s. 22(1)(a)(ii)

From: Andrew McNee
Sent: Wednesday, 23 September 2020 9:52 PM
To: s. 22(1)(a)(ii)
Cc: Larsen, James (Agriculture); Michelle Croker; s. 22(1)(a)(ii) s. 22(1)(a)(ii)
Subject: Status Update: Saint Elmo Vanadium Project [SEC=OFFICIAL]

Follow Up Flag: Follow up
Flag Status: Flagged

Hi s. 22(1)(a)(ii)

A quick status update on the **Saint Elmo Vanadium Project.**

On 25 August 2020, the Queensland Department of Environment and Science completed their Assessment Report for the **Saint Elmo Vanadium Project**. This triggered the start of the EPBC approval clock, with the decision on whether to approve the proposal due by 7 October 2020.

On 10 September 2020, the proponent (Multicom Resources Pty Ltd) provided an Offset Strategy to compensate for the impacts of the proposed action on the Julia Creek Dunnart. As little is known about the species I have stopped the clock on the approval decision timeframe to seek a review of the Offset Strategy by a Julia Creek Dunnart expert, to ensure the proposed offsets are appropriate and will provide a conservation gain for the species.

On completion of the expert review, I will seek a revised Offset Strategy from the proponent which addresses comments resulting from the expert review. The statutory timeframe would resume once these comments have been satisfactorily addressed.

The Department has discussed this proposed approach with the proponent, who is supportive of the approach and considers it will provide rigour to the Offset Strategy. The proponent is aware that the statutory timeframe would be paused. While the proponent is keen to progress the project, they acknowledged the value of the expert review and will update their timeframes accordingly.

The proponent is being assisted by the Major Projects Facilitation Agency (MPFA) in the Department of Industry Science, Energy and Resources (DISER) to secure their major Commonwealth approvals. The Department has provided regular updates to the MPFA and the Critical Minerals Facilitation Office (CMFO) at DISER, who have acknowledged the Department's considerable engagement with the proponent and are supportive of the Department's actions and dealings with the proponent. The Department continues to work with the MPFA and CMFO to ensure their ongoing support.

Happy to discuss further if you have an queries regarding the above.

Thanks, Andrew

Andrew McNee
Assistant Secretary
Environment Assessments (Queensland) and Sea Dumping
Environment Approvals Division
Department of Agriculture, Water and the Environment
Andrew.mcnee@awe.gov.au

s. 22(1)(a)(ii)

From: s. 22(1)(a)(ii)
Sent: Wednesday, 30 September 2020 12:01 PM
To: s. 22(1)(a)(ii) @environment.gov.au>
Subject: RE: Advisors [SEC=OFFICIAL]

Hi s. 22(1)(a)(ii), Saint Elmo points below:

Saint Elmo Vanadium Project EPBC 2017/8007

- On 25 August 2020, the Queensland Department of Environment and Science completed their Assessment Report for the Saint Elmo Vanadium Project. This triggered the start of the EPBC approval clock, with the decision on whether to approve the proposal due by 7 October 2020.

- On 10 September 2020, the proponent (Multicom Resources Pty Ltd) provided an Offset Strategy to compensate for the impacts of the proposed action on the Julia Creek Dunnart. As little is known about the species the Department has stopped the clock on the approval decision timeframe to seek a review of the Offset Strategy by a Julia Creek Dunnart expert, to ensure the proposed offsets are appropriate and will provide a conservation gain for the species.

- The expert review will be completed by 23 October 2020. The Department will then seek a revised Offset Strategy from the proponent which addresses comments resulting from the expert review. The statutory timeframe will resume once these comments have been satisfactorily addressed by the proponent.

- The proponent is supportive of the Department's approach and considers it will provide rigour to the Offset Strategy. The proponent is aware that the statutory timeframe has been paused. While the proponent is keen to progress the project, they acknowledged the value of the expert review and has updated their timeframes accordingly.

From: s. 22(1)(a)(ii) @environment.gov.au>
Sent: Wednesday, 30 September 2020 11:39 AM
To: s. 22(1)(a)(ii) @environment.gov.au>; s. 22(1)(a)(ii) @environment.gov.au>; s. 22(1)(a)(ii) @environment.gov.au>
Subject: FW: Advisors [SEC=OFFICIAL]

Hi all,

In relation to the below could I ask for three or four points each in relation to the following:

- St Elmo: an update on status and noting that the proponent is supportive of our approach

s. 22(1)(a)(ii)

s. 22(1)(a)(ii)

I think that covers it - please add any other key points I've missed or any new developments I'm not aware of. If you could get back to me by midday tomorrow that would be awesome.

Many thanks all!

s. 22(1)(a)(ii)

From: Anu Datta <Anu.Datta@environment.gov.au>
Sent: Tuesday, 29 September 2020 9:59 AM
To: s. 22(1)(a)(ii) @environment.gov.au>; s. 22(1)(a)(ii) @environment.gov.au>; s. 22(1)(a)(ii) @environment.gov.au>; s. 22(1)(a)(ii) @environment.gov.au>
Cc: s. 22(1)(a)(ii) @environment.gov.au>
Subject: Advisors [SEC=OFFICIAL]

Hi colleagues

I will be attending advisors on Friday morning. Could you please provide me with some points on any projects that:

- have previously been discussed and s. 22(1)(a)(ii) may seek an update on
- any new issues that I should raise.

Could you please provide these to me by 4pm on Thursday?

Cheers
Anu

Anu Datta
Acting Assistant Secretary
Environment Assessments Queensland and Sea Dumping Branch
Department of Agriculture, Water and the Environment
T: (02) 6274 2487 | **M:** s. 47F(1)
E: anu.datta@awe.gov.au

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

EPBC Ref: 2017/8007

Mr Nathan Cammerman
Executive Director
Multicom Resources Pty Ltd
PO Box 434
INDOOROOPILLY QLD 4068

Dear Mr Cammerman

Decision on referral
Saint Elmo Vanadium Project, 25 km east of Julia Creek, Queensland

Thank you for submitting a referral under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This is to advise you of my decision about the referral of the proposed action to construct, operate and rehabilitate a vanadium mine on EPM 26410, 25 kilometres east of Julia Creek, Queensland (EPBC 2017/8007).

As a delegate of the Minister for the Environment and Energy, I have decided under section 75 of the EPBC Act that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act. A copy of the document recording this decision is enclosed.

The information that I have considered indicates that the proposed action is likely to have a significant impact on listed threatened species and communities (sections 18 and 18A). Based on the information available in the referral, the proposed action may have or is likely to have a significant impact on the following matters of national environmental significance, but is not limited to:

- Julia Creek Dunnart (*Sminthopsis douglasi*)
- Star Finch (eastern) (*Neochmia ruficauda ruficauda*)

Please note that this decision only relates to the potential for significant impacts on matters protected by the Australian Government under Chapter 2 of the EPBC Ac

A decision has not been made on the assessment approach for the project. I understand that Multicom Pty Ltd is yet to submit an environmental authority or voluntary Environmental Impact Statement (EIS) application for the project under the *Environmental Protection Act 1994* (Qld) to the Queensland Department of Environment and Heritage Protection.

If the project is to be assessed by EIS under the *Environmental Protection Act 1994* (Qld), it may be assessed under the Bilateral Agreement between the Queensland and Commonwealth governments.

Under section 89(2) of the EPBC Act, as delegate of the Minister, I am requesting your advice regarding the method of assessment of the project by the State. I will make a decision on the assessment approach once this information is provided.

I have also written to the following parties to advise them of this decision:

- The Hon Barnaby Joyce – Minister for Agriculture and Water Resources and A/g Minister for Resources and Northern Australia
- Mr Chris Loveday – Delegate for the Queensland Minister for Environment and Heritage Protection, the Hon Dr Steven Miles MP

Please also note that once a proposal to take an action has been referred under the EPBC Act, it is an offence under section 74AA to take the action while the decision making process is on-going (unless that action is specifically excluded from the referral or other exemptions apply). Persons convicted of an offence under this provision of the EPBC Act may be liable for a penalty of up to 500 penalty units. The EPBC Act is available on line at: http://www.environment.gov.au/epbc/about/index.html

The Department has recently published an *Environmental Impact Assessment Client Service Charter* (the Charter) which outlines the Department's commitments when undertaking environmental impact assessments under the EPBC Act. A copy of the Charter can be found at: http://www.environment.gov.au/epbc/publications/index.html.

If you have any questions about the referral process or this decision, please contact the project manager, Christopher Kerin, by telephone 02 6274 2389 or email to Christopher.Kerin@environment.gov.au, and quote the EPBC reference number shown at the beginning of this letter.

Yours sincerely

James Barker
Assistant Secretary
Assessments and Governance Branch
6 September 2017

47G(1)(a), and 47G(1)(b)

s. 22(1)(a)(ii)

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s47G(1)(a), s47G(1)(b), s47F(1), s22(1)(a)(ii)

s. 22(1)(a)(ii)

s47G(1)(a), s47G(1)(b), s47F(1), s22(1)(a)(ii)

s47G(1)(a), s47G(1)(b), s47F(1)

47G(1)(a), 47G(1)(b), s47F(1)

47G(1)(a), 47G(1)(b), s47F(1)

47G(1)(a), 47G(1)(b)

47G(1)(a), 47G(1)(b), s47F(1)

47G(1)(a), 47G(1)(b)

s. 22(1)(a)(ii)

s47G(1)(a), s47G(1)(b), s47F(1)

s47G(1)(a), s47G(1)(b), s47F(1)

s47G(1)(a), s47G(1)(b)

s. 22(1)(a)(ii)

From: s. 22(1)(a)(ii)
Sent: Friday, 14 February 2020 10:37 PM
To: s. 47F(1)
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]
Attachments: Site map.docx

s. 47F(1)
Thanks so much

As discussed the draft EIS is publicly available and can be found here. The attached map shows the location of the project.

Please let me know when you are available to talk. It would be good to hear you thoughts about adequate survey methodology, and ask a few questions regarding the species habitat and behaviour.

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Friday, 14 February 2020 3:29 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 22(1)(a)(ii) some reading matter attached, more to follow! A recent locality record can be added to the map in Mifsud and Woolley at -20.0840ºS , 141.2201ºE .
In haste, s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Wednesday, 12 February 2020 4:26 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

Thanks so much, would it be possible to set up a time to have a teleconference to discuss the Julia Creek Dunnart.

As noted previously we are currently assessing a project that is likely to have potential impact on the Julia Creek Dunnart. I have provided a bit of a background on the project below:

- The proposal is for a vanadium mine within the Mitchell Grass Downs bioregion in Queensland, which is dominated by Mitchell Grass (Astrebla spp.) tussock grasslands on rolling plains (downs). The soils are predominantly deep, heavy clays (see below for more info on geology and soils). The plains are interspersed with drainage lines, supporting open grasslands, herblands or eucalypt woodlands and isolated remnant plateaus.
- The Julia Creek Dunnart was not recorded during the ecological surveys undertaken by the proponent.

- The proposed mining will be undertaken as sequential strip mining across an area of 7,435 ha. Mining depth will vary between 1 m and 40 m below ground level (average 20 m).
- The strip mining method generally involves clearing vegetation, stripping topsoil, removing overburden and then excavation. The overburden will be placed to the side of the working face and is able to be profiled to final landform. The surface will be prepared for vegetating as soon as each area of mined land becomes available for rehabilitation.

Please let me know when would be the best time to chat.

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Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 22(1)(a)(ii)
How can I help?
s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 11 February 2020 8:59 AM
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Appreciate it if you could spare the time to discuss the species and potential impacts of the project.

Regards
s. 22(1)(a)(ii)

Assistant Director
Assessments and Governance Branch
Department of Agriculture, Water and the Environment
P: s. 22(1)(a)(ii)
E: s. 22(1)(a)(ii) @environment.gov.au


epic

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Sent: Friday, 14 February 2020 10:39 PM
To: s. 47F(1)
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Sorry s. 47F(1)

I forgot to add that Chapter 17 of the draft EIS includes the discussion on Commonwealth listed threatened species and Chapter 5 has the information on the proposed rehabilitation.

Cheers
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Assistant Director
Assessments and Governance Branch
Department of Agriculture, Water and the Environment
P: s. 22(1)(a)(ii)
E: @environment.gov.au

s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 18 February 2020 1:47 PM
To: s. 22(1)(a)(ii)
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]
Attachments: JCD repro 2015.pdf; Woolley 2017 Rest sites .pdf

How about 2.30? My office number is s. 47F(1) . Some more reading matter attached. s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 18 February 2020 12:18 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

Thank so much for that-greatly appreciate.

Wednesday afternoon if fine for us, what time would work for you?

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 18 February 2020 11:43 AM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Dear s. 22(1)(a)(ii)
Thank you for sending the map and EIS. I have had a quick look through the EIS for information regarding the JCD and found little! The trapping effort appears to have been minimal – seems they put it in the 'too hard' basket. So far as I could see they did only 800 trap nights in the month of March and the trapping area was small. Please correct me if I am wrong. The site is well within the range of the species and with appropriate methods I feel sure that JCD's would be found. March may not be the best time of the year to detect them by trapping - numbers could be low after the wet season if any flooding occurred. There are more ways than trapping to determine the presence of mammals in an area e.g. collection of owl pellets , examination of scats and stomach contents of cats and foxes. Some years ago I advised RPS Australia East Pty Ltd about appropriate survey methods for the JCD for Mount Margaret Mining Pty Ltd and details can be found in:- RPS R71334 Report - Targeted Julia Creek Dunnart Survey of the E1 lease of the Mount Margaret Mine. My advice was based on my own extensive experience of locating the JCD and the results of work by Greg Mifsud, a student whose Masters Project I supervised.
My own effort in 1991-92 to locate specimens of a species considered extinct at the time was driven by the need to obtain adult male specimens for a study of penis morphology of all members of the genus Sminthopsis. A permit to collect 8 individuals was granted with the condition that I breed them in captivity before pursuing my specific interest!
Would this coming Wednesday afternoon suit you for a chat?
Cheers, s. 47F(1)

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Assistant Director
Assessments and Governance Branch
Department of Agriculture, Water and the Environment
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CSIRO PUBLISHING

Australian Journal of Zoology, 2015, **63**, 411–423
http://dx.doi.org/10.1071/ZO15056

The Julia Creek dunnart, *Sminthopsis douglasi* (Marsupialia : Dasyuridae): breeding of a threatened species in captivity and in wild populations

P. A. Woolley

Department of Ecology, Environment and Evolution, La Trobe University, Melbourne, Vic. 3086, Australia.
Email: p.woolley@latrobe.edu.au

Abstract. A detailed description of the methods used to house, maintain and assess the reproductive condition of captive Julia Creek dunnarts, *Sminthopsis douglasi*, that led to successful breeding of the species in captivity is provided. Basic features of the reproductive biology of this species of *Sminthopsis* have been established from observations made on captive animals. The females are polyoestrous, with a cycle length of ~28 days. Young are born 13–16 days after mating and are dependent on the mother for ~70 days. The age at which captive animals commence breeding ranged from 13 to 38 weeks (females) and 23 to 40 weeks (males). Both sexes are capable of breeding when two years old. Breeding in wild populations is seasonal and occurs over a six-month period from August to March, which encompasses the hottest and wettest time of the year. Both females and males are known to be capable of breeding in more than one season and females have the potential to rear two litters in a season. Recruitment of young to the population may be affected by heavy rainfall during the breeding season that can lead to closure of the cracks and holes in which the dunnarts shelter.

Additional keywords: development of young, longevity, oestrous cycle, reproductive organs, seasonal breeding, tooth eruption.

