Dirk Hartog Island National Park Ecological Restoration Project:

Stage Two – Year Three

Translocation and Monitoring Report

Saul Cowen, Kelly Rayner and Colleen Sims

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Department of Biodiversity, Conservation and Attractions
GOVERNMENT OF WESTERN AUSTRALIA

Department of Biodiversity, Conservation and Attractions
Locked Bag 104
Bentley Delivery Centre WA 6983
Phone: (08) 9219 9000
Fax: (08) 9334 0498

www.dbca.wa.gov.au

This report/document/publication was prepared by Saul Cowen, Kelly Rayner and Colleen Sims.

Questions regarding the use of this material should be directed to:
Research Scientist – DHINPERP Fauna Reconstruction
Biodiversity and Conservation Science
Department of Biodiversity, Conservation and Attractions
Locked Bag 104
Bentley Delivery Centre WA 6983
Phone: 08 9405 5119
Email: saul.cowen@dbca.wa.gov.au

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Front page image: Female dibbler (*Parantechinus apicalis*) (© J. McDonnell/DBCA)

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Appendix 7 Sims, C., K. Rayner, F. Knox and S. Cowen (2020). A trial of transmitter attachment methods for Shark Bay bandicoots (*Perameles bougainville*). Australian Mammalogy. https://doi.org/10.1071/AM20035

Appendix 8 Cowen, S. and C. Sims (2021). Conservation translocation of banded and Shark Bay rufous hare-wallaby to Dirk Hartog Island, Western Australia. Global conservation translocation perspectives: 2021. Case studies from around the globe. P. S. Soorae. Gland, Switzerland: IUCN SSC Conservation Translocation Specialist Group, Environment Agency - Abu Dhabi and Calgary Zoo, Canada. https://iucn-ctsg.org/project/global-conservation-translocation-perspectives-2021/

Appendix 9 Vaughan-Higgins, R. J., S. D. Vitali, C. Sims, M. Page and A. Reiss (2021). Streamlining Disease Risk Analysis for Wildlife Using the Shark Bay Bandicoot as a Model. Ecohealth. https://doi.org/10.1007/s10393-021-01521-3

Appendix 10 Peterson K., M. Barnes, C. Jeynes-Smith, S. Cowen S, L. Gibson, C. Sims, C. Baker and M. Bode (2021). Reconstructing lost ecosystems: a risk analysis framework for planning multispecies reintroductions under severe uncertainty. Journal of Applied Ecology. https://doi.org/10.1111/1365-2664.13965

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Summary

Following on from translocations of Shark Bay bandicoots (*Perameles bougainville*) and dibblers (*Parantechinus apicalis*) in 2019, further releases of these species went ahead in spring 2020. In addition, the first translocations of Shark Bay mice (*Pseudomys fieldi*) and greater stick-nest rats (*Leporillus conditor*) took place in April and May 2021 respectively, bringing the number of mammal species released on Dirk Hartog Island since 2017 to six.

These translocations were closely monitored to evaluate their outcomes against the short- and medium-term success criteria stated in the approved Translocation Proposals. In addition, monitoring was undertaken for the translocated populations of rufous hare-wallaby (*Lagorchestes hirsutus*) and banded hare-wallaby (*Lagostrophus fasciatus*) on Dirk Hartog Island.

Here we present the results of the translocations and subsequent monitoring undertaken between July 2020 and June 2021 on Dirk Hartog Island. We also report on the ongoing monitoring of extant reptiles and mammals on the island.

1 Background

The vision for the ecological restoration of Dirk Hartog Island National Park (DHI) is ‘to create a special place with healthy vegetation and ecosystem processes that support the full suite of terrestrial native mammal species that occurred there at the time of Dirk Hartog’s landing in 1616, and that this is highly valued and appreciated by the community’. By June 2020, the ecological restoration project had achieved eradications of sheep (*Ovis aries*), goats (*Capra hircus*) and feral cats (*Felis catus*) and translocations of four mammal species had been completed or commenced. A strategic framework for the reconstruction of the former fauna assemblage on DHI has been prepared (Morris *et al.* 2017) and outlines a further nine species to be translocated to the island.

