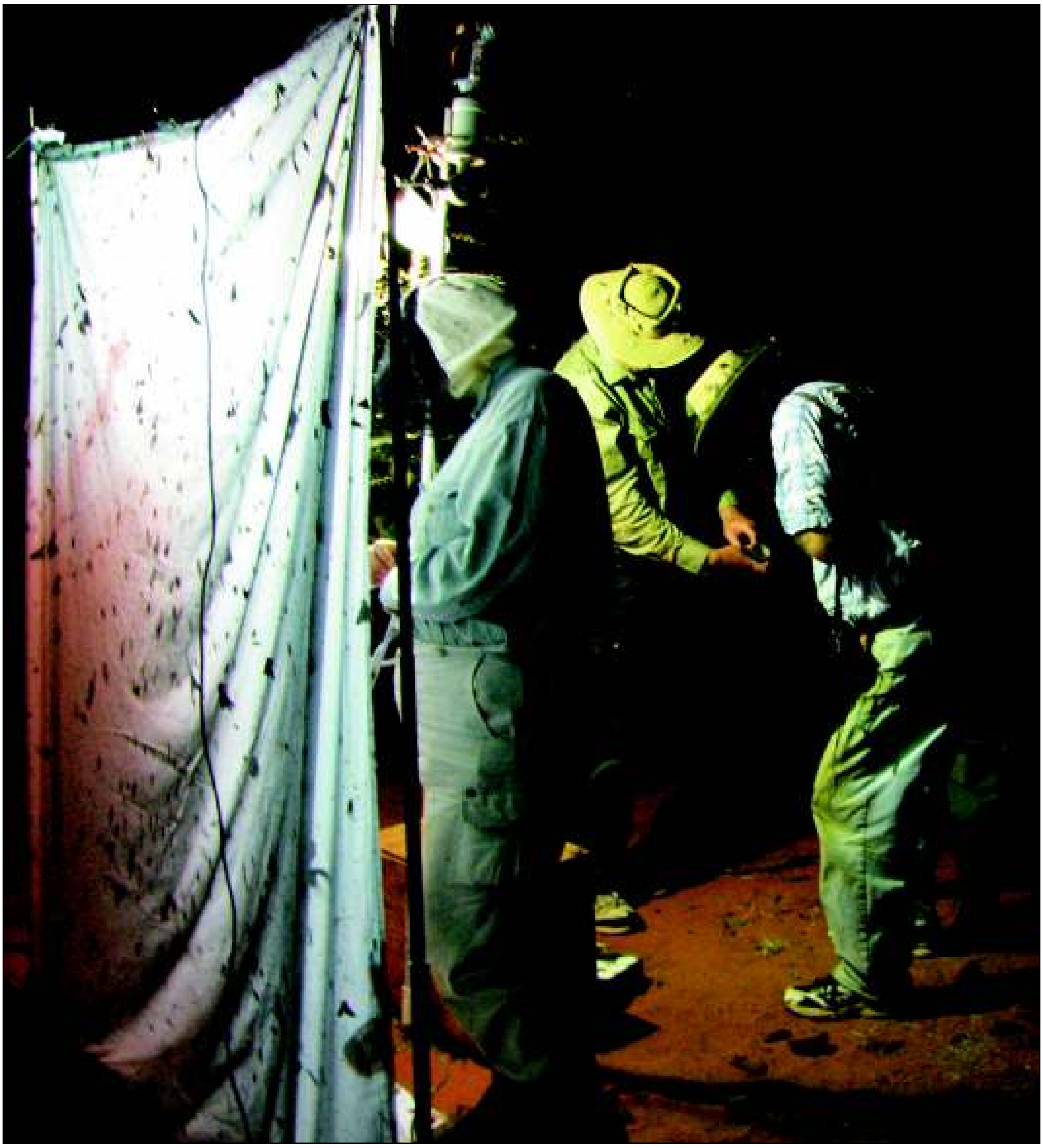


A male moth, *Homadaula lasiochroa* (Galacticidae). This is widespread in the arid zone of Australia where the larvae feed on several species of *Acacia* (Fabaceae). Wingspan: 10mm. Photo: Y.N. Su.

A female *Ixonympha* sp. (Tortricidae). Species of this recently described genus occur sporadically throughout the arid zone. The larvae feed on the deployed seeds of mistletoes (that is after they have gone through a bird and are germinating on a branch). Wingspan: 9mm. Photo Y.N. Su.

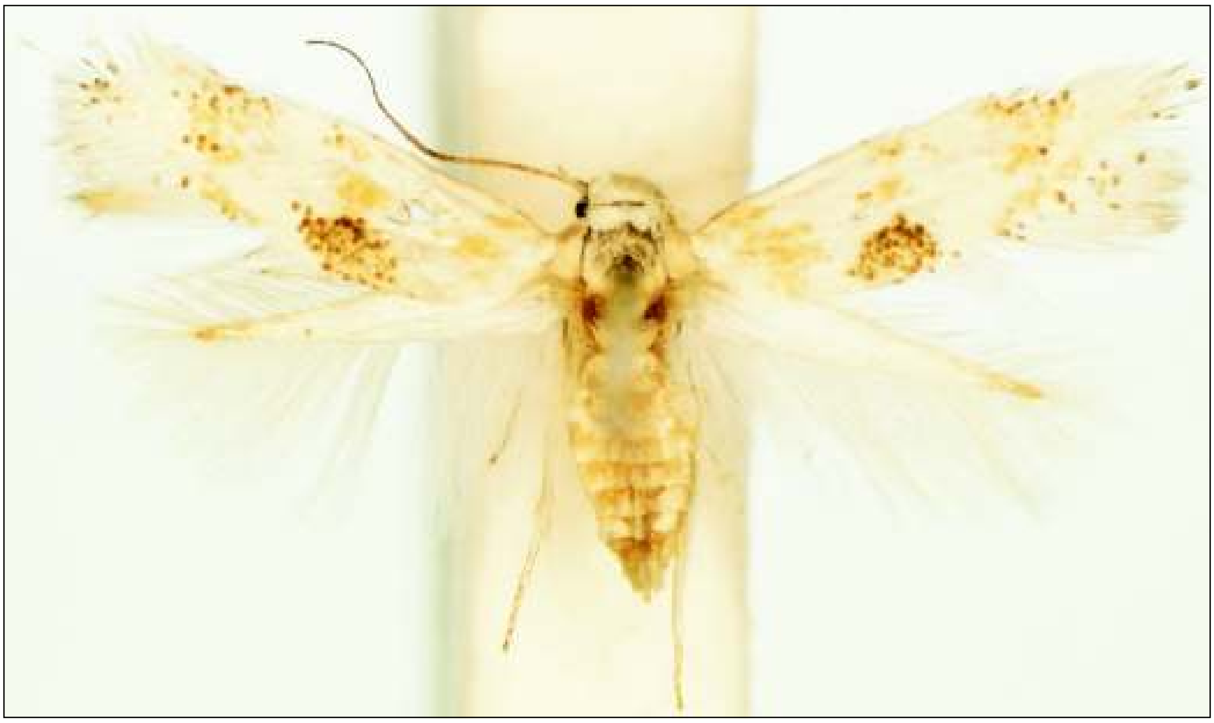
A male *Leptocneria reducta* (Lymantriidae). This is the white cedar moth whose larvae often defoliate cultivated white cedar trees and can cause severe itching. In the absence of white cedar in the Simpson Desert the larvae probably feed on *Owenia* (Meliaceae). Wingspan: 38mm. Photo: Y.N. Su.

This is one of the species of *Macrobathra* (Cosmopterigidae) which, as larvae, form terminal galls in the shoots of *Senna* spp. (Fabaceae). It is widely distributed in the arid zone but this is the first record from Queensland. Wingspan: 13mm. Photo: Y.N. Su.



Moths are attracted to a light near Salty Bore. Following generous rains low powered lights were used but thousands of tiny bugs still swarmed around the light making collecting uncomfortable. L-R. Cate Lemann, Ted Edwards, Col Portley. Photo: Michelle Glover.

A pair of icilius blue butterflies (*Jalmenus icilius*) (Lycaenidae) were photographed mating in a shrub of *Senna artemisioides* (Fabaceae). The caterpillars feed on this plant and are looked after by small black ants. The butterfly is widespread in the arid zone. Photo: Michelle Glover.

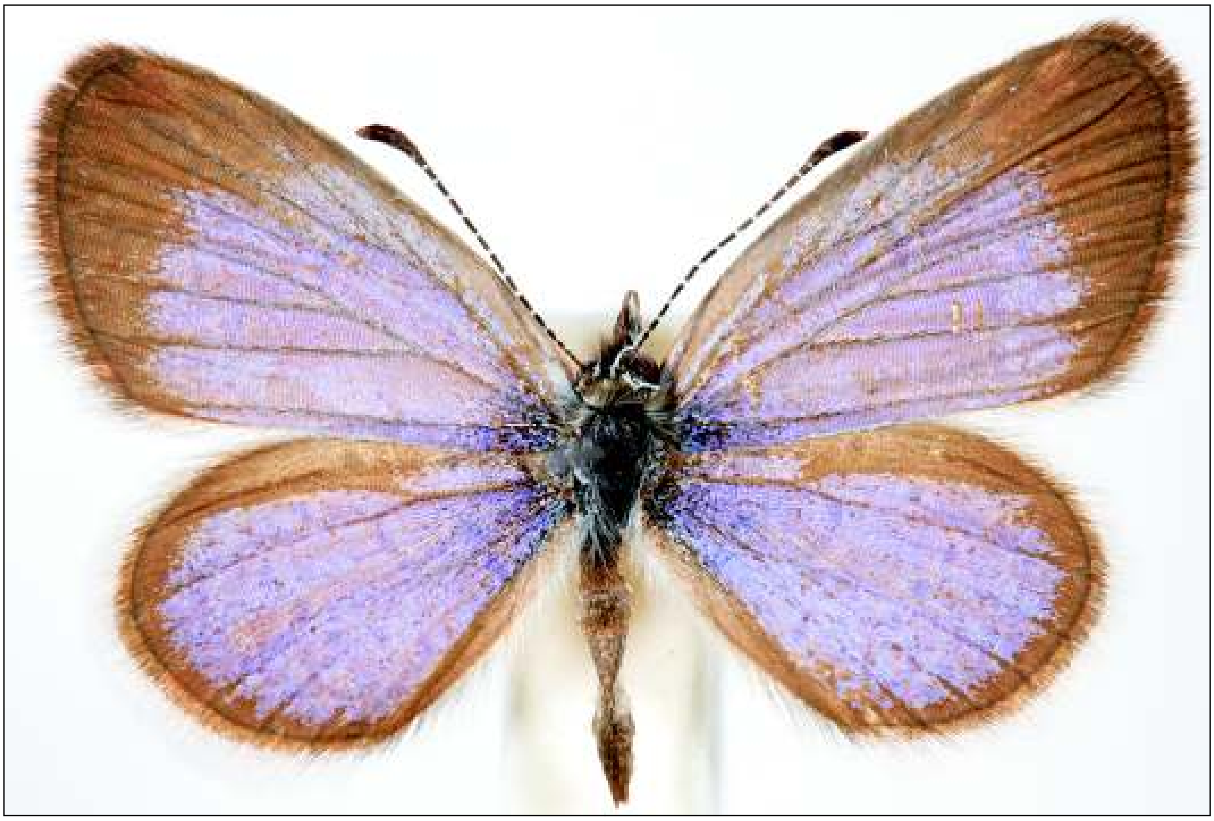


A female of *Notodryas* sp. (Oecophoridae). These very small moths have very reduced hindwings which is unusual in the Oecophoridae. Many species occur in the arid zone. The larvae tie green eucalypt leaves together with silk and live and feed in the shelter so formed. Wingspan: 6mm. Photo Y.N. Su.

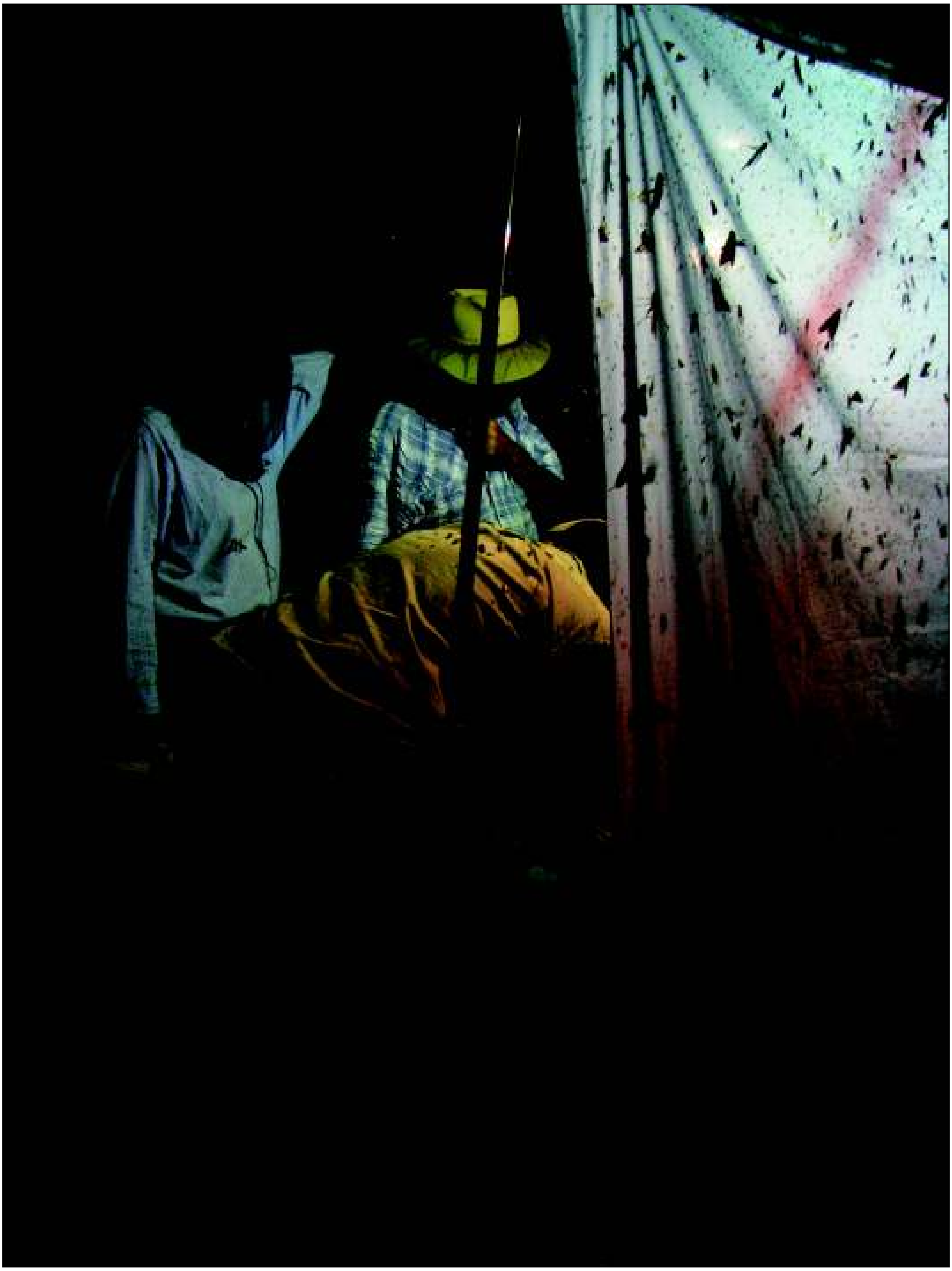
Ted Edwards holds a box of the larger moths collected during the Cravens Peak Survey. Moths are returned to the laboratory in boxes and subsequently set and individually labelled before being identified. They are then amalgamated with the main collection where they are available for future study. Photo: Michelle Glover.

A male of an unidentified genus and species of Oecophoridae. It is typical of the predominantly white colour patterns found in many of the micro moths at Cravens Peak. Wingspan 16mm. Photo: Y.N. Su.

A male of *Paratheta* sp. (Scythrididae). There are many species in this genus and they are found commonly throughout the arid areas of Australia. A smaller, related, species has been reared from galls in stems of *Sclerolaena birchii* (Chenopodiaceae), galvanised burr. Others probably feed on other chenopods. Wingspan: 11mm.
Photo: Y.N. Su.



A male *Zizula hylax* (Lycaenidae) or dainty grass-blue butterfly. It is probably much more widespread in the Simpson Desert than the current lack of records would suggest. Wingspan: 14mm. Photo: Y.N. Su.



The light sheet near Salty Bore. Note the face protection to try to stop the thousands of little bugs attracted to the light from crowding into one's eyes, nose and ears. L-R. Cate Lemann, Ted Edwards (bending) Col Portley. Photo: Michelle Glover.

Amyema sanguineum var. *sanguineum* (Var Mistletoe). Gwenda White

Cicadas of the eastern segment of the Cravens Peak Reserve, northeastern Simpson Desert, S.W. Queensland; January/February 2007

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Abstract A survey of the cicada fauna of the eastern segment of the Cravens Peak Reserve, extending from Carlo northwards to the Mulligan River and near Salty Bore, and west to the Bullock and No. 3 Bores, was carried out between 9 January to 23 February, 2007. The survey commenced after initial rains (60–175 mm) between 24–26 December, 2006, and continued to, and beyond the remarkable rain event occurring between 15–26 January, 2007 (252 mm).

Seventeen species were found, only three previously described (*Tryella graminea*; *Kobonga apicans*; *Burbunga venosa*). The remaining fourteen species comprise eight species previously known elsewhere in western and central Queensland, and six species which appear to be desert specialists. Three of these latter species have sibling species existing peripherally to the desert environment. Descriptions and illustrations of the species are included. Strong northeasterly to southeasterly winds during and following the second rain event are suggested to have blown two of the observed species into the desert, and to have effected the distribution of populations of at least one other species.

Electronic recordings were made of the calling songs of fifteen of the species, these being specific to each species. These songs are normally emitted diurnally, but for three of the species, the main song periods were dusk, extending into the night for two of these. The recorded songs are compared to the equivalent songs of the same, or sibling species from outside the study area from western to southern Queensland, illustrating both the specificities and regional stabilities of the calling songs.

Introduction

Cicadas belong to the Order Hemiptera, the plant-sucking bugs. They are well known insects due to their conspicuous songs, emitted by the males, usually very loud from the larger species, and characteristic of the late Spring-Summer months throughout most of Queensland. In northern and western Queensland, the dominant emergence period of cicadas follows the arrival of the monsoonal rains, typically between the late December-January months. Although it might be assumed that the diversity within the cicada fauna would be relatively lower within the semi-arid regions of western Queensland, it was shown by Ewart and Popple (2001) this may not necessarily be in accordance with observations. These authors report a total of forty-five species known within the region approximately bounded by Windorah–Jundah–Adavale–Thargomindah–Cunnamulla–Charleville–Blackall, the majority small to medium sized, and the majority representing undescribed species.

The 2007 Royal Geographical Society of Queensland Expedition to the northeastern Simpson Desert area provided an exceptional opportunity to survey the cicada fauna of this particularly arid desert environment. Owing to both the relative remoteness of the region, and the difficulties of access/travel within the region after summer rains, when cicadas are expected to emerge, the cicada fauna was effectively unknown. The timing of the field work therefore had to follow the first significant summer rains, these occurring (60–175 mm) between 24–26 December 2006. Observations commenced on 9 January, with six species observed between 9–16 January. Between 15 through to 26 January occurred a remarkable monsoonal rain event producing 252 mm of rain (as measured at the Cravens peak homestead), which appears to have decimated the populations of the observed six cicada species that had previously emerged. This report documents these, together with the re-emergence of cicadas following the major rain event, including their songs, habitat and behaviour preferences. In total, seventeen species were found, only three being previously described (*Tryella graminea*; *Kobonga apicans*; *Burbunga venosa*). The remaining 14 undescribed species comprise 8 that are known elsewhere within western and central Queensland, and not restricted to the Simpson Desert. The 6 remaining species appear to be endemic to the desert environments, including N.T., South Australia, even into Western Australia.

One consequence of the heavy rains was the restriction they placed on access throughout the region. This report is therefore based on observations extending from the Mulligan River crossing (~15 km N. of Cravens Peak homestead) south to the Cravens Peak and Carlo homesteads, south-west and west to Bullock and No. 3 Bores, and northwest to Plum Pudding and towards Salty Bore.

Apart from the capture of cicada specimens, required for subsequent taxonomic studies, the electronic recording of the songs was a major aim of the survey, songs of 15 of the 17 species being recorded and illustrated in this report. Cicada songs often provide the only indication of their presence. The frequencies of these songs generally increase with decreasing body size (e.g. Bennet-Clark & Young, 1994), which make the smallest species progressively more difficult to hear. The songs are emitted by the males for the prime purpose of mate attraction, and are known as calling songs (eg. Claridge 1985), although protest songs (when handled or caught in spider webs) and soft courting songs, (when in proximity to females and sometimes at dusk) are also emitted. In the majority of species, the calling songs are emitted during mornings, gradually reducing during the afternoons, especially when temperatures are relatively high (35°–40°C). Most species also sing for limited periods at dusk. During this survey, three species were observed to have their main singing period at dusk, extending into the night for two of the species. The calling songs are specific to each species, due to the differing temporal, pulse and frequency properties of the songs between species. They therefore not only constitute important taxonomic tools, but also as field tools (once documented) for locating and identifying species (e.g. Gogala and Trilar 2004; Quartau and Simões 2006; Seabra et al. 2006; Simões et al. 2000; Sueur 2002). This is especially valuable for recognizing sibling species, a widespread phenomenon amongst Australian cicadas.

Methods and abbreviations

Song data are illustrated as conventional waveform [amplitude (= volume; mV) versus time (seconds to ms)] plots (Figures 2–10, starting page 134, and 12–18, starting page 144). These were recorded with a Sony MiniDisc Recorder MZ-NH900 (in PCM recording mode) in conjunction with either a Sennheiser microphone (model K6/ME66) or Telinga PRO5 “classic” microphone and parabola. Computer analyses were performed by initial digitizing through an SB Audigy 2ZS sound card at 44.1 KH3 sampling frequency, followed by processing with Avisoft SAS Lab Pro4 software. Recordings were made either directly in the field with the parabola, or in a net cage in the field (with Sennheiser microphone) for the smallest species, or in one case in a container of a species only captured at light. Bat detectors (Ultra Sound Advice models Mini-2 and Mini-3) were used extensively in the field for locating and identifying singing cicadas. The terminology used for describing the song structures in the waveform plots include the hierarchical terms as follows: phrases, sub-phrases, echemes, macrosyllables, syllables and pulses (modified after Ragge and Reynolds 1998). These terms are labeled on relevant song structures within the plots shown. MBL refers to the male *mean total body length* of the species (mm). MDF refers to the *mean dominant frequency* measured from amplitude spectra of the songs (after Ewart and Marques 2008, these not specifically illustrated here).

The existence of such a high proportion of undescribed species presents problems of how the species should be informally named in this report. Two sets of names are used; a more formal name such as ‘*Cicadetta* species A’, etc., wherever possible using the same designation as when previously published (e.g. in Ewart and Popple 2001). An informal name and number are also used (e.g. Gidyea Cicada; no. 207) which follows the website of Eastern Australian Cicadas created by L.W. Popple (http://sci-s03.bacs.uq.edu.au/ins-info/). In order to evaluate possible regional distributions of some of the apparently more desert adapted cicadas found during this survey, the author had access to the extensive collections and sound recordings of Australian cicadas of Dr M.S. Moulds (Kuranda; MSM), and Drs K. Hill (KH) and D. Marshall (DM), University of Connecticut, U.S.A., which are housed at Kuranda in N.E. Queensland. Distribution records from N.T., South Australia and Western Australia are based on these collections. Some comparative recordings of L.W. Popple (LWP) are also included.

Vegetation and land types

Cicada species show strong preferences for particular vegetational communities, which are themselves often correlated with various landform and soil types. Following Wilson et al. (1990), the following types are recognised, each significant in regard to specific cicada species, or species groupings that were observed within and near the Cravens Peak Reserve:

1. Dune systems, dominated by *Triodia*, and shrubby low, open hummock grassland, developed on deep, red siliceous sands and sandy red earths. *T. basedowii* predominates on lower dune slopes and sandy inter-dune areas. Sparse to open hummock grassland is common on mobile dune crests and loose sandy dune slopes.

2. Sand plains (belonging to the Badalia and Mindyalia land systems), with minor run-on areas and low rounded dunes and drainage lines. Vegetation comprise Georgina gidyea (*Acacia georginae*), open shrubland/low open woodland, including local mallee, kerosene grass, ± giant grey spinifex (*T. longiceps*). Deep sandy red earths and red siliceous sands.

3. Scarps and flat to gently undulating tops of dissected tablelands (the Tobin land system) overlying, in the Cravens Peak area, silicified and laterised Ordovician Toko group sediments, which extend NW and SE of Cravens Peak homestead. Soils shallow, gravelly red earths ± clays and desert loams. Vegetation comprises low open shrubland to shrubby sparse grassland, with *Senna artemisioides* subsp. *sturtii* and *Eremophila latrobei* locally dominant, together with scattered *Eucalyptus terminalis* and mineritchie (*Acacia cyperophylla*).

4. Flat to undulating plains, comprising clay deposits overlying Ordovician Toko group sediments. (Nithaka land system). Shallow to deep gravelly loams. Vegetation is open grassland with short grasses and feathertop wire grass, plus associated areas of clay soils with Georgina gidyea open shrubland.

5. Flat alluvial plains with braided channels (Dingera land system). Recent alluvium with deep red to brown cracking clays. Vegetation comprises Mitchell tussock grassland and sparse open grassland, with open shrubland (e.g. *Senna* spp.) along drainage channels, and river red gum along channels, and local patches of open hummock grassland. Relevant area at Cravens peak is the Mulligan River and tributaries.

6. Ephemeral flooded claypans and seasonal lakes (Bilpa land system) floored by recent alluvia. Soils mostly deep red to grey, deep, cracking clays. Vegetation is variable, but includes swamp canegrass (*Eragrostis australasica*), open hummock grassland and open grassland.

Cicada distribution patterns

Although the various cicada species do exhibit strong vegetational preferences, even within a specific vegetation type they exhibit erratic and very localized distributions, being apparently absent from extensive tracks of country even where relevant vegetation communities are well developed. Field observations, however, eventually showed that the locations of highest cicada "productivity" were those in which the most intensive and extensive rain run-off had occurred from higher surrounding areas. These were especially notable in the sand plains, the flat to gently undulating tableland areas (Tobin land system), and the flat plains to undulating clay plains (Nithaka land system), including some inter-dune areas. In the areas occupied by the larger ephemeral lakes (typically lasting ≥ 4 weeks), the resulting grasses growing after drying out were all found to be sterile with respect to cicadas. Cicadas on dune crests were usually very sparse, unless the dunes were relatively low with extensive spinifex covering. Inter-dune areas were again more productive in those areas of more concentrated and extensive rainwater run-off.

Timing of cicada emergences

Initial observations (Figure 1) commenced 14 days (9 Jan 2007) following the initial rains between 24 – 26 December 2006. Observations identified only 6 species in total during the initial week of observations until the major monsoonal rain event between 15 to 26 January. Between 15–22 January, no cicadas at all were heard, or caught at light, even during short intervening sunny periods, and it is inferred that the intensity of the rain completely decimated, presumably by drowning, the existing emergent cicada populations of the area. Renewed emergences occurred on 23–26 January of four species, only in apparently very small numbers (based on aural observation and light trap captures), including two additional species not recorded prior to the main second rain event. Between 23 January –24 February, the observed progressive appearance of species is based on both captures and song records with a final total of 17 species documented (Figure 1). Only one of the original set of 6 species found did not apparently re-emerge, all others of this initial group emerging again after the monsoon rain event, although in the case of *Pauropsalta* species A, apparently in smaller numbers. A question raised by these observations, but which cannot be answered without further observations, is whether, and to what extent, the additional emergences of the 11 species that followed the monsoon rain event would have occurred in the absence of this second rain event.

A further aspect of interest was the apparent absence of a number of species that occur widely in western Queensland, east of the Simpson Desert, and some also in the Alice Springs region. Examples of such species include: *Thopha sessiliba*, and *T. emmotti* (Moulds 2001), *Pipilopsalta ceuthoviridis* (Ewart 2005), *Tryella willsi* (Moulds 2003; Ewart observations), *Burbunga queenslandica* (Moulds 1994), *Kobonga* species near *Cicadetta apicata*, *Macrotristria hillieri*, *Gudanga* sp., *Cicadetta landsboroughi* species complex, and *Cicadetta* species near *C. incepta* (e.g. Ewart and Popple 2001).

Very interesting examples of these absences are illustrated by the two *Thopha* species, amongst the largest of Australian cicadas with very conspicuous loud 'whining songs'. Repeated observations at the Mulligan River crossing 16 km N. of Cravens Peak homestead, and tributaries, failed to reveal their presence here, in spite of the abundance of River Red Gums (*E. camaldulensis*) in which they are normally common. Nevertheless, on the return journey on 23 February, both species were exceptionally abundant in the eucalypts along the Burke River and Sandy Channels at Boulia.

Possible influence of wind for cicada distributions at Cravens Peak

During the observation period, wind was an ever-present climatic feature. Two periods of particularly strong to very strong winds were experienced; (a) 11–22 January, associated with the monsoonal rain event. These were predominantly northeasterly, less often easterly in direction, changing abruptly to a southerly direction late on 20 January, and gradually moderating after 22 January; (b) 1–4 February, during which period very strong southeasterly winds prevailed. Sporadic moderate to strong winds were also experienced during 11, 17 and 20 February.

The pattern of emergences (Figure 1, page 121) exhibited by the observed species was longer than expected. Moreover, certain species were apparently very scarce and localized, most notably the Copper Shrub Buzzer and the Small Acacia Cicada. It is suggested that both species may have been blown into the desert form the east, from beyond the desert environment. The Spinifex Squeaker (see below, page 121) was locally abundant prior to the main rain event, but small numbers were captured at light between 3–5 February at the Cravens Peak homestead. No resident population, however, was found in or near this area and it is inferred that those that came to light had been blown from spinifex covered dunes and sandplains existing between 3–8 km east of the Homestead.

Other late appearing and localized species include *K. apicans* and the Kettledrum Cicada, both restricted to relatively dense inter-dune gidyea woodland. Both are considered to be endemic to these habitats. Similarly, the Cravens Grass Chirper is certainly endemic to the inter-dune, sandplain and alluvial grasslands, although localized, was very abundant when present. The Fishing Reel Buzzer and *T. graminea* were only found along the Mulligan River and its tributaries in the Cravens Peak region, and are also considered to be endemic within these riverine habitats. All other species found are inferred to be endemic to the desert.

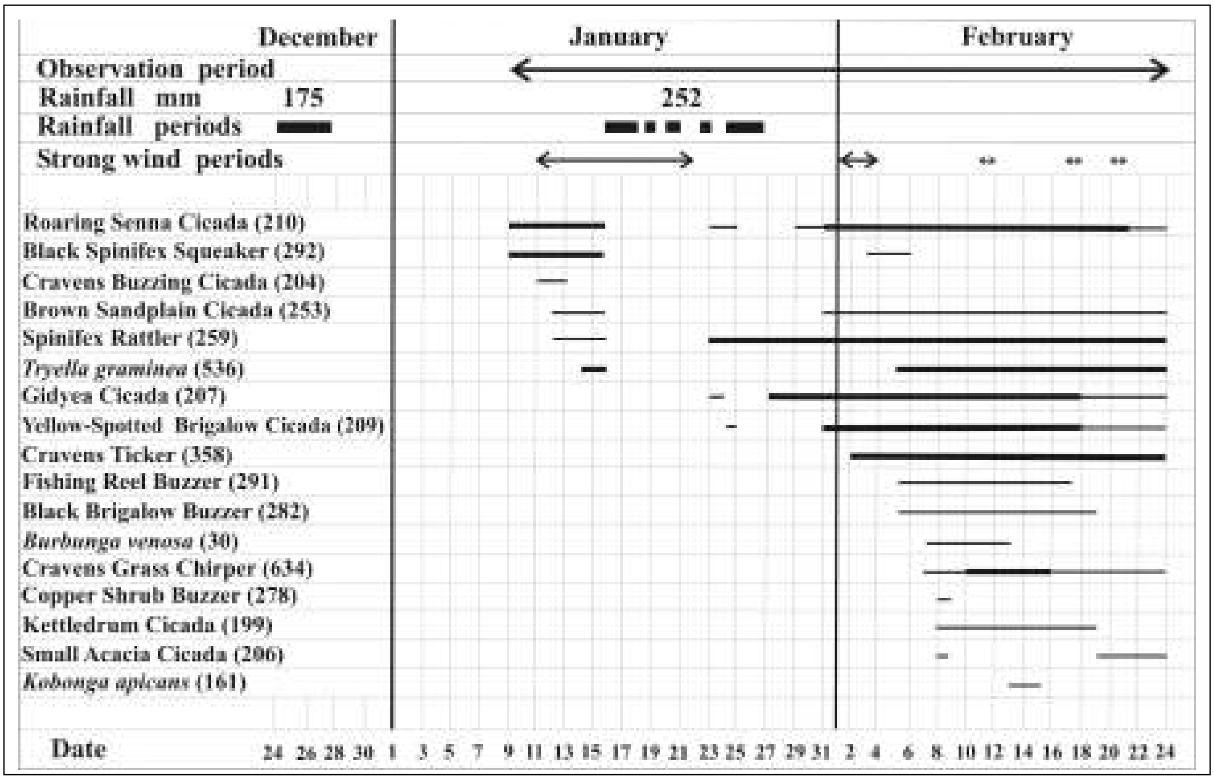

Figure 1. Summary of observations of emergent periods of the various cicada species found at Cravens Peak, January—February 2007. The heavy lines indicate periods of relative high abundance, albeit locally. The thin lines are periods of very localized and relatively low abundance, often associated with collapsing populations at end of their emergent phases. The main periods of rain (as measured at homestead) and strong winds (qualitative observations) are indicated.

Description of the cicada species observed in the Cravens Peak region

Introduction

The cicadas found at Cravens Peak exhibit three broad distributional groupings:

(A) Those relatively widely distributed in Queensland and Northern Territory, although usually restricted to particular vegetation communities. Examples are the Yellow-spotted Brigalow Cicada, Gidyea Cicada, Spinifex Rattler, Kettledrum Cicada, Fishing Reel Buzzer, Black Brigalow Buzzer, Small Acacia Cicada, Copper Shrub Buzzer, *Tryella graminea*, and *Kobonga apicans*, and *Burbunga venosa*.

(B) Those with sibling species (mostly undescribed) existing in western Queensland areas, some immediately peripheral to the Simpson Desert. These include: Roaring Senna cicada and a sibling species, the Capparis cicada; Cravens Grass Chirper and the Jundah Grass Ticker (no. 344); *Crotopsalta* species A (Cravens ticker) and *C. poaecetes* .

(C) Species which appear to be desert specialists, including distributions within the Simpson and Tanami Deserts, and during this survey having been specifically recorded within the Cravens Peak, Carlo and Ethabuka properties/Reserves. These include the Cravens Buzzing Cicada, Roaring Senna Cicada, Black Spinifex Squeaker, Cravens Grass Buzzer, Brown Sandplains Cicada, and Cravens Ticker. As noted in (2) above, several have known sibling species existing within western Queensland outside the northeastern Simpson Desert limits.

Individual species descriptions

Pauropsalta species A [Black Spinifex Squeaker; no. 692]

An undescribed Pauropsalta (Plate 1A, page 122), superficially resembling *P. mneme* in size, shape and predominantly black colouration. It occurs in localized (100–300 m diameter) populations within inter-dune and sand plain spinifex areas, although abundant within those populations. Its size (~18 mm MBL) and black colour make the cicada rather

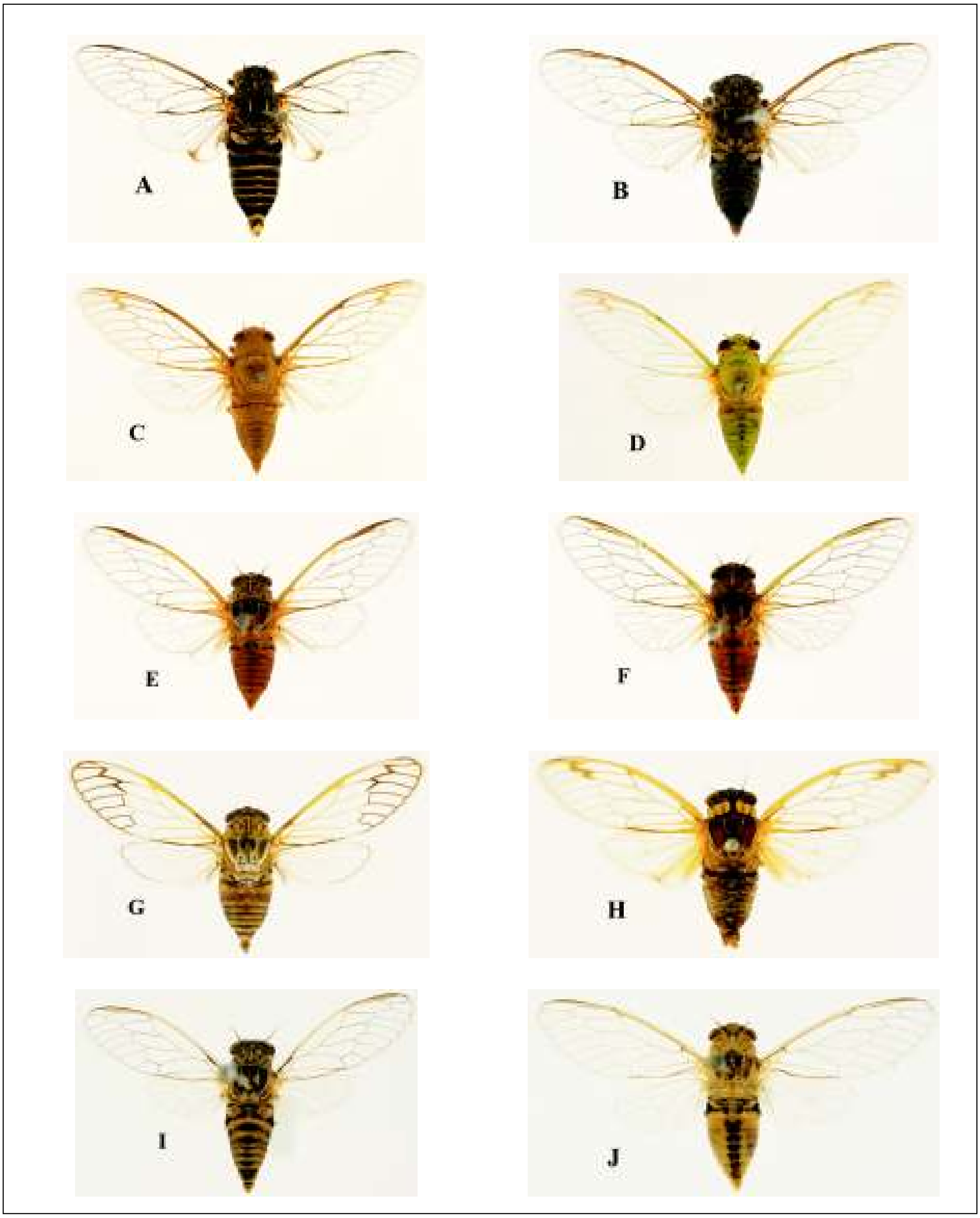

Plate 1. Cravens Peak cicadas. Figures are total body lengths of specimens illustrated. All specimens from Cravens Peak Reserve unless specified otherwise. A: Black Spinifex Squeaker (no. 692), male, 19.0 mm. B: Black Brigalow Buzzer (no. 282), male, from Chinchilla, S.E. Queensland, 15.1 mm. C: Brown Sandplain Cicada (no. 253), male, 21.6 mm. D: Spinifex Rattler (no. 259), male, 16.9 mm. E: Roaring Senna Cicada (no. 210), male, 15.1 mm. F: Cravens Buzzing Cicada (no. 204), male, 14.6 mm. G: *Burbunga venosa* (no. 30), male, 18.0 mm. H: *Tryella graminea* (no. 536), male, 16.8 mm. I: Cravens Ticker (no. 358), male, 9.4 mm. J: Fishing Reel Buzzer (no. 291), male, 13.5 mm.

conspicuous within the spinifex, generally sitting and singing exposed on the stems. It is, however, a wary and mobile cicada, frequently flying to new singing posts, and also readily dropping into the dense cores of spinifex clumps when threatened. It was observed at four localities NW of Cravens Peak Homestead, and collected at two of these localities (25 and 36 km NW of homestead). It was also caught at the Mulligan River crossing (approximately 15 km N. of Cravens peak homestead), and specimens were also collected at light (but not *in situ*; see above) at Cravens Peak homestead, believed to have been blown by strong easterly winds from spinifex areas east of homestead. It also occurs in spinifex sand plains at Ethabuka (Scott Morrison, pers. comm.). No exuviae were found, thought to be due to emergence within the dense spinifex clumps.

This species is recorded from the N.T. Known locations are northwest of Alice Springs along the Tanami Desert road to and beyond Tilmouth Well; 20 km south of Alice Springs, and northwards towards Tennant Creek. An outlying record exists from near Sandstone in Western Australia (MSM, KH, DM).

The song is diurnally emitted, being a discontinuous series of whistles of variable lengths (each an echeme, between 0.2–2.1 s duration), with short inter-echeme intervals of 5–120 ms. The echemes are variable in amplitude which increase and decrease during emission (Figure 2A,B, page 134). In time expanded detail (Figure 2C,D, page 134), each echeme is resolved into continuous trains of syllables, although not clearly partitioned into macrosyllables. They are nevertheless characterized by regularly emitted higher amplitude pulse doublets with a repetition rate of 290–300 Hz. The mean dominant song frequency (MDF) is 4.55 kHz.

Cicadetta species J [Roaring Senna cicada; no. 210]

An undescribed smaller cicada (MBL 14.4 mm; Plate 1E, page 122) with rustic abdominal banding (matching the sandy soil colours of its habitats), locally inhabiting dense shrubland, most notably that dominated by *Senna artemisioides* subsp. *petiolaris* and *Eremophila latrobei*, often with scattered *Corymbia terminalis* and *Hakea eyreana*. A wary and cryptic cicada, difficult to see in the dense shrub foliage. This cicada was localized, but very common in the *Senna-Eremophila* shrubland 2 to 2.4 km north of Cravens Peak homestead, with additional lower density and scattered occurrences between Carlo and Cravens Peak, in inter-dune areas NW of Cravens Peak homestead, and at the Mulligan River crossing.

Records of this species are also available from the N.T. These include northwest of Alice Springs along the Tanami Desert road beyond Yuendumu; 180 km eastwards along the Plenty Highway; 20 km south of Alice Springs. A South Australian record exists from ~130 km southeast of Coober Pedy (MSM, KH, DM).

The song consists of a series of extended and stuttering discrete phrases, starting with a staccato song rising to a peak, and finishing with an extended stuttering phase, slightly decreasing in intensity (Figure 3A). These phrases (Figure 3B, page 135) are seen most clearly in the expanded time plot showing the initial series of clicks, grading by coalescence of macrosyllables to denser and more longer macrosyllables, eventually forming a dense echeme prior to the phrase peak; this is followed by a separate series of macrosyllables of progressively reducing emission rates (the stuttering phase). The dusk song (Figure 3C, page 135) is similar except that the phrases tend to coalesce, producing a more continuous song. Phrase lengths are 3.6–6.1 s in lengths (day songs), extending to 3.4 to approx 9 s at dusk. The repetition rates of the syllables, from which the clicks, macrosyllables and echemes are constructed, actually increase during the emission of each phrase. These start initially at 23 Hz (clicks), 55–97 Hz (leading to echeme), 390 Hz (echeme), and 400–415 Hz (within macrosyllables to end of song). The MDF is 14.0 kHz.

Although this species occurs widely in the desert areas of Central Australia, a morphologically very similar species is known from S.W. and Central Queensland, *Cicadetta* species K (Capparis cicada; no. 219), whose calling song is very distinct from that of the Roaring Senna Cicada, as shown by Figure 3D (page 135).

Cicadetta species A [Brown sand plain cicada; no. 253]

A medium size (MBL 22.2 mm; Plate 1C, page 122) pale fawn-brown cicada, belonging to an undescribed genus, inhabiting grassland, including spinifex on dune and inter-dune areas and sandplains. It is relevant to note that the colour matches closely the fawn-brown to reddish-brown sand colours of the region. The males sing at dusk, none having been heard during the day. It sits deeply embedded in grass and spinifex clumps during the day, and appears to be a relatively sedimentary species by day, flying only when disturbed, but probably more mobile at dusk. Although singing commences at dusk, observation suggests that it does continue into at least the earlier part of the night. What is particularly interesting is the high mobility of the females at and after dusk. During routine light trapping, females were constantly captured, but very rarely males. This species was captured in the dune systems within the southeastern areas of Cravens Peak, and in the vicinities of the Carlo (G. Woods), and Ethabuka homesteads (Scott Morrison).

This species has a wide distribution through inland N.T. Specific locations include Yulara and surrounding areas; northwest of Alice Springs along the Tanami desert road near Rabbit Flat; between Ti Tree and Tenant Creek along Stuart Highway; 32 km south of Elliot; 75 km ESE of Barkly and Tablelands Highways junction (MSM, KH and DM).

The song is a continuous uniform buzzing (Figure 4, page 136), consisting of repetitive and evenly emitted macrosyllables, each macrosyllable composed of four sets of syllables (each a pair with an initial strong and a following weaker pulse). The macrosyllable mean repetition rates and lengths are 14 Hz and 43 ms. The syllable repetition rates within each macrosyllable are variable, the initial two syllables emitted at 52 Hz, the following syllables emitted near 100 Hz. The MDF is 9.9 kHz.

Burbunga venosa **Distant [Cravens Spinifex Buzzer; no. 30]**

A wary medium sized cicada (MBL 17.6 mm; Plate 1G, page 122), which is generically closer to *Parnkalla*. It is pale brown to silvery coloured, with strongly marked forewing infuscations. The habitat is spinifex, within the dense clumps where it is difficult to see, occurring on sand plains, dune and inter-dune areas. Diurnal singing was observed only very sporadically, the main song phases emitted at dusk and extending into early evening. It appears to occur in localized populations, having been caught 1.5 km W of Cravens Peak homestead, and also ~ 50 km SSW of Carlo homestead, near the Ethabuka boundary (G. Woods). Additional records from central and southern N.T. are from south of Ti Tree, extending southwards of Alice Springs to the Finke River and to near Erldunda (MSM).

The song (Figure 5A,B, page 137) is a continuous buzzing call, comprising evenly emitted, relatively dense macrosyllables. Each consists of 3 or 4 sets of triple syllables, the final syllable of each triplet of lower amplitude. Mean macrosyllable repetition rates and lengths are ~ 23 Hz and approximately 25 ms (4 sets of syllable) and 18–19 ms (3 syllable sets). The mean dominant frequency is 7.3 kHz.

A morphologically very similar undescribed species (in fact belonging to a separate genus; Figure 5C,D, page 137), the Cunnamulla Smoky Buzzer (no. 295), is known from open grasslands in inland southern Queensland and northern NSW. The superficially similar song also comprises a continuous buzzing. This again comprises evenly emitted macrosyllables, each comprising 4 sets of syllable doublets, actually separated into 2 discrete sets of doublets. Macrosyllable repetition sets and lengths are 45 Hz and 11.5 ms. The MDF is 10.7 kHz. In spite of their overall morphological and colour similarities, the songs of both species are distinct in their detailed structures and frequencies.

Cicadetta **species F [Spinifex Rattler; no. 259] (See Species F in Ewart and Popple 2001)**

A medium size (MBL 17.5 mm) uniformly apple green cicada with pale brown infuscated apices to forewings (Plate 1D, page 122). This cicada represents another undescribed genus, possibly the same genus as that of the Brown sand plain cicada (see page 123). It inhabits grassland, including spinifex, in the northeastern Simpson Desert, and at Cravens Peak was only observed singing at dusk, extending irregularly into the night (at least 21.00–22.00 h). In inland southern Queensland, it occurs in spinifex covered sand plains, including those south of Charleville. In these localities, the cicada is a diurnal and dusk singer. The colouration of the cicada ensures it to be highly cryptic in the dense grass and spinifex environments, although very wary when approached. It is very active during the dusk-early night singing phases, both males and females being regularly captured at light.

This species (or species complex) is actually very widely distributed throughout the semi arid and arid regions of central Australia. N.T. localities include; Yulara; near Tenant Creek; 25 km east of the Barkly-Tablelands Highways junction. Western Australian locations include Warburton; Sandfire between Broome and Port Hedland; Giles Meteorological Station. The distribution extends into South Australia along the Stuart Highway, 56 km south of the N.T. border (MSM, KH, DM).

The song is a continuous high pitched coarse rattling song, consisting of evenly emitted macrosyllables, each comprising four sets of syllable doublets. Macrosyllable mean repetition rates and lengths are 12.5 Hz and 58 ms. Syllable mean repetition rates are variable, being respectively (for syllable doublets 1 to 4): 41, 60, and 78 Hz. MDF is 14.5 kHz.

The song from a specimen recorded 12 km S. of Charleville (Figure 6C,D, page 138) is shown for comparison, and it is clear that this song is very close to that of this species from Cravens Peak. This is further shown by more detailed measurements. Macrosyllable mean repetition rates and length are 12 Hz and 62 ms. Syllable mean repetition rates are, respectively, 38, 52 and 83 Hz. The MDF is 13.1 kHz.

Cicadetta **species B [Cravens Buzzing Cicada; no. 204]**

A small cicada (MBL 14.0 mm), dominantly rustic coloured, and very close in colour and morphology to the Roaring Senna cicada (described above; see Plate 1F, page 122). The colour matches well the sandy substrate of its habitat. It was found only at one locality, 2.3 km N of Cravens Peak homestead (in which it was very scarce), in the same locality in which the Roaring Senna cicada was most abundant. This cicada is less mobile, inhabiting the lower stems of dense *Eremophila latrobei* and *Senna artemisioides* subsp. *petiolaris*, even in underlying grass. It is a relatively inconspicuous and very cryptic species, in the field only distinguished from the Roaring Senna Cicada by its song. The Cravens Buzzing Cicada is currently known only from this single locality.

The song is a soft buzzing interrupted by brief gaps, effectively dividing the song into phrases (Figure 7A, page 139), varying from approximately 0.1 s to 6.4 s in length. Each phrase consists of trains of macrosyllables which exhibit higher repetition rates at the initial parts (~ first 0.4–0.5 s) of the longer phrases, the emission rates thereafter remaining relatively constant (Figure 7A,B, page 139). Each macrosyllable comprises 3 sets of syllable doublets (Figure 7C, page 139). These syllable doublets are unusual in that each of the high amplitude pulses are preceded by a small, low amplitude pulse, the reverse of the more common arrangement seen in syllable structures. Macrosyllable repetition rates for the longer phrases vary between 63–70 Hz (initial segments) to 45–48 Hz (following segments). For the short phrases, repetition rates range between 66–78 Hz, similar to the initial phases of the longer phrases. Mean macrosyllable widths are 5.6 ms, while the syllable doublet repetition rates are near 550 Hz. The MDF is 12.4 kHz.

Notopsalta **species G [Black Brigalow Buzzer; no. 282] (See Popple and Strange 2002)**

This is a small (MBL 13.2 mm; Plate 1B, page 122) black cicada which inhabits foliage within acacia trees, less commonly eucalypts. It is an exceedingly wary cicada, readily flying when approached, and highly cryptic. It was heard, and aurally recorded once, at only two localities, one in a Mulligan River tributary stream 5.3 km N. of Cravens Peak northern gate, the second in inter-dune dense gidyea low woodland, approximately 5 km southwest of Cravens Peak homestead. This cicada occurs extensively in southern to central Queensland, being very common in Brigalow woodland. The Cravens Peak record represents a significant range extension.

The song consists of a series of distinct soft, markedly uneven buzzing phrases, emitted in extended sequences. The central part within each phrase exhibits a relatively abrupt amplitude increase; the song is very high pitched, although the initial segment of each phrase has a distinct 'rattling' rather than buzzing quality.

The song illustrated (Figure 8A,B, page 140), from 5 km SW of Cravens Peak homestead represents, the best quality song that was recorded, noting the difficulty of approaching this small and mobile cicada in the hot desert summer temperatures. A higher quality comparative plot (Figure 8C, page 140) is provided from Eidsvold, S. Queensland (LWP recording), and shows the songs to be closely similar, and certainly representing the same species. Phrase lengths of the Cravens Peak songs varied between 1.5–1.6 s, with each phrase terminated by a very short sharp echeme, 18–30 ms in length, and inter-phrase gaps of 80–100 ms. These compare with phrase length of the Eidsvold recording of 1.1–2.8 s, final short echemes of 15–24 ms lengths, and inter-phrase gaps of 80–120 ms. The phrases each have 3 segments, the initial segment, the central high amplitude segment, and the final reduced amplitude segment. The basic song structure is built from repeated macrosyllables, each with 4 sets of complex but discrete syllables. Within the initial segment of each phrase, the macrosyllables are emitted singly, but these rapidly become combined into sets of double macrosyllables.

With continued emission of the initial segment, the macrosyllables become progressively more closely packed together, i.e. through coalescence. The high amplitude middle segment of the phrases comprises strongly coalesced macrosyllables which, in the Cravens Peak song, continue to the end of each phrase. There is thus a general increase in the macrosyllable and syllable repetition rates through each phrase. This illustrated in Figure 8B,C (page 140) by the labeling of syllable repetition rates through the progress of the phrases shown. The final 50–100 ms of each phrase is marked by a sharp final 'flourish' of increased syllable repetitive rates. The song of this cicada is quite complex for such a small species. The MDF are 15.4 kHz (Cravens Peak) and 15.0 kHz (Eidsvold).

Cicadetta species I [Small Acacia Cicada; no. 206]

A smallish (MBL 14.8 mm) dark brown to black cicada with small dark apical infuscations on the forewings (Plate 2R, page 127). Superficially, it resembles a smaller version of the gidyea cicada. It is an exceedingly wary species, immediately flying at any proximal movement. It inhabits dense foliage especially within gidyea regrowth, including associated shrubs (e.g. *E. latrobei*), and was only heard and captured (only at light) in the general vicinity of the homestead. A single specimen was found on 8 February, but it was not until 19–21 February that it was again found, in slightly higher numbers. It seems to represent a very late emergence. Although apparently uncommon, this cicada is known from southern inland Queensland at St. George (in *Senna* sp and *A. aneura*), near Moonie, and near Goondiwindi (in *A. harpophylla*). The distribution of this species (or species complex) may actually be very much wider, including the Tanami Desert road northwest of Alice Springs (N.T.); near kalgoorlie (W.A.); approximately 80 km southeast of Pimba on Stuart Highway (S.A.)(MSM, KH, DM).

Figure 9 (page 141) illustrates a container recorded song from Cravens Peak (A,B) and comparative field recorded song recorded from St. George, S. Queensland (C,D). The song consists of phases of regularly emitted single chirps (each a single macrosyllable) interspersed with phases in which the regularly emitted chirps continue, with reduced amplitude, but containing additional asymmetrically inserted sets of double clicks, which result in a distinct 'rattling' quality to the song. For the Cravens Peak recording, the single chirp repetition rates and widths are 12–13 Hz and 12–19 ms, respectively (where no interspersed clicks), and 12 Hz and 14–21 ms (where interspersed clicks occur). The inserted double sets of clicks also have a mean repetition rate 12 Hz. The chirp phrases represent separate macrosyllables, each comprising approximately 12 syllables. The double click phrases are formed from a pair of sharply defined double pulses, the second much weaker in amplitude.

Chirp repetition rates of the St. George song are 13–14 Hz (with and without interspersed clicks), with widths of 11–15 ms. The asymmetrical spacings of the clicks with respect to the chirps are nearly identical to those of the Cravens Peak recording. The MDF are 9.3 (Cravens Peak) and 10.3 kHz (St George). The two sets of songs are very close in their properties and certainly represent the same species.

Crotopsalta species A [Cravens Ticker; no. 358]

A very small (MBL 9.4 mm) true ticking cicada, undescribed, amongst the smallest of known Australian cicadas (Plate 1I, page 122). This is now being described (Ewart in press) as *Crotopsalta leptotigris*. It inhabits open low, mixed grassland and mixed low grassland in open forest/shrubland environments, normally sitting on the grass stems, sometimes low on associated shrubs or forbs (but not spinifex). Species include *Hybanthus aurantiacus*, *Chloris virgata*, *Eriachne aristidea*, *Aristida inaequiglumis*, *Eulalia aurea*, *Urochloa subquadripara* and *Paspalidium rarum* (M. Thomas, pers. comm. and this volume). This cicada is extremely cryptic, wary and fast flying, moving its song positions frequently, especially when approached. This species, like most of the other described here, occurs in strongly localized populations, although relatively common where present. It was notably common at the locality 2–2.3 km N. of Cravens Peak homestead, where most specimens were captured and recorded. It also occurred in smaller and more localized populations at the Mulligan River crossing (15 km N. of homestead), and on inter-dune areas extending from 2–4 km west and southwest of the homestead. It is so far unknown from any other locality outside Cravens Peak.

The song (Figure 10, page 142) is a soft, very high pitched, persistent regular ticking, best located with a bat detector. The tick emission rate varied between 4.1–7.1 s-1. Each tick

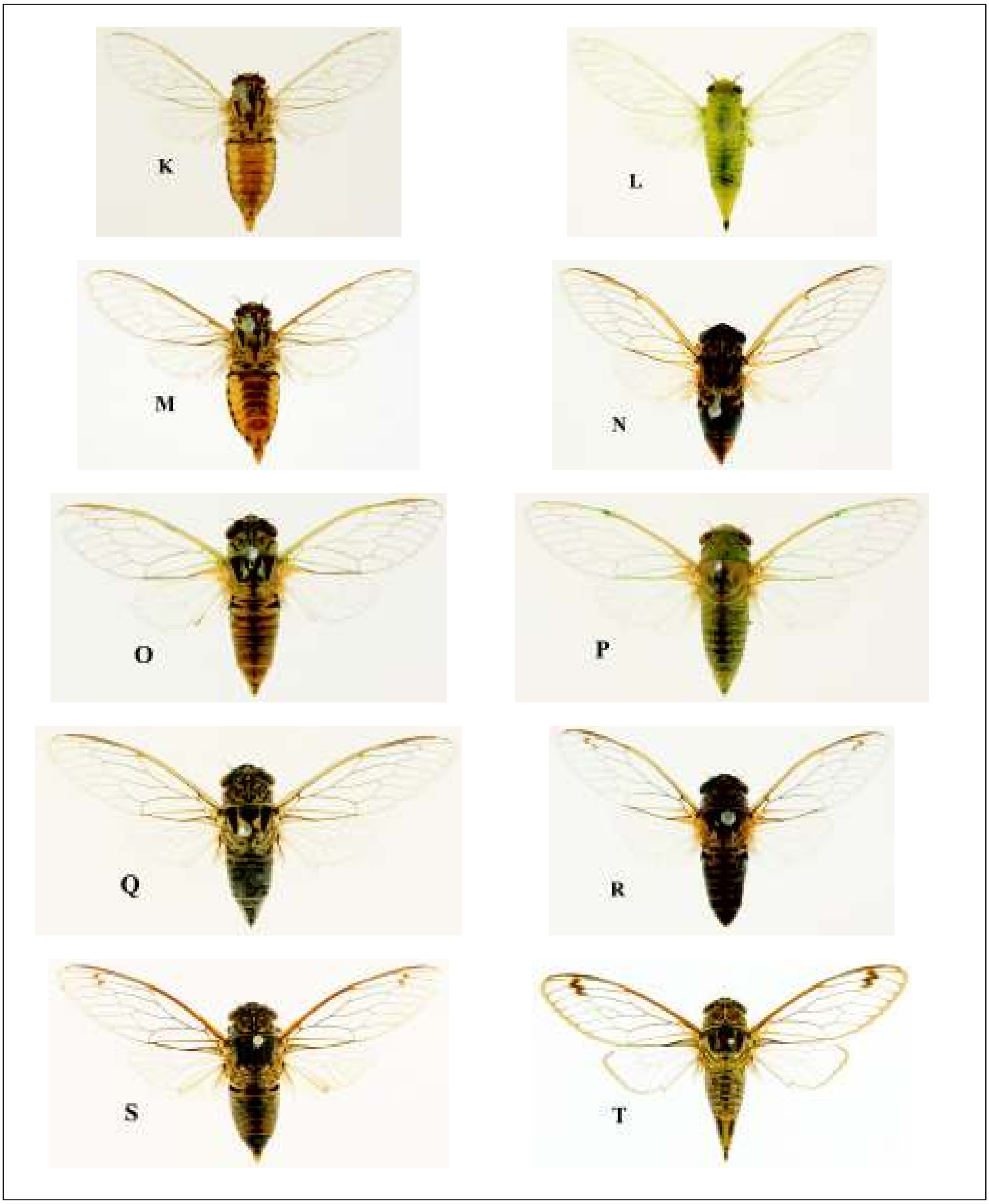

Plate 2. Cravens Peak cicadas. Figures are total body lengths of specimens illustrated. All specimens from Cravens Peak Reserve unless specified otherwise. K: Cravens Grass Chirper (no. 634), male, 13.5 mm. L: Cravens Grass Chirper (no. 634), female, 12.1 mm. M: Jundah Grass Ticker (no. 344), from Thompson River crossing, near Jundah, S.W. Queensland, male, 13.0 mm. N: Copper Shrub Buzzer, (no. 278), from Moothandella, E. Windorah, S.W. Queensland, male,14.7 mm. O: Yellow-Spotted Brigalow Cicada (no. 209), male, 16.0 mm. P: Yellow-Spotted Brigalow Cicada (no. 209), female, 17.7 mm. Q: Gidyea Cicada (no. 207), female, 18.3 mm. R: Small Acacia Cicada (no. 206), female, 14.8 mm. S: Kettledrum Cicada (no. 199), male, 20.5 mm. T: *Kobonga apicans* (no. 161), female, 32.0 mm.

comprises two distinct sharp pulses, an initial high amplitude pulse followed by a lower amplitude pulse. The intervals between the start of each of these pulses, called the inter-pulse interval, are, together with the tick rates, the two parameters used to most easily distinguish the various species within the genus Crotopsalta (Ewart; 2005; see Figure 11). For the Cravens Peak species, the inter-pulse intervals range between 3.8–6.4 ms. A very similar (size, colour, morphology) ticking cicada, *C. poaecetes*, occurs in low grasslands in the Dajarra-Cloncurry-Quamby area of northwestern Queensland. It has a tick rate of between 3.5–6.9 s-1, and inter-pulse intervals of 26–40 ms. Although the tick rates of the two species overlap, the inter-pulse intervals are quite different. The tick structures of a specimen recorded from Quamby is shown for comparison in Figure 10C (page 142). The MDF of the Cravens Peak specimen is 19.0 kHz, that of *C. poaecetes* is 19.3 kHz.

Urabunana **species A [Cravens Grass Chirper; no. 634]**

A small undescribed cicada (MBL 12.5 mm; Plate 2K,L) found abundantly in Button Grass (*Dactyloctenium radulans*) in the vicinity of Cravens Peak homestead, where the native perennial grasses had been degraded by heavy grazing. After the heavy rains this grass grew vigorously on the flat, wide inter-dune 'paddocks' near the homestead in which significant temporary ponding of water followed the rains. This cicada was also found in Button Grass on the Mulligan river flood plain near the fence boundaries separating the Cravens Peak–Carlo-Glenormiston properties. As with most *Urabunana* species, the population of this species exploded abruptly and was nearly extinguished at the end of the observation period, lasting less than 3 weeks. Individual males are constantly on the move, showing classic sing and fly behaviour, sitting on outer grass stems, but normally only flying 1–4 m between song phases. The pale brownish colour, small size, and rapidity of the sheet flights make the cicada difficult to follow in the field. Of particular interest is the pale green female colouration, distinct from the male, which combined with the reduced tendency for flight, ensures that the females are very cryptic, usually only caught by sweeping.

The song (Figure 12, page 144) consists of repetitive discrete phrases (1.5–3.5 s long; repetition rates 0.25–0.57 s-1), each consisting of multiple chirp echemes, usually 4–7 in number. These occur in pairs, comprising an initial long echeme which is followed by a very short echeme, 15–22 ms in length (Figure 12B, page 144). The double echeme lengths range between 0.4–1.05 s in the initial parts of the phrases to 0.29–0.43 s in the later parts; the gaps between the sets of double echemes average 42 ms. The echemes themselves comprise coalesced macrosyllables, whose repetition rates are 415–500 Hz. The MDF is 9.2 kHz.

A remarkably similar sibling species, the Jundah Grass Ticker (No. 344; see Plate 2M, page 127), with almost identical colouration and markings, occurs in southwestern Queensland peripherally to the Simpson Desert, notably the Thompson River flood plain near Jundah and also near Birdsville (LWP observations). The song of this species (Figure12C,D, page 144) most readily distinguishes it as a distinct species from the Cravens Peak species. The song consists of relatively long (9–15 s) repeated phrases. Each phrase comprises some introductory clicks and chirps, followed with increasing amplitude by an extended echeme, further followed by progressively more separated short discrete echemes, these further becoming more separated and 'open' (i.e. less tightly compressed macrosyllables) during the emission of each phrase. There is clearly a marked change of song structure during the progress of each phrase emission. The MDF is 9.6 kHz. The most critical aspect is that the temporal song structure is clearly different from the Cravens Peak species, in spite of the apparent morphological and colour similarities.

Cicadetta **species A [Gidyea Cicada; no. 207] (See Species A in Ewart and Popple 2001)**

An undescribed medium sized (MBL 18.0 mm; Plate 2Q, page 127) dominantly dark brown and black cicada, often common, and restricted to gidyea woodlands. It is a cryptic and mobile species typically confined to inner branches within dense gidyea foliage. This species occur widely in *Acacia cambagei* communities through inland southern, central, extending to western Queensland. In the Cravens Peak region, it occurs in *A. georginae*, especially within the inter-dune systems and outwash sand plains, being localized although common where present.

The song sounds aurally as a rhythmic sequence of complex and simple pulses which resemble the sound of human heart beats. It comprises continuous sequences of distinct, regularly emitted short chirp echemes, with inter-echeme clicks, which as shown in Figure 13A,B (page 145), are recognized to constitute distinct phrases. The click sequences show regularly decreasing, then increasing amplitudes. Each chirp echeme initiates with a sharp high amplitude pulse, a very distinctive song characteristic. Echeme repetition rates and widths are: 1.6 Hz and 48 ms (Cravens Peak); these compare to 1.5 and 52 ms for a comparative recording of the species from Cloncurry, northwest Queensland (Figure 13C, page 145). Inter-echeme clicks each comprise single macrosyllables whose repetition rates change through a phrase from (Cravens Peak recording), 28 Hz (first 8 clicks) to 23, to 29, to 43 Hz (final 2 clicks). The comparative figures for the Cloncurry song are 25, 22, 30, and 43 Hz. The MDF are 9.3 kHz (Cravens Peak) and 9.6 kHz (Cloncurry). The two songs are very close and clearly represent the same species.

Cicadetta species near *C. tigris* [Yellow-spotted Brigalow Cicada; no. 209] See *Notopsalta* species G in Ewart 1998a; also Popple and Strange 2002)

An undescribed small-medium species (MBL 15.6 mm; Plate 2O,P, page 127) with black and yellow-green thorax, and pale red-brown tergites with yellow-green posterior edges to each tergite. At Cravens Peak, it was a locally common species in Georgina gidyea (*A. georginae*), within inter-dune and outwash sand plains, inhabiting the inner branches within the dense foliage. It is an extremely wary and mobile species. This species occurs widely through inland southern and central Queensland, extending through western Queensland, especially in brigalow (*A. harpophylla*) and gidyea (*A. cambagei*); in SW Queensland, outside the desert environment, it also found in *Senna* sp. The insects from Cravens Peak have no forewing markings, in contrast to those from elsewhere in Queensland, which have two small dark spots near the apices of their forewings.

The song (Figure 14, page 146) sounds aurally as a high pitched rattling call, alternating between faster and slower 'rattling' or 'clacking' phases. Song analyses show it to consist of sequences of evenly repeated short single chirps which are interspersed with sequences of double, and often also triple chirps, which then revert with continued emission to single chirps (Figure 14 A, page 146). The double chirps are formed by the asymmetric insertion of an additional chirp within the single chirp sequences (forming effectively 'chirp doublets'), while the triple chirps develop from a second additional insertion of a chirp into the chirp sequences. It is the latter two sequences that sound aurally like 'clacking' sounds. For the Cravens Peak recording, the single chirp repetition rates are 7.9 Hz, becoming 7.2 Hz in the double chirp sequences, and speeding up to 9.9 Hz in the triple sequences, and continuing at 9.6 in the initial part of the following single chirp sequences. The repetition rates for all chirps in the double and triple sequence are 15 and 28 Hz, respectively. In detail, the structures of the chirps change through the 3 sets of chirp phases (Figure 14B,C, page 146), and all become shorter in the triple chirp sequences. The chirps comprise sets of macrosyllables, each comprising between 2 to 8 sets of double syllables, varying according to the chirp type and also whether they are from the single, double or triple chirp sequences (Figure 14C, page 146). The MDF is 10.1 kHz.

Figure 14D (page 146) shows a comparable song of this species from near Mitchell, southern inland Queensland, clearly showing the same chirp structures and sequences. The similarities are emphasized by the chirp repetition rates: single chirps 7.6 Hz, becoming 6.8 Hz in the double sequences, and 8.6 in the triple sequences, and 8.1 in the initial part of the following single sequence. The repetition rates for all chirps in the double and triple sequences are 14 and 27 Hz, respectively. The MDF is 11.5 kHz.

This species illustrates both the complexity of its song and song stability over a significant distance (~980 km) and confirming the conspecific status of these cicadas from the two localities.

Kobonga species C (Kettledrum cicada; no. 199) (See Species C in Ewart and Popple 2001)

An undescribed medium sized cicada (MBL 20.5 mm; Plate 2S, page 127), black and brown head and thorax and mainly black abdomen with orange-brown transverse bands across posterior margins of each tergite. Distinctive double black spots occur towards apices of forewings. A wary and mobile cicada showing a preference for *Acacia* dominated open woodlands. It occurs widely through southern inland to western Queensland, from Jondaryan, westwards to near Windorah, and northwards to near Middleton and Mt. Isa. At Cravens Peak, it was found locally within Georgina gidyea (*A. georginae* in the inter-dune and outwash sand plain environments, apparently never common, and captured only by light trapping.

The song is complex, sounding as a prolonged, rapid melodious clicking and 'clacking', with three distinct tonal variations (phases). As seen in plots of the Cravens Peak recording (Figure 15A–C, page 147), the three phases comprise: (a) Introductory uniformly emitted sets of single clicks, each comprising single macrosyllables, with a repetition rate of approximately 15 Hz; (b) short echemes composed of continuous coalesced macrosyllables, aurally comprising a continuous short 'buzz' (0.2–0.3 s in length) phases; and (c) trains of macrosyllables (clicks) showing complex and varying temporal arrangements (Figure 15B,C, page 147), this sounding aurally as irregular phases of 'clacking' with interspersed 'revving' phases. This third song phase is made up of sets of triplet macrosyllables interspersed with short sequences of sets of five macrosyllables. Within these sets of macrosyllables, complex variations of amplitude occur within certain of the macrosyllables (actually reflecting changing syllable structures), together with temporal variations of the positioning of individual macrosyllables within the triplet and quintuplet macrosyllable groupings. Macrosyllable widths range between 20–23 ms. The MDF is 6.8 kHz, but is a broadband song with marked frequency components extending between 2–12 kHz.

Cicadetta **species H, near** ***C. crucifera*** **[Fishing Reel Buzzer; no. 291] (See Ewart 1998b; Popple and Strange 2002)**

An undescribed small (MBL13.8 mm; Plate 1J), dominantly pale brown, with dark brown markings on mesonotum and a black dorsal fascia running along midline of abdomen. Morphology and colour are very close to *C. crucifera* , but calling songs easily distinguish the two species. *Cicadetta* sp. H is a grassland cicada, both in open dense grassland and dense grassland within open low woodland and shrubland. It is a cryptic, highly wary and mobile species, found widely through southern inland and central Queensland, extending northwards into coastal northeastern Queensland and westwards through the southern Gulf of Carpenteria region into northwestern Queensland and adjacent Northern Territory (Ewart 1998b). It is also recorded from the Alice Springs region (AE). At Cravens Peak it was found to be moderately common in a tributary stream of the Mulligan River, 12 km north of the homestead, and more uncommonly at the main Mulligan River crossing, 15 km north of the homestead.

The song is a high pitched sequence of quasi-continuous repeated phrases (Figure16A), each varying between 0.8–3 s in length. Each phrase consists of sequences of discrete clicks (each comprising double syllables) separated by short echemes (segments of coalesced syllables), which are, for convenience, subdivided into sub-phrases; each comprises a single echeme followed by the sequences of clicks. The number of sub-phrases is variable within the phrases, typically varying between 1 to 6. The short echemes have lengths between 36–110 ms with the intervals between the short echemes of 340–500 ms. The number of clicks between the echemes vary between 24–45, with mean repetition rates between 69–90 Hz, usually decreasing towards the end of each sequence. The MDF is 15.3 kHz. It is a relatively complex song.

A comparative plot of the recording of this species from Alice Springs is presented (Figure 16B, page 148). Phrase lengths are of similar lengths (1<-3 s), with echeme and inter-echeme lengths of 31–110 ms and 400–460 ms, respectively. Intervening clicks range between 24–33 per sequence, with mean repetition rates of 55–85 Hz, again usually slightly decreasing towards the end of each sequence. The MDF is 13.8 kHz. The plots confirm the close similarities between the two songs.

Tryella graminea **Moulds [Grass Buzzing Bullet; no. 536]**

A medium size cicada (MBL 17.0 mm; Plate 1H), predominantly medium to dark brown in colour, but with conspicuous yellow-brown colour over most of pronotum, separated by a dark brown fascia running along dorsal surface. The forewings show conspicuous brown apical zig-zag markings, extending to apical margin; the forewing costa is also a pale yellow brown colour. This is a relatively sedentary species, typically occurring in significant numbers in dense shrubs, thick grass, and low trees. It was found only in the tributary stream of the Mulligan River, 12 km north of the homestead, both before and following the major rains (Figure 1, page 121). It is believed the latter resulted from a continued emergence of insects following the rains. This cicada has a very wide distribution extending from Oodnadatta (S.A.) north through Uluru to Tennant Creek (N.T.), through northwestern into central Queensland, extending south to Charleville (Moulds 2003).

The song is a relatively high pitched, continuous, coarse, slightly rattling buzz. It is composed of short echemes (Figure17, page 149), each consisting of four (rarely five) complex macrosyllables, the initial macrosyllable commonly slightly detached from the following three (or four) coalesced macrosyllables. The macrosyllables each comprise 7–8 distinct syllables. Echeme lengths and mean repetition rate are 18–20 ms (4 macrosyllables) to 24 ms (5 macrosyllables), and 46 Hz. Macrosyllable lengths and inter-echeme intervals are 4.2–5.1 ms and 1.3–2.2 ms. Syllable repetition rates (per macrosyllable) are 545 Hz. The MDF is 11.0 kHz.

Cicadetta species M [Copper Shrub Buzzer; no. 278] (See *Notopsalta* species B in Ewart and Popple 2001)

An undescribed smallish cicada (MBL 14.3 mm; Plate 2N, page 127), dark brown to black cicada with distinct narrow coppery-brown band along posterior edges of each tergite, and coppery coloured membranes at bases of wings and along costa of forewings. It is a relatively static species, occurring from inland southeastern, through southern, to southwestern Queensland, north to the Longreach area (central Queensland), and south to the Flinders Ranges (S.A.; LWP observations). In southwestern Queensland, it occurs almost exclusively in *Eremophila bignoniiflora* in seasonally inundated overflow areas. At Cravens Peak, a definite aural record was obtained in an inter-dune area, 3 km W of homestead, in low dense clumps of *E. macdonnellii*, on 8 February. No aural recordings or capture were made. The song is, however, very distinctive. It appears to be a very rare cicada in the Cravens Peak area, possibly at the extreme limit of its range and thought to have been blown into the area by preceding days of strong easterly winds (see above).

The song is a continuous series of repetitive buzzing phrases. The example shown (Figure 18, page 149) is from a recording made at Moothandella, 35 km SE of Windorah, southwestern Queensland. The phrases, 2–4 s in length, start with a composite echeme (0.24–0.27 s, comprising the partial coalescence of very short echemes) followed by sets of multiple discrete short chirp echemes which tend to increase in length progressively through the phrase sequence (their lengths ranging between 45–145 ms). Detailed examination of all the echeme structures show these to comprise multiple macrosyllables, typically 6–20 in number, each comprising 5–6 syllables. Mean macrosyllable lengths and syllable repetition rates are 8.4 ms and 480 Hz. The MDF of the song is 15.6 kHz.

Kobonga apicans Moulds and Kopestonsky [Northern Robust Clicker; no.161]

A medium-large sized cicada (MBL 23–25 mm; Plate 2T, page 127), with dominantly medium brown to black body colouration. The most distinctive feature is the brown infuscations of the wings. These include the patches along the basal veins of apical cells 2 and 3 on the fore wings, and the bold infuscation along the ambient veins (outer margins) of the fore and hind wings. At Cravens Peak, it appears to be relatively scarce, at least in the eastern part of the reserve, and was only rarely encountered in the denser gidyea (*A. georginae*) woodlands occupying the inter-dune areas extending 1.5–5 km west and southwest of the homestead. Moulds and Kopestonsky (2001) show that this species has a wide distribution extending through central N.T., inland southwestern W.A., and northern S.A.

The song was not recorded at Cravens Peak. A recording from N.T., made available by KH and DM (Figure 19, page 150), show that it possesses a complex calling song. Aurally, this sounds as repeated sequences of rapid sharp double clicks, with repetition rates of 0.55–0.6 s-1, alternating with coarse buzzing echemes (almost a ‘roaring’ sound) with lengths most commonly between 1.7–1.9 s, although sometimes longer. The songs are commonly initiated with short bursts (approximately 1.5 s in length) of rapidly repeated clicks. The MDF is 10 kHz.

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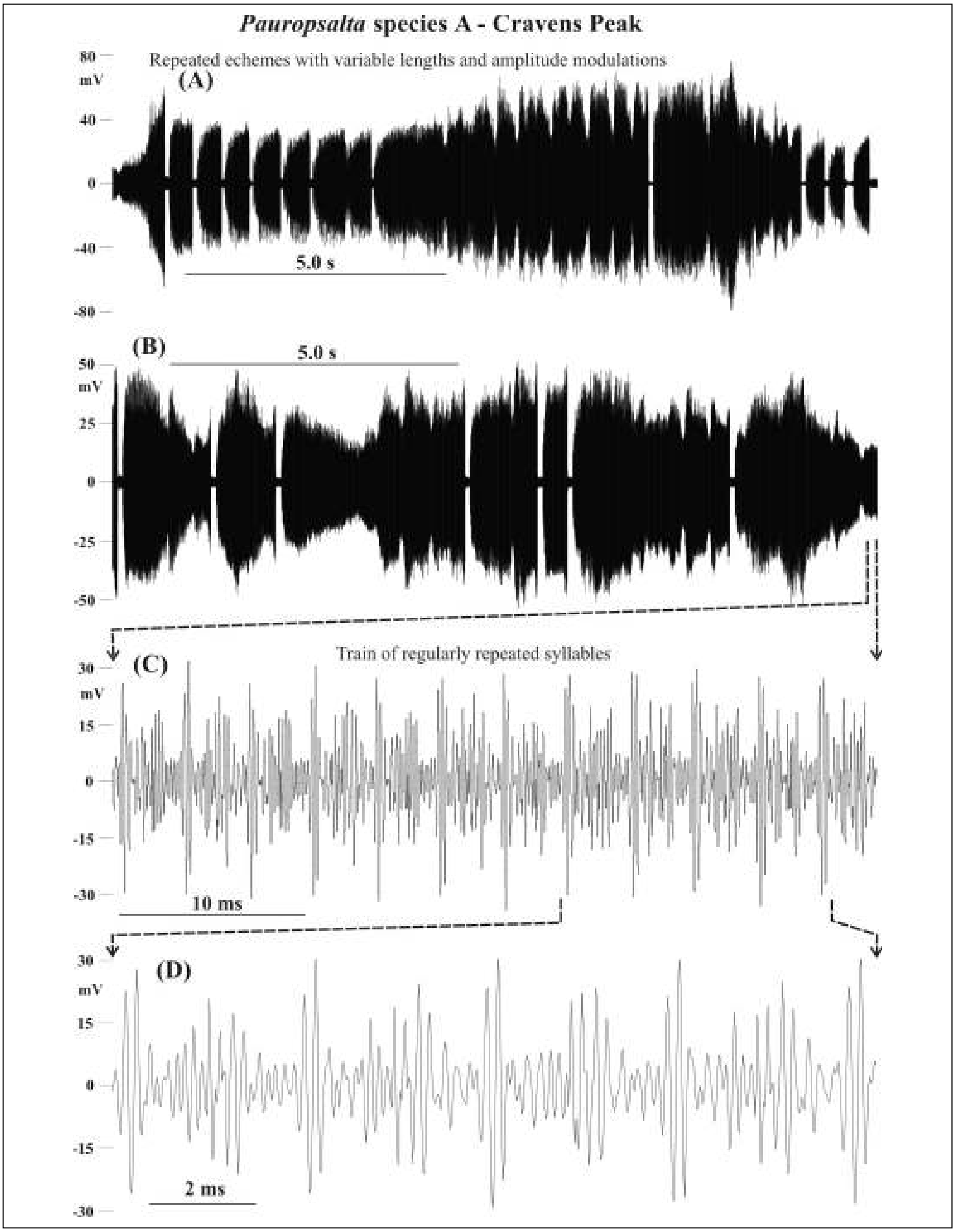

Figure 2. *Pauropsalta* species A [Black Spinifex Squeaker; no. 692]. A, B: Plots (time versus amplitude) of typical calling songs showing the discontinuous echemes, each sounding as a whistle, of various lengths and amplitudes. C, D: Time expanded waveform plots illustrating the finer detail of the continuous syllable trains comprising the echemes, showing regular emission of higher amplitude pulse doublets and more complex intervening sets of 4 to 5 pulses. 27 km NW of Cravens Peak homestead, in spinifex, parabola field recording. Filtered (IIR) to 0.5 kHz.

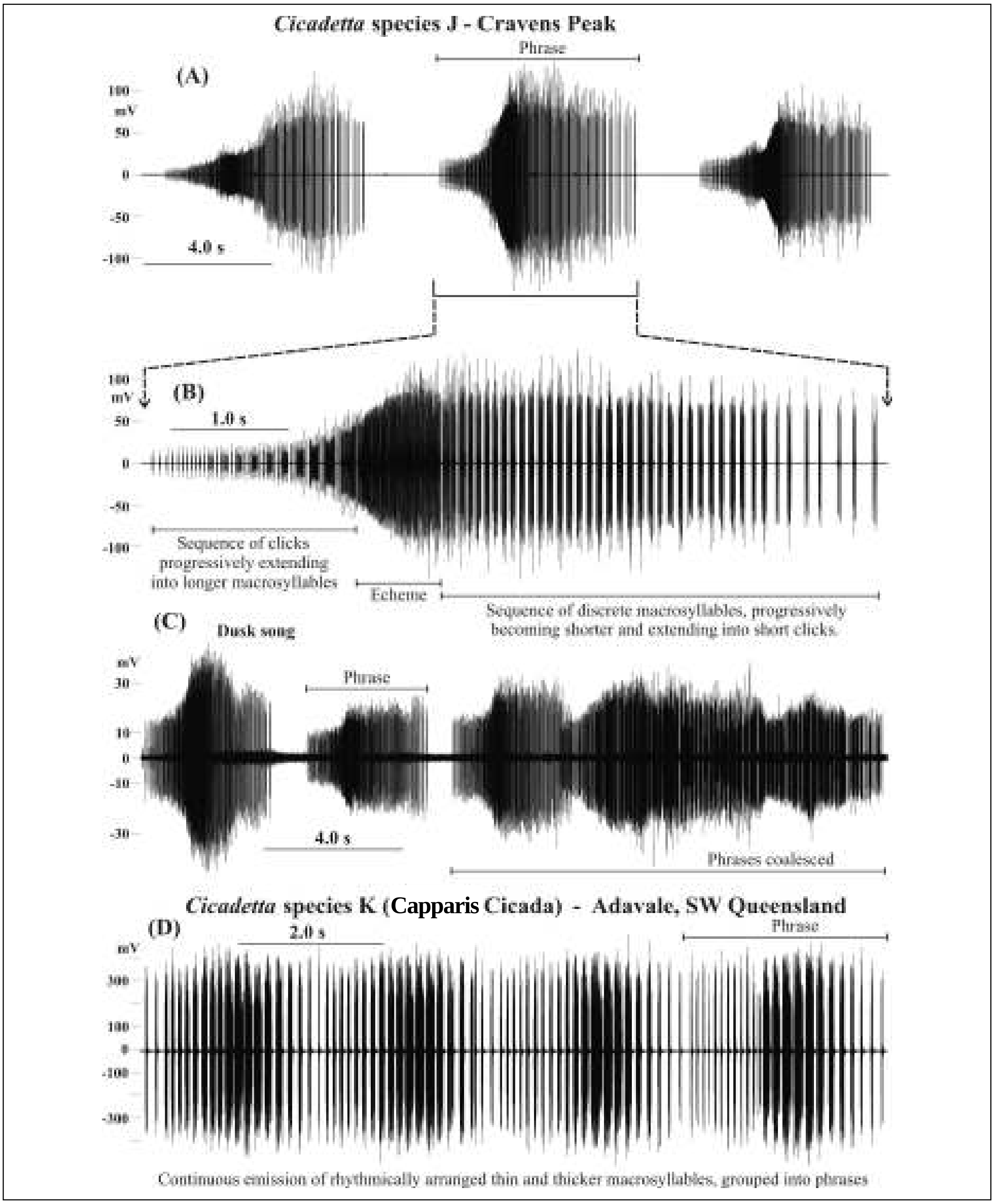

Figure 3. *Cicadetta* species J [Roaring Senna cicada; no. 210]. A: Three discrete calling song phrases from part of a more extended sequences of such phrases. B: Time expanded detail of a single phrase. This starts with a staccato chirping which increases in amplitude and speed of chirp emission, finishing with dropping amplitude and stuttering series of chirps with progressively decreasing emission rate. C: Dusk song showing the tendency of the discrete song phrases to coalesce. 2.3 km north of Cravens Peak homestead, parabola field recording filtered (IIR) to 3 kHz. D: calling song of an undescribed sibling species (Capparis Cicada; no. 219) from near Adavale, 70 km north of Quilpie, S.W. Queensland, unfiltered container recorder. This song structure is markedly different.

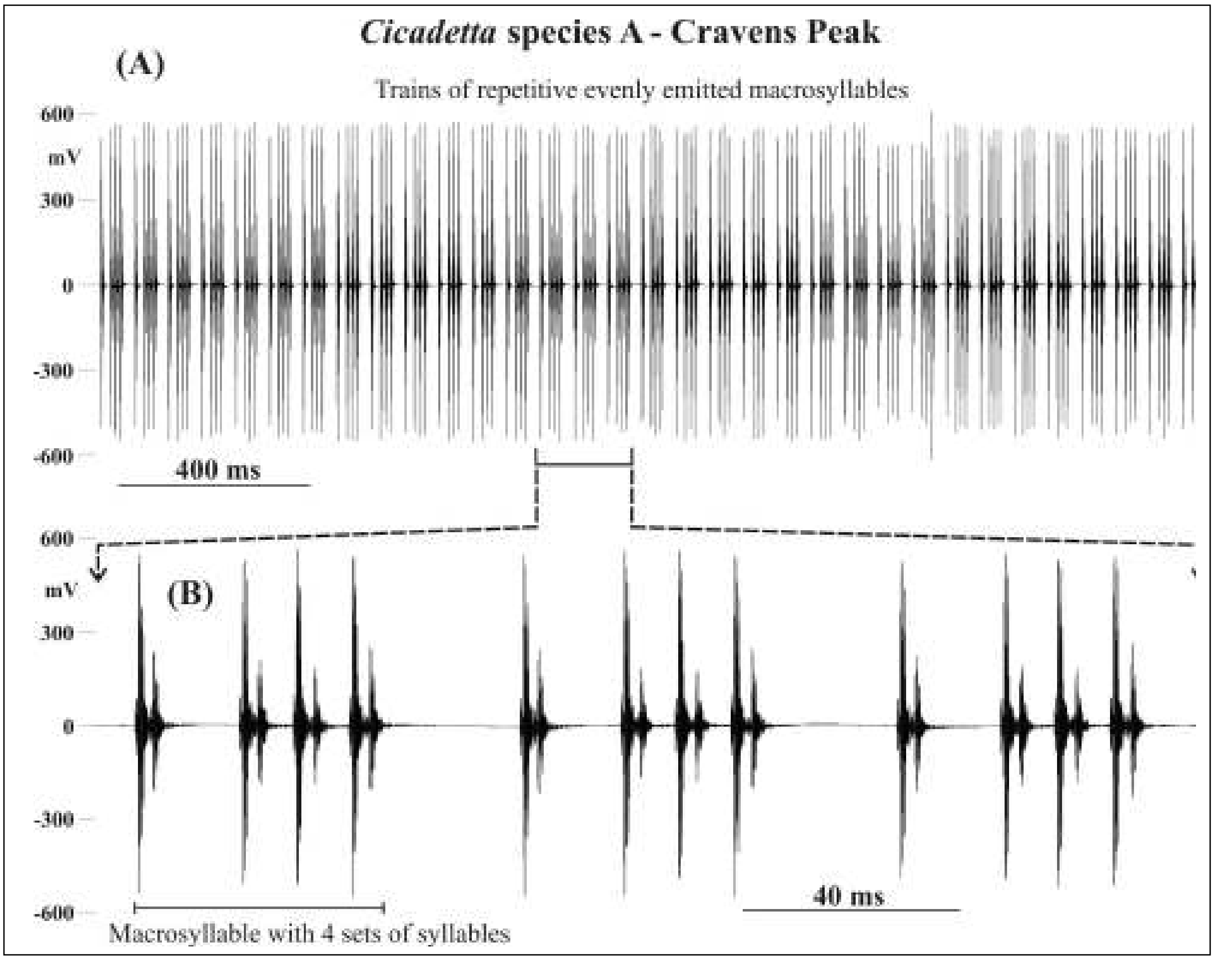

Figure 4. *Cicadetta* species A [Brown Sand Plains cicada; no. 253]. A: Continuous uniform buzzing song showing the repetitive, evenly emitted macrosyllables, each comprising four discrete syllables, further details of which are shown in B. 1.5 km west of Cravens Peak homestead, unfiltered parabola field recording.