Received 14 September 2015, accepted 4 January 2016, published online 2 February 2016

Introduction

Following the rediscovery of the Julia Creek dunnart, *Sminthopsis douglasi*, in north-western Queensland (Woolley 1992) animals were brought into the laboratory in 1992 to study aspects of their reproductive biology and to obtain fresh, adult male specimens for a study of penis morphology (Woolley *et al*. 2007). The wild-caught animals bred in their first year in captivity and a breeding colony was maintained for eight years. Some of the observations made have been reported in brief by Woolley (1995, 1997). In addition to the observations presented here the colony provided material for studies on growth and development from birth to sexual maturity (Beckman 1997; Beckman and Woolley 1997), aspects of maternal behaviour (Woolley *et al*. 1998), cranial and dental deformities (Lade 1998), respiratory physiology (Mortola *et al*. 1999), anatomy and physiology of the gastrointestinal tract (Hume *et al*. 2000), form and function of the pouch musculature (Woolley *et al*. 2002), torpor (observations made by Muller reported by Geiser 2003), anatomy and chromosomes of an intersex (Woolley *et al*. 2003), and molecular studies (Spencer *et al*. 2003; Woolley *et al*. 2007).

The colony was disbanded in November 1999 when, following training of personnel, some animals, as well as materials for their maintenance (cages and running wheels), were transferred to the David Fleay Wildlife Park, Queensland, where they continued to breed, providing animals for behavioural studies aimed at detection of oestrus (Pollock *et al*. 2010) and for study of housing systems (Phillips *et al*. 2012).

In addition to the laboratory studies, observations on breeding have been made on wild populations of the Julia Creek dunnart over the years from November 1991 to November 2001. They include those carried out in collaboration with Mifsud (1999) in 1995–98, some of whose findings have been reported by Woolley (2008), and with the Queensland Parks and Wildlife Service in 2000–01.

At the present time the Julia Creek dunnart is listed as Near Threatened by the IUCN (Burnett and Winter 2008). More recently, the known range of the species has been extended (RPS Australia East Pty Ltd 2012) but it is still categorised as Near Threatened (Woinarski *et al*. 2012). There are no published reports to confirm the continued presence of animals in areas where they have been found in the past. Should reintroduction to parts of their range be deemed necessary in the future a proven method for successful breeding in captivity is essential. This method, together with observations made on the reproductive biology of the founding stock and their progeny in captivity, and on free-ranging animals, is presented here.

Materials and methods

Maintenance of the laboratory colony

The laboratory colony was established in April 1992 with eight animals obtained from the wild. Six (2♀, 4♂) were from Lyrian, one (♂) from Edith Downs and one (♀) from Crendon in north-western Queensland. The animals were housed singly (with the exception of females with young) in fibreglass box cages with wire mesh lids (Woolley 1982). They were provided with a wooden nest box (20 × 20 × 10 cm with a 5 × 5 cm entrance) and a hinged lid, waterproofed with a clear polyurethane paint. Shredded unused newsprint was used as bedding material. Each cage was fitted with a mezzanine floor (a polyvinyl sheet 3 mm thick and 30 cm wide supported on brackets on the side walls of the cage) over the nest box and a specially designed exercise wheel attached to the rear wall of the cage (Woolley 1993). Corrugated cardboard was used as flooring material in the cage, on the mezzanine and in the nest box. Water was provided in a bird seed feeder attached to the wall of the cage above the mezzanine floor, and food was placed on the mezzanine in a glass sponge bowl (diameter 7.5 cm, depth 4 cm). Cages were supported on mobile wooden benches designed to hold 12 cages in two layers. Daylength (sunrise to sunset) was adjusted at intervals of three days to that of Julia Creek, Queensland (20°53′S, 141°45′E) to roughly simulate that in their natural environment but temperature was held at ~21°C. In their natural environment temperature varies considerably throughout the year. Mean monthly temperatures are highest from September to April (maximum ~34–38°C, minimum ~19–24°C) and lowest from May to August (maximum ~27–30°C, minimum ~10–14°C). The animal room was lit with full-spectrum fluorescent light tubes. Infrared heat lamps suspended from the ceiling were switched on from 1300 to 1400 hours, when the room was unattended, to allow animals in the upper layer of cages to bask undisturbed. The layers were interchanged every few days. Cage and mezzanine floor cardboard was replaced twice a week and cages were disassembled and washed every four weeks. A clean nest box was provided at intervals of two weeks and the old one removed once animals started using the new one. Care was taken to ensure that animals were never subjected to a totally fresh cage environment at any one time.

They were fed insects (either mealworms or crickets) together with a minced meat formulation prepared with beef heart (450 g), beef liver (115 g), ground dry cat food (200 g), calcium carbonate (200 g) and egg (1). This mixture was frozen in ice cube trays (one cube = 20 g) for four weeks before use to reduce infectivity of *Toxoplasma* cysts that might be present in the meat (Attwood *et al*. 1975; Woolley 1982). Animals were fed daily in the late afternoon and any uneaten food removed on the following morning.

Females were given 2 g of insects and 10 g of the meat formula (i.e. half a cube) daily and males, 2 g insects and 15 g of the meat formula. The amount of food provided for females suckling young was adjusted as the young aged, with increases at Day 20 (insects, 3 g), Day 30 (meat formula, 15 g), Day 40 (insects, 4 g), Day 50 (meat formula, 20 g) and at Day 60 (insects 2 g and 1 g for each young in litter and meat formula as judged necessary). Weaning occurs around Day 70 and an additional 1 g insects and 5 g meat formula was then provided for each of the young in the litter, together with standard rations for the mother. The quantity of insects supplied for independent young housed with the mother was increased at Day 80 to 2 g. Young remained with the mother for variable periods after weaning, up to an age of 100 days. They were caged separately if signs of aggression among littermates, usually manifested by tail biting, were observed. The amount of meat formula supplied in all cases was sufficient for there to be a small excess. Insects were always eaten in preference to the meat formula. Water with one drop of infant formula 'Pentavite' per 50 mL was available at all times. A serial number was assigned to each animal and this, together with sex, date of capture or birth, parents, siblings and quantity of food required was displayed on a card attached to the front of the cage.

Assessment of reproductive condition

The procedures followed in the laboratory for the detection of oestrus (presence of cornified epithelial cells in the urine, changes in body weight), for monitoring the changes characteristic of pregnancy and pseudopregnancy (appearance of the pouch area, changes in body weight) and male reproductive condition (measurement of scrotal width, occurrence of spermatorrhoea), were the same as those detailed for *Sminthopsis macroura* (Woolley 1990*a*, 1990*b*). Females were generally monitored twice a week, and males once. Females were weighed more frequently when in oestrus to detect the temporary elevation of body weight seen during the oestrous period. The interval between peak body weight in successive oestrous periods provides a measure of the length of the oestrous cycle. They were also monitored more frequently around the expected date of termination of pregnancy. The information obtained at each inspection was transferred daily from laboratory data sheets to the individual's card file and also to graph paper (year by 365 days), so that the reproductive state of the female was obvious at a glance.

Pairing for mating procedure

A male was transferred in his nest box to the cage of the female diagnosed to be in oestrus. The transfer was done on the day that body weight of the female was starting to fall following the peak during the period when cornified epithelial cells were present in the urine, based on observations made on the timing of mating in *S. macroura* (see Woolley 1990*a*). Activity of the animals was closely monitored and if aggressive behaviour was observed the male was removed. Sometimes a different male was introduced on either the same or the following day. Once copulation commenced the animals were left together for the duration (overnight if necessary). A urine sample was obtained from the female and examined for the presence of spermatozoa, providing in some cases confirmation of mating.

Other observations

Tail width was measured at weekly intervals from weaning to maturity, and at monthly intervals thereafter. Foot length was measured at autopsy. Females suckling young were inspected at intervals of five days and developmental features of the young noted. As part of a separate study various measurements were made of young from birth to weaning and beyond to sexual

maturity. The sequence of tooth eruption, especially of the premolar teeth, was studied in both live animals and prepared skulls as a potential aid to assessing the age of immature animals in the field.

The gross appearance of the reproductive tract of females was routinely noted at autopsy and the greatest width of the uteri measured before fixation of the tract in aqueous Bouin's solution. The uteri of some were opened before fixation to determine the number of eggs or embryos. Ovaries for histological study were embedded in paraffin and serial 8-µm sections were prepared to determine, as described by Woolley (1990*a*), the number of either Graafian follicles or corpora lutea. Reproductive organs, including the testes, epididymides, prostate and bulbo-urethral glands were removed from 80 males. The organs were weighed and histological sections of one testis from each male prepared (see Woolley 1990*b* for methods). The penis of a smaller number of males was examined and observations reported elsewhere (Woolley *et al*. 2007).

Field study

Trapping methods used in 1992 are described by Woolley (1992). In later years Elliott traps (23 × 8 × 9 cm) baited with a bacon and peanut butter mix and rebaited as necessary were used. After some preliminary line trapping at two properties (Toorak and Proa), traps were set on these properties on permanently marked grids, with 100 traps placed 50 m apart at each grid site (see Mifsud 1999). At other locations various line trapping configurations were used. Traps were left in position and opened for up to seven, but generally five, consecutive nights in a trapping session. Observations were made on trapped animals (including recaptures) that were transported early in the morning, in the trap in which they were caught, to the field laboratory. Each animal was transferred to a cloth bag for examination. Body weight, width of tail, foot length, and width of the scrotum were recorded. The pouch of each female was examined and the presence/absence of a skin fold, colour of the pouch fur, size of the nipples and mammary tissue and presence of young noted. If young were present, crown–rump length or, in the case of older young, head and foot length, was measured to estimate the age of the young by comparison with observations made on known-age, captive-bred young. An attempt was made to collect a urine sample from both females and males. If obtained, the sample was examined fresh for the presence of cornified epithelial cells (females) or spermatozoa (males). Observations were made on the premolar teeth of some individuals. Each animal, other than the few trapped before 1996, was implanted with an ID-100 passive identification transponder (PIT tag, Trovan Industries). After examination each animal was returned to the trap in which it was caught, provided with food (live insects collected using a light trap) and water and released at the exact site of capture in the late afternoon.

Results

Breeding of the founding stock

The eight wild-caught animals (3♀, 5♂) brought into the laboratory in April 1992 were, with the exception of one female, assessed as reproductively immature. Body weight of the females ranged from 39 to 58 g, that of the mature female being 49 g. The females each had eight nipples; those of the immature females were very small whereas those of the mature female were slightly elongated. The mature female, which was rescued from a cat in November 1991, was known to have at least five young in the pouch at the time (S. Malone, pers. comm.). The pouch hairs of this female were stained a deep reddish-brown colour while those of the immature females were white or very lightly stained. The pouch area of the mature female was defined by a thin circular skin fold (Type 3 pouch: Woolley 1974). Body weight of the males ranged from 29 to 50 g, scrotal width ranged from 6.5 to 8.5 mm, and they were not showing spermatorrhoea.

The females first entered oestrus between 25 June and 7 July 1992 but were not then paired with a male in order to determine the length of the oestrous cycle, based on the assumption that *S. douglasi*, like its congener *S. macroura*, would prove to be polyoestrous (Woolley 1990*a*). They returned to oestrus 25–32 days later. One female was mated at the second oestrus and the other two at the third, resulting in litters of 5, 7 and 8 young born between 22 August and 12 September. The interval between mating and birth of the young in each case was 14 days. All young survived to weaning at ~70 days of age and were separated from their mothers by Day 75. Each of the mothers returned to oestrus in November, within days of the young being weaned. This post-lactation oestrus, which occurs as the mammary glands are regressing and body weight falling, was detected only by the presence of cornified epithelial cells in the urine. Consequently, the length of post-lactation oestrous cycles could not be calculated from peak weight during the period when cornified epithelial cells were present in the urine. These three females continued to enter oestrus at well defined intervals until March 1993. After a period of anoestrus they entered oestrus again, one in May and the other two in June. The length of all cycles for which the interval from peak weight in successive oestrous periods was determined ranged from 25 to 32 days (mean = 28.5, $n = 13$). The three wild-caught females were either not paired, or not successfully mated, for a second time in either their first or second year in captivity but it is clear that females have the potential, realised in the case of the mature-at-capture individual, to breed in two successive years.

Spermatozoa were first seen in the urine of the five wild-caught males between 15 June and 27 July, when scrotal width had increased to 13–14 mm (from 6.5–8.5 mm at capture). One showed spermatorrhoea continuously for 112 weeks, at which time it was found that spermatogenesis was still occurring, and another for 53 weeks, after which spermatorrhoea became intermittent before ceasing some 12 weeks later. Three of the wild-caught males sired young in their first year in captivity, 7–8 weeks after the commencement of spermatorrhoea, and another one sired young by two females in its second year, 62 and 68 weeks after commencement of spermatorrhoea. The litters produced in 1992 resulted from matings between the Crendon female and Edith Downs male (5♀, 3♂ young) and from each of two pairs from Lyrian (3♀, 2♂; 4♀, 3♂).

Breeding of further generations in captivity

Six litters were produced by five captive-bred females and five males (four captive-bred and one, previously unpaired, wild-caught male) in 1993. Twenty-three young (12♀, 11♂) were

retained in the colony. The number of litters raised to weaning were, in subsequent years: 11 in 1994, 7 in 1995, 5 in 1996, 16 in 1997, 22 in 1998, and 8 in 1999. In total, 325 individuals were raised to independence and 270 of these to maturity. The maximum length of time that a female was maintained in captivity was more than three years (164 weeks), and a male more than two years (125 weeks). Surplus stock, including pouch young, were utilised in other studies referred to above.

The 12 females born in captivity in August and September 1992 reached maturity (i.e. first entered oestrus) in January, February and March 1993 when 123–195 days of age (~17–28 weeks). In later years females reached maturity in various months throughout the year at ages ranging from 89 to 270 days (~13–38 weeks). The age at which littermates matured varied by as much as seven weeks. Over the life of the colony a total of 155 females born in captivity reached maturity, some in every month of the year, at a body weight within the range of 37–50 g before the temporary elevation (3.5–7 g) that occurs during the oestrous period. Oestrous cycles ceased for variable periods from late March to early June in all females with the exception of the few that were lactating during this period. The length of the oestrous cycle in captive-bred females, determined for one or more cycles of 79 individuals maintained in the years 1993–99, ranged from 22 to 34 days (mean = 28.1, $n = 213$). Pairs that produced pouch young were observed to copulate for up to 6 h; the minimum duration for success was 30 min. The interval between mating and birth of the young ranged from 13 to 16 days (13 days, $n = 35$; 14, $n = 83$; 15, $n = 39$; 16, $n = 7$) in 164 pregnancies. Thirteen females had only a single pouch young. The young of eight of these females did not survive beyond 10 days, and in the other five the young were removed on the day of birth. All 13 females returned to oestrus as expected if they had not become pregnant. The number of pouch young ranged from 2 to 8 for the other 151 pregnancies. Females were able to raise litters of two to weaning. Mean litter size, excluding non-viable litters of one, was 5.7. Some small losses of young from non-experimental causes occurred during pouch life. Supernumerary young were found in the nest material of some of the 33 females that had the full complement of eight young in the pouch. The sex of all eight young in 22 litters was determined and there were exactly equal numbers of females and males in total. Over the life of the colony, young were born in all months of the year but there were fewer births in the months (March–June) when females were anoestrus for varying periods. Three females each raised three litters, weaning the third when 74, 76 and 90 weeks old. Some females raised two litters in close succession, the second resulting from mating during the post-lactation oestrous period following the first litter. The oldest female to breed in captivity was 105 weeks old when she weaned her second litter.

The eight males born in captivity in 1992 became spermatorrhoeic between 9 March and 13 April 1993, at ages of 199–234 days (28–33 weeks), mostly greater than those at which their female littermates reached maturity (see above). A further 107 captive-bred males commenced spermatorrhoea in all months over the years 1994–99 at ages of 162–280 days (~23–40 weeks). The age at which male littermates matured varied by up to 12 weeks. Over the life of the colony 115 captive-bred males commenced spermatorrhoea, some in each month of the year, at a body weight in the range of 40–71.5 g. Some showed spermatorrhoea continuously up to an age of 125 weeks. The greatest age at which a male sired young was 119 weeks, 84 weeks after the commencement of spermatorrhoea. Males impregnated females as little as two weeks after becoming spermatorrhoeic. Scrotal width at the commencement of spermatorrhoea ranged from 11 to 15 mm, after which it declined by 1–3 mm below the peak value for an individual but never below 10 mm even in males in which spermatorrhoea, and also spermatogenesis (see below), had ceased.