Between September 2020 and May 2021, additional translocations were undertaken for two species (Shark Bay bandicoot and dibbler) as well as the first releases of Shark Bay mouse and greater stick-nest rat. Monitoring is ongoing for all these species, as well as for small reptiles and mammal species that were extant before the commencement of DHINPERP.

1.1 Site Description

Dirk Hartog Island is located in the Shire of Shark Bay in Western Australia (WA) at approximately -26° S and 113° E, and forms part of the Shark Bay UNESCO World Heritage Area. It falls within the DBCA Parks and Wildlife Service’s Gascoyne District in the Midwest Region. The island is approximately 80km long and up to 12km wide with a total area of 63,300 ha, making it the largest island in WA. The island contains a range of terrestrial habitats, including *Acacia*-dominated shrubland communities, *Triodia*-dominated grasslands, *Thryptomene dampieri* heath, consolidated and mobile dune-systems with large areas of *Spinifex longifolius* and many small ‘birrida’ clay-pans vegetated by chenopods (Beard 1976).

Shark Bay bandicoots, dibblers and greater stick-nest rats were released in the area around Herald Bay (Figure 1), approximately half-way along the east coast of DHI. Shark Bay mice were released in *Spinifex longifolius*-dominated dune systems to the west of Tetradon Loop (Figure 1). Previously, banded and rufous hare-wallabies had been released between Notch Point and Cape Ransonnet, with an additional release of rufous hare-wallabies around Herald Bay (Figure 1).

1.2 Rainfall

Dirk Hartog Island has a semi-arid climate, typically receiving most rain over the winter months but with occasional heavy falls in the summer and autumn due to cyclonic events. Annual rainfall for the reporting period (330mm) is approximately 100mm higher than average, with the largest rainfall event (81.8mm over four days) occurring in February as a result of a slow moving Tropical Low (12U).