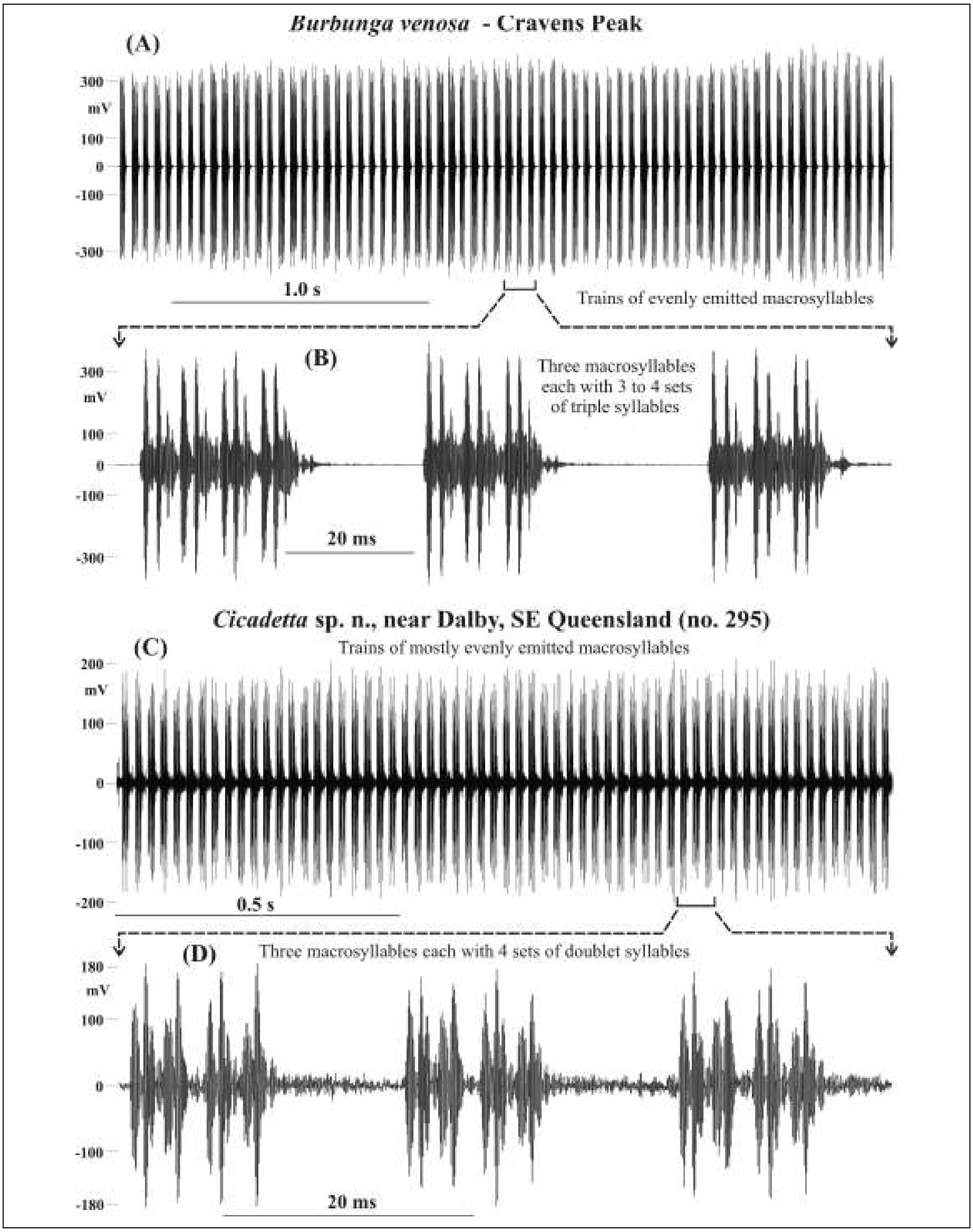

Figure 5. *Burbunga venosa* [Cravens Spinifex Buzzer; no. 30]. A: Continuous buzzing song comprising evenly emitted trains of macrosyllables; B: time expanded details of three macrosyllables, each with 3 to 4 sets of triple syllables. 1.5 km west of Cravens Peak homestead, field parabola recording, filtered (IIR) 0.5 kHz. C, D: Comparable plots of a very similar cicada (Cunnamulla Smoky Buzzer, no. 295), morphologically and in habitat, although of differing genus, showing a superficially similar song, that nevertheless differs detailed syllable structures and frequency. Dalby, S. Queensland, field recording, filtered (IIR) to 7.5 kHz (LWP recording).

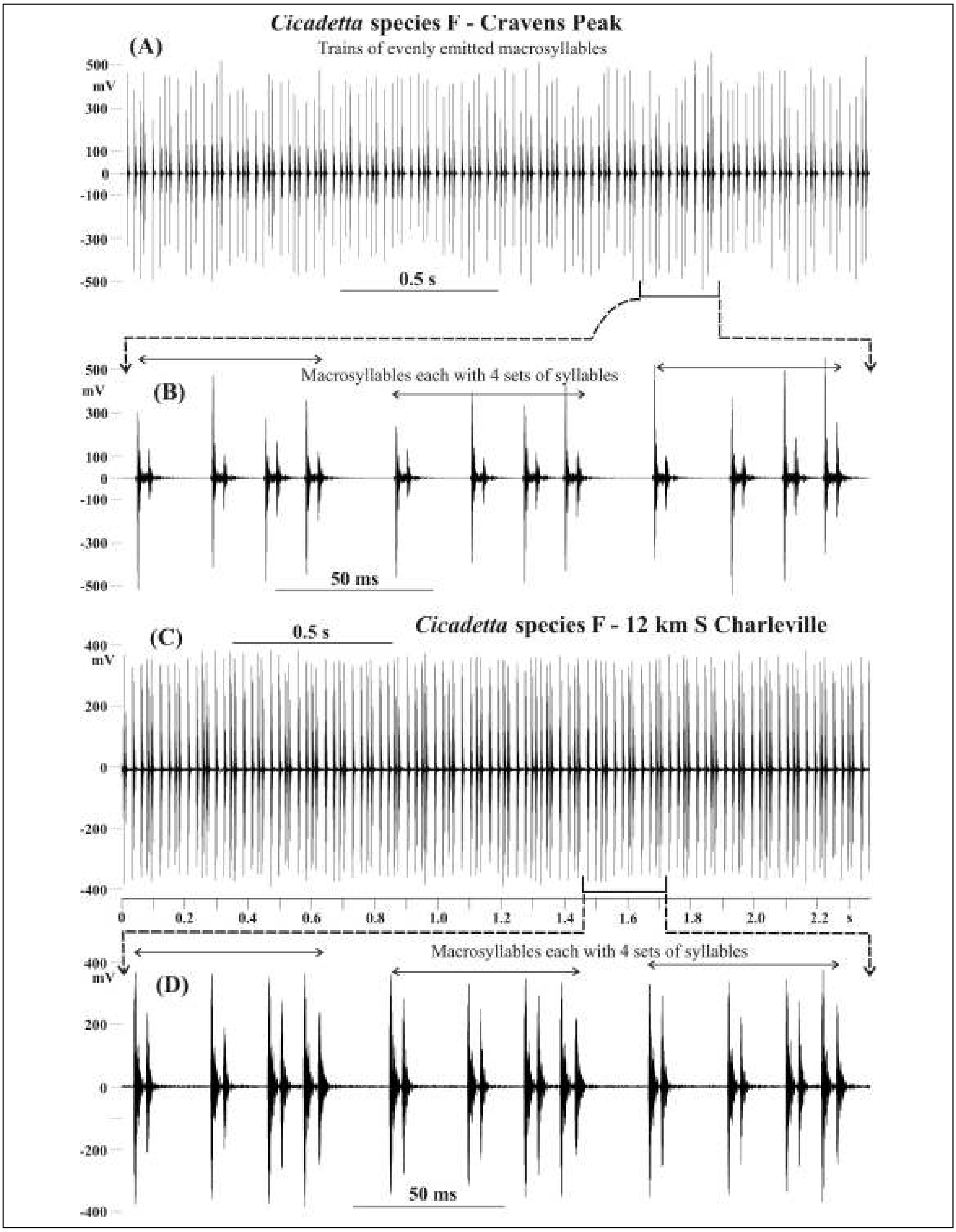

Figure 6. *Cicadetta* species F [Spinifex Rattler; no. 259]. A: Continuous coarse high pitched rattle showing evenly and continuously emitted macrosyllables, each comprising, (B) four sets of syllable doublets. Cravens Peak homestead, field parabola recording, filtered (IIR) to 0.5 kHz. C,D: Comparable plots of the same species from 12 km south of Charleville, S.W. Queensland, container recording, filtered (IIR) to 0.5 kHz. Compare the similarity of these songs to that of the *Cicadetta* species A (cp) (Figure 4, page 136), noting the differing frequency between the songs (see texts).

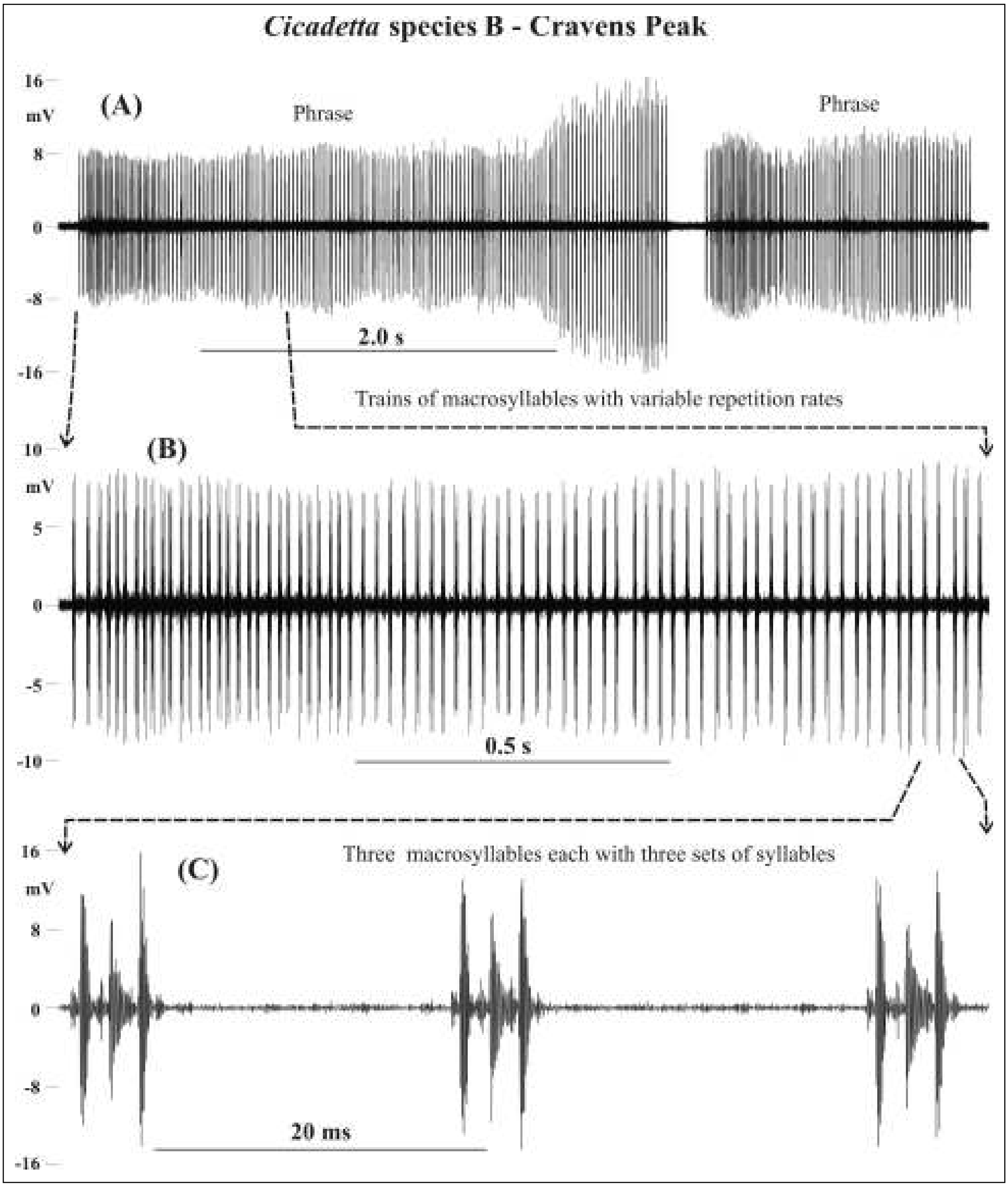

Figure 7. *Cicadetta* species B(cp) [Cravens Buzzing Cicada; no. 204]. A,B: A soft high pitched buzzing song, interrupted by brief gaps, dividing the song into phrases. The phrases comprise trains of macrosyllables which have highest repetition rates within the earliest segments of the phrases. As seen in (C), each macrosyllable comprises 3 sets of syllable doublets, the initial one of low amplitude. 2.3 km N. of Cravens Peak homestead, open net in field with parabola, filtered (IIR) to 4 kHz.

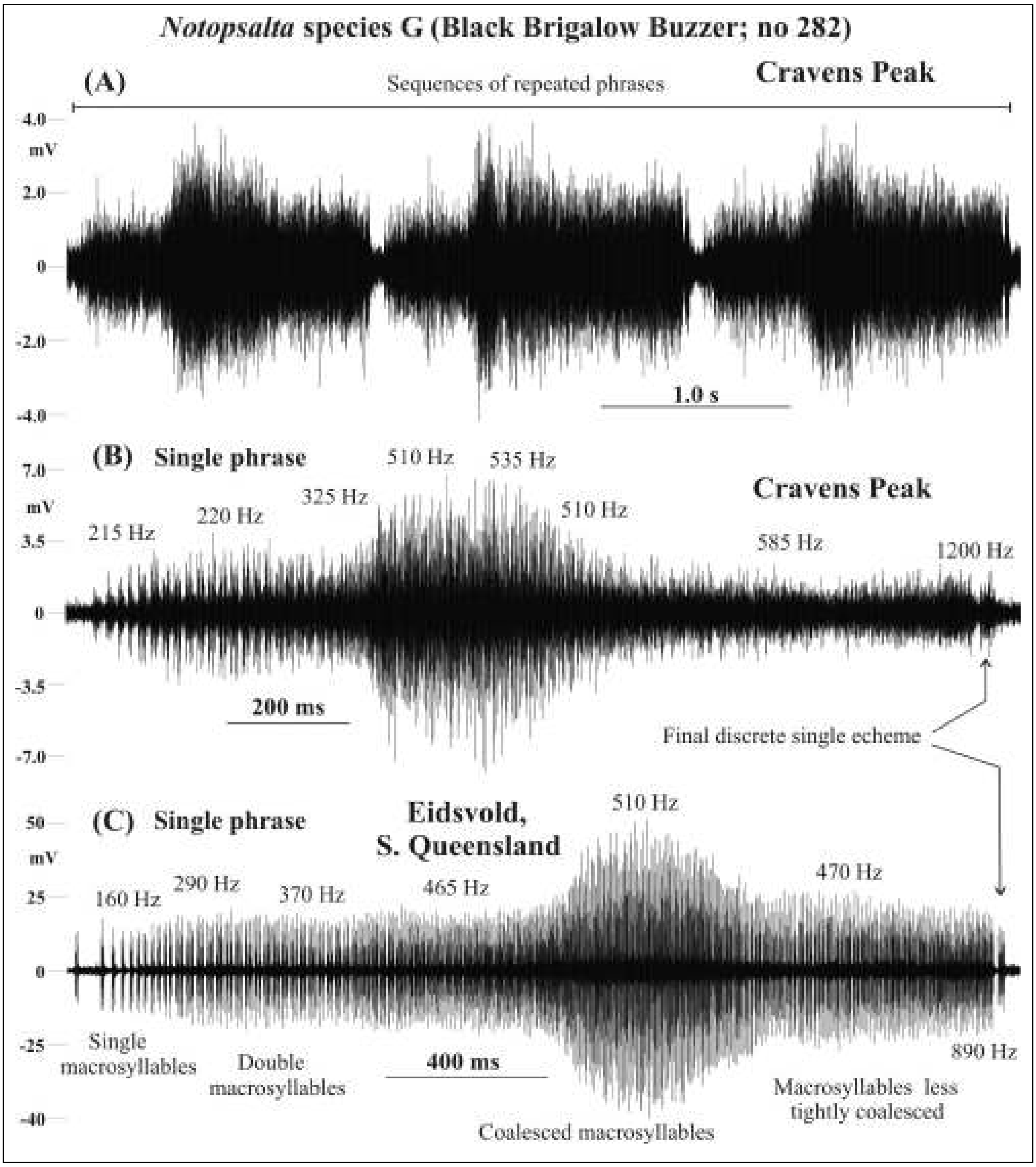

Figure 8. *Notopsalta* species G [Black Brigalow Buzzer; no. 282]. A: a set of three buzzing phrases, which form part of a more extended sequence of such phrases. B: More detailed waveform plot of a single phrase showing the abrupt increase in amplitude within the middle segment of the phrase; also documented is the progressively increasing emission rate of the component macrosyllables as the phrase emission proceeds. 5 km SW of Cravens Peak homestead, parabola field recording, filtered (IIR) to 12 kHz. C: A higher quality recording of the same species from Eidsvold, S. Queensland, showing more clearly the same characteristic features as shown by the recorded Cravens Peak song. LWP field recording, filtered (IIR) to 10 kHz.

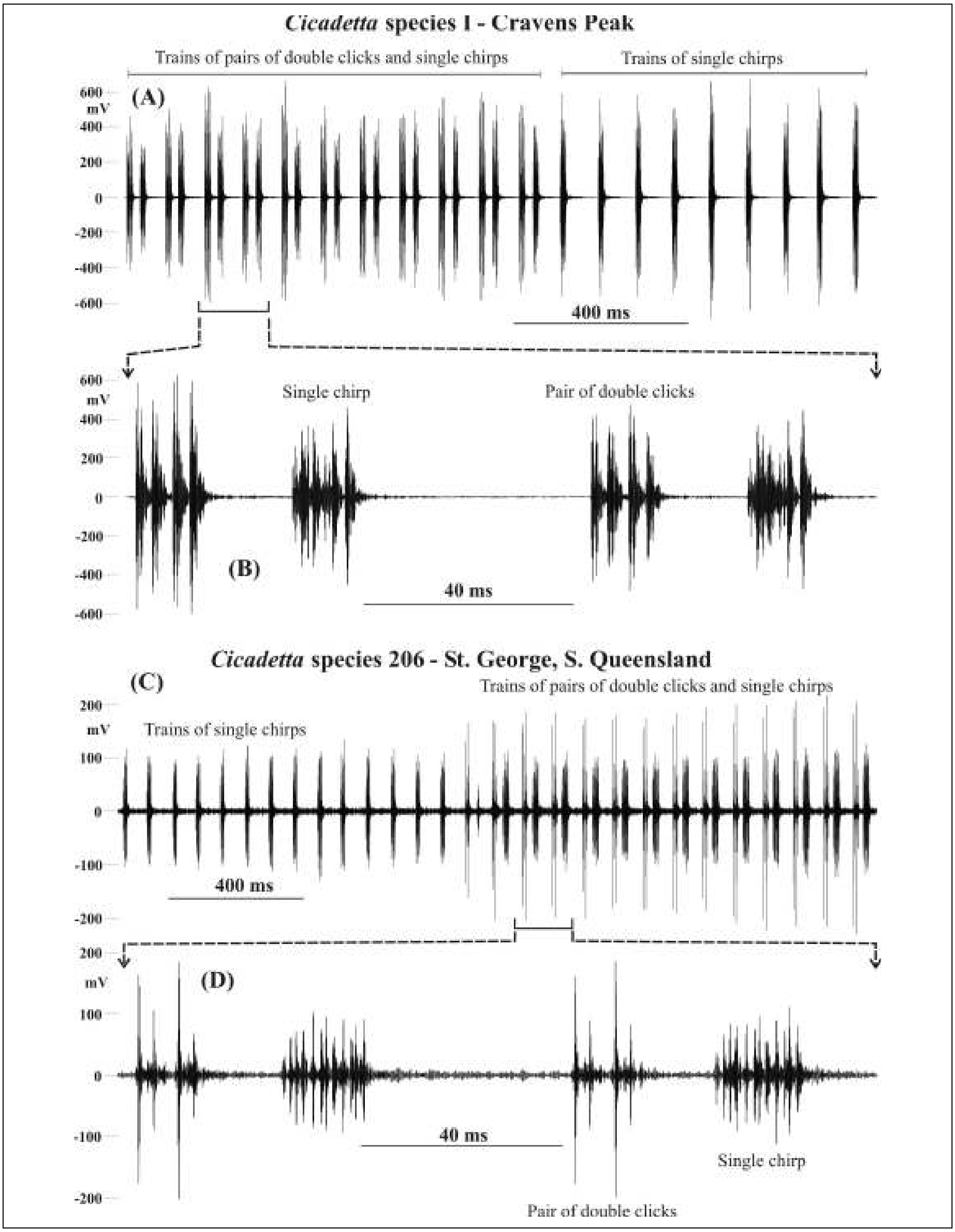

Figure 9. *Cicadetta* species I [Small Acacia Cicada; no. 206]. A: Part of the continuous clicking song showing a phase of single chirps which alternate with phases of doublet clicks. The latter result from the asymmetric insertion of sets of closely spaced double clicks between the single chirps, with differing temporal structures, as shown in B. Cravens Peak homestead, unfiltered container recording. C, D: Comparable song segments from the same species, recorded from St. George, southern inland Queensland, by LWP, parabola field recording, filtered (IIR) to 4 kHz.

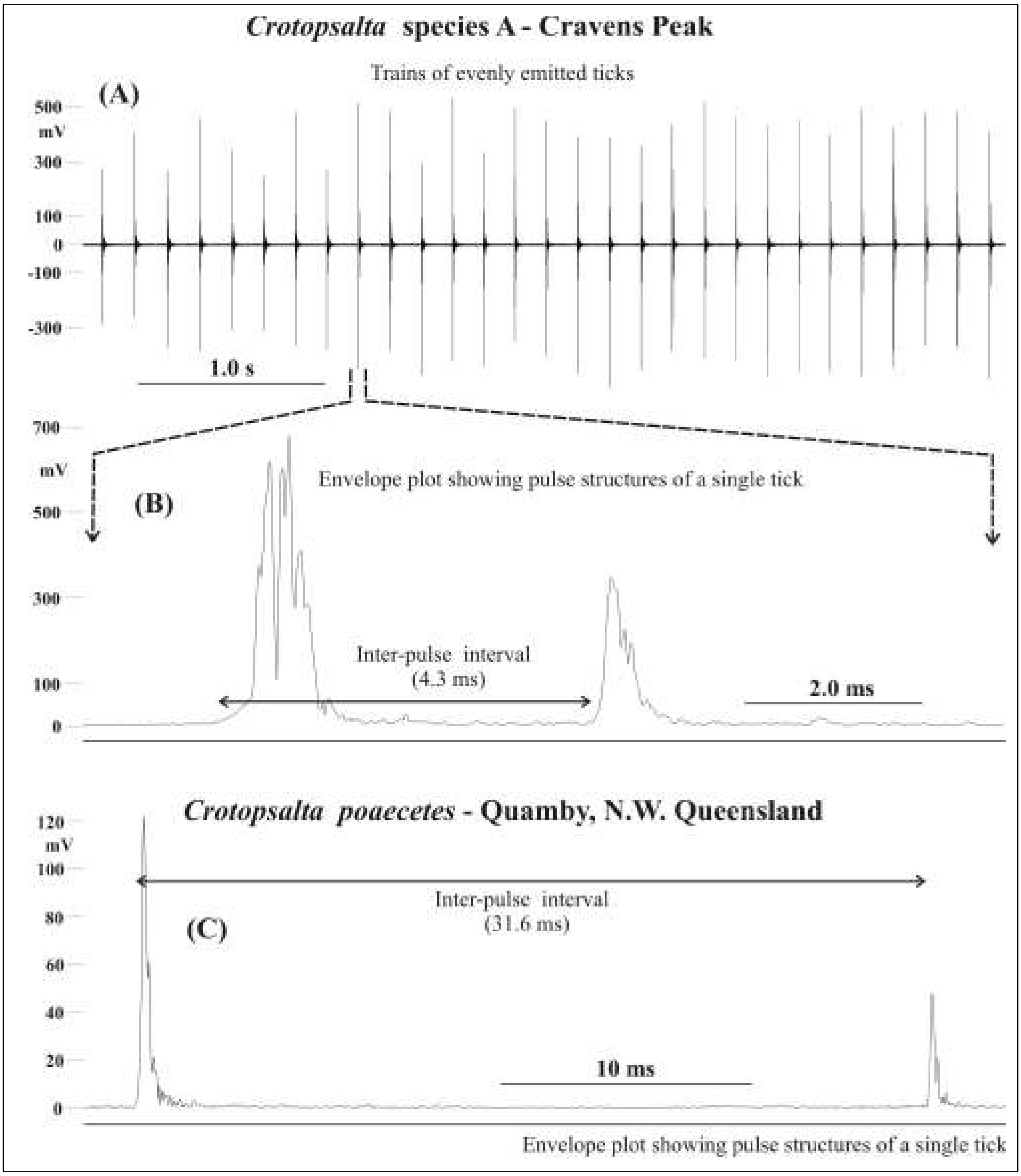

Figure 10. *Crotopsalta* species A [Cravens Ticker; no. 358]. A: Segment of calling song showing the continuous train of sharp ticks, which in the time expanded envelope curve (B) show that each tick actually comprises a set of closely spaced, but discrete double pulses, which have an inter-pulse interval in the example shown of 4.3 ms. 2.3 km north of Cravens Peak homestead, open net field recording, filtered (IIR) to 2 kHz. C: Sibling species from N.W. Queensland, *C. poaecetes* (no. 356), showing a superficially similar song but with much wider double pulse separation (31.6 ms in example shown) within a single tick; the tick repetition rate, however, overlaps that of the Cravens Peak species. Quamby, N.W. Queensland, field recording, 23 January 2008, filtered (IIR) to 13 kHz.

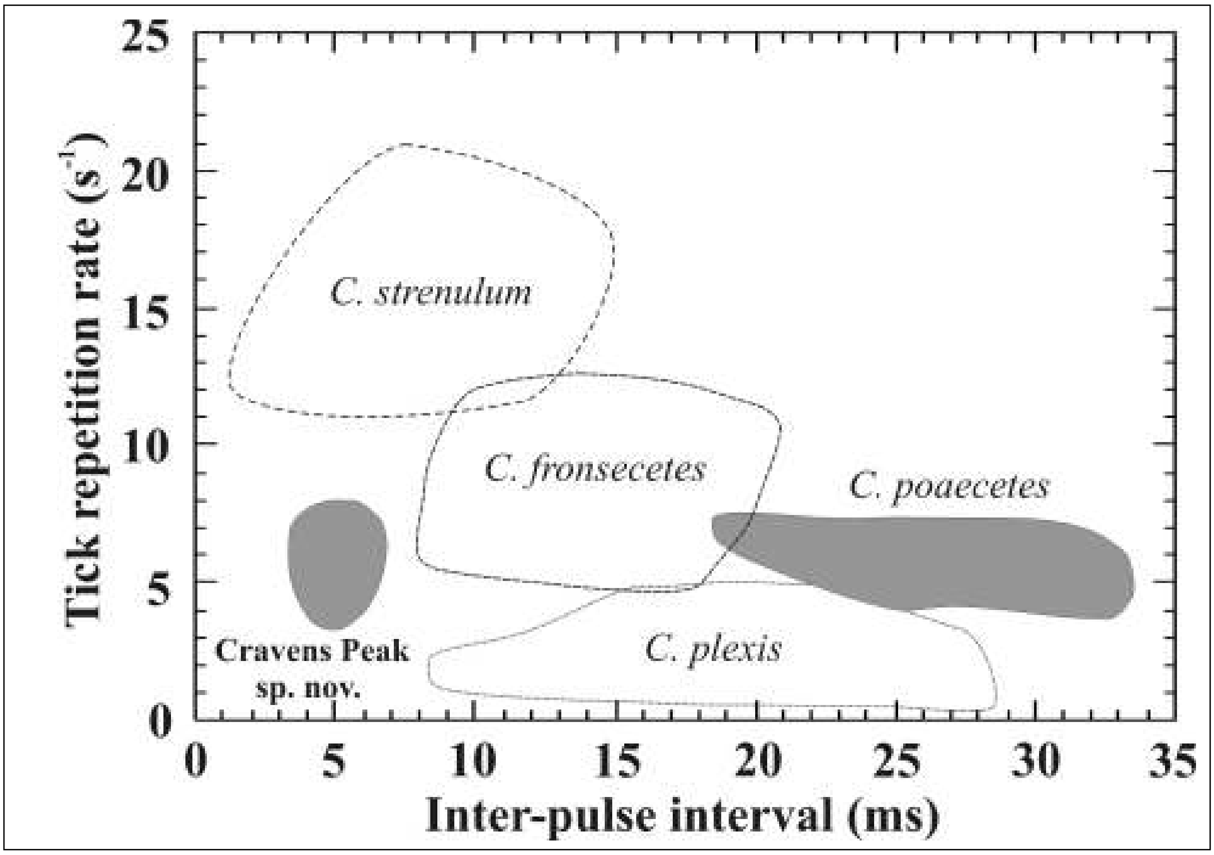

Figure 11. Plot of tick repetition rates (s-1) versus inter-pulse intervals, each based on field recordings, of the four described *Crotopsalta* ticking cicadas from Queensland (Ewart 2005), and the distinctive inter-pulse intervals within the song of the new Cravens Peak species.

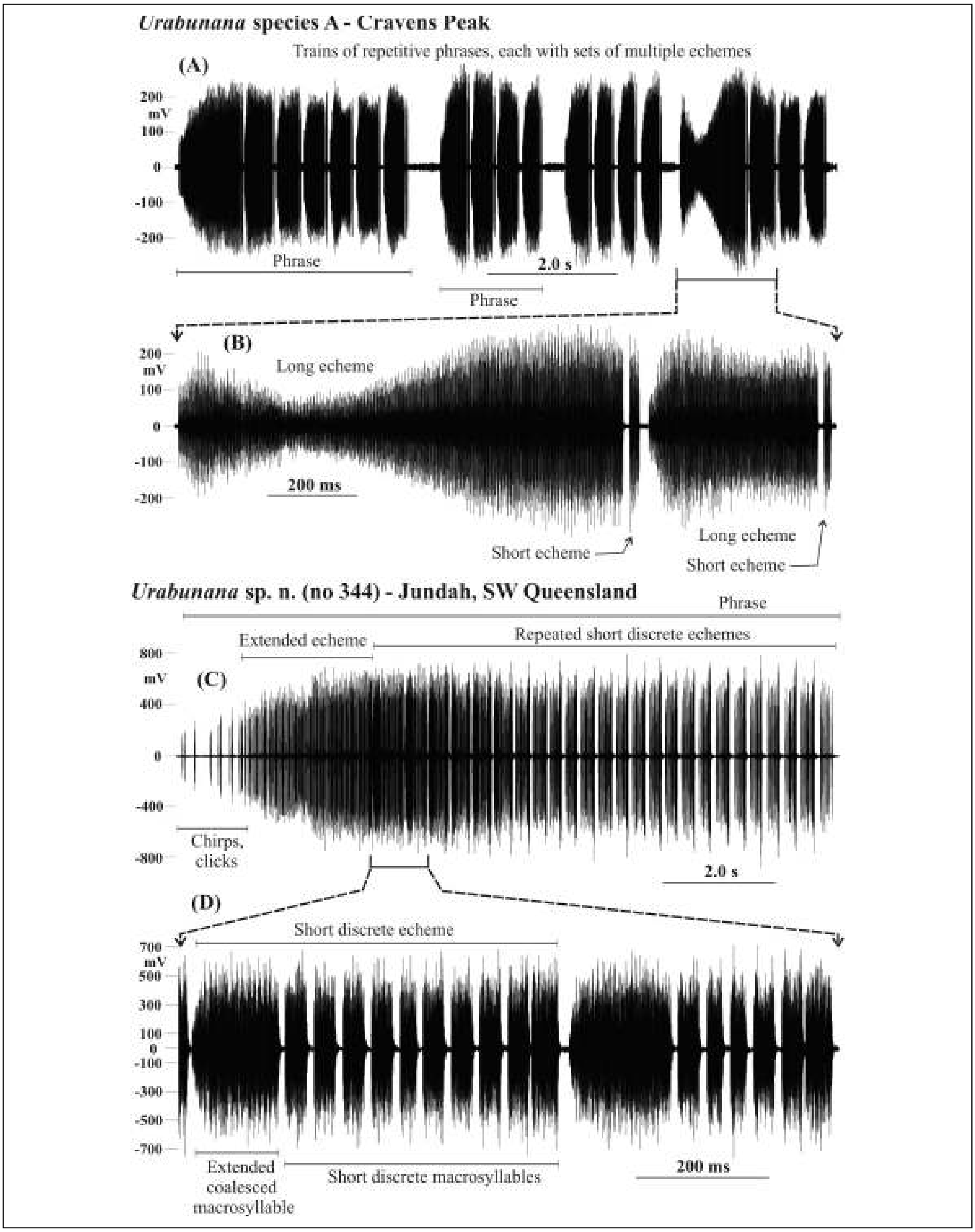

Figure 12. *Urabunana* species A [Cravens Grass Chirper; no. 634]. A: Calling song showing discrete phrases, each consisting of sets of pairs of echemes, an initial long followed by very short echeme. The echemes comprise continuous and partially coalesced macrosyllables (B). Cravens Peak homestead, field parabola recording, filtered (IIR) to 4 kHz. C, D: Comparable plots of a remarkably similar sibling species from S.W. Queensland, showing the contrasting and thus very different temporal structures of the calling song. Unfiltered container recording from 4 km W. Jundah, S.W. Queensland.

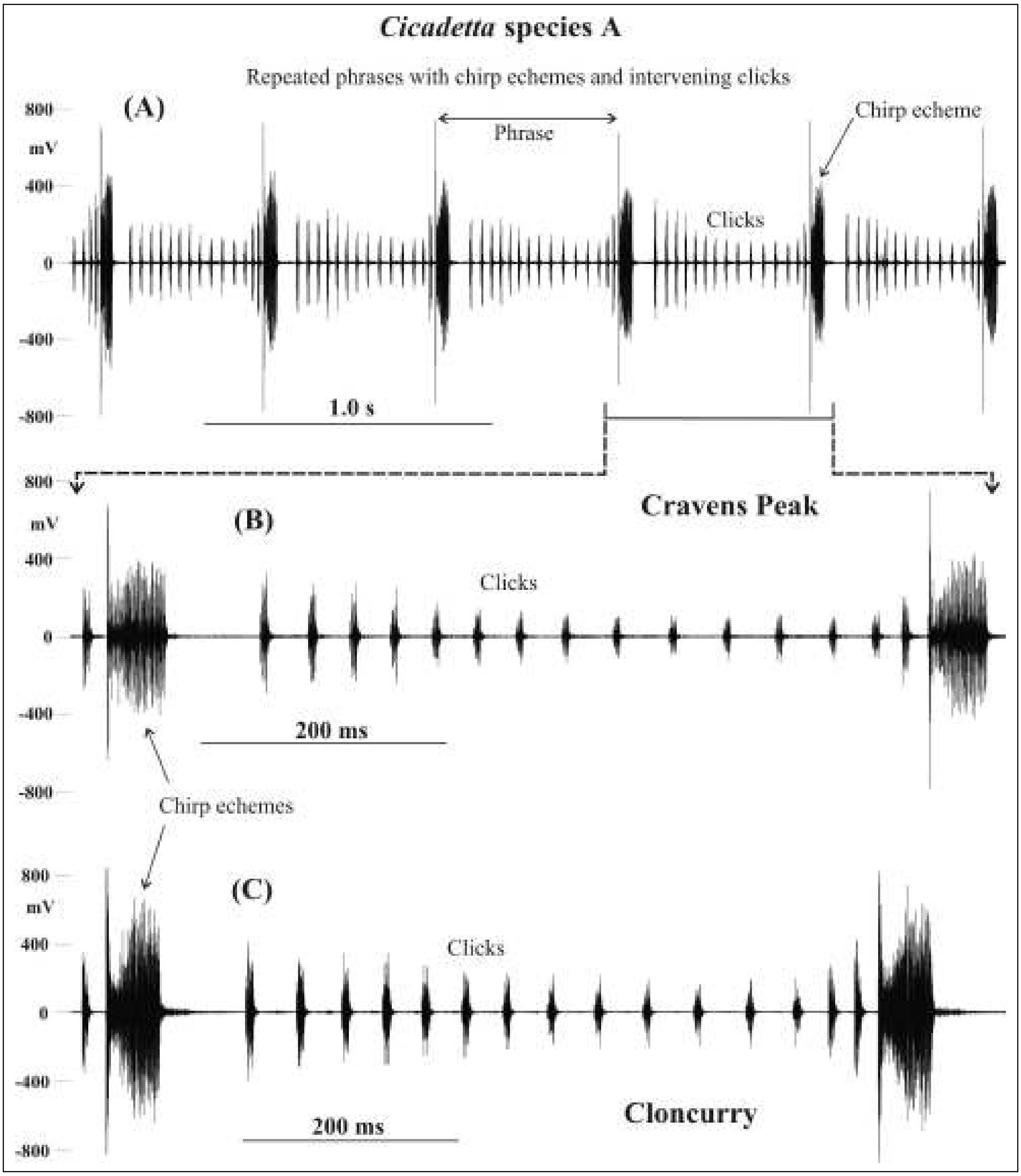

Figure 13. *Cicadetta* species A [Gidyea Cicada; no. 207]. A: The characteristic and repetitive rhythmic sequences of phrases of simple and complex clicks and short echemes. B: Time expanded detail of a single phrase showing the regular short chirp echemes with the sets of intervening (inter-echeme) clicks, exhibiting regular patterns of amplitude variation and varying emission rates. 5 km SW Cravens Peak homestead, field parabola recording, filtered (IIR) 1 kHz. C: Comparable single song phrase (compare to B) of the same species from Cloncurry, N.W. Queensland, showing the close similarity between the song phrases. Container recording, 9 km E. Cloncurry, filtered (IIR) 0.5 kHz.

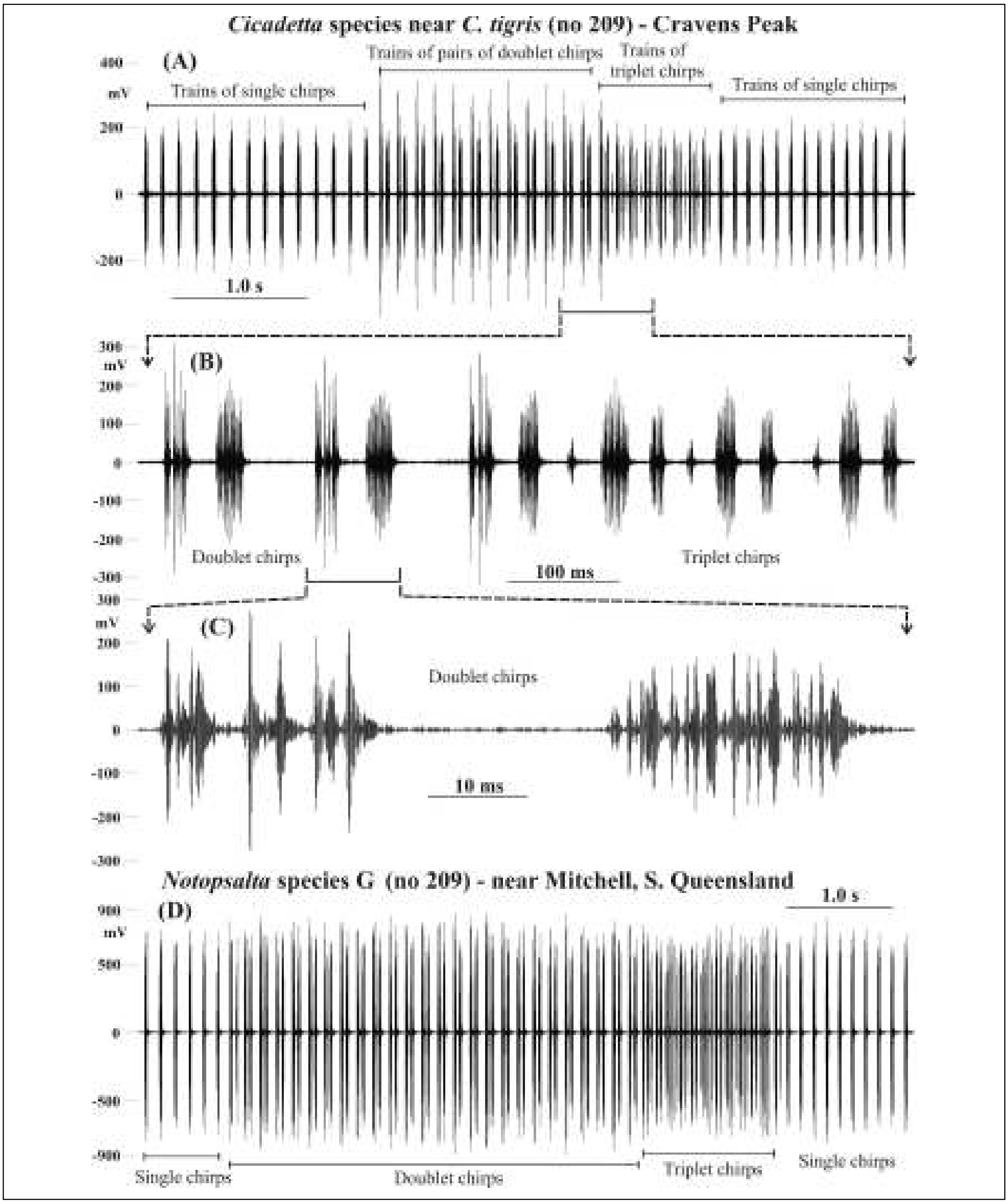

Figure 14. *Cicadetta* species near *C. tigris* [Yellow-Spotted Brigalow Cicada; no. 209]. A, B: The three song phases characteristic of calling song. These comprise a set of evenly repeated single chirps which are periodically interspersed with sequences of double and triple chirps, the sequence then reverting to the single chirp sequences. The double and triple chirps result from the insertion of separate chirps into the single chirp sequences. As shown in B, C, the three chirp structures each differ in their detailed temporal pulse structures. Field parabola recording from 5 km SW Cravens Peak homestead, filtered (IIR) to 4 kHz. D: Comparable plot of song of *Notopsalta* species G, showing the same song chirp sequences, from Womalilla Creek, ~ 20 km W Mitchell, S. Queensland. Container recording filtered (IIR) to 0.5 kHz. These two songs confirm their conspecific status of these cicadas.

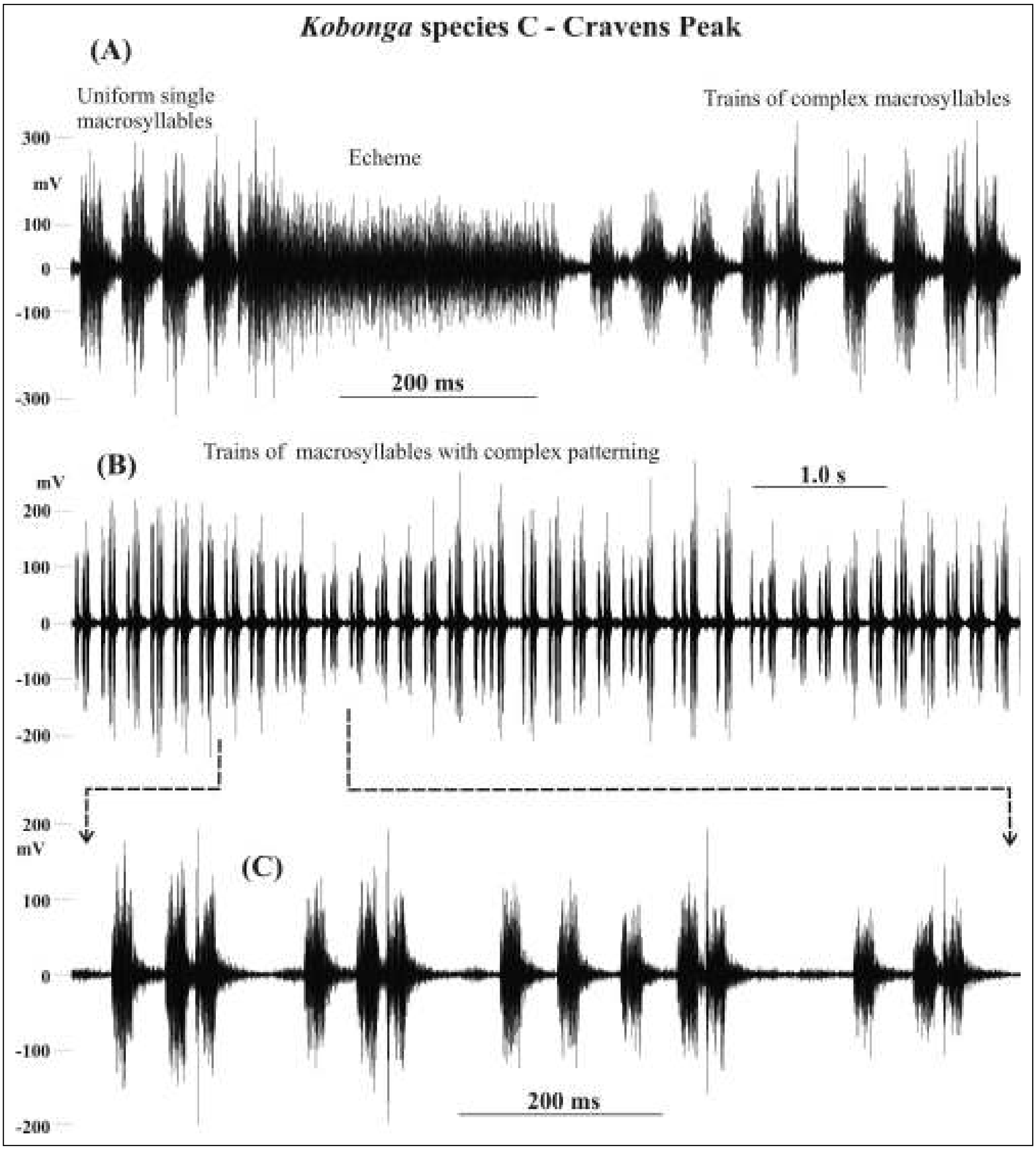

Figure 15. *Kobonga* species C. [Kettledrum Cicada: no. 199]. A, B: A complex and lyrical song comprising three distinct phases; introductory uniform single clicks (macrosyllables); short echemes (buzzes); and trains of clicks (macrosyllables) with complex and variable temporal patterning, shown most clearly in B and C. Parabola recording, 1.5 km W. Cravens Peak homestead, filtered (IIR) 1 kHz.

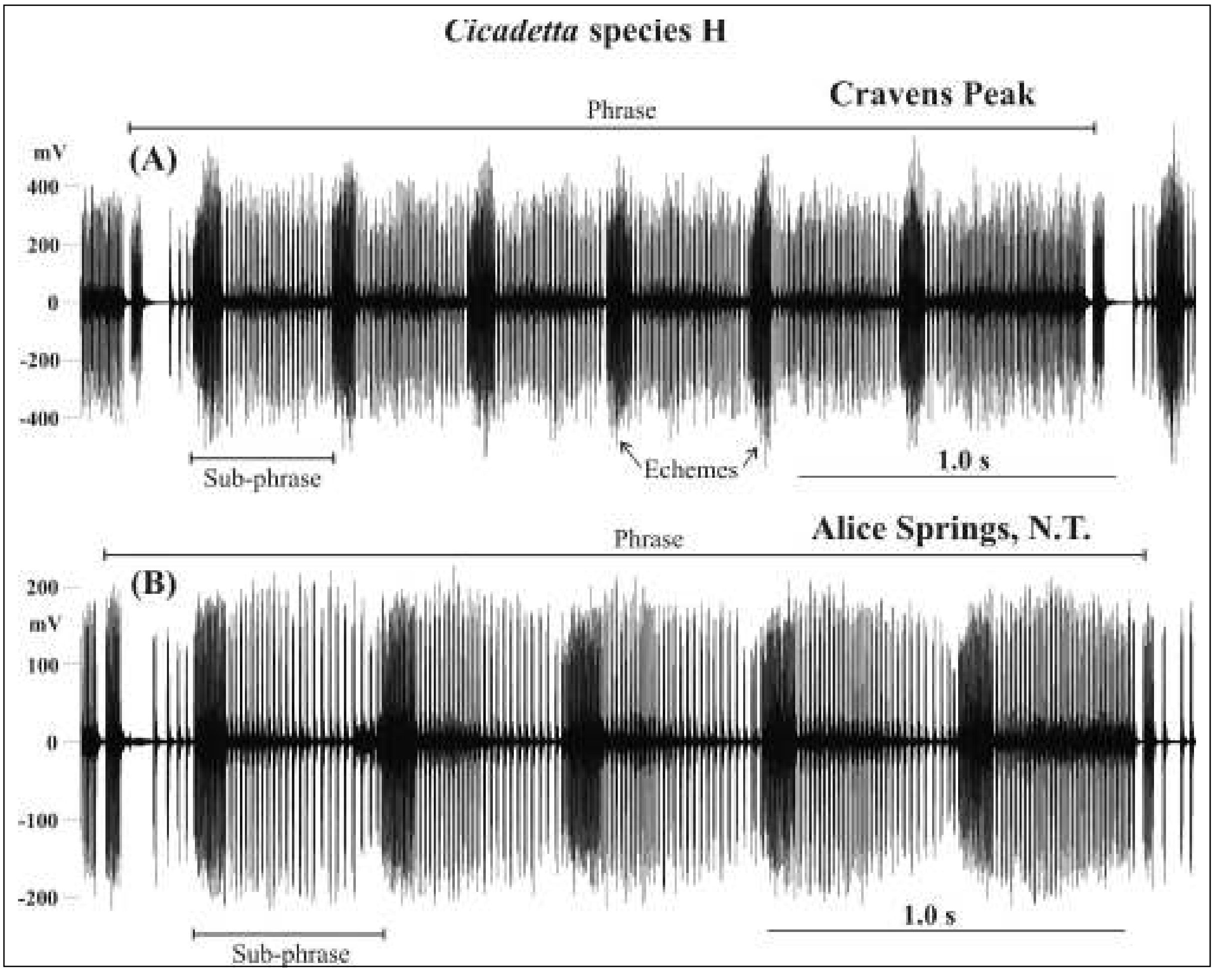

Figure 16. *Cicadetta* species H, near *C. crucifera* [Fishing Reef Buzzer; no. 291]. A: A series of almost continuous repeated phrases, with short gaps separating each phrase. Each phrase comprises sets of ticks, of slightly variable emission rates, separated by short echemes (defining the sub-phrases). The number of sub-phrases varies between phrases. Unfiltered open net recording, 12 km N. Cravens Peak homestead. B: Comparative recording from 8 km W of Alice springs Northern Territory, field parabola recording, filtered (IIR) to 7.5 kHz.

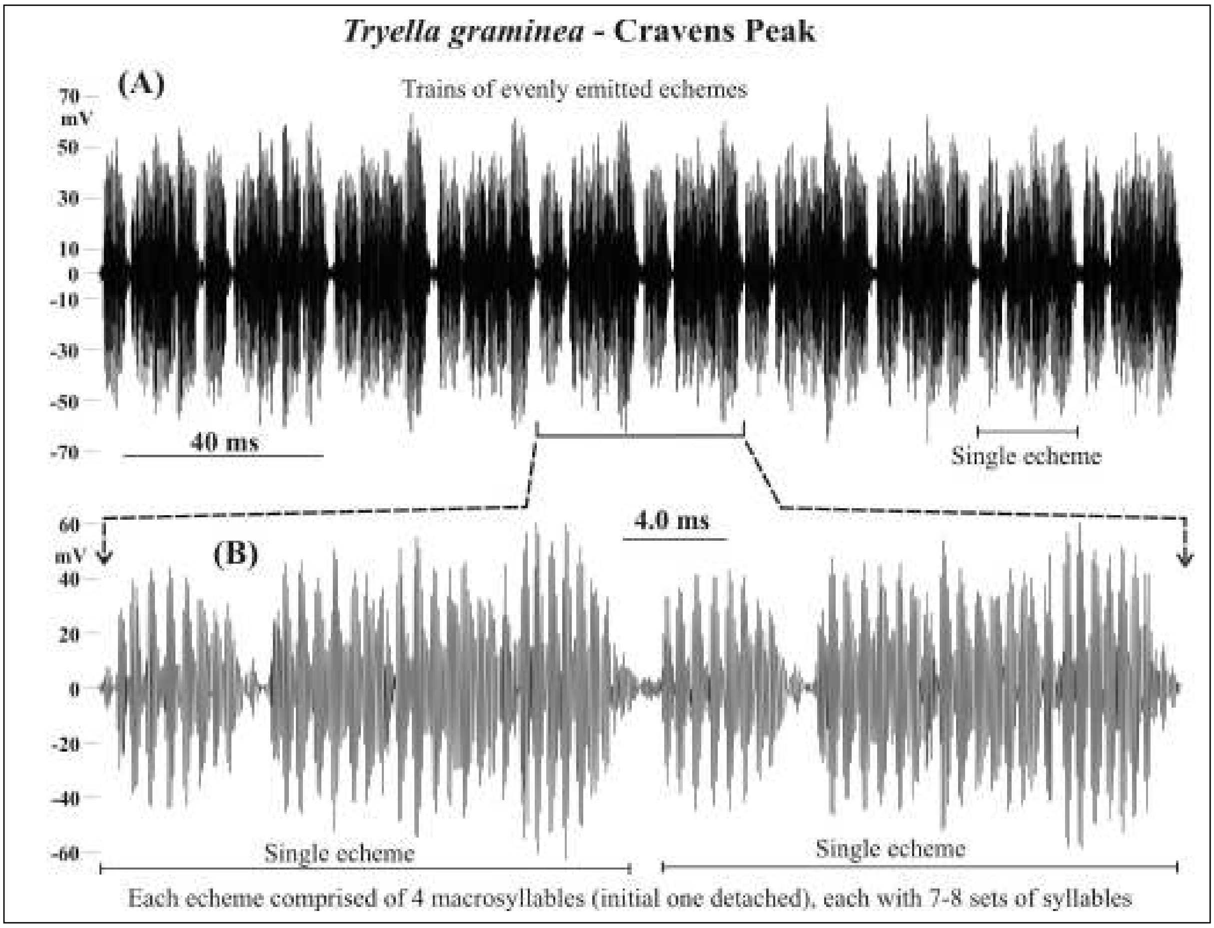

Figure 17. *Tryella graminea* [no. 536]. A: The continuous rattling song is composed of rapidly emitted short echemes, each containing four macrosyllables. B: Time expanded details of macrosyllables, each comprising 7—8 syllables. Field parabola recording, 12 km N. Cravens Peak homestead, filtered (IIR) to 0.5 kHz.

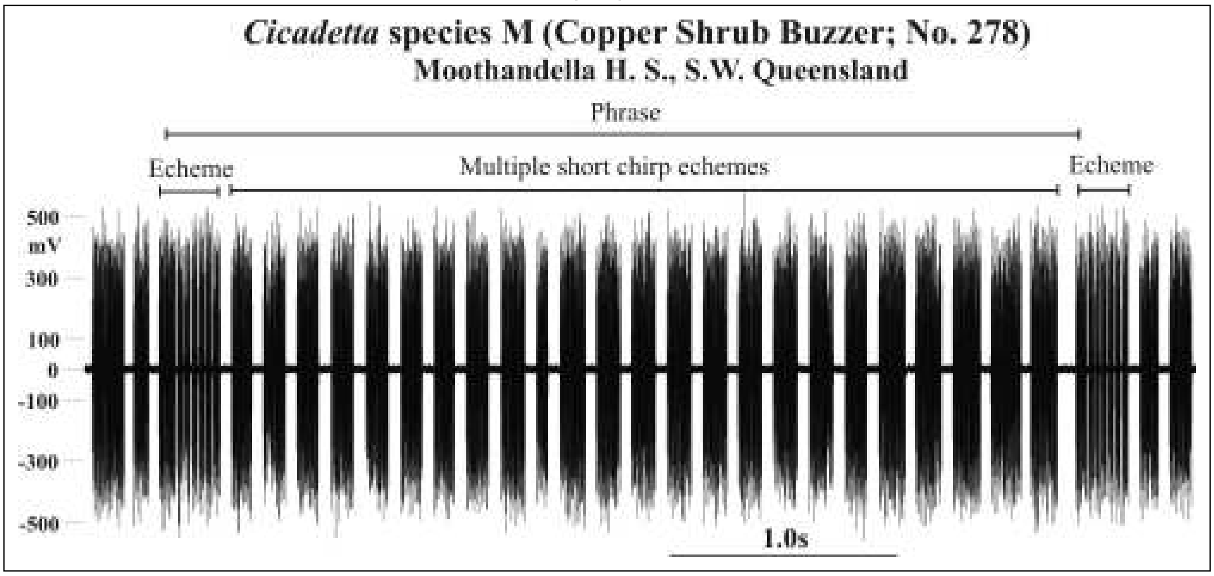

Figure 18. *Cicadetta* species M [Copper Shrub Buzzer; no. 278]. Plot showing the structure of a single phrase. The song comprises the continuous emission of such phrases. Each phrase comprises multiple discrete, short chirp echemes. The start and finish of each phrase are marked by slightly longer, composite echemes. Unfiltered field recording from Moothandella homestead, E. of Windorah, S.W. Queensland.

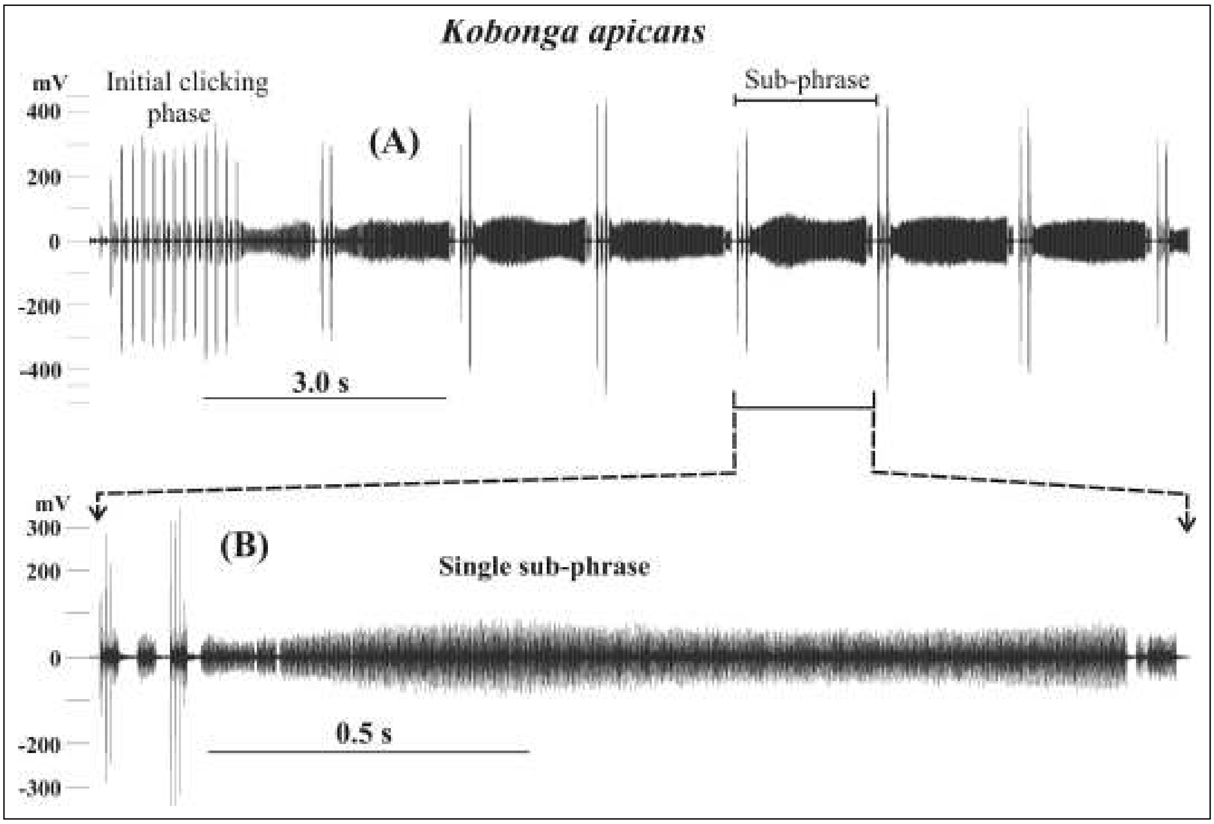

Figure 19. *Kobonga apicans* [no. 161]. A: Complex calling song showing an initial clicking phase, followed by repeated sub-phrases, each comprising an initial set of 2 to 3 rapid clicks (similar in structure to those of the initial clicking phase) followed by coarse buzzing echemes. B: Time expanded detail of a single sub-phrase. Recording by David Marshall and Kathy Hill, from N.T.

Soil invertebrate diversity of different landscape units at Cravens Peak with a focus on Collembola

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Abstract Collections of Collembola (Springtails) and other soil invertebrates taken from Cravens Peak Bush Heritage property are documented. The 23 Springtail species recognised are listed together with their preferred habitat. The fauna was dominated by species of *Folsomides* (Isotomidae) and *Corynephoria* (Bourletiellidae) as is normal in arid environments in Australia. The epigaeic fauna in April 2007 was less abundant than expected but relatively rich in species and it is suggested that this is because of the previous prolonged drought together with more recent water-logging of soil. Soil and leaf litter Collembola were frequent but patchy in distribution. Several species were new including a *Sminthurides* species associated with temporal water bodies. Different landscape units tended to carry different faunal assemblages. Five strategies exhibited by Collembola for surviving in arid environments are discussed in relation to wider aspects of regional resource conservation and their functional role. Some recommendations are made for management of the property.

Introduction

Cravens Peak Station, a Bush Heritage property, is located in a remote part of the northeast Simpson Desert in the extreme west of central Queensland. The property contains a range of landscape units and vegetation types, as described elsewhere in this publication, and so includes a variety of habitats for Collembola and other soil invertebrates. Because of heavy rains over the two months preceding the collecting trip, ephemeral vegetation was widespread and abundant and some ephemeral aquatic habitats were still present during fieldwork. The rains had followed a long period of drought, lasting several years, that would have adversely affected the fauna.

No previous collections have been made in the region, but earlier field trips had collected Collembola and invertebrates from the central Simpson Desert and from other arid areas of Central Australia to the north and west of Alice Springs, and to the south in South Australia. The earlier collecting localities included the Great Victoria Desert, Mabel Creek south of Coober Pedy and the Mound Springs south west of Lake Eyre. The most relevant collection with which to compare the Cravens Peak collections was made from the Hay River region in July 2007, only about 200 km to the southwest of Cravens Peak property (Fig. 1) (Greenslade, 2007). Similar habitats to those at Cravens Peak predominate at all these localities. More specifically, three collections made in the Centre in the same year, Cravens Peak (April 2007), Hay River (July 2007) and Krichauff Range (October 2007) cover an eight month period of gradual drying of the landscape from an extremely wet period (March to April), followed by a slow drying out (July 2007) to a relatively dry landscape (October 2007).

Data and ecological information from some of these collections are considered in this report and, together with the Cravens Peak collection, are beginning to provide a comprehensive picture of the composition, distribution and abundance of the Collembola fauna of central Australia and its responses to different climatic conditions over the last forty years.

Scope of project

To collect Collembola as comprehensively as possible from the main landscape units and vegetation types in order to estimate collembolan species richness and endemism so that recommendations can be made as regards priorities for management.

Detailed objectives

i. To provide a species list of Collembola for Cravens Peak with information on distribution between habitats, vegetation types and landscape units.
ii. To collect Collembola from all fungal samples collected by J. Simpson (JS) and C. Grgurinovic, identify them and compare the results with earlier collections from elsewhere in Australia*.
iii. To collaborate with other invertebrate specialists on the survey to the extent that our methods and sites are comparative or complementary where practical and any Collembola collected by other members of the survey are identified.
iv. To distribute other ground invertebrates collected during the survey to the relevant specialists for study.
v. To deposit all collections made in a relevant institution after completing a report to the RGSQ.
* Aim ii could not be carried out because the mycologists were unable to visit Cravens Peak because of adverse weather conditions. However samples of cut *Triodia* stems from termite nests and *Acacia* and *Eucalyptus* leaf litter were collected and taken to Canberra for JS to culture for fungi. This work will be subject to a separate report in a later publication.

Hypotheses developed from earlier collections were to be tested at Cravens Peak. They are:
i) landscape units of highest local endemism are the most unfavourable sites of rocky outcrops and gibber plains,
ii) vegetation types of highest diversity for Collembola are those with highest plant species richness and most diverse vegetation structure such as shrubland on dunes and sand plains,
iii) ephemeral vegetation such as is found along creek lines or in dune swales can carry high numbers of individuals of a few widespread species,
iv) activity of a high proportion of the fauna is dependent on effective rainfall although some parts of the fauna can be active after ineffective rain,
v) where dunes are present, swales, ridges and slopes of different aspect may carry different suites of species or in differing abundances.

Sites and methods

All sampling took place between April 14th and 24th, 2007. The following main landscape units were sampled: sand dune, sand plains, rocky outcrops, gibber plains (desert pavement) and wetlands. No saltpans or samphire vegetation were sampled as none were found. The main vegetation types sampled were: woodland along creek lines, low and tall shrubland, ephemeral herbland and grassland. Few specialised habitats such as under bark, in fallen timber, under stones, in fungal fruit bodies were sampled as preliminary work indicated that fauna appeared to be extremely sparse or absent from these habitats so they were not further examined. Sites sampled are listed in Table 1 (page 153).

Because Collembola live in a range of microhabitats, different sampling methods were used. A standard protocol was used so that faunas could be compared between landscape units and vegetation types.

Within each landscape unit or vegetation type to be sampled, 5 (rarely 6) pitfalls and 2, 3 or 5 yellow pans were placed in a line across the site, each trap being about 2 m apart. Pitfalls were three quarters filled with absolute alcohol with a few drops of glycerin to retard evaporation and yellow pans were three quarters filled with soapy water. After on average 5 days of trapping, pitfalls were removed. Yellow pans were normally cleared at least once a day and removed after two days. Samples of from one to two litres of leaf litter from the ground, in each vegetation type (if any present), were then taken for Tullgren extraction. Some samples were extracted at Cravens Peak and others returned to Canberra for extraction (see Table 2, page 154, and Table 3, page 155).

All leaf litter samples were dampened for 24 hours before extraction to activate fauna. They were then extracted to dryness for three to seven days depending on the ambient temperature and humidity. Sweeping with a linen net and suction sampling using a custom built suction sampler were also undertaken on some sites where grass was present. Sampling with a fine net from the surface of water bodies was also done. Previously dampened sand from 30

Table 1. Major sites sampled at Cravens Peak April 14 to 24, 2007. First transect from gibber plain to low ridge with *Acacia* sites A to D. Second transect across creek is site E. Third transect across dune is sites F to J.

Site label	Latitude and longitude	Alt. in m (approx)	% Stones	Vegetation type	Comments
A	23° 18' 15.8" 138° 34' 34.3"	445	50	Stony area, scattered grass to 10 cms, coarse red soil	5 m S of road 2.6 km E of homestead
B	23° 18' 15.8" 138° 34' 34.3"	445	0	100% mixed grasses, including *Aristida* and *Eragrostis* spp. scattered shrubs, *Eremophila* sp. to 1 m	50 m from site A
C	23° 17' 57.6" 138° 34' 35.8"	445	5	*Acacia cambagei* grove, height to 3 m, shaded sites, low *Sclerolaena* spp., grass rare	250 m S of sites B, slight NE facing slope
D	23° 17' 54.91" 138° 34' 04.3"	151	50+	Stony area, rare grass, run on area nr shallow galley, slight southern slope	50 m from C
E	23° 19' 24.1" 138° 35' 26.2"		0–100	Transect across dry creek, traps 1 in grass, 2 on sand bank, 3,4,5 in stones in creek, 6 on sand bank,7,8,9 under *Acacia cambagei*, 10 in buffel grass.	Ca.200m E of homestead,
F	23° 19' 35.2" 138° 34' 01.8"		Few	100% grass and herbs, scattered, rare, low shrubs	NW of homestead
G	23° 19' 35.2" 138° 34' 01.8"		Few/absent	south dune slope, 10–50% *Triodia*, 10–15% bare ground, some grass, vegetation to 1 m high, sand	50 m from site F
H	23° 19' 35.2" 138° 34' 01.8"		Absent	Dune top, ground very uneven, 50% vegetation cover, mainly *Triodia*	20 m from site G
I	23° 19' 35.2" 138° 34' 01.8"		Rare/absent	Dune top N side, 90% plant cover 40%*Triodia* 40% grass 10% herbaceous cover	2 m from site I
J	23° - unknown 138° - unknown		50	Interdune scattered *Acacia cambagei* and *Sclerolaena* herbs, grass sparse, button grass	
K	23° 17' 30.7" 138° 33' 09.9"		None	Waterhole (Ibis) 8 km from homestead on Sandhill Bore Road	
L	23° 04'04.1" 138° 21' 01.5"	219	50	Upper reaches of dry creek, 50% bare ground, under *Acacia aneura?*, on escarpment, scattered grasses and *Sclerolaena* to 5% each	50 m S bend camp
M	23° 04' 04.1" 138° 21' 01.5"	Ca 200m	95	Scattered shrubs to 1 m, sparse grass and leaf litter, occasional timber on ground, north facing slope	100m N from S bend camp overlooking river
N	23° 03' 55.4" 138° 20' 57.2"	175	0	North bank of Mulligan River, recently flooded, Tall River Red gums, shaded, leaf litter patchy under trees, bare ground and grass to 0.5 m, sand	
O	23° 03' 55.4" 138° 20' 57.2"	175	0	Flood plain, 100%dry grass and herb coverage to 0.5 m	100 m N site N
P	23° 03' 51.5" 138° 20' 52.8"	178	Low	From under three Eucalypt trees above flood line, in leaf litter	50 m N Site O
Q	23° 03' 52.2" 138° 21' 01.0"	185	>50	On lower part of rocky slope below escarpment, fairly dense *Eremophila* shrubs, some bare ground.	Below site M

Table 2. Samples taken from sites A to Q between April 14 to 24, 2007.

Site name	No. of pitfalls run and dates (trap days in brackets)	No. of yellow pans run and dates	Leaf litter sample	Sweeping (sw) or suction (ss)	Comments
A	5 x 6 days (30)	3 x 3 days (9)	None present		
B	5 x 6 days (30)	3 x 3 days (9)	–	sw. ss	
C	5 x 6 days (30)	3 x 3 days (9)	+		
D	5 x 6 days (30)	3 x 3 days (9)	None present		
E	10 x 6 days (50?)	3 x 3 days (6)	+		Extracted Canberra
F	5 x 5? Days (20)	3 x 2 days (6)	–	sw	
G	5 x 5? Days (20)	3 x 2 days (6)	None present		
H	5 x 5? Days (20)	3 x 2 days (6)	None present		
I	5 x 5? Days (20)	3 x 2 days (6)	None present		
J	5 x 5? Days (20)	3 x 2 days (6)	+		
K	5 x 5 + 10 x 1 days (35)	3 x 1 (3)	–	sw	
L	5 x 2 days (10)	3 x 2 days (6)	–		
M	5 x 2 days (10)	3 x 2 days (6)	–		
N	5 x 2 days (10)	3 x 2 days (6)	+		
O	5 x 2 days (10)	3 x 2 days (6)	–	sw	
P	6 x 2 days (12)	3 x 2 days (6)	+		
Q	5 x 1 day (5)	3 x 2 days (6)	–		
Totals	362 trapping days	111 trapping days	5	4 sw + 1 ss	

Table 3. Other samples taken from Cravens Peak.

Type of sample	Locality	Collector	Date	Comments
Leaf litter	Nr Coolabah Swamp	J. Ambrose		
Leaf litter	Nr Coolabah Swamp	J. Ambrose		
Leaf litter	Nr Coolabah Swamp	J. Ambrose		
Leaf litter	Nr Coolabah Swamp	J. Ambrose		
Pitfall traps (5)	Edge Coolabah Swamp	P. Greenslade		
Water surface	Coolabah Swamp	P. Greenslade		
Water surface	"Ibis" water hole	P. Greenslade		
Deep sand sample	Dune top (site H)	P. Greenslade		Sand wetted on site for 24 hours before extraction in Tullgren funnel
Termite nest sample 1		J. Ambrose		? 16.4.07 Extracted in Canberra
Termite nest sample 2		P. Greenslade	16.4.07	
Acacia aneura leaf litter	About 1 km S of S bend camp 23°03'06.7" 138°16'46.8"	P. Greenslade	19.4.07	Extracted in Canberra
Acacia cambagei leaf litter	East of and near Salty Bore camp site 23°05'18.4'' 138°13'44.3"	P. Greenslade	19.4.07	
Sclerolaena leaf litter	3 km East of Salty Bore camp site	P. Greenslade	19.4.07	Extracted in Canberra
Sweeping grasses	At Salty Bore camp site	P. Greenslade	19.4.07	Mainly Buffel grass
Sweeping grasses	East of and near Salty Bore camp site	P. Greenslade	19.4.07	Some Buffel grass
Acacia cambagei leaf litter	About 100 m E of Coolabah swamp 23°22'09.7" 138°35'50.1"	P. Greenslade	21.4.07	Extracted in Canberra
Eucalyptus leaf litter	2.3 km E of Coolabah swamp	P. Greenslade	?21.4.07	Extracted in Canberra

Table 4. Collembola species collected at Cravens Peak, April 14 to 24, 2007 with notes on habitat and distribution of the 23 species distinguished**.**

Family	Species	Distinguishing marks	Habitat at Cravens Peak	Distribution
Brachystomellidae	*Brachystomella* sp. cf. *dianae* Greenslade and Najt		*Eucalyptus* leaf litter	Widespread in arid zone
	Setanodosa sp.		*Eucalyptus* leaf litter	Widespread in arid zone
Isotomidae	*Folsomides* sp. cf. *arnoldi* Suhardjono & Greenslade		*Eucalyptus* and *Acacia* leaf litter and soil	Widespread in arid zone
	Folsomides sp.1	Grey	In pitfalls	Unknown
	Folsomides sp. 2	Dark grey	*Eucalyptus* and *Acacia* leaf litter	Widespread in arid zone
Entomobryidae	*Drepanosira* sp. 1	Grey	Soil under grasses and stony ground	Uncommon but restricted to arid region
	Drepanosira sp. 2	Mottled	Soil under grasses and stony ground	Uncommon but restricted to arid region
	Drepanura cinquilineata Womersley		Grasses	Widespread in arid zone
	Drepanura sp. 1	Orange and black	Live or dead timber	Unknown
	Drepanura sp. 2	Slight blue bands	Creek line	Widespread in arid zone
	Drepanura sp. 3	Pale grey		Unkown
	Acanthocyrtus sp. cf *halei* Womersley	Orange	Live or dead timber	Unknown
	Seira sp.	Yellowish, blue antennae	Under river red gums	Widespread in arid zone
Sminthurididae	*Sphaeridia* sp.		*Eucalyptus* and *Acacia* leaf litter, damp soil	Widespread in arid zone
	Cf. *Sminthurides* sp.		Damp soil around swamps	Unknown
Bourletiellidae	*Corynephoria* sp. 1	Yellow caramel back skittles	Native grasses	Widespread in arid zone
	Corynephoria sp. 2	Knob	Native grasses	Unknown
	Corynephoria sp. 3	Pustule	Native grasses	Unknown
	Corynephoria sp. 4	Pr broad longit mid dorsal stripes	Native grasses	Unknown
	Prorastriopes sp. 1	12 (6 + 6) white spots	Native grasses	Unknown
	Prorastriopes sp. 2	Elongate abd V post lat dk edge	Native grasses	Unknown
	Prorastriopes sp. 3	5 longit dk stripes on white	Native grasses	Unknown
	Rastriopes sp.	Small speckled	Under *Casuarina*	Unknown

cm deep in a sand dune was taken for funnel extraction but flotation method was not attempted due to time constraints. The samples taken are listed in Tables 2 (page 154) and 3 (page 155).

As recorded in Table 2 (page 154), pitfall traps were run along four transects. The first, sites A to D, crossed a low stony rise consisting of four landscape units, bare gibber on flood plain (A), dense grass on run-on area below northern slope (B), top of rise with small grove of *Acacia* (C) and southern gibber slope with very sparse grass and herbs behind rise (D). The second (Site E) consisted of ten traps across a dry creek line from grassy bank to grassy bank. The third, site F to K, traversed a sand dune from grassy interdune (F),through *Triodia* on the dune slopes (G) and crest (H) and back slope (I) to interdune (J) with chenopodiaceous and *Acacia* shrubland. The fourth was a transect across the Mulligan River from cliff top under *Casuarina* (L), top (M) and bottom (Q) of rocky steep slope to river bank under *Eucalyptus* (N) to flood plain with dense, dry, tall grass (O) and mallee eucalypts on higher gentle slope (P).

Each site was photographed (see Figures, starting page 164) and the percentage cover of vegetation at three heights recorded as well as cover and depth of leaf litter, stones, bare soil and rotting timber where possible (Table 1, page 153). The location of each sampling site was recorded using a GPS.

During the collection period the weather was hot and dry with temperatures regularly in the mid 30°C in the shade and over 45°C in the sun during the day. Several years of drought had been broken about three months earlier with the last heavy fall only about one week before sampling took place. However the ground had dried rapidly in most places.

All material has been deposited in the South Australian Museum in Adelaide from where it will be distributed to other taxonomists on request.

Results

Twenty three species of Collembola were identified (Table 4, page 156, and Appendix 1, page 163). The generic composition of the fauna was similar to earlier collections from the arid centre with the exception of a *Sminthurides* species on the water surface of Coolabah swamp. This genus has not been collected before in the arid zone. Descriptions of the fauna of different habitats and collecting methods are given below.

Sweeping

Sweeps of ephemeral herbs and some grasses around and near the homestead on land that had recently been inundated produced no Collembola. The invertebrate fauna collected consisted mainly of Hemiptera (Cicadellidae and other families), Araneae, Formicidae, Thysanoptera and a few Hymenoptera and Coleoptera (adults and immatures) as well as Lepidoptera larvae. There were a number of species in each taxon collected except for the ants, where only a single species was collected. All these groups are highly mobile (except for ants) and therefore would be able to rapidly colonise ephemeral vegetation that emerged immediately after flooding of the site. Ants would have survived inundation in subterranean nests. At Salty Bore in drier ephemeral herbaceous vegetation and buffel grass, with extensive sweeping only the widespread *Corynephoria* sp. 1 (2 individuals) and *Corynephoria* sp. 2 (1 individual) were found together with the usual range of other invertebrates including here many immature spiders.

Sweeps of perennial native grass areas on transect 3, site F, mainly *Aristida* sp., caught the same range of invertebrate taxa as in other vegetation and a number of Collembola were also present. They belonged to two species of *Corynephoria* sp. 1 and *Corynephoria* sp. 2 (both with 10 individuals). *Corynephoria* sp. 3 was only found on site J in sweeps.

Unexpectedly entomobryids belonging to the genus *Drepanura* were rare in these samples although they almost invariably are collected normally from grasses in the arid and semi arid zone.

Fungal fruiting bodies

Few fungal fruit bodies were seen. They all belonged to the species *Podaxis pistillaris* (L.: Fr.) Fr. and were all dry when observed. No fauna was found on or in them.

Termites

Termites were not conspicuous although a few nests were found under *Triodia* hummocks. The species was not identified but individuals were observed to be harvesting and small lengths of *Triodia* stems covered with fungal hyphae were found in the nest galleries. It is believed that the termites feed on the fungi. Samples of stems from nests were taken and delivered to J. Simpson for a study of the fungi present.

Leaf litter

Leaf litter was sparse and very patchy. It was generally only abundant under *Acacia* shrubs and *Eucalyptus* trees. Accumulated leaf litter had been dumped around tree trunks by flood waters in and close to creeks and the river. It was denuded of fauna. Leaf litter taken from sites above the flood line invariably harboured some fauna but of a low species richness. The only genera present were *Folsomides*, *Brachystomella*, *Setanodosa* (only in eucalypt litter) and *Sphaeridia*. Some Collembola were extracted from every sample taken above the flood line of leaf litter and upper soil including from site J and from in the creek bed of site E. *Folsomides* species were abundant in most samples and several hundred specimens were found in samples of size only about one litre of *Acacia* leaf litter. Apart from a small number of mites and diptera larvae, no other fauna was found in litter samples.

Pitfalls

Faunal differences between sites were marked and consistency between traps within a single landscape unit was high (Appendix 1 page 163). Site A was dominated by nanorchestid mites, site B caught more ants but also commonly *Corynephoria* sp. 1. Site C was dominated by ants and there were large numbers of plant-feeding prostigmatid mites and site D caught large numbers of *Drepanosira* sp. 1 Collembola and Thysanura were also common. On the second transect across the dry creek, ants were very abundant on both sides of the bank, and Entomobryidae were found along all the transect, as were mites. Bourletiellidae Collembola were patchy, but commonest, not where grass was present, but on both edges of the creek where ants were less numerous. The third transect produced fairly high numbers of Collembola. *Prorastriopes* sp. 1 was commonest on this transect and *Corynephoria* sp. 1 was only found on site F where grasses were abundant.

The three *Prorastriopes* sp. were only collected in pitfalls on sites near the homestead and P. sp. 2 and P. sp. 3 only on transect 1. only at (transects 1 and 3).

Ants were least numerous in the interdune (J) and other sites with non-sandy soils and much bare ground while the mite, *Nanorchestes* sp, was highly abundant here as on similar open sites on transects 1 and 3. At transect four, across the Mulligan River, a different species of *Corynephoria* C. sp. 4 was present on grassy areas (O). Otherwise fauna was in low numbers although *Seira* sp. occurred here on all sites. Other fauna collected are listed in Appendix 1 (page163).

Malaise traps

Malaise traps run by CSIRO staff collected three species identified as *Drepanura cinquilineata*, *Drepanura* sp. cf *albocoelura* and *Acanthocyrtus* sp cf *halei*. These animals are active on the ground surface in some vegetation types but are also found on dead timber and above the ground on trees. The Malaise traps were set in localities that the author did not visit, (13 km from S bend camp and 4 km SE of 12 mile bore).

Yellow pans

Entomobryid Collembola belonging to the genus *Drepanosira*, were collected in fairly large numbers on site D. *Corynephoria* sp. 1, the most common, Symphypleona, was found in moderate numbers in yellow pans on all transects except for site E, *Corynephoria* sp. 2 was also found on all transects but in much lower numbers, **(**4 on transect 1 and 5 on transect 3**)**. *Corynephoria* sp. 4 was only found (3 individuals) at the Mulligan River transect. Other taxa collected in yellow pans were winged species of Hymenoptera, Hemiptera and Diptera as well as ants.

Under stones

Some time was spent searching for invertebrates under stones. None were found although signs of earlier activity was observed in the form of burrows and other excavations.

Soil

Deep holes were dug in dune soil to a depth of more than 30 cm and water poured into the hole to attract fauna. Samples were taken after 24 hours and extracted in funnels but no animals were collected. Soil from sites J and E was also collected, wetted and extracted; isotomid Collembola and *Setanodosa* individuals were extracted.

Water bodies

Two swamps near the camp were visited and pitfalls placed in the damp soil surrounding them. A species of *Sminthurides* was caught by netting the water surface of Coolabah swamp and one other specimen in pitfalls set at the edge of the swamp. This genus has not been found before in Central Australia. Other fauna collected in these traps were Dermaptera, Coleoptera (adults and larvae of Carabidae, Staphylinidae and other families), Diptera, Hemiptera and Araneae. Traps around the second swamp (Ibis swamp) caught many *Sphaeridia* specimens and again one specimen of *Sminthurides* but a second set of traps were dug up, presumably by wading birds. A few animals remained in the traps: Dermaptera, Coleoptera, Acarina and Diptera.

Discussion

Of the five hypotheses proposed to be tested, no data was collected to support the first three. However the fifth hypothesis was supported as the results from the transects show that each landscape unit sampled carried a different assemblage of species and/or different relative proportions of species in assemblages, thereby emphasising the patchy distribution of invertebrates in these arid regions. The extremely dense populations of Collembola in leaf litter after wetting, found only under trees and shrubs, also supports this point and also the fourth hypothesis. Even apparently barren, harsh habitats, such as gibber areas lacking vegetation, provided habitat for some species sometimes not found commonly elsewhere in the region. Soil faunal density data was not made but estimates made elsewhere in central Australia are unexpectedly constant if averaged out over different seasons, sites and habitats. At Kunoth Paddock, and Krichauff Ranges, both in East Macdonnel Ranges, densities of 2,268 and 2,300/m^2 respectively were found from dampened soil and leaf litter and at the Hay River, the density over a transect from a rocky mesa to a creek bed through various vegetation types was calculated at 2,700/m^2.

The ubiquity of ants is also evident although in some of the landscape units, notably interdune with more compact soils, fewer ants were trapped. Where ants were trapped in high numbers, possibly near a nest, it was noticeable that numbers of other ground fauna were low. Although ants were not identified to species or even genus here, it was observed that in some habitats, up to ten species were present. Winged groups, Diptera, Hymenoptera, Hemiptera, Coleoptera and Lepidoptera adults may have been attracted to the traps by the preservative and the first three orders were common in yellow pans.

Catches of non-winged groups, such as Collembola, in the yellow pans showed that small-scale dispersal events on air currents are frequent, and nearly continuous in the region. Rapid colonisation by invertebrates of land disturbed by human or other impacts is almost certainly facilitated by this method. The ephemeral vegetation that establishes after flooding, such as in the heavily impacted area adjacent to the homestead, appeared only to be colonised by winged, highly mobile, widely distributed species as shown by the sweeping samples. Collembola were not found there.

Changes either in abundance or species richness in the collembolan fauna in the region over a drying cycle from April to October 2007, were, unexpectedly, not detected. However a marked difference was noted in flying insects over seven months which were extremely numerous at Cravens Peak on some evenings,noticeably less abundant at Hay River (April) and scarce at Krichauff Range (October).

As well as the small-scale fauna differences between land units, similar differences were evident at a larger landscape scale. This was demonstrated by catches of different species of Bourletiellidae,at different localities. *Corynephoria* (sp. 4), was trapped at S bend sites compared to the *Prorastriopes* sp. 1, 2 and 3, the Homestead sites.

Collembola were the most numerous group of invertebrates collected in largest numbers by the methods used here, and the remainder of this discussion will focus on the collembolan data and the contribution the group makes to ecosystem function in Cravens Peak ecosystems.

Collembola were the group of invertebrates collected in largest numbers by the methods used here, consequently the rest of this discussion will concentrate on collembolan data and what contribution they make to ecosystem function in Cravens Peak ecosystems.

Springtails are generally little known because of their small size and cryptic habits but are, with mites, the most abundant arthropods in soils of the arid zone and outnumber mites under moist conditions. The species collected at Cravens Peak were largely fungal feeding and, because of their abundance in leaf litter and humus after wetting samples, play a major role in decomposition by grazing on fungi and in dispersing fungal propagules. As they are present in leaf litter in large numbers, their faecal pellets contribute to soil structure. Springtails can therefore be considered significant ‘ecosystem engineers’ in that they affect the physical space in which other species live and their direct effects can last longer than their lifetime (Hastings et al., 2007). Emphasis on the group in this report is therefore justified. Ants and termites are commonly considered to be the most important ground invertebrates in the arid zone (Orians and Milewski, 2007) but this is probably because they are conspicuous and limiting attention to these groups is probably unjustified.

A further basis for discussion can be made by comparing the fauna at Cravens Peak with collections made in the Simpson Desert and other arid parts of Central Australia. References to earlier reports and publications on which these general comments on the fauna is based are given in the bibliography. Generic composition and abundance, at least of the leaf litter and soil species is similar throughout arid regions of Australia, being dominated by *Folsomides* and *Sphaeridia* species in soil. Other genera presented are *Setanodosa* and *Pseudachorutes* in leaf litter, Entomobryidae, mainly *Drepanura*, on the ground surface and Bourletiellidae, mainly *Orynephoria* species, on grasses. Litter genera are only active after rain. *Folsomides*, *Setanodosa* and *Pseudachorutes* individuals rehydrate from an anhydrobiotic state with rain and desiccation resistant eggs of *Sphaeridia* hatch when wetted. *Corynephoria* individuals are commonly found on native grasses but at Cravens Peak were not on ephemeral herbage or buffel grass. *Prorastriopes* species, a pantropical genus restricted, in Australia, to the northern part of the continent, show a similar pattern. What was unexpected was the apparent low abundance of *Drepanura* individuals that are normally common in leaf litter and grasses in arid and semiarid regions. Notably, Collembola were present in some apparently inhospitable habitats, such as the stony plain sites A and D, and the probably noctural *Drepanosira*, sp. 1 and 2 was fairly abundant there. As noted before, an unexpected result was a finding of a *Sminthurides* sp. in the Coolabah swamp.

Greenslade (1981) described five strategies by which Collembola survive arid environments: desiccation resistant eggs, anhydric states, nocturnal activity, inhabiting cryptic moist microhabitats and morphological adaptations such as tracheae that permit activity above ground on live vegetation, there being some overlap in the last three. Stafford Smith and McAllister (2008), using plants as exemplars, have more recently described similar strategic responses in response to arid conditions. They call these strategies, ephemerals, in-situ persistents, refuging persistents, nomads and exploiters. These strategies can be equated, to some extent, to the strategies proposed by Greenslade (1981) for Collembola as follows: ephemerals (*Sphaeridia*, *Sminthurides* spp.), in situ persistents (*Corynephoria*), refuging persistents (Entomobryidae), and exploiters (*Folsomides*, *Brachystomella*, *Pseudachorutes*). There are no Collembola that could be described on current knowledge as nomads except for possibly epigaeic species dispersed on wind. The ability of the fungal feeding *Folsomides* to rehydrate rapidly after rain is important for nutrient cycling in the arid zone as maximum advantage can therefore be taken of the sporadic unpredictable rain events in the region.

Fauna of other arid regions sampled previously tended to have higher abundance but not richness in the epigaeic genera *Corynephoria*, *Prorastriopes* and *Rastriopes* and higher species richness in *Folsomides*. Rather fewer species (15) were found in the Krichauff Ranges in October, 2007 and after more intensive collecting 15 species were also found at the Hay River in July. At a site 50 km north of Alice Springs (Kunoth Paddock), 38 species were found but this was in the mid 1970s, when conditions has been wet for several years and collections were made in two seasons. There appear to be some different species of Bourletiellidae (*Corynephoria, Prorastriopes, Rastriopes*) at Cravens Peak compared to the Hay River and Krichauff Ranges, indicating the high gamma diversity of this family in the arid zone.