Features of reproduction in the founding stock and their progeny are summarised in Table 1.

Observations on the reproductive organs

Females

Changes in the gross morphology of the reproductive tract of females were essentially the same as those seen in *S. macroura* (Woolley 1990*a*). *S. douglasi* females were found to ovulate spontaneously, as evidenced by the finding of eggs in either the Fallopian tubes (by histological examination) or uteri (freshly dissected) of unmated females. Ovulation occurs during the 2–4-day period when body weight is declining after the peak at oestrus. The number of eggs found in the uteri of each of six individuals ranged from 12 to 22 (mean = 15.8). Counts (both ovaries) of Graafian follicles of seven individuals ranged from 11 to 31 (mean = 22.1) and corpora lutea of 37 individuals from 13 to 30 (mean = 19.6). The number of embryos (two-cell to near full term) found in one uterus from each of 20 individuals examined while fresh ranged from 4 to 13 (mean = 7.75). The number of corpora lutea in the ipsilateral ovary was equal to the number of embryos in seven females but there were fewer embryos (by up to five) in another 13. Among the latter, undivided eggs were sometimes found in the uteri.

Males

Changes in the size of the reproductive organs have been correlated with the reproductive status (immature, mature and senile) of males of various ages (Table 2). Nine males that were immature (i.e. spermatorrhoea had not commenced) at the time of their death fell into two age groups: four were ~17–20 weeks old and five ~27–31 weeks. Scrotal width of the younger males

Table 1. Features of reproduction in the founding stock and their progeny

Feature	Founding stock	Progeny
Age at maturity (weeks)		
Females	Not known	13–38
Males	Not known	23–40
Body weight at maturity (g)		
Females	42.5, 60 ($n = 2$)	37–50 ($n = 155$)
Males	40–52.5 ($n = 5$)	40–71.5 ($n = 115$)
Onset of oestrus (months)	Jun., Jul.	Jan.–Dec.
Length of oestrous cycle (days)	28.5 ($n = 13$)	28.1 ($n = 213$)
Mating to birth of young (days)	14 ($n = 3$)	13–16 ($n = 164$)
Anoestrous period (months)	Mar.–Jun.	Mar.–Jun.
Onset of spermatorrhoea (months)	Jun., Jul.	Jan.– Dec.
Scrotal width at maturity (mm)	13–14 ($n = 5$)	11–15 ($n = 115$)

Table 2. Size of the reproductive organs in immature, mature and senile males
Testis and bulbo-urethral gland weight based on mean value for right and left organs. Numbers in brackets indicate scrotal width at maturity of males in the group

Reproductive status of group (age in weeks)	Body weight (g)	Scrotal width (mm)	Testis weight (mg)	Prostate weight (mg)	Bulbo-urethral gland weight (mg)
Immature					
(~17–20), *n* = 4	37–43	5.5–7.5	15–51	Not developed	Not developed
(~27–31), *n* = 5	49–55	11.5–12.5	131–151	33–129	Not developed, *n* = 2 Developing 6–9.5, *n* = 3
Mature					
(~26–30), *n* = 5	52–62	11–13	156–190	116, 434–804	11.5, 44–81
(~41–53), *n* = 5	54–63	11–13	113–189	800–1100	63–95
(~112–114), *n* = 4	63–74	10–11.5	70–115	974–1213	68–98
Senile					
(~65–95), *n* = 6	54–72	10.5–11 [13–15]	54–99	960–1138	48–79

ranged from 5.5 to 7.5 mm and of the older males 11.5 to 12.5 mm. Spermatogenesis had not progressed beyond the stage of spermatocytes, and development of the accessory reproductive organs (prostate and bulbo-urethral glands) had not commenced in the younger males. In the older males, testis weight was greater and spermatogenesis was complete. Spermatozoa were found in the head of the epididymis but not the tail. Thickening, but not zonation, of the prostatic urethra was evident in all five, enlargement of the bulbo-urethral glands in three and sigmoid flexure of the penis, typical of mature males, was starting to form in three.

Mature males (i.e. males showing spermatorrhoea) were placed in one of three groups (Table 2). The first consisted of individuals between 26 and 30 weeks of age in which spermatorrhoea had commenced only in the week of their death. Testis weight was greatest in the males of this group, and the accessory organs were showing development in all, with one individual having lower values than the other four. The second group (age 41–53 weeks) and third (age 112–114 weeks) were all showing spermatorrhoea but testis weight was generally lower, and prostate and bulbourethral gland weights generally higher, than in the first group.

The senile individuals, in which both spermatorrhoea and spermatogenesis had ceased, were aged from 65 to 95 weeks. Scrotal width of these males had declined and testis weight was lower than that of mature males. Zonation of the prostate was evident in all mature (with the exception of the one in Group 3 with lower values) and senile males. These observations illustrate the variability in age at which individuals mature and senesce in captivity.

Development of the young

Birth to weaning

The developing young remain covered by the pouch skin fold of the mother for ~30 days of pouch life, after which they become increasingly exposed and sometimes can be seen hanging from the nipples (Woolley *et al*. 2002). From about Day 40 the young can relinquish the nipples and may be left in the nest when the mother is out feeding. The eyes open from Day 50 and soon after the young start riding on the mother's back when she leaves the nest box. They were first seen to take solid food at an age of 67 days. Weaning occurs at ~70 days, at which age body weight of females ranged from 9.0 to 19.9 g (*n* = 121) and of males 9.8 to 21.5 g (*n* = 76). Tail width (both sexes) ranged from 3.0 to 4.5 mm and scrotal width from 4.5 to 6.5 mm (*n* = 65). Hind foot length of 70-day-old individuals, obtained at autopsy, ranged from 17.2 to 20.1 mm in females (*n* = 8) and 17.4 to 21.1 mm in males (*n* = 27). The pouch area of 70-day-old females was discernible as a small depression on the abdomen containing a ring of eight minute nipples surrounded by short white hairs.

Weaning to sexual maturity

Body weight of both females and males at sexual maturity, as well as the age at which they reached maturity, was very variable (Table 1). Tail width of females at maturity ranged from 5.0 to 9.0 mm (*n* = 128) and of males 6.5 to 12 mm (*n* = 112). Hind foot length of individuals autopsied at various ages after they had reached maturity and considered to be fully grown ranged in females from 22.2 to 25.0 mm (*n* = 144) and in males from 23.4 to 27.4 mm (*n* = 102). By the time females reached maturity the nipples were covered by a circular skin fold (Type 3 pouch: Woolley 1974) and the pouch hairs had grown longer, sometimes protruding as a tuft from the pouch entrance. Development of the skin fold occurred from a few weeks to a few days before the first oestrous period.

Tooth eruption

Adult *S. douglasi* have four upper and three lower incisors, one upper and one lower canine, three upper and three lower premolars and four upper and four lower molars on each side, represented by the formula $I^{1-4}/_{1-3}$, $C^{1}/_{1}$, $PM^{1-3}/_{1-3}$, $M^{1-4}/_{1-4}$. The third premolar tooth ($dP^{3}/_{3}$) is the only tooth replaced by a second generation tooth ($P^{3}/_{3}$) in the functional dentition (premolar notation follows Luckett and Woolley 1996). The young lack a full complement of teeth at weaning and this may influence their selection of food items. At 70 days of age $I^{2-4}/_{1-3}$, $C^{1}/_{1}$, PM ($=dP^{1-3}/_{1-3}$) and $M^{1-2}/_{1-3}$ have erupted, at least partially. Eruption of the first pair of upper incisors follows the cessation of suckling. As in *S. macroura* (Frigo and Woolley 1997) eruption of each of the upper premolars occurs in advance of the comparable tooth in the lower jaw, and in the case of the molars, those in the lower jaw erupt in advance of

those in the upper jaw. In *S. douglasi* M^3 and M_4 had erupted by an age of 110 days, and M^4 by 130 days. Replacement of $dP^3/_3$ by $P^3/_3$ occurred from age 130 to 170 days, with P3 erupting lingual to dp3.

Breeding in the wild

The field sample

Observations were made on 414 individuals (160 females, 254 males) caught in 10 locations between April 1991 and November 2001 (Table 3), and on two males found dead on roads, one in April 1992 near Lyrian and one in June 1999 on Yorkshire Downs. Trapping was carried out in all months except December. Trapping effort in other months varied with locality and from year to year and, in January and February, trapping was done in one year only. Trapping success (i.e. the number of individuals captured per 100 trap-nights) was generally low and never greater than ~3% in any one trapping period or year. More than half of the dunnarts were trapped only once (Table 4). Some were captured several times (on up to seven consecutive days) within a trapping session and others at intervals of weeks or months. Only the data obtained at first capture within a trapping session were incorporated into monthly sample data. The maximum number of captures for a female was 30 over a period of 24 months spanning three calendar years, followed by 19 for another over 15 months. Three other females were captured several times over 13 months, and one over 12 months. Only two of the 254 males were captured over periods greater than 9 months: one was captured 13 times over 14 months, and another 5 times over 12 months. Mortality of animals as a result of trapping was low over the study period (10 individuals – four female, five male and one whose sex could not be established). Two of the deaths occurred in March following rain that delayed access to the traps, and another two were the result of predation.

Reproductive status of females at capture

Females caught over the years from November 1991 to November 2001 were classed as either immature or mature on the basis of pouch appearance. Immature females either lacked the circular skin fold or had only a thin fold that did not cover minute nipples. Among the immature females a few were recognised as juveniles on the basis of small body size and, in some cases, presence of $dp^3/_3$. Four categories of mature females were recognised: (1) in oestrus or pregnant; (2) lactating, young on nipples; (3) lactating, mammary tissue enlarged and nipples

Table 3. Trapping effort and the number of Julia Creek dunnarts (excluding recaptures) caught in each year

Locality	Year/months of capture	Number (♀, ♂)	No. trap-nights	Trapping success (%)
Crendon (21°26′S, 142°07′E)	1991/Nov.	1 (♀)[A]	–	–
Edith Downs (20°56′S, 142°12′E)	1992/Apr.	1 (♂)	950	0.11
Lyrian (19°21′S, 141°11′E)	1992/Apr.	6 (2♀, 4♂)	2000	0.30
	1994/Jun.	2 (1♀, 1♂)	1350	0.30
Toorak (21°02′S, 141°48′E)	1994/Jul.	1 (♂)	990	0.10
	1995/Aug.	1 (♂)	17 300	0.005
	1997/Apr.	2 (1♀, 1♂)	5600	0.035
	1999/Jun.	7 (3♀, 4♂)	1500	0.46
	2000/May, Aug., Sep.	9 (3♀, 6♂)	3500	0.25
Proa (20°54′S, 142°09′E)	1995/Aug.	1 (♂)	2550	0.04
	1996/Mar., Apr., May, Jun., Aug., Sep., Oct., Nov.	34 (19♀, 15♂)	19 640	0.17
	1997/Feb., Mar., Apr., Jul., Aug., Nov.	62 (22♀, 40♂)	11 010	0.56
	1998/May, Jun., Oct.	40 (15♀, 25♂)	3146	1.97
	1999/Jan., Mar., May, Jun., Aug., Sep., Nov.	54 (19♀, 34♂), 1[B]	7402	0.73
	2000/May, Aug.	9 (3♀, 6♂)	2800	0.32
Moorrinya NP (21°24′S, 145°02′E)	1999/Oct.	1 (♂)	1000	0.10
Woodsberry Reserve (21°25′S, 143°51′E)	1999/Aug.	4 (♂)	500	0.80
Yorkshire Downs (20°53′S, 141°58′E)	1999/Jun.	16 (3♀, 13♂)	1000	1.60
	2000/May, Aug., Sep.	7 (2♀, 5♂)	1467	0.48
Bladensburg NP (22°31′S, 143°02′E)	2000/Jul.	32 (4♀, 28♂)	1150	2.78
	2001/Apr., Jul., Aug., Sep., Oct., Nov.	125 (62♀, 63♂)	8000	1.56
Total		415 (160♀, 254♂), 1[B]	92 855	0.45

[A]Caught by hand.
[B]Sex unknown (partly eaten).

Table 4. Frequency of capture of individual females and males

	Frequency																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	19	30
No. of females (n = 160)	90	30	9	10	4	5	–	2	3	1	1	–	1	1	1	1	1
No. of males (n = 254)	150	52	23	6	8	3	3	4	2	–	1	1	1	–	–	–	–

elongated but no young in pouch; and (4) post-lactation, mammary tissue not enlarged, previously suckled nipples slightly elongated, pouch fur often deeply stained (i.e. individuals that had bred at an earlier time). Juveniles (body weight 18–29 g) were caught in each month from January to June and other immature individuals (16.5–58 g) from March to October. Mature females were caught in all months except January and December (Table 5, Fig. 1). Some were found to be either in oestrus or pregnant in August, September and October. Females with young in the pouch were found in October, November, February and March and females that were lactating but no longer carrying their young in the pouch in November, March and April. A wide range in body weight was seen in the monthly samples (Fig. 1). Mature females were, on average, heavier than immature females and some of the wide range in the weight of mature females can be attributed to reproductive condition, e.g. presence of young in the pouch (litters differing in age and body size) and, to a lesser degree, perhaps age (see below). Foot length of juveniles ranged from 20 to 22 mm, of other immature females from 20.5 to 24.5 mm and of mature females from 21.5 to 24.5 mm.

Based on measurements taken of young in the pouch, an estimate of the date on which females had given birth was obtained by reference to the growth curves for known-age, captive-bred young established by Beckman (1997). Four females with young in the pouch in February and March were calculated to have given birth to their young on 27 January, 12 and 24 February and 1 March. Another 24 females, caught with young in the pouch in October and November, were calculated to have given birth during the period 20 September to 6 November. Two of those that were known to have given birth to young in the early months of the year had another litter in

Table 5. Reproductive status of wild-caught females (1991–2001)

Numbers include individuals recaptured in different months. Oestrus (O) was diagnosed by the presence of cornified epithelial cells in urine, pregnancy (P) by pouch changes indicative of pregnancy

Month	No. caught				No. of mature females			
	Total	Juvenile	Immature	Mature	Oestrus, pregnant	Lactating, young in pouch	Lactating, no young in pouch	Post-lactation
Jan.	1	1	–	–	–	–	–	–
Feb.	2	1	–	1	–	1	–	–
Mar.	15	3	3	9	–	4	1[A]	4
Apr.	71	3	32	36	–	–	7	29
May	13	2	5	6	–	–	–	6
Jun.	27	1	15	11	–	–	–	11
Jul.	11	–	6	5	–	–	–	5
Aug.	28	–	16	12	1(O)	–	–	11
Sep.	22	–	13	9	4(O), 1(P)	–	–	4
Oct.	13	–	6	7	1(O)	6	–	–
Nov.	27	–	–	27	–	22	5	–

[A]This female captured with young in pouch in February.

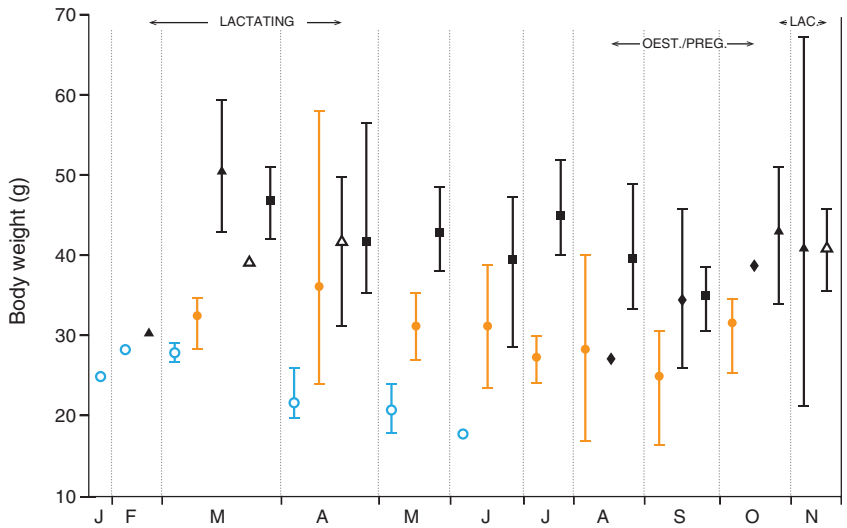

Fig. 1. Body weight (mean and range) of females caught in each month. Juvenile (○), immature (●) and mature: in oestrus or pregnant (♦), lactating, young in pouch (▲), lactating, no young in pouch (△), young suckled previously (■). See Table 5 for number of individuals in each category. Months in which females found in breeding condition are indicated.