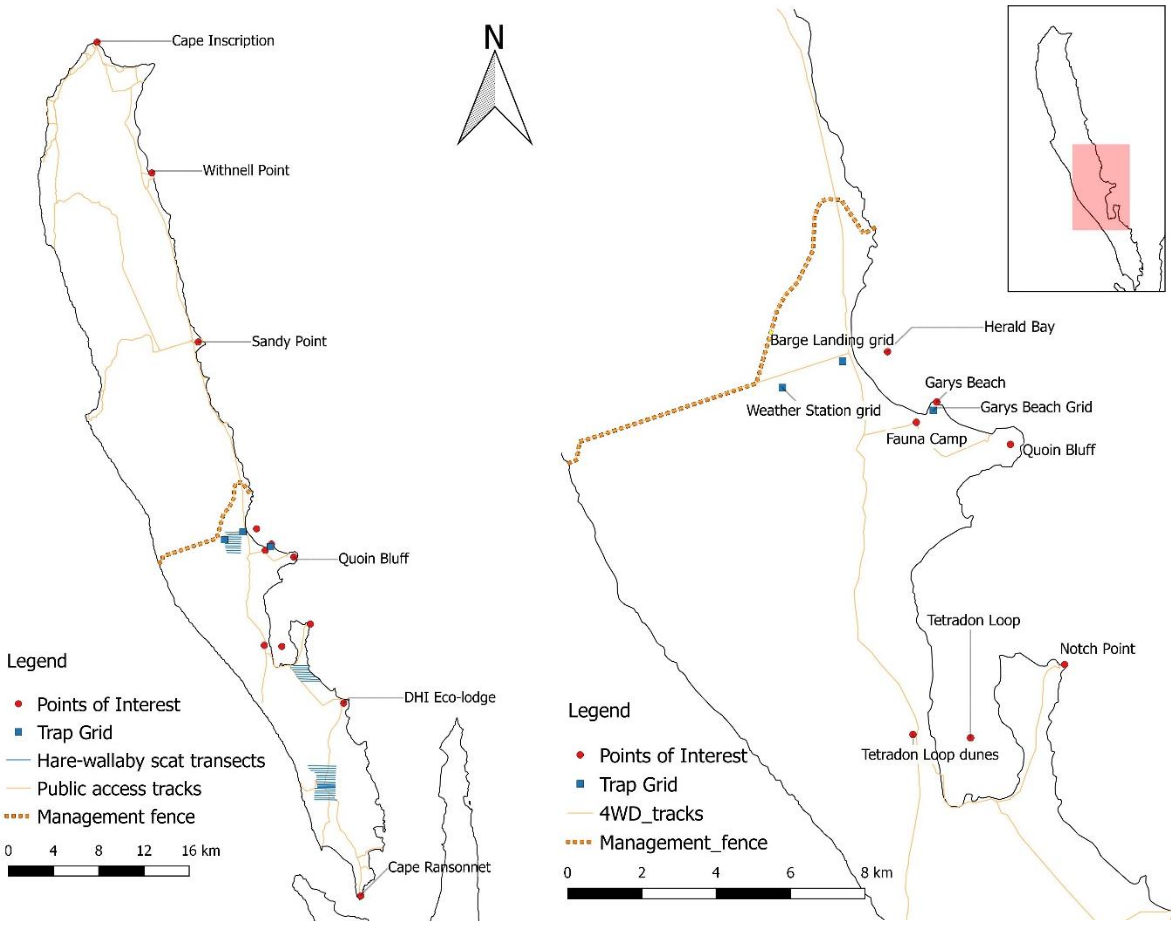


Figure 1. Overview (left) and close-up (right) of DHINPERP areas of operation in 2020-21.

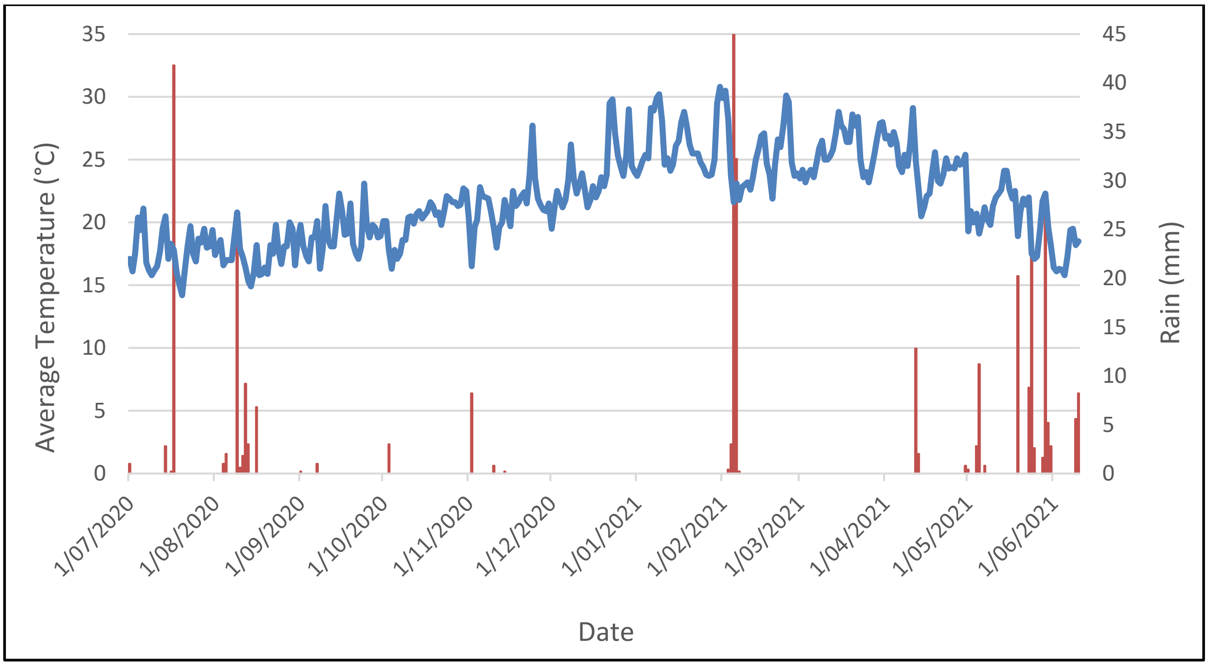


Figure 2. Climate data from DHI weather station (Herald Bay) between 1 July 2020 and 10 June 2021.