With 23 putative species, Cravens Peak could not be described as having an impoverished Springtail fauna. It is suggested that the low abundance of epigaeic species found at Cravens Peak is the result of the previous prolonged drought and these species have not yet built up significantly large populations. They are likely to have survived adverse conditions in refugia in inactive states or have been dispersed after the breaking rains on wind currents from more favourable regions.

Summary of findings

1. Twenty three species of Collembola were identified in collections.
2. In general richness was as expected considering the previous weather conditions but abundances were lower than was expected.
3. Epigaeic Collembola were fairly rare, much less common than collections made 20 to 30 years earlier in the arid zone but in similar numbers to other collections made in 2007.
4. Most species had been collected before but few have been described. All are new to the region and a number had not been collected before (7) indicating possible local endemism.
5. Species were restricted as to habitat, land unit and some to locality.
6. Different strategies for survival in adverse hot dry conditions were demonstrated by the fauna; exploiters probably playing an important role in organic matter decomposition.
7. Swamps provided a very temporary but important habitat for one species.
8. Fauna of dunes and swales differed in response to different vegetation type such as *Triodia* on crests as opposed to native grasses and chenopod shrubs in swales.
9. Leaf litter was abundant but only where it had been deposited by floodwaters onto shrubs and tree trunks. Fauna was absent from this habitat. Other leaf litter was sparse and patchy resulting in highly disjunct but dense populations of Collembola and few other invertebrates.
10. Creek lines had few species probably also because of inundation.
11. Catches in yellow pans on unfavourable sites indicated that wind currents act as an important means of dispersal.

Management recommendations

Few recommendations are indicated by the results of this fieldwork as the current management appears to be sound in attempting to minimise past impacts. If visitor pressure increases, the following comments would be applicable.
1. Leaf litter around shrubs and trees should not be disturbed or removed. Vehicles should avoid such areas and parking, trampling or camping under trees avoided as the species inhabiting leaf litter are almost certainly sensitive to compaction.
2. Ephemeral swamps, even when dry, should be protected from vehicles and should not be trampled as faunal resting stages in the soil are probably sensitive to soil compaction.
3. Even apparently barren ground, such as patches of gibber, harbours unique assemblages of species and should not be considered suitable areas for developments such as car parks or camping areas for which flood plains are most suitable.
4. Attempts should be made to control, preferably remove, exotic plants such as buffel grass as it does not provide habitat for native species.

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Appendix 1. Catches of invertebrates from pitfalls at Cravens Peak, April 14 to 24, 2007. Site descriptions given in Table 1, page 153.

Sites A1–D5

Taxa		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	D1	D2	D3	D4	D5
Collembola																					
Isotomidae																					
Entomobryidae	*Drepanura cinquilineata*	1																			
	other													1			41	18	85	23	20
Bourletiellidae	*Corynephoria* sp. 1	2				1	3	1		6	7								1		
	Corynephoria sp 2						1			1											
	Corynephoria sp. 4																				
	Prorastriopes sp. 1			1																	
	Prorastriopes sp. 2								1		2										
	Prorastriopes sp. 3	1																			
	Rastriopes																				
Thysanura			1						1								2	3	10	1	4
Psocoptera		1			4																
Orthoptera							1									1			1		
Thysanoptera												1	1		1	1					
Hemiptera	Cicadellidae	1				2	1														
	Aphididae	1	1																		
	Other							1				1	2	1	1	6	5				3
Coleoptera	Scarabaeidae									1	1										
	Carabidae: Cicindelinae																				
	Carabidae other										1										
	Staphylinidae										1										
	Pselaphidae																				
	Curculionidae													1							
	Tenebrionidae																	1			
	Larvae																	1			
	Carabidae: Cicindelinae																				
	Other	2			1	1												6	5		3
Diptera	Larvae	1		n		n	n		3			5	14	6	8	2	3	5	8	3	1
	Adults																				
Lepidoptera	larvae	1					1														
Hymenoptera	Formicidae	7	10	1	4	2	50	50	50		70	30	30	4	8	20	9	8	5	4	6
	Other						1														
Araneae				1		1				1	1							1		1	
Acarina	Nanorchestidae	100	nnn	nnn	50	nn	n	n									40	30	10	50	
	Caeculidae																				
	Prostigmata other											20		50	80	100					
	Acarina other	n	n	n	n	n	n			n	n		2					20	10		15
Pseudoscorpionida																					
Crustacea	Isopoda													1							
Myriapoda	Polyxenida																				
	Totals	118	12	3	59	7	58	52	55	9	83	57	49	64	98	130	100	93	135	82	52

Sites E1–G5

Taxa		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	F1	F2	F3	F4	F5	G1	G2	G3	G4	G5
Collembola																					
Isotomidae			1																		
Entomobryidae	*Drepanura cinquilineata*																				
	other	5	1	10	8	9	14	14	15	10	20	1									
Bourletiellidae	*Corynephoria* sp. 1	7										8	2	4	4	2					
	Corynephoria sp 2												1			1			1		
	Corynephoria sp. 4																				
	Prorastriopes sp. 1			14					13	1	1	2	2	1	3	4		2	1	1	
	Prorastriopes sp. 2																				
	Prorastriopes sp. 3																				
	Rastriopes																				
Thysanura															1	1			1		
Psocoptera																					
Orthoptera				1	1						1					2					
Thysanoptera		1		1									1			1		1	1		
Hemiptera	Cicadellidae																				
	Aphididae																				
	Other	2		1	1			2			2	6	2	2	4	3	2	2	4		2
Coleoptera	Scarabaeidae																2				
	Carabidae: Cicindelinae																				
	Carabidae other																				
	Staphylinidae			1																	
	Pselaphidae																			1	
	Curculionidae								1												
	Tenebrionidae																				
	Larvae				1																
	Carabidae: Cicindelinae																				
	Other																				
Diptera	Larvae	1	1	1			1			1	1	2	2		1	1		1	1	6	2
	Adults																				
Lepidoptera	larvae	36		1					1												
Hymenoptera	Formicidae		550	30	20	25	19	55	24	400	30	19	2	18	12	20	60	29	23	75	6
	Other			1			1		1			1				1		1		2	
Araneae				3												1					
Acarina	Nanorchestidae												50	39	20	60					1
	Caeculidae																				
	Prostigmata other																				
	Acarina other	8	4	10	10	10	3	2	13	8	2	10	5	8	10	17	5		3	3	
Pseudoscorpionida			1																		
Crustacea	Isopoda																				
Myriapoda	Polyxenida																				
	Totals	60	558	74	41	44	38	73	68	420	57	49	67	72	55	114	69	36	35	88	11

Sites H1–L5

Taxa		H1	H2	H3	H4	H5	I1	I2	I3	I4	I5	J1	J2	J3	J4	J5	L1	L2	L3	L4	L5
Collembola																					
Isotomidae																					
Entomobryidae	*Drepanura cinquilineata*																				
	other																4	10	2	7	14
Bourletiellidae	*Corynephoria* sp. 1					1					2	1	2	4	6	1					
	Corynephoria sp 2						1	1							1						
	Corynephoria sp. 4																1				
	Prorastriopes sp. 1		6	8	3		4	8	2	3	6		1	1	1						
	Prorastriopes sp. 2																				
	Prorastriopes sp. 3					4															
	Rastriopes																				1
Thysanura										2											
Psocoptera						1						1									
Orthoptera							1														
Thysanoptera			2	1	2		3	1	2		3				1	1					
Hemiptera	Cicadellidae												2								
	Aphididae													1							
	Other		9	4	4	2	1	7	6	4	4	2		4	3		2	1	1		
Coleoptera	Scarabaeidae		1	3																	
	Carabidae: Cicindelinae																				
	Carabidae other																				
	Staphylinidae									1											
	Pselaphidae																				
	Curculionidae																				
	Tenebrionidae																				
	Larvae	1																			5
	Carabidae: Cicindelinae																				
	Other																				
Diptera	Larvae	4		2	4	2		1	4		3			1	1		2		8	2	
	Adults		2																		
Lepidoptera	larvae		2	1	1		1			1							2				
Hymenoptera	Formicidae	60	36	14	23	50	15	28	38	84	20	20	7	7	10	7	13	8	8	16	3
	Other						1		1					1		1			1		
Araneae				1		2			1	1	2	2				2					
Acarina	Nanorchestidae						5		6			20	130	150	180	50	1				
	Caeculidae																				
	Prostigmata other														11						5
	Acarina other		2	7	13	10	5	7	10		10	5	10	4		7		4	2	4	4
Pseudoscorpionida							1														
Crustacea	Isopoda																				
Myriapoda	Polyxenida																				
	Totals	65	60	41	50	72	38	53	70	96	50	51	152	173	214	69	25	23	22	29	32

Sites M1–Q5 and Totals

Taxa		M1	M2	M3	M4	M5	N1	N2	N3	N4	N5	O1	O2	O3	O4	O5	P1	P2	P3	P4	P5	Q1	Q2	Q3	Q4	Q5	Totals
Collembola																											
Isotomidae																											1
Entomobryidae	*Drepanura cinquilineata*																										1
	other	26	4	14	1	11	4	1	3	6						1	1	3		26	7	1	4	3	2	8	458
Bourletiellidae	*Corynephoria* sp. 1											1	1														67
	Corynephoria sp 2																										8
	Corynephoria sp. 4												1	4													6
	Prorastriopes sp. 1																										89
	Prorastriopes sp. 2																										3
	Prorastriopes sp. 3																										5
	Rastriopes																										1
Thysanura										1	1																29
Psocoptera					1		1	1				1	1		1					1							14
Orthoptera									1								1										11
Thysanoptera						1																					27
Hemiptera	Cicadellidae		4	1	1																						12
	Aphididae																										3
	Other	1	1	1	1				3					3	1	3	2				3					1	129
Coleoptera	Scarabaeidae																										8
	Carabidae: Cicindelinae						1																				1
	Carabidae other																										1
	Staphylinidae																										3
	Pselaphidae																										1
	Curculionidae												1														3
	Tenebrionidae																										1
	Larvae			3				1											1								13
	Carabidae: Cicindelinae						1																				1
	Other					3				1				1													23
Diptera	Larvae	1	1	5	3	3	2		1	1		3	6		2	1	4		1			6	2		1	1	159
	Adults					1														1							4
Lepidoptera	larvae									1											1						50
Hymenoptera	Formicidae	1	23	1	15	4		1	9	2		46	19	85	7	80	27	13	22	9	36			2	2	1	2657
	Other										1		2				2				1	1					21
Araneae			1								1													1			24
Acarina	Nanorchestidae				1		2		2	2					7	5		1	3	1	1	1					1018
	Caeculidae																		1								1
	Prostigmata other																										266
	Acarina other	3	6	6	3	7				1			14	6	2	1	1		3	1	4	1	7	5	1	6	360
Pseudoscorpionida																							1				3
Crustacea	Isopoda																										1
Myriapoda	Polyxenida																		1								1
	Totals	32	40	31	26	30	11	4	19	15	3	51	45	99	20	91	38	17	32	39	53	10	14	11	6	17	

Site A

Site A detail

Site B

Site B detail

Site C

Site C detail

Site D

Site D detail


Site E

Site E detail

Site F

Site G

Site G detail

Site H


Site H detail

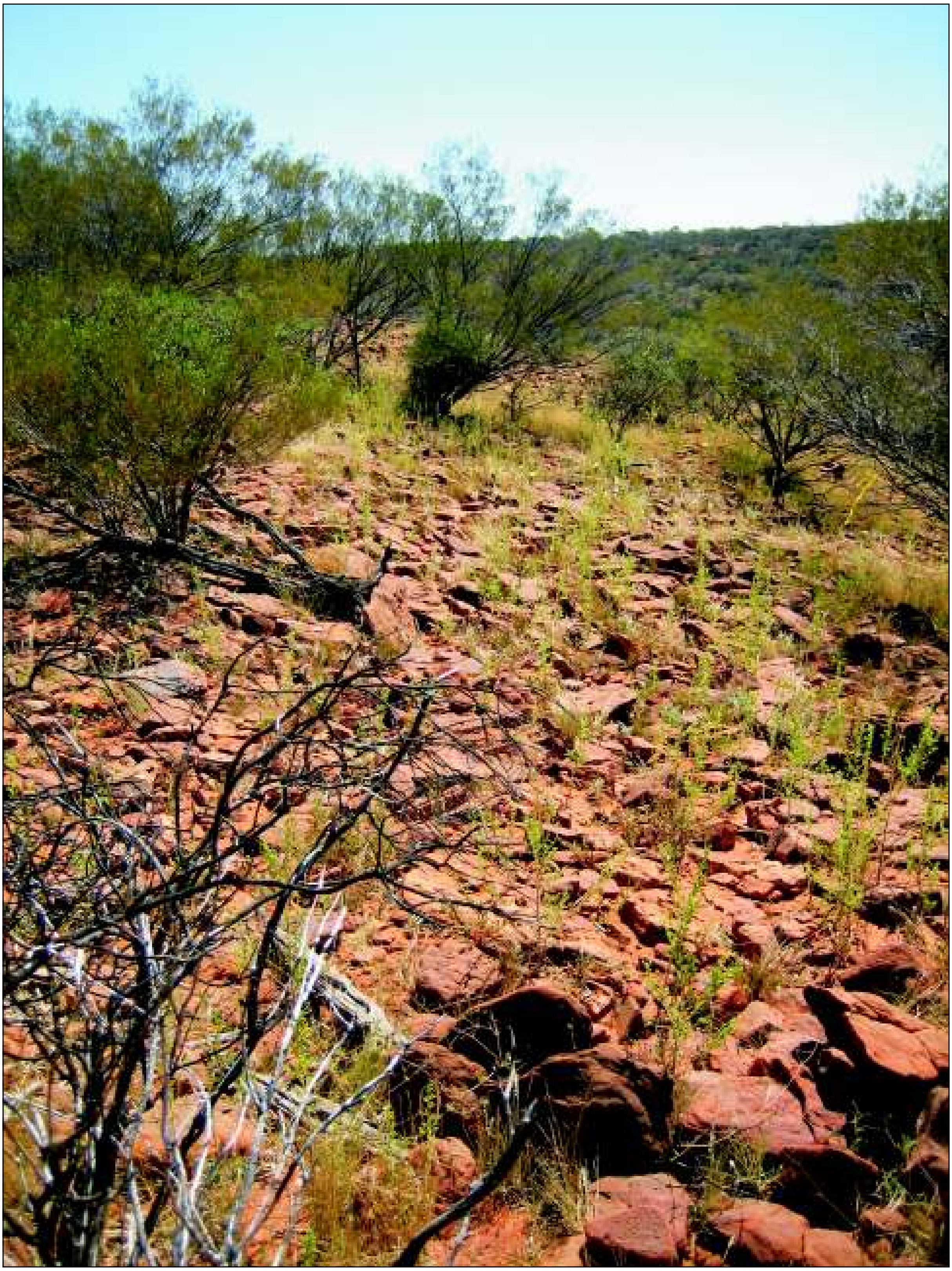
Site I

Site J

Site J detail

Site L

Site L detail



Site M

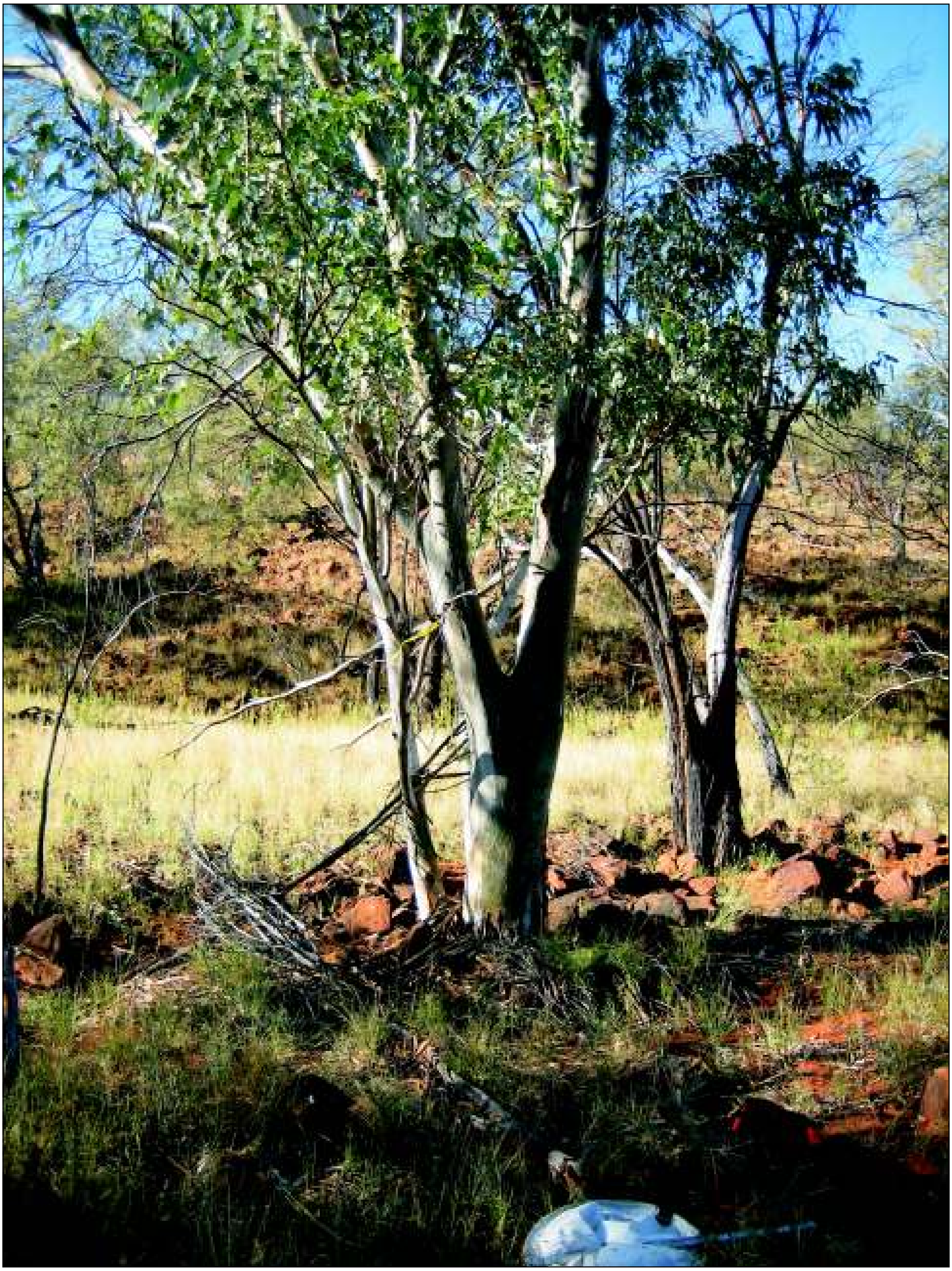
Site M detail

Site N

Site N detail

Site O

Site O detail



Site P

Site P detail

Site Q

Acacia shrubs along dry creek

Acacia shrubs in detail

Buffel grass

Buffel grass in detail

Coolabah waterhole site

Coolabah waterhole detail

Eucalyptus tree

Eucalyptus tree detail

Floodplain near HS

Funnel extraction

Ibis swamp

Ibis swamp, pitfall removed by the water birds

Mulga grove

Mulga grove detail

Pitfall trap

Salty Bore sweep site

A vertebrate fauna survey of Cravens Peak Reserve, far western Queensland

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Abstract A survey of the terrestrial vertebrates of Cravens Peak Reserve, far western Queensland, in March and April 2007 identified six amphibian, 42 reptile, 109 bird (including two feral) and 13 mammal (including five feral) species. Three additional vertebrates (an amphibian, a reptile and a mammal) were not identified to species level but information about these is presented. Details of the sites surveyed and methods used are reported, together with a summary of results that includes notes on the more significant findings. Two reptile species were collected for the first time in Queensland: *Ctenotus calurus* and *Lerista desertorum*. The presence of another species not previously collected in this state, *Ctenotus piankai*, was confirmed from photographs, although our single voucher specimen of a juvenile individual was identified as *C.* cf. *piankai*. Five species encountered are listed as rare under the Queensland *Nature Conservation (Wildlife) Regulation 1994* and its amendments*:* grey falcon, golden-backed (black-chinned) honeyeater, pictorella mannikin, *Ctenotus aphrodite* (? = *C. septenarius*) and *C. ariadnae*. Records of some of these represent range extensions or unusual occurrences. Atypically wet conditions leading up to the period of field work resulted in a higher than expected number of observations of amphibians and wetland-associated birds, as well as a marked abundance of irruptive breeding species such as diamond dove, budgerigar, masked woodswallow and zebra finch. The preceding rainfall events probably also explain the presence of species such as the pictorella mannikin and channel-billed cuckoo, which usually occur in more mesic environs. Identification issues (e.g. concerning blind snakes *Ramphotyphlops* and some *Ctenotus* skinks) and taxonomic uncertainties (e.g. in relation to frogs such as *Neobatrachus* and some *Cyclorana*, and geckos of the genus *Gehyra*) highlight the need for further targeted survey work, including more comprehensive collection efforts. Nevertheless, the results of this short survey demonstrated that Cravens Peak Reserve has a rich and significant biodiversity, worthy of long-term conservation.

Introduction

Cravens Peak Reserve lies at the northern edge of the Simpson Desert in far western Queensland. The homestead is approximately 135km west-southwest of Boulia. The 233 000 ha Reserve is bounded to the west by the Northern Territory, to the north and east by Glenormiston Station and to the south by Carlo Station. It straddles the Simpson-Strezlecki Dunefields and Channel Country bioregions (DEWHA 2008). It was a cattle grazing property prior to its acquisition in 2005 by Bush Heritage Australia for conservation purposes. The southern section of the Reserve is dominated by extensive red dune fields, sand plains, claypans and ephemeral wetlands. This contrasts with the Reserve's northern section, which consists of the weathered, rocky Toomba and Toko Ranges and their associated gorge systems, escarpments, mesas and gibber plains, and the grasslands and open woodlands of the Mulligan River catchment.

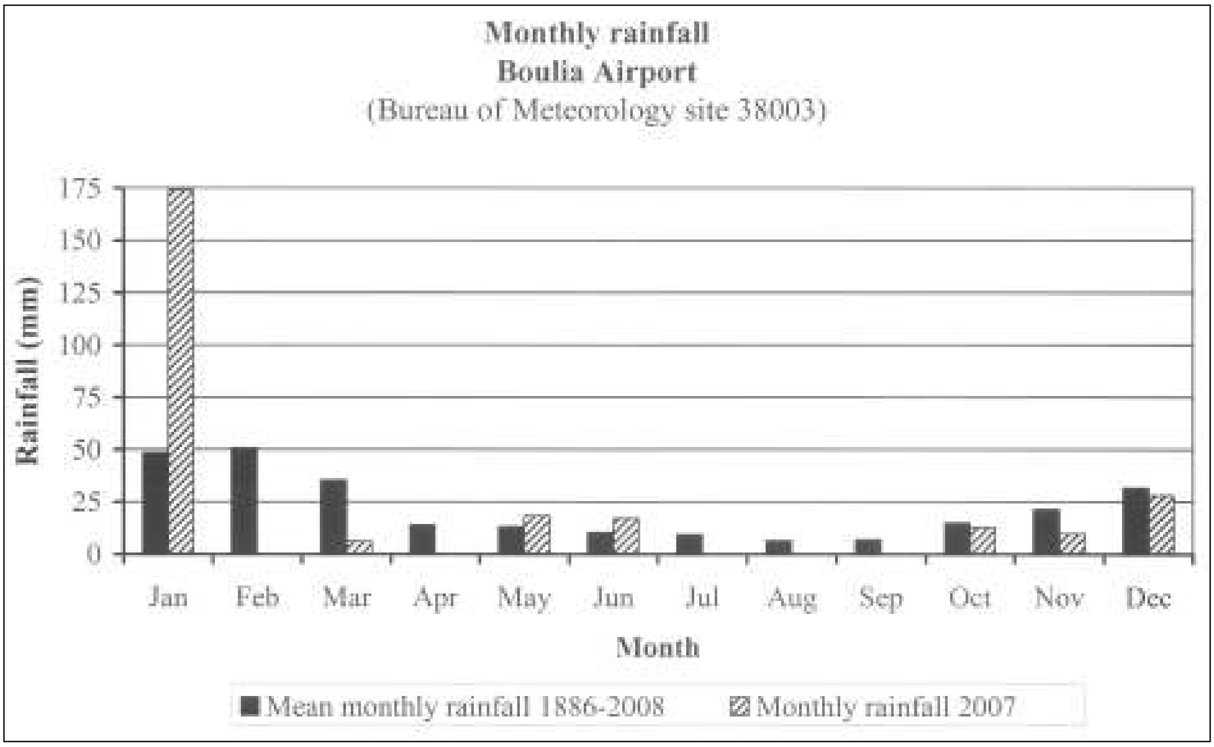

Figure 1a. Boulia mean monthly rainfall from 1886-2008, showing monthly averages for 2007 (BOM 2008).

Following the purchase of Cravens Peak Station by Bush Heritage Australia, de-stocking commenced in 2006 with the aim of improving the conservation values of the property. To this end, the owners undertook to collaborate with The Royal Geographical Society of Queensland in supporting a multi-disciplinary scientific study, with the aim of collecting and assessing baseline data to further progress the conservation management of this significant Reserve. This report presents the results of a short vertebrate fauna survey in a small portion of Cravens Peak Reserve, conducted as one component of this joint study. The primary purpose was to record the presence and abundance of species on the Reserve, particularly in the landscapes of the property's northern section.

Methods

Climate of the study area

The area in which Cravens Peak Reserve is situated is characterised by low and erratic rainfall, high evaporation, very hot summers and cool to cold winters. Mean figures over the period 1886-2008 for Boulia, the nearest official weather station, are an annual rainfall of 262mm (Figure 1a, page 200), annual evaporation of 3066mm, maximum temperatures (Figure 1b, page 201) ranging from 22.9°C (Jul) to 38.6°C (Dec) and minimum temperatures (Figure 1c, page 202) of between 7.7°C (Jul) and 24.5°C (Jan) (BOM 2008).

Annual rainfall at Boulia was below average during the two years prior to the survey, particularly so in 2006 when only 96.5mm fell (BOM 2008). At an official weather station at Bedourie, approximately 145km southeast of Cravens Peak homestead, rainfall during 2006 (67.6mm) was only 37% of the annual average (180.9mm), based on 61 years of observations (BOM 2007a). This dry spell was brought to an end in the summer of 2006-07. During the week leading up to Christmas 2006, Boulia received 28mm of rain and Bedourie 12.7mm (BOM 2008). The next month an active monsoon triggered the development of a tropical depression which tracked over inland Australia and produced widespread rains, including across Queensland's Channel Country (BOM 2007b). As a result, from 14-26 January 2007 falls of 173.9mm were recorded at Boulia (Figure 1a, page 200) and 296.4mm at Bedourie (BOM 2008), indicating that Cravens Peak Reserve also would have received significant precipitation during this period. Between 22 and 24 March 2007, just prior to the commencement of the survey, further rain fell in this region – Boulia recorded 6mm and Bedourie 6.5mm

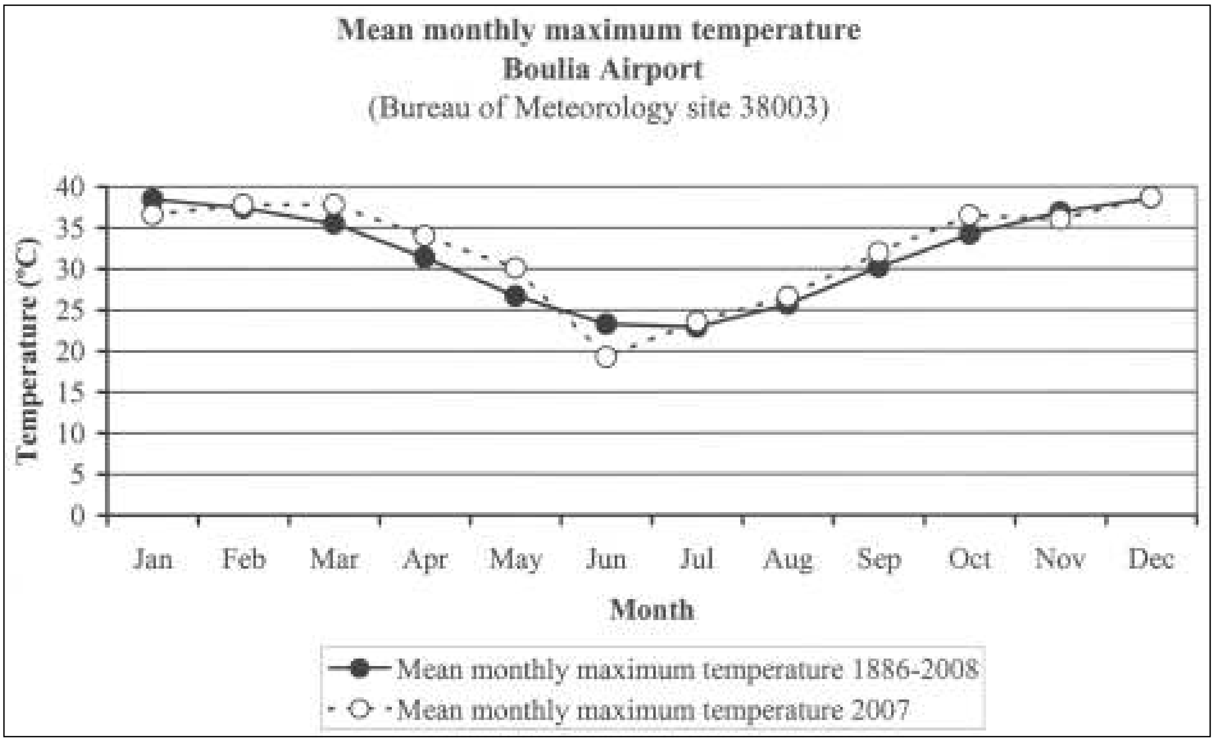

Figure 1b. Boulia mean monthly maximum temperatures from 1886-2008, showing monthly averages for 2007 (BOM 2008).

(BOM 2008), however, an unofficial total of 75mm was received at Cravens Peak homestead on or about 24 March 2007. A further 27mm of rain fell at the homestead during a thunderstorm on 28 March 2007, the day we arrived at the Reserve.

During the period of the fauna survey, the average maximum and minimum temperatures recorded at Boulia were 33.2°C and 18.9°C respectively, with the highest daily maximum of 38.4°C on 28 March 2007 and the lowest of 23.5°C the following day. This marked drop in daytime high temperatures corresponded to the passage of the storm system with its accompanying rain at Cravens Peak homestead on the evening of 28 March (see previous paragraph). The lowest daily minimum recorded at Boulia during the period of this survey was 14.5°C on 1 April 2007 (BOM 2008).

Survey period

The vertebrate survey at Cravens Peak Reserve was planned to commence on 26 March 2007 but rainfall in the region delayed our arrival at the Cravens Peak homestead until 28 March 2007 due to impassable roads. An additional 27mm of rain received at the homestead that evening prevented vehicular access within the Reserve until 1 April 2007. Consequently the extent of the survey had to be reduced in terms of geographic scope, range of environments sampled and effort expended. Opportunistic observations were made within walking distance (~ 9km) of the homestead from our arrival on 28 March until 1 April 2007. Systematic survey sites (see below) were established on 2 April 2007 and sampled until 6 April 2007, with additional opportunistic observations being made on the Reserve until 7 April 2007.

Survey techniques

The methodology for the vertebrate fauna survey entailed several strategies. A series of 18 systematic sites (referred to as CRAV01-18; Tables 1 and 2, pages 203 and 205 respectively) was established at which standardised quadrat sampling techniques were employed. For full details of the layout of these quadrats and the sampling regime used at each, see Kutt et al. (this volume, Figure 1, page 237, and Table 1, page 238). Briefly, each systematic site involved pitfall, Elliott and cage trapping, together with diurnal and nocturnal active searches of set duration. Most of these sites were located in dune/swale habitats to the northwest of Cravens Peak homestead. In addition, targeted active searching, on occasion combined with incidental trapping, was conducted at a further 20 opportunistic sites (referred to as

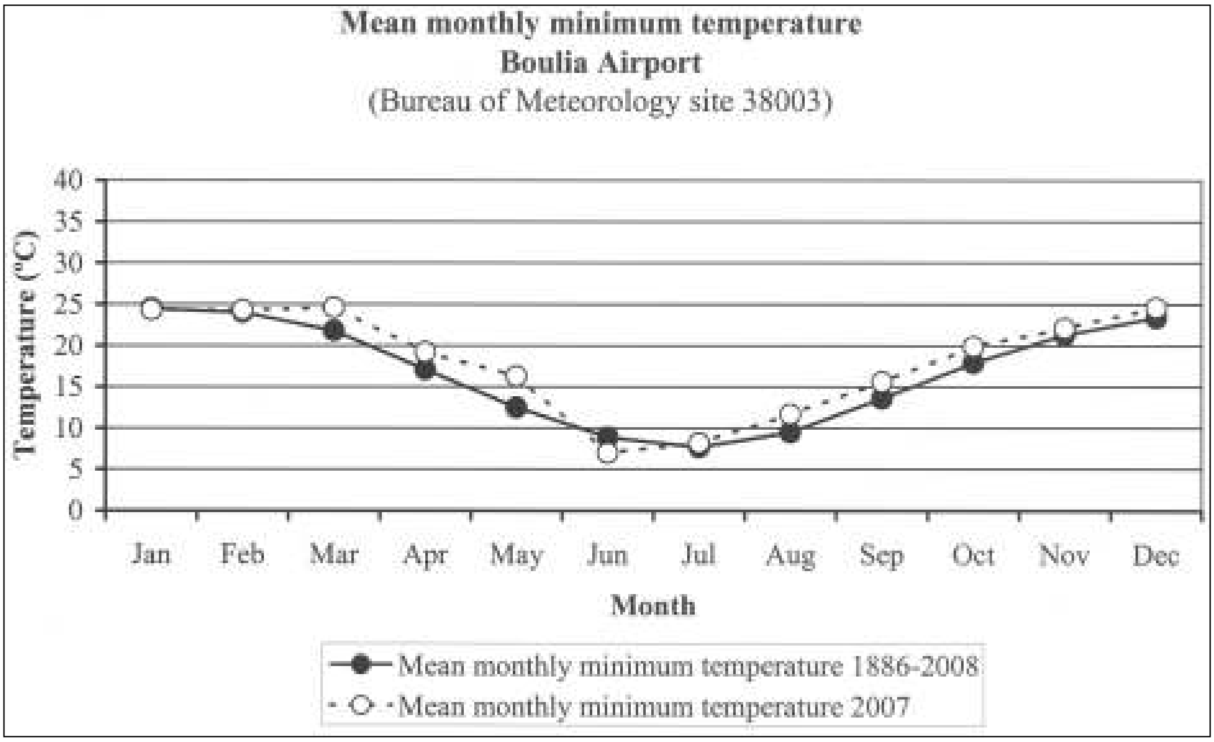

Figure 1c. Boulia mean monthly minimum temperatures from 1886-2008, showing monthly averages for 2007 (BOM 2008).

CPOP01-20; Table 1, page 203). When nocturnal searches were conducted, these involved the use of spotlights and headlamps. Audio recordings of several frog species were also made for subsequent analysis using a Sennheiser ME 67 long gun microphone, a Sony TCD-D100 Digital Audio Tape-recorder and Sony ProDAT Plus digital audio tape. Ambient air and water temperatures at the time of the recording were noted.

Incidental trapping was conducted at two opportunistic sites. A line of 25 Elliott traps was deployed for two nights on the escarpment of the Mulligan River gorge at a site referred to as ‘S-Bend’ (site CPOP05). Further upstream (site CPOP07), three harp traps were deployed (as double and single traps) for two nights over or adjacent to pools of water in the channel bed. Numerous incidental observations elsewhere on the Reserve were also noted (see Figure 2, page 206). It should be noted that although the S-Bend of the Mulligan River and the surrounding area west of the river appear to fall outside of the boundaries of Cravens Peak Reserve in Figure 2 (page 206) this land is actually fenced and managed as part of the property (Len Rule, pers. comm.).

The location of all survey sites and incidental records was accurately determined using either a Garmin 12XL or 76CSx global positioning system. All records were entered into the Department of Environment and Resource Management’s ‘WildNet’ database. Voucher specimens were collected and lodged with the Queensland Museum and where these are referred to in this report the museum accession number is prefixed with ‘QM’. Tissue samples for DNA analyses were taken from most voucher specimens and lodged with the South Australian Museum.

Museum database searches

Searches of the databases at the Australian, Queensland and South Australian Museums were undertaken to extract previous specimen collections from a latitude/longitude rectangle incorporating Cravens Peak Reserve (Australian Museum, June 2008; Queensland Museum, April 2008; South Australian Museum, June 2008). The online search facility (WAM 2008) for the Northern Territory and Western Australian Museums was used to determine whether these institutions held specimens of *Ctenotus calurus*, *C. piankai* and *Lerista desertorum* from Queensland.

Results

During the survey 170 species of terrestrial vertebrates were recorded from Cravens Peak Reserve, comprising six amphibian, 42 reptile,

Table 1. Details of sites surveyed within Cravens Peak Reserve, far western Queensland. The location of systematic sites is provided in Kutt et al. (this volume, Table 1, page 238). The locations of fauna records made at opportunistic survey sites are shown in Figure 2 (page 206), along with the distribution of incidental records. Systematic survey sites have a site code commencing with 'CRAV' and opportunistic survey sites have a site code commencing with 'CPOP'. The datum for geo-references is GDA94.

Site Code	Locality	Latitude	Longitude
CRAV01	On road between Sandhill Bore and Plum Pudding, ca. 2.5km northwest of Sandhill Bore.	23° 14' 57"S	138° 30' 56"E
CRAV02	On road between Sandhill Bore and Plum Pudding, ca. 5.9km northwest of Sandhill Bore.	23° 14' 04"S	138° 29' 14"E
CRAV03	On road between Sandhill Bore and Plum Pudding, ca. 7.6km northwest of Sandhill Bore.	23° 13' 35"S	138° 28' 23"E
CRAV04	On road between Sandhill Bore and Plum Pudding, ca. 8.6km east-southeast of Plum Pudding.	23° 12' 59"S	138° 27' 21"E
CRAV05	On road between Sandhill Bore and Plum Pudding, ca. 4.8km east-southeast of Plum Pudding.	23° 12' 05"S	138° 25' 18"E
CRAV06	On road between Sandhill Bore and Plum Pudding, ca. 2.9km east-southeast of Plum Pudding.	23° 11' 45"S	138° 24' 14"E
CRAV07	On road between Sandhill Bore and Plum Pudding, ca. 1.3km east-southeast of Plum Pudding.	23° 11' 30"S	138° 23' 22"E
CRAV08	On road between Plum Pudding and S-Bend turnoff, ca. 2.9km northwest of Plum Pudding.	23° 09' 45"S	138° 21' 55"E
CRAV09	On road between Plum Pudding and S-Bend turnoff, ca. 5.3km northwest of Plum Pudding.	23° 08' 43"S	138° 21' 03"E
CRAV10	On road between Plum Pudding and S-Bend turnoff, ca. 6.3km northwest of Plum Pudding.	23° 08' 22"S	138° 20' 42"E
CRAV11	On road between Plum Pudding and S-Bend turnoff, ca. 5.6km southeast of S-Bend turnoff.	23° 07' 12"S	138° 19' 55"E
CRAV12	Swamp on road between Plum Pudding and S-Bend turnoff, ca. 1.5km southeast of S-Bend turnoff.	23° 05' 18"S	138° 18' 40"E
CRAV13	Swamp northeast of road between S-Bend turnoff and Salty Bore, ca. 3.3km northwest of S-Bend turnoff.	23° 02' 59"S	138° 17' 25"E
CRAV14	On road between S-Bend turnoff and Salty Bore, ca. 2.7km east of Salty Bore.	23° 01' 36"S	138° 15' 03"E
CRAV15	On road between S-Bend turnoff and Salty Bore, ca. 1.2km northeast of Salty Bore.	23° 01' 00"S	138° 14' 04"E
CRAV16	On road between S-Bend turnoff and Glenormiston boundary, ca. 1.8km southeast of S-Bend turnoff.	23° 05' 03"S	138° 19' 15"E
CRAV17	On road between S-Bend turnoff and Glenormiston boundary, ca. 2.9km southeast of S-Bend turnoff.	23° 05' 13"S	138° 19' 50"E
CRAV18	On road between S-Bend turnoff and Glenormiston boundary, ca. 0.5km northwest of Glenormiston boundary gate.	23° 05' 14"S	138° 21' 10"E
CPOP01	Cravens Peak homestead.	23° 19' 23"S	138° 35' 26"E
CPOP02	Ca. 1.6km southwest of the Cravens Peak homestead.	23° 19' 59"S	138° 34' 48"E
CPOP03	Ca. 1.3km southwest of the Cravens Peak homestead.	23° 20' 00"S	138° 35' 08"E
CPOP04	Ca. 2.5km northwest of the Cravens Peak homestead on the Cravens Peak - Glenormiston Road.	23° 18' 14"S	138° 34' 39"E
CPOP05	The S-Bend of the Mulligan River, ca. 38km northwest of the Cravens Peak homestead.	23° 03' 46"S	138° 21' 06"E
CPOP06	Plum Pudding, ca. 27km northwest of the Cravens Peak homestead.	23° 11' 15"S	138° 22' 39"E
CPOP07	Upstream of the S-Bend, ca. 38km northwest of the Cravens Peak homestead.	23° 03' 46"S	138° 20' 49"E

Continues on following page

continued from previous page

Site Code	Locality	Latitude	Longitude
CPOP08	Disused cattle yards, ca. 0.8km west of the Cravens Peak homestead.	23° 19' 26"S	138° 34' 58"E
CPOP09	Ca. 2.1km southeast of the Cravens Peak homestead.	23° 20' 24"S	138° 35' 37"E
CPOP10	Wetland ca. 0.8km south of Sandhill Bore.	23° 16' 03"S	138° 32' 11"E
CPOP11	Adjacent to the road between the Cravens Peak homestead and Sandhill Bore, ca. 3.2km southeast of Sandhill Bore.	23° 17' 12"S	138° 32' 58"E
CPOP12	Adjacent to the road between the Cravens Peak homestead and Sandhill Bore, ca. 3.8km southeast of Sandhill Bore.	23° 17' 29"S	138° 33' 09"E
CPOP13	Ca. 0.2km south of Sandhill Bore.	23° 15' 44"S	138° 32' 07"E
CPOP14	Coolibah Hole, ca. 5.1km south of the Cravens Peak homestead.	23° 22' 06"S	138° 35' 57"E
CPOP15	Salty Bore, ca. 50km northwest of the Cravens Peak homestead.	23° 01' 22"S	138° 13' 29"E
CPOP16	S-Bend campsite, ca. 1.0km south of the S-Bend of the Mulligan River and 37km northwest of the Cravens Peak homestead.	23° 04' 23"S	138° 21' 01"E
CPOP17	12 Mile Bore, ca. 48km northwest of the Cravens Peak homestead.	23° 09' 34"S	138° 09' 21"E
CPOP18	Painted Gorge, ca. 51km west-northwest of the Cravens Peak homestead.	23° 14' 48"S	138° 05' 59"E
CPOP19	Ca. 1.5km southwest of the Cravens Peak homestead.	23° 19' 58"S	138° 34' 48"E
CPOP20[1]	On road between Plum Pudding and S-Bend turnoff, ca. 1.7km southeast of S-Bend turnoff.	23° 05' 22"S	138° 18' 44"E

[1] Site CPOP20 encompasses site CRAV12 but includes incidental records from a greater radius and range of habitats than systematically surveyed at CRAV12.

109 bird (including two feral) and 13 mammal (including five feral) species. Records of three additional vertebrates (a frog *Cyclorana* sp., a skink *Ctenotus* sp. and a bat *Taphozous* sp.) not identified to species level are described below. The complete list of species recorded from the systematic and opportunistic surveys, as well as those recorded incidentally elsewhere, is presented in Appendix 1, Kutt et al. (this volume, page 248). It shows the location of the systematic trapping sites and summarises the number of captures at each of these. Figure 2 (page 206) illustrates the location all other fauna records (i.e. those made incidentally and at opportunistic survey sites) by vertebrate class. In the text, all species except birds are referred to by scientific name, although common names, where they exist, are provided in Appendix 1 (page 228). For birds, the common names and taxonomic order of Christidis and Boles (2008) are used. For all other vertebrates, we follow the taxonomy used in the WildNet database.

The most frequently observed species at systematic survey sites (i.e. the percentage of the 18 systematic survey sites at which each species was recorded, presented in Appendix 1, page 228 in the '%SS' column) were budgerigar *Melopsittacus undulatus* and zebra finch *Taeniopygia guttata* at 100% of sites, followed by diamond dove *Geopelia cuneata* at 94%, masked woodswallow *Artamus personatus* at 83% and cockatiel *Nymphicus hollandicus* at 78% of the sites. Only five species of reptiles were recorded at 50% or more of systematic survey sites: *Gehyra* cf. *variegata*, *Ctenophorus isolepis*, *Ctenophorus nuchalis*, *Ctenotus helenae* and *Ctenotus pantherinus*, with the last being the most frequently recorded reptile, being detected at 61% of systematic survey sites. No frogs or mammals were recorded at a third or more of systematic survey sites.

Frog activity was much greater than expected, due to rainfall events in the months preceding the survey, in the week prior to our arrival and on the day of arrival. Following the heavy rain on the evening of 28 March 2007, five species of frogs were heard calling in ephemeral wetlands near Cravens Peak homestead (sites CPOP02 & CPOP03; Table 1, page 203). These were *Neobatrachus sudelli*, *Notaden nichollsi*, *Cyclorana cultripes*, *C. platycephala* and another species of *Cyclorana*, we refer to as *C.* cf. *maini* (two individuals heard in the distance – see section on *Cyclorana* species in *Identification and taxonomic issues relating to the herpetofauna*). Call recordings, of a quality suitable for analysis, were made of *Notaden nichollsi* (no associated voucher specimen), *Neobatrachus sudelli* (voucher specimens QM J85395 and QM J85403) and *Cyclorana cultripes* (QM J85394). Calling activity was strongest just after dusk (at 21:30hrs dry bulb air temperature was 25.9ºC and water temperature was 27.0ºC)

Table 2. Landform and regional ecosystem (RE) type and description at each of the sites surveyed systematically at Cravens Peak Reserve, far western Queensland (refer to Table 1, page 203). For a map of the location of these sites, see Kutt et al. (this volume, Figure1, page 237).

Site Title	Landform	RE	Vegetation Description
CRAV01	Swale	5.3.11	*Acacia georginae* tall shrubland with *Senna artemisioides* subsp. *oligophylla* ± *Eremophila freelingii* on alluvium.
CRAV02	Dune	5.6.5	*Triodia basedowii* hummock grassland on sides of, or between dunes
CRAV03	Dune	5.6.5	*Triodia basedowii* hummock grassland on sides of, or between dunes
CRAV04	Swale	5.3.11	*Acacia georginae* tall shrubland with *Senna artemisioides* subsp. *oligophylla* ± *Eremophila freelingii* on alluvium.
CRAV05	Swale	5.3.11	*Acacia georginae* tall shrubland with *Senna artemisioides* subsp. *oligophylla* ± *Eremophila freelingii* on alluvium.
CRAV06	Dune	5.6.5	*Triodia basedowii* hummock grassland on sides of, or between dunes.
CRAV07	Dune	5.6.5	*Triodia basedowii* hummock grassland on sides of, or between dunes.
CRAV08	Dune	5.6.6	*Triodia basedowii* hummock grassland wooded with *Acacia* spp., *Senna* spp., *Grevillea* spp. ± *Eucalyptus* spp. on sand plains and dune fields.
CRAV09	Dune	5.6.6	*Triodia basedowii* hummock grassland wooded with *Acacia* spp., *Senna* spp., *Grevillea* spp. ± *Eucalyptus* spp. on sand plains and dune fields.
CRAV10	Dune	5.6.5	*Triodia basedowii* hummock grassland on sides of, or between dunes
CRAV11	Dune	5.6.6	*Triodia basedowii* hummock grassland wooded with *Acacia* spp., *Senna* spp., *Grevillea* spp. ± *Eucalyptus* spp. on sand plains and dune fields.
CRAV12	Swamp	5.3.14	*Atriplex nummularia* shrubland on claypans between dunes.
CRAV13	Swamp	5.3.13	*Muehlenbeckia florulenta* shrublands in swamps.
CRAV14	Outwash – lower slopes	5.3.11	*Acacia georginae* tall shrubland with *Senna artemisioides* subsp. *oligophylla* ± *Eremophila freelingii* on alluvium.
CRAV15	Outwash – lower slopes	5.3.11	*Acacia georginae* tall shrubland with *Senna artemisioides* subsp. *oligophylla* ± *Eremophila freelingii* on alluvium.
CRAV16	Outwash – lower slopes	5.3.11	*Acacia georginae*tall shrubland with *Senna artemisioides* subsp. *oligophylla* ± *Eremophila freelingii*on alluvium.
CRAV17	Plateau	5.7.12	*Acacia cyperophylla* ± *A. aneura* tall shrubland on scarps and hills of low Ordovician ranges.
CRAV18	Plateau	5.7.12	*Acacia cyperophylla* ± *A. aneura* tall shrubland on scarps and hills of low Ordovician ranges.

but had reduced significantly by midnight as the rain had ceased and cool south-westerly winds had intensified. Weather on 29 March 2007 was overcast and cool (maximum less than 20ºC), with moderate south-westerly winds. The cloud eventually cleared at 19:30hrs. Frog calling activity that night, at these two sites, was nil, although several frogs were observed foraging (at 22:30hrs dry bulb air temperature was 16.5ºC and water temperature was 19.5ºC). No amplexing frogs or frog egg masses were observed during the course of the survey, although search effort was limited.

During the survey, evidence of breeding was noted in eight bird species, including three wetland-associated birds: grey teal *Anas gracilis*, white-necked heron *Ardea pacifica* and glossy ibis *Plegadis falcinellus*. Active nests were discovered of flock bronzewing *Phaps histrionica* (see below), diamond dove (Figure 3a, page 207) and little button-quail *Turnix velox* (Figure 3b, page 207), and observations of dependent young of pallid cuckoo *Cacomantis pallidus* (in the company of adult white-winged trillers *Lalage sueurii*) and crested bellbird *Oreoica gutturalis* were made. On the afternoon of 28 March 2007, IG and HH

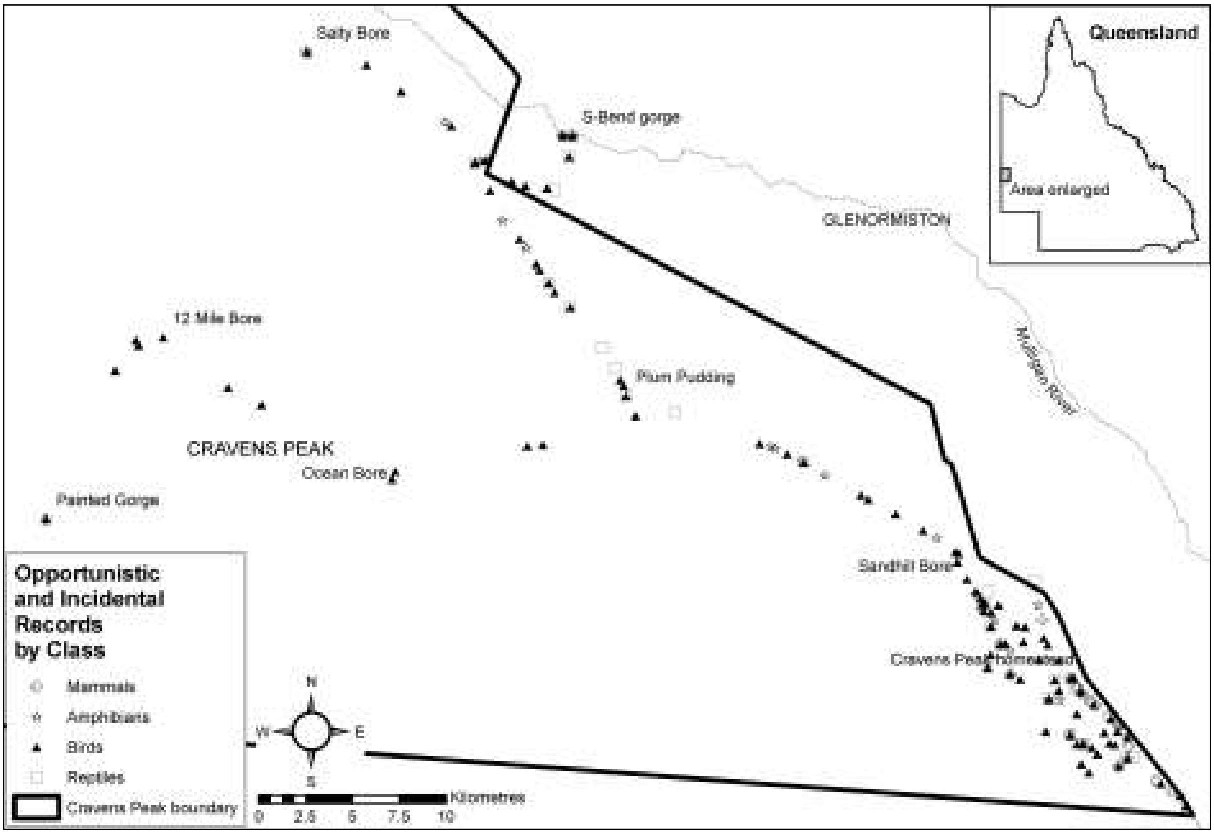

Figure 2. Distribution of fauna records made at locations other than systematic sites during the current survey of Cravens Peak Reserve (i.e. those made incidentally and at opportunistic survey sites), illustrated by vertebrate class. The location of the systematic survey sites is depicted by Kutt et al. (this volume, Table 1, page 238). Note that the area near S-Bend gorge which falls outside the mapped cadastral boundary of the property is fenced within and managed as part of Cravens Peak Reserve.

flushed an adult female flock bronzewing from a nest on a grassy, red loamy plain supporting scattered *Acacia georginae* about 900m south-west of Cravens Peak homestead. The nest, containing two eggs and a newly hatched chick, was on the ground amid 15-20cm tall grass and scattered rocks. The same evening, heavy rain (see above) left the plain awash. When IG checked the location again on 6 April 2007, the nest was empty and apparently deserted.

Notable species – new collections for Queensland

Three species of skinks, *Ctenotus calurus*, *C.* cf. *piankai* and *Lerista desertorum*, collected during the survey apparently represent the first specimen records from Queensland (as determined from database searches of the Queensland, Australian, Western Australian, South Australian and Northern Territory Museums). Observations of these species are presented here.

Ctenotus calurus

Ctenotus calurus appears to be widespread in the dune fields at Cravens Peak Reserve. During the survey it was recorded at seven systematic sites (11 captures in pitfall traps and three observed during diurnal censuses) and at one other site incidentally, where it was hand-captured by EV (Figure 4, page 209; Appendix 1, page 228). Four voucher specimens were retained (QM J85423, QM J85437, QM J85438 and QM J85441).

Cogger (1996) states that *C. calurus* is “widely distributed throughout the desert regions of mid-eastern WA and adjacent desert areas of SA and NT”, while Wilson and Swan (2008) indicate that it occurs in sandy deserts with spinifex from central and southern interior of Western Australia to adjacent corners of the Northern Territory and South Australia, with an isolated population at Exmouth Gulf, Western Australia. Pianka (1969a,b), in his studies of desert lizards in Western Australia, found *C. calurus* to be restricted to habitats containing spinifex (*Triodia*

Figure 3. Examples of nesting birds encountered during the survey of Cravens Peak Reserve, March-April 2007. (Photos: Eric Vanderduys).
A. Diamond dove *Geopelia cuneata*
B. Little button-quail *Turnix velox*

spp.). In a study of response to fire at Uluru, Northern Territory, Masters (1996) classed *C. calurus* as a spinifex specialist. With one exception, all records during our survey were from *Triodia basedowii* hummock grassland on dunes and swales (regional ecosystem types 5.6.5 or 5.6.6), consistent with previously published accounts of the habitat of this species. The remaining record involved a hand-captured individual from a disturbed (formerly heavily impacted by grazing) dune crest dominated by *Tribulus* sp.

Ctenotus piankai

A juvenile *Ctenotus* collected from a pitfall trap at site CRAV08 (Table 1, page 203), a sand dune dominated by spinifex (regional ecosystem 5.6.6; Table 2, page 205), was lodged with the Queensland Museum (QM J85419) and identified by staff as *C.* cf. *piankai* (P. Couper and A. Amey pers. comm.).

Another individual photographed by EV during the survey (Figure 5, page 210) was subsequently identified by Queensland Museum staff from the images as *C. piankai* (P. Couper and S. Wilson pers. comm.). As the precise location details of this photographed individual were not taken, this record is not shown in Appendix 1.

Wilson and Swan (2008) state that *C. piankai* occurs in "spinifex deserts, on dunes and sandy flats, occasionally rocky areas, from nw. coast and interior of WA to central and sthn NT and nw. SA". Cogger (1996) states that this species is "found in a variety of desert habitats, usually in association with spinifex". He also indicates that *C. piankai* is "widely distributed through the interior of WA and the more arid parts of NT and western Qld", the last location of interest as there appear to be no previous collections of this species in Queensland. Pianka (1969a,b) and Masters (1996) found *C. piankai* to be a spinifex (*Triodia* spp.) specialist. Our record of the juvenile (QM J85419), from a spinifex-covered sand dune, is consistent with these previously published accounts. Further collections of *C. piankai* from Queensland are required to clarify the distribution and status of this species in the state.

Lerista desertorum

A single individual captured in a pitfall trap at site CRAV17 (Table 1, page 203) was collected (QM J85444; Figure 6, page 211). The trap line was located on a stony plateau within regional ecosystem 5.7.12 (*Acacia cyperophylla* tall shrubland; Table 2, page 205), with sparse ground cover.

Cogger (1996) states that the distribution of *L. desertorum* is the "south-eastern interior of WA extending to the south-western and north-western desert areas of the NT and SA respectively" and that it is associated with "mulga and other arid *Acacia* scrubs and eucalypt woodlands, often with a ground cover of spinifex". Wilson and Knowles (1988) indicate that this species "favours woodlands and *Acacia* shrublands on reddish sandy or loamy soils from arid south-eastern interior of WA to adjacent NT and SA". Wilson and Swan (2008) illustrate its distribution as being the central interior of Western Australia, southern Northern Territory and central and north-western South Australia, and state that it occurs in shrublands. In contrast to these published accounts, the location of the present record, while in *Acacia* shrubland, was stony and possessed little understorey vegetation.

Notable species – rare or threatened vertebrates

None of the species recorded during the fauna survey of Cravens Peak Reserve is listed as threatened (endangered or vulnerable) at the state or national level. Two skinks and three birds recorded during the present field work are listed as rare under Queensland's *Nature Conservation (Wildlife) Regulation 1994* and its amendments. Details of the records of these rare fauna are presented here.

Ctenotus aphrodite (? = *Ctenotus septenarius*)

This taxon was captured in pitfall (five captures) and funnel traps (three captures) at site CRAV18 (Table 1, page 203), a stony plateau within regional ecosystem 5.7.12 (tall shrubland dominated by *Acacia cyperophylla*; Table 2, page 205). A voucher specimen was collected (QM J85445). In addition, a desiccated specimen (QM J85439) tentatively identified by staff at the Queensland Museum as this taxon was collected from similar habitat nearby at the 'S-Bend campsite' (site CPOP16; Table 1, page 203).

Wilson and Swan (2008) and staff at the Queensland and South Australian Museums regard *C. aphrodite* as a junior synonym of *C. septenarius* (P. Couper pers. comm., M. Hutchinson pers. comm.). However, justification for this has yet to be published. *Ctenotus aphrodite* was described from a single animal (QM J41814) collected from the Oorida area, Diamantina Lakes, southwest Queensland (23° 46'S, 141° 08'E; Ingram and Czechura 1990),

Figure 4. *Ctenotus calurus* from the dune fields of Cravens Peak Reserve, April 2007. (Photo: Eric Vanderduys).

approximately 294km southeast of our Cravens Peak Reserve capture sites. The Queensland Museum has five other specimens of this taxon from further south in the Mount Henderson-Morney Station area, west of Windorah in southwest Queensland. All fall within the Channel Country bioregion. There are no specimens identified as *C. aphrodite* in the Australian, Western Australian or Northern Territory Museums.

According to Wilson and Swan (2008), *C. septenarius* (including *C. aphrodite*) is narrowly restricted in distribution from far eastern Western Australia through far southern Northern Territory and far northern South Australia to the Channel Country bioregion of southwest Queensland. Its habitat is described as sparsely vegetated stony hills and gullies (Wilson and Swan 2008) or weathered stony slopes and mesas (Wilson 2005), both of which apply aptly to site CRAV18 at Cravens Peak Reserve. Our records represent a north-western extension of the known distribution of this taxon in Queensland.

Ctenotus ariadnae

Ctenotus ariadnae was found to be widespread in the dune fields of Cravens Peak Reserve (Figure 7, page 212). During the survey it was recorded at eight systematic sites (22 captures in pitfall traps, five captures in funnel traps and three observed during diurnal censuses; Appendix 1, page 228). Four of these sites were within regional ecosystem 5.6.5 and three within 5.6.6 (both spinifex-dominated communities), as is typical of the species (Cogger 1996, Wilson 2005, Wilson and Swan 2008). One individual was captured at site CRAV16 (Table 1, page 203) within regional ecosystem 5.3.11 (*Acacia georginae* tall shrubland on alluvium; Table 2, page 205). This site did not contain spinifex but nevertheless possessed a well developed grassy understorey. A voucher specimen of *C. ariadnae* (QM J85425) was collected from site CRAV09 (Table 1, page 203).

The distribution of *C. ariadnae* is indicated by different authors as being continuous or broken. Cogger (1996) states the species' range as "central-eastern interior of WA through central Australia to south-western Qld". Wilson (2005) states the distribution as being the far western Channel Country bioregion of Queensland, as well as northern South Australia and central Western Australia. Wilson and Swan (2008) depict three separate

Figure 5. *Ctenotus piankai* from the dune fields of Cravens Peak, April 2007. (Photo: Eric Vanderduys).

subpopulations, two in central Western Australia and one centred on the junction of the borders between Queensland, Northern Territory and South Australia. In Queensland, *C. ariadnae* is poorly known. There are no other specimens in the Queensland Museum, although the Australian Museum has six specimens from three locations at Ethabuka Station and one specimen from Sandringham Station, both of which are properties to the south of Cravens Peak Reserve.

Grey falcon *Falco hypoleucos*

Single individuals were observed on three occasions, all in dune fields, with two of the sightings associated with ephemeral wetlands in dune swales. One bird was observed (by IG, AK, EV and MA) stooping over the extensive wetland adjacent to Sandhill Bore (site CPOP13; Table 1, page 203) on 30 March 2007. Although glossy ibis *Plegadis falcinellus* and several other bird species were flushed, the falcon was not observed to take prey before it circled and glided away to the north. Subsequently, on 1 April 2007, a grey falcon was briefly observed by all authors at site CPOP20 as it stooped (without making contact) on a brown falcon *Falco berigora* and then disappeared from view. This event occurred above a partially flooded *Atriplex nummularia*-covered claypan, lined on its eastern side with acacias (probably *A. georginae*). A third brief encounter involved an individual observed by EV on 5 April 2007 during a standard 10-minutes bird census in *Triodia basedowii* hummock grassland with scattered *Eucalyptus pachyphylla* on dunes at site CRAV10.

The grey falcon occurs at low density in arid and semi-arid Australia, and Cravens Peak Reserve lies within its usual distribution (Storr 1984, Marchant and Higgins 1993, Barrett et al. 2003). The open, treeless or sparsely timbered habitats in which the present observations were made are typical of the species, moreover with Marchant and Higgins (1993) noting that grey falcons occur "near and over swamps, bores and waterholes, where surface water attracts prey". The species is reported to prey predominantly on granivorous parrots and pigeons (Marchant and Higgins 1993). Potential prey in the form of diamond doves and budgerigars was certainly abundant at the time of this fauna survey. *The Action Plan for Australian Birds 2000* lists grey falcon as near threatened (Garnett and Crowley 2000).

Figure 6. *Lerista desertorum* from survey site CRAV17, Cravens Peak Reserve, on 6 April 2007. (Photo: Eric Vanderduys).

Golden-backed honeyeater *Melithreptus gularis laetior*

Two individuals of the golden-backed form of the black-chinned honeyeater were observed by HH and IG at site CRAV10 (Tables 1 and 2, pages 203 and 205 respectively) on 4 April 2007. This dune field location was notable for the presence in the swales of scattered *Eucalyptus pachyphylla*, some of which supported the flowering mistletoe *Lysiana subfalcata*. Although we did not observe the golden-backed honeyeaters foraging it is likely that these mistletoes were the food resource for the birds at this time, as two other honeyeater species (singing *Lichenostomus virescens* and grey-headed honeyeater *L. keartlandi*) were noted probing the blossoms.

The location of this sighting falls outside the described distributional range for the species (Storr 1984, Schodde and Mason 1999, Higgins et al. 2001 and Barrett et al. 2003, who indicate that the black-chinned honeyeater is absent from at least the Queensland portion of the Simpson Desert). Higgins et al. (2001) mention rare and scattered occurrences of the species in the Northern Territory as far south as the Hay River in the northern Simpson Desert, at approximately the same latitude as Cravens Peak Reserve but some 150km further west.

Keast (1968) recorded black-chinned honeyeaters foraging in isolated flowering bloodwoods in extensive sandy desert in the Tanami, suggesting that this species must roam widely in such arid country, utilising patchy resources. Further work is required in the Simpson Desert to determine if a resident population exists or whether birds move into the area from afar to take advantage of temporary blossom resources.

Pictorella mannikin *Heteromunia pectoralis*

Two individuals were observed together by HH, IG and AK approximately 2.5km northwest of the Cravens Peak homestead (site CPOP04; Table 1, page 203) on three occasions over two days (14:00hrs on 30 March 2007; 09:30hrs and 18:30hrs on 31 March 2007). The birds were probably coming to water in a shallow drainage line beside a road. The surrounding area was red loamy soil supporting a dense cover of grass and a moderately well developed shrub layer with scattered low eucalypts. On each occasion the birds were only observed briefly before they flew off.

Figure 7. *Ctenotus ariadnae* from the dune fields of Cravens Peak Reserve, April 2007. (Photo: Eric Vanderduys).

This site at 23° 18' 14"S, 138° 34' 39"E is well south of the typical range of the species (e.g. Storr 1984, Schodde and Mason 1999, Barrett et al. 2003, Higgins et al. 2006). The nearest location at which pictorella mannikin is reported to occur with any frequency is the Mount Isa area, nearly 300km to the north (Horton 1975, Barrett et al. 2003, Higgins et al. 2006), where the species has been recorded breeding. Higgins et al. (2006) summarise dispersive and irruptive occurrences of this species and, together with Storr (1984), suggest that inland movements are associated with wet seasons, visiting arid southern parts of the bird's range mainly after rain. The occurrence of pictorella mannikin at Cravens Peak Reserve after the significant rainfall events of January and March 2007, with the resulting flush in vegetation, is entirely consistent with this proposal.

Other notable species

A number of vertebrates identified during the current survey are worthy of special mention because the records represent range extensions or unusual occurrences, or the species are poorly known in Queensland.

Gehyra nana

Using headlamps, HH and EV observed a total of 15 spotted *Gehyra*, thought to be either *G. nana* or *G. montium*, while searching the rock outcrops of the Mulligan River gorge at S-Bend (site CPOP05; Table 1, page 203). One individual was collected on 2 April 2007 and retained as a voucher specimen (QM J85424); other individuals were photographed by EV on 5 April 2007. Museum staff identified QM J85424 as *G. nana* and the images as *G.* cf. *nana* (P. Couper and A. Amey pers. comm.; Figure 8, page 214).

The Queensland and Australian Museums have no specimens of *G. montium* from Queensland. Wilson (2005) and Wilson and Swan (2008) indicate that the distribution of *G. nana* encompasses areas within the Northwest Highlands, Gulf Plains, Einasleigh Uplands and northern Desert Uplands bioregions in the state's north and northwest. The nearest record from the collection of the Queensland Museum is from 25km east of Mt Isa (20° 46'S, 139° 42'E), some 290km northeast of the S-Bend site at Cravens Peak Reserve. However, further south there are two Australian Museum specimens (AM R142957 and AM R142958) from Hamilton Hotel (22° 47'S, 140° 36'E), 233km to the east-northeast of S-Bend, while another, undated record (AM R51268) is simply labelled 'Simpson Desert'. Our observations at S-Bend gorge confirm that *G. nana* is distributed to at least the northern edge of the Simpson Desert in Queensland.

As a note of caution, Paul Horner of the Northern Territory Museum (pers. comm.) warned that *G. nana* and *G. montium* (the latter currently known from the rocky ranges of central Australia) are probably composite taxa, each comprised of two or more cryptic species. For this reason, further collection of rock-dwelling *Gehyra* from Cravens Peak Reserve, including the retention of tissues for genetic analyses, would be useful.

Morethia ruficauda

Two individuals of *Morethia ruficauda* were recorded during the survey. The first was collected from a funnel trap at site CRAV08 (Table 1, page 203) on 4 April 2007 and retained as a voucher specimen (QM J85435). The sand dune environment here corresponded to regional ecosystem 5.6.6 (see Table 2, page 205 for habitat description). A second animal was captured two days later in a pitfall bucket at site CRAV02 (Table 1, page 203), a sand dune and swale with *Triodia basedowii* hummock grassland (regional ecosystem 5.6.5; Table 2, page 205).

Morethia ruficauda is widespread in dry to arid rocky areas and spinifex dunes across central and north-western Australia, only reaching Queensland in the Northwest Highlands and Channel Country bioregions (Cogger 1996, Wilson 2005, Wilson and Swan 2008). The Queensland Museum has only two other specimens from this state: from Riversleigh (19° 02'S, 138° 44'E) and Diamantina National Park (23° 42'S, 141° 08'E). However, the Australian Museum has two specimens from the Simpson Desert to the south of Cravens Peak Reserve at Ethabuka Station (23° 41'S, 138° 26'E).

Channel-billed cuckoo *Scythrops novaehollandiae*

Channel-billed cuckoos were recorded on multiple occasions during the fauna survey of Cravens Peak Reserve. Three records were from the Toko Range at, or in the vicinity of, the Mulligan River. Calls of single birds were heard by IG on the morning of 4 April 2007 at the S-Bend of the Mulligan River (site CPOP05; Table 1, page 203) and off-site during a bird census by AK at site CRAV18 (Table 1, page 203). Habitat for the former was a *Eucalyptus camaldulensis* riparian corridor through a gorge whereas the latter was a tall shrubland dominated by *Acacia cyperophylla* on a stony plateau (Table 2, page 205). Because these locations were separated by only 2.5km, the records may refer to the same individual. On the morning of 5 April 2007, during a bird census of site CRAV17 (Table 1, page 203), IG observed a single bird off-site as it flew north. This individual called as it flew despite carrying a large insect, which appeared to be an orthopteran, in its bill. The habitat here was similar to that at site CRAV18 (Table 2, page 205), only 2.3km to the east, where this species was recorded the previous day. Another record of this species was made in a very different environment approximately 15km to the south of the S-Bend of the Mulligan River on the morning of 3 April 2007. While at site CRAV07 (Table 1, page 203), two separate series of calls of a channel-billed cuckoo were heard by HH and IG coming from a point estimated to be 1km away to the southwest in the extensive, spinifex-covered dune fields south of Plum Pudding (approximately 23° 11' 50"S, 138° 22' 55"E). This location was not visited and so it was not determined whether the swales in that area contained acacia or eucalypt woodland communities.

Although Higgins (1999) refers to historical and recent scattered records of channel-billed cuckoo from the Diamantina River, and Boulia (22° 54'S, 139° 54'E) northwards to the south-east Gulf of Carpentaria and at Urandangi on the Georgina River (21° 36'S, 138° 18'E), no prior records are described for the Queensland portion of the Simpson Desert including Cravens Peak Reserve. However, in the Northern Territory, this cuckoo has been recorded from Tobermorey Station (22° 17'S, 137° 58'E; 100km northwest of our Cravens Peak Reserve records) and further west at Jinka (22° 55'S, 135° 38'E) and Numery Stations (24° 01'S, 135° 25'E), the last of these lying within the Simpson Desert (Higgins 1999). The closest records of channel-billed cuckoo depicted in *The New Atlas of Australian Birds* (Barrett et al. 2003) are from the 1° grids centred on 23° 30'S, 139° 30'E (which appears to refer to the Georgina River) and 24° 30'S, 140° 30'E (which overlaps the Diamantina River). No Atlas records are shown for any part of the Simpson Desert. Both Higgins (1999) and Barrett et al. (2003) report recent sightings from Alice Springs.

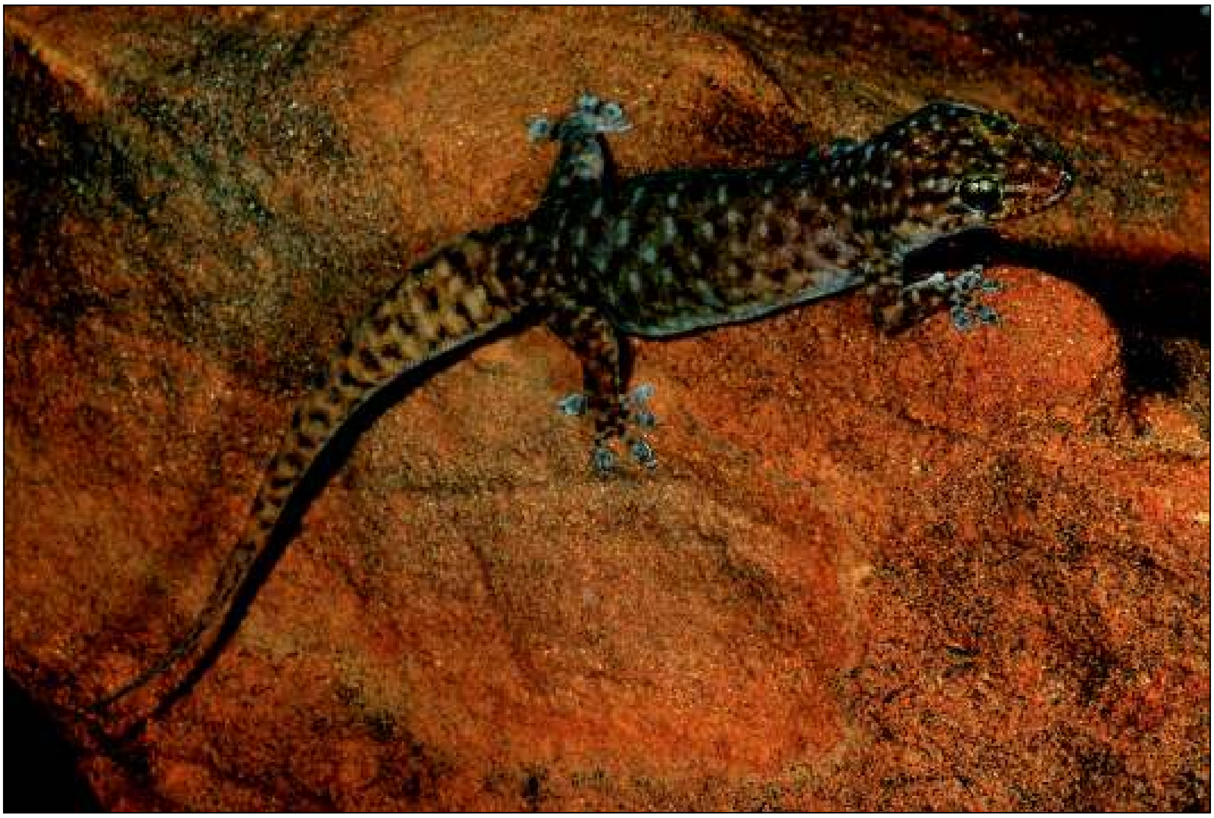

Figure 8. *Gehyra* cf. *nana* from opportunistic survey site CPOP05 at the S-Bend of the Mulligan River, Cravens Peak Reserve, on 5 April 2007. (Photo: Eric Vanderduys).

Existing records suggest that this species is a visitor to the arid interior along major ephemeral rivers, e.g. the Diamantina River, when these are in flood (Higgins 1999). This may account for the presence of channel-billed cuckoos during the present survey at Cravens Peak Reserve, following an unusually wet summer and early autumn. Knowledge of the diet of channel-billed cuckoos is relatively poor but in addition to frugivory the adults are documented to feed on insects (Higgins 1999), including Orthoptera (North in Higgins 1999). During this survey fruit suitable for channel-billed cuckoos was not evident but grasshoppers were in abundance across the Reserve. The sighting of a channel-billed cuckoo with what was assumed to be an orthopteran in its bill may indicate that this food resource was being exploited. Further observations of channel-billed cuckoos in arid Australia are required to determine their diet and the timing and conditions under which these environments are visited.

Slaty-backed thornbill *Acanthiza robustirostris*

This species was observed at two locations over the course of the fauna survey. During the late morning of 3 April 2007, two individuals were observed by EV during a bird census at site CRAV04 (Table 1, page 203) in tall shrubland dominated by *Acacia georginae* growing on alluvium in a dune swale (regional ecosystem 5.3.11; Table 2). Subsequently, the species was observed adjacent to site CRAV17 (Table 1, page 203) during a morning bird census by IG on 5 April 2007. On this occasion, at least two individuals were part of a mixed feeding flock with chestnut-rumped thornbills *Acanthiza uropygialis* in shrubland dominated by *Acacia cyperophylla* on the weathered, stony plateau of the Toko Range (regional ecosystem 5.7.12; Table 2, page 205).

Relatively few records of slaty-backed thornbill exist for Queensland but these include an August 1980 sighting west of Pulchera Waterhole (Sandringham Station; 23° 57'S, 138° 38'E) on the Mulligan River, some 80km south-southeast of the present localities (Schrader 1981, Blakers et al. 1984, Storr 1984, Higgins and Peter 2002). Other sightings of slaty-backed thornbill are reported from further southeast from the vicinities of Jundah (23° 30'S, 139° 30'E), 70km east of Windorah (23° 30'S, 139° 30'E) and 17km southwest of Eromanga (23° 30'S, 139° 30'E), and east or southeast to Adavale (23° 30'S, 139° 30'E) and Eulo (23° 30'S, 139° 30'E) in arid southwest Queensland (Hando 1984, Stewart 1984, Palliser 1985, Inglis et al. 1992, Higgins and Peter 2002). Records depicted in The New Atlas (Barrett et al. 2003) are from similar areas, with none being shown in the far western interior of Queensland. The current sightings, made 27 years after the record of Schrader (1981), confirm the continued occurrence of the species in the northern Simpson Desert of Queensland.

Typical habitat for the slaty-backed thornbill is mulga woodland, usually with an understorey of *Eremophila* (Higgins and Peter 2002). Neither of the sightings made during the present survey was in such habitat. The first observation was from gidgee *Acacia georginae* woodland or tall shrubland. Published records of slaty-backed thornbill using such habitat exist for Queensland (Schrader 1981) and the Lake Eyre Basin of South Australia (Badman 1979). Our second observation of this thornbill, however, was in a vegetation community dominated by *Acacia cyperophylla*; this habitat association does not appear to have been documented specifically in previous accounts.

Taphozous sp. (*hilli*?)

During daylight hours on 7 April 2007, IG hand-captured a solitary adult female *Taphozous* (Figure 9, page 217) roosting in a recess on the roof of a low, approximately 12m long, tunnel-like cave at Painted Gorge in the Toomba Range (23° 14' 48"S, 138° 05' 59"E; site CPOP18). The cave faced a dry creek, lined with *Eucalyptus microtheca* and *E. terminalis*, running through the gorge and bounded on each side by a narrow strip comprising a mix of grasses and forbs. Above this, the rocky slopes of the Range supported a low shrubland of *Acacia* spp. The bat, the only microchiropteran caught during this survey of Cravens Peak Reserve, was photographed and measured before being released at the point of capture. Data recorded were: forearm length 66.0mm, tibia length 27.5mm, ear length 17.8mm and weight 20.9g. A description of the colour of pelage and skin was not taken (but see Figure 9, page 217). The presence of a bare triangular area on the throat, not deep enough to be termed a 'pouch', was noted. The individual had finished breeding, as judged by the regressed state of the teats, and was very docile in the hand, in contrast to *Taphozous georgianus* previously handled at a similar time of year in Boodjamulla National Park in Queensland's Gulf Country (IG pers. obs.)

The body measurements taken overlapped with those documented for *T. georgianus* and *T. hilli* and so did not allow the individual to be assigned with any confidence to either species (Churchill 1998, Reardon and Kitchener 2008). Regrettably, diagnostic measures of intercanine width, length of upper canines, and presence/absence of a small anterobasal cusp on the canine that would allow separation of *T. hilli* from *T. georgianus* (Kitchener 1980) were not taken in the field and cannot be made without a specimen. Kitchener (1980) indicates that females of *T. georgianus* lack a naked gular area, a feature that Churchill (1998) states is present in female *T. hilli*. Although this suggests the individual from Painted Gorge was *T. hilli*, Terry Reardon of the South Australian Museum (pers. comm.) advised that it may be necessary to observe "a lot more individuals throughout the season to be certain whether this character holds".

Williams and Dickman (2004) document *T. hilli* from Painted Gorge, with their identification based on animals captured in a cave roost and ultrasonic call recordings made in 2000. Until then, no *Taphozous* species had been recorded from this part of Queensland (e.g. see Churchill 1998). Reardon and Kitchener (2008) show Painted Gorge as an outlying population of *T. hilli*. Clearly, more field work, with the collection of specimens or tissues for genetic analysis, is required from Cravens Peak Reserve and surrounding locations.

Identification and taxonomic issues relating to the herpetofauna

Some of the herpetofauna recorded during this survey was not identified to species level due either to potential confusion with similar looking species or because of a lack of taxonomic clarity. Below we highlight examples arising from our survey and make recommendations for future workers.

Cyclorana species

Currently eleven species of *Cyclorana* are recognised from Queensland. Three species were recorded during our survey at Cravens Peak Reserve: *C. cultripes*, *C.* cf. *maini* and *C. platycephala*. *Cyclorana cultripes* and *C. maini* belong to a group of species within the genus referred to here as the 'collared frogs' due to the presence of a broad, pale, post-ocular bar in the majority of individuals of most species in the group. The taxonomy and identification of collared frogs is problematic, so it is important to provide some context to the identification of collared frogs at Cravens Peak Reserve.

The taxonomy of collared frogs is reviewed by Tyler and Martin (1977), who describe several new species, including *C. maini*, and redefine *C. cultripes*. These authors show the distribution of *C. cultripes* as being eastern Northern Territory and southwest Queensland, and refer to material from the Queensland localities of Durham Downs and Dynevor Downs (no coordinates provided but, as an approximation, the Gazetteer gives the locations as 27° 05'S, 141° 54'E and 28° 06'S, 144° 21'E respectively). The distribution of *C. maini* is given as central and western Northern Territory and Western Australia. However, Tyler and Martin (1977) were not "able to give a definitive account of variation" in *C. maini*, and there has been no redefinition of *C. maini* since. The diagnostic characters separating *C. cultripes* from *C. maini* are the lack of a dark lateral head stripe in the former and differences in mating call parameters, in particular call duration and dominant frequency. For *C. maini* v. *C. cultripes*, these measures are 814msec v. 221msec, and 1922Hz v. 1879Hz.

Identification keys in subsequent field guides to frogs have relied on the presence of a dark lateral head stripe and/or the degree of rugosity of the dorsum (Tyler and Davies 1986, Barker et al. 1995, Cogger 1996) or on the assumption of allopatric distributions for differentiating between these two species (Tyler et al. 2000). Distributional information provided by Tyler and Martin (1977) and the field guides listed above suggests that *C. cultripes* and *C. maini* are allopatric, although Tyler and Davies (1986, Figure 12) show the two species occurring in very close proximity in the Barrow Creek district, Northern Territory (Gazetteer location: 21° 31'S, 133° 53'E). However, the Queensland Museum has a specimen of *C. maini* from Davenport Downs (24° 20'S, 140° 30'E) and specimens identified as *C.* cf. *maini* from Longreach (23° 21'S, 144° 10'E) and near Aramac (22° 07'S, 145° 12'E), suggesting that assumptions of allopatry may not be warranted.

During our survey at Cravens Peak Reserve collared frogs were observed to exhibit considerable variation with respect to the state of the lateral head stripe and degree of rugosity of the dorsum (see Figure 10, page 218). However, the typical appearance consisted of a rather drab colour pattern, with a dull lateral head stripe, and dorsum with a series of small tubercles, occasionally forming poorly defined ridges. Due to this variation we were not confident in assigning identification to species level. On 28 March 2007, HH recorded and collected a calling male *C. cultripes* (QM J85394; site CPOP03; Table 1, page 203), identified on the basis of morphology (colouration drab, lateral head stripe poorly defined, dorsum with scattered low rounded tubercles) and call (call duration 218 msec at wet bulb temperature of 25.9ºC; dominant frequency not determined as the fundamental frequency and third and fourth harmonics were of a similar intensity, E. Meyer pers. comm.). A few other individuals of *C. cultripes* were calling at this site, within a chorus of *Notaden nichollsi*, *Neobatrachus sudelli* and a few *C. platycephala*. Later that same evening, at a nearby wetland (site CPOP02; Table 1, page 203), two individuals of a second species of collared frog were heard calling briefly, amongst a chorus of *Notaden nichollsi* and *Neobatrachus sudelli* but no other *Cyclorana* species. Two distant calls were recorded but, despite searching, the animals responsible could not be located. These calls were significantly longer in duration (estimated to be 500msec and 750msec) than those of the *C. cultripes* described above and were higher pitched. Although they were shorter in duration than those reported for *C. maini* (Tyler and Martin 1977) we have identified these individuals as *C.* cf. *maini*.

These observations clearly support the presence of at least two species of collared frogs at Cravens Peak Reserve. A number of voucher specimens were collected and lodged with the Queensland Museum. We removed tissue samples for DNA analysis from most of these specimens and lodged these with the South Australian Museum, where research on the taxonomy of Australian-Papuan hylids, including genetic analyses, is currently under way. Until the results of these analyses are available, we have opted to identify the non-calling collared frogs observed at Cravens Peak Reserve as '*Cyclorana* sp. (*cultripes* or *maini*)'. Future field work in this region should target collection of this taxonomically difficult group, including the retention of tissue samples for genetic studies, and where possible record male advertisement calls (with accompanying temperature data).

Figure 9. *Taphozous* sp. (possibly *T. hilli*) from a cave roost at opportunistic survey site CPOP18, Painted Gorge, Cravens Peak Reserve, on 7 April 2007. (Photo: Kevin White).

Neobatrachus species

The literature on *Neobatrachus* taxonomy is confused (D. Roberts pers. comm.) and records of *Neobatrachus* from western Queensland have in the past been assigned variously to *N. sudelli* or *N. centralis*. For example, Cogger (1996) shows a photograph identified as *N. sudelli* from Sandringham Station, while Predavec and Dickman (1993) applied the name *N. centralis* to animals from nearby Ethabuka Station. Keys in field guides (e.g. Barker et al. 1995, Cogger 1996) rely on dorsal skin texture, colour of metatarsal tubercle, dorsal background colour and pattern of darker colouration on the dorsum. Roberts (1978) redefines *N. pictus* and argues that *N. centralis* is a junior synonym of *N. sudelli*. Subsequent data on male call (Roberts 1997a, b) and relationships based on mitochondrial DNA (Mable & Roberts 1997) suggest there is a single taxon ranging from southeast Queensland to western Victoria and southeast South Australia, west to Western Australia and north into the Tanami Desert in the Northern Territory. This set of populations shows remarkably little variation in mitochondrial DNA (Mable & Roberts 1997) but the specimens in that clade have been variously designated in museum collections as *N. sudelli*, *N. centralis* and *N. aquilonius* (e.g. see sample details in Mable & Roberts 1997). Under this scenario *N. sudelli* is a senior synonym of *N. centralis* and *N. aquilonius* and consequently we have referred to our records of *Neobatrachus* from Cravens Peak Reserve as *N. sudelli*, pending further clarification of the taxonomy of this group.

During the survey we collected seven voucher specimens of *N. sudelli*, including two from which calls were recorded (QM J85395 and QM J85403), and lodged these with the Queensland Museum. Tissue samples for DNA analysis taken from all of these specimens were lodged with the South Australian Museum. A number of individuals from ephemeral wetlands and dune fields were photographed (Figure 11, page 219). As with *Cyclorana*, future field work in this region should target collection of this taxonomically difficult group, retaining tissue samples for genetic studies and, where possible, recording male advertisement calls and associated temperature data.

Figure 10. Morphological variation across six individuals of 'collared frogs' (genus *Cyclorana*) at Cravens Peak Reserve, March-April 2007. Advertisement calls of the individual at bottom right were recorded and analysed and, based on morphology and call parameters, we identify this animal as *C. cultripes* (voucher specimen QM J85394; South Australian Museum DNA tissue sample ABTC99830). (Top two photos: Eric Vanderduys; remaining photos: Harry Hines).

Tree-dwelling *Gehyra*

Geckoes of the genus *Gehyra* inhabiting trees, fallen timber or built structures were relatively common and found in a broad variety of habitats and landforms during this survey, with 26 individuals being recorded across 11 systematic sites, four opportunistic sites and a further two incidental locations (Appendix 1, page 228). In the field, we considered most to be *G. variegata*, although two individuals observed and photographed by EV at sites CRAV09 and CRAV10 (Table 1, page 203) on 6 April 2007 were tentatively identified as *G. purpurascens*.

The presence of both species at Cravens Peak Reserve was verified by Queensland Museum staff. Two voucher specimens (QM J85426 and QM J85427), collected on 3 April 2007 from site CRAV04 (Table 1, page 203), were identified as *G. variegata* and the images from sites CRAV09 and CRAV10 (Figure 12, page 220) were confirmed as *G. purpurascens* (P. Couper pers. comm.). However, the situation was not straightforward with respect to animals we had labelled as *G. variegata*. The Queensland Museum identified two specimens (QM J85430 and QM J85431) from site CRAV02 (Table 1, page 203) as *Gehyra* sp. because "some of the characters differed from *G. variegata*" and images taken by EV on 3 April 2007 at site CRAV04 (the site from which *G. variegata* QM J85426 and QM J85427 were collected) were identified as *G.* cf. *variegate* (P. Couper pers. comm.; Figure 13, page 221). As a consequence, in this report we treat all records of tree-dwelling geckoes as *Gehyra* sp., with the exception of the two specimen-backed records of *G. variegata* and the photographed individuals confirmed to be *G. purpurascens*.