November of the same year, while two of those caught with young in the pouch in October/November were known to have young at the same time in the following year. Others that were caught late in the year with young in the pouch were known to have produced young earlier but whether in the same or an earlier year could not be established. Litter size ranged from five to eight in 28 litters. The full complement of eight young was found in 22 litters. There were seven young in four litters, six in one, and five in one.

Reproductive status of males at capture

Males caught over the years from April 1992 to November 2001 were classed as either immature, if scrotal width was less than 11 mm (based on the laboratory finding that spermatorrhoea does not commence until scrotal width reaches at least 11 mm), or mature (or very close to maturity) if scrotal width was 11 mm or more. Among the immature males a few were recognised as juveniles primarily on the basis of scrotal width (<6 mm) and some by the presence of $dp^3/_3$. Maturity was sometimes confirmed by the presence of spermatozoa in the urine. Spermatozoa were not found in the urine of 38 of the males classed as immature (excluding juveniles), providing confirmation of the assessment of their reproductive status based on scrotal width. Juveniles (body weight 14.5–31 g, scrotal width 4–5.5 mm) were caught in each month from January to April, other immature individuals (14.5–50 g, 6–10.5 mm) from March to July and mature individuals (21.5–69 g, 11–15 mm) from April to November (Table 6, Fig. 2). Mature males were, on average, heavier than immature males in the months that both groups were represented in the population. Foot length of juveniles ranged from 20.5 to 23 mm, of other immature males from 20 to 26.5 mm, and of mature males 21 to 26.5 mm.

The number of urine samples obtained from mature males in each month was generally small. Not all had spermatozoa in the urine in April, May and June but with two exceptions all were spermatorrhoeic in the months from July to November (Table 6). One male, caught only in June in consecutive years, was immature at first capture (scrotal width 10.5 mm) and mature at second capture (scrotal width 11.5 mm and showing spermatorrhoea). Males that were immature (including four juveniles) when first captured did not reach maturity before June so males showing spermatorrhoea in April and May were considered to be males that had reached maturity in the previous year. This conclusion is supported by observations made on a male that was captured 11 times between March 1999 and May 2000. It was immature (scrotal width 8 mm) when first caught and mature (scrotal width 11–13 mm) when recaptured in May, June, August and November 1999. It was known to be spermatorrhoeic in August and November, and also in May 2000 when scrotal width was 12.5 mm. One male that was not showing spermatorrhoea in October may have been at the end of its reproductive lifespan. Scrotal width of this male, caught previously in August and September of the same year, had decreased from 12 to 10.5 mm.

Condition of field animals

Tail width provides a measure of the amount of fat stored in the tail and has been used as an indicator of condition. Bone and muscle was found to account for 4.0 mm of the width of the tail of captive adult animals, so individuals (excluding juveniles)

Table 6. Reproductive status of wild-caught males (1992–2001)
Numbers include individuals recaptured in different months

Month	No. caught				No. mature males showing spermatorrhoea/ no. sampled
	Total	Juvenile	Immature	Mature	
Jan.	5	5	–	–	
Feb.	3	3	–	–	
Mar.	16	1	15	–	
Apr.	63	2	55	6	1/3
May	33	–	25	8	1/7
Jun.	37	–	19	18	4/8
Jul.	57	–	7	50	7/7
Aug.	64	–	–	64	24/25
Sep.	21	–	–	21	8/8
Oct.	6	–	–	6	2/3
Nov.	13	–	–	13	8/8

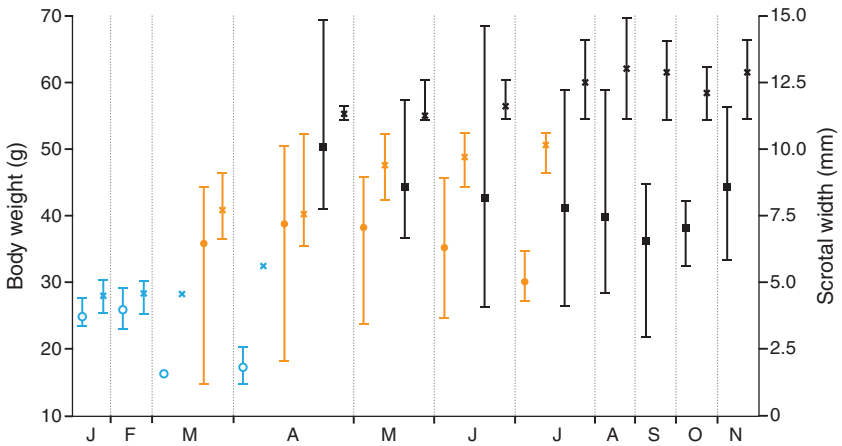

Fig. 2. Body weight (mean and range) and scrotal width (mean and range) of males caught in each month. Body weight: juvenile (○), immature (●) and mature (■); scrotal width (×). See Table 6 for number of individuals in each category.

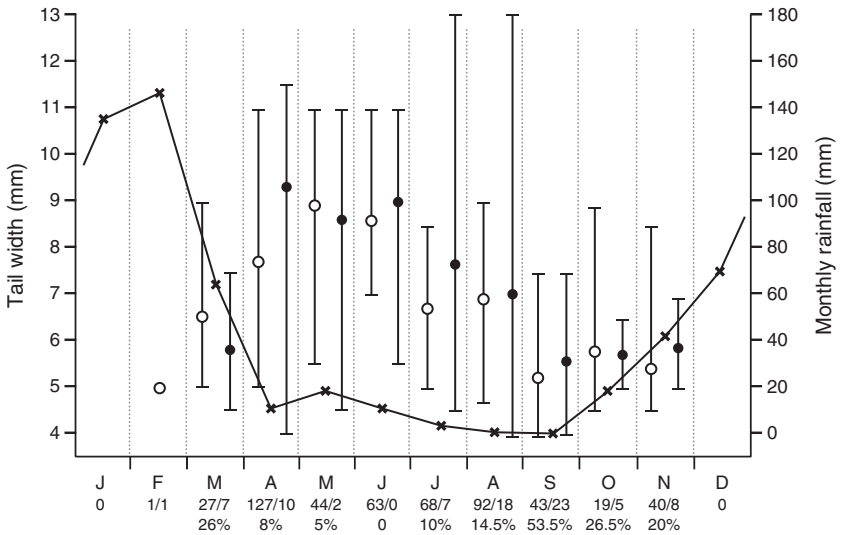

Fig. 3. Tail width (mean and range) of females (○) and males (●) (excluding juveniles) together with mean monthly rainfall (×) for Julia Creek, 1990–2000. Numbers below the baseline in each month are the total number caught followed by the number with thin tails (width 5 mm or less), with the latter expressed as a percentage of the total.

with a tail width of 5 mm (allowing 1 mm for skin thickness) probably have little or no fat stored in the tail. On the basis of tail width (Fig. 3), the majority of both females and males appeared to be in the best condition in the months from April to August, following the wetter period of the year (November to March). In each monthly sample except June there were some individuals with thin tails (width 5 mm or less) but there were proportionally more in months from September to March. Females and males that lacked fat reserves in the tail in the April–August period were not among those recaptured after August. Six of the females caught with young in the pouch in November had thin tails. Three of them were known to have had fat tails (width 7.5–10 mm) when captured earlier between May and August and two were known to breed again in the following year but whether or not they weaned their young is not known. Tail width of males captured several times between March and November increased from 5–6 mm in March to 8–13 mm in August, and fell to 6–7 mm in November.

Marked variation in tail width was seen throughout the life of one female, immature at first capture, which was caught 30 times (in 14 trapping sessions) over a period of 24 months from June 1997 (Fig. 4). Tail width declined in her first year, from a maximum of 10 mm in June to 5 mm in November, at which time she had newborn young in the pouch. By March 1998, when she was still lactating, tail width had increased to 6.5 mm and by the following August it was 9 mm. In June and July of 1999 tail width reached 10.5 mm. When caught in March 1998 it was not known if she was still suckling the young born in November, or if she had failed to rear the young and produced a second litter or if, as is possible given the ~70-day duration of lactation established for captive animals, she had reared the first litter and produced a second one, these young being old enough to be weaned by April 1998, at which time she was no longer lactating. It appears from observations made on her body weight between April and August over consecutive years that she became heavier with age.

Two males, both immature at first capture, were recaptured over two consecutive years and both appeared to become heavier with age. One, first caught in March had a body weight of 44 g and tail width of 7.5 mm. When recaptured in May, late August and late October body weight was unchanged but tail width increased to 9 mm in May and then decreased to 7 mm. In May of the following year body weight was 55 g and tail width 9.5 mm. The other male, captured in June in both years, had a body weight of 35.5 g and tail width of 8.5 mm in the first year and 45.6 g and 10.5 mm in the second year.

Pattern of reproduction

The yearly pattern of reproduction of *S. douglasi* in the wild, established from the findings above, is summarised in Fig. 5. The breeding season (the season when mating and birth occurs) extends from mid-August, when one female was found to be in oestrus, to February (last known birth date estimated as 1 March). Individuals that could be recognised as juveniles were caught in the first six months of the year. Males known from recapture data to be immature first showed spermatorrhoea in June and by August all males caught were mature (according to scrotal width) and all except one of those sampled was showing spermatorrhoea. Mature males caught in April and May were assessed as having matured in an earlier breeding season. Immature females were present in the population from March to October and mature females (i.e. ones that had bred at an earlier time) from March to September. Females were known to produce young in at least two consecutive years. Individuals with young in the pouch were caught from October to March and others that were still lactating but without attached young, in November, March and April. The young can relinquish the nipples about halfway (35–40 days) through the ~70-day period of dependence on the mother so females caught lactating but without attached young in November probably gave birth to their young in September

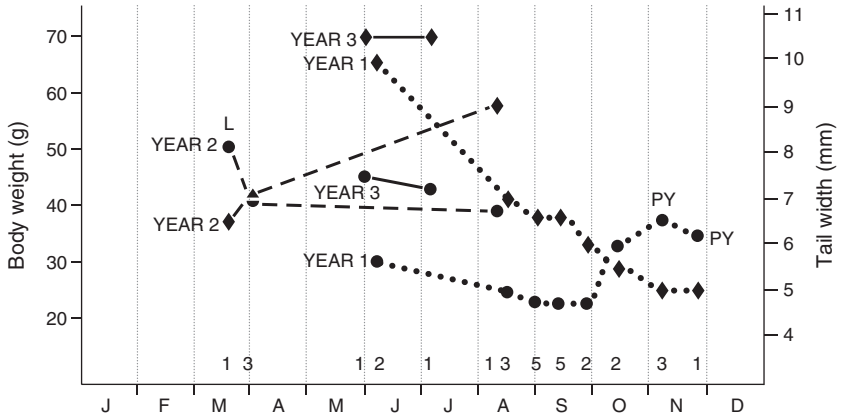

Fig. 4. Body weight (●), tail width (♦) and reproductive status of a female, immature when first captured, in three consecutive years. Figures above baseline are the number of times the female was caught in the trapping period. PY = young in pouch; L = lactating, no young in pouch.

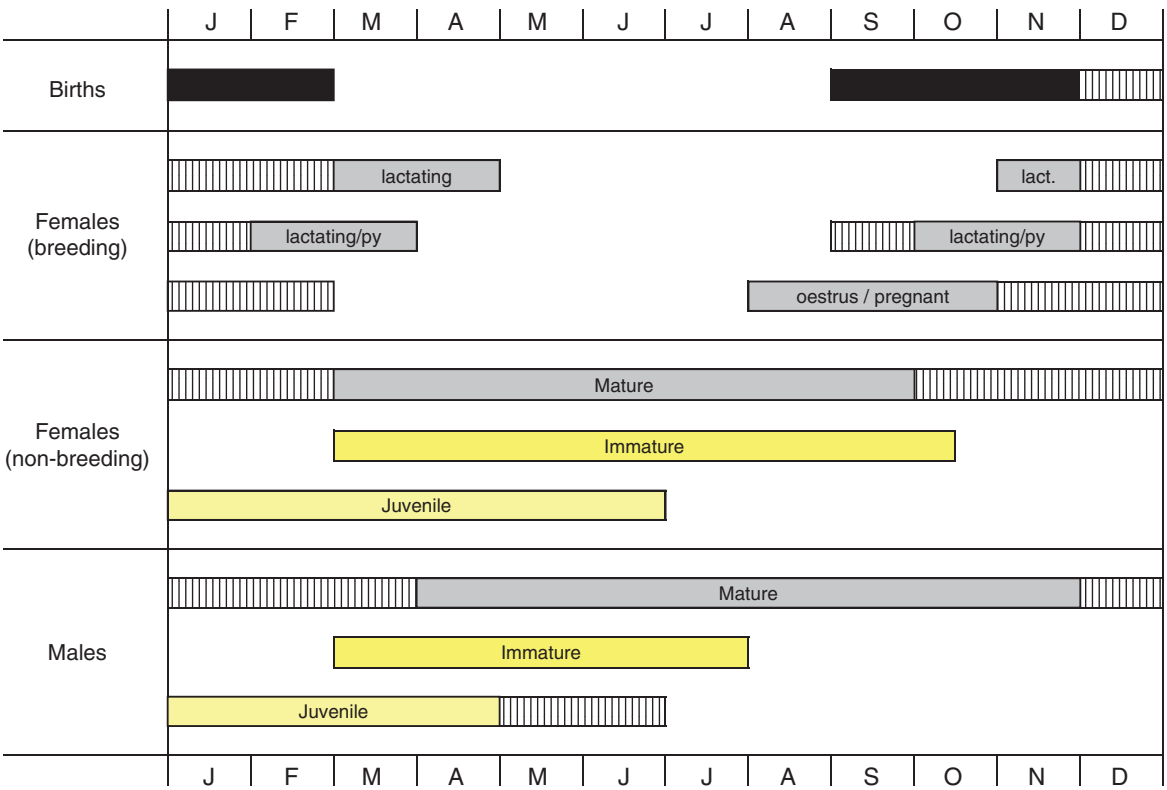

Fig. 5. Pattern of reproduction based on composition of the field population throughout the year. Shaded areas represent information derived from animals captured: vertical lines, presence inferred. Lactating/py = young on the nipples; lactating = no young on the nipples.

and weaned them in December. These females have the potential to return to oestrus and produce a second litter that would be weaned in March or April, along with other litters known to have been born in January and February.

Discussion

Julia Creek dunnarts breed readily in captivity under the conditions described, which allows basic features of their reproductive biology to be established. These features, considered unlikely to be modified to any extent by environmental conditions, aid interpretation of observations made in the field. The females are polyoestrous, with an oestrous cycle length of ~4 weeks. The gestation period is short, ~2 weeks, and the period of dependence of the young on the mother, ~10 weeks. Females return to oestrus as the young are weaned and will mate and produce another litter. Thus, within a six-month period they are capable of rearing two sets of young, which raises the

possibility of this occurring during the six-month breeding season in the field. While no female was known to have produced two litters in the course of the breeding season in the wild, recapture data obtained from at least one female (see above and Fig. 4) strongly suggests that they may.

The founding stock, both females and males, came into breeding condition (i.e. females in oestrus, males showing spermatorrhoea) in June and July of their first year in captivity but over the nine-year life of the colony some females and males reached maturity in other months and young were born in all months of the year. In the wild some males commenced spermatorrhoea in June but no females were observed to be in oestrus before August and births were estimated to have occurred in months from September to 1 March. Enhanced nutrition or more benign environmental conditions may have been factors in the loss of distinct seasonality of breeding of the dunnarts in captivity. Most females in captivity did, however, cease breeding for variable periods during March–June, when there was no breeding activity in the wild. Both sexes were found to be capable of breeding in two consecutive years in captivity and evidence that this occurs in the wild was obtained. The body size of captive-bred animals was very variable, as was the age at which they reached maturity. Females generally matured earlier than their male littermates. Female young of the founding stock, born in August and September, reached maturity in January, February and March of the following year but none of their male siblings reached maturity before March. Such a difference in the wild would reduce the chance of inbreeding occurring. The laboratory findings suggest that the dunnarts would be capable of breeding in the season of their birth in the wild.