2 Shark Bay bandicoot

Shark Bay bandicoots (marl) (*Perameles bougainville*) were first translocated to Dirk Hartog Island in September 2019 from Bernier and Dorre Islands (Cowen *et al.* 2020). An additional translocation to reinforce these initial founder cohorts was undertaken in September 2020, under DBCA Animal Ethics Committee Approval AEC 2019-23.

2.1 Methods

2.1.1 Translocation

Twenty-eight Shark Bay bandicoots (11M:17F) were translocated from Bernier Island to DHI using transport methods described in Cowen *et al.* (2020). Twenty-seven of these animals were released on to DHI bringing the total number of bandicoots translocated to the island to 99 (Table 1). One female was returned to Bernier Island due the presence of symptoms suggestive of bandicoot papillomatosis carcinomatosis virus type 1 (BPCV1). This animal was swabbed for BPCV1 screening and held overnight in the animal processing facility on DHI before being returned and released at the point of capture on Bernier Island. The facility and equipment were cleaned and disinfected with F10SC and the samples from this animal subsequently tested positive for BPCV1.

*Table 1. Capture statistics for Shark Bay bandicoots translocated from Bernier and Dorre Islands 2019-2020 (NB. dates reflect captures occurring before and after midnight; * one animal was returned to Bernier Island, ^ one animal was euthanised)*

Capture date	Source	Female	Male	Total
4-5 September	Bernier Island	5*	2	7
5-6 September		2	2	4
6-7 September		3	2	5
7-8 September		3	1	4
8-9 September		2	1	3
9-10 September		2	3	5
2020 Total		**17***	**11**	**28***
2019 Totals	Dorre Island	25	27	52
	Bernier Island	13	8^	21^
Grand Total		**55***	**46^**	**101*^**

2.1.2 Radio-tracking

Following the methods described in Sims *et al.* (2020), with some minor modifications based on experience and outcomes in 2019, eight Shark Bay bandicoots were radio-collared following translocation from Bernier Island. These animals were recaptured two weeks post-release to check the collar fit and all eight collars were removed between 30 and 35 days post-release. Attempts to locate these animals were made daily between release and collar removal.

2.1.3 Cameras

Sixteen remote cameras deployed in the 2019 Shark Bay bandicoot release areas (Garys Beach and the Weather Station (Figure 1)) were collected in September 2020 (10-month deployment) and re-deployed to assess extent of occurrence in the broader landscape. The 2km grid originally used for monitoring the cat eradication program was used for this purpose, with passive (i.e. no lure) cameras deployed at 24 locations between Tetradon Loop and the management fence (Figure 1). These cameras remained in-situ until March 2021.

Camera images were imported into CPW Photo Warehouse (Ivan and Newkirk 2016) and independent detections assigned automatically for each species of interest with a minimum time of 10 minutes between independent events.

2.1.4 Trapping

Three trapping grids (Garys Beach, Barge Landing and Weather Station; Figure 1) were established within the Shark Bay bandicoot release areas and run twice in the reporting period (November 1-4 2020 and May 11-14 2021). All three grids consisted of ten lines of traps at 50m intervals, with rows at 100m intervals; four at Garys Beach (40 points, each with one Sheffield trap) and six at the Barge Landing (60 points, each with two Elliott traps) and the Weather Station (60 points, each with one Sheffield and one Elliott; Figure 1). Trap grids were run for 4 nights in each session, with a total trapping effort for each session of 1,120 trap nights.