This highlights the difficulties associated with field identification of this group of

Figure 11. *Neobatrachus sudelli* individuals from Cravens Peak Reserve, March-April 2007. (Photos: Eric Vanderduys).

geckoes (refer also to section on *Gehyra nana* above, page 212) and further underscores the need for a genetic investigation of *Gehyra* across Australia to clarify taxonomic boundaries. Additional targeted collection and DNA sampling of the tree-dwelling geckoes at Cravens Peak Reserve would make a valuable contribution to such an investigation, and would assist in determining the number of taxa present on the Reserve.

Ctenotus species

The presence of *Ctenotus piankai* at Cravens Peak Reserve (see *Notable species – new collections for Queensland*), was not recognised by us whilst conducting this field work due to confusion with *C. leae*, another skink found in association with spinifex-covered sand dunes of the Channel Country bioregion and possessing a simple pattern of stripes (Cogger 1996, Wilson 2005, Wilson and Swan 2008). Over the course of the survey, we assigned 15 skinks captured in pitfall traps from six systematic sites in the dune fields to *C. leae* after first closely examining one or two individuals on the initial day of trapping. Regrettably, no record was made of the particular site or sites from which the identified individual/s came, nor were any *C. leae* photographed or retained as voucher specimens. Only when the curator at the Queensland Museum subsequently identified a photograph of a simply-striped *Ctenotus* as *C. piankai* and a specimen as *C.* cf. *piankai* did it become apparent that both species had been present in our traps. Thus, without additional voucher specimens and in the absence of photographs or notes of individuals from designated sites, it is not possible now to assign the relevant capture records to either species. Consequently, we refer to all other records of dune-dwelling *Ctenotus* with a simple pattern of stripes as '*Ctenotus* sp. (*leae* or *piankai*)'. For this reason, *C. leae* does not appear in Appendix 1 (page 228) despite being identified during the survey.

Ctenotus leae was previously known to occur at Cravens Peak Reserve. The Queensland Museum has two specimens from Marked Tree Waterhole (23° 18'S, 138° 10'E), just east of the Toomba Range. The species has also been recorded nearby to the south at Ethabuka Station (see photographs in Cogger 1996 and Wilson 2005). Field workers undertaking future surveys of the dune fields of Queensland's Simpson Desert should be aware of the presence of these two superficially similar species, *C. leae* and *C. piankai*, and the need to differentiate them. It should be noted that *A Field Guide to Reptiles of Queensland* (Wilson 2005) does not include *C. piankai*.

This survey of Cravens Peak Reserve yielded an additional species of *Ctenotus*, although its identity remains to be confirmed. On 6 April 2007, a single *Ctenotus*, removed from a pitfall trap at site CRAV18 in tall shrubland dominated by *Acacia cyperophylla* on the stony plateau of the Toko Range (Tables 1 and 2, pages 203 and 205 respectively), was photographed by EV and released. Images of this individual (Figure 14, page 222) were identified by staff of the Queensland Museum as *C.* cf. *hebetior* (P. Couper and S. Wilson pers. comm.) and showed a clearly different morphology to that of *C. aphrodite* (? = *C. septenarius*) also captured at this site (Appendix 1, page 228). *Ctenotus hebetior* is broadly distributed across northwest, central and southwest Queensland, occupying a "wide variety of semi-arid to arid habitats, from sandy flats and duneslopes to heavy loams and rocky soils" (Wilson 2005). In light of this, its occurrence at Cravens Peak Reserve would not be surprising. Further survey work incorporating targeted collection in the rocky shrublands of the Toko Range is needed to establish the identity of the additional *Ctenotus* recorded at site CRAV18 and determine whether *Ctenotus hebetior* can

Figure 12. *Gehyra purpurascens* from either systematic site CRAV09 or CRAV10, Cravens Peak Reserve, on 6 April 2007 (Photo: Eric Vanderduys).

be added to the Reserve's list of vertebrate fauna.

Ramphotyphlops species

Five individuals of the genus *Ramphotyphlops* were captured in pitfall traps during the fauna survey. Single individuals were caught at sites CRAV03, CRAV06 and CRAV10, all in *Triodia basedowii* hummock grassland on dunes or swales (regional ecosystem 5.6.5), and two from site CRAV15 in regional ecosystem 5.3.11 (*Acacia georginae* tall shrubland on alluvium) on the lower slopes and outwash of an adjacent range (Tables 1 and 2, pages 203 and 205 respectively). This last location, 1.2km northeast of Salty Bore, was 18-34km northwest of the other three dune field sites where *Ramphotyphlops* were trapped.

The first capture during the present field work was made on 3 April 2007 at CRAV15. The individual concerned was not identified to species level but rather retained as a voucher specimen (QM J85421). On the following day, a blind snake caught at CRAV06 was examined closely by EV and identified as *Ramphotyphlops endoterus* on the basis of its geographic location, general appearance and possession of 22 midbody scale rows. This individual was subsequently released. All other *Ramphotyphlops* encountered at Cravens Peak Reserve appeared similar and so, at the time, were assumed to be the same species. Subsequently, however, herpetology staff at the Queensland Museum identified QM J85421 as *R. diversus* (P. Couper and A. Amey pers. comm.), indicating that the survey had confirmed the presence of two *Ramphotyphlops* species at Cravens Peak: *R. diversus* from CRAV15 and *R. endoterus* from CRAV06. Because none of the other *Ramphotyphlops* we captured was collected or had midbody scale rows counted, it is not possible for us to assign the three individuals involved to either taxon with confidence. For this reason, we adopt a cautious approach and refer to each of them here only as *Ramphotyphlops* sp.

Of the two species, *R. diversus* is more widespread in the state, with a distribution stretching from the western Brigalow Belt bioregion in southern inland Queensland to the Northwest Highlands and western Gulf Plains bioregions of northwest Queensland and beyond into the Northern Territory and Western Australia (Wilson 2005, Wilson and Swan 2008). The Queensland Museum has records from Morven (26° 25'S, 147° 07'E), Crawfels

Figure 13. *Gehyra* cf. *variegata* from systematic site CRAV04, Cravens Peak Reserve, on 3 April 2007 (Photo: Eric Vanderduys).

Homestead via Julia Creek (approx. 20° 40'S, 141° 45'E), Cloncurry (20° 42'S, 140° 30'E), Kajabbi (20° 02'S, 140° 02'E), Mt Isa (20° 44'S, 139° 28'E) and Doomadgee (17° 56'S, 138° 49'E). Information about habitat preferences for *R. diversus* is limited, although Wilson (2005) states the species occurs in dry tropical woodlands. By contrast, *R. endoterus* is restricted in Queensland to the sandy spinifex deserts of the Channel Country bioregion (Cogger 1996, Wilson 2005, Wilson and Swan 2008). The Queensland Museum has eight specimens collected in the early 1980s from two localities: Durrie Station via Birdsville (25° 38'S, 140° 14'E) and Eyre Creek west of Birdsville on the 'Shot Road' (25° 54'S, 138° 51'E).

In light of the above information, it is worth noting that our only confirmed record of *R. endoterus* during the present survey was from a spinifex-covered dune whereas the voucher specimen of *R. diversus* came from further north, away from the dune fields, in alluvium on the outwash from a rocky range. Due to the general similarity between these taxa, wider collection of small *Ramphotyphlops* from the area is needed to confirm whether *R. endoterus* is indeed restricted to the sand country and *R. diversus* to the rocky environments and associated run-off areas in the northern section of the Reserve.

Discussion

This survey recorded 173 terrestrial vertebrates from Cravens Peak Reserve, a total that includes one frog, one reptile and one mammal not identified to species level (*Cyclorana* cf. *maini*, *Ctenotus* cf. *hebetior* and *Taphozous* sp., possibly *T. hilli*). The presence of *Taphozous hilli* on Cravens Peak Reserve was established previously by Williams and Dickman (2004) during investigations into the ecology of insectivorous bats at Painted Gorge (our site CPOP18).

Most significantly, the current survey yielded three species of skinks not previously collected in Queensland (*Ctenotus calurus*, *C. piankai* and *Lerista desertorum*) and confirmed extensions of range within this state for two other lizards (*Ctenotus aphrodite* [? = *C. septenarius*] and *Gehyra nana*). We are aware that at least some of these species have been recorded in Queensland by Professor Chris Dickman's group (University of Sydney) during research at Cravens Peak Reserve and

Figure 14. *Ctenotus* cf. *hebetior* from systematic site CRAV18, Cravens Peak Reserve, on 6 April 2007. (Photo: Eric Vanderduys).

Ethabuka and Carlo Stations but relevant details are apparently not yet published. It is unclear whether our records of three bird species (channel-billed cuckoo, golden-backed honeyeater and pictorella mannikin) at the edge of the Simpson Desert in arid far western Queensland also represent true range extensions or simply dispersive movements to exploit temporarily available resources following the major rainfall events in this area earlier in the year. No threatened species listed under State or Commonwealth legislation were recorded during the survey, however, the conservation status of the three skinks added to Queensland's fauna list as a result of this field work will need to be determined through additional surveys and detailed assessment that includes an identification of any threats. Preliminary considerations suggest a status of least concern for these species may be appropriate based on the size of their overall distributions and extent of available habitat in Queensland and elsewhere. This survey recorded five species listed as rare under the Queensland *Nature Conservation (Wildlife) Regulation 1994* and its amendments: *Ctenotus aphrodite, C. ariadnae*, grey falcon, golden-backed (black-chinned) honeyeater and pictorella mannikin.

Despite the diversity of vertebrates we recorded, the present survey did not provide a comprehensive assessment of the faunal values of Cravens Peak Reserve. Our systematic survey was restricted to a small part of the Reserve, conducted over a short time period and employed a limited number of survey techniques. In particular, wet weather prior to the period of field work prevented vehicular access to the Reserve, thereby narrowing the available survey window and reducing the number of sites systematically sampled. Consequently we targeted only a subset of bioregional ecosystems in a relatively small proportion of the Reserve (Figure 2, page 206 and Kutt et al., this volume, Figure 2, page 241), along the access tracks between Sandhill Bore, Plum Pudding, S-Bend Gorge and Salty Bore. Furthermore, the survey was conducted over a brief period in a single season. Although the wet conditions prior to and during this work favoured the detection of fauna groups such as amphibians and waterbirds, other seasonally active or migratory species may not have been recorded. It is also possible that the small mammal fauna of the Simpson Desert, whose abundance is in part dependent upon rainfall and vegetative cover (Predavec 1994, Predavec and Dickman 1994, Dickman et al. 2001), had not yet had sufficient time to respond to the January and March 2007 rainfall events that followed a period of drought in the years prior to this survey. Letnic (2003) also notes that rainfall in the Simpson Desert exhibits high spatial variability, with the quantum of rainfall received at a particular site greatly influencing the dynamics of small mammal populations and the resulting trap success. A detailed consideration of the impact of these factors on our trapping results would require having rainfall records for our systematic sites but such information is not available. In general terms, species present at low densities, as well as those that are highly mobile, elusive or trap-shy, require a long duration, repeated sampling effort to detect. A thorough assessment of the vertebrate faunal values of Cravens Peak Reserve would therefore require a number of surveys to be conducted over several years and across a range of climatic conditions and seasons.

Inherent in any census of terrestrial vertebrates is the selection of appropriate survey methodology and effort within the logistical constraints imposed by factors such as available equipment, the time taken to set up, monitor and travel between sites, and the potential return per unit effort of particular methods. A limitation in our survey is highlighted by the relatively low diversity of mammals detected, which is related to the survey techniques and effort we employed. Firstly, we used only four pitfall traps at each systematic site and the buckets (with a depth of 39cm and diameter of 29cm) are likely to have been too shallow to retain some species. Tracks of various small mammals, suspected to include those of hopping-mice *Notomys* spp., were present at sites in the dune fields and yet such species were not captured. By contrast, previous workers investigating the vertebrate fauna of the Simpson Desert (e.g. Predavec and Dickman 1994, Dickman et al. 2001) employed pitfall traps consisting of PVC tubing with dimensions (60cm deep, 16cm diameter) that limited or prevented the escape of agile species. Moreover, these studies entailed grids of 36 such pitfall traps at each dune/swale site, a far greater trap effort than employed in our survey. Secondly, only a small amount of bat trapping was conducted, with our only records of microchiropteran fauna for the survey resulting from incidental or opportunistic observations. A more complete list of the bats of Cravens Peak Reserve would require a concerted survey effort involving an array of techniques such as harp trapping, mist-netting, trip-lining, detection of ultrasonic calls, and active searches for roost sites (e.g. see Williams and Dickman 2004).

A number of vertebrate species recorded previously from Cravens Peak Reserve was not detected by us during the current survey. A literature search yielded confirmed records of six such species, while searches of the databases of the Queensland and Australian Museums revealed that specimens of a further five vertebrate species had previously been collected from the property and lodged in the Queensland Museum (Table 3, page 224). A Queensland Museum specimen of an additional mammal species, *Acrobates pygmaeus*, identified from bone material in an owl pellet and attributed to a cave on Cravens Peak Reserve located 1km northeast of Eurithethera Soak, Toomba Range, is not included as it is considered erroneous. Although the identification is correct, the occurrence of this eastern Australian species in far western Queensland is unlikely and the record is most probably the result of a labelling error by the collector (S. Van Dyck pers. comm.). The results of the present survey together with the fauna listed in Table 3 (page 224) provide a total of at least 184 vertebrate species for Cravens Peak Reserve, consisting of eight amphibian, 46 reptile, 109 bird and 21 mammal species. Other reports in this volume and the detailed results of previous research conducted on the Reserve by Professor Chris Dickman and his group at the University of Sydney, including their as yet unpublished findings, will undoubtedly contribute additional species to this tally.

The climatic conditions leading up to and during the current field work (i.e. the significant rainfall events in January and March 2007) greatly influenced our survey results, as has been noted in studies of other arid zone areas, e.g. the Tanami Desert (Paltridge and Southgate 2001). The presence of a large amount of standing water in numerous ephemeral wetlands had attracted a diversity of wetland-associated birds and encouraged breeding by at least some of these. Such species would not be expected at Cravens Peak Reserve in dry years. Seven amphibian species were active during our survey, with all but one species heard calling. Four frog species were recorded at 11 of our 18 systematic sites, despite no precipitation occurring during the period of the systematic survey work. In a detailed study of

Table 3. Vertebrate species previously recorded from Cravens Peak Reserve but not detected during the current survey. 'Status' is as per the Queensland *Nature Conservation (Wildlife) Regulation 1994* and its amendments: 'LC' – least concern, 'V' – vulnerable. The origin of the various species records is given in the 'Source' column.

Scientific Name	Common Name	Status	Source
Amphibians			
Opisthodon spenceri	desert burrowing frog	LC	Queensland Museum database
Reptiles			
Cryptoblepharus plagiocephalus [1]		LC	Queensland Museum database
Eremiascincus richardsonii	broad-banded sand swimmer	LC	Queensland Museum database
Pseudonaja modesta	ringed brown snake	LC	Queensland Museum database
Mammals			
Dasycercus cristicauda	mulgara	V	Letnic (2003)
Sminthopsis youngsoni	lesser hairy-footed dunnart	LC	Letnic (2003)
Nyctophilus geoffroyi	lesser long-eared bat	LC	Williams and Dickman (2004)[2]
Vespadelus finlaysoni	Finlayson's cave bat	LC	Williams and Dickman (2004)[2]
Notomys alexis	spinifex hopping-mouse	LC	Letnic (2003)
Pseudomys desertor	desert mouse	LC	Letnic (2003)
Rattus villosissimus	long-haired rat	LC	Queensland Museum database

[1] As a result of the work of Horner (2007), the identity of this specimen needs to be reassessed, as *C. plagiocephalus sensu stricto* does not now occur in Queensland.
[2] Additional microbat species listed by these authors from the rocky habitats of Painted Gorge were only tentatively identified from ultrasonic sound recordings and so are not included here.

frogs over 23 months at Ethabuka Station in the Simpson Desert, Predavec and Dickman (1993) found that frogs were active on the surface only after rain and while water was present in claypans. Interestingly, Predavec and Dickman (1993) trapped *Cyclorana australis*, which we did not detect at Cravens Peak Reserve, and we trapped *Cyclorana* sp. (*cultripes* or *maini*) and *C. platycephala*, which they did not encounter. The rainfall in January 2007 would also account for the observed abundance and widespread occurrence on the property of opportunistic birds such as diamond dove, budgerigar, masked woodswallow and zebra finch, presumably due to an influx and subsequent breeding of these nomadic species.

Reptiles represented a notable component of the terrestrial vertebrate fauna of Cravens Peak Reserve. In particular, a high diversity of the skink genus *Ctenotus* was found to be present, with some species being poorly known or infrequently collected in Queensland. The current work drew attention to problems in field identification of this group of lizards, highlighting the need for caution when different species bear superficially similar patterns and when using regional or state-based identification keys (e.g. Wilson 2005) near the boundary of the area of coverage. The identity of some *Ctenotus* (e.g. *C.* cf. *hebetior*) is yet to be confirmed, indicating that further survey work and collection of voucher and genetic material is warranted. Further targeted collection of herpetofauna at Cravens Peak Reserve will aid in the clarification of the distribution and taxonomy of *Cyclorana*, *Neobatrachus*, *Gehyra* and *Ramphotyphlops* species occurring in this part of the state.

The results of this short survey have highlighted the significant biological values of Cravens Peak Reserve and provided further justification for the property's acquisition and long-term management for conservation, and should assist in directing future survey and research efforts.

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Appendix 1. Species recorded during the survey of Cravens Peak Reserve, 28 March – 7 April 2007.

'Status' is as per the Queensland *Nature Conservation (Wildlife) Regulation 1994* and its amendments: 'LC' – least concern, 'R' – rare; introduced species are denoted by 'I'. The value shown in the '%SS' column indicates the percentage of systematic survey sites from which a species was recorded (note that a score of zero in this column does not indicate absence during the survey but that a species was recorded incidentally and/or at an opportunistic site). Figures under the heading 'Incid' indicate the number of records of species made incidentally away from systematic or opportunistic survey sites. The remaining columns, '01'–'20' refer to opportunistic survey sites CPOP01-20 (see Table 1, page 203, for locality details), with presence of a species being denoted by an 'X' under a site number. Kutt et al. (this volume, Table 1, page 238) provide a more detailed analysis of the faunal assemblages at systematic survey sites.

Scientific Name	Common Name	Status	%SS	Incid	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Amphibians																								
Neobatrachus sudelli	meeowing frog	LC	6	2		X	X																	
Notaden nichollsi	desert shovelfoot	LC	28	13	X	X	X				X													
Cyclorana cultripes	grassland collared frog	LC	0				X																	
Cyclorana cf. *maini*			0			X																		
Cyclorana sp. (*cultripes* or *maini*)			28	1	X	X	X																	
Cyclorana platycephala	water holding frog	LC	6	2	X	X	X																	
Litoria caerulea	common green treefrog	LC	0						X															
Litoria rubella	ruddy treefrog	LC	0						X		X													
Reptiles																								
Diplodactylus conspicillatus	fat-tailed diplodactylus	LC	11																					
Diplodactylus tessellatus	tessellated gecko	LC	0	1																				
Gehyra nana		LC	0						X															
Gehyra purpurascens		LC	11																					
Gehyra variegata	tree dtella	LC	6																					
Gehyra cf. *variegata*			50	2	X							X							X				X	
Heteronotia binoei	Bynoe's gecko	LC	11	2	X				X			X												
Nephrurus levis	smooth knob-tailed gecko	LC	6																					
Rhynchoedura ornata	beaked gecko	LC	6																					
Strophurus ciliaris	spiny-tailed gecko	LC	22																					

Scientific Name	Common Name	Status	%SS	Incid	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Strophurus elderi	jewelled gecko	LC	6																					
Pygopus nigriceps	hooded scaly-foot	LC	6									X												
Amphibolurus gilberti	Gilbert's dragon	LC	0						X															
Ctenophorus caudicinctus	ring-tailed dragon	LC	11																X					
Ctenophorus isolepis	military dragon	LC	50	4						X					X								X	
Ctenophorus nuchalis	central netted dragon	LC	56	6																				
Diporiphora winneckei	canegrass dragon	LC	11																					
Moloch horridus	thorny devil	LC	17	5																				
Pogona vitticeps	central bearded dragon	LC	6	1																				
Varanus brevicauda	short-tailed pygmy monitor	LC	22																					
Varanus eremius	pygmy desert monitor	LC	11																					
Varanus giganteus	perentie	LC	0						X															
Varanus gilleni	pygmy mulga monitor	LC	17																					
Varanus gouldii	sand monitor	LC	6																					
Varanus panoptes	yellow-spotted monitor	LC	0	1																				
Ctenotus aphrodite		R	6																					
Ctenotus cf. *aphrodite*			0																	X				
Ctenotus ariadnae		R	44																					
Ctenotus calurus	blue-tailed ctenotus	LC	39	1																				
Ctenotus dux	narrow-lined ctenotus	LC	28																					
Ctenotus cf. *hebetior*			6																					
Ctenotus helenae		LC	56																					
Ctenotus leonhardii		LC	22																					
Ctenotus pantherinus	leopard ctenotus	LC	61																					
Ctenotus cf. *piankai*			6																					
Ctenotus pulchellus	pretty ctenotus	LC	6																					
Ctenotus regius	royal ctenotus	LC	11																					

Scientific Name	**Common Name**	**Status**	**%SS**	**Incid**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ctenotus sp. (*leae or piankai*)			33																					
Lerista aericeps		LC	11																					
Lerista desertorum		LC	6																					
Lerista labialis		LC	33	1	X							X												
Morethia ruficauda		LC	11																					
Ramphotyphlops diversus		LC	6																					
Ramphotyphlops endoterus		LC	6																					
Ramphotyphlops sp.			17																					
Antaresia stimsoni	Stimson's python	LC	0		X				X															
Suta punctata	little spotted snake	LC	17																					
Birds																								
Dromaius novaehollandiae	emu	LC	11	2				X						X	X									
Dendrocygna eytoni	plumed whistling-duck	LC	0										X			X								
Cygnus atratus	black swan	LC	0												X									
Chenonetta jubata	Australian wood duck	LC	0										X											
Malacorhynchus membranaceus	pink-eared duck	LC	0										X		X			X						
Anas gracilis	grey teal	LC	0	1									X		X			X					X	
Aythya australis	hardhead	LC	0										X		X									
Tachybaptus novaehollandiae	Australasian grebe	LC	0												X									
Poliocephalus poliocephalus	hoary-headed grebe	LC	0		X								X		X			X						
Phaps histrionica	flock bronzewing	LC	6	3																				
Ocyphaps lophotes	crested pigeon	LC	39	3	X									X									X	
Geopelia cuneata	diamond dove	LC	94	34				X	X			X			X	X		X	X	X	X			X
Geopelia striata	peaceful dove	LC	0						X															
Eurostopodus argus	spotted nightjar	LC	39	7						X	X									X				
Aegotheles cristatus	Australian owlet-nightjar	LC	6								X									X				
Apus pacificus	fork-tailed swift	LC	6																					
Phalacrocorax carbo	great cormorant	LC	0										X											

Scientific Name	Common Name	Status	%SS	Incid	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Phalacrocorax sulcirostris	little black cormorant	LC	0															X						
Ardea pacifica	white-necked heron	LC	11	1	X						X			X			X	X						X
Egretta novaehollandiae	white-faced heron	LC	11		X									X			X							X
Nycticorax caledonicus	nankeen night-heron	LC	0	1																				
Plegadis falcinellus	glossy ibis	LC	6											X	X		X						X	
Threskiornis spinicollis	straw-necked ibis	LC	0		X									X		X	X							
Platalea flavipes	yellow-billed spoonbill	LC	0		X									X			X							
Hamirostra melanosternon	black-breasted buzzard	LC	6	1															X					
Haliastur sphenurus	whistling kite	LC	11	1													X							
Milvus migrans	black kite	LC	67	10	X			X	X	X				X	X		X	X	X	X	X	X		X
Accipiter fasciatus	brown goshawk	LC	17					X			X									X				X
Accipiter cirrocephalus	collared sparrowhawk	LC	0		X																			
Circus assimilis	spotted harrier	LC	44	4										X								X		X
Circus approximans	swamp harrier	LC	0	3																				
Aquila audax	wedge-tailed eagle	LC	0	1																				
Hieraaetus morphnoides	little eagle	LC	6	6																				
Falco cenchroides	nankeen kestrel	LC	22	7	X							X	X				X						X	X
Falco berigora	brown falcon	LC	44	6				X									X	X				X		X
Falco longipennis	Australian hobby	LC	22	2	X												X		X		X			
Falco hypoleucos	grey falcon	R	6														X							X
Falco subniger	black falcon	LC	6	4																		X		
Grus rubicunda	brolga	LC	6												X									
Ardeotis australis	Australian bustard	LC	6	3				X																
Himantopus himantopus	black-winged stilt	LC	0	1			X						X		X								X	
Recurvirostra novaehollandiae	red-necked avocet	LC	0										X				X							
Charadrius australis	inland dotterel	LC	0	1																				
Elseyornis melanops	black-fronted dotterel	LC	6															X						
Erythrogonys cinctus	red-kneed dotterel	LC	0																				X	

Scientific Name	Common Name	Status	%SS	Incid	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Vanellus tricolor	banded lapwing	LC	0	2													X						X	
Vanellus miles	masked lapwing	LC	6		X												X							
Turnix velox	little button-quail	LC	61	13		X		X											X			X		
Stiltia isabella	Australian pratincole	LC	0	1													X							
Gelochelidon nilotica	gull-billed tern	LC	0	2	X																			
Chroicocephalus novaehollandiae	silver gull	LC	0	1																				
Eolophus roseicapillus	galah	LC	28	1					X		X						X			X		X	X	
Cacatua sanguinea	little corella	LC	6						X		X								X			X		
Nymphicus hollandicus	cockatiel	LC	78	1					X										X					
Melopsittacus undulatus	budgerigar	LC	100	24	X			X	X		X	X			X		X	X	X	X	X	X	X	X
Scythrops novaehollandiae	channel-billed cuckoo	LC	11	1					X															
Chalcites basalis	Horsfield's bronze-cuckoo	LC	11	2				X										X						
Cacomantis pallidus	pallid cuckoo	LC	0	1														X						
Ninox novaeseelandiae	southern boobook	LC	0	1																				
Tyto javanica	eastern barn owl	LC	0	1																X				
Todiramphus pyrrhopygius	red-backed kingfisher	LC	28	2															X					
Merops ornatus	rainbow bee-eater	LC	6						X									X				X		
Malurus leucopterus	white-winged fairy-wren	LC	11	2											X									
Malurus lamberti	variegated fairy-wren	LC	17	3														X	X					
Smicrornis brevirostris	weebill	LC	6	1																				
Acanthiza robustirostris	slaty-backed thornbill	LC	11																					
Acanthiza uropygialis	chestnut-rumped thornbill	LC	6																					
Aphelocephala nigricincta	banded whiteface	LC	0	3																				
Pardalotus rubricatus	red-browed pardalote	LC	0					X																
Certhionyx variegatus	pied honeyeater	LC	17																					
Lichenostomus virescens	singing honeyeater	LC	67	4	X			X																

Scientific Name	Common Name	Status	%SS	Incid	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Lichenostomus keartlandi	grey-headed honeyeater	LC	44																					
Lichenostomus penicillatus	white-plumed honeyeater	LC	0						X		X													
Manorina flavigula	yellow-throated miner	LC	11	1	X							X		X	X		X	X	X			X	X	
Acanthagenys rufogularis	spiny-cheeked honeyeater	LC	22	2																				
Epthianura tricolor	crimson chat	LC	50	7	X							X						X					X	X
Epthianura aurifrons	orange chat	LC	6																					
Sugomel niger	black honeyeater	LC	6	3																				
Lichmera indistincta	brown honeyeater	LC	6						X															
Melithreptus gularis laetior	golden-backed honeyeater	R	6																					
Pomatostomus superciliosus	white-browed babbler	LC	11	5																				
Cinclosoma cinnamomeum	cinnamon quail-thrush	LC	0	4																				
Psophodes occidentalis	chiming wedgebill	LC	11	4																				
Lalage sueurii	white-winged triller	LC	50	10	X					X		X		X				X	X					X
Pachycephala rufiventris	rufous whistler	LC	22																	X				
Colluricincla harmonica	grey shrike-thrush	LC	0						X											X				
Oreoica gutturalis	crested bellbird	LC	67	2																X				
Artamus leucorynchus	white-breasted woodswallow	LC	6																					
Artamus personatus	masked woodswallow	LC	83	18	X				X			X		X					X				X	X
Artamus superciliosus	white-browed woodswallow	LC	6		X													X						
Artamus cinereus	black-faced woodswallow	LC	56	6								X												X
Cracticus nigrogularis	pied butcherbird	LC	28																X					
Cracticus tibicen	Australian magpie	LC	17		X								X				X	X						
Rhipidura leucophrys	willie wagtail	LC	33	1	X													X	X					
Corvus coronoides	Australian raven	LC	11	1	X																			
Corvus bennetti	little crow	LC	22	2						X								X						
Grallina cyanoleuca	magpie-lark	LC	6	1							X			X	X		X	X	X			X	X	
Petroica goodenovii	red-capped robin	LC	11																	X				

Scientific Name	Common Name	Status	%SS	Incid	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Mirafra javanica	Horsfield's bushlark	LC	0	1								X												
Cincloramphus mathewsi	rufous songlark	LC	22	5				X				X											X	
Cincloramphus cruralis	brown songlark	LC	6	8	X			X				X											X	
Cheramoeca leucosterna	white-backed swallow	LC	22	7																				
Petrochelidon ariel	fairy martin	LC	11		X				X		X											X		
Sturnus vulgaris	common starling	I	0		X																			
Dicaeum hirundinaceum	mistletoebird	LC	11																					
Taeniopygia guttata	zebra finch	LC	100	24	X			X		X	X	X				X		X	X		X	X		X
Heteromunia pectoralis	pictorella mannikin	R	0					X																
Passer domesticus	house sparrow	I	0		X																			
Anthus novaeseelandiae	Australasian pipit	LC	6	2																				
Mammals																								
Tachyglossus aculeatus	short-beaked echidna	LC	6								X													
Ningaui ridei	wongai ningaui	LC	6																					
Sminthopsis crassicaudata	fat-tailed dunnart	LC	11																					
Sminthopsis macroura	stripe-faced dunnart	LC	17		X																			
Macropus robustus	common wallaroo	LC	0						X										X			X		
Macropus rufus	red kangaroo	LC	6	17															X					
Macropus cf. *rufus*			0						X															
Saccolaimus flaviventris	yellow-bellied sheathtail-bat	LC	6	1	X						X													
Taphozous sp.			0																			X		
Mus musculus	house mouse	I	0		X																			
Pseudomys hermannsburg–ensis	sandy inland mouse	LC	6																					
Canis lupus dingo	dingo	I	6	1															X					
Felis catus	cat	I	6																					
Sus scrofa	pig	I	6																					
Camelus dromedarius	one-humped camel	I	0	3																				

Assemblage pattern in the vertebrate fauna of Cravens Peak Reserve, far western Queensland

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Abstract This report presents the results of a short vertebrate fauna survey conducted at Cravens Peak Reserve. We investigated the pattern in the fauna assemblage, using data collected from a series of standardised trapping quadrats across a range of typical vegetation and landforms. Eighteen sites were established and surveyed over a four night – five day interval in April 2007. Standardised sampling included Elliott, cage, pitfall and funnel trapping, repeated bird counts and timed active searches (diurnal and nocturnal). Basic structural and habitat variables were also recorded for each site. A total of 2680 records representing 124 species of vertebrate fauna were recorded using standardised sampling techniques, and these comprised nine mammal species, 71 birds, 40 reptiles and four amphibians. Analysis of Similarity indicated that landform most significantly categorised the differences in composition between the sites (R=0.87). We described patterns of fauna assemblage by reference to variation in taxa richness, abundance, and diversity and species abundance across the five landforms (dune, swale, swamp, outwash-lower slope, plateau). The most apparent variation occurred between dunes sites (*Ctenophorus isolepis*, *C. nuchalis*, *Varanus brevicauda*, *V. eremius*, *Ctenotus ariadnae*, *C. calurus*, *C. dux*) and those with a sparse tree layer (*Ctenophorus caudicinctus*, *V. gilleni*, *C. regius*). Bird assemblage was more subtle with different woodland species more apparent in different timbered landform types (little button-quail and chiming wedgebill in swales; yellow-throated miner, pied butcherbird, Australian magpie in outwash-lower slope; chestnut-rumped thornbill, brown honeyeater, red-capped robin on plateaus). We recognise that the assemblage patterns we recorded might not be enduring due to the short period of our survey; however short inventory survey activities are an important adjunct to more rigorous ecological and biological research.

Introduction

The central deserts hold a special place in the Australian psyche. The red centre is the epitome of Australia's vast emptiness (though biologically the contrary is true), and this country's dire lack of water. The desert also is a great symbol of Australian folly, through searches for an incongruous inland sea (Sturt 1849), the enforced social disintegration of the desert people (Watson 1998) and as the playground for feral animals that have redesigned the fauna of Australia through tragic extinction rates (Johnson 2006). Despite this, Central Australia is a significant centre of endemism for our biota (Baverstock 1982) and has held a strong allure for scientists; from Hedley Finlayson's paralympian exploits and research (Finlayson 1935), through Eric Pianka's unmatched work on desert reptiles (Pianka 1980), to current long term monitoring represented by research that is centred in part on Cravens Peak Reserve (Dickman et al. 1999).

Long term ecological studies are the mainstay of desert research. The cyclical patterns of boom and bust of arid environments reveal themselves only over time (Dickman et al. 1999; Letnic and Dickman 2006), and these patterns are universal to global arid systems (Holmgren et al. 2006). Species respond to changes in ground cover controlled by fire, rainfall, or the two combined (Letnic and Dickman 2005; Letnic et al. 2004). There are confounding influences such as the relative patchiness of a disturbance event (Masters et al. 2003), or the effect of grazing on recovery after rainfall or burning (Letnic 2004). The competitive interactions between populations of desert mammals in response to landscape change affects the total population of species present (Haythornthwaite and Dickman 2006), and this includes the role of native and introduced predators (Johnson et al. 2007). Complex interactions between habitat, habitat preference, physiology and diet have a strong influence on reptile assemblage (Daly et al. 2007; 2008).

Cravens Peak Station was purchased by Bush Heritage Australia in 2005 with the aim of improving the conservation values and long term maintenance of the unique and endemic flora and fauna of the region. A program of destocking, fire management and feral animal control was commenced in 2006, along with existing long-term monitoring of the biota by a research team led by Professor Chris Dickman (University of Sydney). In 2006 Bush Heritage and The Royal Geographical Society of Queensland announced a joint multi-disciplinary Scientific Study, with the aim of collecting and assessing baseline data to further progress the conservation management of this significant Reserve. This report presents the results of a short systematic vertebrate fauna survey conducted at Cravens Peak Reserve, and is complementary to a second report that describes all fauna detected, including incidental records and notes on significant species (Gynther et al. this volume, Table 1, page 203). The primary purpose of this survey was to investigate the pattern in the fauna assemblage, using data collected from a series of standardised trapping quadrats across a range of typical vegetation and landforms. Participation in this expedition was also a unique opportunity to walk in the shadow of the great explorers and scientists of the Australian deserts.

Methods

Study location

Cravens Peak Reserve (23° 15'S, 138°30'E, hereafter referred to as Cravens) is situated approximately 135 km southwest of Boulia (Figure 1, page 237). The 233,000 ha reserve lies on the northern end of the Simpson Desert across the boundary of the Simpson-Strzelecki Dunefields and Channel Country bioregions. The property consists of two major land types; red sandy dune fields, sandy plains and clay pans of the Simpson Desert; and rocky gorges, escarpments, mesas and extensive gibber plains of the Toomba and Toko Ranges. Further information on Cravens Peak, its history, landscapes, management and general wildlife can be found at the Bush Heritage Australia website, www.bushheritage.org.au/our_reserves/state_queensland/reserves_cravens_peak.

Study sites and sampling

Vertebrate fauna surveys were conducted from 2nd – 6th April 2007. A total of 18 sites (Figure 1, page 237) was established and surveyed over a 4 night – 5 day interval. Sites were stratified to capture a variation of landforms and regional ecosystem types along the main access tracks, with at least two sites in each different type (Table 1, page 238). Each site was sampled using a standard quadrat that comprised a nested trap and search array. This incorporates four pitfalls arranged in a 'T' configuration (30 and 20 m of drift fence), six large (430 x 250 x 250 mm) funnel traps (two per pitfall fence "arm"), and twenty small Elliott traps and two cage traps placed in a 50 x 50 m square. All Elliott and cage traps were baited with a mix of peanut butter, oats and honey and every second Elliott trap and all cage traps had dry dog food added. All traps were checked early morning, around midday and in the afternoon.

In addition to the trapping, standard searches and observations were undertaken. Eight bird counts were conducted within a hectare centred about the Elliott trap array. These counts were theoretically instantaneous, though in practice up to ten minutes were allowed for each count. Timing of bird counts was rotated to reduce early morning (i.e. favourable condition) bias. Three active searches were conducted at each site, generally one in the morning, one around midday, and one in the afternoon. Active searches involved 20 person-minutes turning logs and rocks, raking leaf litter and grass cover, peeling bark and shuffling through undergrowth and spinifex hummocks. Active searches were restricted to the area bounded by the 50 x 50 m trap array. Two spotlight searches, each of 20 person-minutes, were conducted at each site. These were restricted to the same hectare as for the bird counts.

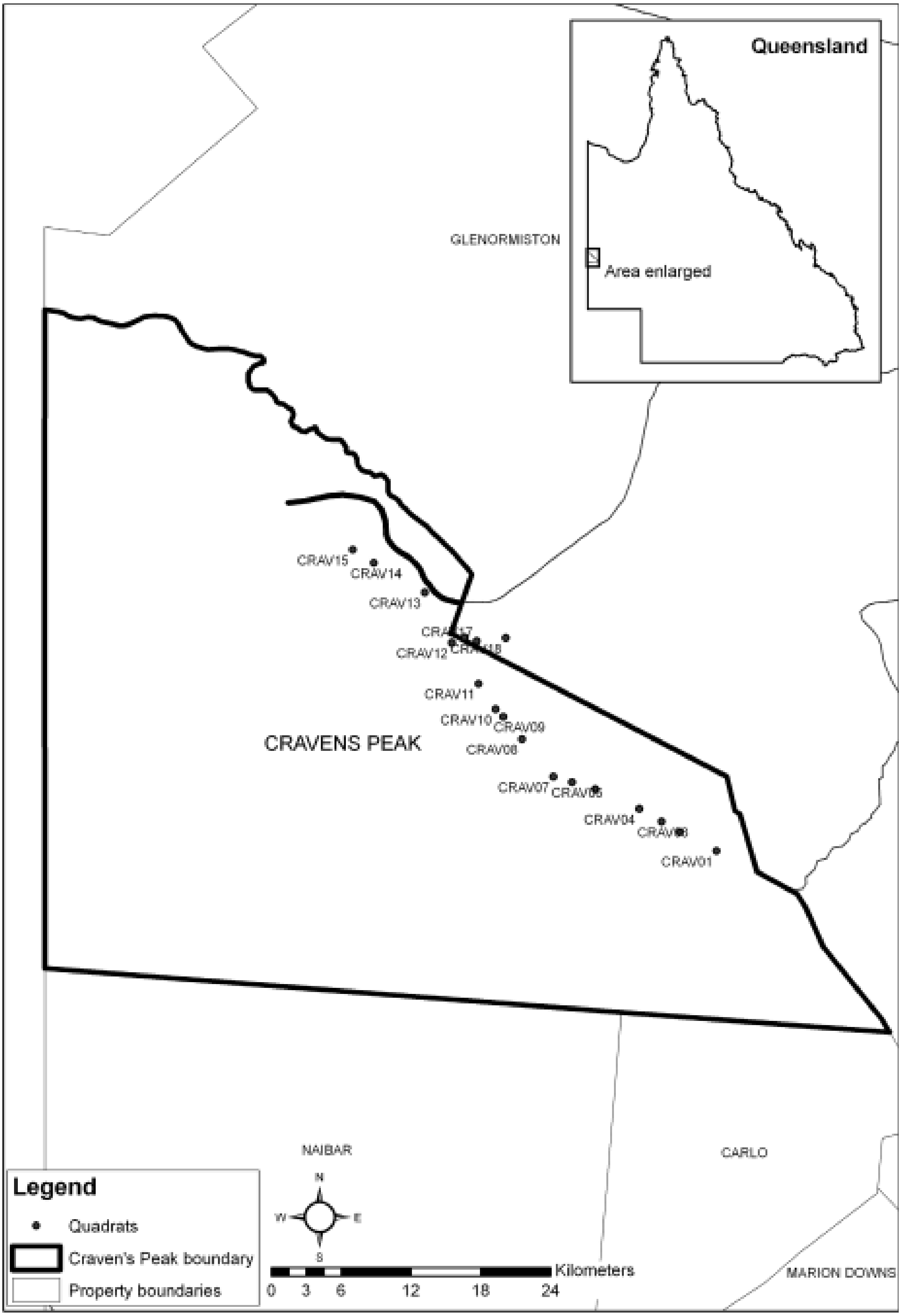

Figure 1. Cravens Peak quadrats.

Table 1. Details of standardised trap sites, their location (decimal latitude and longitude, datum WGS84), landform, landzone and regional ecosystem classification, and a general habitat description.

Site	Latitude	Longitude	Landform	Landzone	RE	Habitat
CRAV01	-23.24911	138.51543	Swale	3	5.3.11	*Acacia georginae* tall shrubland with *Senna artemisioides* subsp. *oligophylla* ± *Eremophila freelingii* on alluvium
CRAV02	-23.23438	138.4872	Dune	6	5.6.5	*Triodia basedowii* hummock grassland on sides of, or between dunes
CRAV03	-23.22646	138.47298	Dune	6	5.6.5	As for CRAV02
CRAV04	-23.21641	138.45586	Swale	3	5.3.11	As for CRAV01
CRAV05	-23.20136	138.4218	Swale	3	5.3.11	As for CRAV01
CRAV06	-23.19584	138.40396	Dune	6	5.6.5	As for CRAV02
CRAV07	-23.19172	138.38953	Dune	6	5.6.5	As for CRAV02
CRAV08	-23.16263	138.3652	Dune	6	5.6.6	*Triodia basedowii* hummock grassland wooded with *Acacia* spp., *Senna* spp., *Grevillea* spp. ± *Eucalyptus* spp. on sand plains and dune fields
CRAV09	-23.14538	138.35094	Dune	6	5.6.6	As for CRAV08
CRAV10	-23.13958	138.34505	Dune	6	5.6.5	As for CRAV02
CRAV11	-23.11994	138.33183	Dune	6	5.6.6	As for CRAV08
CRAV12	-23.08832	138.31122	Swamp	3	5.3.13/14	*Atriplex nummularia* shrubland on claypans between dunes
CRAV13	-23.04958	138.29033	Swamp	3	5.3.13/14	*Muehlenbeckia florulenta* shrublands in swamps
CRAV14	-23.02665	138.2509	Outwash-Lower slope	3	5.3.11	As for CRAV01
CRAV15	-23.01655	138.2345	Outwash-Lower slope	3	5.3.11	As for CRAV01
CRAV16	-23.0842	138.32089	Outwash-Lower slope	3	5.3.11	As for CRAV01
CRAV17	-23.08689	138.33041	Plateau	7	5.7.12	*Acacia cyperophylla* ± *A. aneura* tall shrubland on scarps and hills of low Ordovician ranges
CRAV18	-23.08472	138.35275	Plateau	7	5.7.12	As for CRAV17

Structural and habitat variables were measured following the methods outlined in Neldner et al. (2005) and Eyre et al. (2006), and sampled along the 100 m transect line that encompassed the cage and Elliott traps. Canopy crown cover for each stratum was measured along the transect using a line intercept method. Canopy height of each stratum was measured using a clinometer and measurements were taken at the 0, 50 and 100 m points of the 100 m tape and averaged. Fallen wood debris included all logs >10cm in diameter lying within a 10 x 50 m zone along the centre of the transect. Basal area was measured at the 50 m point along the transect, using a 0.25 Bitterlich gauge. The ground cover (live vegetation cover, rock cover) was visually estimated using 5 x 1 m^2 quadrats placed at the 10, 30, 50, 70 and 90 m marks of the tape. Ground cover was separated into the categories: perennial tussock grass, hummock grass, perennial herbs and forbs, annual herbs, forbs and grass, shrubs (<1m), introduced herbs, forbs and grass, litter, rock and bare ground. Site scores represent the average of the five quadrats.

In regards to vertebrate fauna, standard common names for birds follow Christidis and Boles (2008) and for other vertebrates Clayton et al. (2006). Scientific names are used for amphibians and reptiles because despite attempts to standardise common names for these taxa, workable names are largely unavailable.

Families, scientific names and, where applicable, common names are listed for all species in Appendix 1 (starting on page 248). Where identity of a particular species was not immediately obvious from experience and information in the readily available literature, a voucher specimen was collected for identification by the Queensland Museum. A number of reptiles recorded during our survey activities remain of uncertain identification despite vouchering specimens for the Queensland Museum. These are discussed in detail in Gynther et al. (this volume, page 199).

Analysis

All quadrat and incidental data were assigned a regional ecosystem type by field assessment and referral to the regional ecosystem mapping available for the region (Queensland Herbarium, Environmental Protection Agency 2003).

Analysis of Similarity (ANOSIM) was undertaken to assess the efficacy of different landscape characterisations to distinguish fauna composition (Clarke and Gorley 2006a). ANOSIM statistically compares pair-wise R values to measure similarity between groups. R is distributed around zero with zero indicating completely random grouping, while the higher the value for R the greater the separation of replicates between groups (Clarke and Gorley 2006b). We tested the composition of all fauna species, birds, and reptiles/amphibian/mammals (RAM) combined against three landscape groupings: (1) landforms (n=5), which are standard geomorphic descriptions of major landscape forms (Eyre et al. 2006); (2) landzone (n=3), a simplified geology/substrate-landform classification (Sattler and Williams 1999); and (3) regional ecosystem (n=7), vegetation types that are consistently associated with a particular combination of geology, landform and soil (Sattler and Williams 1999).

The composition of vertebrate species in the quadrats was further examined by multi-dimensional scaling (MDS) in two dimensions, derived from Bray-Curtis association (dissimilarity) indices using square-root transformed vertebrate abundance data (Clarke and Gorley 2006a).

The relationship between multivariate species assemblage pattern and environmental variables associated with those samples was examined using the BIOENV routine in Primer (Clarke and Gorley 2006a). Initially we examined the correlations between all environmental variables using draftsmen plots to define a subset of uncorrelated factors. We used a cut-off correlation of 0.4, and eight environmental factors remained (hummock grass, perennial herbs and forbs, rock, bare ground, canopy, sub-canopy, shrub and ground cover). BIOENV then examines through rank correlations and permutation tests the relationship between the environmental resemblance matrix (normalised and transformed data) and the species resemblance matrix. A search for all possible combinations is made, and the smallest subset of environmental variables that best "explain" the species data is reported (i.e. minimum set and Global R correlation).

Non-parametric (Kruskal-Wallis) one-way analysis of variance was used to examine variation in species abundance and richness, and habitat variables, across the three landforms examined. We tested variation in total species richness, abundance and Shannon-Weiner diversity for all fauna, birds and reptiles/mammals combined, and variation in individual species abundance.

Results

Species

A total of 2680 records representing 124 species of vertebrate fauna was recorded using standardised sampling techniques. These records comprised nine mammal species, 71 birds, 40 reptiles and four amphibians (Appendix 1, page 248). There is some uncertainty about the total number of reptile species recorded due to difficulties in clearly distinguishing *C. leae*, *C. piankai*, *C. aphrodite* and *C. hebetior*, and this is discussed further in Gynther et al. (this volume, page 199).

The most abundant species recorded from each vertebrate class, in decreasing order, were: frogs – 'collared frogs' *Cyclorana cultripes* or *C. maini*, desert shovelfoot *Notaden nichollsi*; birds – diamond dove *Geopelia cuneata*, budgerigar *Melopsittacus undulatus*, zebra finch *Taeniopygia guttata*, little corella *Cacatua sanguinea*, masked woodswallow *Artamus personatus*, little button-quail *Turnix velox*; mammals – stripe-faced dunnart *Sminthopsis macroura*, fat-tailed dunnart *Sminthopsis crassicaudata*, sandy inland mouse *Pseudomys hermannsburgensis*; and the reptiles *Ctenophorus isolepis*, *Ctenotus helenae*, *Gehyra* cf. *variegata*, *Ctenotus ariadnae*, *Ctenotus pantherinus* and *Ctenophorus nuchalis*.

The most frequently recorded species (that is out of eight repeat counts over 18 sites), in decreasing order, were diamond dove *Geopelia cuneata*, budgerigar *Melopsittacus undulatus*, zebra finch *Taeniopygia guttata*, masked woodswallow *Artamus personatus*, black kite *Milvus migrans*, cockatiel *Nymphicus hollandicus*, singing honeyeater *Lichenostomus virescens*, little button-quail *Turnix velox*, *Ctenotus pantherinus*, *Ctenotus helenae*, *Ctenophorus nuchalis*, *Gehyra* cf. *variegata* and *Ctenophorus isolepis*.

A number of species of conservation or other significance were recorded and these are described and discussed in Gynther et al. (this volume, page 199).

The ANOSIM indicated that all three classifications (landform, landzone and regional ecosystems) strongly categorised the variation in composition, though landform was the superior, with strong relationship with all species (0.87), birds (0.61) and reptiles, amphibians and mammals (RAM) combined (0.84) (Table 2, page 240). Examination of the two dimensional ordination for birds (stress=0.17) and RAM (stress=0.09) illustrates the separation between the species composition for the different landforms (Figure 2, page 241). For birds, the dune and swale assemblages overlap to a degree, with the other landforms loosely amalgamating as another but overlapping cluster. For the reptiles, amphibians and mammals, there is clear separation between the dune group and the remaining landforms. The correlation of the environmental factors with the ordination pattern was strong (R>0.5) for all species, birds, and the RAM; bare ground, shrub cover and ground cover being the significant factors for bird composition and hummock grass sub-canopy tree layer and ground cover for RAM.

Given landform was the landscape categorisation that best distinguished the species composition, we examined variation in taxa richness, abundance and diversity and species abundance across the five landforms (Tables 3 and 4, pages 242 and 244 respectively). Using these data (those species or groups with significant variation across landform) and variation in key habitat variables, we can describe in general terms the characteristic fauna assemblage recorded in each landform (Tables 3 and 4, pages 242 and 244 respectively).

Dune (n=8): These sites were characterised by high spinifex hummock grass cover and litter cover, and an almost complete absence of tree cover or fallen timber. The RAM abundance, species richness and diversity was high, in contrast to bird species richness and diversity which was very low. Most abundant species included *Notaden nichollsi*, grey-headed honeyeater, *Ctenotus ariadnae*, *C. calurus*, *C. dux*, *Ctenotus pantherinus* and *Ctenophorus isolepis*.

Swale (n=3): These sites were characterised by high tree cover and fallen timber, high tussock grass cover, and an absence of spinifex. Bird species richness was high and RAM low. Most abundant species in this habitat were little button-quail, crested pigeon, chiming wedgebill, *Sminthopsis macroura* and *Varanus gilleni* .

Swamp (n=2): These sites were characterised by high shrub and annual grass and forb cover. Bird species richness was the highest in this habitat and RAM richness and diversity the lowest. Most abundant species in this habitat were *Cyclorana platycephala*, white-necked heron, black kite, rainbow bee-eater, orange chat, magpie lark, Australasian pipit and brown songlark.

Outwash-Lower Slope (n=3): These sites were characterised by intermediate tree cover,

Table 2. ANOSIM testing *a priori* for three land classifications against composition of all species, birds, and reptile, amphibian and mammals combined. The BIOENV row indicates the combined environmental factors with greatest correlation with the fauna composition. Data represents the Global R statistic. Significance values: **p<0.01, ***p<0.001.

Classification	n	All Species	Birds	Reptiles, Amphibians and Mammals
Landform	5	0.87***	0.61***	0.84***
Landzone	3	0.69***	0.34**	0.82***
Regional ecosystem	7	0.69***	0.37**	0.65***
BIOENV	8	0.71*** Hummock grass, shrub and ground cover	0.58*** Bare ground, shrub and ground cover	0.66*** Hummock grass, sub-canopy tree layer and ground cover

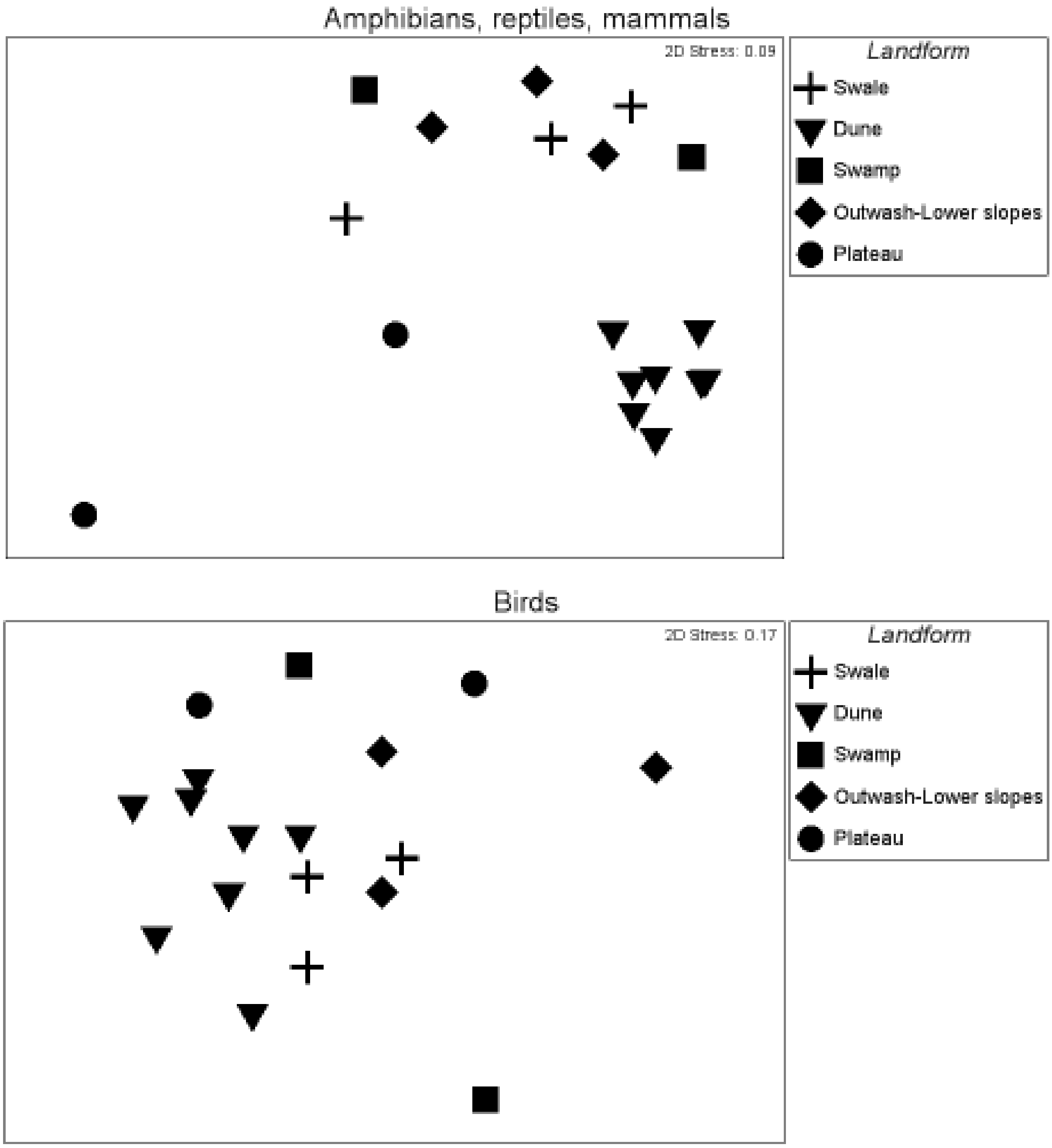

Figure 2. Fauna composition for different landforms in the Cravens Peak area.

Table 3. Mean values for habitat variables within each landform. O-LS = outwash lower-slope. Redundant measures (no significant variation) were omitted. The highest mean value for each landform type is presented in bold. Significance in variation measured by Kruskal-Wallis non-parametric ANOVA, expressed as test statistic $\mathbf{H}^p$, with superscript denoting significance values as follows: * p=<0.05, **p=<0.01.

Landform	Dune	Swale	Swamp	O-LS	Plateau	H^p
Basal area	0	**5.7**	0	4.3	5.0	15.4**
Fallen woody material	0	**6.3**	0	5.3	4.5	12.8*
Tussock grass cover (%)	0	**11.7**	0	3.3	5.0	16.5**
Hummock grass cover (%)	**29.8**	0	0	0	1.0	14.8**
Annual grass and forb cover (%)	0.6	19.7	14.5	**20.7**	3.5	13.1*
Shrub cover (%)	0	0	**16.5**	0	2.5	14.3**
Litter cover (%)	**20.1**	8.3	0	7.3	8.5	12.4*
Rock cover (%)	0	0	2.0	0	**39.0**	16.9**
Sub-canopy tree cover (%)	1.3	**8.3**	0.0	1.0	4.0	10.3*

fallen woody material and high annual grass and forb cover. Bird and RAM abundance, richness and diversity were low. Most abundant species in this habitat were black kite, yellow-throated miner, masked woodswallow, pied butcherbird, Australian magpie *Gehyra* cf. *variegata* and *Ctenotus regius*.

Plateau (n=2): These sites were characterised by intermediate tree cover, fallen woody material and very high rock cover. Bird and RAM abundance, richness and diversity were low. Most abundant species in this habitat were channel-billed cuckoo, chestnut-rumped thornbill, brown honeyeater, black honeyeater, red-capped robin, rufous whistler and *Ctenophorus caudicinctus*.

Discussion

The pattern in desert fauna assemblage will generally only manifest over many seasons, years and decades (Dickman et al. 1999; Holmgren et al. 2006). Mammal populations cycle with rainfall, ground cover and resource availability, with many species subject to pseudo-disappearances, only to irrupt when conditions are suitable (Dickman et al. 1999). Birds similarly can be driven by climate, but pattern locally due to the patch dynamics (Legge et al. 2008), or at the landscape scale due to a combination of rainfall and larger scale resource management factors such as grazing and fire (Franklin et al. 2005; Read et al. 2000; Reid and Fleming 1992; Ziembicki and Woinarski 2007). Reptiles, though sedentary, can display remarkable diversity that continues to increase over time of sampling (Thompson et al. 2007), though are similarly affected by local resource conditions (Daly et al. 2008). Despite the temporal limitations of our survey, and recognition that it is only the barest of snapshots of assemblage pattern and change, the survey indicated a remarkably strong partitioning of the vertebrate fauna according to landform. Substrate (as a corollary of landform) is recognised as a significant factor in the distribution of vertebrate species in tropical environments, and through gradients of increasing aridity (Gambold and Woinarski 1993; Woinarski et al. 1999). For comparison, variation in the composition in woodland birds is more influenced by contrasting woody vegetation density (including clearing), rather than subtle changes in soil substrate (Tassicker et al. 2006).

Our survey coincided with a period of significant preceding rainfall (Gynther et al. this volume, page 199). Birds, particularly in arid areas, are strongly associated with short and longer term climatic conditions, and can be locally nomadic, sedentary and irruptive or subject to landscape scale variation in patterns (i.e. presence or breeding) (Burbidge and Fuller 2007; Roshier et al. 2008; Shephard et al. 2005). In this survey, we noted high abundances of little button-quail, diamond dove, budgerigar, zebra finch and little corella; granivorous birds that migrate or irrupt due to rainfall and flushes of annual seed sources (Burbidge and Fuller 2007; Franklin et al. 2005; Zann et al. 1995). Congregations of tens to hundreds of diamond doves were particularly notable in the *Acacia* wooded swales where they were breeding, but they were prevalent everywhere. Similarly there were large numbers of masked woodswallows, an insectivorous and predator-vigilant species associated with large mixed feeding flocks (Davis and Recher 2002).

With respect to bird assemblage across the landform, swamp areas were the most species rich and abundant, a typical pattern where birds congregate around water sources in arid areas, either to breed, utilise the water for drinking (granivores) or feed on ephemeral aquatic insects or annual herb and forb seed (Burbidge and Fuller 2007). These included aquatic species (white-necked heron), raptors (black kite), species typical of open ground (Australasian pipit, brown songlark) and specialist species associated with blue bush (orange chat). Where there was increased tree cover (outwash-lower slopes, plateau), there was a concomitant increase in typical woodland bird species (Tassicker et al. 2006) such as pied butcherbird, Australian magpie, rufous whistler, yellow-throated miner and brown honeyeater. The plateau was preferred habitat for two species commonly associated with dense timber and bare ground cover: red-capped robin and chestnut-rumped thornbill. The swales, also a habitat with high timber cover, differed from the other wooded habitats possibly due to their location between the dunes. Chiming wedgebills and little button-quail were abundant there. The dunes and swales were generally species poor, possibly associated with the lack of tree cover which normally is strongly correlated with bird diversity (Recher 1969). Grey-headed honeyeaters were most abundant, associated with the sparse, flowering eucalypts present.

The unique global diversity of reptiles of the Australian deserts has been well documented (Pianka 1969a; b; 1980). The exact mechanisms of this diversity have been well studied and debated (James and Shine 1988; James 1996; James and Shine 2000), though it is agreed that a combination of large habitat area (isolation and homogeneity), the relationship to food resources (high termite diversity) and habitat are the key determinants (Haydon et al. 2000; Pianka 1981). More recently examination of field and experimental interactions between species of agamid lizards indicates that co-varying and diverging niche factors such as habitat, diet and thermal tolerance control species abundance and assemblage (Daly et al. 2007; 2008). In our study we identified a strong relationship between reptile species richness and diversity and habitat type, with highest species richness occurring on the dunes, in keeping with previously published data for Australian deserts (Pianka 1981). There was also clear difference in species assemblage among landforms, driven partly by clear separation between congenerics between habitat types: *Ctenophorus isolepis* and *C. nuchalis* in dunes, *C. Caudicinctus* on the plateaus; *Varanus brevicauda* and *V. eremius* on dunes and *V. gilleni* in swales and outwash-lower slopes (James 1996); *Ctenotus ariadnae*, *C. calurus*, *C. dux* on dunes and *Ctenotus aphrodite* and *C. regius* on plateaus. However we recognise that in species rich reptile communities, it often takes long term sampling to gain a full understanding of the total reptile assemblage present (Thompson et al. 2007). The location of a new reptile for the fauna list of Queensland during the survey is evidence of this (Gynther et al. this volume, page 206).

The mammals and amphibians were the least abundant and species rich of the fauna taxa that we sampled. This is unsurprising as both groups are most subject to the vagaries of climatic variability, and undergo cyclical irruption or breeding events (Cartledge et al. 2006; Dickman et al. 1999). Only four species of native small mammal were recorded from a much larger suite of rodents and dasyurids recorded from the region (Dickman et al. 1999; Glen and Dickman 2005; Haythornthwaite and Dickman 2006) and only one in sufficient numbers to identify variation in abundance across habitats (*Sminthopsis macroura* in swales and swamps). However *Sminthopsis macroura* is expected to range widely across all habitats we sampled. Similarly the habitats where the most abundant amphibians were recorded (*Notaden nichollsi* on dunes, *Cyclorana platycephala* in swamps) conform to expected patterns of habitat preference for these species. *Notaden* burrow deeply in soft sands in intervening dry periods (Cartledge et al. 2006) and *Cyclorana* are associated with heavy clay soil waterholes (Tracy et al. 2007).

Conclusion

In conclusion, our short foray in the arid environments of Cravens Peak Reserve allowed us to touch upon some aspects of fauna species distribution, abundance and assemblage in the desert landforms we sampled. The patterns we recorded conformed to many of those previously published, though the short duration of our survey mutes the applicability of our

Table 4. Mean abundance of species that identified significant variation between landforms. O-LS = outwash lower-slope. Redundant measures (no significant variation) were omitted. The highest mean value for each significant species or group of species is presented in bold. Differences in mean values tested with Kruskal-Wallis non-parametric ANOVA, expressed as test statistic $\mathbf{H^p}$, with superscript denoting significance values as follows: $^{<0.1}$=p<0.1, *=p<0.05, **=p<0.01. The abbreviation ns=not significant.

Species or Group	Dune	Swale	Swamp	O-LS	Ridge	H^p
Fauna abundance	129.3	261.3	242.0	111.3	64.5	ns
Fauna species richness	26.0	26.7	27.5	25.0	25.5	ns
Fauna diversity	2.5	1.9	2.2	2.5	2.7	ns
Bird abundance	87.1	232.3	222.5	86.0	44.5	ns
Bird species richness	10.0	15.7	**18.5**	12.7	11.0	10.2*
Bird diversity	1.7	1.6	1.9	2.0	1.9	ns
RAM abundance	**38.6**	20.3	13.0	19.7	11.0	12.0*
RAM species richness	**13.0**	7.0	4.0	7.3	5.5	12.8*
RAM diversity	**2.1**	1.5	1.1	1.7	1.3	10.2*
Amphibians						
Cyclorana platycephala	0	0	**1.5**	0	0	$8.0^{<0.1}$
Notaden nichollsi	**1.4**	0	0	0	0	$7.9^{<0.1}$
Birds						
white-necked heron	0	0	**2.0**	0	0	16.9**
black kite	0.4	1.3	**4.0**	**4.0**	0.5	12.8*
little button-quail	4.0	**17.7**	0	0.3	0.5	9.9*
crested pigeon	0	**2.0**	0.5	1.0	1.0	9.8*
channel-billed cuckoo	0	0	0	0	**1.0**	17.0**
rainbow bee-eater	0	0	**0.5**	0	0	$8.0^{<0.1}$
chestnut-rumped thornbill	0	0	0	0	**0.5**	$8.0^{<0.1}$
yellow-throated miner	0	0	0	**4.0**	0	10.6*
grey-headed honeyeater	**6.9**	0.7	0	0	0	$8.9^{<0.1}$
brown honeyeater	0	0	0	0	**1.5**	$8.0^{<0.1}$
black honeyeater	0	0	0	0	**1.0**	$8.0^{<0.1}$
orange chat	0	0	**2.5**	0	0	$8.0^{<0.1}$
red-capped robin	0	0	0	0	**3.0**	$8.0^{<0.1}$
chiming wedgebill	0	**2.7**	0	0	0	10.5*
rufous whistler	0	0.3	0	0.3	**1.0**	9.7*
magpie-lark	0	0	**1.5**	0	0	$8.0^{<0.1}$
white-winged triller	0.3	1.0	**5.0**	1.3	0	$8.4^{<0.1}$
white-breasted woodswallow	0	0	**7.5**	0	0	$8.0^{<0.1}$
masked woodswallow	1.8	7.3	3.5	**16.3**	10.5	9.9*
pied butcherbird	0.1	0	0	**1.0**	0.5	10.5*
Australian magpie	0	0	0	**0.7**	0.5	9.1*
Australasian pipit	0	0	**0.5**	0	0	$8.0^{<0.1}$
brown songlark	0	0	**2.5**	0	0	16.9**
Mammals						
Sminthopsis macroura	0	**0.7**	0.5	0	0	9.6*
Reptiles						
Gehyra cf. *variegata*	0.6	4.0	4.0	**6.0**	1.0	$8.0^{<0.1}$
Ctenotus ariadnae	**3.4**	0	0	0.3	0	11.7*
Ctenotus calurus	**2.0**	0	0	0	0	12.6*
Ctenotus dux	**1.4**	0	0	0	0	$8.0^{<0.1}$
Ctenotus pantherinus	**2.5**	0.7	1.0	0	0	11.9*
Ctenotus regius	0	0	0	**0.7**	0	10.6*
Ctenophorus caudicinctus	0	0	0	0	**2.0**	16.9**
Ctenophorus isolepis	**12.3**	0	0	0	0.5	14.8**
Varanus gilleni	0	**1.0**	0	0.3	0	$8.0^{<0.1}$

findings more widely. Nevertheless, there were some strong patterns in species habitat divergence and occurrence across the landforms that we believe are indicative of a more intrinsic vertebrate pattern at Cravens Peak. The most obvious of these was the division between congeneric species from sandy to hard landforms (especially *Ctenotus*, *Ctenophorus*). The patterns in the bird assemblage from dune to timbered habitats (e.g. open country species versus woodland species), we also believe to be typical of broader avifaunal assemblages. The location of a new reptile species for the fauna list of Queensland (Gynther et al. this volume, page 206) also highlights the importance of inventory survey activities as an adjunct to more rigorous ecological and biological research.

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Appendix 1. Complete site by species array for all survey quadrats, including family, scientific name, common name (if available) and total abundance for that site

Family	Scientific Name	Common Name	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
Amphibians																				
Hylidae	*Cyclorana cultripes* or *C. maini*	collared frogs			2	22								4		7		1		
Hylidae	*Cyclorana platycephala*	water holding frog													3					
Myobatrachidae	*Neobatrachus sudelli*	eastern metal-eyed frog	1																	
Myobatrachidae	*Notaden nichollsi*	desert shovelfoot			4			4	1			1	1							
Birds																				
Casuariidae	*Dromaius novaehollandiae*	emu					1				1									
Ardeidae	*Egretta novaehollandiae*	white-faced heron												2						
Ardeidae	*Ardea pacifica*	white-necked heron												3	1					
Threskiornithidae	*Plegadis falcinellus*	glossy ibis													1					
Accipitridae	*Hamirostra melanosternon*	black-breasted buzzard	1																	
Accipitridae	*Milvus migrans*	black kite	2		1	1	1		1			1		6	2	4	5	3	1	
Accipitridae	*Haliastur sphenurus*	whistling kite													1	1				
Accipitridae	*Circus assimilis*	spotted harrier		1					1				1			1	1			
Accipitridae	*Accipiter fasciatus*	brown goshawk			2													1		
Accipitridae	*Hieraaetus morphnoides*	little eagle										1								
Falconidae	*Falco berigora*	brown falcon	1			2							2	1		1	1		1	1
Falconidae	*Falco longipennis*	Australian hobby			1									1		1				
Falconidae	*Falco hypoleucos*	grey falcon										1								
Falconidae	*Falco subniger*	black falcon														1				
Falconidae	*Falco cenchroides*	nankeen kestrel												1		4	1		1	
Gruidae	*Grus rubicunda*	brolga												2						
Otididae	*Ardeotis australis*	Australian bustard												1						
Turnicidae	*Turnix velox*	little button-quail	21	9	12	4	28	1	4			3	3			1				1
Charadriidae	*Elseyornis melanops*	black-fronted dotterel													7					
Columbidae	*Phaps histrionica*	flock bronzewing													1					
Columbidae	*Ocyphaps lophotes*	crested pigeon	1			4	1								1	1		2	2	

Family	Scientific Name	Common Name	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
Columbidae	*Geopelia cuneata*	diamond dove	61	14	11	311	65	12	24	14	15	11	23	14	6		11	64	4	21
Cacatuidae	*Eolophus roseicapillus*	galah		1	5		1	2							9					
Cacatuidae	*Cacatua sanguinea*	little corella													231					
Cacatuidae	*Nymphicus hollandicus*	cockatiel	4	2	7	3	1	1	11			1		1	11	4	4	2		1
Psittacidae	*Melopsittacus undulatus*	budgerigar	24	11	34	11	11	1	4	3	8	134	21	1	18	11	3	22	6	1
Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo	1								1									
Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo																	1	1
Caprimulgidae	*Eurostopodus argus*	spotted nightjar	1					1		2	1		1	1	1					
Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar				1														
Apodidae	*Apus pacificus*	fork-tailed swift										1								
Halcyonidae	*Todiramphus pyrrhopygius*	red-backed kingfisher	1			1											2			1
Meropidae	*Merops ornatus*	rainbow bee-eater													1					
Maluridae	*Malurus lamberti*	variegated fairy-wren					3			9										4
Maluridae	*Malurus leucopterus*	white-winged fairy-wren											1		25					
Acanthizidae	*Smicrornis brevirostris*	weebill				1														
Acanthizidae	*Acanthiza uropygialis*	chestnut-rumped thornbill																	1	
Acanthizidae	*Acanthiza robustirostris*	slaty-backed thornbill				2													1	
Meliphagidae	*Acanthagenys rufogularis*	spiny-cheeked honeyeater				1				1							1		1	
Meliphagidae	*Manorina flavigula*	yellow-throated miner														11	1			
Meliphagidae	*Lichenostomus virescens*	singing honeyeater	4	1	2		3		1	6		1	1		4			3	1	2
Meliphagidae	*Lichenostomus keartlandi*	grey-headed honeyeater		2		1	1		3	13	9	24	4							
Meliphagidae	*Melithreptus gularis laetior*	golden-backed honeyeater										2								
Meliphagidae	*Lichmera indistincta*	brown honeyeater																	3	
Meliphagidae	*Sugomel niger*	black honeyeater																	2	
Meliphagidae	*Certhionyx variegatus*	pied honeyeater								1	1							1		
Meliphagidae	*Epthianura tricolor*	crimson chat	11						1		1	2		3	5		1	11		1
Meliphagidae	*Epthianura aurifrons*	orange chat													5					

Family	Scientific Name	Common Name	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
Petroicidae	*Petroica goodenovii*	red-capped robin																	6	
Pomatostomidae	*Pomatostomus superciliosus*	white-browed babbler					4											2		
Psophodidae	*Psophodes occidentalis*	chiming wedgebill	7			1														
Pachycephalidae	*Oreoica gutturalis*	crested bellbird	1		1		1	1	1	1	1	1	1					1	1	1
Pachycephalidae	*Pachycephala rufiventris*	rufous whistler				1												1	1	1
Monarchidae	*Grallina cyanoleuca*	magpie-lark													3					
Rhipiduridae	*Rhipidura leucophrys*	willie wagtail				1			1						11			1	1	1
Campephagidae	*Lalage sueurii*	white-winged triller	1			1	1		1	1				1	9			4		
Artamidae	*Artamus leucorynchus*	white-breasted woodswallow													15					
Artamidae	*Artamus personatus*	masked woodswallow				6	16		2	3	2	3	4	1	6	14	14	21	13	8
Artamidae	*Artamus superciliosus*	white-browed woodswallow															1			
Artamidae	*Artamus cinereus albiventris*	black-faced woodswallow	3			3		1	2			1	2	1			1	1		1
Artamidae	*Cracticus nigrogularis*	pied butcherbird							1							1	1	1	1	
Artamidae	*Cracticus tibicen*	Australian magpie															1	1	1	
Corvidae	*Corvus coronoides*	Australian raven													1		1			
Corvidae	*Corvus bennetti*	little crow		1		2													1	
Motacillidae	*Anthus novaeseelandiae*	Australasian pipit													1					
Estrildidae	*Taeniopygia guttata*	zebra finch	9	8	4	27	38	21	14	23	14	53	38	23	12	1	9	14	5	4
Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird				1	1													
Hirundinidae	*Cheramoeca leucosterna*	white-backed swallow		1					1		1	3								
Hirundinidae	*Petrochelidon ariel*	fairy martin													1				1	
Megaluridae	*Cincloramphus mathewsi*	rufous songlark	5		2		1											3		
Megaluridae	*Cincloramphus cruralis*	brown songlark												1	4					
Mammals																				
Tachyglossidae	*Tachyglossus aculeatus*	short-beaked echidna										1								
Dasyuridae	*Ningaui ridei*	wongai ningaui							1											
Dasyuridae	*Sminthopsis crassicaudata*	fat-tailed dunnart												1				1		
Dasyuridae	*Sminthopsis macroura*	stripe-faced dunnart				1	1							1						

Family	Scientific Name	Common Name	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
Emballonuridae	*Saccolaimus flaviventris*	yellow-bellied sheathtail bat												1						
Muridae	*Pseudomys hermannsburg-ensis*	sandy inland mouse						2												
Canidae	*Canis lupus dingo*	dingo															1			
Felidae	*Felis catus*	cat							1											
Suidae	*Sus scrofa*	pig																		1
Reptiles																				
Gekkonidae	*Diplodactylus conspicillatus*	fat-tailed diplodactylus			1						2									
Gekkonidae	*Gehyra* cf. *variegata*		7	5		3	2								8	11	6	1	2	
Gekkonidae	*Gehyra purpurascens*										1	1								
Gekkonidae	*Gehyra variegata*	tree dtella				2														
Gekkonidae	*Heteronotia binoei*	Bynoe's gecko				1													1	
Gekkonidae	*Nephrurus levis*												1							
Gekkonidae	*Rhynchoedura ornata*	beaked gecko			1															
Gekkonidae	*Strophurus ciliaris*	spiny-tailed gecko		1			1	5	1											
Gekkonidae	*Strophurus elderi*	jewelled gecko										1								
Pygopodidae	*Pygopus nigriceps*	hooded scaly-foot										1								
Scincidae	*Ctenotus aphrodite*																			1
Scincidae	*Ctenotus* sp. (*aphrodite*?)																	1	4	6
Scincidae	*Ctenotus ariadnae*			3	3				3	2	7	4	5					1		
Scincidae	*Ctenotus calurus*			2	1			1	2	3	4	3								
Scincidae	*Ctenotus* cf. *hebetior*																			1
Scincidae	*Ctenotus dux*				1			1	2		2		5							
Scincidae	*Ctenotus helenae*		2	5		3		3		6	7	1	11	6				2		
Scincidae	*Ctenotus leonhardii*		2			1										5		2		
Scincidae	*Ctenotus leae* or *C. piankai*			2	1			2		2	1		5							
Scincidae	*Ctenotus pantherinus*		1	4	1	1		1	2	3	3	4	2	2						
Scincidae	*Ctenotus* cf. *piankai*									1										
Scincidae	*Ctenotus pulchellus*		1																	
Scincidae	*Ctenotus regius*															1		1		

Family	Scientific Name	Common Name	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
Scincidae	*Lerista aericeps*							1	1											
Scincidae	*Lerista desertorum*																		1	
Scincidae	*Lerista labialis*			2	4			3	2			4						3		
Scincidae	*Morethia ruficauda*			1						1										
Agamidae	*Ctenophorus caudicinctus*	ring-tailed dragon																	3	1
Agamidae	*Ctenophorus isolepis*	military dragon		3	16			15	13	16	14	14	7						1	
Agamidae	*Ctenophorus nuchalis*	central netted dragon	4		1				2			1	2	1		1	6	3	1	
Agamidae	*Diporiphora winneckei*							1	2											
Agamidae	*Moloch horridus*	thorny devil			1				1	1										
Agamidae	*Pogona vitticeps*	western bearded dragon						1												
Varanidae	*Varanus brevicauda*	short-tailed pygmy monitor		1				1		1		1								
Varanidae	*Varanus eremius*	rusty desert monitor						1												
Varanidae	*Varanus gilleni*	pygmy mulga monitor	1			2												1		
Varanidae	*Varanus gouldii*	sand monitor						1												
Typhlopidae	*Ramphotyphlops diversus*																1			
Typhlopidae	*Ramphotyphlops diversus* or *R. endoterus*				1							1					1			
Typhlopidae	*Ramphotyphlops endoterus*							1												
Elapidae	*Suta punctata*	little spotted snake				2							1			2				

Baseline Studies of the Beetles (Insecta: Coleoptera) of the Cravens Peak Station Area

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Abstract One hundred and twenty four beetle taxa were identified from nine families and small numbers of specimens from a further twenty two families were taken in this exploratory study. Notes are given on the distribution, habitat preferences and behaviour of the species, where known.

Introduction

The Cravens Peak Station area in western Queensland is largely unrepresented in the Australian National Insect Collection (ANIC). The objective of this study was to collect beetles from a range of locations and habitats across the property to establish some baseline information on beetle fauna occurring in the region. Especially considering the preceding years of drought, some extensive fire events on the property, recent destocking and the rainfall events just prior to collection in 2007 it was also intended that this collection event would result in informative starting point data for the Bush Heritage Trust in their management of Cravens Peak Station.

Methods

Field work was carried out by C. Lemann in conjunction with Dr. B. Richardson (collecting spiders) and M. Glover and E. Edwards (collecting Lepidoptera). A variety of collecting methods were used to collect beetles, with varying degrees of success. Details of collection sites and methods used at each site can be found in Table 1 (starting on page 254).

Flight intercept traps (Malaise traps with collection bottles at the top and collecting trays at the bottom of the intercept netting, Figure 1, page 256) were set up for three days at two sites accessible from each of the base camps. Insects in the top collecting bottle were killed in absolute ethanol and those at ground level in propylene glycol as ethanol would have evaporated too quickly during the hot days.

A range of hand collecting techniques were used to sample vegetation for beetles during the day. These included: beating (using a stick to beat vegetation and dislodge insects into a collecting net held below); bark peeling; collecting bush litter, spreading it on a white sheet and searching through this for beetles; digging up Spinifex and spreading it on a white sheet to find beetles; and sweeping grasses and herbs with a long handled insect net to dislodge insects.

Light sheet collecting was achieved by attracting insects to, and selecting beetles from, a white sheet hung next to a single suspended 160 watt blended mercury vapour lamp run by a generator (Figure 2, page 256). This wattage bulb was chosen in an attempt to reduce the influx of seasonally (post rain) prolific bugs, midges and crickets which overcrowded and disturbed the collecting sheet making beetle selection from the sheet difficult. The light was run from 7:00pm (dusk) and finished around 10:00pm because of the fall off in numbers of new beetle taxa coming to the light and the vast build up of non target insects. In an attempt to minimise wind disruption of the collecting sheet, light collecting was restricted to wind sheltered areas as much as possible, such as creek lines, dense vegetation and dune swales. Sites selected for light collecting were at distances as far as practical from each base camp in an attempt to sample areas less affected by the previous vegetation damage from the stock grazing pressure associated with the bores near which base camps were located. Beetles collected from the light sheet were killed and preserved in absolute ethanol to ensure best possible preservation for potential DNA analysis.

Beetle specimens not needed by other researchers were also obtained as opportunities arose. We received beetles from: D. Black, collected in pitfall traps (open test tubes of

Table 1: Location and description of beetle collection sites on Cravens Peak station and collection methods used at each site, April 2007.

Site No.	Beetle Collection Dates, Site Locations and Site descriptions	Collection Methods
1	9 Apr 2007, 13km W of Longreach. 23°19'51"S 144°9'11"E. Mitchell grass & *Acacia* sp. plain.	Beating
2	10-14 Apr 2007, Cravens Peak Station, rocky valley ENE of Salty Bore. 23°1'13"S 138°13'39"E. A rocky drainage line with *Acacia georginae*, *Eremophila* spp.	Malaise trap, Beating, Light sheet
3	11-14 Apr 2007, Cravens Peak Station, billabong W of Salty Bore. 23°1'22"S 138°13'18"E. *Eucalyptus coolabah*, and herbs and grasses beside billabong.	Malaise trap & trough, Beating
4	11-14 Apr 2007, Cravens Peak Station, Salty Bore camp site. 23°1'22"S 138°13'29"E. Camp site lights, near bore and cattle yards.	At light
5	11-12 Apr 2007, Cravens Peak Station, 2km SW of Salty Bore. 23°2'12"S 138°12'44"E. Dry creek bed with *Acacia georginae*, *A. cyperophylla*, *Eremophila* spp.	Light sheet, Beating
6	12 Apr 2007, Cravens Peak Station, 1km NE of Salty Bore. 23°0'50"S 138°13'57"E. Open plain with *Acacia georginae*, grasses & herbs.	Beating
7	12-13 Apr 2007, Cravens Peak Station, 0.5km S of Salty Bore. 23°1'40"S 138°13'37"E. Dry creek bed with *Acacia georginae*, *Eremophila* spp.	Light sheet, Beating
8	13 Apr 2007, Cravens Peak Station, 1.5km SW of Salty Bore. 23°2'0"S 138°13'0"E. Dry creek bed with *Acacia georginae*, *A. cyperophylla*,*Eremophila* spp.	Light sheet
9	14-17 Apr 2007, Cravens Peak Station, below S-Bend Camp site, Toko Range. 23°3'57"S 138°21'6"E. Between waters edge *Eucalyptus coolabah*, *E. camaldulensis* and rock face.	Malaise trap & trough
10	14, 16 Apr 2007, Cravens Peak Station, near Mulligan River, below S-Bend camp. 23°3'50"S 138°21'20"E. *Eucalyptus camaldulensis*, *Acacia georginae*, *A. cyperophylla*, *Eremophila* spp., grasses, numerous herbs.	Light sheet, Beating
11	15 Apr 2007, Cravens Peak Station, S-Bend Camp site, Toko Range. 23°3'51"S 138°21'6"E. Camp site lights, rocky hill top.	At light
12	15-17 Apr 2007, Cravens Peak Station, 13km from S-Bend camp on Plum Pudding track. 23°6'34"S 138°19'26"E. East side of 1st dune swale with *Acacia georginae*, *Eucalyptus pachyphylla*, *Triodia* sp., grasses, herbs.	Malaise trap & trough, Beating
13	15 Apr 2007, Cravens Peak Station, 11km from S-Bend Camp on Plum Pudding track. 23°5'33"S 138°18'50"E. Dune swale with *Acacia georginae*, *Eucalyptus pachyphylla*, *Triodia* sp., grasses, herbs.	Light sheet
14	16 Apr 2007, Cravens Peak Station, end of dunes, 8km W of S-Bend Camp. 23°4'61"S 138°18'27"E. Level sand area east side of dunes with *Corymbia terminalis*, *Atalaya hemiglauca*, *Senna artemisioides*, *Eremophila* spp., *Zygochloa paradoxa*, other grasses and herbs.	Light sheet
15	17-21 Apr 2007, Cravens Peak Station, N side of track, 4km SE of 12 Mile Bore. 23°11'1"S 138°11'15"E. Green depression. *Corymbia terminalis*, *Senna artemisioides*, *Acacia georginae*, *Eremophila* spp., *Hakea eyreana*, grasses, herbs.	Malaise trap & trough, Beating
16	17 Apr 2007, Cravens Peak Station, S side of track, 4km SE of 12 Mile Bore. 23°11'3"S 138°11'17"E. Green depression. *Corymbia terminalis*, *Senna artemisioides*, *Acacia georginae*, *Eremophila* spp., *Hakea eyreana*, grasses, herbs.	Light sheet
17	17-19 Apr 2007, Cravens Peak Station, 12 Mile Bore camp site. 23°9'34"S 138°9'21"E. Open plain with *Acacia georginae*, grasses & herbs.	Pitfall, at light
18	18-21 Apr 2007, Cravens Peak Station, 11km NNE of 12 Mile Bore. 23°4'0"S 138°11'32"E. Edge of Nardoo swamp with *Marsilea drummondii*, *Acacia* spp, *Eremophila* spp., and grasses.	Malaise trap & trough, Beating, Pitfall
19	18, 20 Apr 2007, Cravens Peak Station, Gap Hole. 23°14'51"S 138°5'51"E. Dry creek bed running through gap in Toomba Range. Very mixed vegetation with *Eucalyptus camaldulensis*, *Senna artemisioides*, *Acacia georginae*, *Eremophila* spp., *Hakea eyreana*, *Grevillea striata*, numerous grasses and herbs.	Light sheet, Beating
20	19 Apr 2007, Cravens Peak Station, 4.5km NNE 12 of Mile Bore. 23°7'5"S 138°10'14"E. Sandhill and swale. *Eucalyptus pachyphylla*, *Calandrinia balonensis*, *Triodia* sp. sparse grasses, herbs.	At light

Continues on following page

Table 1 continued from previous page

Site No.	Beetle Collection Dates, Site Locations and Site descriptions	Collection Methods
21	20 Apr 2007, Cravens Peak Station, 8km SW 12 of Mile Bore. 23°13'6"S 138°6'16"E. Open plain with *Acacia georginae*, grasses & herbs.	Beating
22	20 Apr 2007, Cravens Peak Station, The Duck Pond. 23°16'25"S 138°4'26"E. Bore filled waterhole.	Water sweep, Beating
23	14-17 Apr 2007, Cravens Peak Station, near 12 Mile Bore. 23°13'30"S 138°15'12"E. Open plain with *Acacia georginae*, grasses & herbs.	Pitfall
24	20 Apr 2007, Cravens Peak Station, W of Gap Hole. 23°14'50"S 138°5'51"E. Dry creek bed running through gap in Toomba Range. Very mixed vegetation with *Eucalyptus camaldulensis*, *Senna artemisioides*, *Acacia georginae*, *Eremophila* spp., *Hakea eyreana*, *Grevillea striata*, numerous grasses and herbs.	Light sheet
25	21-24 Apr 2007, Cravens Peak Station, 3.2km NW of homestead on Plum Pudding track. 23°19'0"S 138°33'47"E. Open plain with *Acacia georginae*, grasses & herbs.	Malaise trap & trough
26	21-24 Apr 2007, Cravens Peak Station, 3.6km NW of homestead on Plum Pudding track. 23°18'46"S 138°33'45"E. Open grass plain with scattered trees, *Triodia* sp., grasses and herbs.	Malaise trap & trough
27	22 Apr 2007, Cravens Peak Station, 8km SW of homestead on Carlo Rd. 23°23'15"S 138°38'47"E. Steep eastern side of rocky ridge with *Acacia georginae*, *Eremophila* spp.	Beating
28	22 Apr 2007, Cravens Peak Station, waterhole 7km SW of homestead off Carlo Rd. 23°22'54"S 138°38'18"E. *Acacia farnesiana* at edge of waterhole.	Beating
29	22 Apr 2007, Cravens Peak Station, Homestead. 23°19'23"S 138°35'26"E. Open plain with *Acacia georginae*, grasses & herbs.	Beating
30	22 Apr 2007, Cravens Peak Station, 7km NW of homestead on Plum Pudding track. 23°17'0"S 138°32'46"E. Sandhills and moist depression. *Acacia georginae*, *Eremophila* spp. *Triodia* sp. *Marsilea* sp. grasses, herbs.	At light
31	23 Apr 2007, Cravens Peak Station, 2km N of homestead. 23°18'19"S 138°34'45"E. Sandy creekline in depression. *Corymbia terminalis*, *Acacia georginae*, *Senna artemisioides*, *Eremophila* spp., grasses, herbs.	At light
32	19 Jan - 21 Feb 2007, Cravens Peak Station, Homestead. 23°19'23"S 138°35'26"E. Open plain with *Acacia georginae*, grasses & herbs.	MV light

ethylene glycol dug into the soil at several locations around 12mile Bore); and from T. Ewart who ran a mercury vapour lamp between 19th Jan and 21st Feb near the homestead.

Specimens that were collected into absolute ethanol (hand collecting, malaise trap and light sheet) were kept refrigerated in a portable refrigerator in our vehicle and the ethanol was changed 3 times as recommended for potential DNA analysis. All samples were labelled in the field with date, collector/s, latitude and longitude (obtained by GPS) and location descriptions.

Beetle sorting and identification was carried out by T. Weir, Dr. R. Oberprieler, Dr. M. Wanat and C. Lemann in the ANIC laboratories in Canberra.

Results

The results and notes on specific taxa identified in this study are presented below in four broad categories: aquatic beetles, Adephaga: Carabidae, Scarbaeoidea and Curculionoidea.