Examination of the reproductive organs of animals found dead in the wild allows more accurate assessment of their reproductive condition to be made. Superficial examination of a male (scrotal width 11.5 mm, body weight 69 g) found dead on the road in April 1992, in the same month as immature male colony founders (scrotal width 6.5–8.5 mm, body weight 29–50 g) were caught, might have led to the assumption that the road-kill male, given its large scrotum, was already mature. Histological examination of one testis (weight 125 mg) from this animal revealed that spermatogenesis was occurring; however, it was not reproductively mature – the prostate was not fully developed (weight 55 mg) and it lacked the zonation characteristic of mature males. Comparison with observations made on immature males caught at the same time suggest that the road-kill male was older, i.e. presumably born earlier in the 1991–92 breeding season than the other males. The possibility that it would have commenced showing spermatorrhoea before them is considered unlikely because none of the wild males known to be approaching maturity commenced spermatorrhoea before June. Examination of the reproductive organs of two males found dead in early June (one trap death and one road-kill) confirmed their immature status (based on scrotal width), and for another two (both trap deaths) in late August, their maturity.

The method used for detecting oestrus, i.e. collection of urine samples to examine for the presence of cornified epithelial cells (itself a modification of the more invasive technique of vaginal smearing made possible by the arrangement of the marsupial urinogenital system) together with changes in body weight has been criticised by both Bjursell (2006) and Pollock *et al*. (2010). Bjursell (2006) claims that removing animals from their cages and restraining them to obtain a urine sample is stressful for the animals but it must be pointed out that the animals do not have to be ‘restrained’. With care, captive dunnarts show little resistance to being handled. They usually urinate when first handled but if they do not they are placed in a small clean cage, covered and left undisturbed until they urinate, as described by Woolley (1990*a*). Pollock *et al*. (2010) consider that the procedure for obtaining a urine sample has several disadvantages as it is time consuming, labour intensive and requires the regular handling of individual animals. However, by combining observations on changes in body weight with presence of cells in the urine to determine the appropriate time to pair animals for mating is a method which has proved successful in breeding of many species of dasyurid marsupials (e.g. *Sminthopsis macroura*: Woolley 1990*a*, Selwood and Woolley 1991; *Antechinomys laniger*: Woolley 1984; *Sminthopsis longicaudata*: Woolley and Valente 1986; *Dasykaluta rosamondae*: Woolley 1991), as well as in the present study of the Julia Creek dunnart.

For a species that, in its natural environment, is thought to shelter during the day mostly in cracks and holes in grass-covered, cracking clay soils the mezzanine floor in the cages used in this study provides cover for the animals when they emerge from the nest box, and the running wheel provides a means of exercising in a confined space. The wheels were used extensively by both sexes. Housing the dunnarts singly, appropriate for a species thought to be solitary in the wild, ensures that each animal has access to an adequate food supply and eliminates the danger of potentially harmful aggressive interactions occurring at times when they are not under observation. Future attempts at breeding in captivity should ensure the conditions for these dasyurids meet similar standards.

The breeding season of the Julia Creek dunnart encompasses the wet season. Access to field study sites is not always possible following rain, so little trapping was done during the wettest months (December–February) to avoid the risk of animals dying in unchecked traps. Survival of young during the wet season may be affected by heavy rains that cause the cracks and holes in which the dunnarts seek refuge during the day to close up. Young no longer suckling continuously could become separated from their mothers, or be more susceptible to predation if forced to shelter in vegetation. It is possible that abandoned young might find surrogate mothers, given the laboratory finding that mothers with young 50 days and older can foster young that were from 12 days younger to 2 days older than their own young (Woolley *et al*. 1998). Females have the potential to raise two litters in the course of the breeding season and those that lose their young prematurely can return to oestrus and become pregnant again. However, recruitment of young to populations may be affected by the amount of rain and the month in which it falls as rainfall can vary among years and in different locations across the range of the species.

The proximate factor determining the onset of breeding in this species has not been established but weaning of the young presumably occurs when conditions are most favourable for their survival. Studies on the availability of insects and other arthropods that form the main components of the diet of the dunnarts were trialled during drier months of the year using a

variety of methods (flight intercept, light, pit and sticky traps) but no information is available for the wet season. An increase in insect abundance could be expected following the growth of vegetation after rain and the dunnarts were found to be in best condition, based on fat stores in the tail, in the months following the wet season (April–August). Early in this period would therefore seem to be the best time to release captive-bred animals should reintroduction to areas in the wild be considered necessary. Animals with very fat tails were caught at times when locusts, which may have become available after successful breeding in other parts of northern Australia, were abundant. Individuals that were recaptured showed considerable variation in tail width over time (see Fig. 4), suggesting localised differences in food availability.

It seems that both the direct and indirect effects of rainfall could influence the survival of local populations of the Julia Creek dunnart. Drought conditions, which have prevailed across the range of the species in recent years may reduce both ground cover and the availability of food and may have a detrimental effect on populations. Natural factors, together with suspected threatening processes such as grazing, invasion of the habitat by woody weeds, fire and introduced predators, may affect the long-term survival of a species with a very restricted distribution.

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Research Note

Diurnal resting sites of the nocturnal dasyurid marsupial *Sminthopsis douglasi* in Bladensburg National Park, Queensland

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Abstract. An attempt has been made to determine where Julia Creek dunnarts (*Sminthopsis douglasi*), small nocturnal dasyurid marsupials, rest during the day under differing seasonal conditions. A short-term study was carried out in Bladensburg National Park, near the southern edge of its known distribution on the Mitchell grass downs in Queensland. Radio-collared individuals were located in cracks and holes. None of the males and females (including one with young in the pouch) were found to use the same resting site over periods of up to nine days, suggesting that they may be nomadic. Climatic factors may have affected the size of the dunnart population over the course of the study.

Additional keywords: home range, nomadic, radio-tracking, threatened species.

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Introduction

The Julia Creek dunnart (*Sminthopsis douglasi*) is a small, nocturnal dasyurid marsupial with a restricted distribution in Mitchell grass downs country in north-western Queensland. Currently its conservation status is listed as Near Threatened (Woinarski *et al*. 2014). Since its distribution was mapped in detail by Mifsud and Woolley (2012) it has been found in only one other location, the Mt Margaret mine site near Cloncurry to the west of Julia Creek (RPS Australia East Pty Ltd 2012). The downs are typified by predominantly grass-covered, cracking clay soils. Characteristically, growth of vegetation occurs during the wet season (~November–March) and the ground swells. Cracking occurs as the ground dries out. Surface cracks may be 50–75 mm wide, and they may extend downwards in roughly polygonal columns (Orr 1975) to a depth of ~30 inches (~760 cm) (Everist 1964). Mifsud (1999) considered that Julia Creek dunnarts prefer habitats with high densities of cracks and holes and plant assemblages that produce dense ground cover. Animals released after capture have been seen to seek cover either in vegetation or to enter cracks and holes in the ground but beyond that there is no information on where they rest when inactive during daylight hours. The breeding season of the Julia Creek dunnart encompasses the wet season (Woolley 2015), when cracks and holes in the ground may close. An attempt to obtain information about the diurnal resting sites of the dunnarts, in both the dry and wet seasons, by locating radio-collared individuals is reported here. The study was carried out in Bladensburg National Park, Queensland, where Julia Creek dunnarts were first found in July 2000 (Mifsud 2000).

Materials and methods

Elliott traps ($23 \times 8 \times 9$ cm) baited with bacon and peanut butter were set in a line along three sides of a rectangle that started and finished on the Powerline track close to the northern boundary of Bladensburg National Park, ~12 km south-east of Winton (Fig. 1*a*). Traps were checked daily soon after sunrise. Each animal trapped was implanted with an ID-100 passive identification transponder (PIT tag, Trovan Industries), assigned a serial number and released in the evening of the day of capture. Some were fitted with a Titley Electronics model LT2 single-stage transmitter, modified by the addition of a second antenna to increase signal strength when the animals were underground, on a cable tie collar. Weight of the unit was 900 mg (never more than 2.5% of the body weight of the individual to which it was fitted) and life of the battery was 10–12 days. The unit was smaller than the head of the animal, and so was unlikely to impede movement through cracks in the ground. These animals were located daily, on up to nine following days, in their daytime resting site using a hand-held Yagi AY/C antenna and a Regal 2000 receiver. Coordinates of resting sites were recorded using a Garmin 12XL personal navigator and plotted using ArcView. Trapping was carried out in 2001, on 17 nights from 3 April (during the dry season), and 10 nights from 9 November (during the wet season). In April, and for the first three nights of trapping in November 50 traps were set ~50 m apart along the trap line. An additional 50 traps were placed on the line, one between each of the previously established trap sites, for the last seven nights of trapping in November, giving a trap spacing then of ~25 m.

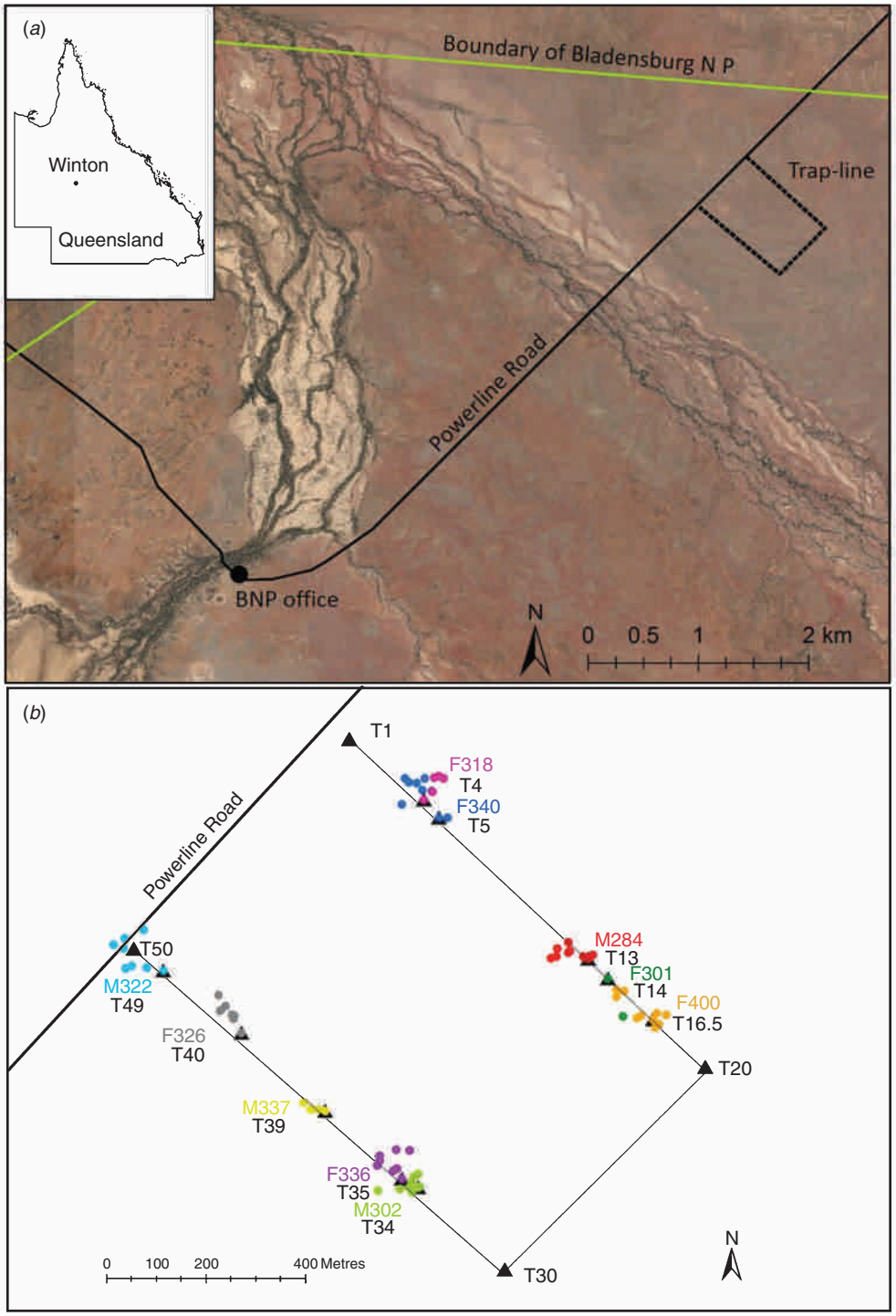

Fig. 1. (*a*) Location of the trap line (- - -) in Bladensburg National Park (BNP). (*b*) Trap sites (T▲), and resting sites (●) in relation to the trap line, of radio-tracked Julia Creek dunnarts.

Results

Trapping

Fifty-four Julia Creek dunnarts (28 ♀, 26 ♂) were caught in 850 trap-nights (6.3% trapping success) in April and only one (♀) in 850 trap-nights (0.1% trapping success) in November. Nearly half (13) of the females were mature (i.e. individuals with elongated nipples that had bred previously) but only one male, with a scrotal width of 11.5 mm, was assessed as mature (see Woolley 2015). Scrotal width of the other 25 males, considered to be immature,

ranged from 5.5 to 8.5 mm. In the April trapping period, 25 individuals (14 ♀, 11 ♂) were caught more than once. One female was recaptured on four occasions, three on three, and 10 on one. Five males were recaptured twice and six, once. Previously unmarked individuals were captured on all except Nights 7 and 15 of the 17-night trapping period The female caught in November, on the fourth night of trapping when trap spacing had been reduced, was recaptured twice on the trap-line and once more at the conclusion of tracking (see below). This female had seven young, with a crown–rump length of 10.5 mm at final release, in the pouch. No mammals other than Julia Creek dunnarts were caught on the trap line in either April or November.

Dunnarts were trapped at 38 of the 50 trap sites in April (Table 1). The greatest distance between sites of capture (Traps 17–21) for an individual was ~200 m. There were no major gaps along the trap line in the sites of capture of animals, the greatest distance being ~150 m (between Traps 30 and 33, and between Traps 35 and 38). The traps most frequently entered were Traps 13 (6 captures, 4 individuals), 34 (5 captures, 3 individuals) and 39 (10 captures, 5 individuals). It can be seen from Table 1 that, in April, animals not fitted with radio-collars were present in the same areas as those that were tracked. The female caught in November was trapped at three of the 100 trap sites, Traps 15, 16.5 (between 16 and 17) and 17, with a maximum distance between sites of ~100 m.