2.2 Results

2.2.1 Radio-tracking

All collared Shark Bay bandicoots survived the immediate post release period (~four weeks). Like animals collared in 2019, animals established suitable refuges consisting of dense leaf litter under shrubs. Animals remained close to the release area during the tracking period, moving less than 2km from their release points.

Table 2. Results of survivorship and recapture information from Shark Bay bandicoots radio-collared in the immediate post-release monitoring period in 2020 (PY, Pouch young)

Animal ID	Sex	Release date	Collar removal	Days elapsed	Weight change (%)	Reproductive status
SBB03-20	M	05/09/20	04/10/20	30	+16	
SBB04-20	F	05/06/20	03/10/20	29	+26	2 PY
SBB16-20	M	07/09/20	05/10/20	35	+2	
SBB19-20	F	08/09/20	05/10/20	34	+12	
SBB21-20	F	09/09/20	06/10/20	34	+2	2 PY
SBB22-20	F	09/09/20	06/10/20	34	+18	
SBB25-20	M	10/09/20	07/10/20	34	-3	
SBB26-20	M	10/09/20	07/10/20	34	0	

Six of the eight collared animals gained weight in the four weeks following release, the largest weight loss during this time was 5g (~3%) (Table 2). Upon capture for collar removal, two females were carrying two pouch young each.

2.2.2 Cameras

Of the 24 cameras deployed on a 2km grid between September 2020 and March 2021, Shark Bay bandicoots were recorded on 15 (Figure 3). The number of independent detections varied between one and 54. It should be noted that evidence of Shark Bay bandicoot presence (either from tracks or cameras for other monitoring purposes) has also been noted north-west of Sandy Point and south of Tetradon Loop.

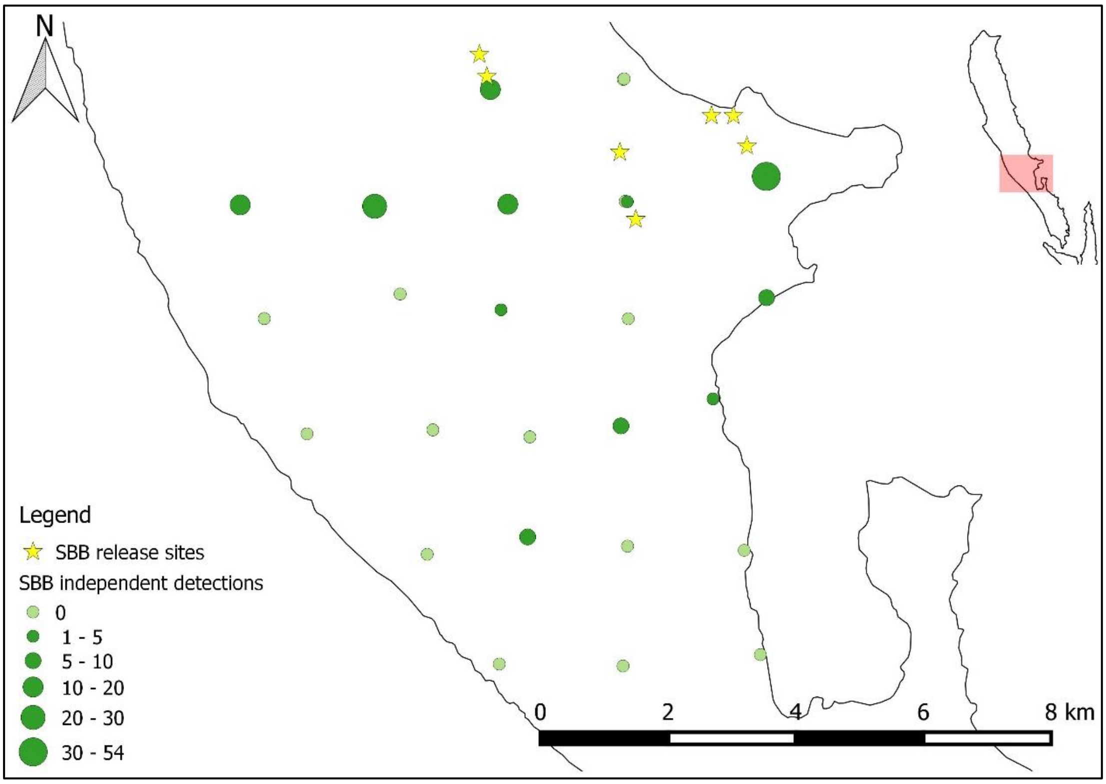


Figure 3. Map of independent detections of Shark Bay bandicoots on camera traps between management fence and Tetradon Loop dunes.