1: Aquatic beetles

Twenty one species from three families of aquatic beetles were collected in this study. Table 2 (page 257) lists the species identified and the sites at which they were taken.

Gyrinidae: *whirligig beetles*

Dineutus (Cyclous) australis Fabricius were found in numbers in clear pools along a tributary canyon north of the Mulligan River near S-bend and taken singly at light at other sites. This species has a widespread and abundant distribution across Australia (Watts, 2002). Gyrinidae are often found in conspicuous groups on the surface of permanent or semi-permanent water bodies. Their distinctive paddle like mid and hind legs are used to propel them around rapidly on the water surface where they use their long raptorial forelegs for predatory feeding on other invertebrates.

Figure 1: Flight intercept trap set on Cravens Peak Station April 2007

Figure 2: Light sheet collection at Cravens Peak Station April 2007

Table 2. Identified aquatic beetle taxa and their collection sites on Cravens Peak Station, April 2007.

Family	Site Number																
Genus species Author	2	4	5	7	8	10	11	13	14	16	19	22	20	24	30	31	32
Dytiscidae																	
Allodessus bistrigatus (Clark)	X		X	X	X	X			X			X			X	X	
Antiporus gilberti (Clark)																X	
Cybister tripunctatus (Olivier)			X	X	X	X							X		X	X	
Eretes australis (Erichson)	X	X	X	X	X	X				X	X	X	X		X	X	X
Hydaticus consanguineus Aube						X											
Hydroglyphus grammopterus (Zimmerman)	X					X			X	X							
Hyphydrus lyratus Swartz	X		X	X	X	X			X	X	X	X				X	
Megaporus howittii (Clark)												X			X		
Platynectes nr. *ocularis/octodecimmaculatus*																X	
Hydrophilidae																	
Berosus approximans Fairmaire									X	X							X
Berosus australiae Mulsant	X									X							X
Berosus macumbensis Blackburn	X		X	X	X	X			X	X			X	X		X	X
Berosus nr. *nicholasi*																	X
Berosus nr. *vijae*						X									X		X
Berosus nutans Macleay	X					X				X		X			X	X	X
Berosus pulchellus Macleay			X													X	
Enochrus (Methydrus) elongatulus (Macleay)	X					X			X	X	X				X	X	
Enochrus nr. *deserticola/maculiceps*						X											
Hydrophilus brevispina Fairmaire											X					X	X
Paracymus pygmaeus (Macleay)	X														X		
Sternolophus immarginatus d'Orchymont			X			X	X	X	X						X	X	X
Gyrinidae																	
Dineutus (Cyclous) australis Fabricius						X				X					X	X	

Flattened and streamlined bodies assist the adults to stay on the water surface, however they will also quickly dive beneath the surface when disturbed. They have divided eyes for above and below water surface vision (Watts, 2002).The fully aquatic larvae of Gyrinidae are also invertebrate predators (CSIRO n.d.1).

Dytiscidae: *predaceous water beetles*

Both the larvae and adults of Dytiscidae are predaceous and have been reported feeding on a wide variety of aquatic organisms including some small vertebrates (Lawrence & Britton, 1994). Dytiscidae in turn, have been reported in the diet of water rats (CSIRO 2004 a), turtles (Chessman, 1984), birds (Dostine & Morton, 1988) and fish. They are a diverse and commonly encountered group of aquatic beetles with smooth elongate oval bodies and distinctive oar like, enlarged and hair fringed, hind legs used for strong swimming under water (CSIRO 2004 a & n.d.2)

Nine species from nine different Dytiscidae genera were taken at light demonstrating the strong flying ability of this beetle family (Table 2, page 257).

Several species: *Allodessus bistrigatus* (Clark), *Cybister tripunctatus* (Olivier), *Eretes australis* (Erichson) and *Hyphydrus lyratus* Swartz were taken at the majority of sites (Table 2). The small *A. bistrigatus* (.5mm), the large *C. tripunctatus* (≈30mm) and the medium sized *E. australis* (≈ 15mm) are three widespread and abundant species often found in permanent and semi-permanent inland water. The genus *Eretes* is known for its exceptional dispersal ability and fast development which enables it to exploit the temporary resources of inland ephemeral water-bodies such as those associated with the rain events at Cravens Peak prior to this study (Miller, 2002).

H. lyratus and *Hydroglyphus grammopterus* (Zimmerman) (the next most common species taken) are also common inland and have generally northern Australian distribution (Watts 1978 & 2002). *Hydaticus consanguineus* Aube is also known to have a northern distribution (Watts 1978) and this single site record adds to the patchy inland records for this species in the ANIC.

Small numbers of *Megaporus howittii* (Clark) and *Antiporus gilberti* (Clark) were taken in this study. These species are both more commonly found in southern Australia (Watts, 1978), however these records fall within the northern range of specimens in the ANIC.

Current taxonomy, distribution and habit knowledge of the genus *Platynectes* is in some disarray so definite identification of the specimen was not possible. Observation of the specimen puts it near *Platynectes ocularis/ octodecimmaculatus.*

Hydrophilidae: *water scavenger beetles*

Like Dytiscidae, the Hydrophilidae are a diverse and commonly encountered group of largely aquatic beetles. While the larvae are predatory the adults of Hydrophilidae are either plant feeders or scavengers (Lawrence & Britton, 1994) as the common name suggests. Most species have swimming hairs on their hind legs, however they are poorer swimmers than Dytiscidae and generally crawl around the substrate (Gooderham & Tsyrlin, 2002). They are often found in still and slow-moving water such as bores, billabongs, remnant pools in ephemeral water-bodies and swamp areas such as those on Cravens Peak station following the rain events prior to this study. They are varied in body form with some being streamlined oval, like Dytiscidae, others, like the genus *Berosus* being more globular and some, such as *Georissus* being compact and sculptured. Adult Hydrophilidae are capable flyers and are often found in isolated water bodies and, with their larvae, are a food source for turtles (Chessman, 1984), fish and birds.

Twelve species from 5 genera were taken in this study (Table 2, page 257).

Specimens from the genus *Berosus* were the majority of Hydrophilidae taken in this study with 5 definite species and 2 “near” species being identified (Table 2). Of these *Berosus macumbensis* Blackburn and *Berosus nutans* Macleay were the most prevalent and both are readily identified, widespread inland species with *B. nutans* having a somewhat more southern distribution (Watts, 1987). *Berosus pulchellus* Macleay is noted and mapped by Watts (1987) as a tropical species with some inland records and it is most commonly found in sandy pools of drying northern rivers such as the conditions on Cravens Peak during this study. The presence of *Berosus approximans* Fairmaire adds to the few known inland records, and is at the northern end of the distribution range known for the species. Another inland gap in records is improved by the presence of *Berosus australiae* Mulsant which is know from a wide, although mostly eastern, Australian distribution (Watts, 1987). Of the two which the unidentified are near to (*Berosus* nr. *nicholasi* and *Berosus* nr. *vijae*), *Berosus vijae* Watts is a known central and northern Australian inhabitant while *Berosus nicholasi* Watts only has one other inland record in ANIC and is primarily a northern coastal species (Watts 1987).

Enochrus (Methydrus) elongatulus (Macleay) is a common and widespread species (Watts, 1998, Anderson, 1976). It was not possible to further identify the single *Enochrus* nr. *deserticola/maculiceps* specimen as there is some ambiguity in descriptions and keys for the *Enochrus deserticola* complex.

The genus *Hydrophilus* is comprised of the largest Hydrophilidae species in Australia. The large olive green *Hydrophilus brevispina* Fairmaire (up to 35mm) is a species rare in the south-east and south-west with the most widespread and comprehensively inland species distribution of the Australian *Hydrophilus* (Watts, 1988). They are sometimes taken in large numbers from drying inland pools but are generally not abundant in any one water body (Watts, 1988)

Paracymus pygmaeus (Macleay) is, again, a widespread Australian species (Gentili, 2000) and this record increases the patchy knowledge of its inland distribution.

Sternolophus immarginatus d’Orchymont is the representative of another common Hydrophilidae genus taken in this study. The genus is generally absent from the cooler, wet coastal regions of the south-west and south-east and all species occur across inland and northern Australia (Watts, 1989). These medium sized beetles (≈ 12mm) are another that can sometimes be found in hundreds in drying inland water bodies (Watts, 1989)

2: Adephaga: Carabidae

Fifty two species from fifteen sub-families of Carabidae were collected in this study. Table 3 (starting page 260) lists the species identified and the sites at which they were taken.

Carabidae: *ground beetles*

This is the dominant family of Adephaga and one of the largest families of Coleoptera. For the most part they are terrestrial throughout their lives, a fact reflected in their common name "ground beetles", although some groups have adopted a life style associated with plants in one way or another. Both adults and larvae are mostly general predators (Moore et al 1987).

Apotominae

Apotomines are small, distinctively shaped carabids about 3mm long that are somewhat hygrophilous and can be found in wet areas such as swamps and near the borders of pools, rivers and lakes, as well as flying readily to light. There are only two species in Australia and *Apotomus australis* Castelnau is our most widespread species, occurring over most of the mainland (Baehr 1990a).

Bembidiinae

Bembidiines are also small carabids, most in the size range of 2-3mm. Most, including the genera *Bembidion*, *Elaphropus* and *Pericompsus* are also somewhat hygrophilous while members of the genus *Tachys* are members of the under bark of eucalypts community (Baehr 1987a, 1990b, Erwin 1974, Toledano 2005) *Bembidion riverinae* Sloane and *Bembidion jacksoniense* Guerin-Meneville are both widespread over the Australian mainland (Toledano 2005). *Pericompsus australis* (Schaum) shows an eastern Australian distribution (Erwin 1974) while *Elaphropus spenceri* (Sloane) is widely distributed across northern Australia (Baehr 1987a). *Tachys lindi* Blackburn and *Tachys similis* Blackburn are known from a few localities in the north of the continent.

Broscinae

Broscines are medium to rather large flightless carabids with a pedunculate body form. *Adotela frenchi* Sloane is some 20mm long and was previously known from inland NT and WA.

Carabinae

These are large metallic ground beetles. The widespread *Calosoma schayeri* Erichson is broad, bright metallic green, about 25mm long and feeds on lepidopterous caterpillars. When handled, it gives off a strong musk-like odour (salicylaldehyde) (Moore 1982).

Chlaeniinae

Chlaeniines are medium sized winged species with the elytral pubescence (at least at the sides) giving a velvet-like sheen, usually with metallic tints. *Chlaenius australis* Dejean and *Chlaenius darlingensis* Castelnau are both widespread species about 15mm long with the latter seeming to prefer somewhat moister habitats than the former (Moore 1983).

Cicindelinae

Cicindelines are commonly known as tiger beetles and are agile, with slender legs, large eyes and characteristically toothed mandibles. The larvae are different from that of most other carabids in that they live in burrows, have a strange shape with head and prothorax forming a shield, and seize passing prey (Moore 1983). *Cicindela semicincta* Brulle (9-12mm) is widespread and is perhaps the commonest of all Australian tiger beetles. The slightly larger *Megacephala bostockii bostockii* (Castelnau) is also widespread, but prefers the northern half of the continent.

Harpalinae

Harpalines are a large group of carabids in which many have secondarily become largely phytophagous, consumiming seeds or other vegetable matter. They are mostly unattractive species that are difficult to identify.

Amblystomus contains the smallest species in this group at about 3mm in length. Both *A. laetus* (Blackburn) and *A. nigrinus* Csiki are known from the Murray-Darling basin and surrounding areas. The new genus and species of Anisodactylina is known from near Longreach and Camooweal and the collection at Cravens Peak extends its known range. *Gnathaphanus herbaceous* Sloane is a green beetle, about 15mm long known from Murray-Darling and Lake Eyre Basins, while *Gnathaphanus pulcher* (Dejean) is of similar size with metallic green pronotum and bronze elytra but is more widely distributed. *Gnathaphanus picipes* (Macleay) at 10mm is all black and shows a more northerly distribution. *Haplaner insulicola* Blackburn is a small black beetle

Table 3: Identified Carabidae beetles and their collection sites on Cravens Peak Station, April 2007

FAMILY																			
Subfamily	**Site Number**																		
***Genus species* Author**	**2**	**3**	**5**	**7**	**10**	**11**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**23**	**24**	**26**	**30**	**31**
CARABIDAE																			
Apotominae																			
Apotomus australis Castelnau					X			X									X		
Bembidiinae																			
Bembidion (Notaphocampa) riverinae Sloane	X			X				X										X	X
Bembidion (Sloanephila) jacksoniense Guerin-Meneville	X			X	X			X		X				X				X	X
Elaphropus spenceri (Sloane)					X														
Pericompsus (Upocompsus) australis (Schaum)					X														
Tachys lindi Blackburn					X														
Tachys similis Blackburn					X										X			X	
Broscinae																			
Adotela frenchi Sloane															X				
Carabinae																			
Calosoma schayeri Erichson	X																		
Chlaeniinae																			
Chalenius darlingensis Castelnau															X				
Chlaenius australis Dejean		X			X				X		X	X			X			X	
Cicindelinae																			
Cicindela semicincta Brulle								X											
Megacephala bostockii bostockii (Castelnau)															X			X	
Harpalinae																			
Amblystomus laetus (Blackburn)						X							X						
Amblystomus nigrinus Csiki				X								X							
Anisodactylina n.gen. n.sp																		X	
Gnathaphanus herbaceous Sloane					X	X		X				X							X
Gnathaphanus picipes (Macleay)	X						X					X							
Gnathaphanus pulcher (Dejean)	X												X						
Haplaner insulicola Blackburn								X		X		X		X					
Hypharpax assimilis Macleay	X		X							X								X	
Hypharpax kreftii (Castlenau)	X		X		X		X	X		X	X	X	X	X		X		X	X
Hypharpax queenlsandicus Csiki	X																		
Hypharpax sp.			X																
Phorticosomus gularis Sloane			X											X					
Phorticosomus randalli Blackburn																X	X	X	X
Phorticosomus sp. 1									X	X	X								
Phorticosomus sp. 2											X								
Stenolophus (Egadroma) quadrimaculatus (Macleay)													X						
Stenolophus (Egadroma) suturalis Macleay												X							
Helluoninae																			
Gigadema sp.														X					
Helluarchus whitei Lea														X					

Continues on following page

Table 3 continued from previous page

FAMILY																			
Subfamily	**Site Number**																		
***Genus species* Author**	**2**	**3**	**5**	**7**	**10**	**11**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**23**	**24**	**26**	**30**	**31**
Lebiinae																			
Anomotarus crudelis (Newman)												X							
Demetrida sp.				X	X							X							
Microlestodes macleayi (Csiki)		X																	
Oodinae																			
Oodes waterhousei Castelnau																			X
Pseudomorphinae																			
Sphallomorpha uniformis Baehr								X						X					
Pterostichinae																			
Loxandrus sp.1	X																		
Loxandrus sp.2	X							X				X						X	X
Platycaelus melliei (Montrouzier)												X			X				
Rhytisternus laevilaterus (Chaudoir)											X								
Rhytisternus limbatus Macleay							X												X
Rhytisternus miser (Chaudoir)														X				X	
Scaritinae																			
Carenum rectangulare Macleay															X				
Carenum sp.															X				
Clivina felix Sloane												X							
Clivina sp.												X							
Geoscaptus laevissimus Chaudoir	X																		X
Tetragonoderinae																			
Sarothrocrepis sp.1			X	X	X			X		X		X		X		X			
Sarothrocrepis sp.2					X				X			X							
Zuphinae																			
Zuphium sp.								X											X

about 5mm long which is known across northern Australia.

The three species of *Hypharpax* are all northern species. *H. kreftii* (Casatelnau) is 10mm long and black, while *H. assimilis* Macleay and *H. queenslandicus* Csiki are 4-6mm in length and black-brown. *Phorticosomus gularis* Sloane (17mm) and *P. randalli* Blackburn (12mm) are both known from localities in inland Australia and are some of the more predacious members of the group. *Stenolophus* are smaller harpalines with *S. quadrimaculatus* (Macleay) (4mm) and *S. suturalis* Macleay (6mm) both having yellowish spots on the elytra and exhibiting a northern distribution.

Helluoninae

This is a group of medium to large beetles, mostly elongate, flattened and rather heavily built species of which some are found under bark (*Gigadema* spp). The discovery of *Helluarchus whitei* Lea at Cravens Peak was exciting as this was previously known in the ANIC only from the Tanami and Finke River areas in NT (Moore et al 1987). This is quite distinctive black flightless beetle (30mm long) having deep elytra with a flattened area bounded by carinae on top.

Lebiinae

Lebiines are small to medium sized mostly winged carabids with truncate elytra that leave the last abdominal segment exposed (Moore 1983). Species of *Demetrida* are commonly collected under bark while *Anomotarus crudelis* (Newman) (6mm) and *Microlestodes macleayi* (Csiki) (3mm) are ground dwellers. The former is widespread across southern and inland Australia (Baehr 2005) while the latter has an even wider distribution over most of Australia (Baehr 1987b).

Oodinae

These are medium sized winged carabids with a characteristic oval form that are usually associated with damp places (Moore 1983). *Oodes waterhousei* Castelnau (14mm) appears to have an inland distribution (Moore et al 1987)

Pseudomorphinae

Pseudomorphines are very aberrant carabids with smooth, compact oval or cylindrical bodies and short retractile antennae and legs, that can move very fast (Moore 1983). They are part of the under bark carabid community (Baehr 1990b). *Sphallomorpha uniformis* Baehr (6mm) is known from widely separated inland localities across the continent from WA to Queensland (Baehr 1992).

Pterostichinae

Pterostichines are a large group of medium to large black species with prominent secateur-like mandibles of which many are flightless. They are the dominant group of carabids of the coastal wet forests from Mt Gambier to the tip of Cape York (Moore 1983). The three genera collected here represent a group of hygrophilous species with a much wider distribution, extending into the drier areas of the continent. *Loxandrus* is currently under revision. *Platycaelus melliei* (Montrouzier) (15mm) and *Rhytisternus miser* (Chaudoir) (10mm) are both widespread in Australia with the former extending to New Caledonia and the latter having been accidentally introduced to New Zealand (Moore et al 1987). *R. laevilaterus* (Chaudoir) (15mm) and *R. limbatus* Macleay (10mm) are also recorded from the Murray-Darling basin and other inland areas.

Scaritinae

Scaritines are similar to broscines in that they have a pedunculate body form, but are robust burrowing species with multidentate fore tibae (Moore 1982), ranging in size from small to large. *Carenum* and *Clivina* are the two largest genera with widespread distributions and both are in need of taxonomic revision. *Carenum rectangulare* Macleay is known from inland NT (Moore et al 1987) where it prefers sandy soils, while *Geoscaptus laevissimus* Chaudoir is a hygrophilous species found across the northern, eastern and inland parts of the continent.

Tetragonoderinae

This is a group of small to medium mostly bicoloured species similar to lebiines but with elytra not so truncate and having long tibial spurs on the hind legs. *Sarothrocrepis* is the dominant genus and is part of the under bark community (Baehr 1990b).

Zuphiinae

This group resembles lebiines in being somewhat flattened and having the elytra elongate, but *Zuphium* is more hirsute with lengthened antennae. Baehr, 1986 records only five species from Australia but also regards some of these as having subspecies as well and says that little is known of their biology except that they come to light. He postulates a northern immigration route into Australia as shown by the distribution of three species and three subspecies in tropical northern Australia, two species in the south and one in the northeast.

3: Scarabaeoidea

Thirty seven species from two families of Scarabaeoidea were collected in this study. Table 4 (page 263) lists the species identified and the sites at which they were taken.

Bolboceratidae

Adults and larvae of this widely distributed family are mainly mycetophagous with adults provisioning larvae in subterranean burrows, although several species have been recorded as feeding on finely divided humus (Cassis & Weir 1992a). *Australobolbus bihamus* Howden is one of the most widely distributed species of the genus, having been recorded from all mainland states (Howden 1992). The two larger species, *Blackburnium neocavicolle* Howden, and *Bolboleaus truncatus* (Blackburn) and the smaller *Bolbobaineus planiceps* (Macleay) also have a wide distribution, being recorded from all mainland states except Victoria (Howden 1979, 1985, 1992).

Scarabaeidae

This is by far the largest family of the Scarabaeoidea and contains well defined subfamilies as detailed below. They are commonly referred to as dung beetles, chafers or flower beetles and exhibit a biology that is varied.

Aphodiinae

Aphodiines as a group are amongst the smallest of the scarabs, with an average body length of 4-5mm, and contain both coprophagous and saprophagous species (Cassis & Weir 1992b).

Aphodius lividus (Olivier) is a cosmopolitan species accidentally introduced to Australia. It is very widespread in all states and is common in various types of dung and is attracted to

Table 4: Identified Scarabaeoidea beetles and their collection sites on Cravens Peak Station, April 2007.

FAMILY																			
Subfamily	**Site Number**																		
***Genus species* Author**	**2**	**3**	**4**	**5**	**7**	**8**	**10**	**11**	**12**	**13**	**15**	**16**	**17**	**19**	**20**	**24**	**30**	**31**	**32**
BOLBOCERATIDAE																			
Australobolbus bihamus Howden											X								
Blackburnium neocavicolle Howden			X																
Bolbobaineus planiceps (Macleay)			X						X				X						
Bolboleaus truncatus (Blackburn)			X					X			X	X							
SCARABAEIDAE																			
Aphodiinae																			
Aphodius lividus (Olivier)																			X
Aphodopsammobius australicus (Blackburn)							X							X					
Australammoecius goyderensis (Blackburn)		X			X		X					X	X	X		X			X
Dynastinae																			
Neodon glauerti Carne										X							X		
Neodon laevipennis (Blackburn)				X				X						X		X			X
Neodon pecuarius (Reiche)																			X
Xynedria interioris Blackburn		X																	
Melolonthinae																			
Colpochila deceptor Blackburn														X		X			
Colpochila longior (Blackburn)																	X		
Colpochila sp. nr. *parva/iota*															X				
Heteronyx australis Guerin-Meneville							X												
Heteronyx mimus Blackburn							X									X			
Heteronyx parvulus Macleay	X																	X	
Heteronyx pauxillus Blackburn				X		X								X					
Heteronyx transversicollis Maleay							X										X		
Heteronyx sp. nov. nr. *pellucida* Burmeister						X	X												
Heteronyx sp. nr. *advena* Blackburn										X		X				X	X		
Heteronyx sp. nr. *beltanae/frenchi*	X			X		X													
Heteronyx sp. nr. *bovilli* Blackburn														X					
Heteronyx sp. nr. *merus* Blackburn							X												
Heteronyx sp. nr. *pumilus* Sharp										X									
Heteronyx sp. nr. *punctipennis* Blackburn				X															
Heteronyx sp. nr. *squalidus* Blackburn							X												
Heteronyx sp. nr. *tepperi* Blackburn										X									
Heteronyx sp.1						X													
Heteronyx sp.2												X							
Heteronyx sp.3																	X		
Lepidiota squamulata Waterhouse										X									
Liparetrus minimus Britton										X					X		X	X	
Liparetrus sp. nr. *pallens* Lea															X				
Liparetrus sp.nr. *pallidus* Macleay														X					
Scarabaeinae																			
Onthophagus consentaneus Harold			X							X		X	X						X
Onthophagus gazella (Fabricius)	X		X		X		X					X		X	X	X	X	X	X

lights (Stebnicka & Howden 1995). *Aphodopsammobius australicus* (Blackburn) and *Australammoecius goyderensis* (Blackburn) are both widespread across northern and central Australia. Little is known about their habits except that they are attracted to light (Stebnicka & Howden 1996).

Dynastinae

Dynastines as a group are mainly black or brown and range in size from 9 to 60mm and the biology of the Australian species is not well known. Adults are usually nocturnal, associated with the soils and feed on things other than leaves, while the larvae feed on roots or decaying vegetable matter in the soil or rotten logs (Cassis & Weir 1992e).

Neodon contains 8 species of medium sized, reddish brown dynastines, of which three were taken here. *Neodon pecuarius* (Reiche) is the most widespread of these species, occurring in all mainland states, while *Neodon glauerti* Carne and *Neodon laevipennis* (Blackburn) exhibit a more northern and central distribution (Carne 1957).

Xynedria interioris Blackburn is rare in collections, having been collected only a few times in the vicinity of Alice Springs (Carne 1957). It is one of the significant finds of this survey.

Melolonthinae: *chafers*

Adults of this largest subfamily are usually reddish brown in colour, are commonly called chafers and range in length from 3 to 32mm. They are generally distributed throughout mainland Australia, although some tribes show more defined distributions. The biology of the majority of species is poorly known but indications are that the adult life is short and the larval life is long. Many adults feed on the leaves of various trees while the larvae are found in the ground and feed on roots and humus (Cassis & Weir 1992d).

Colpochila and *Liparetrus* are both speciose genera belonging to the tribe Liparetrini and occur mainly in the drier areas of the continent including open woodland, mallee, grassland and semi-desert (Britton 1986). *Colpochila deceptor* Blackburn has a wide distribution over much of inland Australia except WA, while all of the localities recorded for *Colpochila longior* (Blackburn) are in SA (Britton 1986). Both species have been taken at several of the same sites in SA and this record for *C. longior* is a northern extension of its range. *Liparetrus minimus* Britton is recorded from the interior of NT and WA (Britton 1980) and this record extends its distribution further east.

Heteronyx, in the tribe Heteronychini is the largest and most confusing of the melolonthine genera. Britton's 2000 review of the genus only dealt with the described species and he listed some 206 species from Australia, but many more await description. Of the 17 species collected at Cravens Peak, only 5 could be assigned to described species. *Heteronyx australis*, Guerin-Meneville is widespread recorded from all mainland states except Victoria while *Heteronyx mimus* Blackburn is known from inland WA and NT. Heteronyx parvulus Macleay and *Heteronyx transversicollis* Macleay are known from northern and central NT while *Heteronyx pauxillus* Blackburn is recorded from the more northern parts of WA and NT. The collection of the last 4 species at Cravens Peak represents an eastward expansion of their known range.

Lepidiota squamulata Waterhouse belongs to the tribe Melolonthini which contains a number of species considered to be pests of various crops. This species is the most widely distributed species of the genus in Australia and is recorded from much of northern Australia (Britton 1978)

Scarabaeinae: *dung beetles*

Scarabaeines are the most highly evolved of all the scarabaeid groups and feed on bacteria rich, semi-liquid foods, mainly dung. They use this material to make brood balls for the larvae which live in burrows or chambers in the ground constructed by the adults (Cassis & Weir 1992c).

Only two species from the large genus *Onthophagus* were collected during the survey. *Onthophagus consentaneus* Harold is a native species that is widely distributed across most of northern Australia including inland areas where it prefers open grassland and savannah (Matthews 1972). *Onthophagus gazella* (Fabricius) is one of the most successful of the species introduced to remove cattle dung from Australian pastures. It is widespread in northern and eastern Australia and is the dominant species in many subtropical areas.

4: Curculionoidea: weevils

Curculionoidea are an enormous group of beetles that have successfully inhabited nearly every possible terrestrial habitat. They were almost the only group of beetles that were taken by beating vegetation during this study and even then in surprisingly low numbers. Some individuals were also collected at light and in the malaise and pitfall traps. Identification to genus (all time permitted) was carried out by Dr R. Oberprieler (ANIC), with the following notes on some genera resulting from personal communication with him. Table 5 (page 265) lists the fourteen genera of Curculionoidea taken during this study.

Belidae: *belid weevils*

Belids are a relict group of primitive weevils (characterised by having straight, not elbowed, antennae) that is most diverse in Australia. They mostly have an elongate rostrum like typical weevils. Both adults and larvae are plant feeders, the larvae boring in stems of mainly acacias. Only a single specimen of *Rhinotia* sp. was taken, by beating vegetation along the creek line and base of rock walls at Gap Hole.

Brentidae: *straight-snouted weevils*

Brentidae are another relatively primitive weevil family, distinguished from the true weevils by their straight antennae. They also tend to have a narrow rostrum and many in the family are small, such as the Apioninae, which are usually dark, shiny and somewhat globular in shape. Most Australian species are still classified in the genus *Apion*, but their classification is currently under review and several new species are being described (M. Wanat, pers. com.). The widespread *Apion philanthum* Lea was taken in this study.

The other genus of Brentidae taken was *Austronanodes*, which belongs in the subfamily Nanophyinae and comprises five species in Australia. These weevils are associated with moist environments (Hawking et.al. 2006) as their larvae develop on aquatic ferns.

Curculionidae: *true weevils*

The true weevils made up the majority of Curculionoidea taken in this study (Table 5), and many species have very specific plant associations, of which only a small portion are fully understood. Genera of several subfamilies are represented among the material collected during the study.

Table 5: Identified Curculionoidea and their collection sites on Cravens Peak Station, April 2007.

SUPERFAMILY																											
Family	**Site Number**																										
***Genus species* Author**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**23**	**24**	**25**	**26**	**27**	**28**	**30**	**31**	**32**
CURCULIONOIDEA																											
Belidae																											
Rhinotia sp.																	X										
Brentidae																											
Apion gestroi sp. group				X				X					X		X												
Apion philanthum Lea		X																									
Austronanodes sp.																									X		X
Curculionidae																											
Basedowia basicollis Lea										X						X						X					
Echinocnemus sp.				X			X					X		X		X	X	X							X		
Hackeria sp.						X		X									X						X				
Leptopius sp.													X						X								
Lixus sp.							X																				
Melanterius sp.														X													
Myllocerus spp.	X	X	X	X		X		X	X	X	X		X		X		X	X		X	X	X	X		X	X	X
Steriphus sp.				X			X	X	X		X			X	X	X	X	X		X					X	X	X
Oxyops sp.		X								X	X						X								X		X
Ophryota sp.					X	X																					
Tychiini indet.		X											X			X								X			

Echinocnemus, a large but poorly studied genus of the primitive subfamily Erirhininae, is associated with moist environments, being semi-aquatic and its larvae (as far as known) living on aquatic ferns. *Steriphus* (subfamily Cyclominae) also prefers moist areas, its larvae living in soil feeding on herbs and pastures, while the related *Ophryota* occurs in drier regions, where its larvae (as far as known) are associated with bulbous monocotyledons.

One of the largest subfamilies of Curculionidae in Australia is the Entiminae, of which four genera were collected. *Basedowia basicollis* Lea is an uncommon, compact species that inhabits arid inland regions, where its larvae likely feed on roots in the soil. The specimens taken are useful additions to the ANIC collection. The largest Australian Entiminae belongs to the genus *Leptopius*, whose larvae also feed on roots in the soil. Much more diverse in the material collected is the genus *Myllocerus*, of which up to 12 different species were taken. These weevils are good flyers and have the ability to persist in low numbers during poor seasons. Their larvae, as those of the closely related genus *Hackeria*, again feed on roots in the soil. By contrast, the slimy larvae of *Oxyops*, classified in the tribe Gonipterini, make characteristic feeding trenches on the surface of leaves of various *Eucalyptus* trees.

The genus *Lixus* (subfamily Lixinae or Molytinae) is widespread in the world but not very diverse, or common, in Australia. Its larvae feed in the underground portions of stems of shrubs. *Melanterius* (subfamily Curculioninae) is a large genus in Australia associated with acacias, where its larvae feed on the developing seeds. Several species are successful biocontrol agents of invasive Australian acacias in other countries. The Tychiini, commonly known as flower weevils, are a large and taxonomically confused group of weevils whose larvae generally develop in flower and seed buds of a variety of plants. Considering the prolific plant growth and flowering on Cravens Peak Station prior to and during this study, the presence of several species of these flower weevils was understandable.

Other taxa

Most beetles collected were from the families treated above. However, other families were also collected (Table 6, page 267).

Although expertise and time prevented further identification of these groups at the time of preparing this report, the specimens have been sorted to family and are being kept refrigerated in absolute ethanol as part of a bulk repository within ANIC for study at a later date.

Discussion

Scarcity of beetle specimens in the ANIC from the Cravens Peak Station area (QLD) initiated this study which provided an excellent opportunity to increase this areas representation in the collection and to add to the often patchy knowledge of species distribution in inland Australia.

There are some fortuitous environmental factors to be taken into account while considering the beetle fauna collected during this study. Following a period of extended dry conditions, previous stocking with cattle and some bush fires on the property, there was significant rainfall and associated flooding in the area prior to collecting. Luckily waters had receded enough to allow access to a broad range of habitat types across the property and the ongoing presence of surface water in swampy depressions, billabongs and rivers, in addition to the ground water filled bores, meant collection of several of the opportunistic inland aquatic and semi-aquatic taxa was possible. At the time of sampling the initial post rain bloom of desert flowers and grasses was over, as evidenced by empty seed pods and grass heads, and it appeared that most of the perennial plants were in a phase of prolific vegetative growth and recovery from drought, stock pressure and fire.

Many arid zone insect taxa respond rapidly and prolifically to rainfall events and although seasonally abundant midges, grass and water bugs limited the effective nightly duration of collecting at light, and made it quite uncomfortable, this was the most successful method for beetle collecting during the study. The most prominent groups of beetles resulting from light sheet sampling were adult aquatic and semi-aquatic taxa, and night active Carabidae, Scaraboidea and Curculionoidea. In addition to this, individual specimens and small series from a further 22 families were collected. Concerted daytime sampling effort (beating, sweeping, bark peeling, litter examination and digging) was, considering the vegetation growth at the time, unexpectedly unproductive with small numbers of Curculionoidea and Chrysomelidae being the only consistent beetle groups collected. By endeavouring to sample as broadly across the property as possible, time constraints at each of the base camps resulted in

Table 6: Additional beetles identified to family and their methods of collection on Cravens Peak Station, April 2007.

FAMILY	Collection method				
	At light	Beating	Malaise trap	Malaise trough	Pitfall
ANOBIIDAE	X			X	
ANTHICIDAE	X	X	X	X	X
BOSTRICHIDAE	X		X		
BOTHRIDERIDAE	X				
BUPRESTIDAE		X	X	X	
CERAMBYCIDAE	X		X		
CHRYSOMELIDAE	X	X	X	X	X
CLERIDAE	X		X		
COCCINELLIDAE	X	X	X	X	X
CORYLOPHIDAE	X		X		
DERMESTIDAE	X	X	X	X	
ELATERIDAE	X		X	X	
HETEROCERIDAE	X			X	X
LANGURIIDAE	X				
LATRIDIIDAE				X	
LIMNICHIDAE	X				
MELYRIDAE	X	X	X	X	
MORDELLIDAE			X		
PHALACRIDAE	X	X			
SCRAPTIIDAE	X		X	X	
STAPHYLINIDAE	X		X	X	X
TENEBRIONIDAE	X		X	X	X

malaise traps being set for only three days and quite windy conditions would have contributed to the low catch numbers by this method.

Many water beetle species are able to take seasonally opportunistic advantage of temporary circumstances and therefore find and occupy short-lived habitats (Larson 1997). Larson (1997) also states that water beetle faunas change over time in still water environments. Therefore, the collection of Gyrinidae, Dytiscidae and Hydrophilidae on Cravens Peak Station can be considered a snapshot rather than an indication of what species may always be present. The species taken in this study were relatively common and have known distributions which include the Cravens Peak Station area. The new records for some species, such as *Antiporus gilberti* and *Megaporus howittii*, are around the known northern limit of their distribution. The location of Cravens Peak Station does appear to be within a cross-over zone between tropical species (eg. *Berosus nicholasi*) and southern species (eg: *Berosus approximans*). This may lead to extra diversity in collections during seasons when appropriate habitat is available such as during this study. It has been useful to increase the known remote inland localities of the species collected.

In an arid environment it stands to reason that nocturnal and/or cryptic habits enhance survival by minimising exposure to heat and desiccation. The most diverse family of beetles collected in this study was the Carabidae (ground beetles) which, as their common name suggests, are primarily ground dwelling, often nocturnal, and consequently well adapted for survival in the Cravens Peak Station area. The majority of carabids being predatory, they were taken in small numbers per taxa except for the seed eating Harplines which were more abundant possibly in response to post rain seed proliferation prior to this study. Many of the

Scarabaeoidea are also nocturnal and associated with soil and again were collected at light in this study. The most speciose sub-family collected was the Melolonthinae (chafers) which has a rich, complicated and not fully described or understood Australian fauna. Serious defoliation can occur as a result of Melolonthine feeding although very little leaf damage was found, particularly on new growth, on the Cravens Peak Station vegetation.

Curculionoidea were not collected in large numbers during this study; however they were almost the only group of beetles successfully collected directly from vegetation. The prevalence of *Myllocerus* species in this early period of post rain plant growth makes sense as this genus is known to persist through poor seasons and able to disperse as it is a good flyer. Presence of the variety of plant associated genera of weevils is also understandable considering the diverse and prolific vegetative growth happening at the time of sampling. This abundant vegetation may also in part explain the low numbers of beetles found in that those that persisted through poor seasons were probably widely dispersed over the abundant vegetation on the property and beetle population recovery may have some time lag compared to the vegetative response to rain. Moist habitat availability was reflected in the capture of three genera of weevils associated with aquatic or moist environments (*Austronanodes*, *Echinocnemus* and *Steriphus*). Particularly useful specimens of the uncommon *Basedowia basicollis* and *Lixus* sp. have now been added to the ANIC as a result of this study and are available for future study of these taxa.

By far the majority of beetles collected in this study were from species with widespread distributions that include the Cravens Peak Station area, all be it with many not previously specifically recorded from there. However there are some noteworthy records and range extensions as a result of this study shown in Table 7 (starting on page 268).

The identification of one hundred and twenty four beetle taxa from nine families and a small numbers of specimens from a further twenty two families taken in this exploratory study creates a useful baseline beetle fauna list for Cravens Peak Station which can only be added to by future collecting.

Table 7: Noteworthy records and range extensions as a result of sampling on Cravens Peak Station April 2007.

FAMILY / **Subfamily** / ***Genus species* Author**	**Notes on records and range extension**
CARABIDAE	
Bembidiinae	
Pericompsus (Upocompsus) australis (Schaum)	western limits of known eastern distribution
Tachys lindi Blackburn	previously only known from a few northern localities
Tachys similis Blackburn	previously only known from a few northern localities
Broscinae	
Adotela frenchi Sloane	previously recorded in interior Northern Territory and Western Australia, easterly extension of known distribution
Harpalinae	
Amblystomus laetus (Blackburn)	previously known from the Murray Darling Basin, northerly extension of known distribution
Amblystomus nigrinus Csiki	previously known from the Murray Darling Basin, northerly extension of known distribution
Anisodactylina n.gen. n.sp	previously known only from Camooweal and Longreach
Gnathaphanus herbaceous Sloane	previously known from the Murray Darling and Lake Eyre Basins, northerly extension of known distribution

Continues on following page

Table 7 continued from previous page

FAMILY Subfamily *Genus species* Author	Notes on records and range extension
Helluoninae	
Helluarchus whitei Lea	very rare in collections, previously known only from the Tanami and Finke River area in Northern Territory
Pseudomorphinae	
Sphallomorpha uniformis Baehr	this is an additional record in a distribution known from widely separated inland localities across the continent from WA to Queensland
Scaritinae	
Carenum rectangulare Macleay	previously known from inland Northern Territory, slight easterly extension of known distribution
CURCULIONIDAE	
Basedowia basicollis Lea	uncommon species with few records in collections
Lixus sp.	widespread but uncommon genus
DYTISCIDAE	
Antiporus gilberti (Clark)	northern limits of known southern distribution
Megaporus howittii (Clark)	northern limits of known southern distribution
HYDROPHILIDAE	
Berosus approximans Fairmaire	additional inland record and at northern end of known distribution
Berosus nr. *nicholasi*	*Berosus nicholasi* known primarily as a northern coastal species with only one inland record
Berosus pulchellus Macleay	additional inland record for this tropical species
Paracymus pygmaeus (Macleay)	additional inland record for widespread species with patchy inland records
SCARABAEIDAE	
Dynastinae	
Xynedria interioris Blackburn	rare in collections, previously known only from Alice Springs area
Melolonthinae	
Colpochila longior (Blackburn)	previously recorded in South Australia, northerly extension of known distribution
Liparetrus minimus Britton	previously recorded in interior Northern Territory and Western Australia, easterly extension of known distribution

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Baseline Studies of the Aquatic and Semi-Aquatic Hemiptera of the Cravens Peak Station Area

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Abstract Eight species of aquatic bugs in three families of Nepomorpha and one species of Gerromorpha (Hemiptera) were collected during the RGSQ expedition to the Cravens Peak Station area of western Queensland in April 2007. Notes are given on the distribution and habitat preferences of the species, where known.

Introduction

The Cravens Peak Station area in western Queensland is largely unrepresented in the Australian National Insect Collection. The objective of this study was to collect aquatic and semi-aquatic Hemiptera from a range of locations across the property to establish some baseline information on their distribution in the region. Especially considering the preceding years of drought, some extensive fire events on the property, recent destocking and the rainfall events just prior to collection in 2007 it was also intended that this collection event would yield informative baseline data for the Bush Heritage Trust in their management of Cravens Peak Station.

Methods

Collection of aquatic and semi-aquatic Hemiptera was carried out in conjunction with beetle collecting during the RGSQ expedition in April 2007. Details of collection sites and methods used at each site can be found in Table 1 (page 275). The collecting of Hemiptera was done primarily at the light sheet as it was found that prolific numbers were attracted to the light. Observations were made, and some exploratory sweep netting was carried out, at bores and natural water bodies in an attempt to find other species which did not come to the light, however none of the water surface dwellers were observed.

Light sheet collecting was achieved by attracting insects to, and selecting the aquatic and semi-aquatic Hemiptera from a white sheet hung next to a single suspended 160 watt blended mercury vapour lamp run by a generator (Figure 1, page 274). This wattage bulb was chosen in an attempt to reduce the influx of seasonally (post rain) prolific bugs, midges and crickets which overcrowded and disturbed the collecting sheet making target insect selection from the sheet difficult. The light was run from 7:00pm (dusk) and finished around 10:00pm because of the fall off in numbers of new taxa coming to the light and the vast build up of non target insects. In an attempt to minimise wind disruption of the collecting sheet, light collecting was restricted to wind sheltered areas as much as possible, such as creek lines, dense vegetation and dune swales. Sites selected for light collecting were located at distances as far as practical from each base camp in an attempt to sample areas less affected by the previous vegetation damage from the stock grazing pressure associated with the bores near which base camps were located.

Specimens were collected into absolute ethanol (hand collecting, malaise trap and light sheet) and kept refrigerated in a portable refrigerator and the ethanol was changed three times as recommended for potential DNA analysis. All samples were labelled in the field with date, collector/s, latitude and longitude (obtained by GPS) and location descriptions.

Results

Eleven species from four families of aquatic and semi-aquatic Hemiptera were identified in this study. Table 2 (page 276) lists the species identified and the sites at which they were taken.

Figure 1: Light sheet collection at Cravens Peak Station April 2007

Nepomorpha (aquatic bugs)

1: Belostomatidae (giant water bugs)

A single specimen of *Lethocerus (Lethocerus) distinctifemur* Menke was attracted to light near Salty Bore (site 4). This is the largest of the Australian aquatic bugs and is widely distributed over much of northern and central Australia where it inhabits lakes and ponds (Andersen & Weir 2004). It preys on other aquatic animals, including vertebrates.

2: Corixidae (water boatmen)

Micronecta spp. are prolific at nearly all sites, but no attempt was made to sort these to species as the genus is currently being revised. These are the smallest of the Australian aquatic bugs and are typical inhabitants of lakes, ponds and stream pools and come readily to light, often in large numbers (Andersen & Weir 2004).

Agraptocorixa parvipunctata (Hale) is a widespread species, distributed over most of Australia (Lansbury 1984) and was taken at sites 2, 7, 8, 9 and 10. *Agraptocorixa hirtifrons* (Hale) has a somewhat more southerly and sporadic distribution (Lansbury 1984) and here was only found at site 12, north of the homestead. This is the most northerly record of this species so far recorded.

3: Notonectidae (backswimmers)

Five species of *Anisops* were caught at a range of sites across the station, but exhibit slightly different patterns of distribution elsewhere in Australia. *Anisops gratus* Hale (8 sites), *Anisops paraexigerus* Lansbury (6 sites) and *Anisops stali* Kirkaldy (8 sites) are widespread across much of Australia and common inland, with *A. gratus* extending to Tasmania. *Anisops nasutus* Fieber (1 site) tends to have a more northern element to its distribution as well as inland areas and extends to the SE Pacific region. On the other hand, *Anisops thienemanni* Lundblad (3 sites) is found more in the eastern and southern areas on the continent as well as Tasmania and is one of the first water bugs to colonise ephemeral pools (Lansbury, 1984, 1995, Lansbury & Lake 2002).

Gerromorpha (semi-aquatic bugs)

4: Gerridae (water striders)

Limnogonus (Limnogonus) fossarum gilguy Andersen & Weir was the only species

Table 1: Details of aquatic and semi-aquatic Hemiptera collection sites and methods.

Site No.	Collection Dates & Site Locations	Collection Methods
1	10 Apr 2007, Cravens Peak Station, rocky valley ENE of Salty Bore. 23°1’13"S 138°13’39"E. A rocky drainage line with *Acacia georginae*, *Eremophila* spp.	Light Sheet
2	11 Apr 2007, Cravens Peak Station, 2km SW of Satly Bore. 23°2’12"S 138°12’44"E. Dry creek bed with *Acacia georginae*, *Acacia cyperophylla*, *Eremophila* spp.	Light Sheet
3	12 Apr 2007, Cravens Peak Station, 0.5km S of Salty Bore. 23°1’40"S 138°13’37"E. Dry creek bed with *Acacia georginae*, *Eremophila* spp.	Light Sheet
4	13 Apr 2007, Cravens Peak Station, 1.5km SW of Salty Bore. 23°2’0"S 138°13’0"E. Dry creek bed with *Acacia georginae*, *A. cyperophylla*, *Eremophila* spp.	Light Sheet
5	14 Apr 2007, Cravens Peak Station, near Mulligan River, below S-Bend camp. 23°3’50"S 138°21’20"E. *Eucalyptus camaldulensis*, *Acacia georginae*, *A. cyperophylla*, *Eremophila* spp., grasses, numerous herbs.	Light Sheet
6	15 Apr 2007, Cravens Peak Station, S-Bend Camp site, Toko Range. 23°3’51"S 138°21’6"E. Camp site lights, rocky hill top.	Light Sheet
7	17 Apr 2007, Cravens Peak Station, S side of track, 4km SE of 12 Mile Bore. 23°11’3"S 138°11’17"E. Green depression. *Corymbia terminalis*, *Senna artemisioides*, *Acacia georginae*, *Eremophila* spp., *Hakea eyreana*, grasses, herbs.	Light Sheet
8	18 Apr 2007, Cravens Peak Station, Gap Hole. 23°14’51"S 138°5’51"E. Dry creek bed running through gap in Toomba Range. Very mixed vegetation with *Eucalyptus camaldulensis*, *Senna artemisioides*, *Acacia georginae*, *Eremophila* spp., *Hakea eyreana*, *Grevillea striata*, numerous grasses and herbs.	Light Sheet
9	19 Apr 2007, Cravens Peak Station, 4.5km NNE 12 of Mile Bore. 23°7’5"S 138°10’14"E. Sandhill and swale. *Eucalyptus pachyphylla*, *Calandrinia balonensis*, *Triodia* sp. sparse grasses, herbs.	Light Sheet
10	20 Apr 2007, Cravens Peak Station, The Duck Pond. 23°16’25"S 138°4’26"E. Bore filled waterhole.	Water sweep
11	22 Apr 2007, Cravens Peak Station, 7km NW of homestead on Plum Pudding track. 23°17’0"S 138°32’46"E. Sandhills and moist depression. *Acacia georginae*, *Eremophila* spp. *Triodia* sp. *Marsilea* sp. grasses, herbs.	Light Sheet
12	23 Apr 2007, Cravens Peak Station, 2km N of homestead. 23°18’19"S 138°34’45"E. Sandy creekline in depression. *Corymbia terminalis*, *Acacia georginae*, *Senna artemisioides*, *Eremophila* spp., grasses, herbs.	Light Sheet

collected during the survey, being taken at light at sites 3, 4 and 12. This is a widespread and common species that extends over much of northern Australia from southern Queensland to the Pilbara region of WA and down to the Alice Springs area of NT. It is one of the most eurytopic Australian gerrids, being able to utilise the surface of a wide variety of habitats such as lakes, ponds, slow streams and temporary pools, and flies readily to light (Andersen & Weir 2004).

Discussion

As most of the specimens were collected at light rather than by dedicated aquatic collecting methods, the species list should be considered only as a snapshot of the aquatic and semi-aquatic bug fauna of the Cravens Peak Station area. It is an indication of the vagility of many members of these families that this many species were able to be recorded. In general terms, all of the species can be considered to be common and widespread in Australia, but each to varying degrees and none can be said to be restricted to the Cravens Peak area. Further intensive collecting in aquatic environments could be expected to produce members of at least the gerromorphan families Veliidae, Mesoveliidae and Hydrometridae and the nepomorphan family Nepidae (Andersen & Weir 2004, Gooderham and Tsyrlin 2002).

Table 2. Identified aquatic and semi-aquatic Hemiptera taxa and their collection sites on Cravens Peak Station, April 2007.

Infraorder / **Family** / ***Genus species* Author**	**Site Number**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Nepomorpha												
Belostomatidae												
Lethocerus (Lethocerus) distinctifemur Menke				x								
Corixidae												
Agraptocorixa hirtifrons (Hale)												x
Agraptocorixa parvipunctata (Hale)		x					x	x	x	x		
Micronecta spp.	x	x	x		x		x	x	x	x	x	x
Notonectidae												
Anisops gratus Hale	x	x	x				x	x	x		x	x
Anisops nasutus Fieber		x										
Anisops paraexigerus Lansbury					x	x	x		x		x	x
Anisops stali Kirkaldy	x	x	x		x	x	x			x		x
Anisops thienemanni Lundblad								x		x		x
Anisops spp. unidentifiable females		x							x	x		
Gerromorpha												
Gerridae												
Limnogonus (Limnogonus) fossarum gilguy Anderson & Weir			x	x								x

Acknowledgements

The authors would like to thank all the wonderful volunteers of the Royal Geographical Society of Queensland and the Bush Heritage Trust manager of Cravens Peak Station for the infrastructure and administrative support that made this survey possible. We would also like to thank B. Richardson, E. Edwards, M. Glover, & J. Ambrose for assistance during field work.

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Some observations on the biology of the desert shovelfoot frog (*Notaden nichollsi*) in south-western Queensland

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Abstract This report describes observations on the behaviour of the desert shovelfoot frog (*Notaden nichollsi*) made in April 2007 at Cravens Peak Station in the north-eastern Simpson Desert. Pitfall trapping, spotlighting and opportunistic observations indicated that juveniles (2.5 to 11 gm) were present in substantial numbers in sand dunes and in lesser numbers in plains habitat, but absent from rocky upland habitats. Adults were evidently present in much lower densities as they were rarely encountered in sand dunes, and not encountered in either of the other habitats. Desert shovelfoots were active at night and juveniles seemed to be equally active before and after midnight. In burrowing shovelfoots produced two kinds of structures at the soil surface; essentially flat-surfaced mounds, which seem to be associated with occupied shallow burrows, and conically-concave surfaced mounds, which are postulated to be associated with evacuated shallow burrows. There was some evidence that the burrows formed by this species at Cravens Peak at this time were much shallower (less than 30 cm) than those encountered in previous studies, which is consistent with limited data indicating sufficient moisture at shallow depths during our study to allow shovelfoots to maintain water balance. It has recently been suggested on metabolic grounds that desert shovelfoots must emerge every five to six months to feed if they are to avoid energetic exhaustion. Our observations are consistent with this view, in so far as they suggest that, in periods immediately following rainfall, this species uses a pattern of activity involving nocturnal foraging above ground every one to few nights, and daily use of shallow burrows. No evidence for ongoing breeding was obtained during our time on Cravens Peak, although observations made prior to our arrival and the presence of two small juveniles indicate that some breeding had occurred a few weeks earlier. Body size suggests that all the juveniles we encountered were spawned in the summer of 2006-2007, and if breeding in *N. nichollsi* is only initiated after torrential rainfall events then rainfall records indicate that all the juveniles we encountered would have been less than four months old, and that each of the few adults we encountered would have been at least four years old.

Introduction

Notaden nichollsi is a medium-sized, non-cocooning, burrowing frog which occurs across a broad area of arid Australia (Barker et al. 1995; Cogger et al. 1983). This species has a range that extends from near Port Hedland in north-western Western Australia (Ealey and Main 1960) to western Queensland (Ingram and Raven 1991; Predavic and Dickman 1993) and takes in much of the sand dune region of inland Australia (Cogger 2000).

At least three common names are associated with *N. nichollsi*. Until recently it was usually known as the desert spadefoot toad (e.g. Cogger 2000), but in recent years it has also been referred to as the ruby-spotted orbfrog and the desert shovelfoot. Here we follow (Ingram et al. 2002) in using the name desert shovelfoot.

Despite their extensive range, desert shovelfoots are rarely encountered. They only appear above ground following rain (Predavec and Dickman 1993) and post-metamorphosis are essentially nocturnal (Cogger et al. 1983). Large numbers of desert shovelfoots may become evident following rain, but between rainfall events they are usually located deep in sand dunes (Slater and Main 1963; Paltridge and Nano 2001; Thompson et al. 2005), where they survive by substantially lowering their metabolic rate (McMaster 2006) and using water stored in their large capacity bladder (Main and Bentley 1964; Cartledge et al. 2006).

The diet of post-metamorphic desert shovelfoots seems to consist almost entirely of termites and ants. Calaby (1960) examined the gut contents of three desert shovelfoots from two localities in north-western Western Australia and found mainly members of these two insect groups. In a more recent study of the gut contents of 24 animals from south-western Queensland, Predavec and Dickman (1993) found that termites (65%) and ants (34%) were the main components of diet.

Reproduction in the desert shovelfoot is entirely dependent on free water. The eggs are laid in temporary water bodies (Barker et al. 1995; Tyler 1994) and after hatching the larvae spend all their time in water. However, the larval phase of the life cycle is extremely brief and is completed within 16-30 days (Main 1968), which is amongst the shortest times so far reported for an Australian anuran (Tyler 1994).

Breeding in *N. nichollsi* is evidently aseasonal, opportunistic and explosive. Main (1968) listed *N. nichollsi* as a summer breeder in southern Western Australia, but this probably reflects the pronounced seasonality of rainfall in this part of the species' range. Pitfall studies in south-western Queensland indicate that breeding can occur in spring, summer and/ or winter depending upon rainfall events (Predavic and Dickman 1993). Indeed, Predavic and Dickman (1993) report that all the desert shovelfoots that appeared during rainfall were large, while juveniles were captured two or three weeks after rain.

We present here an account of observations made on desert shovelfoots during the course of 10 days on Cravens Peak Station in south-western Queensland in the middle of April 2007. Rain had fallen during three of the four months preceding our visit and this seems to have resulted in large numbers of these animals foraging above ground each night. Our observations cast further light on habitat use, on the time of activity and burrowing behaviour of juveniles, and on the breeding biology of this very interesting, but poorly understood amphibian.

Methods

Our observations on desert shovelfoots and were made during nine nights of investigation into the activity patterns of various nocturnal animals from a base camp at 12 Mile Bore (23° 09' 38" S; 138° 09' 09" E). In undertaking those investigations we used pitfall trap lines in two habitat types (sand dune and plains) and spotlight transects in three habitat types (sand dune, plains, and rocky upland) to assess the relative abundance of large invertebrate and small vertebrate animals that were nocturnally-active. We employed these techniques in a manner that allowed us to assess the extent to which particular species might be more active in the first versus the second half of the night.

Six pitfall trap lines were used. Three were set in the sand dune and three in the plains habitats. Each trap line consisted of six 20-litre buckets set at four metre intervals along the base of a 30 cm high plastic drift fence 28 metres long. On the evenings that a trap line was used it was opened around dusk (5 – 6 pm), inspected and cleared of captured animals around midnight (11.20 pm – 1.30 am), and then inspected, cleared and closed around dawn (5.50 – 7.00 am). If large numbers of ants were observed in or near any bucket, the lid was either left on the bucket (at dusk and midnight) or placed on the bucket (at midnight) to avoid ant attacks on captured animals. The three trap lines in the sand dunes were opened on the evenings of 12th, 15th and 18th July, while the three trap lines in the plains were opened on the evening of 13th, 16th and 19th July.

Three spotlight transects were used with one located in each of the three habitats investigated. Each transect was 100 m long and 6 m wide. A 100 m long measuring tape extended down the middle of each transect and the lateral margins were marked by plastic flags placed 3 m out from the tape. During surveys each spotlight transect was walked by two observers equipped with head torches who travelled steadily in parallel along opposite sides of the measuring tape noting and recording the position along the transect of all animals which could be observed on their halves of the transect. Once the end of transect was reached

Table 1. *Notaden nichollsi* captured in 28 metre pitfall trap lines on Cravens Peak Station in July 2007. The 3rd to 5th rows record the catch per unit effort (and number of buckets open) for each trapline at each period it was open. Each trapline consisted of a 30 cm high plastic drift fence and 6 (20 litre) buckets spaced 4 m apart. The buckets were opened around dusk (5 – 6 pm), inspected around midnight (11.20 pm – 1.30 am), and inspected again and closed around dawn (5.50 – 7.00 am). Due to the presence of large numbers of ants, several buckets in each trapline sometimes had to be left closed or closed around midnight.

	Sand Dunes Line 1		Sand Dunes Line 2		Sand Dunes Line 3		Plains Line 1		Plains Line 2		Plains Line 3	
	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM
Night 1	0.00 (6)	0.00 (6)	0.00 (4)	2.33 (3)	0.33 (6)	0.33 (6)	0.33 (6)	0.00 (6)	0.17 (6)	0.00 (6)	0.67 (6)	0.25 (4)
Night 2	0.00 (6)	0.0 (5)	0.00 (3)	3.00 (1)	1.00 (6)	0.50 (6)	0.00 (6)	0.00 (6)	0.00 (6)	0.00 (6)	0.67 (6)	0.33 (6)
Night 3	0.00 (6)	0.00 (6)	1.67 (3)	1.00 (3)	0.33 (6)	0.00 (6)	0.00 (6)	0.00 (6)	0.00 (6)	0.00 (6)	0.00 (6)	0.00 (6)
Total no. captures	0	0	5	13	10	5	2	0	1	0	8	3
Total trap effort	18	17	10	7	18	18	18	18	18	18	18	16
Total captures per unit effort	0.00	0.00	0.50	1.86	0.56	0.28	0.11	0.00	0.06	0.00	0.45	0.19

the observers swapped side and repeated the process travelling in the reverse direction. Thus each half transect was examined twice (once by each observer) each time it was surveyed. On evenings when a spotlight transect was used it was walked twice; around 10.30 –11.00 pm and around 2.30 – 3.00 am. The rocky upland transect was walked twice on each of the evenings of 11th, 14th and 17th July, the sand dune transect was walked twice on each of the evenings of 12th, 15th and 18th July, and the plains transect was walked twice on the evenings of 13th, 16th and 19th July.

For a fuller account of the methods employed and the location of study sites see Black and Pridmore (2009).

Results

Habitat Use

No adult shovelfoots were encountered during pitfall trapping or spotlighting. However, considerable numbers of juvenile shovelfoots were captured in some pitfall trap lines and small numbers of juveniles were observed with spotlights when we walked the sand dune transect at night. Other juvenile shovelfoots were observed while driving along tracks at night, and fourteen juvenile and two adult shovelfoots were found dead on vehicle tracks during daylight hours. In the very early morning (*c*. 2 am) on 19th April juvenile shovelfoots were so frequently encountered on one of the vehicle tracks that we had to stop the vehicle and remove them from the road. After doing this several times we decided to weigh the animals as we moved them. A similar situation occurred after sunset that evening (*c*. 9 pm) and we again weighed animals as we moved them off the road. The weights of the eighteen juveniles we handled that morning and evening ranged between 2.5 g and 11.0 g, and their mean weight was 7.0 g. These weight data show no evidence of a multimodal distribution; although due to the small number of animals involved this cannot be ruled out.

The pitfall trap line data (Table 1, page 279) indicate that juvenile shovelfoots were present in greater densities in the sand dune habitat than in the plains habitat. Juvenile shovelfoots were found in the sand dune pitfall traps on 33 occasions, whereas they were found in the plains pitfall traps on only 14 occasions. However, these numbers fail to take account of the fact that sand dune trap lines were more frequently subject to partial closure because of ants. If returns per unit effort (number of shovelfoots caught per open bucket per half-night) are considered for the two habitats then greater differences in relative abundance are indicated. In the sand dune habitat 0.38 juveniles were caught on average per open bucket per half-night, whereas in the plains habitat an average of 0.13 juveniles was caught per unit effort. Due to the nature of the substrate in the rocky uplands we were unable to install pitfall traps in that habitat.

Spotlight data support the view that juvenile shovelfoots were present in greater densities in the sand dune habitat than in the plain habitat since they were only seen on the sand dune transect and never observed on the plains transect (Table 2, page 281). No shovelfoots were observed while spotlighting in the rocky upland habitat. It is unlikely that these differences are due to differences in detectability since the light vegetation cover allowed us to scan the ground surface thoroughly when walking all three transects; a range of invertebrates, including ants and crickets, were readily detected during spotlighting in all three habitats.

During the course of six spotlight runs (twice a night on three evenings) on the sand dune transect we encountered juvenile shovelfoots six times. The maximum number of animals encountered on the sand dune transect during any single spotlight run was three, and since this transect had an area of 600 m^2, this suggests a juvenile shovelfoot density in this habitat of approximately 50/ha.

Four additional types of observations that were made opportunistically in the course of running our pitfall trap lines and spotlight transects support the view that shovelfoots occurred in greater densities in the sand dunes than in the plains habitat. Firstly, during the early evening when we were driving back to camp after setting our trap lines, and later at night when we were travelling to or from our trap lines, we often encountered juvenile shovelfoots on the four-wheel drive tracks we were using. Although shovelfoots were observed on tracks passing through both sand dune and plains habitats, they were more frequently encountered on tracks passing through sand dune country than on tracks passing through plains country, even though we spent more time travelling on tracks of the latter type.

Secondly, on two mornings when we walked sections of track near our parked vehicle to look for signs of animal activity, we found the remains of dead shovelfoots that had been killed by vehicles passing along the track the previous night. No dead shovelfoots were observed along sections of track passing through plains habitat, but quite a number of dead shovelfoots were found along a section of track that passed through sand dunes. Most of these (14) were juveniles, but we also found two adult road-killed shovelfoots on sections of track passing through dunes.

Thirdly, when we were passing on foot through areas of sand dune or plains, such as when walking between our vehicle and our trap lines, or when exploring areas of either habitat type, we encountered many more shovelfoot trackways on areas of sand dune than we encountered when walking through areas of plains habitat. The likelihood that this was caused by differences in trackway detectability is small as the two habitats had similar sandy soils and similar low levels of vegetation cover. No shovelfoot trackways were ever observed on areas of rocky upland habitat; although due to the nature of the ground surface it is doubtful that any shovelfoots that moved through this habitat would have left detectable trackways.

Fourthly, when travelling on foot along four-wheel drive tracks or across country we frequently found signs which indicated where shovelfoots had burrowed into the ground (see below). These burrow signs were far more common in sand dune areas than in areas of plains habitat and were never encountered in areas of rocky upland habitat.

Diel activity and burrowing behaviour

During our time at Cravens Peak Station juvenile and adult shovelfoots were essentially nocturnal. We never observed live juvenile or adult shovelfoots during the day, except for a single juvenile which was observed burrowing into the sand at the base of a wheel rut on a four-wheel drive track nearly two hours after sunrise at 7.45 am on the morning of 17th April.

Juvenile shovelfoots seem to have emerged from their burrows after sunset, which at the time of our study varied between 6.38 and 6.31 pm. The earliest time in the evening that we noticed an active animal was at 7.24 pm on the evening of 18th April. When we drove out to our spotlight transects around 9.30 pm we often saw juveniles on tracks.

Our data on juvenile shovelfoot activity do not show any marked difference between the first half of the night (sunset to midnight) and the second half (midnight to sunrise). Our pitfall trapping data for sand dune trap line 2 (Table 1, page 279) indicate that juvenile shovelfoots were less active during the first half than in the second half of the night, but data for sand dune trap line 3 show the reverse. Spotlight data (Table 2, page 281) suggest that juvenile shovelfoots were slightly more common on

Table 2. Number of *Notaden nichollsi* observed on spotlight transects on Cravens Peak Station in April 2007. The three transects were 100 m long and 6 m wide. During each census, a transect was walked in both directions by two observers, equipped with head torches, travelling in parallel on different halves of the transect. Each transect was censused twice per night (around 10.30 -11.00 pm and around 2.30 – 3.00 am) on three nights. The positions of animals were recorded by the observers while walking and the number of individuals encountered on a transect at the time of walking were later tallied.

	Sand Dunes Transect		**Plains Transect**		**Rocky Upland Transect**	
	PM	**AM**	**PM**	**AM**	**PM**	**AM**
Night 1	0	0	0	0	0	0
Night 2	3	1	0	0	0	0
Night 3	2	0	0	0	0	0
Av.	1.67	0.33	0.00	0.00	0.00	0.00

the sand dune transect around 10.30 – 11.00 pm than around 2.30 – 3.00 am. Fewer pitfall captures were made on the plains habitat (Table 1, page 279), but these suggest that juvenile shovelfoots may have been more active in this habitat during the first half of the night than in the second. No shovelfoots were observed on the plains spotlight transect in either half of the night.

In the course of our time at Cravens Peak Station we encountered several different kinds of animal tracks and established that one quite distinctive type was the product of shovelfoot locomotion (Figure 2, page 283). We achieved this by examining the soil surface around shovelfoots that we encountered while spotlighting, and by examining the trackways that were produced by shovelfoots following their release from pitfall traps.

Later we found that many shovelfoot trackways ended in small (typically 4 to 5 cm in diameter), slightly-raised mounds. These mounds seemed to be of two kinds. In one kind (Figure 3A, page 284) the inner surface of the mound was essentially flat, and separated by a narrow furrow from an annular rim, which, like the inner surface, was slightly raised above the surrounding soil surface. In the other kind (Figure 3A, page 284), a similar annular margin was present, but the inner surface was conically-concave rather than flat. Most mounds could be readily assigned to one of these two categories, but a small number (Figure 3B, page 284) seemed to be intermediate in form.

Because of their association with shovelfoot trackways, we considered it likely that these mounds indicated where shovelfoots had recently either burrowed into or out of the soil. We postulated that the level-surfaced mounds might indicate where shovelfoots had entered the soil, and that the conically-concave mounds might indicate where they had exited the soil. Our line of thought was that when a frog extracted itself from beneath the ground surface, compaction of the soil would generate a concave surface.

Support for our interpretation of the level-surfaced mounds was provided by two kinds of further observations. One kind concerned two juveniles that were observed to burrow into the sand. One of these was the juvenile specimen mentioned earlier that was observed on the morning of 17th April. This juvenile shovelfoot used its hind legs to dig, and rotated its way, rear-end first, into the sand at the edge of a four-wheel drive track. In a matter of minutes it had disappeared from view. By the time no further soil movements could be observed, a low flat-surfaced, mound was left to mark its point of entry into the sand.

A similar observation was made away from the four-wheel drive track on the crest of a dune around 1.30 am at night on the 19th April. While walking into one of our sand dune pitfall trap lines a juvenile shovelfoot was observed partly immersed, such that only its head projected out of the sand. When we walked out from our trap line some 15 minutes later, this animal had completely disappeared and a level-surfaced mound marked the spot where its head had been seen earlier.

The second kind of observation concerns two, flat-surfaced mounds that we encountered on dune slopes on the 19th April. One of these was located in a wheel rut at the edge of a vehicle track in the morning. This mound had an outside diameter of about 3.5 cm and on excavation yielded a small (5.5 gm) juvenile

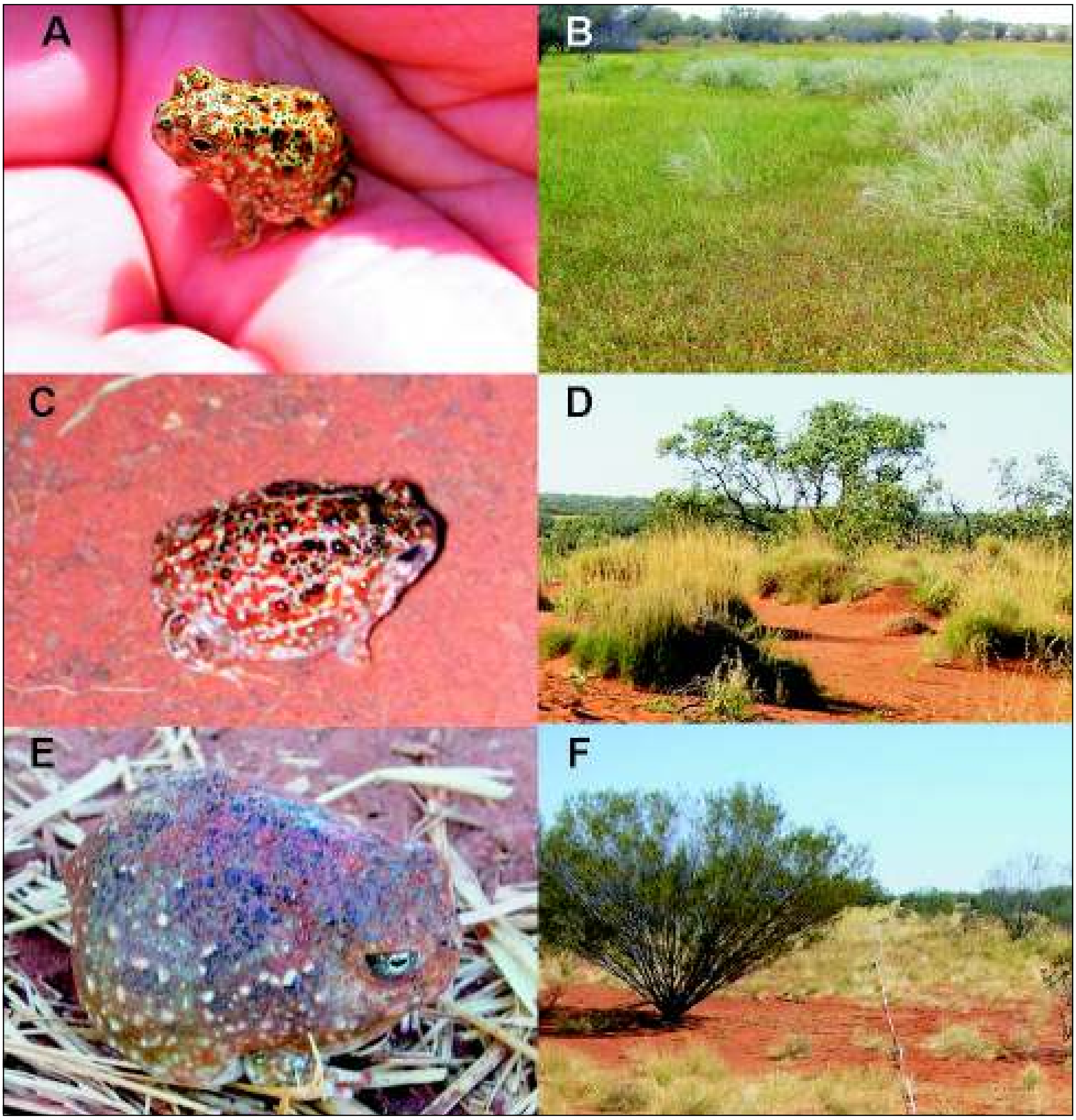

Figure 1. Specimens and habitats of *Notaden nichollsi* on Cravens Peak Station.
A. small juvenile observed in ephemeral wetland,
B. Shallow, ephemeral wetland in which the small juvenile shown in A was observed,
C. Larger juvenile,
D. Sand dune the favoured habitat of larger juvenile and adult frogs,
E. Mature adult,
F. Plains country the habitat used by a small proportion of larger juvenile frogs.
The animal in A is shown at around 1.7 times life size, while the animals in C and E are shown at approximately life size.

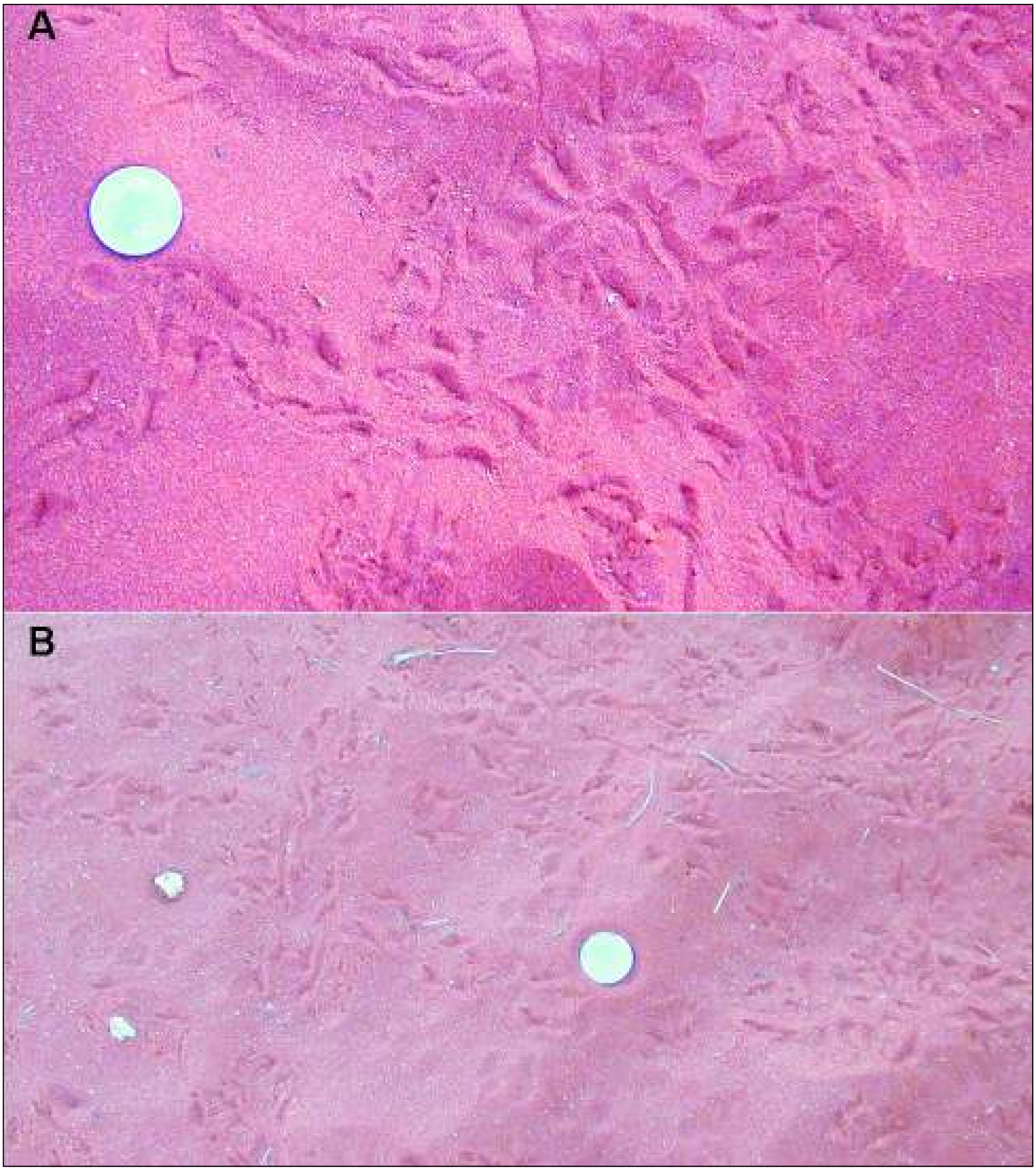

Figure 2. Trackways of juvenile *Notaden nichollsi*. A twenty cent coin provides scale in both pictures.

shovelfoot. The second mound, which was noticed some metres away from the vehicle track in the afternoon, had a diameter of around 8 cm, and so was almost twice as wide as most of the mounds we encountered. Excavation of this mound yielded the adult shovelfoot shown in Figure 1E (page 282). This animal was found some 20 to 30 cm below the surface of the dune in damp sand.

We did not excavate any of the conically-concave-surfaced mounds and so did not verify that shovelfoots were absent beneath these. However, in areas where mounds were abundant it was evident that conically-concave-surfaced mounds were far more common than flat-surfaced mounds. This is to be expected (in the absence of wind) if shovelfoots enter the soil at a new place after each evening on the surface, for if there is no

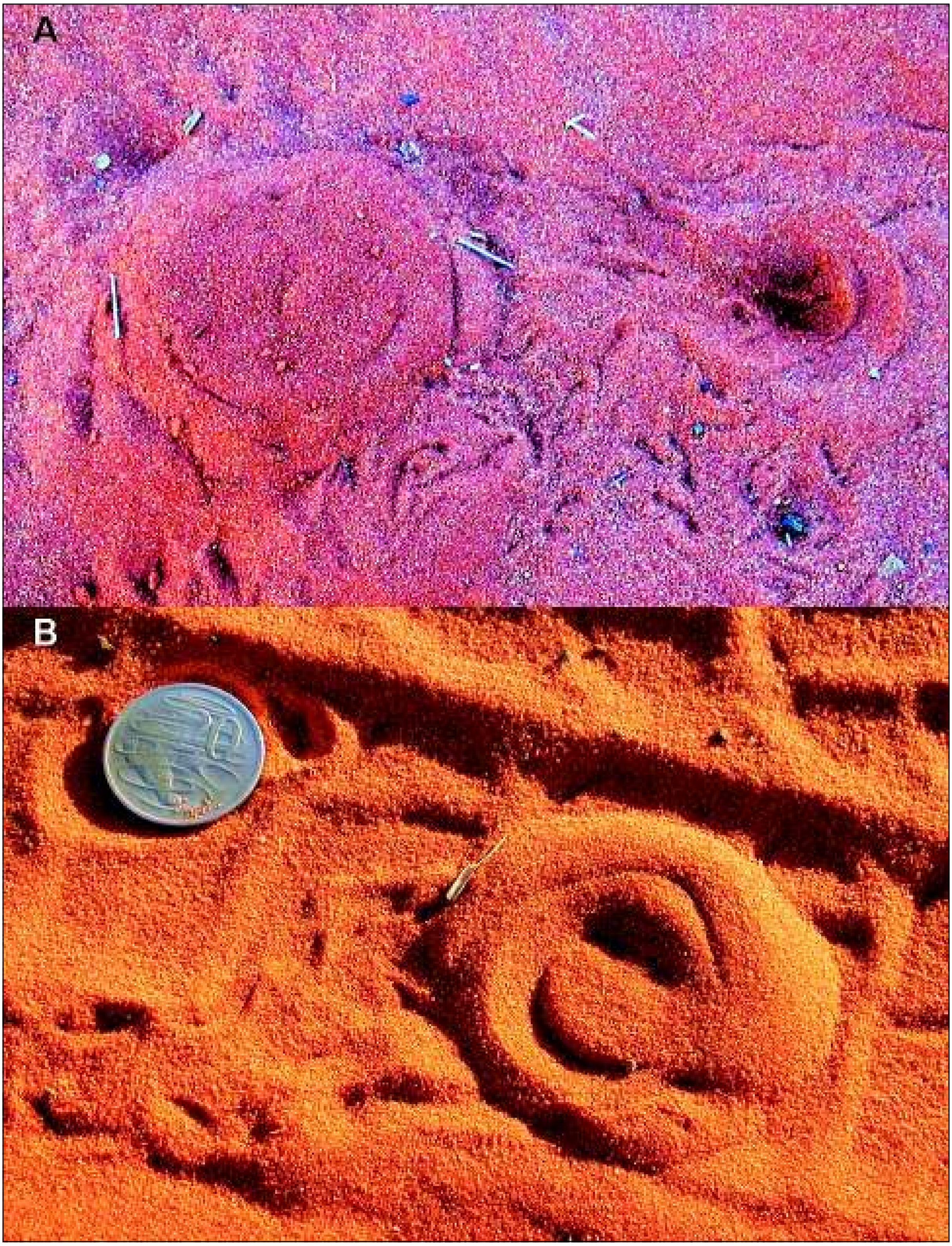

Figure 3. Surface features associated with burrows of *Notaden nichollsi*.
A. The two common forms of surface features. On the left is the centrally-flattened form attributed to the entry of a shovelfoot into the soil. On the right is the centrally-cratered form attributed to a shovelfoot exiting the soil with the result that there is collapse of soil back into the burrow.
B. Burrow surface mound of intermediate character.

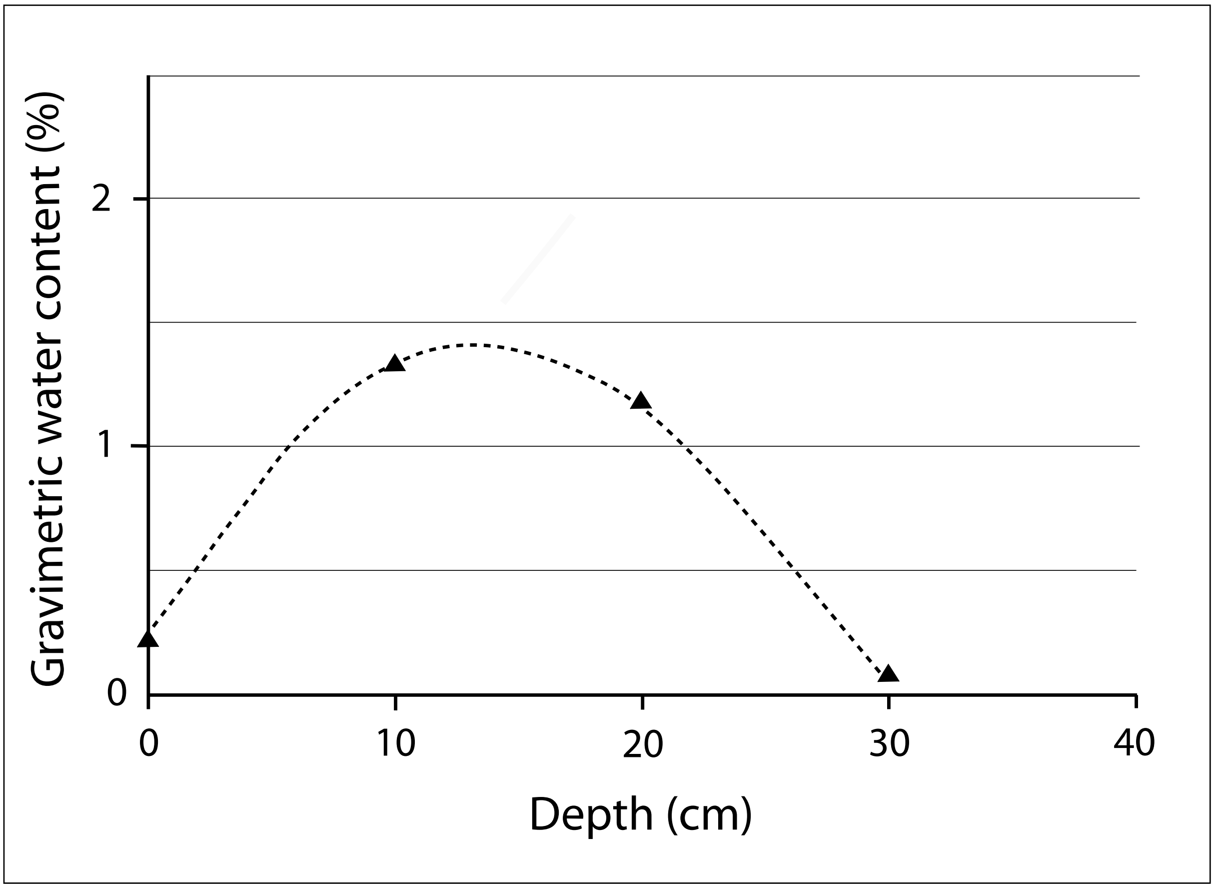

Figure 4. Soil moisture content at 10 cm intervals down through the crest of the sand dune at pitfall trap site 2.

wind to obliterate the evidence of burrows previously evacuated, there should be several conically-concave-surfaced (empty) burrow mounds for each frog, but only one flat-surfaced (occupied) burrow mound.

In order to understand the conditions encountered by shovelfoots while they were underground, we decided to take samples of sand at intervals down through the crest of the dune at pitfall site 2. These samples were obtained at 8.45 am on the morning of 19th April by forcing 35 ml plastic film canisters into a vertical excavation face at 10 cm intervals. As soon as the samples were obtained, the canisters were capped and sealed with tape. After we had returned from the field the samples were weighed in a laboratory immediately after they were opened, and again after being dried to constant weight, so that we could calculate the percent gravimetric water content (= 100 x difference in mass of sample when wet and dry, divided by dry weight of sample). The data obtained through this analysis are shown in Figure 4 (page 285). It is evident from this plot that, at this location, the water content of the sand was elevated at a depth of 10 to 20 cm, compared to depths closer to the surface and somewhat deeper than this.

Breeding

No breeding adult desert shovelfoots or desert shovelfoot eggs were observed during our time on Cravens Peak Station. While this might be explained by the fact that we spent rather little of our time examining temporary wetlands, it seems more likely that any courtship and egg-laying had ceased by the time we arrived there on 10th April 2007.

Evidence indicating some recent breeding was provided by two very small juveniles that we encountered. One of these (Figure 1A, page 282) was observed on the afternoon of 18th April in shallow water at the edge of an unnamed, but extensive, shallow wetland located at 23° 04’ 00.1” S, 138° 11’ 31.7” E, and situated approximately 12 km north-north-east of 12 Mile Bore. This individual had well developed limbs and no tail stub (Figure 1A, page 282) and exhibited the colouration and colour patterning observed in more advanced juveniles. Under the system of developmental stages of Anstis (2002) it would have been at, or just beyond, stage 46. Unfortunately, we did not record its body weight.

We spent several daylight hours investigating the animal life of this wetland, which at that time had a maximum water depth of about 12 cm and supported a dense, continuous stand of nardoo (*Marsilea* sp.) (Figure 1B, page 282), and found a range of aquatic invertebrates, but no other specimens of *N. nichollsi*. Despite our relatively extensive examination of this wetland, we neither heard nor saw any adult frogs, nor did we see any submerged egg chains, nor tadpoles of any frog species.

A second very small (2.5 g) juvenile shovelfoot was found in a pitfall trap on the morning of 19th April. The trap line where we caught this animal was located in a sand dune about 12 km east-south-east of 12 Mile Bore.

Discussion

Habitat use

Our observations suggest that sand dunes on Cravens Peak Station support greater numbers of juveniles of *N. nichollsi* than plains habitat and that no juvenile shovelfoots occur on the rocky uplands. The sand dunes also appear to support greater numbers of adults than the plains, but our data on adults are too limited to be confident that this is the case.

Our pitfall data (Table 1, page 279) suggest that there was considerable local variation in the density of juvenile *N. nichollsi* within both the sand dunes and plains habitats. No juvenile spadefoots were caught on any night in any of the pitfall traps of sand dunes trap line 1, whereas at least two juveniles were caught every trap night in each of the other two trap lines in the sand dunes. In the plains habitat rather more juveniles were captured in plains trap line 3 than in either of the other two trap lines.

It is difficult to make robust estimates of the density and biomass of juvenile *N. nichollsi* in the sand dune habitat and impossible to make any credible estimate of their density or biomass in the plains habitat. Our spotlight transect data for the sand dunes suggest a density of around 50 juveniles/hectare, and if we convert this value to biomass per unit area (using the mean value of the juveniles we weighed on 19th April) then a juvenile biomass of around 390 g/hectare is indicated for this habitat at this time. However, neither value cannot be considered particularly reliable, since our density estimate does not take account of non-foraging (underground) shovelfoots, and being based on a single transect and a small number of animals, involves considerable potential for error. Considerably higher values (2315 g/hectare in April 1992 and 1805 g/hectare in May 1993) were calculated for desert frogs (mostly, but not solely *N. nichollsi*) living in Simpson Desert sand dunes approximately 8 km further south by Predavec and Dickman (1993). Comparison of our estimate with the two earlier estimates is difficult as those of Predavec and Dickman were based on a 1 hectare grid of pitfall traps, and it is unclear how capture area was assessed in their study. Nevertheless, despite the considerable difference between their estimates and ours, our estimate gives support to their contention that the (generally unseen) biomass of frogs may exceed that of reptiles or mammals in some Australian arid lands.

Although our observations indicate that there were many fewer adults than juveniles in the sand dunes, we have no quantitative data on which to base an estimate of adult *N. nichollsi* densities. However, it can be noted that a pit-trap study of frog densities in spinifex grasslands in the Tanami Desert of the Northern Territory (Morton et al. 1993) indicated that, where they occurred, adults of this species had densities in the range 1.4 to 14.3 per hectare. Such a range is not inconsistent with our very limited observations on adult frogs at Cravens Peak. Interestingly, no juvenile shovelfoots were encountered in the Tanami Desert study.

Whether the greater numbers of juveniles we found in sand dunes is in any way related to food availability is unclear. Predavec and Dickman (1993)) found that the gut contents of 24 specimens of *N. nichollsi* from nearby Ethabuka consisted almost entirely of termites (65%) and ants (34%). Ants were present in substantial numbers at night in both the sand dune and plains areas and were regularly caught in our pitfall traps and observed when spotlighting. However, no termites were ever observed in pitfall traps or while spotlighting and in the absence of information about the relative availability of this important component of the diet it is not possible to pursue this issue.

Since the survival of shovelfoots during extended dry periods depends upon their capacity to dig deep enough to find moist sand (Cartledge et al. 2006), it may simply be that the plains of Cravens Peak are less suited to this than the sand dunes. Accordingly, it is relevant to note that in setting out one of our pitfall lines in the plains habitat we encountered a thick (10 cm) layer of calcrete around 15 to 20 cm below the soil surface. This layer, which we could only break with a crowbar, would undoubtedly stop shovelfoots from digging deeper in pursuit of moisture as the upper layers of soil dry out. On the other hand, in the immediate aftermath of rainfall it might hinder the percolation of water into the soil and so, in the short term, produce a layer of moisture-rich sand just below the ground surface.

Diel activity and burrowing behaviour

Based on our observations most juveniles and adult shovelfoots were only active on the surface during the night hours. Like other desert anurans, shovelfoots are increasingly at risk of overheating and/or desiccation if they remain above ground once the sun rises (Warburg 1997). However, as there is no clear evidence that juveniles were more active in the first half of the night than in the second, it would seem that nightly air temperatures, which ranged between 35° C (around sunset) and 15° C (pre-sunrise) in the course of the night, had little influence on their pattern of nocturnal activity at this time of year. This is unsurprising as healthy specimens of *N. nichollsi* have been found in burrows at temperatures of 33.6° C (Slater and Main 1963), and sub-adult specimens of this species exhibit relatively low mass specific evaporative water loss (Withers 1998). Experimental studies indicate that juveniles have considerable capacity for surviving water loss (Main and Bentley 1964).