Table 1. Dunnarts captured at each trap site in April 2001
Numbers in parentheses indicate the number of times captured at the site. Individuals fitted with radio-transmitters are shown in bold type

Trap site	ID of animals caught at site	Trap site	ID of animals caught at site
1	♀347 (×2), ♀371	26	–
2	–	27	♀311, ♂287
3	♂367	28	♀311
4	♀**318** (×2)	29	–
5	♀**340**	30	♀288 (×4)
6	♂282	31	–
7	♀283, ♂282 (×2) ♂363	32	–
8	♂330	33	♀349, ♀364, ♂360 (×2)
9	♂330	34	♀372, ♂289 (×3), ♂**302**
10	♀368	35	♀**336**, ♂**302**
11	–	36	–
12	♀308, ♂284	37	–
13	♀300 (×2), ♂284, ♂307, ♂348 (×2)	38	♀303 (×3), ♀320
14	♀**301** (×2), ♂362	39	♀290 (×3), ♀303, ♀320, ♀342 (×2), ♂**337** (×3)
15	♂285, ♂319	40	♂312
16	–	41	♀290 (×2)
17	♀286, ♀369	42	–
18	–	43	♀343 (×2), ♂304
19	♀358, ♂341,	44	♀**326**, ♂304, ♂373
20	–	45	♀**326**
21	♀286	46	♀321 (×3), ♂370
22	♀309	47	♂291
23	♀310	48	♀321, ♂291, ♂361
24	♂359	49	♂291, ♂**322**, ♂350
25	♂296	50	♀313, ♂**322**

Radio-tracking

Five females (Nos 301, 318, 326, 336 and 340, all of which except 318 were mature) and four males (Nos 284, 302, 322 and 337, all immature) were fitted with radio-collars in April and one female with pouch young (No. 400) in November. The trap sites at which each animal was captured, and the resting sites (cracks or holes) in which each was located are shown in Fig. 1*b*. The grassland habitat, and positions of the trap site and resting sites of one individual (♀340), can be seen in Fig. 2. The greatest distance between resting sites of individuals on consecutive days ranged from 31.7 m to 111.6 m (Table 1) and the area enclosed by trap and rest sites, a measure of the home range of individual animals over the period they were studied, from 139 m^2 to 3908 m^2 (Table 2). Five of the dunnarts radio-collared in April were sometimes visible in the holes or cracks where they were resting, at depths of 10–50 cm (♀318 at 10 and 50 cm, ♀340 at 32 cm, ♀336 at 41 cm, ♀326 at 15 cm and 33 cm, ♂322 at 33 cm).

None of the animals returned to the same below-ground daytime resting site while under study but two (♂337 and ♀400) returned, each one twice, to a trap. The sequence of the positions in which two individuals (♂322, ♀400) were found are shown in Fig. 3. Female 400, following release in the evening on both days that she was recaptured, was seen to enter holes at distances of 10 and 17 m respectively from the trap site.

Collars were retrieved from three individuals: ♀318, when found dead at its fourth resting site; ♂337, when trapped for the third time six days after initial capture; and ♀400, when it was recaptured, on the night following dismantling of the trap line in November, by setting five traps around the last resting site. The first two collars retrieved were transferred to other individuals. Collars were shed, but not found, by ♀301 and ♀336 in April, and one collar, possibly that of ♂332 (tracked in April) was found on the ground near Trap 49 in November.

Discussion

The results of this admittedly very short-term study suggest that Julia Creek dunnarts may be nomadic (by definition: leading a wandering life) within their home range, finding a place to shelter at the end of their night time foraging activity in any nearby crack or hole. None of the radio-collared dunnarts, including a female with young in the pouch, that were located on up to nine consecutive days in their daytime resting site was found to reuse the same site. This contrasts with the findings of Warnecke *et al.* (2012) for three other species of small dasyurid marsupials. In their short-term radio-tracking study (5–25 days) of the movement patterns of *Sminthopsis crassicaudata*, *Sminthopsis macroura* and *Planigale gilesi* in a semiarid environment they found some reuse of resting sites in soil cracks by individuals of *S. crassicaudata* and *P. gilesi*, and under bushes or in hollow logs by *S. macroura*. Haythornthwaite and Dickman (2006), in a radio-tracking study of *Sminthopsis youngsoni* in the dune fields of the Simpson Desert where the animals utilised scorpion and spider burrows as resting sites, found one individual in the same location over a period of three days.

The home range of the Julia Creek dunnarts, based on the location of both the sites at which they were trapped and rested over a maximum period of nine days, was smaller (536 m^2

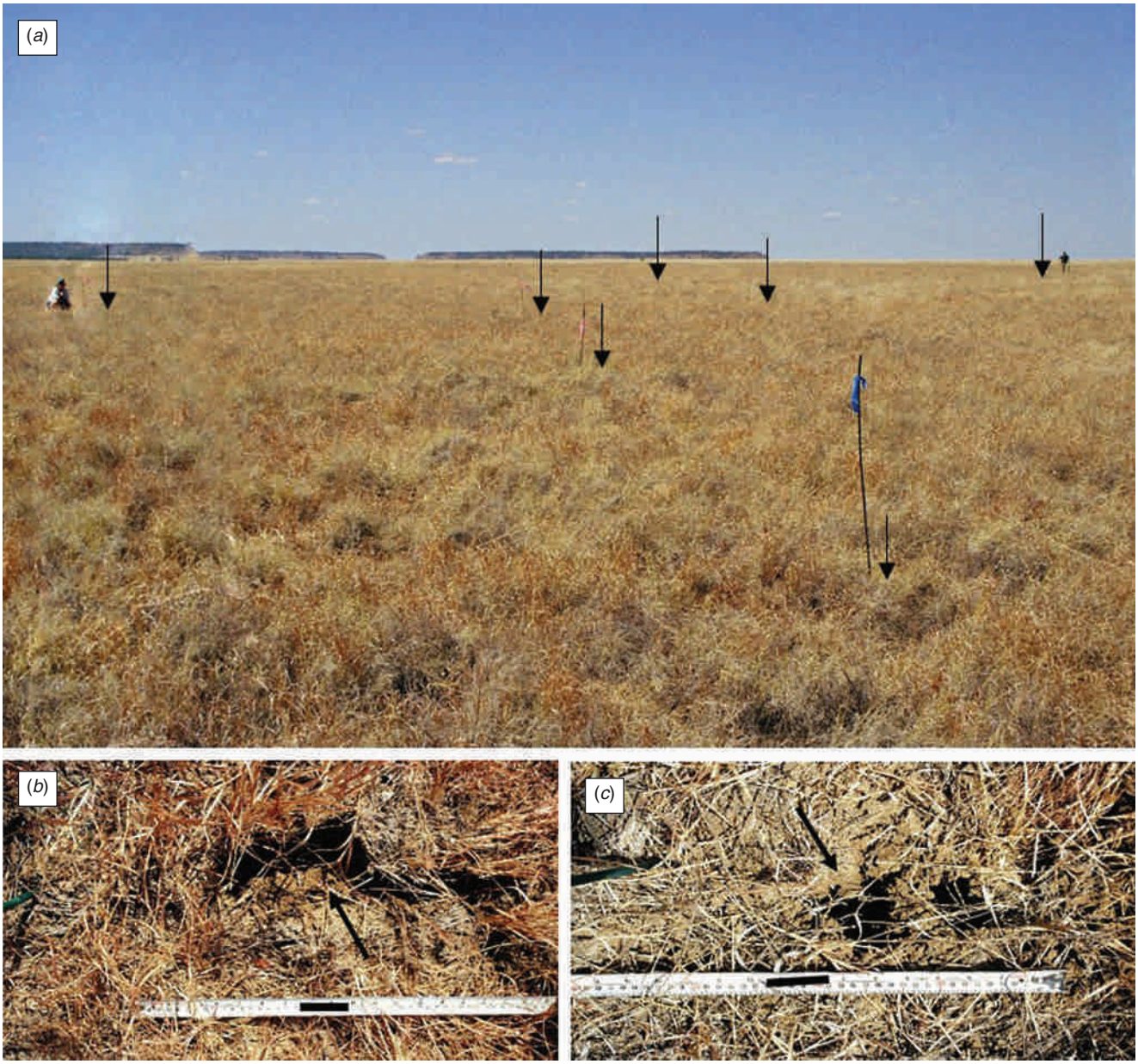

Fig. 2. (*a*) Habitat of the Julia Creek dunnart in Bladensburg National Park. The trap site (blue tape on pole) and resting sites (arrows beside poles) of one of the radio-tracked dunnarts (♀340). Photograph taken from most westerly resting site. (*b*) Crack (arrowed) at a resting site of ♀326. Scale bar 5 cm. (*c*) Hole (arrowed) at a resting site of ♂322. Scale bar 5 cm.

to 3908 m^2 = 0.0536 ha to 0.3908 ha) than that found in the longer-term trapping study by Mifsud (1999). He found the home range, based on 28 animals trapped three or more times (providing this did not occur within a single five-day trapping period) over periods ranging from 2 to 39 weeks varied from 0.5 ha to 8.0 ha. Two of the Julia Creek dunnarts returned to traps while fitted with radio-collars, presumably to obtain food, i.e. the bacon and peanut butter mixture used as bait that is known to be eaten by the dunnarts (see Woolley 2015). In the field study by Mifsud (1999) it was not unusual to find Julia Creek dunnarts returning to the same or different traps for five consecutive nights, sometimes repeated after an interval of one week, without any obvious deleterious effects in all except one case.

Dasyurid marsupials are known to build nests in underground burrows, e.g. two species of *Murexia* (as *Antechinus*) (*M. naso* and *M. habbema*: Woolley 1989), and *Dasycercus blythi* (as *D. cristicauda*) (Woolley 1990). Other species utilise tree hollows, rock overhangs or other protective structures and both males and females, not only when the latter have young, may build nests Croft (2003). No sign of nests was found in the present study in the cases of those males and females that could be seen in bare cracks and holes in April during the non-breeding period. The one

Table 2. Resting sites of tracked dunnarts
cs, collar shed; cr, collar removed

Dunnart no.	Date collar fitted	Trap no.	No. of resting sites[A]	Greatest distance between rest (or trap) sites on consecutive days (m)	Area enclosed by resting sites (m^2)
♂284	12 Apr. 2001	13	8	67.0 (Site 5 to Site 6)	1136
♀301	12 Apr. 2001	14	1[cs]	81.3 (Trap 14 to Site 1)	–
♂302	11 Apr. 2001	34	9	40.4 (Site 8 to Site 9)	819
♀318	12 Apr. 2001	4	4[B]	55 0 (Trap 4 to Site 1)	497
♂322	12 Apr. 2001	49	7	96.5 (Trap 49 to Site 1)	3908
♀326	13 Apr. 2001	44	7	61.4 (Trap 44 to Site 1)	536
♀336	11 Apr. 2001	35	7[cs]	56.7 (Site 2 to Site 3)	1642
♂337	11 Apr. 2001	39	4 (2)[cr]	31.7 (Site 4 to Site 5)	139
♀340	12 Apr. 2001	5	8	111.6 (Site 3 to Site 4)	2491
♀400	12 Nov. 2001	16.5	7 (2)[cr]	104.8 (Site 4 to Trap 17)	2808

[A]Numbers in parentheses indicate number of times trapped after initial capture and fitting of collar.
[B]Found dead at last resting site.

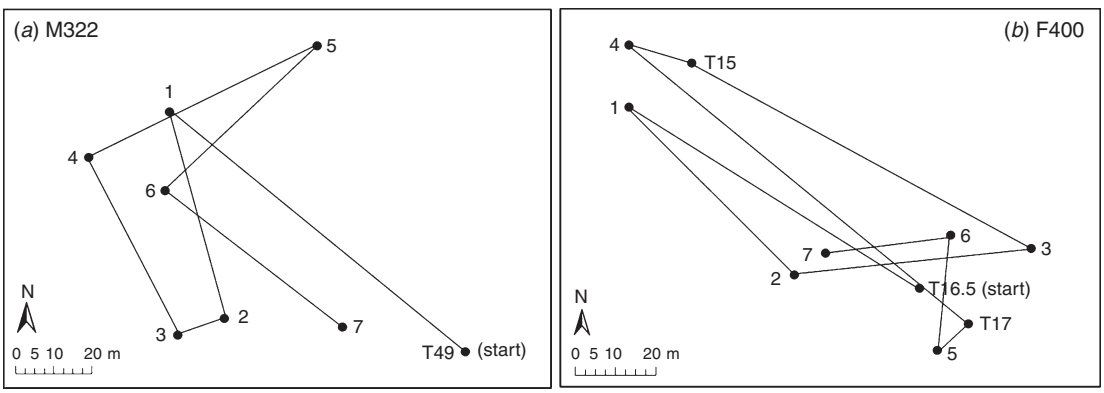

Fig. 3. Sequence of positions where (*a*) ♂322 and (*b*) ♀400 were trapped and located.

female trapped in November with small pouch young, not yet at the stage of development where they could relinquish the nipples (see Woolley *et al*. 2002), was never seen in her daytime resting sites. The fact that she did not reuse a site suggests that she did not have a permanent nest but there may have been sufficient plant debris where she was resting below ground level to form a temporary nest. Given that breeding occurs during the wet season, when cracks and holes may close up, females may continue to be nomadic and to utilise temporary nests, perhaps in vegetation, in which to leave young when they are able to relinquish the nipples while the mother is out foraging. Planned late wet season trapping and tracking of individuals to their diurnal resting sites in March 2002 could not be undertaken because the area was inaccessible as a result of heavy rain. Any future attempt to determine if females build nests that are reused, particularly when the young have reached the stage of development that allows the mother to forage unencumbered, should be carried out in an area carefully selected to ensure access throughout the wet season.

Trapping success was high in April 2001 (6.3%) and much greater than that found in any locality in previous studies (Woolley 2015). The possibility that the prevailing wet conditions in November were restricting the movements of animals led to the placement of additional traps on the line after the three days in which no animals were trapped. This did not result in the hoped-for increase in trapping success, which was much lower (0.1%) than in April. The population of dunnarts on the trap line appears to have declined between April (54 individuals captured) and November, when only one female was captured. It is evident that there was good recruitment to the population in 2001 as more than half the animals captured in April were immature (i.e. born in the 2000–01 season). The reasons for the decline are not obvious but much lower rainfall, as recorded by the Bureau of Meteorology for Bladensburg National Park over the months from February to October 2001 (149 mm compared with 413 mm for the same period in 2000), may have led to a reduction in the availability of their largely insect-based diet as vegetation dried out. A shortage of their natural food may have played a part in the high trapping success seen in April. Vegetation cover was not assessed but the dunnarts may also have been exposed to a greater risk of predation in the drier conditions prevailing in 2001. Further long-term study of populations of the Julia Creek dunnart are clearly required in relation to climatic and other factors that may be affecting their survival.

Acknowledgements

This study was carried out under scientific purposes permit W4/002646/01/SAA. It was greatly facilitated by Dr G. Lundie-Jenkins while the author was an Honorary Research Associate of the Queensland Parks and Wildlife Service and by V. Kiernan, Ranger in Charge, Bladensburg National Park.

Financial support was received from the Margaret Middleton Fund. G. Mifsud, R. Griffiths, L. Seabrook and B. Kingston are thanked for assistance in the field, J. Webb for assistance with ArcView and A. Haslem and S. Leonard for assistance in the preparation of figures.

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s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Wednesday, 19 February 2020 4:31 PM
To: s. 22(1)(a)(ii)
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]
Attachments: RPS Report.pdf

s. 47F(1)
Cover page RPS Report attached.

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Wednesday, 19 February 2020 10:38 AM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Thanks really appreciate that- look forward to discussing further this afternoon.

From: s. 47F(1) @latrobe.edu.au>
Sent: Wednesday, 19 February 2020 10:21 AM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

A quick answer – yes. s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 18 February 2020 5:26 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

A quick question, based on your surveys have you recorded the JCD in areas that have been grazed or have low density of Prickly Acacia?

Thanks
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 18 February 2020 3:45 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

3pm OK- s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 18 February 2020 2:40 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Thanks s. 47F(1)

Would 3pm be ok?

We are meeting with the proponent and their team including EPIC consultants, Trish O'Hara and Kayler Plant, tomorrow morning to discuss the project. So we should be able to provide you with an update.

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 18 February 2020 1:47 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

How about 2.30? My office number is 9479 2240. Some more reading matter attached. s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 18 February 2020 12:18 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

Thank so much for that-greatly appreciate.

Wednesday afternoon if fine for us, what time would work for you?

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 18 February 2020 11:43 AM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Dear s. 22(1)(a)(ii)
Thank you for sending the map and EIS. I have had a quick look through the EIS for information regarding the JCD and found little! The trapping effort appears to have been minimal – seems they put it in the 'too hard' basket. So far as I could see they did only 800 trap nights in the month of March and the trapping area was small. Please correct me if I am wrong. The site is well within the range of the species and with appropriate methods I feel sure that JCD's would be found. March may not be the best time of the year to detect them by trapping - numbers could be low after the wet season if any flooding occurred. There are more ways than trapping to determine the presence of mammals in an area e.g. collection of owl pellets , examination of scats and stomach contents of cats and foxes. Some years ago I advised RPS Australia East Pty Ltd about appropriate survey methods for the JCD for Mount Margaret Mining Pty Ltd and details can be found in:- RPS R71334 Report - Targeted Julia Creek Dunnart Survey of the E1 lease of the Mount Margaret Mine. My advice was based on my own extensive experience of locating the JCD and the results of work by Greg Mifsud, a student whose Masters Project I supervised.
My own effort in 1991-92 to locate specimens of a species considered extinct at the time was driven by the need to obtain adult male specimens for a study of penis morphology of all members of the genus Sminthopsis. A permit to collect 8 individuals was granted with the condition that I breed them in captivity before pursuing my specific interest!
Would this coming Wednesday afternoon suit you for a chat?
Cheers s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Friday, 14 February 2020 10:37 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Thanks so much s. 47F(1)

As discussed the draft EIS is publicly available and can be found here. The attached map shows the location of the project.

Please let me know when you are available to talk. It would be good to hear you thoughts about adequate survey methodology, and ask a few questions regarding the species habitat and behaviour.

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Friday, 14 February 2020 3:29 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 22(1)(a)(ii) some reading matter attached, more to follow! A recent locality record can be added to the map in Mifsud and Woolley at -20.0840ºS , 141.2201ºE .
In haste, s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Wednesday, 12 February 2020 4:26 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

Thanks so much, would it be possible to set up a time to have a teleconference to discuss the Julia Creek Dunnart.

As noted previously we are currently assessing a project that is likely to have potential impact on the Julia Creek Dunnart. I have provided a bit of a background on the project below:

- The proposal is for a vanadium mine within the Mitchell Grass Downs bioregion in Queensland, which is dominated by Mitchell Grass (Astrebla spp.) tussock grasslands on rolling plains (downs). The soils are predominantly deep, heavy clays (see below for more info on geology and soils). The plains are interspersed with drainage lines, supporting open grasslands, herblands or eucalypt woodlands and isolated remnant plateaus.
- The Julia Creek Dunnart was not recorded during the ecological surveys undertaken by the proponent.
- The proposed mining will be undertaken as sequential strip mining across an area of 7,435 ha. Mining depth will vary between 1 m and 40 m below ground level (average 20 m).
- The strip mining method generally involves clearing vegetation, stripping topsoil, removing overburden and then excavation. The overburden will be placed to the side of the working face and is able to be profiled to final landform. The surface will be prepared for vegetating as soon as each area of mined land becomes available for rehabilitation.

Please let me know when would be the best time to chat.

Cheers

From: s. 47F(1) @latrobe.edu.au>
Sent: Wednesday, 12 February 2020 2:37 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 22(1)(a)(ii)
How can I help?
s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 11 February 2020 8:59 AM
To: s. 47F(1) @latrobe.edu.au>
Subject: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

I work in the Environmental Approval Branch in the Department of Agriculture, Water and the Environment. I'm currently working on a project that may impact on the Julia Creek Dunnart and understand that you have knowledge of this species. I'm seeking to gain a better understanding of the Julia creek Dunnart, it distribution and habitat requirement..

Appreciate it if you could spare the time to discuss the species and potential impacts of the project.

Regards
s. 22(1)(a)(ii)

Assistant Director
Assessments and Governance Branch
Department of Agriculture, Water and the Environment
P: s. 22(1)(a)(ii)
E: @environment.gov.au

RPS

R71334

Report - Targeted Julia Creek Dunnart Survey of the EI Lease of the Mount Margaret Mine

Prepared by:

RPS AUSTRALIA EAST PTY LTD

135 Abbott St
4870

T: s. 47F(1)
F:
E: s. 47F(1) @rpsgroup.com.au

Client Manager: s. 47F(1)
Report Number: Pr112098-2
Version / Date: Version 1-20/09/2012

Prepared for:

MOUNT MARGARET MINING PTY LTD

New Zingari Road
CLONCURRY QLD 4824

s. 22(1)(a)(ii)

From: s. 22(1)(a)(ii)
Sent: Wednesday, 19 February 2020 10:38 AM
To: s. 47F(1)
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Thanks really appreciate that- look forward to discussing further this afternoon.

From: s. 47F(1)
Sent: Wednesday, 19 February 2020 10:21 AM
To: s. 22(1)(a)(ii)
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

A quick answer – yes. s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 18 February 2020 5:26 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

A quick question, based on your surveys have you recorded the JCD in areas that have been grazed or have low density of Prickly Acacia?

Thanks
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 18 February 2020 3:45 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

s. 47F(1)
3pm OK-

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 18 February 2020 2:40 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Thanks s. 47F(1)

Would 3pm be ok?

We are meeting with the proponent and their team including EPIC consultants, Trish O'Hara and Kayler Plant, tomorrow morning to discuss the project. So we should be able to provide you with an update.

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 18 February 2020 1:47 PM

To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

How about 2.30? My office number is 9479 2240. Some more reading matter attached. s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 18 February 2020 12:18 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

Thank so much for that-greatly appreciate.

Wednesday afternoon if fine for us, what time would work for you?

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 18 February 2020 11:43 AM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Dears. 22(1)(a)(ii)
Thank you for sending the map and EIS. I have had a quick look through the EIS for information regarding the JCD and found little! The trapping effort appears to have been minimal – seems they put it in the 'too hard' basket. So far as I could see they did only 800 trap nights in the month of March and the trapping area was small. Please correct me if I am wrong. The site is well within the range of the species and with appropriate methods I feel sure that JCD's would be found. March may not be the best time of the year to detect them by trapping - numbers could be low after the wet season if any flooding occurred. There are more ways than trapping to determine the presence of mammals in an area e.g. collection of owl pellets , examination of scats and stomach contents of cats and foxes. Some years ago I advised RPS Australia East Pty Ltd about appropriate survey methods for the JCD for Mount Margaret Mining Pty Ltd and details can be found in:- RPS R71334 Report - Targeted Julia Creek Dunnart Survey of the E1 lease of the Mount Margaret Mine. My advice was based on my own extensive experience of locating the JCD and the results of work by Greg Mifsud, a student whose Masters Project I supervised.
My own effort in 1991-92 to locate specimens of a species considered extinct at the time was driven by the need to obtain adult male specimens for a study of penis morphology of all members of the genus Sminthopsis. A permit to collect 8 individuals was granted with the condition that I breed them in captivity before pursuing my specific interest!
Would this coming Wednesday afternoon suit you for a chat?
Cheers,s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Friday, 14 February 2020 10:37 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Thanks so much s. 47F(1)

As discussed the draft EIS is publicly available and can be found here. The attached map shows the location of the project.

Please let me know when you are available to talk. It would be good to hear you thoughts about adequate survey methodology, and ask a few questions regarding the species habitat and behaviour.

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Friday, 14 February 2020 3:29 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 22(1)(a)(ii) some reading matter attached, more to follow! A recent locality record can be added to the map in Mifsud and Woolley at -20.0840ºS , 141.2201ºE .
In haste, s. 47F (1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Wednesday, 12 February 2020 4:26 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

Thanks so much, would it be possible to set up a time to have a teleconference to discuss the Julia Creek Dunnart.

As noted previously we are currently assessing a project that is likely to have potential impact on the Julia Creek Dunnart. I have provided a bit of a background on the project below:

- The proposal is for a vanadium mine within the Mitchell Grass Downs bioregion in Queensland, which is dominated by Mitchell Grass (Astrebla spp.) tussock grasslands on rolling plains (downs). The soils are predominantly deep, heavy clays (see below for more info on geology and soils). The plains are interspersed with drainage lines, supporting open grasslands, herblands or eucalypt woodlands and isolated remnant plateaus.
- The Julia Creek Dunnart was not recorded during the ecological surveys undertaken by the proponent.
- The proposed mining will be undertaken as sequential strip mining across an area of 7,435 ha. Mining depth will vary between 1 m and 40 m below ground level (average 20 m).
- The strip mining method generally involves clearing vegetation, stripping topsoil, removing overburden and then excavation. The overburden will be placed to the side of the working face and is able to be profiled to final landform. The surface will be prepared for vegetating as soon as each area of mined land becomes available for rehabilitation.

Please let me know when would be the best time to chat.

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Wednesday, 12 February 2020 2:37 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 22(1)(a)(ii)

How can I help?
s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 11 February 2020 8:59 AM
To: s. 47F(1) @latrobe.edu.au>
Subject: Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

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Appreciate it if you could spare the time to discuss the species and potential impacts of the project.

Regards
s. 22(1)(a)(ii)

Assistant Director
Assessments and Governance Branch
Department of Agriculture, Water and the Environment
P: s. 22(1)(a)(ii)
E: @environment.gov.au

s. 22(1)(a)(ii)

From: s. 22(1)(a)(ii)
Sent: Tuesday, 12 May 2020 5:16 PM
To: s. 47F(1)
Subject: RE: St Elmos project- Julia Creek Dunnart [SEC=UNOFFICIAL]

Thanks so much.

Would it be useful if we set up a time to discuss as we use the Department teleconference numbers.

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1)
Sent: Tuesday, 12 May 2020 4:56 PM
To: s. 22(1)(a)(ii)
Subject: RE: St Elmos project- Julia Creek Dunnart [SEC=UNOFFICIAL]

I shall wait to hear further from you - s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Monday, 11 May 2020 4:59 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: St Elmos project- Julia Creek Dunnart [SEC=UNOFFICIAL]

Thanks s. 47F(1)

I'm keeping well thank you. I hope you and your friends and family are safe and well.

It might be best to discuss the details of the review over the phone. Basically what I think we are seeking is an expert of the Dunnart to review the information provided (including survey effort, description of habitat, impacts of the proposal on the Julia Creek Dunnart, effectiveness of the proposed mitigation measures and the offset strategy). We can work on the actually scope.

At this stage the final EIS is due at the end of June. We can discussing timing once we have a better indication of the scope.

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Monday, 11 May 2020 4:21 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: St Elmos project- Julia Creek Dunnart [SEC=UNOFFICIAL]

Dear s. 22(1)(a)(ii)
My apologies for the delayed response. I am working from home and have not had an internet connection until a few days ago.
I have never done a review of an EIS and have no idea of what is involved. Can you perhaps elaborate? Would there be other reviewers? What would be the time-frame?
I trust you are keeping well in these difficult days.
s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Friday, 1 May 2020 2:30 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: St Elmos project- Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

I hope you are well. As previously discussed we are currently in the process of assessing the Multicom Resources proposed St Elmo's Vanadium mine near Julia Creek. As you know the project has the potential to impact on the Julia Creek Dunnart. The proponent is currently finalising the Environmental Impact Statement and proposed offset strategy.

I was wondering if you would be open to undertaking a formal review of the Environmental Impact Statement and proposed offset strategy. If you are interested, I'll move to contact our procurement team to work out how this can be done.

Thanks
s. 22(1)(a)(ii)

Assistant Director
Assessments and Governance Branch
Department of Agriculture, Water and the Environment
P: s. 22(1)(a)(ii)
E: @awe.gov.au

s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Friday, 15 May 2020 8:47 PM
To: s. 22(1)(a)(ii)
Subject: RE: St Elmos project- Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 22(1)(a)(ii)
I was supposed to get back to you! Apolgies. I will be home (? where else) on Monday and my phone number is s. 47F(1)
s. 47F(1)

s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Friday, 15 May 2020 6:01 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: St Elmos project- Julia Creek Dunnart [SEC=UNOFFICIAL]

Hi s. 47F(1)

So sorry I have taken so long to get back to you. Are you free on Monday to chat about the project.

I'm going over the assessment now- trying to answer a couple of questions which you may be able to help me with. I was also thinking they may be the best way to structure a review -eg we can ask a serious of questions(but only if it will help you).

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 12 May 2020 4:56 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: St Elmos project- Julia Creek Dunnart [SEC=UNOFFICIAL]

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I was wondering if you would be open to undertaking a formal review of the Environmental Impact Statement and proposed offset strategy. If you are interested, I'll move to contact our procurement team to work out how this can be done.

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s. 22(1)(a)(ii)

Assistant Director
Assessments and Governance Branch
Department of Agriculture, Water and the Environment
P:s. 22(1)(a)(ii)
E: @awe,gov.au

s. 22(1)(a)(ii)

From: s. 22(1)(a)(ii)
Sent: Thursday, 30 July 2020 11:28 AM
To: s. 47F(1)
Subject: RE: St Elmos project [SEC=UNOFFICIAL]
Attachments: 2017-8007 - Offset Strategy - June 2020 - extracts.pdf

s. 47F(1)
Hi

I have taken out some of the key sections of the proponents proposed offset strategy and placed in a new document (see attached) for your information.

Please note table 2 sets out the proposed offset. There's a lot of information in this table most is repetition. The most important column is the first as it set out the offset item. The last column and column 2 are also key as they describe the conservation gain for that offset item (column 2) and provide how the conservation gain be measured (last column).

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Wednesday, 29 July 2020 3:37 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: St Elmos project [SEC=UNOFFICIAL]

I had better do my homework. With the passage of time since we last talked my attention has been on other things and whatever brilliant thoughts I may have had do not readily spring to mind! Talk tomorrow.s. 47F(1)

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Thanks s. 47F(1)

4pm tomorrow sounds good.

I noted previously you mentioned you had ideas of a what should be done if the project is approved, so I just wanted to know what the ideas are and also ask a few questions.

Please call the toll-free dial-in number: s. 22(1)(a)(ii)

Then enter the passcode followed by the # key:

Guest Passcode: s. 47F(1)

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
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Sent: Wednesday, 29 July 2020 1:14 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: RE: St Elmos project [SEC=UNOFFICIAL]

Thank so much would tomorrow at 4pm be ok?

I can send you our teleconference details.

Cheers
s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Wednesday, 29 July 2020 12:49 PM
To: s. 22(1)(a)(ii) @awe.gov.au>
Subject: RE: St Elmos project [SEC=UNOFFICIAL]

Hi s. 22(1)(a)(ii) Sorry for slow response. When would you like to talk ? Afternoons this week would be best for me. s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Tuesday, 28 July 2020 5:52 PM
To: s. 47F(1) @latrobe.edu.au>
Subject: St Elmos project [SEC=UNOFFICIAL]

Hi s. 47F(1)

I hope you are safe and well. Just wondering if you would have some time to discuss the Julia Creek Dunnart and the St Elmos Vanadium mining project. We are having a work shop with the proponent next week and I would like to, if possible, get your ideas on what they are proposing, and what should be done.

Regards
s. 22(1)(a)(ii)

Assistant Director
Assessments and Support Branch
Department of Agriculture, Water and the Environment
P: s. 22(1)(a)(ii)
E: @awe.gov.au

s47G(1)(a), s47G(1)(b)

s47G(1)(a), s47G(1)(b)

s47G(1)(a), s47G(1)(b)

s47G(1)(a), s47G(1)(b)

[redacted]
s47G(1)(a), s47G(1)(b)

s47G(1)(a), s47G(1)(b)

s47G(1)(a), s47G(1)(b)

s47G(1)(a), s47G(1)(b)

s47G(1)(a), s47G(1)(b)

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[redacted]
s47G(1)(a), s47G(1)(b)

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s47G(1)(a), s47G(1)(b)

s47G(1)(a), s47G(1)(b)

s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Wednesday, 5 August 2020 9:27 AM
To: s. 22(1)(a)(ii)
Subject: RE: St Elmos project [SEC=UNOFFICIAL]
Attachments: Dunnarts Woolley Poster.pdf

Dear s. 22(1)(a)(ii)
Please see attached. This may help you to understand some of the research that has been done on the JCD. It is a poster that I prepared for the 50th Anniversary Open Day at Toorak Research Station on 29 August 2000. Not much has happened since - I think you have all my publications but I will put a list together and send later today. (There has been a very small range extension and the work at Bladensburg).
The poster was prepared on four separate sheets and it has been on the wall in my office ever since as a ready reminder. I am not able to access my office but luckily the lab manager (who has to attend for various reasons) has the skills to photograph the large individual sheets and put them together into one.
I hope this overview is useful.
Best wishes, s. 47F(1)

From: s. 22(1)(a)(ii) @awe.gov.au>
Sent: Thursday, 30 July 2020 11:28 AM
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Regards
s. 22(1)(a)(ii)

Assistant Director
Assessments and Support Branch

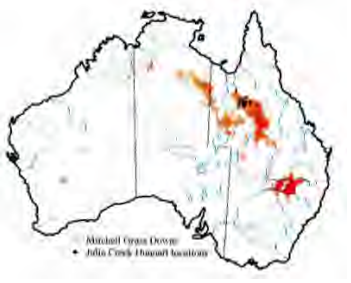
Department of Agriculture, Water and the Environment
P: s. 22(1)(a)(ii)
E: @awe.gov.au

Research on the Endangered Julia Creek Dunnart

Dr Patricia A. Woolley & Greg Mifsud

DISTRIBUTION

The Julia Creek Dunnart has a very restricted distribution on the Mitchell Grass Downs of north-western Queensland. Because of the small area in which it is known to occur it has been classified as an endangered species. Further survey work may reveal that it is more widely distributed than studies over the past ten years have indicated .