The shovelfoot trackways we observed suggested that juveniles may travel several metres each night while foraging, but we made no attempt to assess the length of particular trackways. However, using radiotelemetry, McMaster (2006) found that individuals inhabiting sand dunes south of Onslow in north-western Western Australia during the wet season, generally did not move great distances or move frequently; although individuals occasionally covered distances of up to 75 metres in 24 hours.

Our observations on burrowing behaviour are incomplete, but seem to provide new insights into the life style of *N. nichollsi*. Previous authors have not distinguished two conditions of burrow entrance. While this may reflect differences in soil conditions between Cravens Peak and elsewhere, we believe it largely reflects the fact that we were observing shovelfoots during a period of their life cycle when they were using shallow (less than 30 cm deep), temporary, non-aestivating burrows, whereas other authors (Slater and Main 1963; Paltridge and Nano 2001; Thompson et al. 2005; McMaster 2006) have been concerned with investigating shovelfoots that were inhabiting deep (50 – 240 cm), aestivating burrows that are occupied over many weeks. When shovelfoots on Cravens Peak Station move into their much deeper aestivation burrows, we expect that the 'entry' mounds with flat inner surfaces that we found (Figure 3, page 284) are likely to be replaced by ones with conical inner surfaces as a result of soil compaction down the length of a considerably longer burrow. Obviously, this expectation requires verification.

Most previous studies of the ecology of *N. nichollsi* have focused on the manner in which members of this species survive extended periods of drought and, to a lesser extent, on its breeding. Relatively little attention has been paid to the phase in the life cycle between metamorphosis and adulthood; although it is evident that considerable food must be consumed by the small (13-14 mm long and *c*. 1 gm weight) (Slater and Main 1963; Predavec and Dickman 1993) immediately post-metamorphic juveniles for them to grow into full-sized (60 –67 mm and 50 – 75 gm weight) (Predavec and Dickman 1993) adults.

Based on a careful analysis of metabolic data, McMaster (2006) has argued that specimens of *N. nichollsi* must emerge to feed and replenish fat stores every 5 to 6 months. She points out that this is less than the time elapsing between significant rainfall events in Australian deserts, and notes that desert shovelfoots have been observed to emerge and feed after very small (1 mm) rainfall during the dry season. Obviously, more frequent emergences would be needed if desert shovelfoots are to achieve even some moderate rate of growth.

An additional point made by McMaster (2006) is that specimens of *N. nichollsi* can potentially maintain water balance in sand dunes provided that the gravimetric water content of the sand is 1.2% or greater. This suggests that in situations where sand with a moisture content exceeding 1.2% lies close to the surface, desert shovelfoots do not need to burrow deeply. Thus, it is possible that members of this species can undertake nocturnal foraging from shallow burrows for some days after small, and several weeks after large, rainfall events, without putting their water balance at risk.

Observations bearing on this are quite limited, but we know from this study that one adult specimen and one juvenile specimen of *N. nichollsi* were positioned quite shallowly (20 to 30 cm) while we were on Cravens Peak Station, and we suspect that many other juveniles were also positioned quite close to the surface, although we have no real evidence for this. Furthermore, we know from the sand samples taken at different depths down through the crest of the dune at pitfall site 2 (Figure 4, page 285) that at, at least, one site the soil moisture at depths around 8 to 20 cm exceeded the level (1.2%) required for desert shovelfoots to maintain water balance. A similar elevation in soil moisture at shallow depth (40 cm) is evident in one of the soil moisture plots of shovelfoot burrows in the Gibson Desert in central Australia shown in Cartledge et al. (2006, fig. 1A)

How much these few observations reflect the broader picture for this species is unclear. Nevertheless, it is evident that under certain conditions this species could continue to forage above ground each night (or every few nights) over a considerably longer period following rainfall than has generally been appreciated. Provided that a desert shovelfoot can maintain water balance, and that the energy obtained during bouts of nocturnal foraging exceeds the total energetic cost of climbing out of a burrow, foraging and re-burrowing, it will be energetically beneficial for an individual to continue its nocturnal foraging. Of course the capacity of an individual to maintain water balance will depend upon the soil moisture profile and as a sand dune dries out an animal will likely have to spend longer underground re-hydrating between foraging bouts and/or burrow further down into the dune after each foraging bout. Accordingly, one might expect that in the weeks following a rainfall event individual shovelfoots will change from a pattern of frequent foraging (i.e. every night) to one of less frequent foraging (i.e. every second or third night) to allow sufficient time underground for re-hydration to occur. Clearly, these are issues that require further investigation.

If desert shovelfoots do employ a foraging strategy that involves the use of shallow burrows and foraging every night or every few nights in periods following rainfall, how often might individuals on Cravens Peak Station forage? This presumably depends not only upon the amount of rain that falls, but also on how recently it follows upon other falls. McMaster (2006) reports that during the wet season near Onslow in Western Australia, desert shovelfoots were observed foraging at night after rainfalls of less than 1 mm. Given this an examination of a decade of monthly rainfall records from Plum Pudding Bore (middle section of Figure 5), which lies around 15 to 20 km east of our pitfall sites, suggests that the shovelfoots in our study areas have had at least one extended opportunity for foraging each year over the past ten years, and that in most years they would have had one or two briefer foraging opportunities as well. Again these are matters requiring further investigation.

It should be noted that our interpretation of burrow usage and foraging in *N. nichollsi* shows some parallels to what is known of these matters in certain North American pelmobatid anurans of the genera *Scaphiopus* and *Spea*. For example, in south-eastern Arizona, the western spadefoot toad, *Spea hammondii*, remains underground throughout the long dry season (September to June), and only appears above ground during, and for a short period following, summer rains (Ruibal et al. 1969). In this area this species breeds in temporary water bodies that are filled by the first heavy rains of summer, which normally occur in early July, and after breeding moves away from these to inhabit desert grasslands and scrubs. During the period of lighter summer rains (later July and August) it uses quite shallow (1.3 to 4.9 cm) burrows during the day and emerges every few nights to forage. Once rainfall has ceased (September and October) it uses deeper (8 to 38 cm) burrows, and by late winter and early spring (February and March), by which time it evidently enters torpor, it is found in even deeper (28 – 91 cm) burrows.

A number of recent studies of Australian desert anurans have focused on the relative merit of cocoon-forming and non-cocoon-forming strategies for surviving periods of drought below ground. While cocoon formation has been shown to reduce moisture loss (Withers 1998) and allows burrowing frogs to use a wider variety of soil types as aestivation sites (McMaster 2006), it would seem not allow a burrowed animal to move underground in search of moister conditions, or to emerge rapidly from a state of reduced metabolism and move to the surface to take advantage of brief periods of moisture and food availability (McMaster 2006). Thus the lack of a cocoon may benefit desert shovelfoots in so far as it allows them to forage opportunistically after light, as well as heavy, rainfall.

Breeding and age structure

Although no courting shovelfoots or shovelfoot eggs were observed during our time on Cravens Peak Station, members of the earlier RGSQ party who visited Cravens Peak Station immediately prior to us identified and recorded vocalisations of this species within mixed choruses of frogs calling in ephemeral wetlands close to the homestead on the evening of 28th March 2007 (Gynther et al. 2009). These vocalisations suggest that breeding took place in these wetlands at that time; although this may have been somewhat limited if mature females in the area had already spawned as a result of the heavy rain of December 2006 (see Figure 5, page 291).

Whatever the situation in this wetland, the size of the two smallest juveniles that we encountered elsewhere on Cravens Peak during our visit suggest there was widespread breeding of shovelfoots on the property in the weeks immediately prior to our arrival. One of these, the unweighed animal found on the 18th April in the extensive, shallow wetland located north-north-east of 12 Mile Bore, was presumably the product of spawning that took place in this wetland. The other, the 2.5 gm juvenile removed from a pit fall trap line in sand dune habitat on the morning of 19th April, seems to have originated elsewhere. Topographic maps indicate that the point where this animal was trapped is separated from the wetland just mentioned by at least 15 km of dry country. Furthermore, these maps show that a sizeable ephemeral wetland lies about six km south of the pitfall trap line location and that a somewhat smaller ephemeral wetland lies about seven km east-north-east of this location. We consider these to be plausible sites for the spawning and larval development of this animal. It can be noted that the locations where these two small juveniles were encountered both lie more than 30 km from the wetland where members of the earlier RGSQ party heard shovelfoot vocalisations in late March.

Body size would seem to suggest that all of the juveniles we encountered in April were the products of spawnings that occurred in the summer of 2006–2007. Indeed, some of these animals were of a size (2.5 to 5.5 gm), would seem to indicate that they had only recently undergone metamorphosis. According to Main (1968), *N. nichollsi* can complete the larval phase in 16-30 days, which suggests that the substantial rain that fell on Cravens Peak Station on 24th March 2007 could have initiated the breeding events that produced these small animals. This is consistent with observations made by Predavec and Dickman (1993), on Ethabuka Station some eight km to the south, who report finding juveniles with a mean body weight of 3.6 gm two to three weeks after rain. However, an earlier spawning date would be involved if the larval phase extended over 60 days, as is indicated by Tyler (1992). Good rains also fell on Cravens Peak on 21st December 2006 and initiation of breeding at this time would be consistent with a longer larval phase.

The ages of the larger-bodied juveniles (9.5 to 11 gm) we encountered would seem to have been generally greater. Members of the earlier RGSO party encountered a number of juveniles of various sizes in late March (Hines pers. comm.). As all these animals were post-metamorphic, they cannot have been spawned in response to the rainfall of late March, but must have been the products of earlier breeding events. Based on their size, all these larger juveniles may have been the products of breeding that was initiated by the rain of 21st December 2006; although if this is so, then some members of this cohort achieved better than five-fold increases in post-metamorphic body mass in the course of three months.

As reported in the results, the eighteen juvenile animals we weighed on the 19th April showed no indication of a bimodal distribution in body size. This may be due to the small number of animals involved, but it may also reflect variation in the conditions of the temporary wetlands where these animals were spawned. The degree of crowding in spawning ponds has been shown to affect both the duration of the larval phase and body size at metamorphosis in the eastern spadefoot toad, *Scaphiopus holbrookii*, of North America (Semlitsch and Caldwell 1982), and these parameters are thought to be similarly influenced in the trilling frog, *Neobatrachus centralis*, of central Australia (Read 1999). Moreover, in *Neobatrachus centralis*, other spawning pond characteristics (water depth and presence/absence of vegetation) affect the speed of metamorphosis (Reed 1999). Accordingly, a fair degree of variation in body weight is to be expected amongst juvenile specimens of *N. nichollsi*, even when they are the products of contemporary spawning events.

An alternative approach to aging the shovelfoots we encountered on Cravens Peak, and one which seems to hold some potential for assessing the age of adult animals, involves examining rainfall records for the station and using these to assess the likelihood of breeding in a particular year. Such an approach is based in the first instance upon the fact that free water is required for breeding in *N. nichollsi*.

An examination of the lower section of Figure 5 (page 291), which shows yearly rainfall totals for Plum Pudding Bore over the decade June 1997 to July 2007, reveals that while substantial rain fell in 1999-2000 and 2000-2001, falls were substantially lower in other years, especially in 1988-1999, 2001-2002, 2003-2004, and 2005-2006. If total annual rainfall is a good indicator of breeding success, then large numbers of animals should have been recruited to the local population of *N. nichollsi* in the years 1999-2000 and 2002-2002, somewhat lower numbers recruited in 1997-1998, considerably lower numbers recruited in the years 2002-2003, 2004-2005 and 2006-2007, and few if any animals recruited in the lowest rainfall years of 1998-1999, 2001-2002, 2003-2004 and 2005-2006. From this perspective any of the animals we encountered that were not the products of breeding in the summer of 2006 or 2007, would seem to have been at least two years old (i.e. recruited in 2004-2005 or earlier).

The middle section of Figure 5 (page 291) shows monthly totals for the same decade. Evident in this are variation in both the monthly totals and the extent to which there was rain fall (or lack of it) over successive months. Monthly total rainfall should be a better indicator of the potential for breeding than total annual rainfall since it allows years when free water is likely to have remained long enough in ephemeral wetlands for larval development to have been completed (i.e. years when there was substantial rainfall in one month or in two consecutive months) to be distinguished from years of similar total rainfall when ephemeral wetlands are likely to have dried out before the completion of larval development due to the rainfall being dispersed in time (i.e. years when there were many small falls over several months, or moderate rainfalls on non-consecutive months). From this perspective 1997-1998, 1999-2000, 2000-2001, 2002-2003, 2004-2005, and 2006-2007 would seem to be years in which *N. nichollsi* might have bred on Cravens Peak, with the years 1999-2000 and 2000-2001 appearing especially suitable. This perspective also suggests that any animals we encountered that were not spawned in the summer of 2006-2007, would have been at least two years old.

In some desert anurans brief, intense storms seem to be required for breeding. Breeding is strongly associated with such events in the mainly desert-living, North American pelmobatids mentioned earlier. In most members of the genera *Scaphiopus* and *Spea* breeding follows, or coincides with, heavy seasonal rainfall that inundates previously empty depressions which are used for spawning. This is the case not only in the desert forms *Scaphiopus couchii* (Tinsley and Tocque 1999, Morey and Resnik 2004), *S. hurterii* (Bragg 1944), *Spea bombifrons* (Lauzon 1999), *S. hammondii* (Morey and Resnick 2004), and *S. multiplicata* (Dimmitt and Ruibal 1980), but is also true of *Scaphiopus holbrookii* (Pearson 1955, Hansen 1958), which inhabits less arid regions.

Bragg (1944) suggested that while breeding may be stimulated by heavy rainfall events in some of these species, in others storm violence may be more significant than the amount of rain that falls. More recent observations support his suggestion that features of storms other than the amount of rainfall may have a role in stimulating breeding. Thus, Dimmitt and Ruibal (1980) report that specimens of *S. multiplicata* sometimes leave their burrows after light rain and travel to dry breeding ponds ahead of these being filled by heavy rainfall events, and a recent study of *S. holbrookii* found the best predictors of breeding in this species to be heavy rains falling within a one-to three day period, maximum changes in barometric pressure, and an interaction between these two variables (Greenberg and Tanner 2004).

Occasional heavy rainfall events are evidently important for breeding in at least one Australian arid zone frog. Such events seem to have initiated each of the breeding events documented in Read's 11- year study of the population ecology of *Neobatrachus centralis* at Olympic Dam in central South Australia (Reed 1999); although it is unclear whether these rainfall events did anything more than provide access to free water.

At present there seems to be no evidence bearing directly on the question of whether breeding initiation in *N. nichollsi* requires brief, very heavy rainfall. A number of authors have made observations indicating that breeding in this species is always associated with

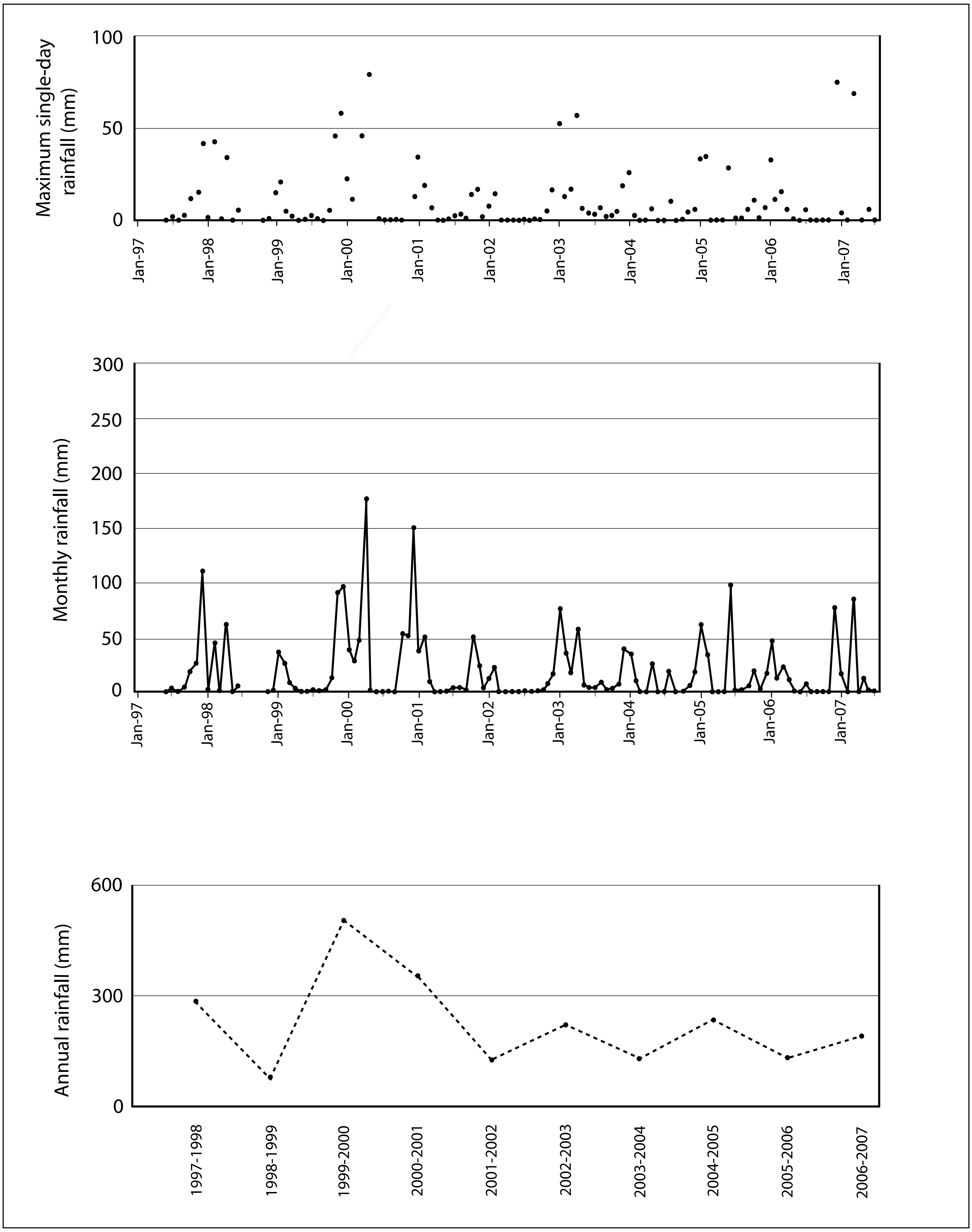

Figure 5. Rainfall recorded at Plum Pudding Bore between June 1997 and July 2007. The upper plot shows the maximum rainfall recorded in any single day for each month, and is complete, except that no values are available for the period July 1998 to October 1998 when the rain gauge was damaged. The middle plot shows the total rainfall recorded each month and is also complete, other than for the period July 1998 to October 1998. The lower plot shows total the rainfall recorded each year. Years that run from July one year to June the next are used because most rainfall events occurred in the summer months.

rainfall events (e.g. Slater and Main 1963, Predavec and Dickman 1993), but in no case do these observations suggest anything other than the need for access to free water, which could presumably be supplied by more extended, less heavy falls.

Nevertheless, it is interesting to examine what the requirement of a brief, very heavy rainfall event to initiate spawning might suggest about breeding by shovelfoots on Cravens Peak Station. The upper section of Figure 5 (page 291) shows the maximum amount of rain that fell in any single day for each month of the decade June 1997 to July 2007. It is evident when rainfall is assessed this way that days of very high rainfall were extremely rare at Plum Pudding Bore over this period. Indeed, on only six occasions in this decade were there days when the total precipitation exceeded 50 mm. One of these was in December 1999 (when 59.8 mm fell); the second was in April 2000 (79.8 mm); the third was in January 2003 (52 mm), the fourth was in April 2003 (57.2 mm), the fifth was in December 2006 (75.4 mm); and the sixth was in March 2007 (69.8 mm).

Accepting that heavy rainfall events are required to initiate breeding in *N. nichollsi*, our use of the maximum single-day-rainfall record to assess past breeding is dependent upon our ability to recognise suitably heavy rainfall events, and it is not obvious what these might be for this species. Read's consideration of demographic changes in *Neobatrachus centralis* (Read 1999) in relation to rainfall suggests that rainfall events exceeding 70 mm might be needed to initiate spawning in that species. While lesser amounts of rain in a single day might initiate breeding in shovelfoot frogs, it would seem (from the courtship vocalisations of *N. nichollsi* males heard by Gynther et al. (2009) near the station homestead four days after the downpour of 69.8 mm was recorded some 30 km away at Plum Pudding Bore) that falls of around 70 mm per day can probably be considered sufficient to elicit breeding behaviour in *N. nichollsi*.

Whether single day rainfalls lower than 70 mm might reasonably be considered sufficient to initiate breeding in *N. nichollsi* is unclear. Presumably the level that is sufficient to fill breeding ponds depends both on local topography and soil porosity. Morton et al. (1993) observed no breeding behaviour in a small number of adults of this species that emerged (along with numbers of adults of three other anuran species) in the Tanami Desert during, and immediately following, showers of rain that fell over a seven day period in March 1989. They indicate that daily falls of somewhat less than 50 mm occurred on the three or four days of heaviest rainfall so that their observations might suggest that falls greater than this are required. However, their account suggests that the falls they encountered were not adequate to produce more than momentary pools in that environment, so that the absence of breeding may have been due to a lack of free water, rather than the rainfall being insufficiently heavy.

If it is assumed that the lower limit of rainfall that will initiate breeding in *N. nichollsi*, is around 65 mm in a day, then over the decade June 1997 to July 2007 (Figure 5 upper section) there have been only three occasions when breeding would have been initiated in this species in the vicinity of Plum Pudding Bore. If this is the case, all the shovelfoots we encountered in our study area were the progeny of breeding events initiated in the summer of 2006-2007 (by the heavy rainfall events of 21st December 2006 and/or 24th March 2007), the progeny of breeding events initiated in autumn (April) 2000, or the progeny of breeding events initiated prior to June 1997. Based on their size, and the evidence that any April 2000 cohort would have had plenty of feeding opportunities in the period prior to 2006-2007 (see middle section of Figure 5), we believe it unlikely that any of the juveniles we encountered were the progeny of breeding events prior to the summer of 2006-2007. Thus under the assumption that breeding in *N. nichollsi* is initiated by heavy rainfall events involving falls exceeding 65 mm in one day, all the juveniles we encountered in April 2007 are identified as the progeny of the summer of 2006-2007, and each of the small number of adults we encountered is identified as being at least seven years old.

If the lower rainfall limit for the initiation of breeding is 50 mm per day, then (as indicated above) there have been six occasions over the decade when shovelfoots near Plum Pudding Bore might have bred. Under this scenario, for reasons already indicated, all the juveniles we encountered are still identified as progeny of breeding in the summer of 2006-2007. However, the few adults we encountered would likely have included some that were four years old, as well as others older than this. Under either scenario *N. nichollsi*, like the cocoon-forming *Neobatrachus centralis* (Read 1999), appears to breed only a few times per decade.

Morton et al. (1993), who found only adult frogs in their Tanami Desert study, were puzzled as to where the shovelfoots (and other frog species) they encountered bred. They suggested that breeding in these species must either be a very rare event (once every decade or so), occur in a few widely separated pools (with the frogs dispersing from these after maturing and returning to them when conditions allowed breeding), or involve use of partially terrestrial situations (such as sodden sub-surface sand). Both their first and second suggestions seem to hold true for *N. nichollsi* on Cravens Peak Station. Furthermore, we believe that our interpretations of the breeding requirements and growth rates of *N. nichollsi*, explain why these researchers did not encounter any juveniles of this species.

It is obvious that our inferences about the ages of the older shovelfoot frogs we encountered on Cravens Peak Station rest heavily upon the assumption that breeding in this species is induced by very heavy rainfall events, and that this has yet to be demonstrated. However, this assumption is open to investigation through comparisons of the timing of future breeding events in this species and of heavy rainfall events, and through comparisons of past rainfall records and of bone histology in this species (see Tinsley and Tocque 1995 and references therein).

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The jumping spiders (Salticidae: Araneae) found or predicted to be found on Cravens Peak Station

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Abstract A total of 45 lots containing 99 salticid specimens were collected. Fifteen species, (13 undescribed) were found. Seven of the eleven genera predicted to be present using BIOCLIM and museum data sets were found, while one genus of the eight predicted to be present in the general region but not on the station was also found. The four genera predicted but not collected were all likely to be ground dwellers and so their apparent absence, given the heavy flooding that had recently occurred, was not surprising. Only one unpredicted and little-known genera was collected, and this had not been included in the original BIOCLIM analysis due to lack of material in collections.

The value of collecting expeditions of this type is clearly shown in that the majority of salticid genera predicted to be present in the area were collected in the relatively short time period available.

Introduction

Jumping spiders, the salticids, are a diverse component of the Australian fauna, with over 350 species described and possibly a further 1000 species present (Richardson and Zabka, 2008). The family is found in all terrestrial and arboreal habitats throughout Australia. They are skilful jumpers that use their excellent vision to hunt in daylight. Richardson et al (2006) developed predictions of the geographical distributions of 51 jumping spider genera using the program BIOCLIM and site records for specimens. On the basis of this information they predicted the distribution of each genus by landscape regions (Bridgewater 1987). They suggested that "mapping genera rather than species allows all records for the genus, including those for undescribed species and for specimens not identified below genus level to be used. As a consequence, the distribution map will hopefully identify areas inhabited by undescribed, as well as known species." They proposed that a list of "genera can be obtained in advance to assist planning field work to these areas,[and] provide a more efficient starting point for management and conservation."

The aim of the work at Cravens Peak Station was to compare the set of genera actually collected during the study with the lists of genera predicted to be present in the surrounding regions by Richardson et al (2006), and the genera actually predicted to be found on the station (using the same methodology) to see if the predictions can provide useful lists of genera present in the absence of collection records for a site, as proposed by Richardson et al (2006).

As well, an examination of the distribution of specimens made by Richardson et al (2006; Figure 1) showed that very little collecting has occurred in most of inland Australia and consequently the aim was to improve the quality of collections to support management and conservation in these areas. The nearest specimens in the collections of ANIC and the Australian Museum were collected more than 200km from Cravens Peak Station.

Methods

Predicted distributions

Table 2 in Richardson et al (2006) was used to compile a list of genera found in the landscape Regions: Simpson, Thompson, Georgina and Cooper.

A set of 5556 locality records for specimens of salticid species from the Australian Museum, the Australian National Insect Collection and published records were used to predict the distributions of the 18 genera predicted to be found in the general area where locality records were well distributed and for which at least 6 (median 30) well distributed collecting localities were available.

The data on locality records was stored in BioLink (version 2.0; Shattuck & Fitzsimmon, 2002). The predicted distribution map for each genus was generated on the basis of its bioclimatic envelope, using the boxcar version of BIOCLIM available in BioLink. The use of BIOCLIM to examine the distribution of continental faunas can be found in Nix (1986), Lindenmayer et al. (1991) and Richardson et al (2006). The final maps were examined to see if the genera were likely to be present on Cravens Peak Station.

Field collecting

Collections were made between 11-23 April 2006 at 14 locations around the homestead and the three field camps at Salty Bore, S bend and Twelve Mile Bore. The collecting methods used were beating trees and shrubs, sweeping ground cover, shaking out upturned saltbush and searching through litter. The last two methods were quite unsuccessful, presumably due to the long drought and recent floods.

The specimens collected were returned to ANIC where they were identified to at least genus and added to the collection. In several cases material was too immature to allow identification even to this level.

Results

The genera predicted to be present in the surrounding landscape regions are listed in Table 1 (page 296). Of these, eleven genera (Table 1) were predicted to be present on, or close to, Cravens Peak Station. A total of 45 lots containing 99 specimens were added to the collection. Fifteen species, including 13 undescribed species, in the following eight genera (Table 1) were found:

- *Afraflacilla* Berland and Millot 1941

Several (perhaps five) species, none matching published descriptions. This was the most frequently collected genus.

- *Bianor* Peckham and Peckham 1886

Two species, neither matching published descriptions.

Table 1. Genera predicted using BIOCLIM to be found in bio-geographic regions surrounding Cravens Peak Station by Richardson and Zabka (2006), predictions of genera likely to be present on Cravens Peak Station obtained using BIOCLIM and genera found during the study on Cravens Peak Station.

Relevant genera	Predicted in Cravens Peak Station region	Predicted on Cravens Peak Station	Found on Cravens Peak Station
Afraflacilla	yes	yes	yes
Bianor	yes	no	yes
Clynotis	yes	no	no
Cosmophasis	yes	no	no
Cytaea	yes	nearby	yes
Damoetus	not modelled	nearby	yes
Gangus	yes	yes	no
Greyenulla	yes	no	no
Helpis	yes	no	no
Holoplatys	yes	yes	yes
Jotus	yes	no	no
Lycidas	yes	yes	probably
Maratus	yes	no	no
Myrmarachne	yes	yes	no
Ocrisiona	yes	no	no
Paraplatoides	yes	yes	yes
Simaetha	yes	yes	yes
Zenodorus	yes	nearby	no
Zebraplatys	yes	yes	no

• *Cytaea* Keyserling 1882
A large number of juvenile specimens of this genus were collected, along with several adults. They probably all belonged to one species. Similarly coloured specimens were previously collected in Pilbara (author, unpubl. data).

• *Damoetus* Peckham and Peckham 1886
Two or three species, including *D. nitidus*, the only described Australian species.

• *Holoplatys* Simon 1885
One species, the single specimen is immature but very distinctive. This genus, and *Paraplatoides*, are inhabitants of tree trunks where they live under the bark. Efforts to collect specimens by bark stripping were unsuccessful as there was very little activity on the trunks by any arthropod species

• *Lycidas* Karsch 1878
One immature specimen similar in form to members of this genus was collected. The genus occurs in litter but despite some searching, no litter other than recent flood debris was found.

• *Paraplatoides* Zabka 1992
One specimen was collected. While distinctive, it was most similar to *P. longulus*, originally collected near Winton.

• *Simaetha* Thorell 1881
Specimens of two species, *S. tenuior* and, possibly, *S. almadensis* were collected.

A summary of the numbers of genera predicted and observed at Cravens Peak station is given in Table 2 (page 297). Seven of the eleven predicted genera were found, while one genus of the eight predicted to be present in the general region but not on the station was found.

The four genera expected to be present but not collected were *Myrmarachne* Macleay 1839, *Gangus* Simon 1902, *Zebraplatys* Zabka 1992 and *Zenodorus* Peckham and Peckham, 1886. *Gangus*, and *Zebraplatys* are both grass living genera and their absence is not surprising, given the recent history of fire, drought and flood on the property. *Myrmarachne* and *Zenodorus*, though occasionally found on trees, are basically ground dwellers and so were also affected by the floods. *Zenodorus* was not actually predicted to present on the property.

The genus *Bianor* was found but not predicted to be present on the station, though it was predicted to be present in surrounding regions. Figure 1 (page 298) shows the change in predicted distribution of *Bianor* caused by the addition of specimens from Cravens Peak station. As well as areas north of the Simpson Desert, the predicted distribution of the genus in the Pilbara and other areas of WA is extended.

The genus *Damoetus* is an ant mimic known from only a few sites. Because of the paucity of data it was not modelled by Richardson et al (2006) and so not included in the original list of genera considered. When modelled, even with the limited data available, it was predicted to be near but not on Cravens Peak station.

Discussion

The addition of material from Cravens Peak station to the national collection has significantly improved our capacity to predict the distribution of salticid genera because it adds material from a bio-climatically distinctive region. Never-the-less the capacity of present collections to predict the genera likely to be present shows the value of the technique in supporting conservation and management decisions. Only one unpredicted genera was collected, and this had not been included in the original analysis due to lack of specimens in museum collections. The four genera predicted to be present but not collected will probably all be found eventually as their absence from the field collection can be explained on the basis of recent extreme weather conditions.

Richardson et al (2006) suggest that predicting the distribution of genera, rather than known species is the best approach in poorly known groups. This is supported by the present study which shows that most of the species found are undescribed and so their presence would not be predicted using species level analyses. As members of known genera,

Table 2. Of the genera predicted to be found in the surrounding landscape regions, those predicted and found or not found on the property.

Predicted	Found	Not found
Yes	4 (5)	3
Nearby	2	1
No	1	7

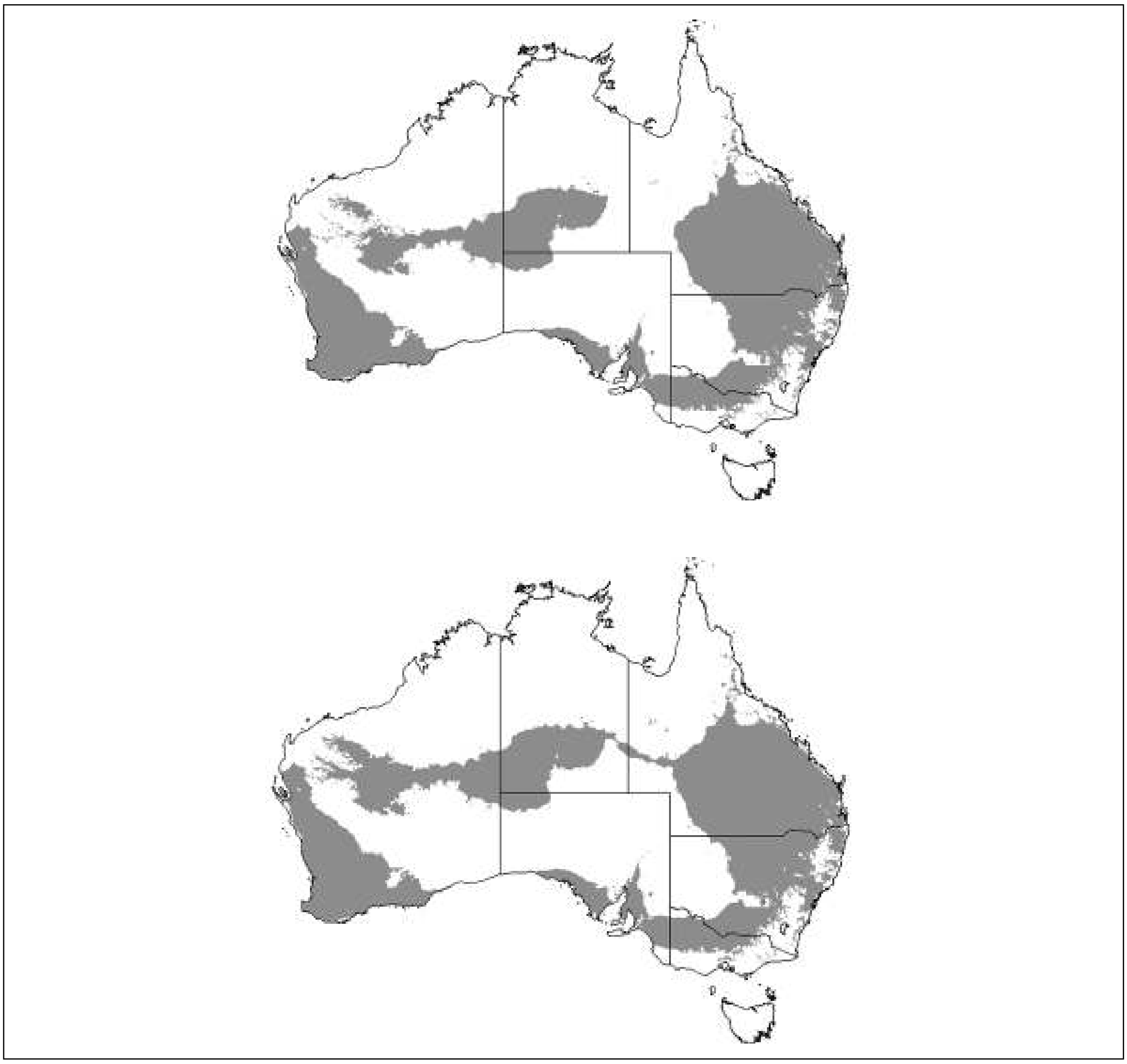

Figure 1.
A (top): The predicted distribution of the genus *Bianor* based on previous records.
B (bottom): The predicted distribution of *Bianor* based on previous records plus those from Cravens Peak station.

however they were predicted to be present on or very near Cravens Peak station.

It is noteworthy that, even a short, one-off, field expedition of this type collected most of the salticid genera predicted to be present in the area.

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Tribulus hystrix (Sandhill puncture vine). Gwenda White

Vascular plants collected during the Cravens Peak Scientific Study, 2nd–7th April 2007

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Nomenclature follows that of the Queensland Herbarium, Census of the Queensland Flora 2007.

Abstract A plant collection was undertaken over 6 days at Cravens Peak station, 194 km by road south west of Boulia, Queensland. An annotated checklist of the flora is provided. 326 specimens of 224 species were collected and lodged in the Queensland Herbarium. *Bergia henshallii* was collected in Queensland for the first time and *Brachyscome tesquorum* for the second time.

Introduction

Many parts of Queensland remain poorly explored botanically. This statement can be especially applied to large areas of western Queensland. Prior to the current study, the Queensland Herbarium had no specimens recorded from Cravens Peak. Of the 400 records from a 15,000 km^2 area surrounding Cravens Peak, most were collected by R.W. Purdie from Glenormiston and Carlo holdings during the Western Arid Land Use Surveys of the late 1970s. The locality descriptions, especially for old records, are imprecise with a spatial precision of 1,600m or greater (Queensland Herbarium 2007). The 326 specimens collected during the survey all have a spatial accuracy of 100m or less.

Climate

The plants and vegetation at Cravens Peak are defined almost exclusively by the climate. Cravens Peak is situated in the arid zone of Australia and is characterised by low and extremely variable rainfall. The average annual rainfall is less than 200mm.

Summers are hot and dry, with average daily maximum temperatures between 30°C—33°C. Winters are mild with average daily minimums of between 15°C—18°C. The average annual evaporation is between 3200 and 3600mm (Bureau of Meteorology 2008).

Flora

The plants in this region can be divided into 3 main groups (namely ephemerals, short lived perennial herbs/woody forbs and woody perennials) (Purdie in Wilson et al 1990), with a number of adaptations enabling them to tolerate, or to avoid the predominantly extreme climatic conditions.

After brief periods of high soil moisture, ephemeral herbs (e.g. many daisies, legumes, sedges and grasses) germinate, mature and set seed which then remains dormant in the soil until the next set of favourable conditions. These ephemeral herbs can be considered to 'avoid' the usual field conditions of drought and extreme temperatures.

Short lived perennials have features such as tubers, rhizomes, deep tap roots and strongly tufted root systems, enabling regeneration following the death of the above ground parts. These perennials are able to 'tolerate' field conditions of extreme temperatures and erratic rainfall to a certain degree, notably by shedding top growth and re-shooting from the subterranean organs. Eventually if drought conditions persist, they 'avoid' the available environment entirely by persisting only in the soil seed bank.

Woody perennials (e.g. eucalypts, wattles, Eremophilas) have tough, desiccation resistant foliage, or are able to survive in a leafless state. These persistent plants can be considered to 'tolerate' the field conditions, although they may gain little in top growth and lose much of their foliage during drought. In very dry periods, even individuals of these plants may die,

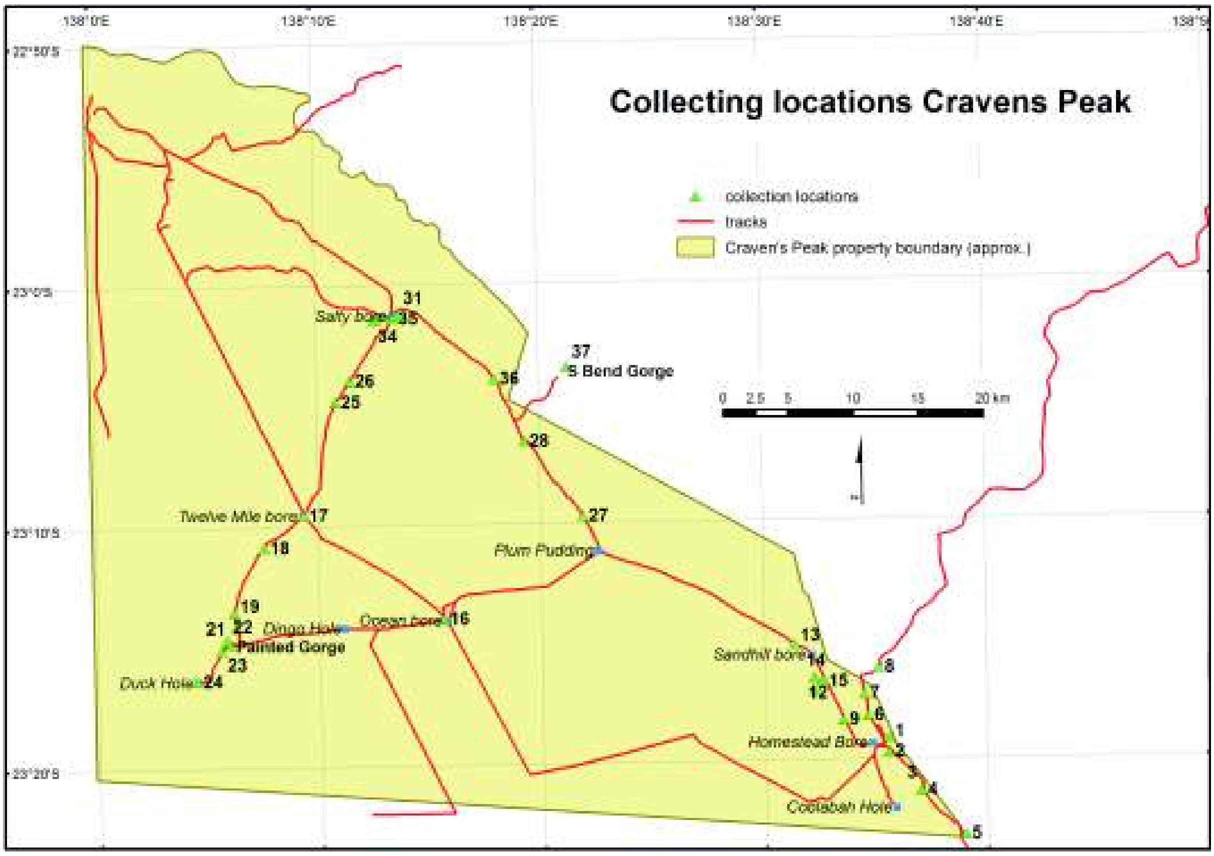

Figure1. Collecting sites at Cravens Peak—cartography by Rosemary Niehus.

often triggering a transition to a different plant community or at least an earlier seral stage.

Methodology

Because of recent storms, access to Cravens Peak was not possible until 1st April due to impassable roads and flooding in the Mulligan River. This restricted the total time available for collecting and surveying to six days. Not withstanding these constraints, as many different vegetation types and regional ecosystems as possible were surveyed. From the homestead, two days intensive collecting was undertaken, north to Sandhill Bore and south to the Carlo boundary (see Figure 1, page 302). From a camp at Twelve Mile Bore two days collecting were conducted, mainly in the Painted Gorge area with only a brief excursion north on the track to Salty Bore to the point where it became impassable. From Salty Bore, one day was spent on the tops and sides of the hard residuals and along the water course within walking distance of the bore, there being no vehicular access beyond. The final day was spent in transit back to the homestead with a stop between Salty Bore and S Bend Gorge and on the top and escarpment slope at S Bend Gorge on the Mulligan River. See Figure 1 (page 302) for collection sites.

Results and Discussion

The species collected were predominantly ephemeral herbs (85 species/38%) and, short lived perennial herbs/woody forbs (103 species/46%), with relatively few woody perennials (36 species/17%). Table 1 (below) shows the taxonomic breakdown for the species.

	No. families	No. genera	No. species
Dicotyledons	43	94	161
Monocotyledons	2	34	57
Pteridophyta	2	2	6
Total	47	130	224

Table 1. Distribution of the species collected, in the major plant groups

The year of survey was one of above average rainfall. In the months preceding the survey, Glenormiston Station (50km NNE) recorded 260mm in January with a further 70mm in March. This resulted in ideal conditions for plant collecting. Summer rainfall favours growth of grasses, (Poaceae) and Summer/ Winter rain, chenopods (Chenopodiaceae) and legumes (Fabaceae) (Purdie in Wilson et al. 1990). One third of species collected at Cravens Peak were in these 3 families, as shown in Table 2 (below).

Family	Number of Species
Poaceae	45
Fabaceae	17
Chenopodiaceae	13
Cyperaceae	12
Malvaceae	11
Amaranthaceae	10
Asteraceae	10

Table 2. Families with 10 or more species collected.

A collection of significance was *Bergia henshallii*, a new record for Queensland. This species is a small mat forming herb and was found growing in silt on the edge of an ephemeral lake. It is known to be widespread in the Northern Territory in this habitat and also occurs in Western Australia. (Australia's Virtual Herbarium 2008)

The other significant species collected was *Brachyscome tesquorum* a soft herbaceous daisy with pale blue flowers. It is listed as Rare under the Queensland Nature Conservation (Wildlife) Regulations 2006. The collection of this species is the second record for Queensland. While it is reasonably widespread in central Australia it reaches the eastern edge of its known range at Cravens Peak and Glenormiston.

The flora in areas surveyed contained very few introduced species. Only seven non native species were recorded and none of these was observed in overwhelming proportions including *Pennisetum ciliare* (Buffel grass).

Acknowledgements

We thank Bush Heritage Australia for allowing access to Cravens Peak reserve and acknowledge the excellent planning and organisation of the scientific study by the Royal Geographic Society of Queensland. The facilities, meals and support of the volunteers enabled us to make the best use of the time available and we are most grateful for this. Thanks also to Dr Paul Forster for comments on the manuscript.

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http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/evaporation.cgi Viewed September 2008

http://www.rbg.vic.gov.au/avh/ Viewed September 2008

Appendix 1. List of plants collected at Cravens Peak

Family	Species	Life form
Acanthaceae	*Dipteracanthus australasicus*	H
Acanthaceae	*Rostellularia adscendens*	P
Adiantaceae	*Cheilanthes brownii*	E
Adiantaceae	*Cheilanthes sieberi* subsp. *seeberi*	E
Aizoaceae	*Trianthema pilosa*	P
Aizoaceae	*Trianthema triquetra*	H
Aizoaceae	*Zaleya galericulata*	H
Amaranthaceae	*Alternanthera angustifolia*	H
Amaranthaceae	*Alternanthera nodiflora*	E
Amaranthaceae	*Amaranthus interruptus*	H
Amaranthaceae	*Amaranthus mitchellii*	E
Amaranthaceae	*Gomphrena lanata*	E
Amaranthaceae	*Ptilotus exaltatus*	H
Amaranthaceae	*Ptilotus helipteroides*	H
Amaranthaceae	*Ptilotus obovatus*	P
Amaranthaceae	*Ptilotus polystachyus* forma *polystachyus*	H
Amaranthaceae	*Ptilotus schwartzii*	H
Apiaceae	*Trachymene glaucifolia*	E
Apocynaceae	*Marsdenia australis*	V
Apocynaceae	*Sarcostemma brevipedicellatum*	S
Asteraceae	**Bidens pilosa*	E
Asteraceae	*Brachyscome tesquorum*	H
Asteraceae	*Calotis erinacea*	P
Asteraceae	*Calotis porphyroglossa*	E
Asteraceae	*Centipeda minima* subsp. *minima*	E
Asteraceae	*Pluchea rubelliflora*	P
Asteraceae	*Rutidosis helichrysoides*	E
Asteraceae	*Streptoglossa adscendens*	E
Asteraceae	*Streptoglossa bubakii*	P
Asteraceae	* *Xanthium occidentale*	E
Boraginaceae	* *Heliotropium curassavicum*	H
Boraginaceae	*Heliotropium moorei*	P
Boraginaceae	**Heliotropium supinum*	P
Boraginaceae	*Heliotropium tanythrix*	P
Boraginaceae	*Trichodesma zeylanica*	E
Brassicaceae	*Lepidium phlebopetalum*	E
Byttneriaceae	*Keraudrenia nephrosperma*	S
Caesalpiniaceae	*Senna artemisioides* subsp. *artemisioides*	S
Caesalpiniaceae	*Senna artemisioides* subsp. *oligophylla*	S
Caesalpiniaceae	*Senna artemisioides* subsp. *petiolaris*	S

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Family	Species	Life form
Campanulaceae	*Wahlenbergia tumidifructa*	E
Caryophyllaceae	*Polycarpaea breviflora*	H
Chenopodiaceae	*Atriplex elachophylla*	E
Chenopodiaceae	*Atriplex limbata*	H
Chenopodiaceae	*Chenopodium auricomum*	S
Chenopodiaceae	*Chenopodium desertorum* subsp. *anidiophyllum*	H
Chenopodiaceae	*Enchylaena tomentosa*	P
Chenopodiaceae	*Maireana coronata*	H
Chenopodiaceae	*Maireana dichoptera*	E
Chenopodiaceae	*Maireana georgei*	S
Chenopodiaceae	*Salsola kali*	H
Chenopodiaceae	*Sclerolaena bicornis* var. *horrida*	H
Chenopodiaceae	*Sclerolaena convexula*	H
Chenopodiaceae	*Sclerolaena glabra*	E
Chenopodiaceae	*Sclerolaena muricata*	H
Cleomaceae	*Cleome viscosa*	H
Convolvulaceae	*Convolvulus clementii*	H
Convolvulaceae	*Cuscuta victoriana*	P
Convolvulaceae	*Evolvulus alsinoides* var. *villosicalyx*	H
Convolvulaceae	*Ipomoea muelleri*	H
Convolvulaceae	*Ipomoea plebeian*	H
Convolvulaceae	*Ipomoea polymorpha*	E
Convolvulaceae	*Ipomoea racemigera*	H
Cucurbitaceae	*Austrobryonia micrantha*	H
Cucurbitaceae	*Cucumis melo* subsp. *agrestis*	E
Cyperaceae	*Abildgaardia vaginata*	H
Cyperaceae	*Bulbostylis barbata*	H
Cyperaceae	*Cyperus castaneus*	E
Cyperaceae	*Cyperus cunninghamii*	H
Cyperaceae	*Cyperus difformis*	E
Cyperaceae	*Cyperus iria*	E
Cyperaceae	*Cyperus tenuispica*	E
Cyperaceae	*Cyperus victoriensis*	P
Cyperaceae	*Eleocharis pallens*	H
Cyperaceae	*Fimbristylis dichotoma*	H
Cyperaceae	*Schoenoplectus dissachanthus*	H
Cyperaceae	*Schoenoplectus lateriflorus*	H
Droseraceae	*Drosera angustifolia*	E
Elatinaceae	*Bergia ammannioides*	E
Elatinaceae	*Bergia henshallii*	E

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Family	Species	Life form
Elatinaceae	*Bergia pedicellaris*	E
Euphorbiaceae	*Chamaesyce biconvexa*	H
Euphorbiaceae	*Chamaesyce centralis*	E
Euphorbiaceae	*Chamaesyce drummondii*	E
Euphorbiaceae	*Euphorbia tannensis* subsp. *eremophila*	E
Fabaceae	*Aeschynomene indica*	H
Fabaceae	*Crotalaria medicaginea*	P
Fabaceae	*Crotalaria smithiana*	P
Fabaceae	*Cullen cinereum*	H
Fabaceae	*Glycine canescens*	V
Fabaceae	*Indigastrum parviflorum*	P
Fabaceae	*Indigofera colutea*	E
Fabaceae	*Indigofera hirsuta*	H
Fabaceae	*Indigofera linifolia*	E
Fabaceae	*Indigofera linnaei*	E
Fabaceae	*Swainsona canescens*	H
Fabaceae	*Swainsona microphylla*	E
Fabaceae	*Swainsona oroboides*	H
Fabaceae	*Swainsona phacoides*	H
Fabaceae	*Tephrosia* sp. (Glenormiston R.W.Purdie 1362)	P
Fabaceae	*Tephrosia supina*	P
Fabaceae	*Vigna lanceolata* var. *lanceolata*	E
Frankeniaceae	*Frankenia serpyllifolia*	P
Goodeniaceae	*Goodenia fascicularis*	H
Goodeniaceae	*Goodenia lunata*	H
Goodeniaceae	*Goodenia* sp.	H
Goodeniaceae	*Goodenia vilmoriniae*	H
Goodeniaceae	*Scaevola depauperata*	S
Haloragaceae	*Haloragis gossei*	E
Lamiaceae	*Teucrium* sp.	H
Loranthaceae	*Amyema maidenii* subsp. *maidenii*	M
Loranthaceae	*Lysiana subfalcata*	M
Lythraceae	*Ammannia multiflora*	E
Lythraceae	*Rotala diandra*	E
Malvaceae	*Abutilon macrum*	P
Malvaceae	*Abutilon malvifolium*	E
Malvaceae	*Abutilon otocarpum*	P
Malvaceae	*Gossypium australe*	S
Malvaceae	*Hibiscus burtonii*	P
Malvaceae	*Hibiscus sturtii*	P

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Family	Species	Life form
Malvaceae	**Malvastrum americanum*	H
Malvaceae	*Sida corrugata*	H
Malvaceae	*Sida platycalyx*	E
Malvaceae	*Sida rohlenae*	H
Malvaceae	*Sida* sp. (Musselbrook M.B.Thomas + MRS 437)	H
Marsileaceae	*Marsilea costulifera*	E
Marsileaceae	*Marsilea drummondii*	E
Marsileaceae	*Marsilea exarata*	E
Marsileaceae	*Marsilea hirsuta*	E
Meliaceae	*Owenia acidula*	T
Mimosaceae	*Acacia ancistrocarpa*	S
Mimosaceae	*Acacia aneura*	S
Mimosaceae	*Acacia bivenosa*	S
Mimosaceae	*Acacia coriacea* subsp. *Sericophylla*	T
Mimosaceae	*Acacia cyperophylla*	T
Mimosaceae	*Acacia dictyophleba*	S
Mimosaceae	*Acacia georginae*	T
Mimosaceae	*Acacia stipuligera*	S
Mimosaceae	*Acacia stowardii*	S
Myoporaceae	*Eremophila cordatisepala*	S
Myoporaceae	*Eremophila freelingii*	S
Myoporaceae	*Eremophila latrobei* subsp. *glabra*	S
Myoporaceae	*Eremophila longifolia*	S
Myoporaceae	*Eremophila obovata* subsp. *obovata*	S
Myrtaceae	*Corymbia terminalis*	T
Myrtaceae	*Eucalyptus camaldulensis*	T
Myrtaceae	*Eucalyptus coolabah*	T
Myrtaceae	*Eucalyptus pachyphylla*	T
Nyctaginaceae	*Boerhavia burbidgeana*	E
Nyctaginaceae	*Boerhavia pubescens*	E
Phyllanthaceae	*Sauropus trachyspermus*	E
Poaceae	* *Pennisetum ciliare*	P
Poaceae	*Aristida anthoxanthoides*	H
Poaceae	*Aristida contorta*	H
Poaceae	*Aristida holathera* var. *holathera*	H
Poaceae	*Aristida hygrometrica*	E
Poaceae	*Aristida inaequiglumis*	H
Poaceae	*Chloris pectinata*	E
Poaceae	* *Chloris virgata*	H
Poaceae	*Chrysopogon fallax*	P

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Family	Species	Life form
Poaceae	*Dactyloctenium radulans*	E
Poaceae	*Dichanthium sericeum* subsp. *humilis*	H
Poaceae	*Elytrophorus spicatu*	E
Poaceae	*Enneapogon cylindricus*	H
Poaceae	*Enneapogon polyphyllus*	H
Poaceae	*Eragrostis confertiflora*	E
Poaceae	*Eragrostis cumingii*	E
Poaceae	*Eragrostis exigua*	E
Poaceae	*Eragrostis leptocarpa*	H
Poaceae	*Eragrostis pergracilis*	E
Poaceae	*Eragrostis setifolia*	P
Poaceae	*Eragrostis speciosa*	H
Poaceae	*Eragrostis tenellula*	E
Poaceae	*Eriachne aristidea*	E
Poaceae	*Eriachne mucronata*	P
Poaceae	*Eriachne pulchella* subsp. *Pulchella*	E
Poaceae	*Eulalia aurea*	H
Poaceae	*Iseilema membranaceum*	E
Poaceae	*Leptochloa fusca* subsp. *muelleri*	H
Poaceae	*Paractaenum refractum*	E
Poaceae	*Paraneurachne muelleri*	H
Poaceae	*Paspalidium rarum*	E
Poaceae	* *Pennisetum ciliare*	P
Poaceae	*Perotis rara*	E
Poaceae	*Schizachyrium fragile*	E
Poaceae	*Setaria surgens*	E
Poaceae	*Sporobolus australasicus*	E
Poaceae	*Sporobolus caroli*	H
Poaceae	*Tragus australiensis*	E
Poaceae	*Triodia basedowii*	P
Poaceae	*Tripogon loliiformis*	E
Poaceae	*Triraphis mollis*	H
Poaceae	*Urochloa piligera*	E
Poaceae	*Urochloa praetervisa*	E
Poaceae	*Urochloa subquadripara*	E
Poaceae	*Yakirra australiensis* var. *australiensis*	E
Poaceae	*Zygochloa paradoxa*	P
Portulacaceae	*Calandrinia ptychosperma*	E
Portulacaceae	*Calandrinia pumilio*	E
Portulacaceae	*Calandrinia* sp.	E

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Family	Species	Life form
Portulacaceae	*Portulaca australis*	E
Portulacaceae	*Portulaca oleracea*	E
Proteaceae	*Grevillea stenobotrya*	S
Proteaceae	*Hakea eyreana*	S
Rubiaceae	*Psydrax ammophila*	S
Rubiaceae	*Spermacoce auriculata*	H
Rubiaceae	*Synaptantha tillaeacea* var. *tillaeacea*	E
Santalaceae	*Exocarpos sparteus*	S
Santalaceae	*Santalum lanceolatum*	S
Sapindaceae	*Dodonaea viscosa* subsp. *angustissima*	S
Scrophulariaceae	*Glossostigma cleistanthum*	E
Scrophulariaceae	*Mimulus prostratus*	H
Scrophulariaceae	*Peplidium* sp.	E
Scrophulariaceae	*Stemodia florulenta*	P
Scrophulariaceae	*Stemodia glabella*	H
Solanaceae	*Nicotiana megalosiphon* subsp. *sessiliflora*	H
Solanaceae	*Nicotiana occidentalis* subsp. *obliqua*	H
Solanaceae	*Solanum chenopodinum*	H
Solanaceae	*Solanum esuriale*	E
Solanaceae	*Solanum quadriloculatum*	H
Stackhousiaceae	*Stackhousia viminea*	H
Violaceae	*Hybanthus aurantiacus*	P
Zygophyllaceae	*Tribulopis angustifolius*	E
Zygophyllaceae	*Tribulus cistoides*	E
Zygophyllaceae	*Tribulus hystrix*	E
Zygophyllaceae	*Tribulus terrestris*	E

E—ephemeral herb
H—annual or short lived perennial herb
P—woody perennial forb, subshrub, or long lived perennial graminoid
S—shrub
T—tree
M—mistletoe
V—vine
* non native species (7)
Additional collectors for the survey—Gwenda White (3), Rod Fensham (6) & Eric Anderson (1)

Abutilon leucopetalum with *Agrius* sp (Desert Chinese Lantern with two Hawk moths).
Gwenda White

A vegetation communities and regional ecosystem survey and mapping of Cravens Peak

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Abstract A Vegetation Communities and Regional Ecosystem Survey and Mapping of the Cravens Peak property were carried out from the 2nd April to 7th April 2007 as part of the Cravens Peak Scientific Study. The scientific study, organized by The Royal Geographic Society of Queensland, included a multi-disciplinary team consisting of botanists, geologists and zoologists. Within the study area, twenty two Regional Ecosystems (RE) covering four Land Zones have been identified and described. The Vegetation Management Act status (December 2005) and Biodiversity status of twenty one of the twenty two RE within Cravens Peak is listed as 'Not of Concern' (NC), the exception being RE 5.3.20 which is listed as 'Of Concern' (OC). Most of the RE have low or no representation in reserves or protected areas within the Channel Country bio-region.

Introduction

Cravens Peak Station is situated 190km south west of Boulia, in far western Queensland and is on the Mt Whelan 1:250,000 mapsheet and part of the Glenormiston 1:250,000 mapsheet. Cravens Peak Station has been bought by Bush Heritage Australia; it is the largest of all their reserves covering an estimated 228,812ha. It extends from the Mulligan River gravelly plains and parts of Toko and Tooma Ranges south to the Simpson Desert dune fields. The landscape includes desert dunes, ancient low ranges, grasslands and woodland plains.

The vegetation and mapping survey reported here was undertaken as part of the Cravens Peak Scientific Study, which included a multi-disciplinary team consisting of botanists, geologists and zoologists. The scientific study, organized by The Royal Geographic Society of Queensland, was undertaken over 6 days from 2nd April to 7th April 2007.

Previous mapping of the area had been carried out by the Queensland Department of Primary Industries Western Arid Land Use Study (Part VI) that commenced in 1969 (Wilson and Purdie1990) This was followed by the Queensland Herbarium Vegetation Mapping project of Queensland at a scale of 1:100 000 with compilation at 1:250 000 scale (Neldner 1991).

Since 1997, the Queensland Herbarium has developed a Regional Ecosystems (RE) framework that is now the statewide standard for the mapping and classification of vegetation systems across Queensland (Sattler and Williams 1999). Queensland Herbarium Vegetation maps compiled prior to 1999 have since been assigned to regional ecosystems by Queensland Herbarium staff.

The aim of the study was to obtain detailed field site data and to use this data to revise and improve the existing RE map coverage and descriptions.

Methods

Field sampling

Sampling methods described by Neldner et al. (2004) were used for the survey. Two types of sampling sites were recorded during the survey, observational quaternary sites and more detailed secondary sites. A global positioning system (GPS) was used to record the location of all sites to an accuracy of ± 10m.

Secondary sites are used to classify and provide detailed descriptions of regional ecosystems and vegetation communities. 10 x 50m plots were used. The data collected included overall structural information, a list of all species present, projective foliage cover and basal area of tree layer as well as location, soil, landform and aspect. For more details, see Neldner et al. (2004).

Because of time restrictions, recent wet weather and impassable roads, only a total of seven detailed sites were recorded, with only three sites actually on the Cravens Peak property. Site data are stored on CORVEG, which is a Queensland Herbarium database for field data.

Quaternary sites are used to ground truth the maps. Dominant vegetation species and landscape types are recorded at regular intervals while traversing along tracks, and/or at boundaries of regional ecosystems and vegetation community change. A total of 661 quaternary sites were recorded and the data entered onto an Excel spreadsheet and imported into the Queensland Herbarium database.

Regional ecosystems mapping

The vegetation map of the study area was prepared by a revision of the mapping by Neldner (1991). Polygons on the map were delineated using Mt Whelan 1:80,000 black and white aerial photographs (1969). Polygons or unique mapping areas (UMA's) are derived by viewing pairs of aerial photographs under a stereoscope allowing a three dimensional view of the landscape and vegetation. The UMA's are delineated using fine pointed overhead projection pens onto clear plastic overlays attached to the aerial photographs showing areas of similar photo-pattern, such as texture and tone, colour, height of vegetation and landform. Satellite imagery at various dates (2003, 2004, and 2005) and the Mt Whelan 1:250,000 geology map (1969) were used also, in combination with the field data obtained during the survey and previous mapping data. The GIS program ARCinfo and Arcmap (ESRI (2008) was used to digitise linework and manipulate data.

Results

Regional ecosystems

Regional ecosystems are vegetation communities which are consistently associated with a particular combination of geology, landform and soil (Sattler and Williams 1999). As described in the Regional Ecosystem Description Database (REDD) (EPA 2005), regional ecosystems are based on a hierarchy representing bio-region, land zone (simplified geology/substrate classification for Queensland) and vegetation (denotes different vegetation types), and is reflected in a three part number. Bio-regions are the biogeographic regions in which the RE are found with Queensland having 13 bio-regions (numbered 1 to 13). For example, 5.3.3 is in the Channel Country (bio-region 5), occurs on alluvia (landzone3), and is dominated by *Eucalyptus camaldulensis* (River red gum vegetation community 3).

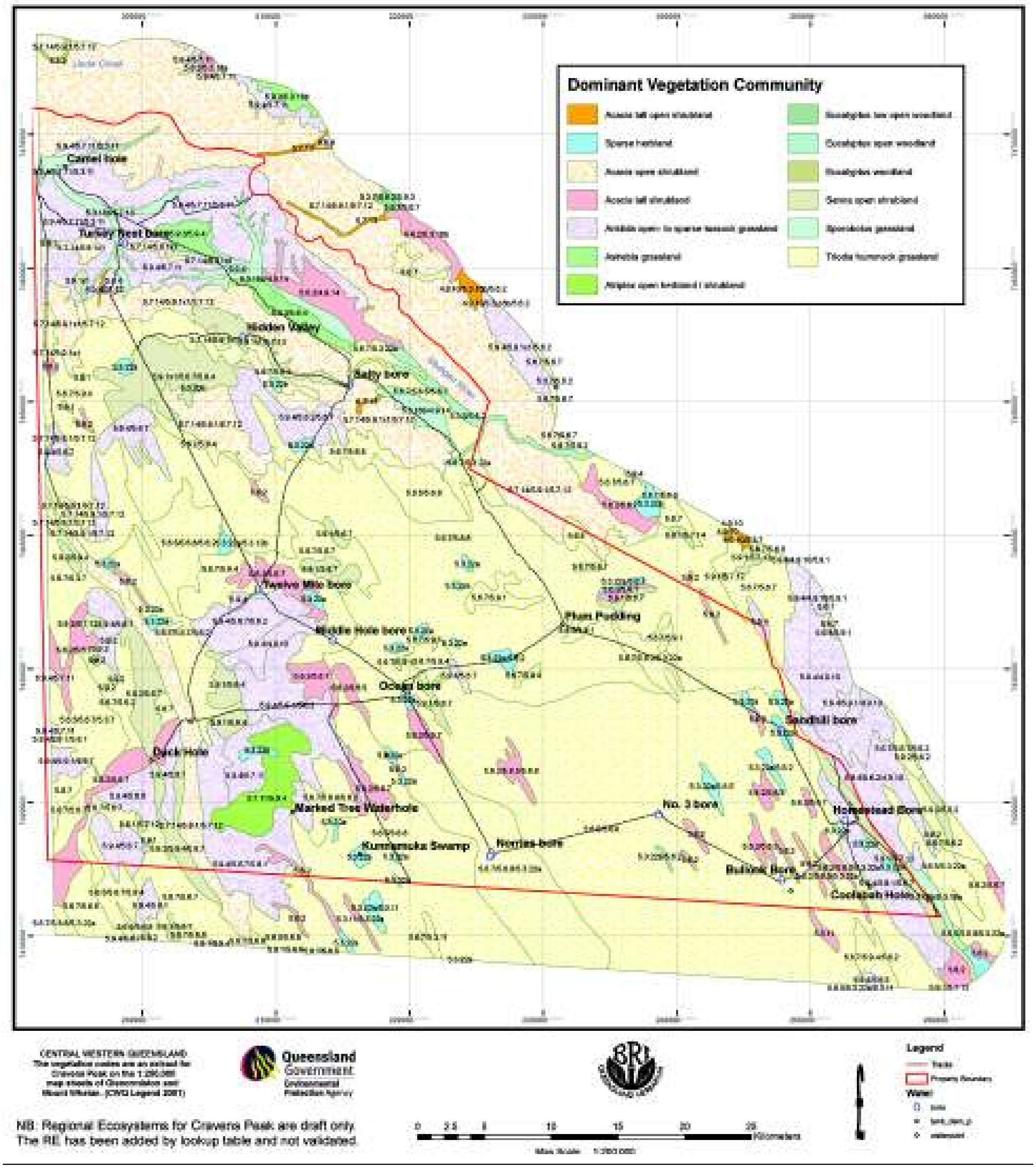
Most of the RE in the Cravens Peak study area are in heterogeneous polygons (see map, page 313). Heterogeneous polygons are used where two or more ecosystems are present but are unable to be mapped separately at a 1:100,000 scale (Bean et al. 1998).

The twenty two regional ecosystems described in Appendix 1 (page 318) cover four land zone types within the Cravens Peak area. Listed below are the abbreviated descriptions of the regional ecosystems as described in the Regional Ecosystem Database (REDD) (EPA 2004) and their extent and percentage of the study area (see Appendix 1, page 318 for detailed list).

The *Triodia basedowii* hummock grassland with *Eucalyptus pachyphylla* on sand plains and dune fields (5.6.7) covers the largest area (64675 Ha) followed by *Triodia basedowii* hummock grassland on or between dunes (5.6.5) and *Zygochloa paradoxa* ± *Triodia basedowii* open grassland on sand dunes (5.6.8) with 37526 Ha and 28804 Ha respectively. The least area covered is *Eucalyptus coolabah* ± *E. camaldulensis* open woodland fringing billabongs and permanent waterholes (5.3.20) with 23 Ha. Two of the RE in the study area *Acacia georginae* tall open shrubland on Cambrian limestone (4.9.10) and *Acacia georginae* low open woodland with *Astrebla* spp. on Cambrian limestone (4.9.14) are outliers of the Mitchell Grass Downs bioregion. Outliers are described as RE that do not match a description of a RE in the bioregion in which it occurs, but matches the definition of an RE in an adjacent bioregion (Neldner et al. 2004) (see Table 1, page 314).

Ten RE are important habitats for rare and threatened flora and fauna. Most notable is RE 5.6.7 which is an important habitat for the

Regional Ecosytems and Vegetation Communities of Cravens Peak



Night Parrot (*Pezoporus occidentalis*) (REDD) (EPA 2004). See Table 2, page 315.

Land zones

There are four land zone types within the Cravens Peak study area.

Listed in Table 3, page 315 are the descriptions of the land zones as described in the Regional Ecosystem Database (REDD) (EPA 2004) with their extent and percentage of the study area.

Seven RE are represented in land zone 3, four in land zone 6, three in land zone 7 and five in land zone 9. While land zone 3 has the most numbers of RE (seven), it covers the least area with 11857 Ha. Land zone 6 covers more than half of the total area of the Cravens Peak property (62.94%).

Table 1. Regional ecosystems of study area

RE No.	Abbreviated RE Descriptions	VMA Status	Biodiversity Status	Extent in Reserves	Area (Ha)	Area (%)
4.9.10	*Acacia georginae* tall open shrubland on Cambrian limestone	NC	NOC	No representation	382	0.17
4.9.14	*Acacia georginae* low open woodland with *Astrebla* spp. on Cambrian limestone	NC	NOC	No representation	1275	0.56
5.3.5	*Eucalyptus coolabah* ± *E. camaldulensis* ± *Lysiphyllum gilvum* open woodland on major drainage lines	NC	NOC	Low	520	0.23
5.3.7	*Eucalyptus coolabah* ± *Lysiphyllum gilvum* ± *Acacia cambagei* low open woodland on drainage lines	NC	NOC	Low	1784	0.78
5.3.11	*Acacia georginae* tall shrubland with *Senna artemisioides* subsp. *oligophylla* ± *Eremophila freelingii* on alluvium	NC	NOC	No representation	2145	0.94
5.3.12	*Chenopodium auricomum* ± *Muehlenbeckia florulenta* open shrubland in swamps and some claypans between dunes	NC	NOC	Low	41	0.02
5.3.18	Short grasses ± forbs open herbland on braided channel systems	NC	NOC	Low	2735	1.19
5.3.20	*Eucalyptus coolabah* ± *E. camaldulensis* open woodland fringing billabongs and permanent waterholes	NC	OC	Low	23	0.01
5.3.22	Sparse herbland on floodplain lakes or fringing claypans between dunes or on sandplains	NC	NOC	Low	4609	2.01
5.6.2	*Acacia georginae*, *Eremophila obovata* ± *Eucalyptus macdonnellii* tall shrubland on clay plains between sand dunes	NC	NOC	High	12528	5.47
5.6.5	*Triodia basedowii* hummock grassland on sides of, or between dunes	NC	NOC	High	37526	16.40
5.6.6	*Triodia basedowii* hummock grassland wooded with *Acacia* spp., *Senna* spp., *Grevillea* spp. ± *Eucalyptus* spp. on sand plains and dune fields	NC	NOC	Low	489	0.21
5.6.7	*Triodia basedowii* hummock grassland wooded with *Eucalyptus pachyphylla* on sand plains	NC	NOC	Low	64675	28.26
5.6.8	*Zygochloa paradoxa* ± *Triodia basedowii* open grassland on sand dunes	NC	NOC	High	28804	12.59
5.7.11	Fluctuating climax of *Atriplex* spp., *Sclerolaena* sp. ± short grasses open herbland on mantled pediments with dense silcrete cover	NC	NOC	No representation	6047	2.64
5.7.12	*Acacia cyperophylla* ± *A. aneura* tall shrubland on scarps and hills of low Ordovician ranges	NC	NOC	Low	5250	2.29
5.7.13	*Acacia cyperophylla* ± *Acacia cambagei* or *Acacia georginae* ± *Atalaya hemiglauca* tall shrubland on drainage lines within low Ordovician ranges	NC	NOC	No representation	1017	0.44
5.7.14	*Acacia stowardii*, *Hakea eyreana* ± *A. aneura* ± *Eremophila freelingii* open shrubland on Ordovician sandstones	NC	NOC	No representation	12737	5.57
5.9.1	*Senna* spp., *Eremophila* spp. ± *Acacia tetragonophylla* open shrubland on Tertiary on flat to undulating tops and scarps of dissected tablelands	NC	NOC	Low	16069	7.02
5.9.2	*Senna helmsii* ± *Senna artemisioides* subsp. oligophylla ± *Acacia georginae* ± Acacia spp. open shrubland on Cambrian limestone	NC	NOC	Low	2040	0.89
5.9.3	*Astrebla pectinata* ± short grasses ± forbs on Cretaceous sediments with gibbers	NC	NOC	No representation	1344	0.59
5.9.4	*Aristida contorta* ± short grasses ± forbs on Cretaceous sediments with dense gravel cover	NC	NOC	Low	26772	11.70

Discussion

As none of any Regional Ecosystems mapped were previously in Reserves on Cravens Peak the area of them conserved has been increased by the purchase by Bush Heritage of the property. This is despite the fact 21 of the 22 RE present in the Study Area have a Vegetation Management Act Biodiversity Status of 'Not of Concern' and most have low or no representations in reserves or protected areas within the Channel Country bioregion (see Table 1, page 314). The exception is RE 5.3.20 that has a VMA Status of 'Of Concern' and 6.24% (945 Ha) already in reserves outside the Study Area. The need to conserve areas of regional ecosystems in these categories should not be overlooked, particularly given the presence of some RE that hold special values which therefore warrant protection. For example, RE 5.6.7 which is found only in the far central west and south west of Queensland contains the plant

Table 2. Regional Ecosystems of Special Values

RE	Special Values	Threatening Processes
5.3.12	Important seasonal water bird habitat.	None noted in REDD
5.3.18	Potential habitat for rare and threatened fauna species including plains-wanderer Pedionomus torquatus and fierce snake (western taipan) *Oxyuranus microlepidotus.* Provides wetland habitat for a wide range of water birds and other flora and fauna	Varying degrees of degradation occur including scalding and vegetation loss associated with total grazing pressure (Dawson 1974).
5.3.20	Wetlands that provide drought refuge and water bird habitat. Habitat for rare and threatened fauna species including freckled duck *Stictonetta naevosa*.	Highly modified floristic and structural composition due to heavy trampling and grazing by domestic stock and feral animals such as pigs
5.3.22	Provides wetland habitat for a flora and fauna.	Trampling of regeneration and high total grazing pressure
5.6.5	High reptile diversity. Potential habitat for rare and threatened fauna species including mulgara *Dasycercus cristicauda*.	Requires burning in a mosaic pattern to maintain habitat values.
5.6.6	Habitat for small reptiles and rare and threatened fauna species including the night parrot *Pezoporus occidentalis*.	Requires burning in a mosaic pattern to maintain habitat values
5.6.7	Habitat for small reptiles and rare and threatened fauna species including the night parrot *Pezoporus occidentalis*.	Requires burning in a mosaic pattern to maintain habitat values
5.6.8	Habitat for the endemic eyrean grass wren *Amytornis goyderi* and rare and threatened fauna species including the dusky hopping mouse *Notomys fuscus*, mulgara *Dasycercus cristicauda* and flora species including *Sclerolaena everistiana*.	Heavily grazed by rabbits
5.9.2	Habitat for rare and threatened flora species including *Eremophila tetraptera*	Many *Acacia georginae* tall shrubs stand dead with little regeneration present
5.9.4	Habitat for rare and threatened fauna species including kowari *Dasyuroides byrnei*	Some localised sheet erosion and associated change in floristic composition evident (Wilson and Purdie 1990b)

Table 3. Land Zones of study area

Land Zone	Land Zone Description	Study Area (Ha)	Study area (%)	No. of REs
3	Quaternary alluvial systems, including braided channels, drainage lines, floodplain lakes, intermittent lakes and clay pans within Land Zone 6	11857	5.18	7
6	Quaternary inland dunefields, sand dunes and sand plains	144022	62.94	4
7	Exposed or shallowly covered duricrusts, mantled pediments, scarps and hilltops, drainage lines of residuals and associated undulating plains and on upper slopes and tops of ranges	25051	10.95	3
9	gently undulating landscapes on more or less horizontally bedded fine grained sedimentary rocks, Siltstones, mudstones, shales, calcareous sediments, and lithic and labile sandstones are typical rock types although minor interbedded volcanics may occur	47882	20.93	5

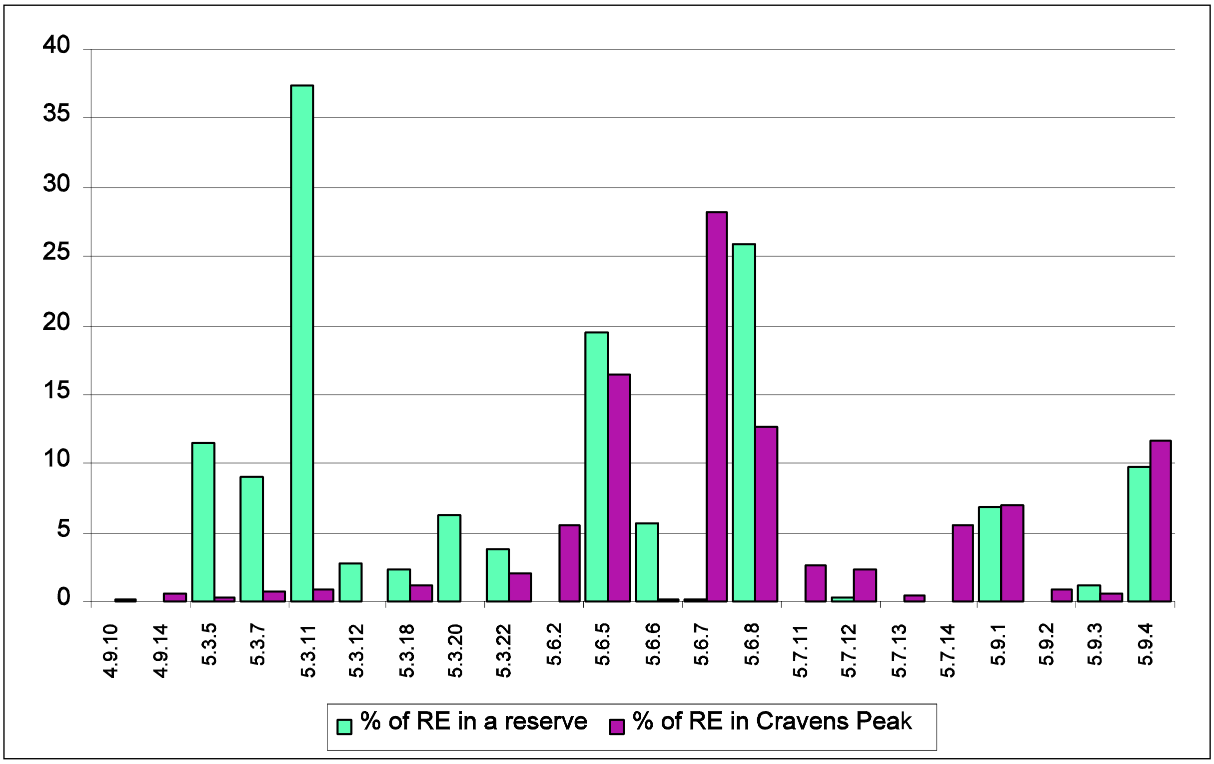


Figure 1. A graph showing the percentage of area Regional Ecosystems in reserves in the Channel Country bioregion and the percentage of area of the total for the Channel Country Regional Ecosystems mapped on Cravens Peak

Table 4. Regional Ecosystems that are not currently represented in the reserve system in the bio-region.

Regional Ecosystem	% currently in reserve in the bio-region	Area (Ha) in the Study Area	Area as a percent of the total of the Regional Ecosystem
4.9.10	0	382	0.17
4.9.14	0	1275	0.56
5.6.2	0	12528	5.47
5.7.11	0	6047	2.64
5.7.13	0	1017	0.44
5.7.14	0	12737	5.57
5.9.2	0	2040	0.89

species *Eucalyptus pachyphylla*. Although *E. pachyphylla* is reasonably widespread in Central Australia, it reaches its eastern range in Cravens Peak. RE 5.6.7 also provides a potential habitat for small reptiles and rare and threatened fauna species including the Night Parrot *Pezoporus occidentalis* which was thought to be extinct until the recent recoveries of two dead specimens from western Queensland (Boles et al. 1994). Incidentally, RE 5.6.7 covers the largest areas of all RE's on Cravens Peak (64,675 Ha) but has low representation in reserves within the bio-region so it is particularly important to note that the amount conserved has risen from 0.1% (158 Ha) of the total area of the RE in the Bio-region to 28.27% (45,895 Ha) of the total area (see Figure 1, page 316). Table 2 lists other RE's that provide potential habitats for small reptiles and rare and threatened flora and fauna species.

Smaller in extent but more important in conservation value are those Regional Ecosystems that are not currently represented in the reserve system in the bio-region. (See Table 4, page 316.)

However, the percentage of Regional Ecosystem conserved by the purchase of the property sufficient to fulfil desired conservation theory extent, i.e. #5%, is only achieved for RE 5.6.2 and RE 5.7.14. While the area of the other five Regional Ecosystems listed above is important it is insufficient for the effective conservation of them.

Table 2, page 315, also lists the threatening processes. Land zone 3 RE, which usually provide wetland habitats for flora and fauna, are threatened by heavy trampling and grazing by domestic and feral animals. Of particular concern is RE 5.3.20 that has an estimated area of 23 Ha and is threatened by grazing and trampling by domestic stock and feral animals. The grasslands on land zone 6 require burning in a mosaic pattern to maintain habitat values. Dead Acacia shrubs with little regeneration, were observed on land zone 9. This may be the influence of drought which is a feature of this region (Boyland 1984). Land zone 9 RE are also subject to sheet erosion and associated change in floristic composition. A few camels were observed on the Cravens Peak property. Dorges et al. (2003) estimates that camels browse on more than 80%of the available plant species, including rare or endangered, and have the potential to contribute to their extinction.

Conclusion

Given the great diversity of flora and fauna, including rare and threatened species that reside in these habitats, it is important that the regional ecosystems on Cravens Peak are protected. Thus its acquisition by Bush Heritage Australia will ensure that these regional ecosystems and associated environmental values remain protected. The value of the purchase of the property is likely to be further enhanced when the above data is added to that from the nearby property Ethabuka which is also owned by Bush Heritage. An analysis of the regional ecosystems on this property is required for such a comparison and should be conducted as a mater of urgency as it will also emphasise the collective value of the acquisition of these two properties.

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Appendix 1. Detailed Descriptions of Vegetation Communities (REDD) (EPA 2005)

4.9.10

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 1.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: No representation

Short Description: *Acacia georginae* tall open shrubland on Cambrian limestone

Structure Category: Very sparse

Description: *Acacia georginae* grassy tall open shrub land (Ht 5-6m; density 25-100/ha), with scattered *Ptilotus obovatus* sub shrubs frequently present, to shrubby open tussock grassland. The ground stratum is dominated by short-lived perennial grasses *Aristida latifolia* and *Enneapogon polyphyllus* (PFC 10-20%) with *Aristida calycina* and the ephemeral *Enneapogon avenaceus* co-dominant in some areas. The long-lived perennial grasses *Enteropogon acicularis* and *Eragrostis xerophila*, and the shorter-lived sedge *Fimbristylis dichotoma* occur frequently. A wide range of forbs may be present. The present *Ipomoea muelleri*, *Pterocaulon serrulatum* , *Solanum quadriloculatum* and *Streptoglossa odora* occur frequently. *Sclerolaena* spp., *Calotis* spp., *Hibiscus* spp., *Portulaca* spp., *Sida* spp., *Stenopetalum* spp. and other genera occur infrequently but many become seasonally prominent. Occurs on flat to undulating plains (slopes 0-2%) derived from Cambrian limestone. Soils shallow to moderately deep, crusted red clays with large amounts of siliceous and minor ironstone gravel on the surface. Soils are moderately alkaline at depth.

Supplementary Description: Neldner (1991), 28b (24); Wilson and Purdie (1990a), T2 (44)

Protected Areas: No representation.

Comments: In many places, 80-90% of tall shrubs stand dead with little or no regeneration. Density of short grasses increases after several wet summers. This includes ecosystems listed under 4.3.7 in Sattler and Williams (1999) which have been re-allocated to the correct land zone. 4.9.10x1: Occurs on Cainozoic clay plains (land zone 4)

4.9.14

Regional Ecosystem: Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 1, 7.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: No representation

Short Description: *Acacia georginae* low open woodland with *Astrebla* spp. on Cambrian limestone

Structure Category: Very sparse

Description: *Acacia georginae* grassy tall open shrubland (Ht 5-7m; density 50-150/ha, becoming a shrubby open tussock grassland in some areas. Scattered *Senna artemisioides* subsp. *oligophylla* shrubs (Htm) are usually present. The ground stratum is dominated by the long-lived perennial grass *Astrebla pectinata* (PFC 10-40%) with *Aristida latifolia*, *Eragrostis setifolia* and the ephemerals *Enneapogon avenaceus*, *Iseilema vaginiflorum*, and *Tripogon loliiformis* occurring frequently. A variety of ephemeral and some perennial forbs may be present, the former often becoming seasonally prominent. Frequent species include *Sclerolaena lanicuspis*, *Crotalaria dissitiflora*, *Goodenia fascicularis*, *Rhynchosia minim*, *Salsola kali*, *Sida fibulifera*, *S. trichopoda* and *Zygophyllum ammophilum*. Species from Asteraceae, Chenopodiaceae, Malvaceae and other families occurs infrequently. Occurs on flat to gently undulating plains (slopes 0-1%) formed from Cainozoic deposits overlying fine grained sediments. Soils are moderately deep-to-deep, red cracking clays with self-mulching surfaces. Weak gilgai micro relief and surface crusts are common. Soils are moderately to very strongly alkaline usually with lime present throughout the profile and small amounts of gypsum at depth. Scattered siliceous and ironstone gravel occurs at the surface.

Major vegetation communities include: 4.9.14x1: *Acacia georginae* grassy tall open shrubland (Ht 5-7m; density 50-150/ha, becoming a shrubby open tussock grassland in some areas. Occurs on gently undulating plains

(0-1%) formed on alluvial clay plains overlying a wide range of geological beds.

Supplementary Description: Wilson and Purdie (1990a), T2 (40); Neldner (1991), 10a, 10b (20)

Protected Areas: No representation.

Comments: Ephemeral herbs occur seasonally, grasses in summer and forbs in winter. Ephemeral herbs occur seasonally, grasses in summer and forbs in winter. This regional ecosystem occurs on Cainozoic deposits (land zone 4). 4.9.14x1: Occurs on alluvial clay plains (land zone 3)

5.3.5

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 2, 3, 4.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Wetland:Riverine wetland or fringing riverine wetland.

Short Description: *Eucalyptus coolabah* ± *E. camaldulensis* ± *Lysiphyllum gilvum* open woodland on major drainage lines.

Structure Category: Very sparse

Description: *Eucalyptus coolabah* predominates forming a well defined but discontinuous canopy (8-15-m tall) with sparsely scattered trees such as *Acacia cambagei* and *Lysiphyllum gilvum* and shrubs such as *Acacia salicina*, *Acacia stenophylla* and *Eremophila bignoniiflora* occurring frequently. *Muehlenbeckia florulenta* is often prominent. The ground stratum ranges from sparse to dense and is dominated by perennial grasses and sedges. Species such as *Cyperus victoriensis*, *Dichanthium fecundum*, *Paspalidium jubiflorum* and *Sporobolus mitchellii* are common. Occurs on levees and banks of major drainage channels on braided alluvial plains. Soils very deep, brown or grey clays with sand and silt bands common in profile. Generally broadly wooded braided channel systems.

Supplementary Description: Neldner (1991), 2a (63); Mills and Lee (1982), W2 (71); Turner et al. (1978), W3 (24)

Protected Areas: Bladensburg NP, Diamantina NP, Goneaway NP, Lochern NP.

Comments: Heavily impacted by total grazing pressure. Habitat for feral pigs. Asteraceae prevalent following favourable seasons.

5.3.7

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 1, 2, 4, 5, 6.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Wetland: Riverine wetland or fringing riverine wetland.

Short Description: *Eucalyptus coolabah* ± *Lysiphyllum gilvum* ± *Acacia cambagei* low open woodland on drainage lines

Structure Category: Very sparse

Description: *Eucalyptus coolabah* predominates forming a well defined but discontinuous canopy (8-115-m tall) and usually with a prominent low shrub stratum (1-2m tall) dominated by *Muehlenbeckia florulenta* and sometimes *Chenopodium auricomum*. Scattered tall shrubs and low trees, (5-6 m) including *Acacia stenophylla*usually 25/ha) frequently occur. The channel beds and lower slopes of the banks are usually bare although the ephemeral sedge *Cyperus pygmaeus* and *Isolepis australiensis* and forbs such as *Glinus lotoides*, *Mimulus gracilis*, *Stemodia glabella*, *Polygonum plebeium*, *Rorippa eustylis* and *Rumex crystallinus* colonise the moist mud as floodwaters recede. The upper slopes and flats are dominated by the perennial graminoids *Cyperus victoriensis* and *Sporobolus mitchellii* (PFC 10%), with *Eragrostis setifolia* common in some areas. Scattered tussocks of *Paspalidium jubiflorum* are frequently present. The ephemeral forb *Psoralea cinerea* may be seasonally co-dominant while *Persicaria lapathifolia*and *Polymeria longifolia* are locally prominent in some areas. *Calotis hispidula*, *Chamaesyce drummondii* and *Wahlenbergia gracilis* occur frequently, while a variety of other forbs are present infrequently and occurs along seasonally flooded major stream channels on alluvial plains. Associated soils are often very deep, alkaline, grey, red or brown cracking clays with some alluvial texture contrast soils. Surface silt and sand often form a surface crust.

Supplementary Description: Neldner (1991), 17a; Boyland (1984), 8; Wilson and Purdie (1990a), C1, C3 (76), (73 on Georgina)

Protected Areas: Astrebla Downs NP, Diamantina NP, Simpson Desert NP.