The Julia Creek Dunnart is one member of a community of five small mammals (three marsupials and two rodents) known to occur on the Mitchell Grass Downs. All except the Julia Creek Dunnart are widely distributed and can be found in a variety of habitats.

Julia Creek Dunnart
Sminthopsis douglasi

Stripe-faced Dunnart
Sminthopsis macroura

Long-tailed Planigale
Planigale ingrami

Long-haired Rat
Rattus villosissimus

Forrest's Mouse
Leggadina forresti

HABITAT

The Mitchell Grass Downs are characterized by undulating grasslands dominated by tussocks of perennial Mitchell grasses, with both perennial and annual grasses and forbs growing between the tussocks. In some areas Flinders Grass, an annual, is very abundant. The clay soils of the Downs crack deeply when dry but the cracks close up when the soil swells after rain. Seasonal changes are seen in the number of cracks, and in the cover provided by the vegetation. These changes were monitored at fixed sampling sites at intervals throughout the year.

Mitchell Grass dominant
April 1996

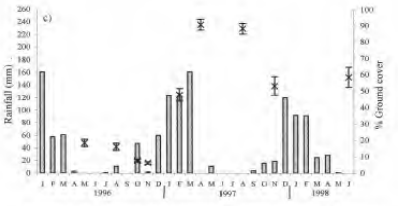
Flinders Grass dominant
November 1996

Mitchell Grass dominant
March 1997

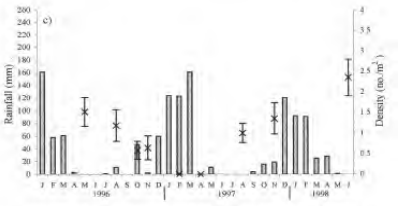
Flinders Grass dominant
April 1997

Site 4 October 1998

Site 4 March 1999

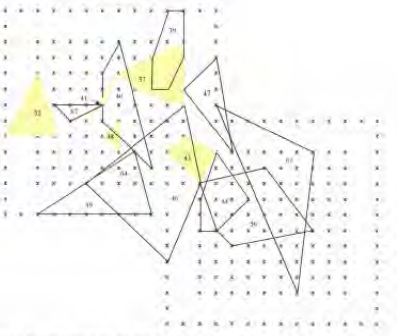


Projected ground cover (X) in relation to monthly rainfall (solid bars)



Density of cracks (X) in relation to monthly rainfall (solid bars)

Populations of Julia Creek Dunnarts have been hard to find and the effort required to trap them great. Over the past five years only 235 individuals have been trapped in 100,000 trap-nights. Long term studies on permanently marked trapping grids have provided information on various aspects of the ecology of the Julia Creek Dunnart. They appear to favour areas of high crack density and dense ground cover, especially that provided by Flinders Grass. Marked individuals captured on more than one occasion have been found to move up to 150 m overnight, and to have home ranges varying in size from 0.25 ha to 7.125 ha. Males generally are more mobile, and have larger home ranges, than females.



The home range of animals captured in 1997 on the permanently marked trapping grids. Home ranges of females are shown in yellow and those of males are outlined.

LIFE HISTORY

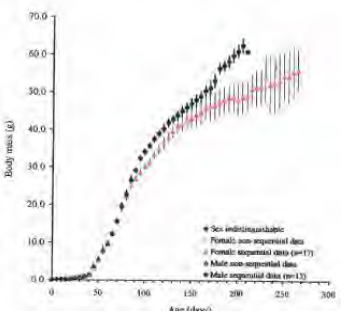
Wild-caught Julia Creek Dunnart with eight pouch young estimated to be 35 days old

The breeding season (the season when mating occurs) extends from September to February in the wild. This has been established by trapping at intervals throughout the year in an area where a population of Julia Creek Dunnarts has persisted over the past five years.

In captivity Julia Creek Dunnarts can breed throughout the year, perhaps because the environmental conditions under which they are maintained are less extreme than in the wild, and food supplies are always abundant.

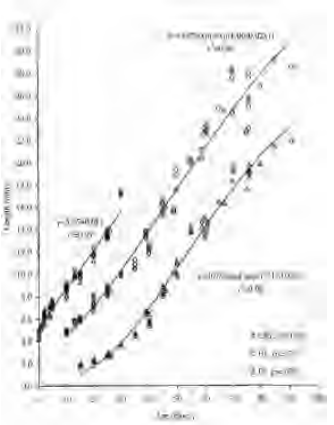
Pat Woolley in the animal room at La Trobe University

Julia Creek Dunnarts have been bred at La Trobe University over the past ten years, and a large body of information prolonged affair, lasting for up to four hours. The young are born about 13 days later and are smaller than a grain of rice. There are eight nipples in the pouch and this determines the maximum number of young that can be suckled, because each young is permanently attached to a nipple for the first 40 days of life. By then they have a light covering of hair and the combined weight of a litter of eight is nearly equal to the weight of the mother. The mother may then leave the young in a nest when she goes out to hunt. The eyes of the young open at about 50 days of age and at 60-65 days they may ride on the mother's back. They start to eat solid food at 65-70 days and are weaned soon after. Males grow to a larger size than females.



Females mature more rapidly than males and, in the wild, may be able to breed in the season in which they are born. Females have the potential to produce two litters in a breeding season, and they may breed in two or more years.

By weighing and measuring known-age captive-bred young growth curves can be prepared and the age (and date of birth) of wild-caught young estimated.



Newborn young

Mother with 65 day old young

THREATS TO SURVIVAL

Julia Creek Dunnarts are adapted for life in seasonally arid grasslands. They require cracks in the ground for shelter and, when the cracks close up during the wet season, good ground cover for protection from both natural and introduced predators. Dunnarts feed on insects, spiders, centipedes and scorpions (as determined by analysis of remains in scats) that in turn are dependent on the vegetation.

Methods for sampling the invertebrate fauna

Flight intercept trap

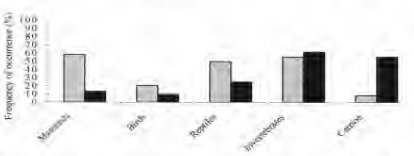
Sticky trap

THREATENING PROCESSES

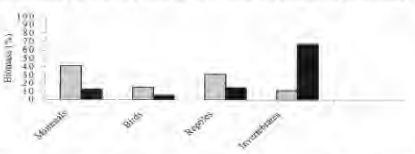
Grazing
Sheep and cattle reduce the amount of ground cover and cause compaction of the soil. Our studies to date suggest that moderate stocking rates do not affect Julia Creek Dunnart numbers.

Fire
Crack dwelling Julia Creek Dunnarts (and other small mammals) may survive fire but their food supplies may be affected by the loss of vegetation.

Cats and foxes
These introduced predators prey on a wide variety of wildlife and both cats and foxes are common throughout the range of the Julia Creek Dunnart.



The frequency of each prey group in the stomachs of cats (grey) & foxes (black)



The biomass of each prey group in the stomachs of cats (grey) & foxes (black)

Control of introduced predators
Foxes can be controlled more readily than cats by the use of poison baits that can be distributed over a wide area by aerial drops. Such baiting poses a threat to working dogs and non-target species. Controlled baiting methods using bait stations for the delivery of baits in selected areas, together with the use of baits that are especially attractive to cats, are being tested on Toorak Research Station.

Flooding
If flooding occurs at a time when young are being left in the nest mortality could result. The ability of the Julia Creek Dunnart to breed twice in a season may be an 'insurance policy' against such an event.

Invasion by woody weeds
Weeds such as Prickly Acacia cause loss of grass cover and soil degradation. They also provide refuge areas for feral cats and foxes.

Dietary studies of cats and foxes.
Over a two and a half year period 199 cats and 57 foxes were shot and their stomachs examined. Feral cats preyed upon 32 species of vertebrates, including mammals, birds and reptiles, and 4 groups of invertebrates. All five species of mammals occurring in the area were preyed upon, and the remains of up to 11 planigales, or 7 rats were found in a single cat stomach. The stomachs of 11 cats contained the remains of 18 Julia Creek Dunnarts. Small amounts of carrion were found in the stomachs of 16 cats collected mainly during the colder months.

Foxes preyed upon 9 species of vertebrates as well as invertebrates and carrion. Carrion formed a much larger component of the diet of foxes than it did for cats. No Julia Creek Dunnarts were found in the stomachs of the foxes in this sample but they have been found since.

Feral cats tend to hunt rather than scavenge and they prey on a wider range of species than do foxes. Their impact on native fauna is profound. We have estimated that one cat will consume 45 kg of native animals per year.

s. 22(1)(a)(ii)

From: s. 47F(1) @latrobe.edu.au>
Sent: Wednesday, 5 August 2020 9:39 AM
To: s. 22(1)(a)(ii)
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s. 47F(1)
Hi

He is going to get back to me with his thesis.

Very happy to pass on your comments.

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Sent: Tuesday, 11 August 2020 5:00 PM
To: s. 22(1)(a)(ii)
Subject: FW: cost of surveys [SEC=UNOFFICIAL]
Attachments: Sminthopsis douglasi.docx

Follow Up Flag: Follow up
Flag Status: Flagged

FYI

From: s. 47F(1) @latrobe.edu.au>
Sent: Tuesday, 11 August 2020 1:06 PM
To: s. 22(1)(a)(ii) @environment.gov.au>
Subject: RE: cost of surveys [SEC=UNOFFICIAL]

Dears. 22(1)(a)(ii)
Apologies for my delayed response. As a retired academic I am not in a position to be able to provide actual costing, especially at this time when all the usual office services are disrupted.
Basically all I can do is provide recommendations for what I think needs to be done. Current knowledge of the Julia Creek Dunnart (*Sminthopsis douglasi*) population is based on work carried out 20-30 years ago, largely by myself and three students. The species was thought to be extinct until I went in search of them to fill a gap in knowledge regarding anatomy of the penis in all 19 species of the genus Sminthopsis. I guess I was lucky in that the methods I used were successful. I was not given a permit to kill a male to obtain this information until I had demonstrated that they could be bred in captivity. Work that followed from this included studies on the development of the pouch young, predation by owls, cats and foxes, diet of the dunnarts in the field and habitat requirements. I have been extremely disappointed by the lack of commitment by the students to fully publish their results. I attach a list of all publications that have come out this work to date (those likely to be of most interest to you in bold type.)

We have no virtually no information on where the dunnarts can be found at the present time. To the best of my knowledge there has been only one recent record, in the northern part of the established range. The recent floods are likely to have had an effect on populations. It might be that survey work carried out by trapping at the present time would suggest that the species is again 'extinct'. Trapping alone is not the answer to the problem, because trapping success is very low.

Indirect methods of survey such as collection and analysis of owl pellets and public awareness campaigns (such as the one I carried out in which information was sought by a mail out to all ratepayers in the McKinlay Shire) are required. It seems to me that what is needed now is more or less a repeat of the work done earlier. This would require salaries and running costs for the research to be carried out over a number of years to establish if and where dunnarts can be found at the present time.

Their previous occurrence in National Parks does not necessarily mean that they can still be found there. Additionally, the extent of their occurrence in National Parks (I.e. Bladensburg) has not been fully investigated and it should not be assumed that suitable habitat occurs throughout the Park.

In my experience suitable habitat is very limited in Moorinya NP, which is on the eastern edge of the known range of the species. Limited extent of suitable habitat most probably accounts for the paucity of records obtained there in the course of survey work which, as I understand, was carried out on annual student field trips over a small number of years.

My lack of familiarity with the proposed mining site makes it difficult for me to assess the likelihood of it being suitable habitat for the Julia Creek Dunnart.

I wish I could be more helpful. As I see it the interests of government in mining projects and the economy will outweigh any consideration for the environment. I can only reflect upon my success many years ago in preventing the sale of a property in Western Australia, that was likely habitat for an endangered species, until a comprehensive survey had been carried out.
Regards, s. 47F(1)

Sminthopsis douglasi - Publications from research at La Trobe University

Woolley, P. A. (1992). New records of the Julia Creek Dunnart, *Sminthopsis douglasi* (Marsupialia: Dasyuridae). *Wildlife Research* 19, 779-783.

Mortola, J. P., Frappell, P. B., and Woolley, P. A. (1999). Breathing through skin in a newborn mammal. *Nature* **397**, 660.

Krajewski, C., Woolley, P. A., and Westerman, M. (2000). The evolution of reproductive strategies in dasyurid marsupials: implications of molecular phylogeny. *Biological Journal of the Linnean Society* **71**, 417-435.

Spencer, P. B. S., Fletcher, T. P., and Woolley, P. A. (2003). Microsatellite markers from the Julia Creek dunnart *Sminthopsis douglasi* (Marsupialia: Dasyuridae). *Molecular Ecology Notes* **3**, 570-571.

Hume, L D., Smith, C., and Woolley, P. A. (2000). Anatomy and physiology of the gastrointestinal tract of the Julia Creek dunnart, *Sminthopsis douglasi* (Marsupialia: Dasyuridae). *Australian Journal of Zoology* **48**, 475-485.

Woolley, P. A., Patterson, M. P., Stephenson, G. M., and Stephenson, D. G. (2002). The ilio-marsupialis muscle in the dasyurid marsupial *Sminthopsis douglasi:* form, function and fibre-type profiles in females with and without suckling young. *The Journal of Experimental Biology* **205**, 3775-3781.

Woolley, P. A., Guedelha, N., and Graves, J. A. M. (2003). Anatomy and chromosomes of two intersexual dasyurid marsupials. *Reproduction, Fertility and Development* **15**, 293-301.

Woolley P. A, Westerman, M. and Krajewski, C. (2007). Interspecific affinities within the genus *Sminthopsis* (Dasyuromorphia: Dasyuridae) based on morphology of the penis: congruence with other anatomical and molecular data. *Journal of Mammalogy* **88**, 1381-1392.

Woolley, P. A. (2008). Julia Creek Dunnart, *Sminthopsis douglasi.* pp 136-137. In '*The Mammals of Australia'* (Eds S. Van Dyck and R. Strahan.) (New Holland Publishers: Australia.)

Woolley, P. A. (2010). The Julia Creek dunnart and other prey of the barn owl in Mitchell grass downs of north-western Queensland. *Memoirs of the Queensland Museum* 55, 107-117.

Mifsud, G., and Woolley, P. A. (2012). Predation of the Julia Creek dunnart, *Sminthopsis douglasi*, and other native fauna by cats and foxes on the Mitchell grass downs in Queensland. *Australian Mammalogy* 34, 188-195.

Woolley, P. A. (2015). The Julia Creek dunnart *Sminthopsis douglasi* (Marsupialia: Dasyuridae): breeding of a threatened species in captivity and in wild populations. *Australian Journal of Zoology* 63, 411-423.

Woolley, P. A. and Tyndale-Biscoe, C. H. (2017). Side-tracked: unique evidence for passage of foetus through the lateral vaginal canals in a dasyurid marsupial, *Sminthopsis douglasi*. *Australian Mammalogy* **39**, 115-117.

Woolley, P. A. (2017). Diurnal resting sites of the nocturnal dasyurid marsupial *Sminthopsis douglasi* in Bladensburg National Park, Queensland. *Australian Mammalogy* 39, 121-126