Comments: Highly modified floristic composition of ground layer. Feral pig habitat. Naturalised species associated with this regional ecosystem include * *Portulaca oleracea*. Tree height decreases in less frequently flooded areas. Low woodland may develop along larger channels.

5.3.11

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 1, 5.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: No representation

Short Description: *Acacia georginae* tall shrubland with *Senna artemisioides* subsp. *oligophylla* ± *Eremophila freelingii* on alluvium

Structure Category: Sparse

Description: *Acacia georginae* predominates forming a distinct but discontinuous canopy. A tall open shrub layer of *Senna artemisioides* subsp. *oligophylla*, *Eremophila freelingii* is generally present. The ground layer is usually sparse to open, and dominated by perennial grasses. *Eragrostis setifolia* and *Enneapogon avenaceus* are the dominant grasses on the texture contrast soils and non-cracking red clays. While *Bothriochloa ewartiana*, *Eulalia aurea*, *Eragrostis setifolia* and *Astrebla pectinata* tend to dominate in the drainage lines and on red and brown cracking clays. A variety of forbs from the families Asteraceae, Chenopodiaceae, Fabaceae and Malvaceae occur infrequently, but may be seasonally co dominant. (Occurs along drainage lines) Soils vary from deep, red and brown cracking clays to alluvial texture contrast soils and non-cracking clays.

Supplementary Description: Neldner (1991), 28d (23); Boyland (1984), 15b; Wilson and Purdie (1990a), S2 (11), A2 (43)

Protected Areas: No representation.

Comments: Georgina River area. In many areas 30-50% of tall shrubs stand dead, although regeneration of *Acacia georginae*present in some areas (Neldner, 1991).

5.3.12

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 2, 4.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Wetland: Palustrine wetland (e.g. vegetated swamp).

Short Description: *Chenopodium auricomum* ± *Muehlenbeckia florulenta* open shrubland in swamps and some claypans between dunes.

Structure Category: Mid-dense

Description: *Chenopodium auricomum* predominates and forms a well defined but discontinuous canopy. *Chenopodium auricomum* frequently forms pure stands; however, scattered *Eucalyptus coolabah* low trees and *Eremophila bignoniiflora* tall shrubs may be present. The ground layer is usually sparse, and seasonally dominated by grasses, sedges and forbs. The sedge *Eleocharis pallens*or perennial grass *Eragrostis setifolia* frequently dominate the ground layer. *Sporobolus mitchellii* is frequently dominant in the channels. Occurs in swampy depressions on alluvial plains or on frequently flooded inter- dune flats and clay pans. Soils very deep, grey cracking clays of light to medium texture, and contain varying amounts of silt and sand.

Major vegetation communities include:

5.3.12a: Palustrine wetland (e.g. vegetated swamp). *Chenopodium auricomum* predominates and forms a well defined but discontinuous canopy. *Chenopodium auricomum* frequently forms pure stands; however, scattered *Eucalyptus coolabah* low trees and *Eremophila bignoniiflora* tall shrubs may be present. The ground layer is usually sparse, and seasonally dominated by grasses, sedges and forbs. The sedge *Eleocharis pallens* or perennial grass *Eragrostis setifolia* frequently dominate the ground layer. *Sporobolus mitchellii* is frequently dominant in the channels. Occurs in swampy depressions on alluvial plains. Soils very deep, grey cracking clays of light to medium texture, and contain varying amounts of silt and sand.

5.3.12b: Palustrine wetland (e.g. vegetated swamp). *Chenopodium auricomum* predominates and forms a well defined but discontinuous canopy. *Chenopodium auricomum* frequently forms pure stands; however, scattered *Eucalyptus coolabah* low trees and *Eremophila bignoniiflora* tall shrubs may be present. The ground layer is usually sparse, and seasonally dominated by grasses, sedges and forbs. The sedge *Eleocharis pallens* or perennial grass *Eragrostis setifolia* frequently dominate the ground layer. *Sporobolus mitchellii* is frequently dominant in the channels. Occurs in swampy depressions on frequently flooded inter- dune flats and clay pans. Soils very deep, grey cracking clays of light to medium texture, and contain varying amounts of silt and sand.

Supplementary Description: Neldner (1991), 35a (76); Boyland (1984), 19a, 19b; Wilson and Purdie (1990a), C1, C2, W2 (79)

Protected Areas: Astrebla Downs NP, Diamantina NP, Welford NP.

5.3.18

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 2, 4, 5, 6.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Wetland: Contains palustrine wetland (e.g. in swales).

Short Description: Short grasses ± forbs open herbland on braided channel systems

Structure Category: Very sparse

Description: Sparse to open grassland or herbland, with sparsely scattered *Eucalyptus coolabah* (7-8m high). *Chenopodium auricomum* and *Muehlenbeckia florulenta* (1m) often present along channels. The perennial grass *Sporobolus mitchellii* occurs frequently and may be prominent (5-15% cover), with *Echinochloa turneriana*, *Eragrostis setifolia* and the perennial sedge *Cyperus bifax* locally prominent and the perennial sedge *Eleocharis pallens* frequently present. Ephemeral herb and may be seasonally codominant in the grassland or predominant in the herbland. Other common grasses include *Eragrostis tenellula*, *Iseilema membranaceum*, *I. vaginiflorum*, and *Panicum laevinode*, while common forbs are *Goodenia fascicularis*, *Haloragis glauca*, *Cullen cinereum*, *Brachyscome curvicarpa*, *Bulbine alata*, *Chamaesyce drummondii*, *Marsilea drummondii*, *Senecio depressicola* and *Ipomoea diamantinensis* occur frequently. *Sesbania cannabina* or *Aeschynomene indica* may be abundant depending on seasonal flood regime. Occurs on frequently flooded alluvial plains with shallow (1m) braided stream channels and formed from recent clay alluvia. Associated soils and very deep, neutral to strongly alkaline grey cracking clays. Surfaces may be crusted or self-mulching. Soils crack widely on drying and strongly sodic at depth.

Major vegetation communities include:

5.3.18a: Palustrine wetland (e.g. vegetated swamp). *Chenopodium auricomum* predominates and forms a well defined but discontinuous canopy. *C. auricomum* frequently forms pure stands; however, scattered *Eucalyptus coolabah* low trees and *Eremophila bignoniiflora* tall shrubs may be present. The ground layer is usually sparse, and seasonally dominated by grasses, sedges and forbs. The sedge *Eleocharis pallens* or perennial grass *Eragrostis setifolia* frequently dominate the ground layer. *Sporobolus mitchellii* is frequently dominant in the channels. Occurs along shallow braided channels

5.3.18b: Floodplain (other than floodplain wetlands). Either grasses or forbs dominate the ground layer depending on seasonal conditions and at times extensive areas may be denuded of any species. *Sporobolus mitchellii* occurs frequently and may be prominent (5-15% cover), while *Eragrostis setifolia* is locally common. After favourable seasons, herbs form a distinct but discontinuous ground cover. The dominant ephemerals include *Iseilema vaginiflorum*, *Arabidella nasturtium*, *Atriplex velutinella* , *Brachyscome dentata* , *Pycnosorus pleiocephalus* , *Epaltes cunninghamii* , *Chamaesyce drummondii*, *Goodenia fascicularis* and *Senecio depressicola* . Scattered low shrubs may occur with emergent trees fringing the association. Scattered low shrubs may occur. After summer local flooding, *Dactyloctenium radulans*, *Panicum laevinode*, *Iseilema* spp. and *Chloris pectinata* usually predominate. *Atriplex* spp., *Sclerolaena* spp., and Asteraceae conspicuous after winter local flooding. *Echinochloa turneriana* usually predominates after early summer (general) flooding with *Pycnosorus pleiocephalus* and *Trigonella suavissima* conspicuous after early winter flooding. Occurs on frequently flooded flat alluvial plains of major rivers or in interchannel areas of braided floodplains. Associated soils are very deep, crusted, red, brown and grey cracking clays that are subject to scalding. Surfaces may be weakly self mulching.

Supplementary Description: Dawson (19) C1; Neldner (1991) 48; Boyland (1984), 29b; Wilson and Purdie (1990a), C1, (75)

Protected Areas: Diamantina NP, Welford NP.

Comments: Varying degrees of degradation occur including scalding and vegetation loss associated with total grazing pressure (Dawson 1974). Associated drainage lines are frequently fringed by *Eucalyptus coolabah* low open-woodland or other species depending on the local habitat. Major component of 'channel country complex'. 5.3.18a: Includes many small braided (riverine channels) fringed by palustrine vegetated wetlands.

5.3.20

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: Of concern. Threatening processes other than clearing.

Subregion: 2, 4.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Wetland: Palustrine wetland (e.g. vegetated swamp).

Short Description: *Eucalyptus coolabah* ± *E. camaldulensis* open woodland fringing billabongs and permanent waterholes.

Structure Category: Very sparse

Description: *Eucalyptus coolabah* usually predominates forming a distinct but discontinuous upper canopy layer with *E. camaldulensis* is conspicuous in sandy or gravelly channels. Occurs surrounding permanent waterholes in major rivers, billabongs or small lakes. Soils very deep clays with sand and silt bands common in profile.

Major vegetation communities include:

5.3.20a: Riverine wetland or fringing riverine wetland. *Eucalyptus coolabah* usually predominates forming a distinct but discontinuous upper canopy layer fringing water holes in drainage lines. *E. camaldulensis* is conspicuous in some larger sandy waterholes. A lower tree understorey or tall shrub layer may be present in places. Low shrubs frequently occur and in places form a distinct layer. The ground layer is variable being composed of grasses and forbs with either predominating depending on seasonal conditions. Occurs on waterholes in rivers and braided channel systems. Soils very deep, brown or grey clays with sand and silt bands common in profile.

5.3.20b: Riverine wetland or fringing riverine wetland. *Eucalyptus coolabah* usually predominates forming a distinct but discontinuous upper canopy layer with *E. camaldulensis* sometimes present. A lower tree understorey or tall shrub layer may be present in places. The ground layer is variable being composed of grasses and forbs with either predominating depending on seasonal conditions. Occurs on waterholes in major river systems. Soils very deep, brown or grey clays with sand and silt bands common in profile.

5.3.20c: Palustrine wetland (e.g. vegetated swamp). *Eucalyptus coolabah* usually predominates forming a distinct but discontinuous upper canopy layer with *E. camaldulensis* sometimes present or dominant. A lower tree understorey or tall shrub layer may be present in places. Low shrubs frequently occur and in places form a distinct layer. The ground layer is variable being composed of grasses and forbs with either predominating depending on seasonal conditions. Occurs surrounding permanent small billabongs and lakes on edge of floodplains divorced from channel systems. Soils very deep, brown or grey clays with sand and silt bands common in profile.

Supplementary Description: Neldner (1991), 51a (63); Boyland (1984), 32; Pettit (2002)

Protected Areas: Astrebla Downs NP, Diamantina NP, Welford NP.

Comments: Highly modified floristic and structural composition due to heavy trampling and grazing by domestic stock and feral animals such as pigs. There is considerable floristic and structural variation in this regional ecosystem associated with local environmental conditions. *Asteraceae* spp. prevalent following favourable seasons. *E. coolabah* is found on higher, less frequently flooded areas compared to *E. camaldulensis* (Pettit 2002). Localised areas of soil compaction and bare ground are associated with domestic stock congregation points. Function as important aquatic refugia during dry times (Hamilton et al. 2005)

5.3.22

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 1, 2, 4.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low
Wetland: Lacustrine wetland (e.g. lake).
Short Description: Sparse herbland on floodplain lakes
Structure Category: Very sparse
Description: Scattered ephemeral vegetation of variable floristic and structural composition. Bare areas, water or grasses and sedges may dominate the lake bed. Very occasional low shrubs such as *Chenopodium auricomum*, *Muehlenbeckia florulenta* and *Sclerostegia tenuis* may be present. Occurs on lakes on floodplains or between dunes. Soils very deep, grey cracking clays.
Major vegetation communities include:
5.3.22a: Lacustrine wetland (e.g. lake). Scattered ephemeral vegetation of variable floristic and structural composition. Bare areas, water or *Eleocharis pallens* may predominate the lake bed. Very occasional low shrubs such as *Chenopodium auricomum*, *Muehlenbeckia florulenta* and *Sclerostegia tenuis* may be present. Occurs on or fringing claypans between dunes or on sandplains. Soils very deep, grey cracking clays.
5.3.22b: Lacustrine wetland (e.g. lake). Scattered ephemeral vegetation of variable floristic and structural composition. Bare areas, water, sedges or grasses may predominate Occurs on or fringing lakes on floodplains. Soils very deep, grey cracking clays.
5.3.22c: Lacustrine wetland (e.g. lake). Scattered ephemeral vegetation of variable floristic and structural composition. Bare areas, water, sedges or grasses may predominate. Occurs on lakes usually fed by drainage lines
Supplementary Description: Neldner (1991), 51b; Boyland (1984), 32; Wilson and Purdie (1990a), L1 ()
Protected Areas: Diamantina NP, Simpson Desert NP.
Comments: Threatened by trampling of regeneration and high total grazing pressure.

5.6.2

Vegetation Management Act status (December 2005): Not of concern
Biodiversity Status: No concern at present
Subregion: 1, 5.
Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.
Extent in Reserves: High
Short Description: *Acacia georginae*, *Eremophila obovata* ± *Eucalyptus macdonnellii* tall shrubland on clay plains between sand dunes.
Structure Category: Sparse
Description: *Acacia georginae* predominates forming a distinct but discontinuous canopy. *Eremophila obovata* and *Eucalyptus macdonnellii* form an open low shrub layer (0.5m tall) in run-on areas. The ground layer is seasonably variable, but usually dominated by *Aristida holathera* var. *holathera*, with *Enteropogon acicularis* and *Eragrostis eriopoda* being locally abundant. *Triodia longiceps* is often dominant on low dunes. Tree height greatest in run-on areas. Occurs on interdune areas or flat plains, run-on areas, and low sandy rises and rounded dunes. Soils deep to very deep, sandy red earths, sandy-surfaced duplex soils, occasionally red earthy sands.
Supplementary Description: Neldner (1991), 29 (21); Boyland (1984), 15b; Wilson and Purdie (1990a), S2 (9, 10)
Protected Areas: Simpson Desert NP.
Comments: Mulligan River - Toko Range area.

5.6.5

Vegetation Management Act status (December 2005): Not of concern
Biodiversity Status: No concern at present
Subregion: 1, 2, 4.
Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.
Extent in Reserves: High
Short Description: *Triodia basedowii* hummock grassland on sides of, or between dunes
Structure Category: Very sparse
Description: *Triodia basedowii* predominates forming a distinct ground layer canopy (0.5-1.0m high), which is very discontinuous. Isolated trees and tall shrubs are usually present emerging above the canopy. Usually low shrubs occur and may form a well defined layer in some situations. The ground cover is variable with the areas between the hummocks either devoid of vegetation or supporting short grasses and forbs. Occurs on low sloping flanks of dunes and sandy interdune areas. Soils deep to very deep, red, yellow and white earthy sands, occasionally red siliceous sands.
Major vegetation communities include:
5.6.5b: *Acacia ramulosa* usually predominates forming a distinct layer with a discontinuous canopy. Emergent trees may occur. A lower shrub layer is well defined in places, but in other situations consists only of scattered shrubs. Ground cover is variable composed of

grasses and forbs. Occurs on scattered sand plains of low relief associated with dunefields. Soils moderately deep red texture contrast soils with sandy loams overlying the sandy clays.

Supplementary Description: Neldner (1991), 36 (106), 25a (13); Boyland (1984), 22; Wilson and Purdie (1990a), D1, D2 (1); Dawson (1974), D1, D2 (8).

Protected Areas: Diamantina NP, Simpson Desert NP, Welford NP.

Comments: Simpson Desert. Requires burning in a mosaic pattern to maintain habitat values. Density of shrubs and floristic composition vary with topographic position and disturbance. *Triodia longiceps* may be dominant on calcareous sands in north-east section of Simpson Desert. Composition of ground flora dependent on seasonal conditions and to a lesser degree both current and past land use.

5.6.6

Not of concern

Biodiversity Status: No concern at present

Subregion: 1, 4, 5.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Short Description: *Triodia basedowii* hummock grassland wooded with *Acacia* spp., *Senna* spp., *Grevillea* spp. ± *Eucalyptus* spp. on sand plains and dune fields

Structure Category: Very sparse

Description: *Triodia basedowii* predominates forming a distinct but discontinuous ground layer canopy (0.5-1.0m tall). Trees and tall shrubs emerge above the canopy almost approaching a tall open-shrubland or low open-woodland in places. Low shrubs are conspicuous forming a very well defined layer in places where disturbance, either natural or man made has occurred. Ground cover is variable depending on seasonal conditions both present and past as well as land use. Occurs on flat to gently undulating plains associated with sand plains and dune fields in south-east. Soils deep to very deep, slightly acid to neutral, red earthy sands and occasional red siliceous sands.

Major vegetation communities include:

5.6.6a: Open grassland of *Eriachne mucronata*, *Aristida contorta* to forbland of *Sclerolaena lanicuspis* with isolated trees of *Ventilago viminalis*, *Corymbia terminalis*, *Atalaya hemiglauca* and *Grevillea striata*, with isolated shrubs of *Acacia tetragonophylla* or *Acacia brachystachya* and *Eremophila duttonii*.

5.6.6b: *Triodia basedowii* predominates forming a distinct but discontinuous ground layer canopy (0.5-1.0m tall). Trees and tall shrubs emerge above the canopy almost approaching a tall open-shrubland or low open-woodland in places. Low shrubs are conspicuous forming a very well defined layer in places where disturbance, either natural or man made has occurred. Ground cover is variable depending on seasonal conditions both present and past as well as land use.

Supplementary Description: Neldner (1991), 37a (107); Boyland (1984), 23; Wilson and Purdie (1990a), S1 (5)

Protected Areas: Welford NP.

Comments: Requires burning in a mosaic pattern to maintain habitat values.

5.6.7

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 1, 5.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Short Description: *Triodia basedowii* hummock grassland wooded with *Eucalyptus pachyphylla* on sand plains.

Structure Category: Very sparse

Description: *Triodia basedowii* predominates forming a conspicuous but broken canopy (0.3-0.5m tall). Scattered emergent tall shrubs and low shrubs are frequent. *Eucalyptus pachyphylla* (3-4m tall) is conspicuous on the dunes, and may form a tall open-shrubland (3-4m tall) in places. The ground between the *Triodia basedowii* hummocks is usually bare, although some ephemeral herbs occur after rain. Occurs on flat plains and low stable dunes. Soils very deep, sandy red earths and red siliceous sands.

Supplementary Description:Neldner (1991), 37b, c (108); Boyland (1984), 23; Wilson and Purdie (1990a), S1 (6)

Protected Areas: Simpson Desert NP.

Comments: East of Georgina River and along Gnallan-a-gea Creek in Simpson Desert. Requires burning in a mosaic pattern to maintain habitat values.

5.6.8

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 1, 2, 4.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: High

Short Description: *Zygochloa paradoxa* ± *Triodia basedowii* open grassland on sand dunes

Structure Category: Very sparse

Description: *Zygochloa paradoxa* predominates forming an open-hummock grassland (1.0-1.5m tall). Scattered hummocks of *Triodia basedowii* may be frequent. Sparsely scattered low shrubs (1-2m tall) are usually present with *Crotalaria cunninghamii*, *C. eremaea*. *Acacia ligulata* and *Lechenaultia divaricata* being the most frequent. The ground between the hummocks and shrubs is usually bare, excepting when ephemeral herbs become seasonally abundant. *Aristida holathera*var. *holathera*, *Chamaesyce myrtoides* and *Cullen pallidum* occur frequently between the hummocks. Shrubs usually sparse, except in disturbed areas where they may form open-shrublands. Occurs on mobile crests and loose sandy slopes of sand dunes. Soils very deep, white, yellow and red siliceous sands.

Supplementary Description: Neldner (1991), 41a (109); Boyland (1984), 24; Wilson and Purdie (1990a), D1, D2 (2); Dawson (1974), D1, D2 (14).

Protected Areas: Diamantina NP, Simpson Desert NP.

Comments: Heavily grazed by rabbits.

5.7.11

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 2, 5.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: No representation

Short Description: Fluctuating climax of *Atriplex* spp., *Sclerolaena* sp. ± short grasses open herbland on mantled pediments with dense silcrete cover.

Structure Category: Very sparse

Description: Ephemeral forbs usually predominate with *Atriplex spongiosa*, *Sclerolaena lanicuspis* and *S. glabra* being the most abundant. *Atriplex fissivalvis*, *Rhodanthe floribunda*, *Maireana ciliata* and *Osteocarpum dipterocarpum* are locally abundant, while *Gnephosis arachnoidea* and *Salsola kali* occur frequently. *Tripogon loliiformis* and *Sporobolus actinocladus* become co-dominant or dominant in areas where the stone pavement is less dense. *Astrebla pectinata* and ephemeral forbs become dominant where the stone pavement is absent and in gilgai depressions. Local deposits of windblown sand support ephemeral forbs such as *Calotis plumulifera*, *Gnephosis eriocarpa*, *Rhodanthe moschata* and *Polycalymma stuartii*. Trees and shrubs are usually absent. Floristic composition varies with seasonal conditions, density of stone pavement and gilgai micro relief. Occurs on flat to gently undulating plains and on benched areas where gilgai micro relief present that are formed on mantled pediments, fresh rock and deeply weathered rock associated with erosion of the Tertiary land surface exposing Cretaceous sediments. Soils deep to moderately deep, desert loams with very dense silcrete, or occasionally ironstone, surface pavement. Red and brown cracking clays occur in gilgais.

Supplementary Description: Wilson and Purdie (1990a), P2, F4 (60); Neldner (1991), 50 (104)

Protected Areas: No representation.

Comments: Soils subject to sheet and some gully erosion with associated change in floristic composition (Wilson and Purdie 1990b; P2). Occasionally, scattered *Acacia stowardii* is present.

5.7.12

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 3, 5.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Short Description: *Acacia cyperophylla* ± *A. aneura* tall shrubland on scarps and hills of low Ordovician ranges

Structure Category: Sparse

Description: *Acacia cyperophylla* var. *cyperophylla*, frequently with *A. aneura*, forms a distinct but very discontinuous tall shrub layer (2-6m tall). In the central-east, *A. cyperophylla* var. *cyperophylla* forms low woodlands (7-10m tall; 10-15 % PFC). Scattered low shrubs are usually present, and frequently form a very sparse low shrub layer. The ground layer is sparse with a variety of ephemeral tussock grasses and forbs occurring infrequently. *Triodia pungens* frequently dominates the ground layer in the central-east. Occurs mainly on scarps and hill tops in central-western residuals. Minor outliers on scattered residuals. The soils usually very shallow, gravelly lithosols with much exposed rock. Siliceous gravel and stone usually spread throughout the profile.
Supplementary Description: Neldner (1991), 27a (32); Boyland (1984), E; Wilson and Purdie (1990a), R2 (26)
Protected Areas: Bladensburg NP, Diamantina NP (300 ha).
Comments: In the central-east, and Allen's Range south of Winton.

5.7.13

Vegetation Management Act status (December 2005): Not of concern
Biodiversity Status: No concern at present
Subregion: 5.
Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.
Extent in Reserves: No representation
Short Description: *Acacia cyperophylla* ± *A. cambagei* or *A. georginae* ± *Atalaya hemiglauca* tall shrubland on drainage lines within low Ordovician ranges.
Structure Category: Sparse
Description: *Acacia cyperophylla* var. *cyperophylla* predominates forming a distinct but discontinuous canopy (4-7 m, up to 11m tall). *Acacia cambagei* or *A. georginae* (4-5m tall) frequently occur as co dominants, and *Atalaya hemiglauca* is usually present as scattered tall shrubs. *Eucalyptus coolabah* or *E. camaldulensis* may occur as scattered trees in some drainage lines. Low shrubs are frequently present, but only rarely is a conspicuous low shrub layer of *Senna artemisioides* subsp. *oligophylla* and/or *Eremophila freelingii* formed. The ground layer varies from sparse to open, and is frequently dominated by *Eulalia aurea*, *Themeda triandra*, *Eriachne mucronata* and *Enteropogon acicularis*. Scattered forbs and sub shrubs are frequently present also. Occurs on drainage lines of residuals and associated undulating plains. Soils variable depending on position, but mainly deep, gravelly, sandy clay loams in upper drainage lines, and deep, gravelly, red clays lower in landscape.
Supplementary Description: Neldner (1991), 27b (33); Wilson and Purdie (1990a), R2 (27)
Protected Areas: No representation.

5.7.14

Vegetation Management Act status (December 2005): Not of concern
Biodiversity Status: No concern at present
Subregion: 3, 5.
Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.
Extent in Reserves: No representation
Short Description: *Acacia stowardii*, *Hakea eyreana* ± *A. aneura* ± *Eremophila freelingii* open shrubland on Ordovician sandstones
Structure Category: Mid-dense
Description: *Acacia stowardii* predominates and together with *Hakea eyreana* forms a sparse canopy layer. Scattered emergent *Acacia aneura* and *Corymbia terminalis* (6-7m tall) are frequently present. A number of scattered shrubs are present, but do not form a conspicuous layer. The ground layer is very sparse with much exposed rock on the surface. Occurs on upper slopes and tops of range. Soils shallow, stony, lithosols and gravelly red earths, with exposed sandstone rocks covering soil surface.
Supplementary Description: Neldner (1991), 32d (36)
Protected Areas: No representation.
Comments: Toko Range

5.9.1

Vegetation Management Act status (December 2005): Not of concern
Biodiversity Status: No concern at present
Subregion: 3, 5.
Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.
Extent in Reserves: Low
Short Description: *Senna* spp., *Eremophila* spp. ± *Acacia tetragonophylla* open shrubland on Tertiary on flat to undulating tops and scarps of dissected tablelands.
Structure Category: Mid-dense
Description: A variety of low shrub species occur together to form an open-shrubland. *Senna artemisioides* subsp. *helmsii*, *Senna*

artemisioides subsp. *oligophylla*, *S. glutinosa* subsp. *pruinose*, *Eremophila freelingii* and *Dodonaea microzyga* usually dominate the low shrub layer (1-2m tall). Other frequent shrubs include *E. tetraptera* (2-4m tall), *Acacia tetragonophylla* (2-3m tall) and *Scaevola spinescens* (1-2m tall). Sparsely scattered *Corymbia terminalis* (5-6m tall) occur as emergent trees. The sparse ground layer is dominated by the short grasses *Aristida* spp., *Enneapogon avenaceus*, *Chamaesyce australis*, *Anemocarpa podolepidium*, *Lawrencia glomerata*, *Digitaria brownii* and *Enneapogon polyphyllus*, and the forbs *Abutilon fraseri*, *Ptilotus* spp. and *Sclerolaena* spp. Shrub density highest in drainage lines on residual scarps. Occurs on flat to gently undulating tableland tops and foot slopes of Cambrian limestone residuals. Soils predominantly shallow, red, calcareous loams and earths with limestone fragments in profile and on surface.

Major vegetation communities include:

5.9.1x1: Occurs on flat to undulating tops and scarps of dissected tablelands. Soils generally shallow, gravelly red earths, lithosols and lateritic outcrops.

Supplementary Description: Neldner (1991), 34 (53, 54); Wilson and Purdie (1990a), R3 (29)

Protected Areas: Diamantina NP.

5.9.2

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 3, 5.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Short Description: *Senna helmsii* ± *Senna artemisioides* subsp. *oligophylla* ± *Acacia georginae* ± *Acacia* spp. open shrubland on Cambrian limestone

Structure Category: Mid-dense

Description: *Senna artemisioides* subsp. *helmsii* and *Senna artemisioides* subsp. *oligophylla* predominate forming a distinct, open to mid-dense low shrub layer (1.0-1.5m tall). Other low shrubs are frequently present. Scattered emergent low trees may be present in places. The ground layer is usually sparse to open, and dominated by *Aristida* spp., *Enneapogon* spp. and a variety of forbs. In gilgai, *Astrebla pectinata*, *Chrysopogon fallax* and *Eulalia aurea* may be abundant. Occurs on flat to gently undulating tableland tops and foot slopes of Cambrian limestone residuals. Soils predominantly shallow, red, calcareous loams and earths with limestone fragments in profile and on surface.

Supplementary Description: Neldner (1991), 33 (52); Wilson and Purdie (1990a), R3 (29)

Protected Areas: Diamantina NP.

Comments: Many *Acacia georginae* tall shrubs stand dead with little regeneration present.

5.9.3

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 2, 4, 6.

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: No representation

Short Description: *Astrebla pectinata* ± short grasses ± forbs on Cretaceous sediments with gibbers.

Structure Category: Grassland

Description: *Astrebla pectinata* predominates forming a distinct but discontinuous canopy (5-30% cover). Other tussock grasses may be present occupying the spaces between the tussocks of *Astrebla pectinata*. *Dactyloctenium radulans*, *Brachyachne convergens* and *Iseilema* spp. may predominate in some areas. Forbs such as *Atriplex* spp. and *Sclerolaena* spp. occur and in less favourable seasons tend to predominate forming a sparse ground cover (%). Isolated shrubs may be conspicuous, but trees are absent. Occurs on flat to gently undulating plains with slopes usually less than 3% (sometimes up to 5%). Soils stony, deep to moderately deep, red and brown cracking clays, or rarely desert loams. Formed on mantled pediments from fresh rock x associated with erosion of the Tertiary land surface exposing Cretaceous Winton Formation. Dense surface stone pavements which often have a desert varnish are derived from Tertiary surface.

Major vegetation communities include:

5.9.3x1: *Astrebla squarrosa* usually predominates with A. pectinata being codominant, and together form a tussock grassland. *Iseilema vaginiflorum* and *Aristida latifolia* are frequent and abundant in heavily grazed areas. Shrubs are very sparse and infrequent. A number of forbs occur and may become abundant after winter rain. Occurs on flat clay plains of Winton plateau. Associated soils are moderately deep grey cracking clays, strongly self mulching surface.

Supplementary Description: Neldner (1991), 47a (92); Boyland (1984), 27; Dawson (1974), F1-4 (84, 85); Wilson and Purdie (1992), F4 (55); Mills (1980), F2 (69)

Protected Areas: No representation.

Comments: Surface stone (gibbers) may be desert varnished (Dawson, 1984; Wilson and Purdie, 1992). Composition of flora depends on seasonal conditions and past land use. *Astrebla elymoides* and *Astrebla squarrosa* associated with infrequent gilgais. A fluctuating climax with *Astrebla pectinata* and short grasses dominating in favourable years, and *Atriplex* spp. and *Sclerolaena* spp. dominating in poorer seasons. It is not unusual for *Astrebla* spp. to be inconspicuous for considerable periods, particularly under grazing.

5.9.4

Vegetation Management Act status (December 2005): Not of concern

Biodiversity Status: No concern at present

Subregion: 2, 4, 6

Estimated Extent: In September 2003, remnant extent was 10,000 ha and 30% of the pre-clearing area remained.

Extent in Reserves: Low

Short Description: *Aristida contorta* ± short grasses ± forbs on Cretaceous sediments with dense gravel cover.

Structure Category: Grassland

Description:

Aristida contorta usually predominates forming an open to sparse tussock grassland. Other short grasses such as *Oxychloris scariosa*, *Enneapogon avenaceus* and *Sporobolus actinocladus* may be co dominant. Ephemeral grasses such as *Brachyachne prostrata*, *Eriachne pulchella* and *Tripogon loliiformis* occur frequently, while the perennial *Aristida latifolia* and *Eragrostis xerophila* may be locally common. Ephemeral forbs such as *Gnephosis arachnoidea*, *Rhodanthe floribunda*, *Maireana dichoptera* and *Sclerolaena lanicuspis* may predominate after winter rain. Sparsely scattered shrubs may occur in places. Short grasses build up after wet summers, while forbs common after winter rainfall. Occurs on flat to gently undulating plains with abundant surface gravel cover of ironstone, chalcedony, laterite, silcrete or silicified sandstone. Soils shallow to deep, desert loams, with gravelly, sandy clay loams overlying structured medium clays. Ground cover always sparse, varies with amount of stone cover and seasonal conditions.

Supplementary Description: Wilson and Purdie (1990a), P1 (56); Mills and Boyland (1979) F4 (60); Neldner (1991), 47b (96)

Protected Areas: Diamantina NP.

Comments: Some localised sheet erosion and associated change in floristic composition evident (Wilson and Purdie 1990b; F4).

Report on the geology of parts of the Cravens Peak area, Georgina Basin, north–west Queensland

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Abstract Geological and palaeontological investigations of a number of areas in the Cravens Peak area were undertaken. A range of Ordovician marine fossils was found in the Salty Bore area. Abundant trace fossils were found near the western end of Painted Gorge. Close to Cravens Peak homestead, a fossil–rich deflation armour and some remnant original outcrop was located, plus richly fossiliferous coquinite layers scattered through the Nora Formation, previously undescribed from this location. Abundant marine fossils were identified and the layer is assigned an Arenig age. Overlying these sediments, scattered Mesozoic sandstones were found, some with plant remains.

Introduction

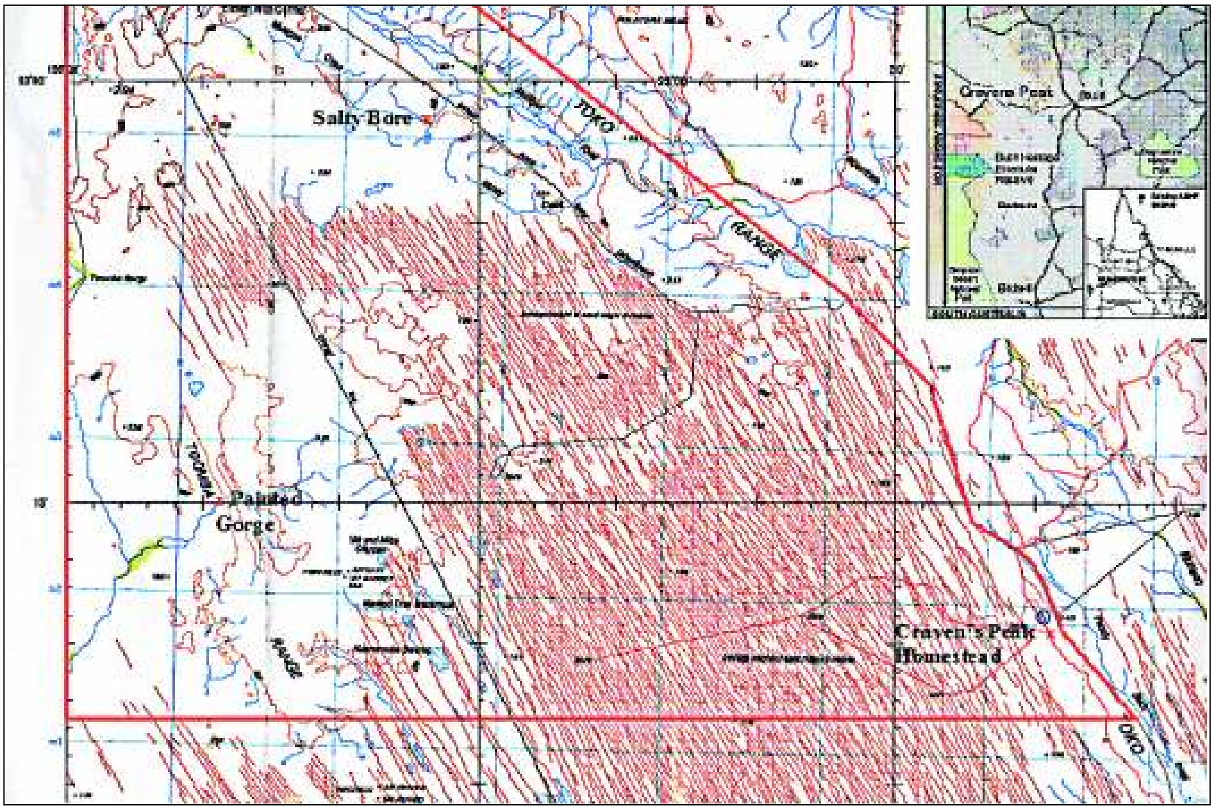
In late 2005, Australian Bush Heritage acquired the 2330 square kilometre former beef property "Cravens Peak" as part of its "Anchors in the Landscape" programme under the National Reserve System. The property is situated 180km southwest of Boulia within the Mulligan River catchment and within the primarily Ordovician Georgina Basin of north–west Queensland and eastern Northern Territory. During 2007, the Royal Geographical Society of Queensland coordinated the studies of some 40 researchers in a variety of fields as a baseline study on which to found a management plan for the reserve. A shorter visit during 2008 was also undertaken. This report deals with the geological data collected. Three widely separated areas were targeted—Salty Bore in the north, Painted Gorge in the west and around the homestead in the east, with the aim of investigating mainly the Nora Formation. (See Map 1, page 330.)

Previous work

Hodgkinson (1877) first mentioned sandstone and limestone in the area he named the Cairns Range (now the Toko Range), and Jack (1897) reported Ordovician cephlapods and trilobites just north of the present study area. During 1927, Whitehouse worked extensively in the area and reported (1930, 1936) on the "Toko Series" with rich cephalopod limestone overlain by sandstones with asaphid trilobites, suggesting a Middle Ordovician age. As a result of joint Bureau of Mineral Resources and Geological Survey of Queensland mapping in 1957–58, Casey (1959) proposed the name "Toko Beds". As well, Casey (in Smith, 1963) formally defined the Nora Formation, and later, (in Smith, 1965), assigned a Lower to Middle Ordovician age to the "Toko Group", consisting of the Coolibah, Nora, Carlo and Mithaka Formations. Smith (1967) listed nautiloids, pelecypods, brachiopods, trilobites, gastropods, bryozoa and trace fossils for the Nora Formation, while Beard (1969) described endoceroid nautiloids and Nieper (1970) conodonts, both from the base of the formation. Shergold (1985) described the Nora Formation on the Glenormiston and Mt Whelan sheet areas from both surface and sub–surface evidence and Kruse (2000) added much supporting detail from the adjoining Tobermory sheet area.

Salty Bore area

A closely–packed scree slope surrounding a mesa just east and south–east of Salty Bore (Map Reference 54K 215876 7451654) yielded a range of fossils, including lower Ordovician pelecypods and nautiloids and numerous trace fossils. The mesa is capped by a highly–resistant, yellow–brown iron–impregnated sandstone which splits into 1cm thick slabs, some with small (~2–4mm) clay balls; it persists down



Map 1. Craven's Peak—Locality

the flanks of the mesa. This caprock at Salty Bore is quite different from the Carlo Sandstone to be found capping the ridge near the homestead and has been mapped by Shergold (1985) as the Ethabuka Sandstone. The Nora Formation below exhibits two distinct lithologies. Dull red medium sandstone can be found particularly towards the upper slopes while pale yellow to brown very fine sandstone is found mainly mid– to lower–slope. Both are massive, with no bedding apparent in either. With the disguise of obvious bedrock by the scree, no opinion could be formed of the relationship between the two members, nor outlines of the outcrop. See Map 2, page 331.

The lower slopes of the mesa scarps south east of the Salty Bore site yielded a range of trace fossils in fine sandstone. See Figure 1, page 332, Figure 2, page 333, Figure 3, page 334, Figure 4, page 334.

Systematic palaeontology:

Classification: *Cruziana* sp.
Locality: 54K 218569 7450095
Diagnosis: Central smooth drag path with bilateral spine or ridge tracks overlain by appendage impressions.
Remarks Common
See Figure 5, page 335.

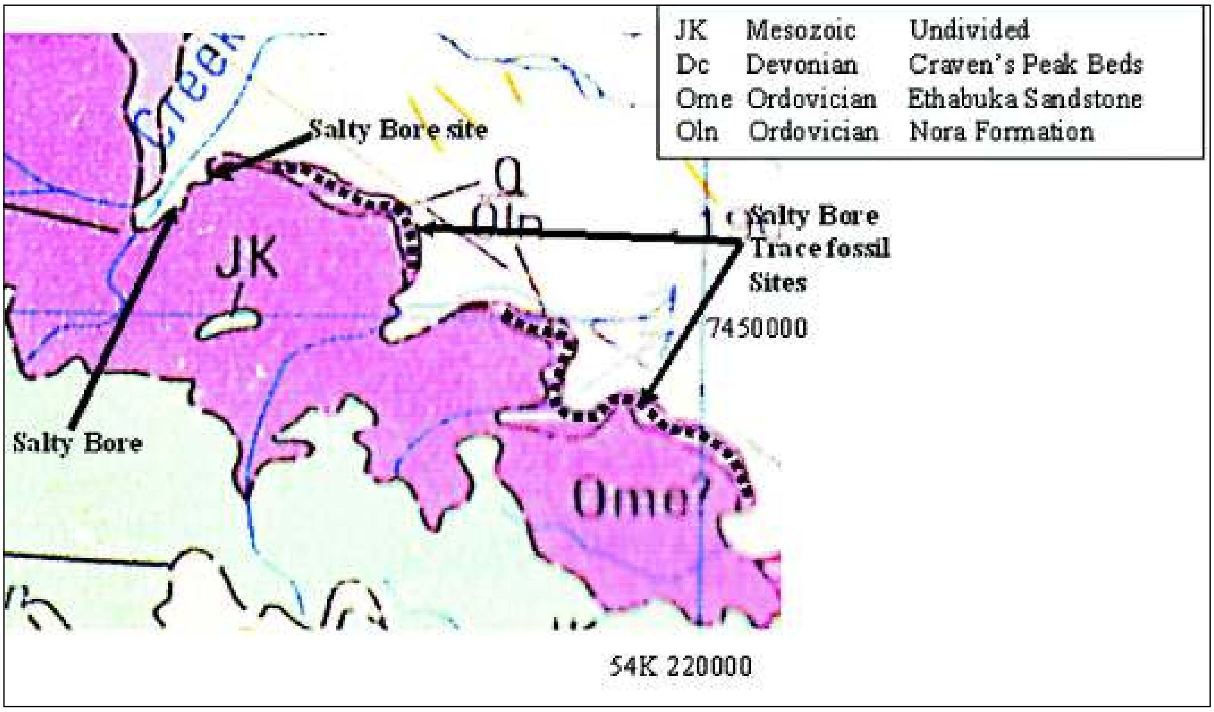
Classification: Extensive bioturbidation and Planolites sp
Locality: 54K 218585 7450115
Diagnosis: Irregular burrows with some external features of the species preserved on the inner walls of the burrow.
Remarks Very common
See Figure 6 (page 336)

Painted Gorge area

Lower Ordovician sediments of the Toko Group dipping steeply to the east are incised by a westward–flowing creek at Painted Gorge. The lithologies present are very similar to those at Salty Bore—fine pale sandstone, massive coarse red sandstone, with the addition of yellow siltstone. At the western end of the gorge (Map Reference 54K 203128 7425944), a rich deposit of trace fossils was found at the base of the Nora Formation (Shergold, 1985). See Map 3, page 337., Figure 7, page 337, Figure 8, page 338.

Systematic palaeontology

Classification: Planolites sp
Locality: 54K 203128 7425944
Diagnosis: Infill of irregular burrows with some external features (mainly segmentation) of the species preserved on the outer



Map 2. Salty Bore area. Adapted from Shergold, 1985.

parts of the cast.
Remarks Abundant

Classification: *Arthrophycus* sp.
Locality: 54K 203128 7425944
Diagnosis: Confused short featureless ridges.
Remarks Abundant
See Figure 9, page 339.

Cravens Peak Homestead area

The homestead sits on a ridge–top protected by massive reddish jointed Carlo Sandstone highly resistant to weathering. This produces a blocky deflation armour which is persistent over the softer and diverse Nora Formation outcropping to the east. Widely–scattered small outcrops of a massive sandstone, some with fragmentary plant fossils, overly both older strata.

Nora formation

In the area north to south–east of the Cravens Peak Homestead was scattered to extensive outcrop of a variety of rock types in three main facies, each with its own fossil assemblage. The whole formation dips shallowly (range 4 to 15°, median 9°) south–west. Mainly in the east (oldest) of the survey area were thinly–layered fine sandstones and grey shales (tentatively named Craven A Unit), near the middle of the survey area were a variety of coquinites and some shale (tentatively named Craven B Unit), and mainly toward the west (youngest) shales and fine sandstones of a variety of colours (tentatively named Craven C Unit).

Craven A Unit

This collection of fine well–sorted sandstones (variously white, cream, grey, pale green and pale red, some micaceous), pale grey shale and very occasional thin coquinite layers near the middle of the Nora Formation shows large ripple marks (≅ 15cm) at a number of sites. It has few body fossils but is intensely bioturbidated. Numerous bedding planes show animal tracks, with worm burrows both horizontal and vertical. While a number of shell–shaped impressions were observed, the only body fossil collected was a trilobite pygydium.
See Figure 10, page 340.

Systematic palaeontology:

Classification: *Proteus* sp.
Locality: 54K 255934 7418784
Diagnosis: External mold of pygidium
Remarks Rare.
See Figure 11, page 341.

Craven B Unit

Within the middle of the survey area are two main thick layers and numerous thinner layers of coquinite, plus grey shale. They range from

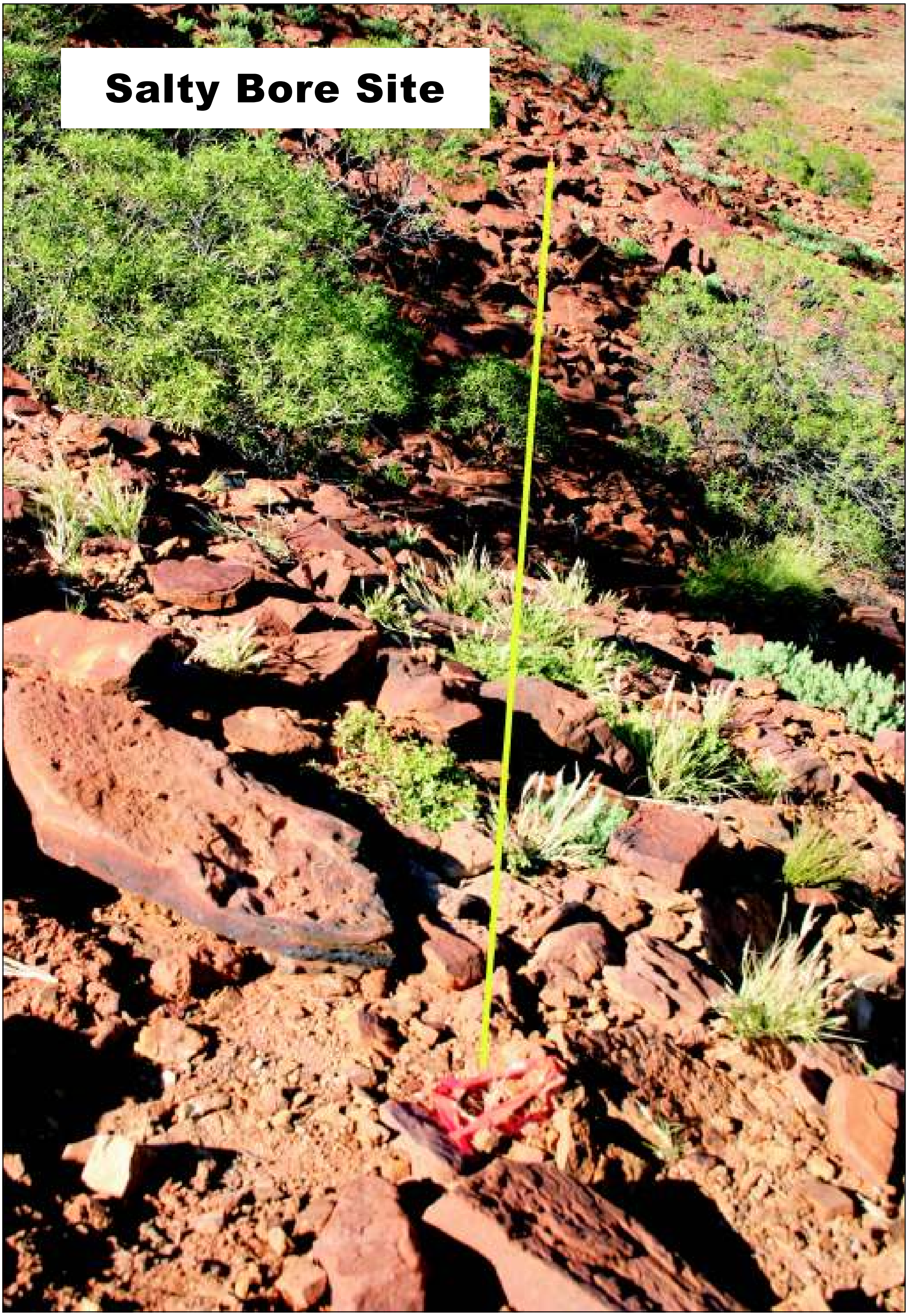


Figure 1. Salty Bore site.

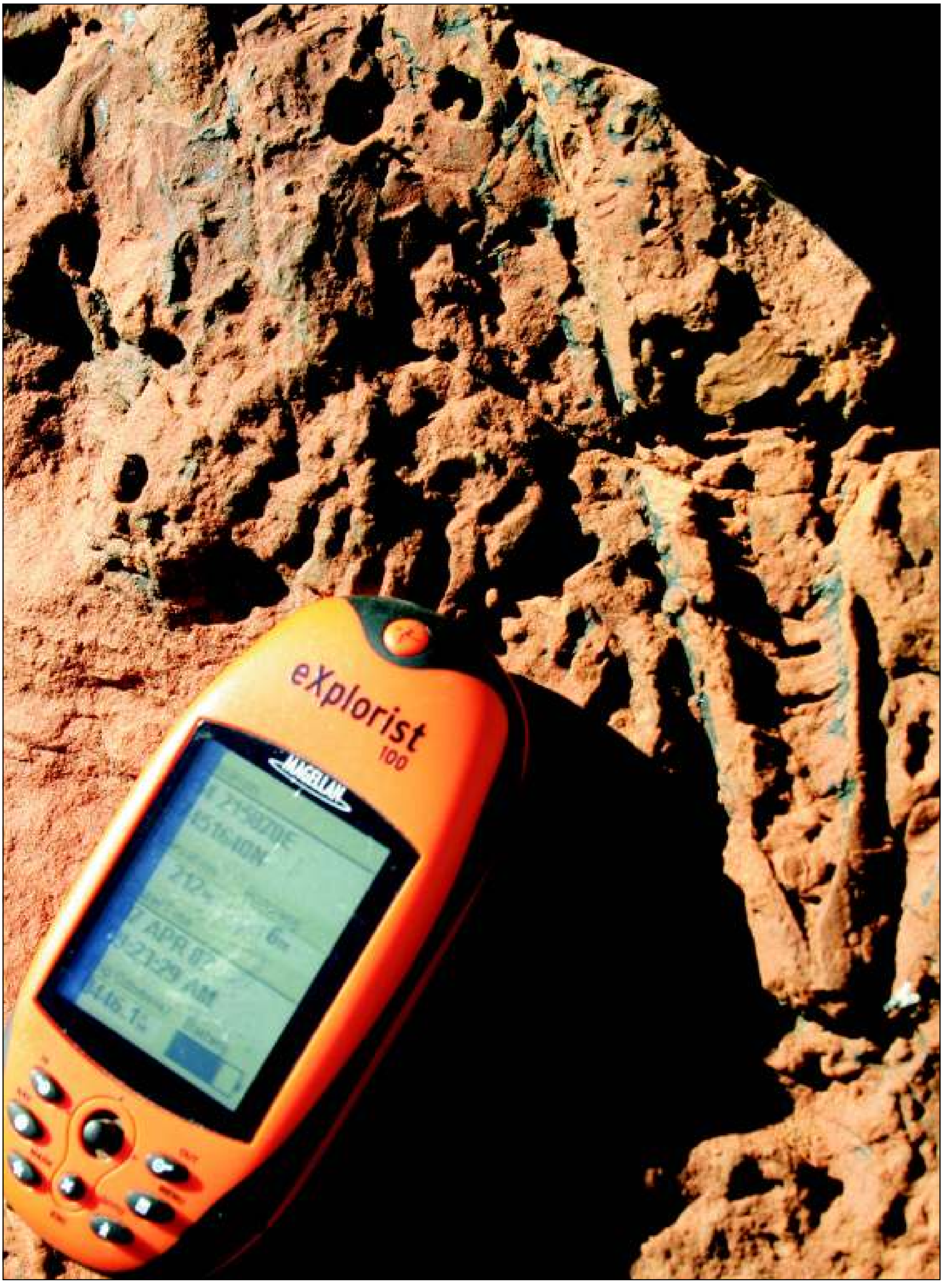


Figure 2. *Nautiloid*

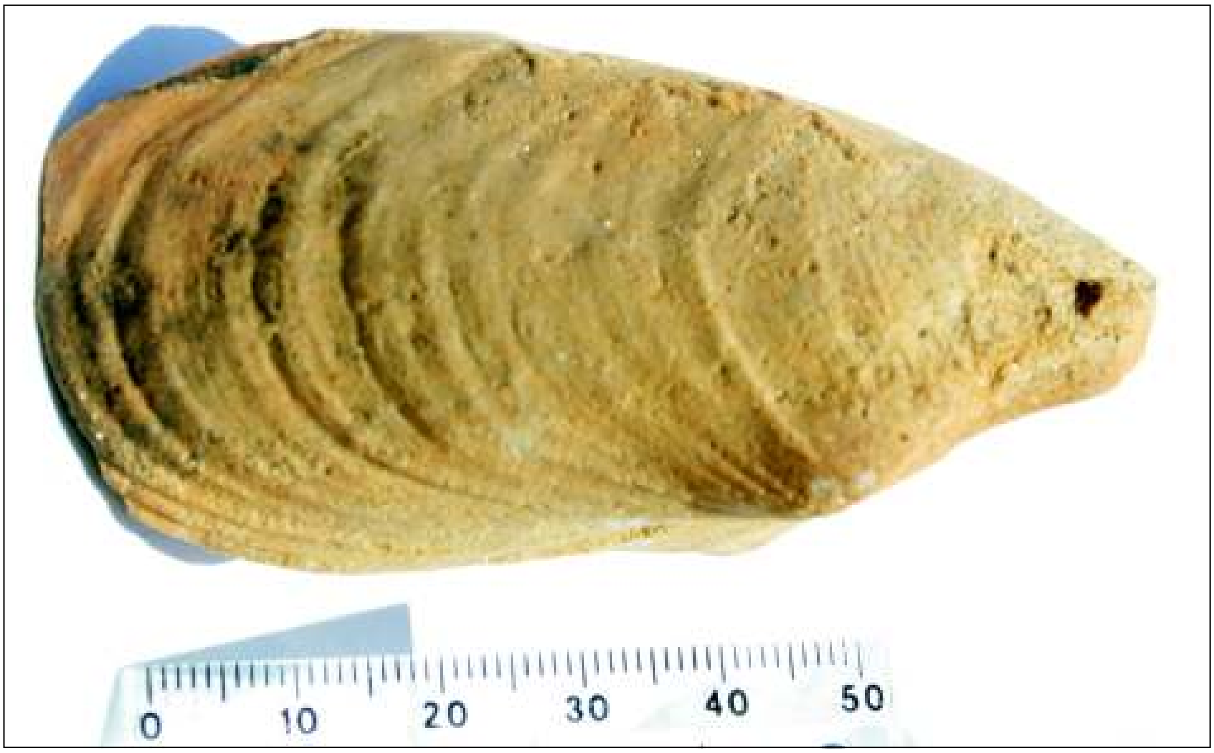


Figure 3. *Pelecypod* 1

Figure 4. *Pelecypod* 2

Figure 5. *Cruziana*

grey to yellow–brown coquinite, and many are densely iron–stained. A number of samples show grains of haematite, most of which are clearly rounded. The upper parts of all layers are intensely bioturbidated, especially with Planolites sp. See Figures 12, page 351, 13, page 351, and 14, page 352.

Systematic palaeontology:

The layer contained abundant nautiloids and gastropods, common pelecypods, conodonts and brachiopods, and rare crinoidal and arthropod remains.

Classification: *Ophileta gilesi*
Locality: 54K 253351 7421330
Diagnosis: Very low spire, tight coiling.
Remarks Abundant.
See Figure 15, page 353.

Classification: *Actinoceras* sp.
Locality: 54K 253871 7420516
Diagnosis: LS showing evenly–spaced septa, cyrtochoanitic necks, cameral deposits. Also found large annular endosiphuncular deposit with septal grooves
Remarks Abundant.
See Figure 16, page 354.

Classification: Actinoceratid sp.
Locality: 54K 257886 7415275
Diagnosis: Large annular endosiphuncular deposits with septal grooves
Remarks Rare.
See Figure 17, page 355.

Classification: *Drepanoistodus* sp.
Locality: 54K 253871 7420516
Remarks Common
See Figure 18, page 356.

Figure 6. Extensive turbidation and Planolites sp.

Classification: *Triangulodus* sp.
Locality: 54K 253871 7420516
Remarks Common
See Figure 19, page 357.

Most parts of the outcrop have been slightly recrystallised, making specific identification difficult. However, some tentative identifications of common fossils have been attempted. See Figure 20, page 357, and Figure 21, page 357.

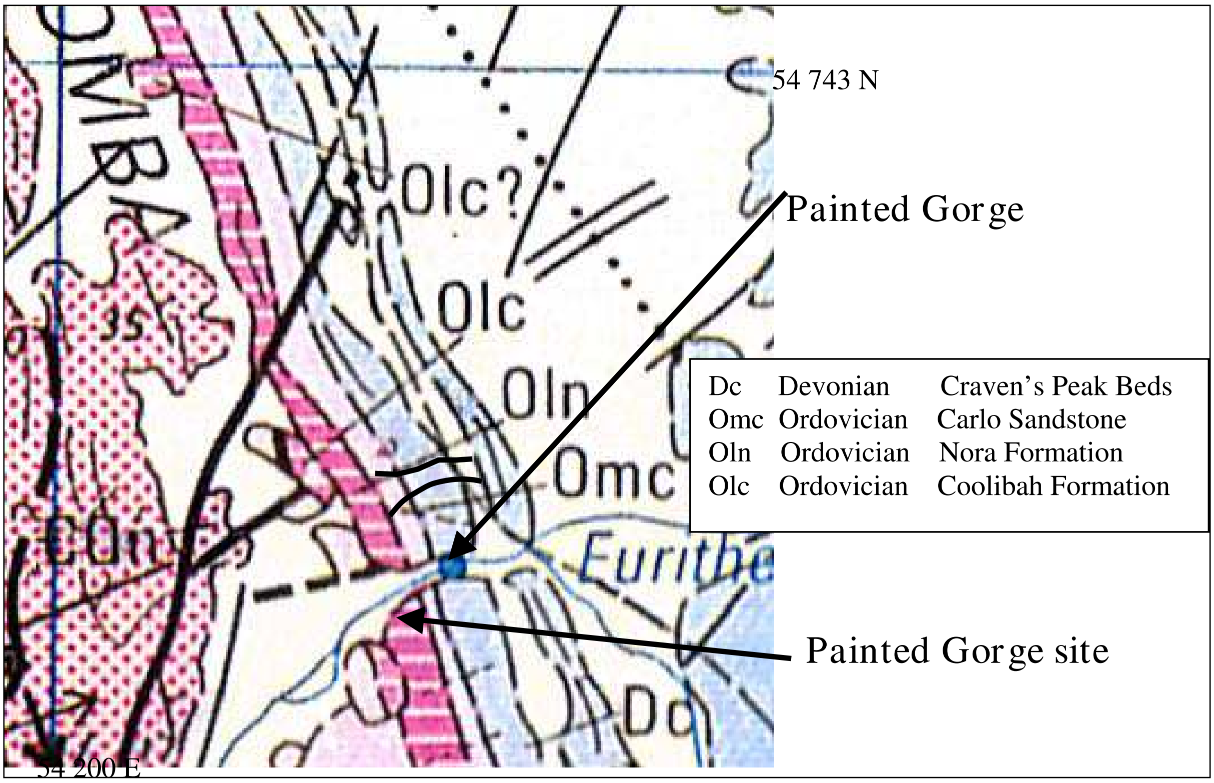
Classification: *Talassoceras* sp.?
Locality: 54K 253859 7420602
Diagnosis: Natural LS offset from axis. Closely–spaced septa, marginal siphuncle.
Remarks Common
See Figure 22, page 358.

Classification: *Proterocameroceras* ?
Locality: 54K 253871 7420516
Diagnosis: Endosiphocone shows striae, TS shows irregular and branching blades, particularly strong ventral and dorsal ones.
Remarks Common
See Figure 23, page 358.

Classification: *Manchuroceras* ?
Locality: 54K 252911 7421754
Diagnosis: Natural LS, showing blades. TS shows wedge and loop.
Remarks Common
See Figure 24, page 359, Figure 25, page 359, and Figure 26, page 360.

Craven C Unit

The youngest section of the Nora Formation at Craven's Peak (tentatively named Craven C) is variable from iron–stained mudstone, fine sandstone to grey, green, brown and yellow shales. It is found as widely–scattered small



Map 3. Painted Gorge area. Adapted from Shergold, 1985.

Figure 7. Site at western end of Painted Gorge.

outcrops, mainly in gullies, and intermittently as part of a deflation armour over about 20 km^2. At two sites where the Nora Formation—Carlo Sandstone boundary could be identified, the distinctive top member was a pale brown, fine, well–sorted sandstone with some rounded fragments of an earlier white sandstone. It contained common arthropod plates and suggestive voids like a low spire gastropod (cf. *Raphistoma*) but no body fossils. See Figure 27, page 360 and Figure 28, page 361.

Systematic palaeontology:

The fossil assemblage was entirely benthic and contained abundant gastropods, and brachiopods but no cephlapods nor conodonts.

Classification: *Raphistoma* sp.
Locality: 54K 254383 7418771
Diagnosis: Low spire (almost planispiral)
Remarks Abundant.
See Figure 29, page 362.

Classification: *Teiichispira cornucopiae*
Locality: 54K 254383 7418771
Diagnosis: External moulds,

Figure 8. Planolites sp.

shallow-domed ventral surface, filled apical cavity with impressions of keel.
Remarks Abundant.
See Figure 30, page 362.

Discussion

Age: Arenig

Depositional Setting: All lithologies are characteristically fine, suggesting a quiet depositional setting while the rounding of the grains of haematite suggests either a tidal or close–to–wave base movement during deposition. Necessarily, this would be shallow and close off–shore. The gradual change of fossil assemblage from free–swimming species in Craven B to more benthic ones in Craven C also suggests this section of the Nora Formation is a regressive sequence.

Measured section

South–east of the homestead, the mesa flank is dissected by a number of gullies with outcrop. One in particular, from 54K 258822 7412610 to 54K 258983 7412771, contained sufficient outcrop to measure. This plus the survey data east of the gully was used to produce a section of the top half of the Nora Formation in the Craven's Peak area. The survey was conducted with Differential GPS with averaged multiple measurements to improve the accuracy of (particularly) the altitude measurements. Analysis suggests accuracy of ± 0.1m horizontally and ±0.3m vertically.

The schematic cross section of the area appears at Figure 31 (page 363).

The section has an arbitrary zero at the base of a sequence of grey shale layers at the eastern extremity of the study area, still approximately 1.2km south–west of the previously mapped lower boundary of the Nora Formation. See Figure 32, page 364

Carlo Sandstone

The Carlo Sandstone lies conformably above the Nora Formation. It is a massive, pale, well–sorted fine sandstone, mostly showing little or no bedding, except for one site showing clear current bedding. It is well–jointed, with iron oxide staining of the joint surfaces and a little penetration into the body of the rock. Just above the base is a layer containing abundant clay balls mainly 2–4mm in diameter but ranging up to 10mm. No fossils were found. The fine particle size and the clay ball layer are consistent with conditions suggested above for the Nora Formation, with the current bedding indicating a short–lived shallower episode. In the north–west of Map 4, an area around 54K 248687 7423914 marked as Mesozoic in the 1985 map was investigated. Samples indicate it and adjacent close areas of sandstone outcrop to the north–west are of Carlo

Figure 9. *Arthrophycus* sp.

Sandstone. See Figure 33, page 365, and Figure 34, page 366.

Mesozoic Sandstones

A large number of small, scattered outcrops of a distinctive, dense, pale green sandstone, commonly with fragmented complex plant material occur in the homestead area and as far west as 54K 211710 7433538 (45km west). This lies unconformably above both the Nora Formation and Carlo Sandstone where a relationship can be established. This rock has similarities to parts of the Hooray Sandstone described by Mond and Harrison (in Senior et al 1978) and is so assigned. See Figure 35, page 366, Figure 36, page 367, and Map 4, page 368.

Acknowledgements

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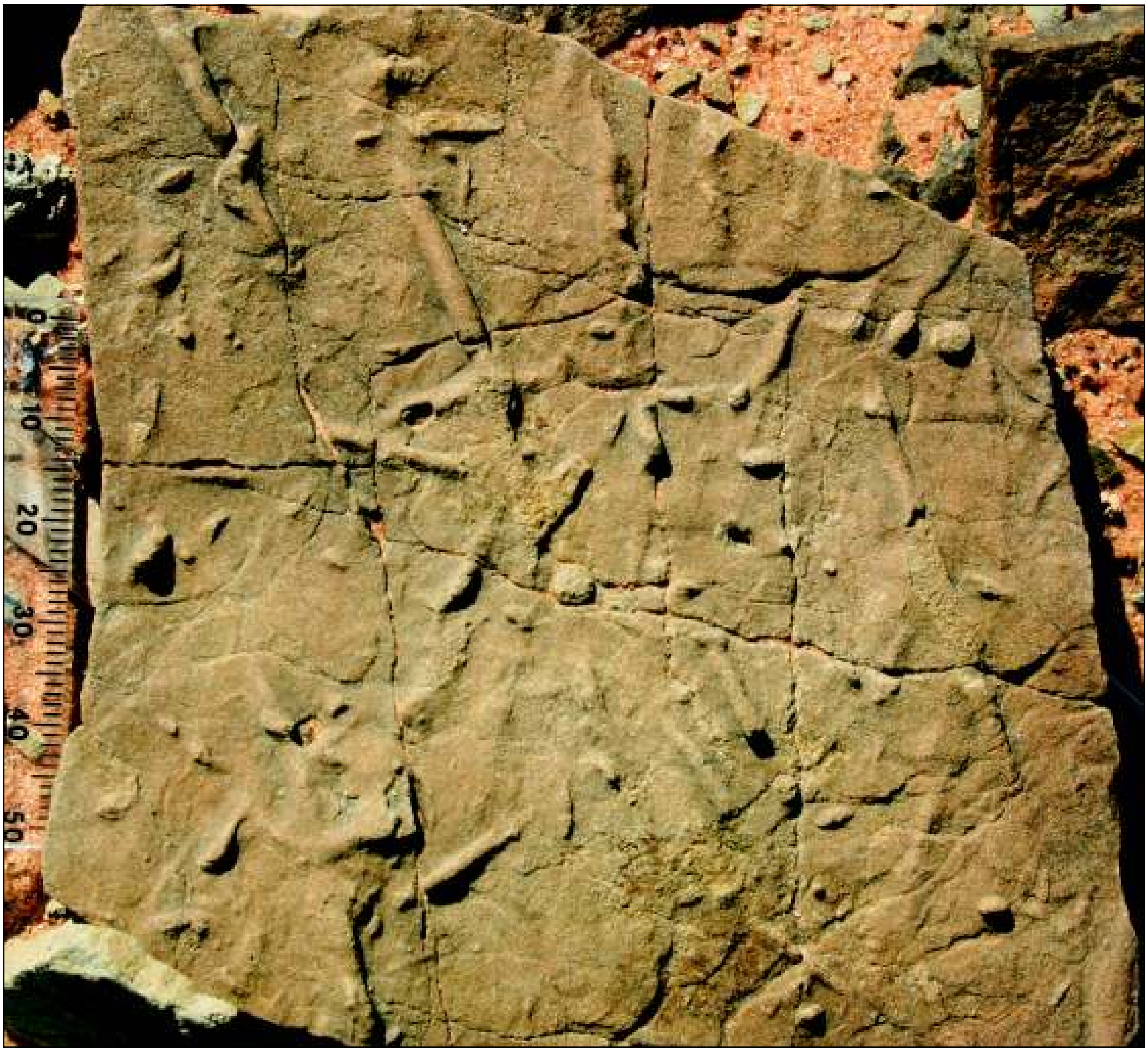

Figure 10. Animal tracks.

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Figure 11. *Proteus* sp.

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Appendix 1. Primary Data

All position data below is referenced to WGS84 on Universal Transverse Mercator projection (Zone 54K). All position data was collected with a Differential GPS receiver (accuracy ± 3m) with multiple averaged readings (accuracy horizontal ± 0.1m, vertical ±0.3m) for data points M001-M012.

Data Point	Formation	Rock	Colour	Fossils	Sample	Notes	Easting	Northing	Alt
0001	Nora C	Sst	Fe Rich	*Raphistoma*			253875	7418608	
0002	Nora C	Sst				Deflation armour	254412	7418771	
0003	Nora C	Sst		*Raphistoma*	1-3	Deflation armour, fossil band~220m Wide E-W	254383	7418771	
0004	Nora C	Sst			4-7	Outcrop, gully	254410	7418863	
0005	Nora B	Coquniite			8-10, 15-17		253871	7420516	
0006	Nora C	Sst			11,12	Deflation armour	254136	7419588	
0007	Nora C	Sst				Deflation armour	254539	7418614	
0008	Nora B	Coquniite					255242	7417696	
0009	Nora B	Coquniite					255384	7417448	
0010	Nora B	Coquniite				Layer 200m N-S X 2-5m E-W	255635	7417142	
0011	Nora C	Sst				Deflation armour	255861	7416733	
0012	Nora B	Coquinite					255945	7416785	
0013	Nora C	Sst				Deflation armour	256119	7416537	
0014	Nora C	Sst		Pelecypods			256185	7416296	
0015	Nora C	Sst		*Raphistoma*		Deflation armour	256338	7416256	
0016	Nora C	Sst		*Raphistoma*			256618	7415967	
0017	Nora B	Coquinite				Outcrop	257040	7415012	
0018	Nora B	Coquinite				Outcrop	254411	7419713	
0019	Nora B	Coquinite				Outcrop	254337	7419878	
0020	Nora B	Coquinite				Outcrop	254308	7419932	
0021	Nora B	Coquinite				Outcrop	254248	7420038	
0022	Nora B	Coquinite				Outcrop	254182	7420123	
0023	Nora B	Coquinite				Outcrop	254148	7420172	
0024	Nora B	Coquinite				Outcrop	254078	7420233	
0025	Nora B	Coquinite				Outcrop	253999	7420350	
0026	Nora B	Coquinite				Outcrop	253988	7420484	
0027	Nora B	Coquinite				Outcrop	253859	7420602	
0028	Nora B	Coquinite				Outcrop	253775	7420697	
0029	Nora B	Coquinite				Outcrop	253699	7420791	
0030	Nora B	Coquinite				Outcrop	253642	7420858	
0031	Nora B	Coquinite				Outcrop	253599	7420905	

Data Point	Formation	Rock	Colour	Fossils	Sample	Notes	Easting	Northing	Alt
0032	Nora B	Coquinite				Outcrop	253550	7420927	
0033	Nora B	Coquinite				Outcrop	253456	7420976	
0034	Nora B	Coquinite				Outcrop	253402	7421116	
0035	Nora B	Coquinite				Outcrop	253486	7421090	
0036	Nora B	Coquinite				Outcrop	253420	7421191	
0037	Nora B	Coquinite				Outcrop	253351	7421276	
0038	Nora B	Coquinite				Outcrop	253204	7421522	
0039	Nora B	Coquinite				Outcrop	253145	7421597	
0040	Nora B	Coquinite				Outcrop	253054	7421647	
0041	Nora B	Coquinite			19	Outcrop	252911	7421754	
0042	Nora B	Coquinite				Outcrop	252725	7422010	
0043	Nora B	Coquinite				Outcrop	252485	7422270	
0044	Nora B	Coquinite				Outcrop	252314	7422447	
0045	Nora B	Coquinite				Outcrop	252136	7422587	
0046	Nora B	Coquinite				Outcrop	252023	7422723	
0047	Nora B	Coquinite				Outcrop	251871	7422830	
0048	Nora B	Coquinite				Outcrop	251564	7423272	
0049	Nora B	Coquinite				Outcrop	251184	7423841	
0050	Nora C	Sst				Deflation armour	250733	7423962	
0051	Nora C	Sst				Deflation armour	250838	7423716	
0052	Nora C	Sst				Deflation armour	251100	7423446	
0053	Nora C	Sst				Deflation armour	251387	7423053	
0054	Nora C	Sst				Deflation armour	251439	7422986	
0055	Nora C	Sst					251554	7422789	
0057	Nora B	Coquinite				Outcrop	254504	7419534	
0058	Nora B	Coquinite				Outcrop	254727	7419208	
0059	Nora B	Coquinite				Outcrop	255127	7418313	
0060	Nora B	Coquinite				Outcrop	255157	7418208	
0061	Nora B	Coquinite				Outcrop	255094	7418170	
0062	Nora B	Coquinite				Outcrop	255118	7418136	
0063	Nora B	Coquinite				Outcrop	255204	7417978	
0064	Nora B	Coquinite				Outcrop	255284	7417854	
0065	Nora B	Coquinite				Outcrop	255368	7417772	
0066	Nora B	Coquinite				Outcrop	255427	7417694	
0067	Nora B	Coquinite				Outcrop	255472	7417576	
0068	Nora B	Coquinite				Outcrop	255508	7417503	
0069	Nora B	Coquinite				Outcrop	255572	7417300	
0070	Nora B	Coquinite				Outcrop	255810	7416950	

Data Point	Formation	Rock	Colour	Fossils	Sample	Notes	Easting	Northing	Alt
0071	Nora B	Coquinite			14	Outcrop	253937	7420055	
0072	Nora B	Coquinite				Outcrop	253537	7421014	
0073	Nora B	Coquinite				Outcrop	253325	7421321	
1101	Carlo	Sst					253583	7418491	
1102	Nora A	Sst/Sh				Scattered	256083	7418491	
1103	Nora B	Coquinite					255071	7419991	
1104	Carlo	Sst					253159	7419991	
1105	Carlo	Sst					252910	7420491	
1106	Nora A	Sst					254733	7420491	
1107	Nora A	Sst					253721	7421991	
1108	Nora C	Sst					252096	7421991	
1109	Hooray?	Sst	Pale				254034	7418505	145
1110	Hooray?	Sst	Pale		S4	Dip 12° to 175°M	254124	7418470	143
1112	Nora B	Coquinite					255135	7418496	136
1114	Nora A	Sst			S1	Creek	255934	7418784	140
1115	Nora B	Coquinite		Dark	S2 S3	Outcrop	255728	7419104	142
1116	Nora B	Coquinite				Outcrop, Dip13° to 200°M	255521	7419398	145
1117	Nora B	Coquinite					255452	7419528	137
1118	Nora A	Sst				Minor coquinite	255109	7420042	140
1119	Nora B	Coquinite				Outcrop	254525	7419990	144
1120	Hooray?	Sst	Pale				253084	7420173	148
1121	Hooray?	Sst	Pale				253030	7420324	150
1122	Hooray?	Sst	Pale				253090	7420503	154
1124	Nora B	Coquinite					253887	7420511	146
1125	Nora B	Coquinite				Outcrop	253904	7420544	144
1126	Nora A	Sst		Animal Tr		Outcrop	254444	7420972	140
1127	Nora A	Sst		Animal Tr			253803	7421816	148
1129	Nora B	Coquinite				Outcrop	252510	7422001	145
1130	Hooray?	Sst	Pale Green				253722	7418749	
1201	Carlo						253372	7418991	
1202	Nora A	Sst	Pale Green			Large outcrop	255446	7418991	
1203	Nora A	Sst/Sh				Scattered	255108	7419491	
1204	Carlo	Sst					253056	7419491	
1205	Carlo	Sst					252177	7420991	
1206	Nora A	Sst/Sh				Scattered	254096	7420991	
1207	Nora A	Sst/Sh				Scattered	253758	7421491	

Data Point	Formation	Rock	Colour	Fossils	Sample	Notes	Easting	Northing	Alt
1208	Carlo	Sst					252178	7421491	
1209	Hooray?	Sst	Pale				253826	7418948	
1210	Hooray?	Sst	Pale		D2		254214	7418801	
1211	Hooray?	Sst	Pale		D3		254288	7418898	
1213	Hooray?	Sst	Pale		D5	Large blocks	255072	7418852	
1214	Nora A	Sst	Pale Green	Fossils	D6a	Large outcrop	255216	7418852	
1215	Nora A	Sst	Pale Green	Fossils	D7		255242	7419047	
1217	Carlo	Sst				Ridge	253977	7419371	
1218	Hooray?	Sst	Pale Green				253635	7419495	
1219	Carlo	Sst			D8	Creek	252741	7420889	
1220	Carlo	Sst				Ridge	252821	7421039	
1221	Nora B	Coquinite			D9	Outcrop	253442	7421249	
1222	Nora A	Sst			D10	Thin bedded, hard	253607	7421368	
1223	Nora A	Sst				Thin bedded, hard	253748	7421574	
1224	Nora A	Sst				Thin bedded, hard	253451	7421932	
1225	Nora B	Coquinite	Green			Outcrop	252364	7421755	
2101	Nora C	Sst/Sh		Rich		Scattered, gibber	251945	7422476	
2102	Nora A	Sst	Red/ Cream, Mottled				254445	7422476	
2103	Nora A	Sst	Pale Red				253519	7423976	
2106	Nora A	Sst	Pale				253210	7424476	
2107	Nora A	Sst	Dark Red			Very hard	252284	7425976	
2108	Nora A	Sst	Pale				248845	7425976	
2109	Nora B	Coquinite				Small outcrop	252163	7422487	151
2110	Nora B	Coquinite				Small outcrop	252275	7422492	149
2112	Nora A	Sst	Grey			Crystalline, fence	252949	7422483	146
2114	Nora A	Sst	Red/ Cream, Mottled				254017	7422470	147
2115	Nora A	Sst	Pale				254119	7422980	144
2116	Nora A	Sst				Crystalline, creek	253829	7423430	149
2117	Nora A	Sst	Pale				253488	7423968	152
2122	Nora A	Sst	Pale			Crystalline	252485	7423990	151
2123	Nora A	Sst	Pale			Crystalline	252249	7423976	152
2126	Nora B	Coquinite				Outcrop, creek	251355	7424235	153

Data Point	Formation	Rock	Colour	Fossils	Sample	Notes	Easting	Northing	Alt
2127	Nora B	Coquinite				Extensive outcrop	251275	7424181	155
2128	Nora B	Coquinite				Extensive outcrop	250977	7424424	155
2131	Nora A	Sst	Pale			Fence intersection	251159	7424607	158
2133	Nora A	Sst	Pale			Creek	251389	7424487	159
2134	Nora B	Coquinite -Top			S5 S6 S7	Sst-Mid,Sh-Bottom, Dip 9° to 265°M	251499	7424502	153
2136	Nora A	Sst	Pale			Creek	252098	7424482	153
2140	Nora A	Sst	Pale Brown		S	Dip 15° to 285°M	253180	7424540	152
2143	Nora A	Sst	Pale			Dune	252808	7425127	159
2144	Nora A	Sst	Pale		S8	Hilltop	252543	7425753	161
2145	Nora A	Sst	Fe Rich			Very hard	252449	7425811	157
2146	Nora A	Sst	Pale			Creek	252365	7425927	155
2147	Nora A	Sst	Pale			Dune	252217	7425966	159
2148	Nora A	Sst	Pale			Dune	251831	7425988	157
2150	Nora A	Sst	Pale Brown		S9	Creek	251645	7425973	154
2151	Nora A	Sst	Pale				251474	7425963	157
2152	Nora A	Sst	Pale			Hooray? Fragments, dune to E	250958	7425981	157
2153	Nora A	Sst	Pale			Fence	250005	7425978	158
2156	Nora B	Coquinite				Outcrop, fence	251446	7423962	154
2201	Nora B	Coquinite				Outcrop	251817	7422976	
2202	Nora A	Sst	Pale				253836	7422976	
2203	Nora A	Sst	Pale				253528	7423476	
2204	Nora B	Coquinite				Outcrop	251699	7423476	
2205	Nora B	Coquinite				Outcrop, fence	249733	7424976	
2206	Nora A	Sst	Pale				252601	7424976	
2207	Nora A	Sst	Fe Rich			Very hard	252293	7425476	
2208	Nora A	Sst	Pale			Fence	249021	7425476	
2209	Nora B	Coquinite				Outcrop	251817	7423016	
2210	Nora B	Coquinite				Outcrop	251823	7423186	
2211	Nora B	Coquinite				Outcrop, fence	250614	7424516	
2212	Nora B	Coquinite				Outcrop	251961	7422916	
2214	Nora B	Coquinite				Outcrop	249936	7425038	
2215	Nora A	Sst			D23	Fence	252661	7422860	
2216	Nora A	Sst			D26		253707	7422971	
2217	Nora A	Sst					252120	7423703	

Data Point	Formation	Rock	Colour	Fossils	Sample	Notes	Easting	Northing	Alt
2218	Nora A	Sst	Light & Dark Bands				250326	7424645	
2219	Nora A	Sst	Pale				250220	7425174	
2220	Nora A	Sst	Green/ Beige		D29	Gibber	250773	7425263	
2221	Nora A	Sst	Brown	Pygidium	D24		252839	7422926	
2222	Nora A	Sst	Brown		D25		253124	7422940	
2223	Hooray?	Sst	Green		D28		250314	7425188	
2224	Nora A	Sst	Brown				251174	7425497	
2229	Nora A	Sst	Fe Rich			Very hard, dune	252152	7425254	
2232	Nora A	Sst	Fe Rich		D31	Black nodules	252190	7425420	
2233	Nora A	Sst			D32	Ripple marks	251491	7425555	
2234	Hooray?	Sst	Pale Green	No Plants			252220	7423687	
2235	Nora B	Coquinite				Outcrop	251089	7425388	
2236	Nora B	Coquinite				Outcrop	249851	7425002	
2237	Hooray?	Sst	Green/ Brown			Fence	250631	7425227	
2238	Hooray?	Sst	Green				250463	7425436	
3118	Carlo	Sst			S13		248687	7423914	163
3119	Carlo	Sst			S		248975	7423345	157
3120	Carlo	Sst				Gully	249205	7422872	156
3121	Carlo	Sst			S15 S16	Large outcrop	250386	7420509	153
3122	Carlo	Sst				Outcrop	251413	7418459	148
3213	Carlo	Sst				S10 S11 S12	247339	7425922	
3220	Carlo	Sst			S14		249334	7422690	160
4101	Carlo	Sst					254092	7417991	
4102	Nora A	Sh	Grey	Animal Tr		Minor coquinite, ripple marks	256592	7417991	
4103	Nora A	Sst	Grey			Sandplain	257875	7416491	
4104	Carlo	Sst				Gibber	256091	7416491	
4105	Nora C	Sst	Pale Brown			Outcrop, gully	256474	7415991	
4106	Nora A	Sh	Grey/ Green				258302	7415991	
4108	Carlo	Sst					256824	7414491	
4109	Carlo	Sst				Edge of ridge	254399	7418014	147
4110	Nora C	Sh	Grey	Animal Tr			254537	7418030	142
4112	Nora B	Coquinite				Scattered	255212	7418041	138
4113	Nora B	Coquinite				Outcrop	255394	7417997	136
4114	Nora B	Coquinite				Scattered	255597	7418007	138

Data Point	Formation	Rock	Colour	Fossils	Sample	Notes	Easting	Northing	Alt
4115	Nora B	Coquinite				Outcrop	255987	7418000	133
4116	Nora A	Sst	Grey				256053	7418008	136
4117	Nora B	Coquinite	Dark			Outcrop	256299	7418008	
4118	Nora A	Sst	Grey				256423	7418009	137
4120	Nora B	Coquinite			S17	Creek	256763	7417811	132
4122	Nora B	Coquinite				Layers Trend 155°M	257725	7416460	130
4124	Nora B	Coquinite				Creek	257273	7416475	133
4125	Nora B	Coquinite				Major creek	257053	7416456	135
4126	Nora B	Coquinite					256549	7416440	134
4128	Nora C	Sst	Grey			Outcrop, gully	256174	7416400	134
4129	Nora C	Sst	Grey			Outcrop, gully	256214	7416320	138
4130	Carlo?	Sst				Scree, Pelecypods cf Salty Bore	256173	7416274	141
4131	Nora C	Sst	Grey			Outcrop, gully	256276	7416211	137
4132	Nora C	Sst				Outcrop, gully, fence	256501	7416126	132
4133	Nora C	Sst				Bottom of outcrop, gully	256488	7416115	131
4134	Nora C	Sst	Grey	Rich		Outcrop, gully	256464	7416112	131
4135	Nora C	Sst	Grey			Top of outcrop, gully	256379	7416070	136
4136	Nora C	Sst	Grey			Outcrop, gully	256394	7416016	137
4137	Nora C	Sst	Grey/ Green			Outcrop, gully, fence	256591	7416013	132
4138	Nora B	Coquinite	Red				256822	7415999	131
4140	Nora A	Sh	Grey	Animal Tr			257656	7416003	125
4141	Nora B	Coquinite				Layers trend 140°M	257907	7416001	127
4142	Nora A	Sst	Grey			Large outcrop, layers trend 150°M	258532	7415741	127
4144	Nora A	Sh	Grey	Animal Tr			259213	7415035	124
4147	Nora B	Coquinite				Creek	257900	7414500	127
4148	Nora B	Coquinite	Brown		S18	Creek	257835	7414490	127
4150	Nora B	Coquinite				Outcrop	257745	7414459	130
4151	Nora B	Coquinite				Outcrop	257481	7414481	126
4152	Nora A	Sst					255810	7417997	
4153	Nora B	Coquinite				Outcrop	257684	7416687	
4201	Carlo	Sst					254576	7417491	
4202	Nora A	Sh	Grey	*Raphistoma*			256720	7417491	
4203	Nora A	Sst	Brown				257147	7416991	
4204	Carlo	Sst	Brown				255077	7416991	
4205	Carlo	Sst	Brown				256445	7415491	
4206	Nora B	Coquinite				Outcrop	258430	7415491	

Data Point	Formation	Rock	Colour	Fossils	Sample	Notes	Easting	Northing	Alt
4207	Nora B	Coquinite				Outcrop	258857	7414991	
4208	Carlo	Sst					256536	7414991	
4209	Nora C	Cgt			D33	Layer of fragments, base of scarp, gully	254819	7417538	
4210	Nora C	Sst		*Raphistoma*	D34		254972	7417552	
4211	Nora C	Sh	Grey		D35		255011	7417530	
4212	Nora C	Sh	Grey	*Raphistoma*			255121	7417521	
4214	Nora C	Sst			D36	Weathered, gibber	255919	7417005	
4215	Nora C	Sst	Dark Banded			Fence, gully	255896	7416900	
4216	Nora C	Sst	Brown				255742	7416821	
4217	Nora C	Sst	Green			Base of scarp	255541	7416813	
4218	Carlo	Sst	Brown			Edge of ridge	255106	7417048	
4219	Carlo	Sst	Pale				256454	7415538	
4220	Carlo	Sst	Green/ Brown		D37		256499	7415189	
4222	Nora B	Coquinite					257120	7415294	
4223	Nora B	Coquinite			D38	Gully	257144	7415606	
4224	Nora B	Coquinite			D44	Gully	257886	7415275	
4225	Nora B	Coquinite				Surface band	258360	7415196	
4226	Nora B	Coquinite		Poorer	D39		258139	7414990	
4227	Nora B	Coquinite					257408	7414944	
4228	Nora A	Sst	Fe Rich				258475	7414895	
5101	Carlo	Sst					257183	7413991	
5102	Nora A	Sst	Grey	Animal Tr			259683	7413991	
5104	Carlo	Sst					259138	7412491	
5109	Nora C	Sst	Grey	*Raphistoma*		Outcrop, gully	257544	7413976	127
5110	Nora C	Sst					257742	7413938	125
5111	Nora B	Coquinite				Scattered outcrop	257903	7413944	124
5112	Nora B	Coquinite				Large outcrop trends 150°M	258096	7413965	127
5113	Nora A	Sst		Animal Tr		Isolated pieces coquinite, fence	258242	7413961	120
5115	Nora A	Sst	Pale Brown			Isolated pieces coquinite	258931	7414029	127
5116	Nora A	Sst	Pale Brown				259419	7414030	130
5118	Nora B	Coquinite				Layer Trends 110°M	260129	7413472	123
5119	Nora A	Sst	Grey		S19	Photos	260182	7413332	123
5124	Nora A	Sst	Grey			Outcrop	260758	7412414	121
5125	Nora B	Coquinite				Grey shale in swale, dune	260631	7412409	127

Data Point	Formation	Rock	Colour	Fossils	Sample	Notes	Easting	Northing	Alt
5126	Nora B	Coquinite				Dune	260179	7412420	126
5128	Nora C	Sst	Grey	*Raphistoma*		Gully	259366	7412475	123
5129	Nora C	Sst	Grey	*Raphistoma*		Gully	259322	7412465	122
5130	Carlo	Sst	Pale		S20	Rounded clay pellets, bottom?	259289	7412459	130
5131	Nora A	Sst	Grey	Animal Tr		Layer Trends 110°M	260122	7413472	123
5201	Carlo	Sst					257652	7413491	
5202	Nora A	Sst	Grey				259502	7413491	
5203	Nora A	Sst	Grey	Animal Tr			259971	7412991	
5204	Carlo	Sst					258344	7412991	
5209	Nora C	Sst	Green/ Grey		D40		257891	7413544	
5210	Nora B	Coquinite					258270	7413521	
5211	Nora B	Coquinite				Large slabs, weathered	259749	7412934	
5214	Nora A	Sst	Grey		D41		259430	7413374	
5215	Nora A	Sst	Grey	Animal Tr	D42	Weathered	259918	7413425	
5216	Carlo	Sst	Pale		D43		258544	7412984	
Home	Cravens Peak Homestead				21		253598	7418653	145
M001	Carlo	Sst	Pale	None	M001	Head of gully, Photos1-3, Dip 6° to 215°M	258822	7412610	132
M002	Carlo	Sst	Pale	None	M002	Cross-Bedding, Photos4-6	258839	7412645	130
M003	Carlo	Sst	Pale	None	M003	Photos 8,9	258846	7412661	129
M004	Carlo	Sst	Pale	None	M004	Bottom, Photos, Dip 8° to 220°M	258858	7412693	128
M005	Nora C	Sst	Pale	None	M005	Top, very weathered, Dip 8° to 218°M	258859	7412693	128
M006	Nora C	Sst	Green	None	M006	20cm vert, Photos, Dip 9° to 212°M	258919	7412732	126
M007	Nora C	Sst	Brown	None	M007	14cm vert, Dip 4° to 265°M	258935	7412746	125
M008	Nora C	Sst	Brown	*Raphistoma*	M008	15cm vert, Dip 7° to 232°M	258955	7412747	125
M009	Nora C	Sst	Brown	*Raphistoma*	M009	10cm vert, Dip 11° to 228°M	258957	7412756	121
M010	Nora C	Sst	Brown	*Raphistoma*	M010	10cm vert, Dip 8° to 216°M	258963	7412762	119
M011	Nora C	Sst	Brown		M011	30cm vert, Dip 11° to 226°M	258972	7412768	118
M012	Nora C	Sst	Brown		M012a&b	100cm vert, Dip 7° to 242°M	258983	7412771	116

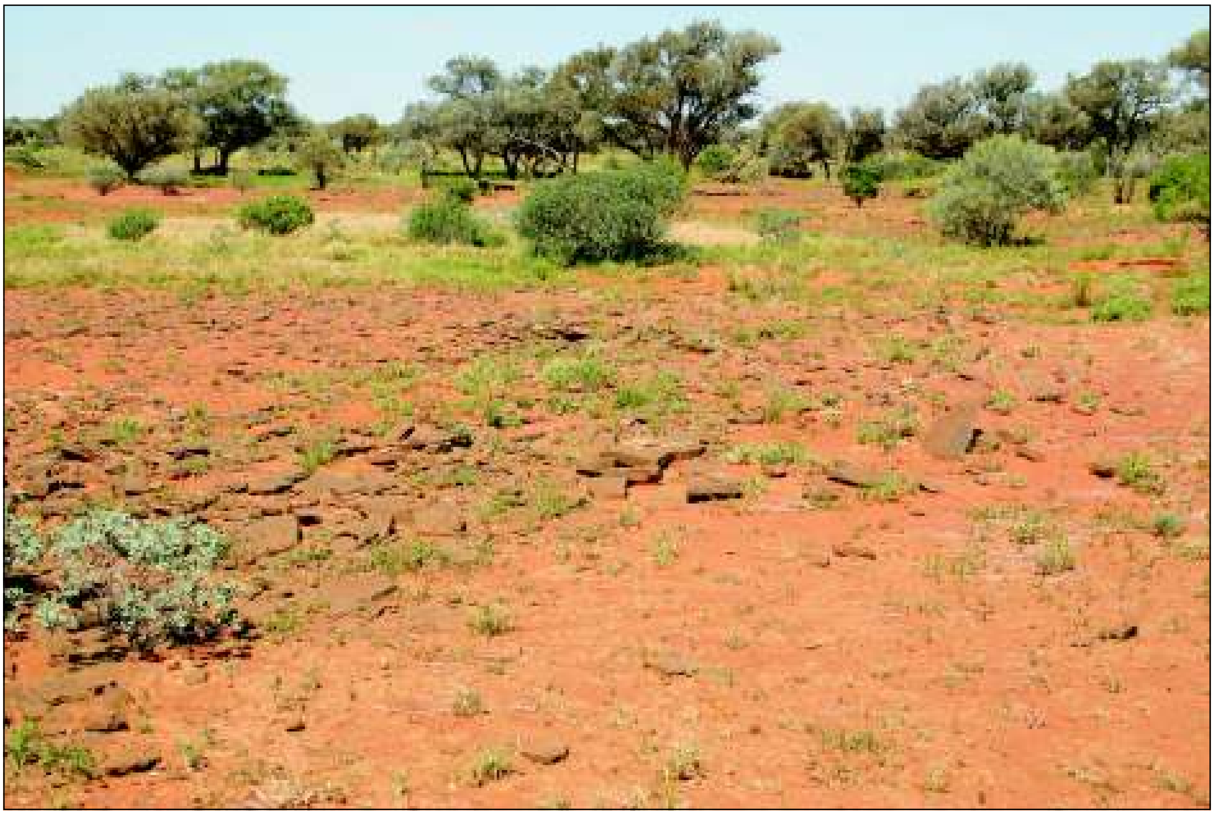


Figure 12. Typical coquinite outcrop.

Figure 13. Typical coquinite sample.

Figure 14. Photomicrograph—Coquinite—reflected light.

Figure 15. *Ophileta gilesi*.

Figure 16. *Actinoceras* sp.

Figure 17. Actinoceratid endosiphuncular deposit.

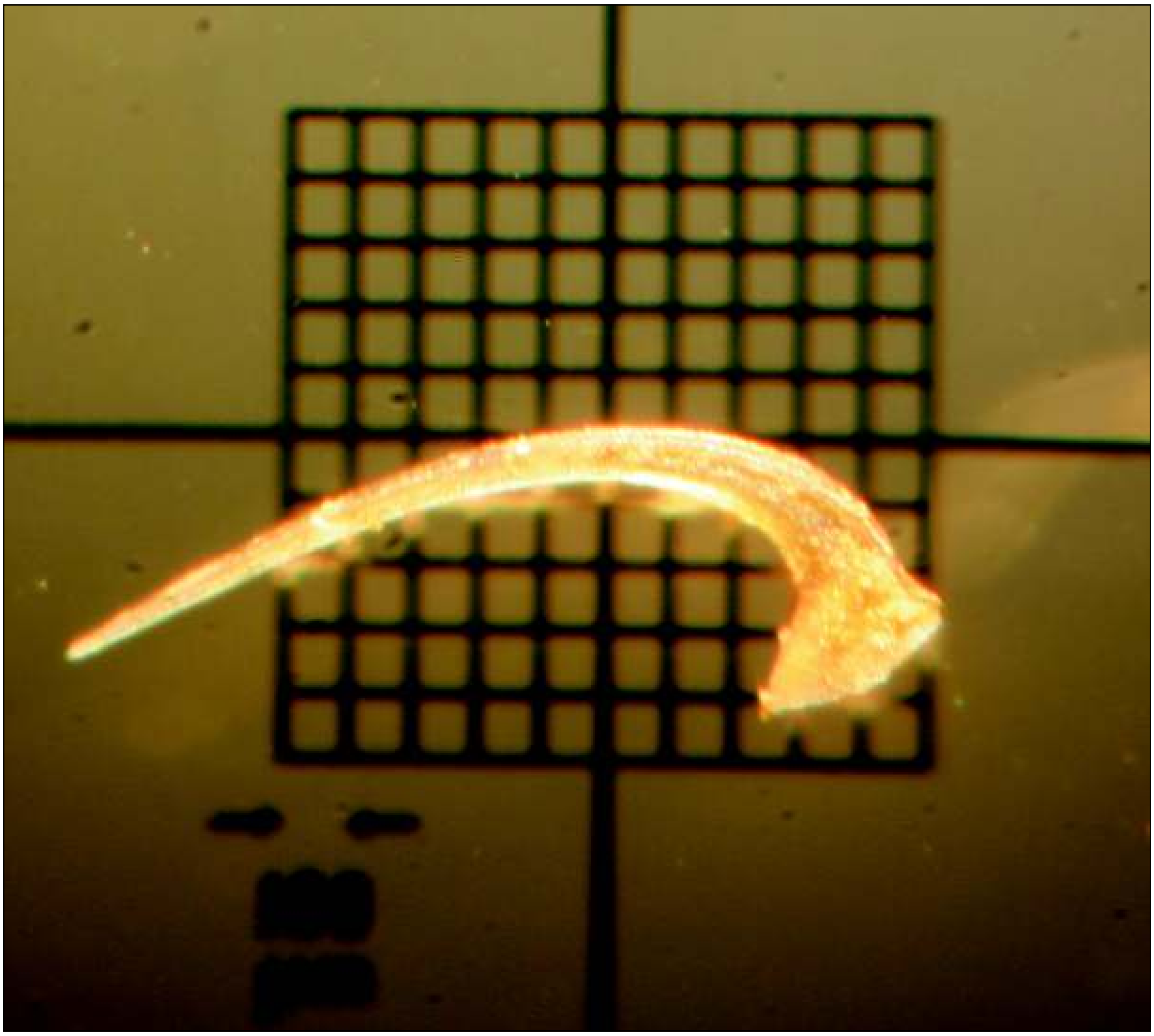


Figure 18. *Drepanoistodus* sp.

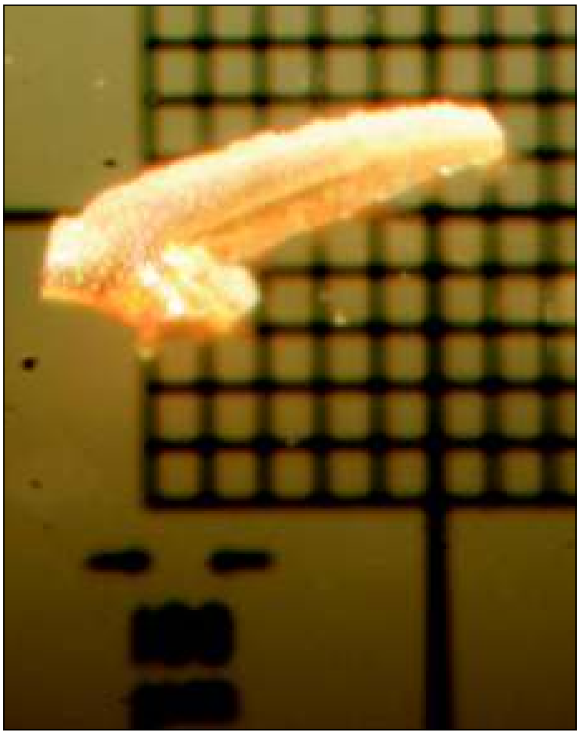


Figure 19. *Triangulodus* sp.

Figure 20. *Orthoid*

Figure 21. *Plectambonitoid*

Figure 22. *Talassoceras* sp. ?

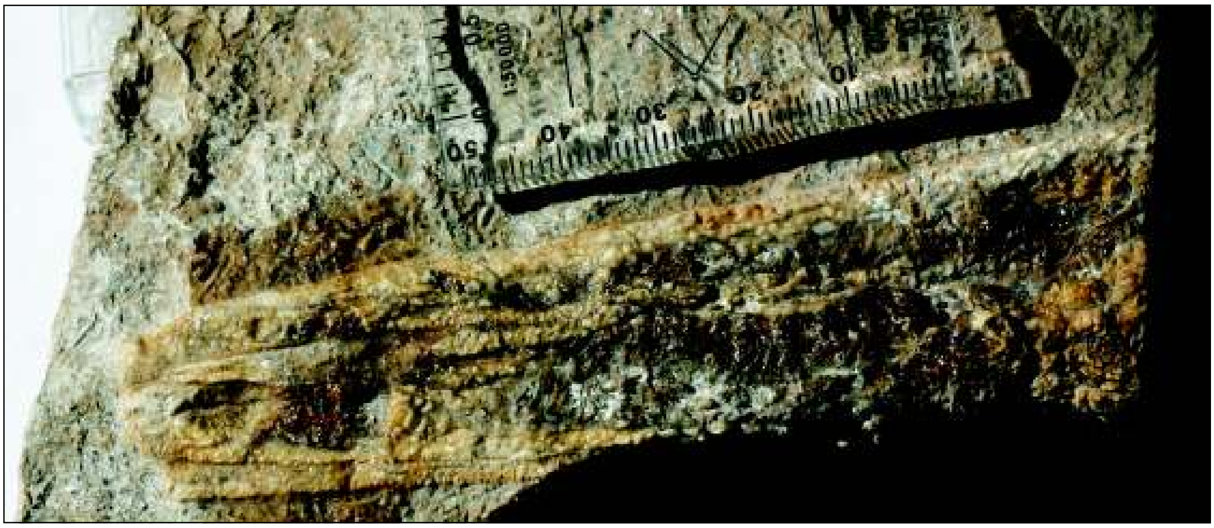


Figure 23. *Proterocameroceras*

Figure 24. *Manchuroceras ? (sample & TS)*

Figure 25. *Nanno*

Figure 26. *Mirabiloceras* ?


Figure 27. Typical Craven C outcrop.

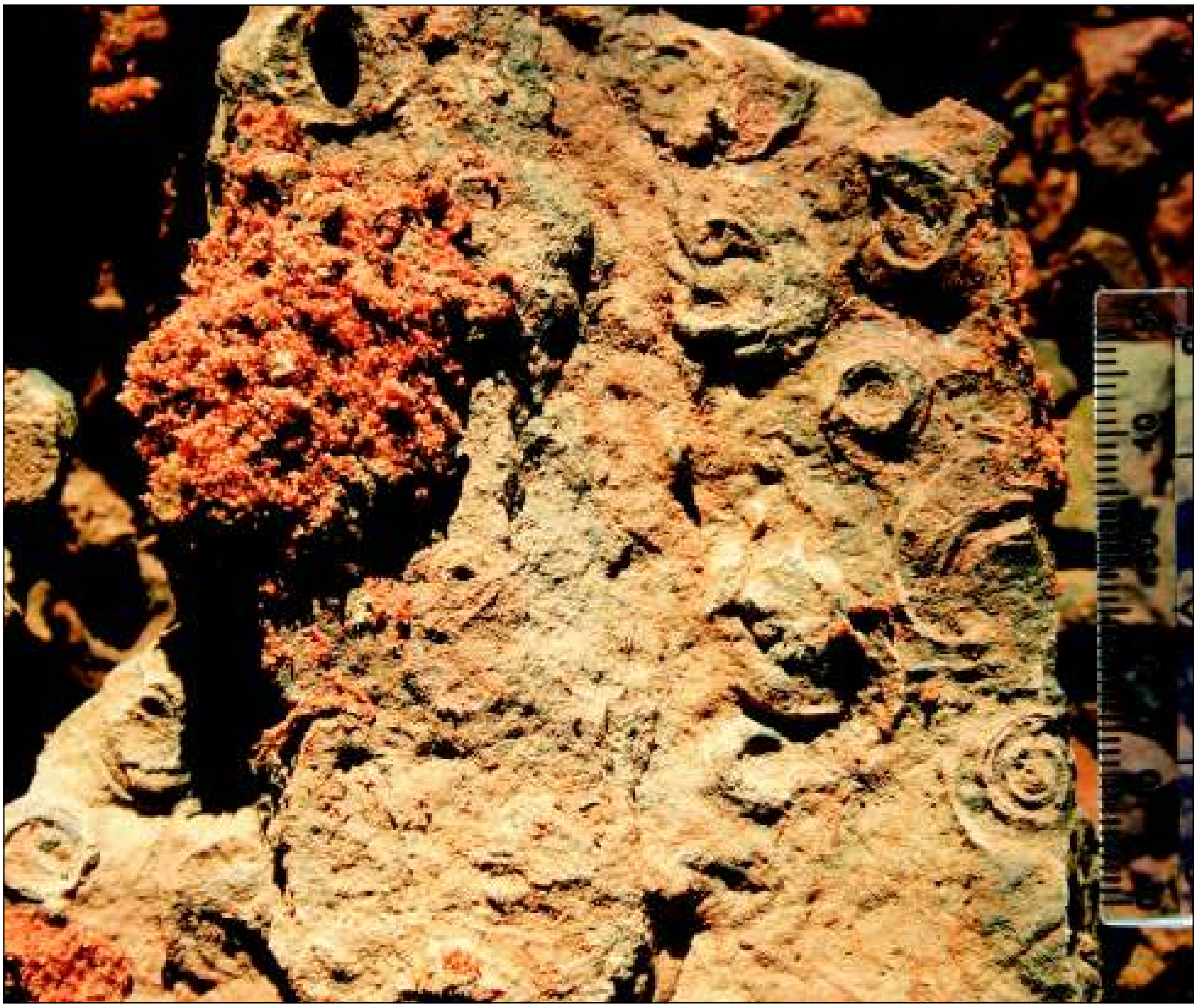


Figure 28. Typical Craven C sample.

Figure 29. *Raphistoma* sp.

Figure 30. *Teiichispira cornucopiae*

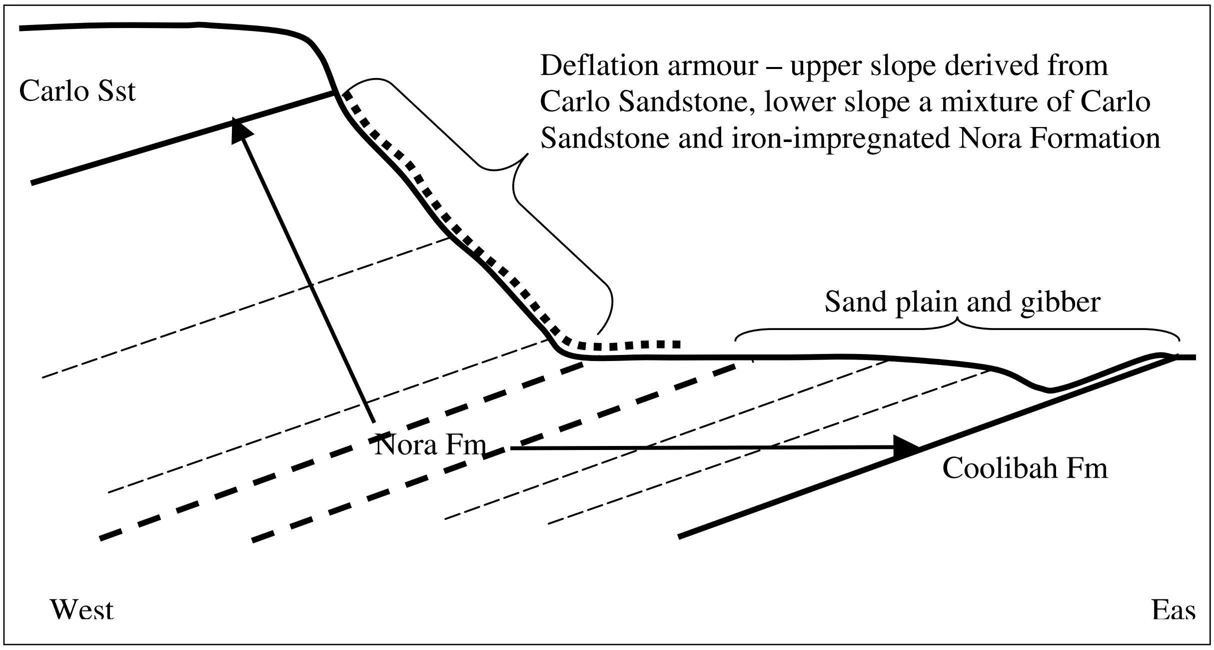


Figure 31. Schematic cross-section (not to scale).

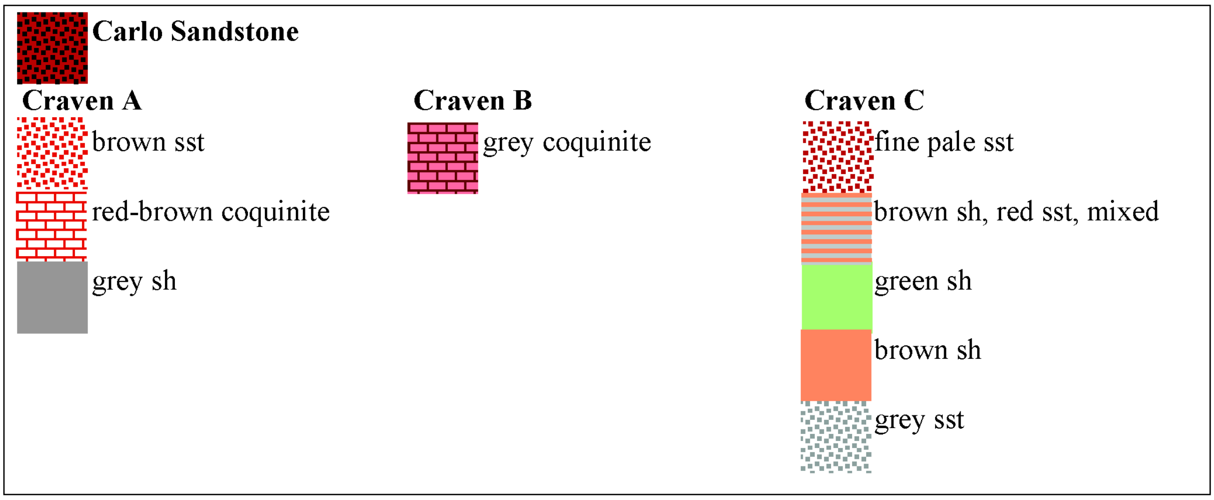


Fig 32. Measured section—Legend (See Figure 32 on page 364)

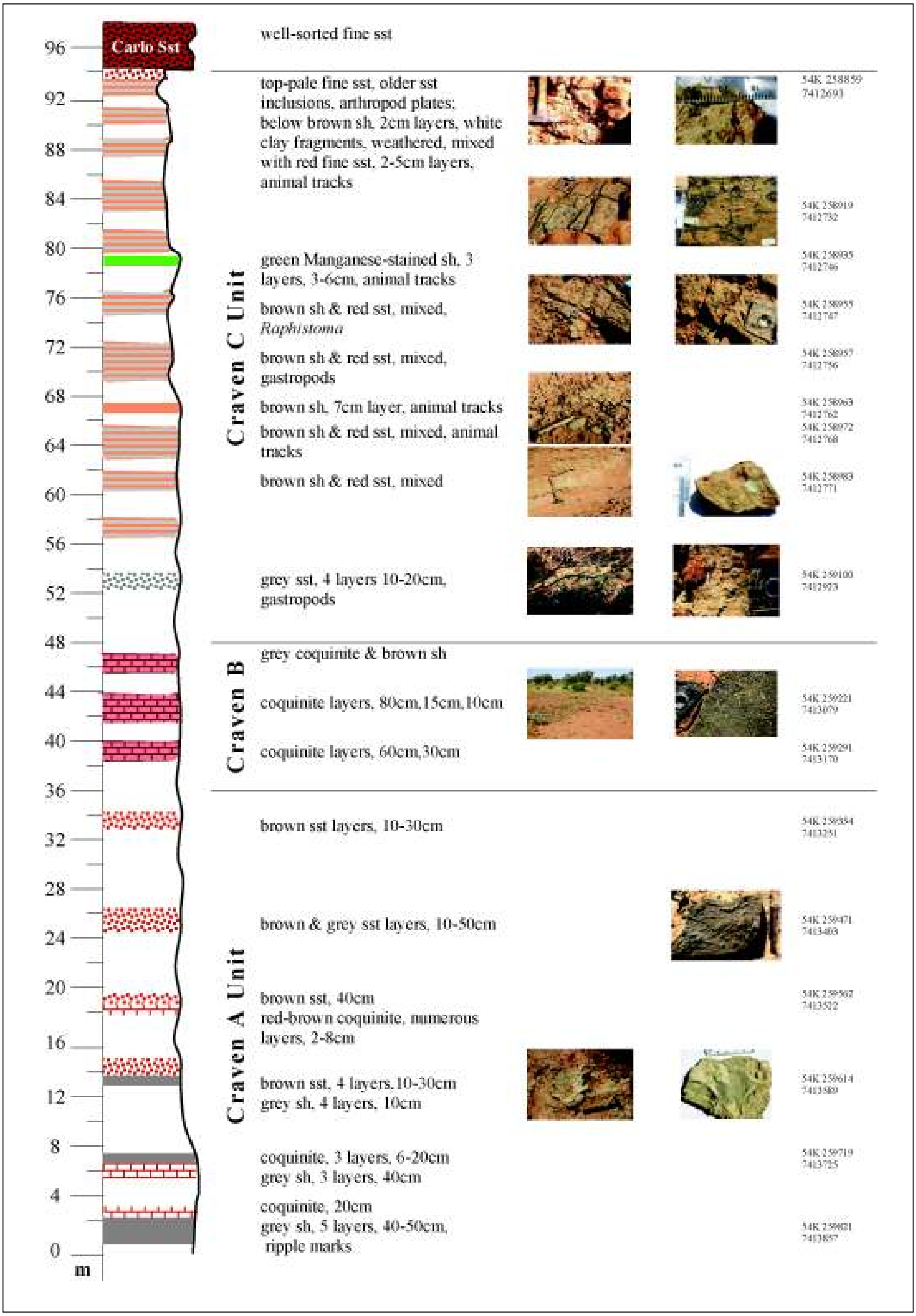


Figure 32. Measured Section (see Legend on page 363).

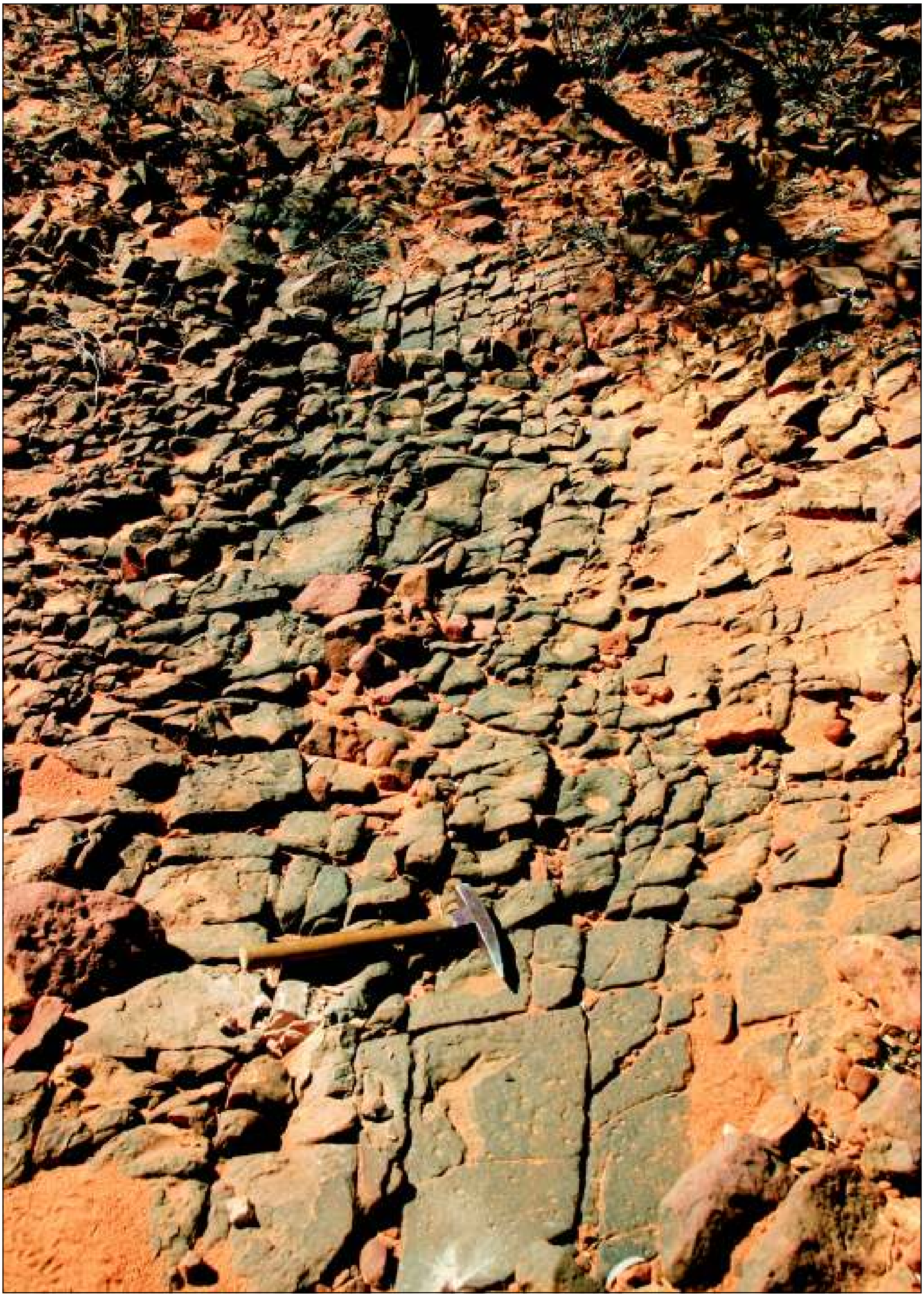
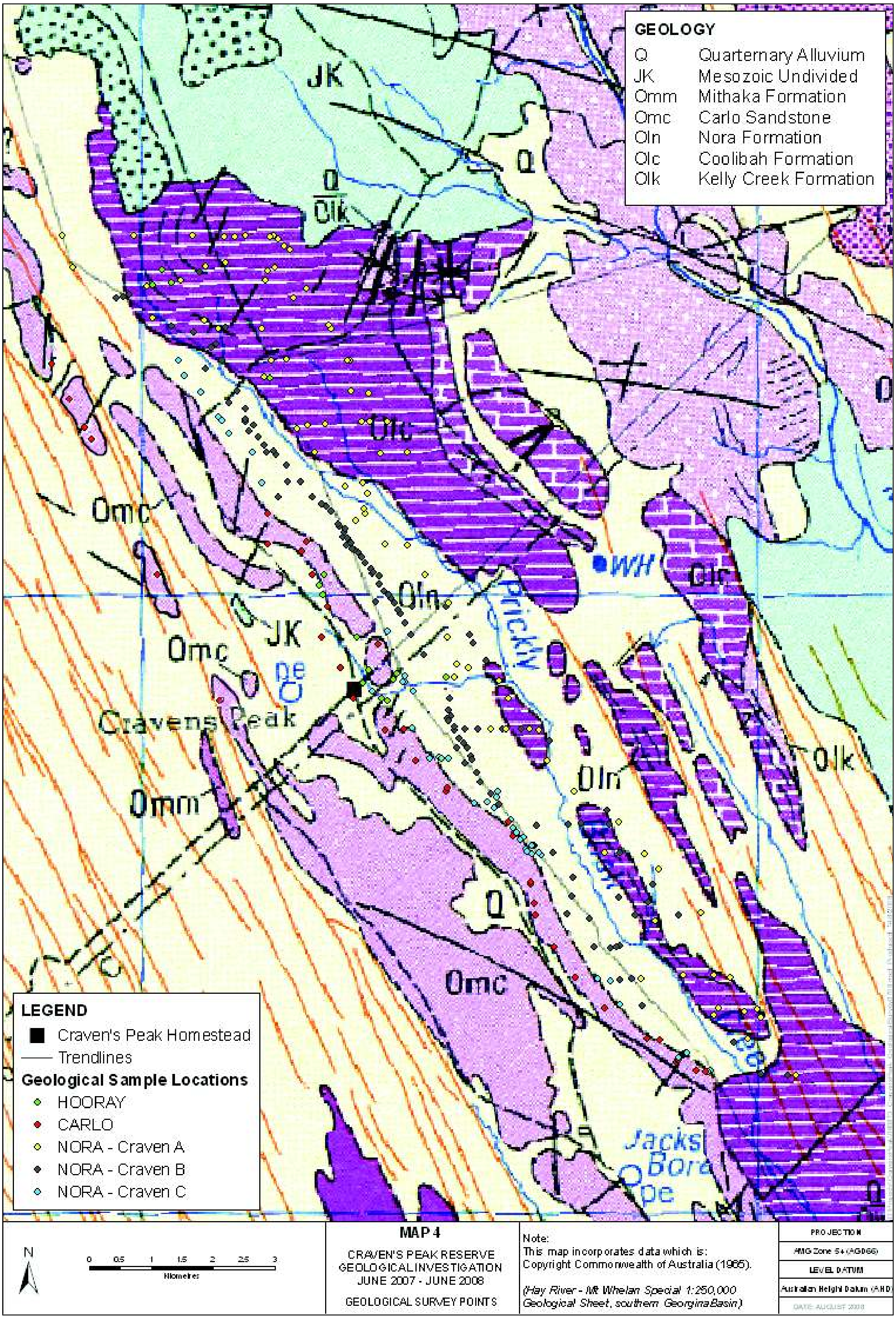


Figure 33. Carlo Sandstone—typical outcrop.

Figure 34. Carlo Sandstone—typical sample.

Figure 35. Mesozoic Sandstone—typical outcrop.

Figure 36. Plant fossils—Mesozoic Sandstone.



Map 4. Geological sample locations.

The Birds of the Bush Heritage Cravens Peak Reserve

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Abstract Bird communities were studied in two subregional areas of Cravens Peak, the Toko Plains and the Simpson–Strzelecki Dunefields, using the point counts method. A total of 42 2ha 20 minute surveys, 46 five–hundred metre radius area surveys and 170 5km drive through area surveys were conducted and observations made. Bird species were identified, counted and recorded. The data were compared in the two subregions and, as a whole, considering species groups according to land system on which the ecosystem occurs, the specific ecosystem and according to their general feeding habits (insectivore, omnivore, frugivore, granivore, nectarivore and carnivore). Species richness and species relative abundance were compared using Simpson's Diversity Index and the data revealed that species are distributed largely on the basis of habitat. In general, areas with a greater number of vegetation strata recorded greater species diversity. Overall, the Tall Open *Acacia georginae* Shrubland on alluvial floodplains has a greater diversity of birds in a 2ha area (0.87, Simpson's Index of Diversity 1–D) compared to the other survey sites.

Introduction

This paper reviews the birds of the Craven Peak based on new data collected during ten days of surveying on the property from the 18th to 28th April 2007. Details of all birds recorded are provided and information on the frequency of occurrence in the region with that of habitat selection is summarised. The remoteness of much of the study area is an underlying cause of the lack of historical data on birds in this region. Recent neighbouring avifauna surveys occurred in 2006 and 2007 on Mulligan River Nature Reserve, where a total of 136 species was identified (Anderson, 2006).

Cravens Peak is located, 135kms south–west of Boulia, on the Queensland side of the Queensland and Northern Territory border. The 233,000 ha reserve is divided into two subregions, the Toko Plains and the Simpson–Strzelecki Dunefields (Sattler and Williams, 1999). Nationally, the property is located across the Channel Country and Simpson–Strzelecki Dunefields interim bioregions of Australia (Thackway, R. and Cresswell I, 1995). The property is bounded to the north and east by the Toko Range and to the west by the Toomba Range. This area together is called the Toko Plains subregion, and includes spectacular landforms such as gorges, dissected uplands, alluvial flats and gibber plains. Up through the middle of the property extends the northern section of the Simpson Desert with red sandy dunefields with an average dune height of 9m. Both subregions contain several claypans that at times fill to become ephemeral swamps.

The multiple aims of the present paper are:

1) To give an account of the avifauna species richness of Craven Peak, as a subset of its two subregions, Toko Plains and Simpson–Strzelecki Dunefields.

2) To compare species diversity to regional ecosystems, vegetation communities and general feeding habits.

3) To identify species and sites of notable conservation status.

Methods

Survey methodologies used in this report are based on *The New Atlas of Australian Birds* (Barrett et al.2003). Taxonomy and nomenclature is based on *Systematics and Taxonomy of Australian Birds* (Christidis, L. and Boles, W. 2008). Updated draft regional ecosystem mapping from the Queensland Herbarium has been used in this report for identifying habitat types across Craven Peak. The draft regional ecosystems used in this report are based on those defined by Sattler and Williams (1999) as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.

Each species was placed in one of four categories of occurrence as defined below:

Sedentary—present in the region throughout the year.

Nomadic—occurrence in the region is dependent on unpredictable factors (e.g. rainfall). These species are often irruptive, so when present occur in large numbers.

Migratory—present in the study area between August and April.

Vagrant—occurs irregularly outside the normal identified range for the species.

Each bird species was placed in one of six primary feeding habits as defined below. However, most species will opportunistically eat a number of these food types:

Insectivore—consumes insects or other arthropods/small crustaceans.

Nectarivore—consumes the sugar–rich nectar produced by flowering plants.

Granivore—selectively consumes the nutrient–rich seeds produced by plants.

Herbivore—consumes plants (e.g. grass or aquatic plants).

Carnivore—consumes meat.

Frugivore—consumes fruit.

Birds were categorised into groups based on the Birds Australia Atlas survey form. These categories are shown below:

EMBQ—Emus, Mound Builders, Quail
SGDG—Swans, Geese, Ducks, Grebes
HIS—Herons, Ibis, Spoonbills
BOP—Birds of Prey
BCR—Brolgas, Crakes, Rails
BBQ—Bustard, Button-quail
W—Waders
GT—Gulls, Terns
PD—Pigeons, Doves
CP—Cockatoos, Parrots
C—Cuckoos
NB—Night Birds
SK—Swifts, Kingfishers
AWP—Aust. Wrens, Pardalotes
SA—Scrubwrens & Allies
H—Honeyeaters
CR—Chats, Robins
BW—Babblers, Whipbirds
QTA—Quail-Thrush & Allies
WST—Whistlers, Shrike-thrushes
MF—Magpie-lark, Flycatchers
CSO—Cuckoo-shrikes, Orioles
WS—Woodswallows
MB—Magpie, Butcherbirds
RM—Ravens, Mud-nesters
BLP—Bowerbirds, Larks, Pipit
SF—Sparrows, Finches
SM—Sunbird, Mistletoebird
SB—Swallows, Bulbul
OWWT—Old World Warblers, Thrush
MS—Myna, Starling

Surveys were undertaken using “active timed area search” methodology of Birds Australia in three formats; 2ha 20 minute survey; within 500m area search; and large area search within 5km. An observer records the number of species seen while actively searching a certain area over a fixed time period (Field et al; Anjos, 2004). A stratified sampling method was used to select sites for field surveys. Accessibility and National Vegetation Information System (NVIS) were used to select the widest geographical spread of sites across the major vegetation communities (Table 1, page 371).

Avian communities were surveyed using the following three Birds Australia Atlas methods:

1. *2ha 20min Search*—This method involved searching a 2ha area for a set period of 20 minutes. Bird species and numbers of each species were recorded. Two hectares for ease of future surveying was defined as a circular area contained within a radius of 80m from a central GPS location. However, sites situated on creeks varied in structure to surveying 400m along the creek and 25m either side. Only birds within the 2ha area were recorded. Birds flying over were included in the count (e.g. foraging birds of prey). Waterbirds flying through not usually associated with the habitat being surveyed were not included (e.g. a pelican would not normally be associated with a dune). An Atlas Habitat Form was completed for each 2ha site surveyed.

2. *500m Area Search*—This method involved searching a circular area contained within a radius of 500m from a central GPS location. The presence of bird species was recorded. A 500m Area Search was conducted at each 2ha site. The 2ha survey was conducted prior to the 500m survey. The standard procedure was for surveyors to search for birds over a period of one hour, and

- If no new species was found in the last 15 minutes then the search was concluded at one hour.

Table 1: Number of surveys compiled and completed.

NVIS broad Floristics	Approximate % coverage of Craven Peak covered using NVIS	Number of Surveys to be completed	Number of 500m Area Surveys Actually Completed according to NVIS	Number of 500m Area Surveys Actually Completed based on true reflection of R.E.
Eucalyptus woodland	0.5%	2	2	7 (5.3.5)
Acacia low open woodland	7.5%	3	3	2 (5.3.11)
Acacia sparse shrubland	10%	4	4	2 (5.6.2), 2 (5.7.12)
Acacia open shrubland	2.0%	2	0	5 (5.7.14), 3 (5.9.1)
Acacia low woodland	0.5%	2	0	0
Triodia low hummock grassland	33%	12	14	4 (5.6.6), 8 (5.6.7)
Triodia open hummock grassland	22%	9	1	0
Atriplex (mixed) open forbland	1.0%	2	3	0
Astrebla open tussock grassland	0.5%	2	2	2 (5.9.3)
Atriplex low sparse forbland	1.5%	2	0	0
Senna (mixed) tall sparse shrubland	5%	2	1	0
Aristida low sparse tussock grassland	15%	6	6	1 (5.9.4)
Centipeda tall sparse forbland	1.5%	2	10	10 (5.3.22)
		50 surveys	46 surveys	46 surveys

- If a new species was found in the last 15 minutes then the surveyor continued searching for another 15 minutes after the one hour.
- If a new species was found in the next 15 minutes, then the surveyor continued for another 15 minutes.
- This survey technique was continued until no new species was found.

3. *1 Minute Grid Surveys (5km Area Survey)*—This method was used while surveyors travelled from one site to the next over a period of ten days. A surveyor would record all birds sighted within defined 1 minute grids. The standard procedure was that all vehicles travelling in a group would radio birds sighted to the lead vehicle as vehicles passed through defined grid zones. A new 1 minute grid zone was identified each time the minute on a GPS changed for either latitude or longitude and the lead vehicle would inform the other vehicles of a new survey. Over ten days, a list of birds was identified for each 1 minute grid zone providing, a wide–ranging representation of avifauna using particular vegetation communities.

Each survey site was identified with a set code (see Appendix 1, page 381). Codes stand for a description of site, landscape and vegetation as shown below:

(property)/
(surveyed from which camp or a known site)/
(general landform)/
(dominant vegetation).
For example: CPSBUASX
CP = Cravens Peak
SB = Salty Bore campsite
U = Upland Residual
ASX = Acacia and Spinifex

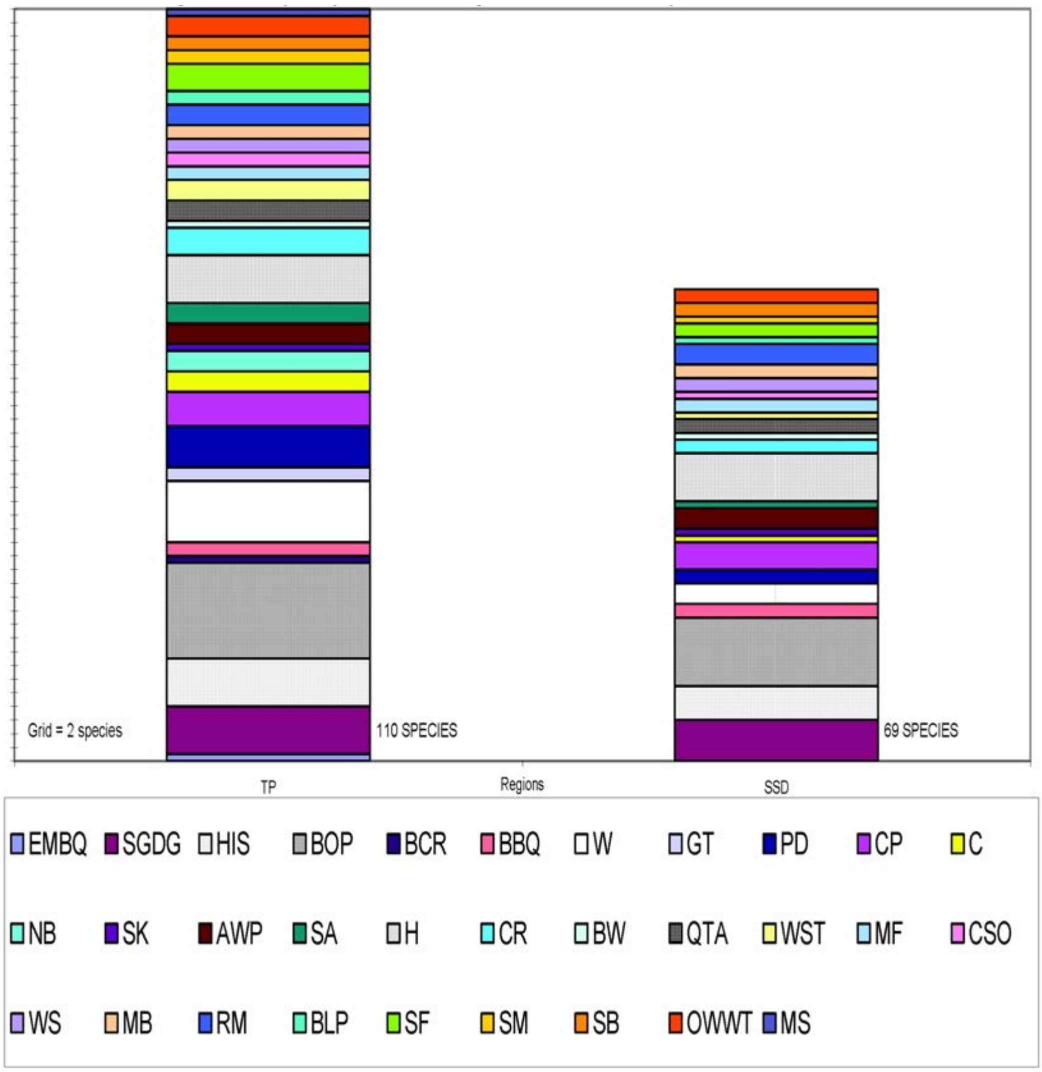
Data collected for the 2ha surveys were analysed using Simpson's Index of Diversity:

$$1 - \frac{n(n-1)}{N(N-1)}$$

where n = the total number of individuals of a particular species and N = the total number of individuals of all species. Species diversity is a measure of the evenness of species and the species richness in a population (Offwell Woodland & Wildlife Trust, 2004).

Results

There was a difference in the number of bird groups and number of species between the Simpson–Strzelecki Dunefields and the Toko Plains subregions of Craven Peak. Twenty–six



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C—Cuckoos
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AWP—Aust. Wrens, Pardalotes
SA—Scrubwrens & Allies
H—Honeyeaters
CR—Chats, Robins
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WST—Whistlers, Shrike-thrushes
MF—Magpie-lark, Flycatchers
CSO—Cuckoo-shrikes, Orioles
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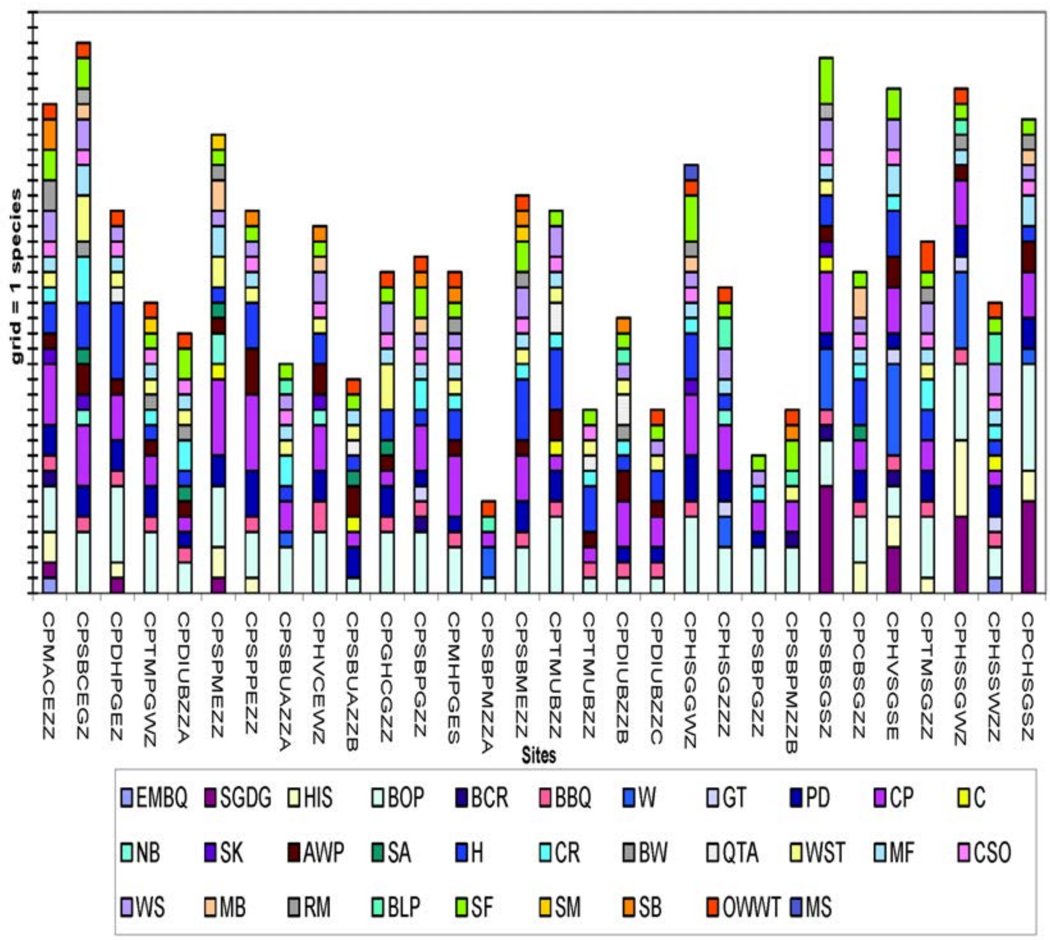
BLP—Bowerbirds, Larks, Pipit
SF—Sparrows, Finches
SM—Sunbird, Mistletoebird
SB—Swallows, Bulbul
OWWT—Old World Warblers, Thrush
MS—Myna, Starling

Figure 1. Bird Group comparison—Toko Plains & Simpson-Strzelecki Dunefield

groups of birds were present in the Simpson–Strzelecki Dunefields subregion compared to thirty–one groups of birds in the Toko Plains subregion of Craven Peak. One hundred and ten species were identified in the Toko Plains sub-region and sixty–nine species in the Simpson–Strzelecki Dunefields subregion. The Birds of Prey (BOP) constituted the largest representation in both subregions, however Waders (W) were the next most prevalent in the Toko Plains subregion and Honeyeaters (H) in the



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WS—Woodswallows
MB—Magpie, Butcherbirds
RM—Ravens, Mud-nesters
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SF—Sparrows, Finches
SM—Sunbird, Mistletoebird
SB—Swallows, Bulbul
OWWT—Old World Warblers, Thrush
MS—Myna, Starling

Figure 2. Toko Plain number of bird species in bird groups

Simpson–Strzelecki Dunefields (Figure 1, page 372).

The Toko Plains subregion contained eight regional ecosystems (R.E. 5.3.5, 5.3.11, 5.3.22, 5.7.12, 5.7.14, 5.9.1, 5.9.3, and 5.9.4 whilst the Simpson–Strzelecki Dunefields contained only four regional ecosystems (R.E. 5.3.22, 5.6.2, 5.6.6, and 5.6.7). The sparse herbland on claypans, filled with water during the survey forming ephemeral lakes (R.E.5.3.22), contained the highest species richness, 81 species. The alluvial open woodlands (R.E.5.3.5) interspersed with water–filled channels also contained high species richness at 70 species. These regional ecosystems are broadly described in Table 2 (page 374) and list the most abundant species found in these ecosystems. (See Appendix 3, starting on page 386 for visual characterisation.)

Table 2: Regional ecosystem description, dominant vegetation and species at Cravens Peak

Regional Ecosystem (Environmental Protection Agency, 2008)	**Location**	**Dominant vegetation height (m)**	**Number of vertical strata**	**No. of species**	**Dominant plants**	**Dominant species**
Alluvium open woodland (R.E.5.3.5)	Toko Plain	10-20	4-5	70	*Eucalyptus coolabah*	Black Kite, Little Button-quail, Crested Pigeon, Diamond Dove, Budgerigar, Cockatiel, Galah, Red-browed Pardalote, Variegated Fairy-wren, Singing Honeyeater, Yellow-throated Miner, Rufous Whistler, Magpie-lark, White-winged Triller, Black-faced Woodswallow, Masked Woodswallow and Zebra Finch
Sparse Herbland on claypans (Ephemeral Lake) These were often inundated after a recent major flood event (R.E.5.3.22)	Toko Plain and Simpson-Strzelecki Dunefields	0.5	1 dry and 5 wet	81	Variable herbs	Black Kite, Little Button-quail, Diamond Dove, Budgerigar, Galah, Magpie-lark, Black-faced Woodswallow, Masked Woodswallow, Willie Wagtail, Zebra Finch, Australian Wood duck, Hardhead, Blue-billed Duck, Grey Teal, Pink-eared Duck, Plumed Whistling Duck, Red-necked Avocet and Glossy Ibis.
Alluvium tall open shrubland (R.E.5.3.11)	Toko Plain	3-5	3-4	23	*Acacia georginae*, *Senna artemisioides*	Black Kite, Diamond Dove, Budgerigar, Cockatiel, Black-faced Woodswallow, Nankeen Kestrel, Crimson Chat and Zebra Finch
Interdunal tall open shrubland (R.E.5.6.2)	Simpson-Strzelecki Dunefields	3-5	3	27	*Acacia georginae*, *Eremophila obovata*	Black Kite, Little Button-quail, Crested Pigeon, Diamond Dove, Budgerigar, Galah, Variegated Fairy-wren, Singing Honeyeater, Crimson Chat, White-browed Babbler, Crested Bellbird, Willie Wagtail, White-winged Triller and Zebra Finch
Interdunal hummock grassland/Tall open shrubland (R.E.5.6.6)	Simpson-Strzelecki Dunefields	0.5-1	3	28	*Triodia basedowii* predominates, some shrubs	Black Kite, Little Button-quail, Diamond Dove, Budgerigar, Grey-headed Honeyeater, Singing Honeyeater, Black-faced Woodswallow, Zebra Finch
Interdunal tall open shrubland (R.E.5.6.7)	Simpson-Strzelecki Dunefields	0.3-4	3	42	*Triodia basedowii*, *Eucalyptus pachyphylla*, *Eucalyptus gamophylla*	Black Kite, Little Button-quail, Diamond Dove, Budgerigar, Grey-headed Honeyeater, Singing Honeyeater, Crimson Chat, Black-faced Woodswallow, Zebra Finch
Ironstone jump-up low woodland (R.E.5.7.12)	Toko Plain	7-10	2	24	*Acacia cyperophylla*, *Acacia aneura*	Nankeen Kestrel, Budgerigar, Crested Bellbird, Willie Wagtail, Zebra Finch
Jump-up open shrubland (R.E.5.7.14)	Toko Plain	4-7	2	39	*Acacia* spp. and *Hakea eyreana*	Black Kite, Brown Falcon, Little Button-quail, Diamond Dove, Budgerigar, Variegated Fairy-wren, Singing Honeyeater, Crimson Chat, Crested Bellbird, White-winged Triller, Black-faced Woodswallow, Zebra Finch.

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Regional Ecosystem (Environmental Protection Agency, 2008)	**Location**	**Dominant vegetation height (m)**	**Number of vertical strata**	**No. of species**	**Dominant plants**	**Dominant species**
Undulating country open shrubland (R.E.5.9.1)	Toko Plain	1-2	2	43	*Senna* spp., *Eremophila* spp.	Black Kite, Little Button-quail, Diamond Dove, Budgerigar, Variegated Fairy-wren, Singing Honeyeater, Rufous Whistler, Willie Wagtail, White-winged Triller, Black-faced Woodswallow, Zebra Finch
Undulating country tussock-grassland (R.E.5.9.3)	Toko Plain	0.6-1.2	1	18	*Astrebla pectinata*	Black Kite, Brown Falcon, Budgerigar, Cockatiel, Galah, Zebra Finch, Brown Songlark
Undulating country sparse-tussock grassland (R.E.5.9.4)	Toko Plain	0.2 -0.3	1	19	*Aristida contorta*	Black Kite, Brown Falcon, Diamond Dove, Budgerigar, Cockatiel, Galah, Spotted Nightjar, Willie Wagtail, Zebra Finch, Brown Songlark

Seven sites in Toko Plains subregion surveyed had twenty–eight or more species; all were associated with water (creeks or ephemeral swamps). Two sites had fewer than ten species; both were on *Aristida contorta* sparse tussock grasslands around Salty Bore (Figure 2, page 373).

Three sites in Simpson–Strzelecki Dunefields subregion had twenty–six or more species; all were associated with water (ephemeral swamps) (Figure 3, page 376).

Birds of prey are dominant in all landforms. Honeyeaters are abundant in dunes, alluvial flats, jump–ups and undulating country. Cockatiels and parrots are abundant on alluvial flats, and waders are abundant in ephemeral swamps (Figure 4, page 377).

Swamps and areas associated with water had the highest Simpson's Diversity index. Ecosystems with high numbers of strata had higher diversity (Table 3, page 378).

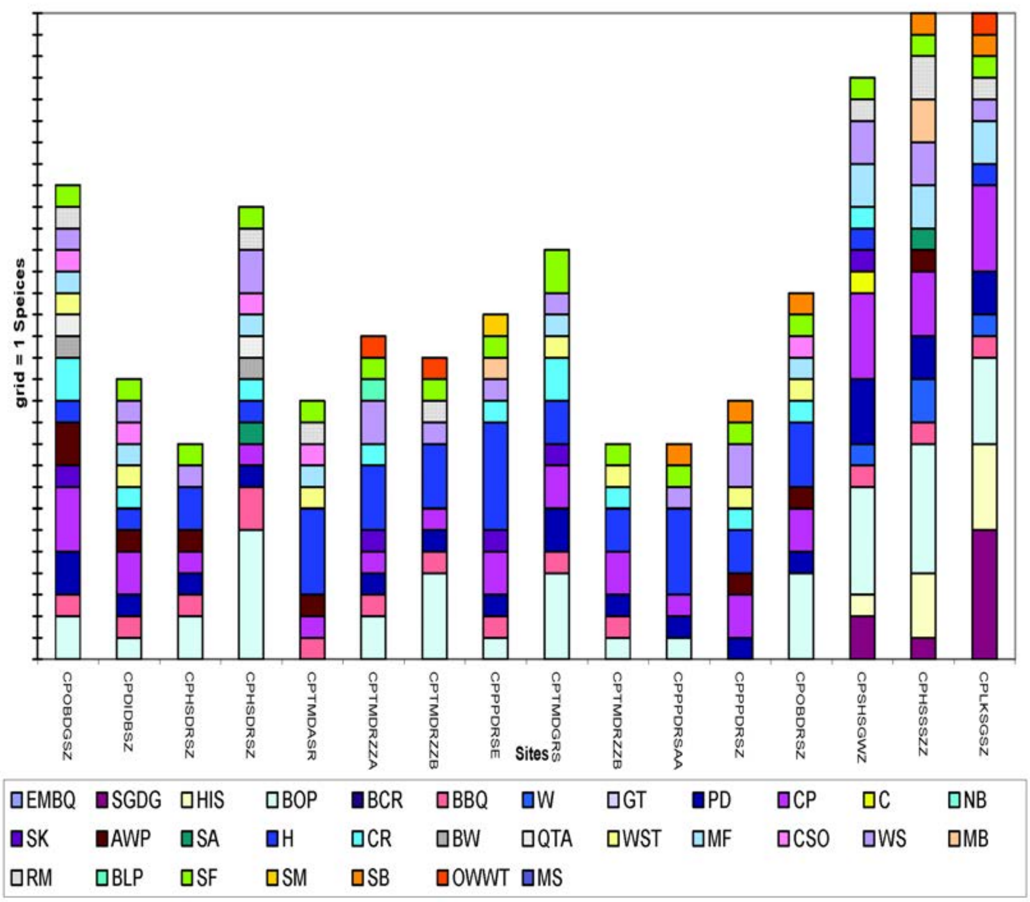
Figures 5 and 6 (pages 378 and 379 respectively) show that the majority of the birds at Craven Peak are nomadic and either insectivorous or granivorous in feeding habit. This is similar to the finding of Ziembicki (2007), who states that "large proportion of birds in the monsoonal and arid grasslands of Australia are characterised by dispersive, nomadic movements and large population fluctuations in response to variable climatic conditions".

Discussion

A total of 119 species of birds distributed among 48 families and 18 orders (Appendix 2, page 382) was encountered in the Craven Peak Bush Heritage Reserve over the study period. Of these, 110 were found in the Toko Plains subregion and 69 in the Simpson–Strzelecki Dunefields (Figure 1, page 372).

Three weeks prior to undertaking the survey, Cravens Peak received significant amounts of rain, many areas in the south and in the far north of the property were inaccessible due to the roads being flooded and unable to be traversed. Many of the low lying clay pans filled with water and became expansive lakes, cutting roads in half. Sites containing regional ecosystems 36 (Hard Spinifex Hummock Grasslands), 22% of the vegetation type, and regional ecosystem 50 (Fluctuating climax of Barley Mitchell Grass, Bindieyes & Daisies Sparse–Herbland), 2% of the vegetation type, could not be sampled. The number of ephemeral lakes (on a property which has very few working turkey nest dams, permanent water or natural springs) increased (Table 1, page 371). When filled turkey nest dams become an important source of water for birds at Cravens Peak, during times of scarce rainfall.

Toko Plains contained more regional ecosystem communities than the Simpson–Strzelecki Dunefields, eight and four regional ecosystems, respectively. This diversity in habitats was also



EMBQ —Emus, Mound Builders, Quail
SGDG—Swans, Geese, Ducks, Grebes
HIS—Herons, Ibis, Spoonbills
BOP—Birds of Prey
BCR—Brolgas, Crakes, Rails
BBQ—Bustard, Button-quail
W—Waders
GT—Gulls, Terns
PD—Pigeons, Doves
CP—Cockatoos, Parrots
C—Cuckoos
NB—Night Birds
SK—Swifts, Kingfishers
AWP—Aust. Wrens, Pardalotes
SA—Scrubwrens & Allies
H—Honeyeaters
CR—Chats, Robins
BW—Babblers, Whipbirds
QTA—Quail-Thrush & Allies
WST—Whistlers, Shrike-thrushes
MF—Magpie-lark, Flycatchers
CSO—Cuckoo-shrikes, Orioles
WS—Woodswallows
MB—Magpie, Butcherbirds
RM—Ravens, Mud-nesters
BLP—Bowerbirds, Larks, Pipit
SF—Sparrows, Finches
SM—Sunbird, Mistletoebird
SB—Swallows, Bulbul
OWWT—Old World Warblers, Thrush
MS—Myna, Starling

Figure 3. Simpson-Strzelecki Dunefields number of bird species in bird groups

reflected in the number of species of birds identified: 110 and 69 species, respectively.

Ephemeral swamps were more prevalent on the Toko Plains subregion (ten sites), whereas the Simpson–Strzelecki Dunefields subregion contained three sites.

Species richness, the number of species found in a particular ecosystem, was highest in ecosystems associated with water, such as ephemeral swamps on claypans (80 species) and channel country with numerous creeks (65 species).

Species diversity, a measure of the species richness and evenness (relative abundance of the different species), was highest in regional ecosystems associated with water, shrubland on floodplains (0.85), ephemeral swamp (0.77) and woodland on floodplains (0.74).

Thinh (2006) states that “vegetation structure explains well bird species diversity”. At Cravens Peak, those ecosystems with the

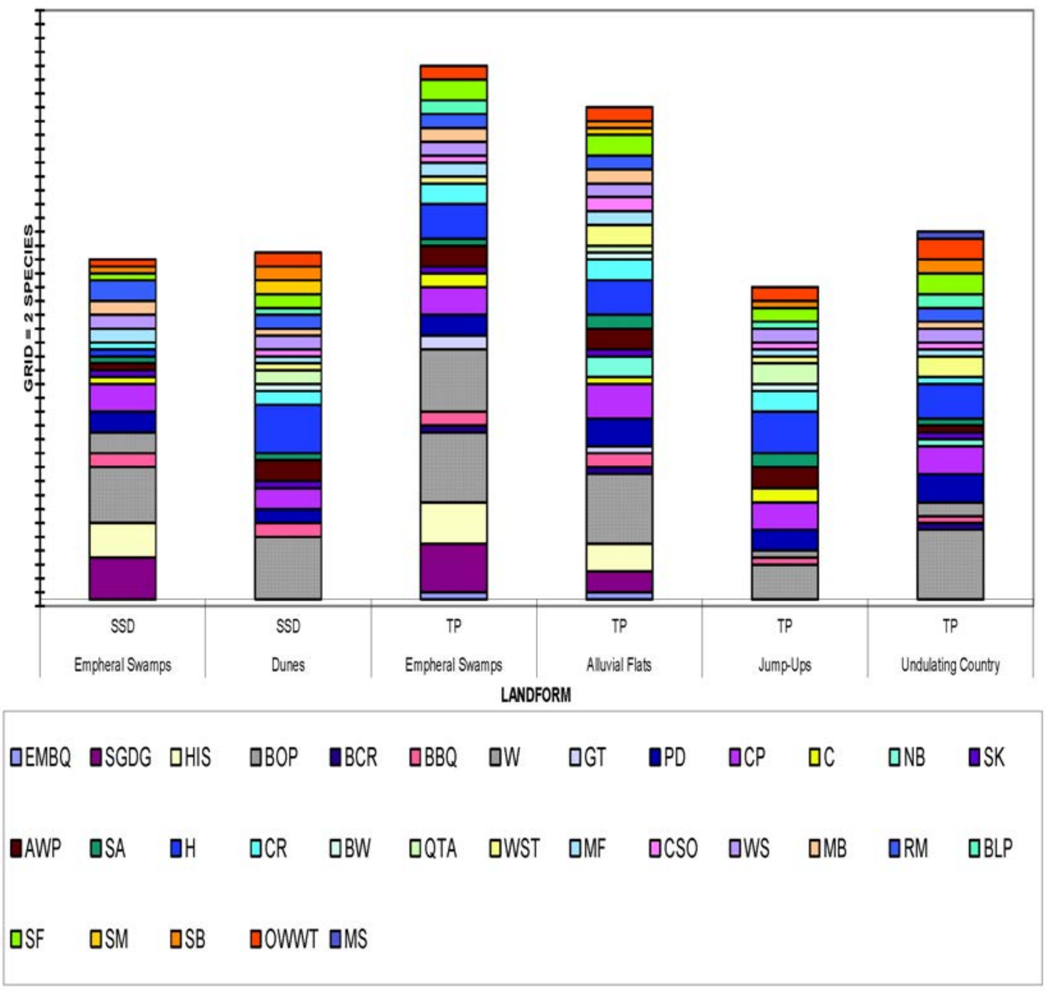


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Figure 4. Number of bird species in each landform type.

greatest number of strata (4–5 strata) had the greatest species diversity (average 0.76) while those with the least numbers of strata had the lowest, 3 strata (average 0.71), 2 strata (average 0.52) and 1 stratum (average 0.26). Of note was regional ecosystem 5.3.22 (sparse herbland). During dry seasons, this ecosystem would contain one stratum; however, when water fills these claypans to form ephemeral swamps, the number of strata increased. In this study, the surrounding herbland, shallow water, aquatic vegetation, deep water and isolated shrubs/trees all constituted different strata within the habitat and therefore this ecosystem was regarded as having five strata, due to the recent filling event.

Table 3. 2ha Surveys of Cravens Peak – Species diversity in varying numbers of strata

Habitat Description	Regional Ecosystem	No. of Strata	Simpson's Diversity Index
Open *Eucalyptus* woodland on floodplain	5.3.5	5	0.74
Sparse Herbland (Empheral Swamps)	5.3.22	5	0.77
Tall Open *Acacia georginae* Shrubland on floodplain	5.3.11	4	0.82
Interdunal Tall Open Shrubland *Acacia georginae* dominate	5.6.2	3	0.71
Interdunal Tall Open *Eucalyptus pachyphylla* and *Eucalyptus gamophylla* Shrubland	5.6.7	3	0.70
Interdunal Hummock Grassland/ Mixed Tall Open Shrubland	5.6.6	3	0.60
Undulating country *Senna* spp. and *Eremophila* spp. open shrubland	5.9.1	2	0.57
Acacia spp. and *Hakea eyreana* Open Shrubland on scarps and hills	5.7.14	2	0.42
Acacia cyperophylla low Woodland on scarps and hills	5.7.12	2	0.39
Undulating country *Aristida contorta* Sparse-Tussock-Grassland	5.9.4	1	0.46
Undulating country *Astrebla pectinata* Tussock-Grassland	5.9.3	1	0

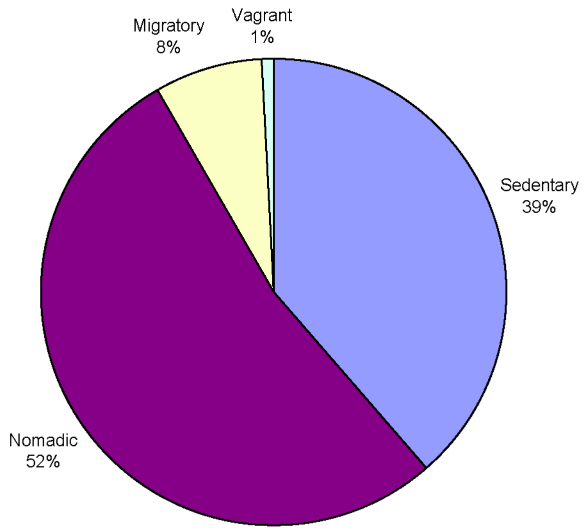

Figure 5. Categories of occurrence

Important Bird Areas (IBAs) are sites of global bird conservation importance (Birds Australia, online 2008). They are priority areas for bird conservation. Cravens Peak meets IBA criteria and should be managed to conserve the birds identified as a globally threatened, restricted range and biome–restricted site. A site is defined as "Global Threatened" if it regularly holds significant numbers of a globally threatened species or other species of global conservation concern. Cravens Peak birds identified in this category are Grey Falcon (2% of surveyed sites) and Blue–billed Duck (2%). Other researchers on the property have identified Plains–wanderer; however, no sighting of this species was made during the ten day survey.

A site is defined as "Restricted–range" if it is known or thought to hold a significant component of a group of species whose breeding distributions define an Endemic Bird Area or Secondary Area. Endemic Bird Areas are defined as places where two or more species of restricted range occur together. Secondary Areas usually have just one restricted–range species confined to the area. Cravens Peak would be defined as an Endemic Bird Area as it contains more than one restricted–range species—the Australian Bustard (9% of surveyed sites) and Pictorella Mannikin (15%).

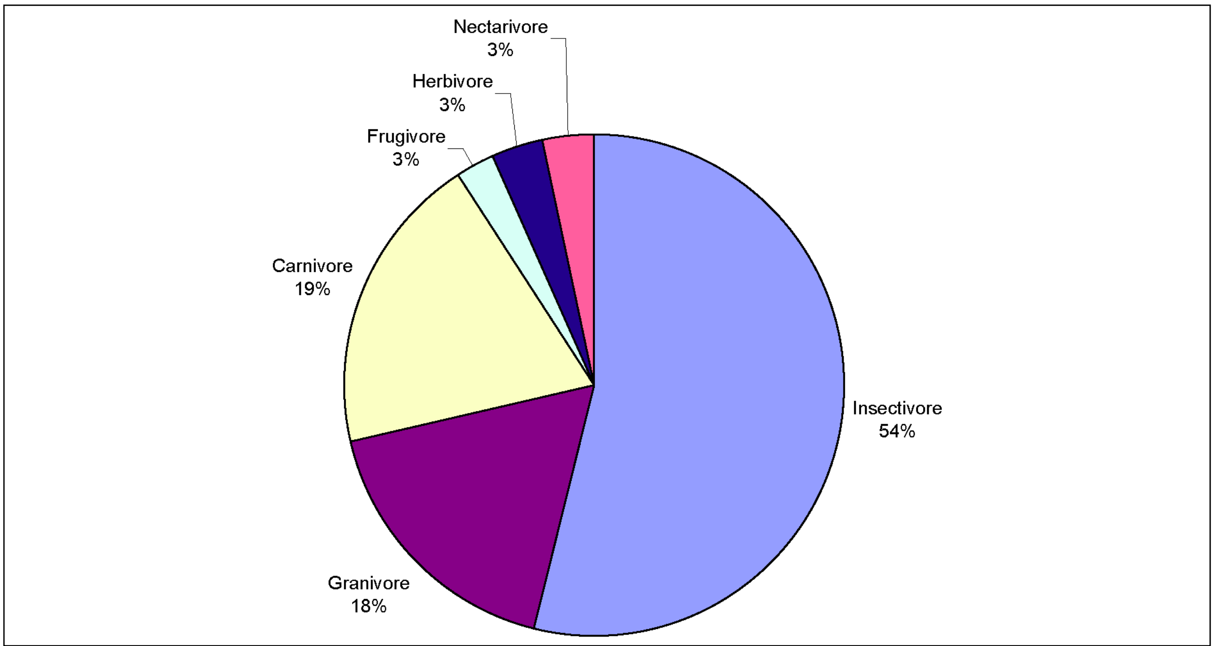

Figure 6. Feeding habits

A site is defined as "Biome–restricted" if it is known or thought to hold a significant component of the group of species whose distributions are largely or wholly confined to one biome. Craven Peak falls under the Australian arid zone biome and birds identified at Craven Peak falling in this category are the Grey Falcon (2% of surveyed sites), Banded Whiteface (4%), Grey–headed Honeyeater (30%), Pied Honeyeater (7%), Black Honeyeater (17%), Grey Honeyeater (2%), Gibberbird (2%), Chiming Wedgebill (9%), Cinnamon Quail–thrush (7%), and Painted Finch (9%).

Cravens Peak Bush Heritage Reserve, with 119 species and nine regional ecosystems, is a site of Australian and Global conservation significance for the birds.

Acknowledgements

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Appendix 1. Sites

Site	Latitude	Longitude
CPSBPGZZ	23° 02' 29"	138° 16' 38"
CPCBSGZZ	23° 00' 29"	138° 03' 40"
CPCHSGSZ	23° 22' 02"	138° 35' 52"
CPHSSGWZ	23° 20' 18"	138° 35' 49"
CPHSSSZZ	23° 17' 23"	138° 33' 03"
CPHSSWZZ	23° 21' 15"	138° 36' 44"
CPHVSGSE	23° 01' 03"	138° 10' 20"
CPLKSGSZ	23° 20' 35"	138° 14' 58"
CPSBSGSZ	22° 59' 45"	138° 14' 09"
CPSHSGWZ	23° 15' 39"	138° 32' 05"
CPTMSGZZ	23° 03' 48"	138° 11' 24"
CPDHPGEZ	23° 16' 38"	138° 04' 10"
CPHVCEWZ	23° 00' 59"	138° 11' 50"
CPMACEZZ	22° 53' 46"	138° 02' 11"
CPSBCEGZ	23° 01' 10"	138° 12' 45"
CPSBMEZZ	22° 56' 52"	138° 09' 38"
CPSPMEZZ	23° 03' 48"	138° 20' 49"
CPSPPEZZ	23° 04' 33"	138° 18' 18"
CPOBDGSZ	23° 14' 13"	138° 13' 36"
CPTMPGWZ	23° 09' 35"	138° 09' 21"
CPDIDBSZ	23° 18' 59"	138° 14' 22"
CPTMDASR	23° 04' 18"	138° 06' 38"
CPTMDRZZA	23° 06' 09"	138° 10' 24"

Site	Latitude	Longitude
CPTMDRZZB	23° 06' 27"	138° 07' 45"
CPHSDRSZ	23° 11' 52"	138° 24' 34"
CPHSDRSZ	23° 11' 52"	138° 24' 34"
CPOBDRSZ	23° 14' 07"	138° 14' 35"
CPPPDRSAA	23° 08' 33"	138° 20' 56"
CPPPDRSE	23° 06' 38"	138° 19' 31"
CPPPDRSZ	23° 11' 57"	138° 21' 27"
CPTMDGRS	23° 07' 27"	138° 08' 17"
CPTMDRZZC	23° 07' 34"	138° 10' 11"
CPSBUAZZA	22° 59' 06"	138° 10' 41"
CPSBUAZZB	23° 01' 28"	138° 13' 55"
CPDIUBZZA	23° 16' 54"	138° 13' 15"
CPDIUBZZB	23° 14' 24"	138° 10' 04"
CPDIUBZZC	23° 14' 43"	138° 08' 55"
CPTMUBZZ	23° 10' 53"	138° 10' 53"
CPTMUBZZ	23° 10' 53"	138° 10' 53"
CPGHCGZZ	23° 14' 29"	138° 07' 15"
CPHSGGWZ	23° 19' 23"	138° 35' 26"
CPMHPGES	23° 11' 42"	138° 12' 29"
CPSBPMZZA	22° 55' 35"	138° 06' 14"
CPSBPMZZB	22° 54' 26"	138° 03' 49"
CPHSGZZZ	23° 22' 56"	138° 38' 31"

Each survey site was identified with a set code. Codes stand for a description of site, landscape and vegetation as shown below: (property)/(surveyed from which camp or a known site)/(general landform)/(dominant vegetation)

Property: (1st two letters)

CP—Cravens Peak

Surveyed from: (2nd two letters)

SB—Salty Bore
TM—Twelve Mile
DH—Duck Hole
GH—Gap Hole
LK—Little Kunnamuka
CB—Corner Bore
DI—Dingo Hole
OB—Ocean Bore
PP—Plum Pudding
SP—Star Picket
HV—Hidden Valley
MA—Malvine Creek
CH—Coolabah Waterhole
HS—Homestead
SH—Sandhill Bore

Landform: (next letter)

U—Upland Residuals
D—Dunes
C—Creek
S—Swamp
M—Mulligan River
G—Gibber Plain
P—Plain

Dominant Vegetation: (rest of letters)

A—*Acacia* sp. Shrubland
R—Mallee
G—Gidgee
S—Spinifex (*Triodia* sp.)
M—Mitchell Grass (*Astrebla* sp.)
W—Wiregrass (*Aristida* sp.)
E—Eucalyptus trees (*E. camaldulensis* / *E. coolabah*)
B—*Acacia aneura* complex (Mulga)
Z—Vegetation not identified.

Appendix 2. List of bird species recorded over ten days

Order & Family Christidis, L and Boles, W. (2008)	Species: Common Name	Status	Distribution	Feeding habit
		Pizzey, G and Knight, F. (2007) 8th Ed.		Reader's Digest (1990)
Order Anseriformes				
Anatidae (Ducks & Swan)	Plumed Whistling-Duck	Secure	Nomadic	Herbivore
	Grey Teal	Secure	Nomadic	Herbivore
	Blue-billed Duck	Vulnerable	Uncommon, Nomadic	Insectivore
	Australian Wood Duck	Secure	Abundant, Nomadic	Herbivore
	Pink-eared Duck	Secure	Nomadic	Herbivore
	Hardhead	Secure	Nomadic	Insectivore
Order Podicipediformes				
Podicipedidae (Grebes)	Australasian Grebe	Secure	Uncommon, Nomadic	Insectivore
	Hoary-headed Grebe	Secure	Scarce, Nomadic	Insectivore
Order Ciconiiformes				
Ardeidae (Herons & Egret)	White-faced Heron	Secure	Common, Nomadic	Carnivore
	White-necked Heron	Secure	Common, Nomadic	Carnivore
	Nankeen Night Heron	Secure	Scarce, Nomadic	Carnivore
Threskiornithidae (Ibis & Spoonbills)	Glossy Ibis	Secure	Uncommon, Nomadic	Insectivore
	Australian White Ibis	Secure	Common, Nomadic	Insectivore
	Straw-necked Ibis	Secure	Common, Nomadic	Insectivore
	Yellow-billed Spoonbill	Secure	Common, Nomadic	Carnivore
Order Acciptriformes				
Accipitridae (Kites, Goshawks, Eagles, Harriers)	Swamp Harrier	Vulnerable	Uncommon, Nomadic	Carnivore
	Spotted Harrier	Secure	Common, Nomadic	Carnivore
	Wedge-tailed Eagle	Secure	Common, Sedentary	Carnivore
	Black Kite	Secure	Common, Nomadic	Carnivore
	Black-breasted Buzzard	Secure	Common, Sedentary	Carnivore
	Brown Goshawk	Secure	Common, Sedentary	Carnivore
	Collared Sparrowhawk	Secure	Common, Sedentary	Carnivore
	Little Eagle	Secure	Uncommon, Nomadic	Carnivore
	Whistling Kite	Secure	Common, Nomadic	Carnivore
Order Falconiformes				
Falconidae (Falcons)	Brown Falcon	Secure	Common, Nomadic	Carnivore
	Nankeen Kestrel	Secure	Common, Nomadic	Insectivore
	Australian Hobby	Secure	Uncommon, Sedentary	Carnivore
	Black Falcon	Secure	Uncommon, Sedentary	Carnivore
	Grey Falcon	Near-Threatened	Rare, Nomadic	Carnivore
Order Gruiformes				
Gruidae (Cranes)	Brolga	Secure.	Uncommon/Dispersive, Nomadic	Carnivore

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Order & Family Christidis, L and Boles, W. (2008)	**Species: Common Name**	**Status**	**Distribution**	**Feeding habit**
		Pizzey, G and Knight, F. (2007) 8th Ed.		Reader's Digest (1990)
Otididae (Bustards)	Australian Bustard	Near-Threatened/ Vulnerable	Uncommon, Nomadic	Carnivore
Order Charadriiformes				
Scolopacidae (Sandpipers & allies)	Latham's Snipe	Secure.	Uncommon, Migratory	Insectivore
	Marsh Sandpiper	Secure.	Uncommon, Migratory	Insectivore
Turnicidae (Button-quails)	Little Button-quail	Secure.	Common, Nomadic	Granivore
Recurvirostridae (Stilts & Avocets)	Black-winged Stilt	Secure	Common, Nomadic	Insectivore
	Red-necked Avocet	Secure	Common, Nomadic	Insectivore
Charadriidae (Plovers & allies)	Red-capped Plover	Secure	Nomadic	Insectivore
	Black-fronted Dotterel	Secure	Common, Nomadic	Insectivore
	Red-kneed Dotterel	Secure	Nomadic	Insectivore
	Banded Lapwing	Secure	Common, Nomadic	Insectivore
Pedionmidae (Plains-wanderer)	Plains-wanderer – sighted by other researchers	Endangered	Rare, Sedentary	Granivore
Glareolidae (Pratincoles)	Australian Pratincole	Secure	Common, Nomadic	Insectivore
Laridae (Gulls & Terns)	Silver Gull	Secure	Sporadic, Nomadic	Carnivore
	Gull-billed Tern	Secure	Sporadic, Nomadic	Carnivore
Order Casuariiformes				
Casuariidae (Emu)	Emu	Secure	Abundant, Nomadic	Frugivore
Order Galliformes				
Phasianidae (Pheasant, Grouse, Turkeys, Partridges)	Stubble Quail	Secure	Common, Nomadic	Granivore
Order Columbiformes				
Columbidae (Pigeons, Doves)	Common Bronzewing	Secure	Nomadic	Granivore
	Crested Pigeon	Secure	Common, Sedentary	Granivore
	Diamond Dove	Secure	Nomadic	Granivore
	Flock Bronzewing	Secure	Common, Nomadic	Granivore
	Peaceful Dove	Secure	Common, Sedentary	Granivore
	Spinifex Pigeon	Secure	Common, Sedentary	Granivore
Order Psittaciformes				
Psittacidae (Rosellas and Lorikeets)	Australian Ringneck	Secure	Common, Sedentary	Granivore
	Budgerigar	Secure	Nomadic	Granivore
Cacatuidae (Cockatoos and Corellas)	Cockatiel	Secure	Nomadic	Granivore
	Galah	Secure	Common, Sedentary	Granivore
	Little Corella	Secure	Nomadic	Granivore
Order Cuculiformes				
Cuculidae (Old World Cuckoos)	Channel-billed Cuckoo	Secure	Uncommon Migrant	Frugivore
	Horsfield's Bronze-Cuckoo	Secure	Common, Vagrant	Insectivore
	Pallid Cuckoo	Secure	Common, Migrant	Insectivore

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Order & Family Christidis, L and Boles, W. (2008)	Species: Common Name	Status	Distribution	Feeding habit
		Pizzey, G and Knight, F. (2007) 8th Ed.		Reader's Digest (1990)
Order Apodiformes				
Aegothelidae (Owlet-nightjars)	Australian Owlet-nightjar	Secure	Common, Sedentary	Insectivore
Order Caprimulgiformes				
Eurostopodidae (Nightjars)	Spotted Nightjar	Secure	Sedentary	Insectivore
Order Strigiformes				
Strigidae (Typical Owls)	Southern Boobook	Secure	Common, Sedentary	Carnivore
Order Coraciiformes				
Halcyonidae (Halcyonid Kingfishers)	Red-backed Kingfisher	Secure	Nomadic	Insectivore
Meropidae (Bee-eaters)	Rainbow Bee-eater	Secure	Common, Migratory	Insectivore
Order Passeriformes				
Maluridae (Fairy-wrens and Allies)	Variegated Fairy-wren	Secure	Common, Sedentary	Insectivore
	White-winged Fairy-wren	Secure	Common, Sedentary	Insectivore
Meliphagidae (Honeyeaters, Chats)	Yellow Chat	Endangered	Rare, Sedentary	Insectivore
	Crimson Chat	Secure	Common, Nomadic	Insectivore
	Black Honeyeater	Secure	Common, Nomadic	Nectarivore.
	Gibberbird	Secure	Uncommon, Nomadic	Insectivore
	Grey Honeyeater	Endangered	Rare, Nomadic	Insectivore
	Grey-headed Honeyeater	Secure	Common, Nomadic	Nectarivore.
	Pied Honeyeater	Secure	Rare, Nomadic	Nectarivore.
	Black-chinned Honeyeater	Secure	Uncommon, Nomadic	Insectivore
	Singing Honeyeater	Secure	Common, Nomadic	Nectarivore.
	Spiny-cheeked Honeyeater	Secure	Common, Nomadic	Insectivore
	White-fronted Honeyeater	Secure	Common, Nomadic	Insectivore
	White-plumed Honeyeater	Secure	Common, Nomadic	Insectivore
	Yellow-throated Miner	Secure	Common, Nomadic	Insectivore
Pardalotidae (Pardalotes)	Red-browed Pardalote	Secure	Common, Sedentary	Insectivore
Acanthizidae (Gerygones and Thornbills)	Banded Whiteface	Secure	Uncommon, Nomadic	Insectivore
	Chestnut-rumped Thornbill	Secure	Common, Nomadic	Insectivore
	Redthroat	Vulnerable	Uncommon, Sedentary	Insectivore
	Weebill	Secure	Common, Nomadic	Insectivore
Petroicidae (Australo-Papuan Robins)	Hooded Robin	Secure	Uncommon, Sedentary	Insectivore
	Red-capped Robin	Secure	Common, Nomadic	Insectivore
Pomatostomidae (Australo-Papuan Babblers)	White-browed Babbler	Secure	Common, Sedentary	Insectivore
Corvidae (Ravens and Crows)	Australian Raven	Secure	Common, Sedentary	Carnivore
	Little Crow	Secure	Abundant, Nomadic	Insectivore
	Torresian Crow	Secure	Common, Sedentary	Insectivore

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Order & Family Christidis, L and Boles, W. (2008)	**Species: Common Name**	**Status**	**Distribution**	**Feeding habit**
		Pizzey, G and Knight, F. (2007) 8th Ed.		Reader's Digest (1990)
Artamidae (Woodswallows, Butcherbirds, Currawongs and magpies)	Australian Magpie	Secure	Common, Sedentary	Insectivore
	Black-faced Woodswallow	Secure	Common, Sedentary	Insectivore
	Masked Woodswallow	Secure	Common, Migratory	Insectivore
	Pied Butcherbird	Secure	Common, Sedentary	Insectivore
Monarchidae (Flycatchers, Monarchs)	Magpie-lark	Secure	Abundant, Sedentary	Insectivore
Pachycephalidae (Whistlers, Shrike-thrush and Bellbirds)	Crested Bellbird	Secure	Common, Sedentary	Insectivore
	Grey Shrike-thrush	Secure	Common, Sedentary	Insectivore
	Rufous Whistler	Secure	Common, Sedentary	Insectivore
Campephagidae (Cuckoo-shrikes and Trillers)	Black-faced Cuckoo-shrike	Secure	Common, Nomadic	Insectivore
	White-winged Triller	Secure	Common, Migratory	Insectivore
Neosittidae (Sittella)	Varied Sittella	Secure	Common, Sedentary	Insectivore
Psophodidae (Quail-thrush and Wedgebills)	Cinnamon Quail-Thrush	Secure	Common, Sedentary	Insectivore
	Chiming Wedgebill	Secure	Common, Sedentary	Insectivore
Rhipiduridae (Fantails)	Willie Wagtail	Secure	Common, Nomadic	Insectivore
Sturnidae (Starlings, Mynas)	Common Starling (introduced)	Secure	Common, Nomadic	Insectivore
Hirundinidae (Swallows, Martins)	Fairy Martin	Secure	Uncommon, migratory	Insectivore
	Tree Martin	Secure	Common, Migratory	Insectivore
	White-backed Swallow	Secure	Uncommon, Sedentary	Insectivore
Megaluridae (Old World Warblers and Allies)	Little Grassbird	Secure	Common, Sedentary	Insectivore
	Brown Songlark	Secure	Common, Sedentary	Granivore
	Rufous Songlark	Secure	Common, Sedentary	Granivore
Alaudidae (Old World Larks)	Horsfield's Bushlark	Secure	Common, Sedentary	Granivore
Nectariniidae (Sunbirds, Sugarbirds, Flowerpeckers)	Mistletoebird	Secure	Common, Sedentary	Frugivore
Motacillidae (Pipits)	Australasian Pipit	Secure	Common, Sedentary	Insectivore
Passeridae (Sparrows)	House Sparrow (introduced)	Secure	Common, Sedentary	Granivore
Estrildidae (Finches)	Painted Finch	Secure	Patchy, Sedentary	Granivore
	Pictorella Mannikin	Near-Threatened	Uncommon, Nomadic	Granivore
	Zebra Finch	Secure	Common, Sedentary	Granivore

Appendix 3. Regional Ecosystem Images

Alluvium open woodland (R.E.5.3.5)

Sparse Herbland on claypans (Ephemeral Lake). These were often inundated after a recent major flood event. (R.E.5.3.22)

Sparse Herbland on claypans. (Ephemeral Lake) These were often inundated after a recent major flood event. (R.E.5.3.22)

Alluvium tall open shrubland. (R.E.5.3.11)

Interdunal tall open shrubland. (R.E.5.6.2)

Interdunal hummock grassland/Tall open shrubland (R.E.5.6.6)

Interdunal hummock grassland/Tall open shrubland (R.E.5.6.6)

Interdunal tall open shrubland (R.E.5.6.7(1))

Interdunal tall open shrubland (R.E.5.6.7 (2))

Ironstone jump–up; low woodland (R.E.5.7.12)


Undulating country; open shrubland (R.E.5.9.1)


Undulating country; tussock–grassland (R.E.5.9.3)


Undulating country' sparse–tussock grassland (Gibber Plain) (R.E.5.9.4)

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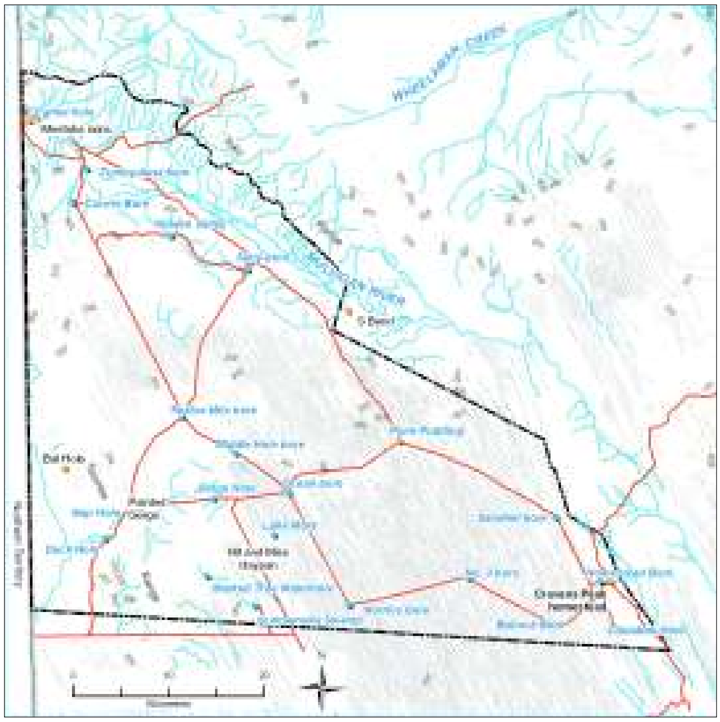
Painted
Gorge
Cravens Peak