2.2.3 Trapping

Trap success between the two trapping sessions was markedly different. In November 2020, total trap success was 9.9% and in May 2021 it was 73.4% (Appendix 1). Trap success for Shark Bay bandicoots in these two sessions was 1.3% and 5.4% respectively (Appendix 1). A total of 23 new Shark Bay bandicoots were captured across the two sessions and 100% of adult females were reproductively active (lactating or carrying pouch young). Most captures of bandicoots were in cage traps, validating the decision to include this method of capture in addition to Elliott traps.

In May 2021, a lesion was observed on the hind foot of a Shark Bay bandicoot caught on the Weather Station grid. Presentation was not typical for BPCV1, but the lesion was swabbed and sent off for analysis and subsequently tested negative. A second incidence of fur loss (which can be indicative of BPCV1) was noted in a bandicoot caught in June 2021 and again swabs were taken for analysis. Again these swabs tested negative.

3 Dibbler

Dibblers (*Parantechinus apicalis*) were first translocated to Dirk Hartog Island in October 2019 from a captive breeding program at Perth Zoo (Cowen *et al.* 2020). The original founders of this population were from the islands of Boullanger, Whitlock and Escape in Jurien Bay. An additional translocation to reinforce these initial founder cohorts was undertaken in October 2020, under DBCA Animal Ethics Committee Approval AEC 2020-20.

3.1 Methods

3.1.1 Translocation

As per methods described in Cowen *et al.* (2020), 31 dibblers from Perth Zoo were translocated and released on DHI on 6 October 2020. This cohort consisted of 17 captive-bred subadults and 14 adults originally captured on Escape (6) and Whitlock (8) Islands (Table 3). The sex ratio was 14 males and 17 females. Animals were released within the same area as those translocated to DHI in 2019, in the vicinity of the Barge Landing trapping grid (Figure 1).

Table 3. Numbers of dibblers translocated and released on Dirk Hartog Island on 6 October 2020.

Source	Age	Female	Male	Total
Whitlock Island (Wild-born)	Adult	4	4	8
Escape Island (Wild-born)	Adult	3	3	6
Perth Zoo (Captive-bred)	Sub-adult	10	7	17
Total		**17**	**14**	**31**

3.1.2 Radio-tracking

Following a collar trial that took place at on captive individuals at Perth Zoo, nine animals (four adults and five sub-adults) selected for release on DHI were fitted with radio-collars using a similar design to that used on Shark Bay bandicoots (Sims *et al.* 2020). This took place under a general anaesthetic at the Perth Zoo veterinary facilities on the 1 and 2 October 2020. The anticipated battery life of these collars was up to four weeks. Collars were checked prior to release on the island and two were removed due to rubbing, leaving seven dibblers to be released with radio-collars.

3.1.3 Cameras

The grid of dibbler cameras reported on in Cowen *et al.* (2020) remained in place until 3 September 2020 and was then rearranged to include 25 cameras on a 300m grid over the release area. Camera set up and image management methods remain the same as those reported in Cowen *et al.* (2020). The array of 25 cameras deployed in 2020 remains in-situ and was last serviced in March 2021.

3.1.4 Trapping

Two trapping grids (Barge Landing and Weather Station) were used in the release area to monitor dibblers (see Section 2.1.4) in November 2020 and May 2021.

3.2 Results

3.2.1 Radio-tracking

Of the seven collared dibblers, collars were retrieved from four. This number included one dropped collar (five days post-release), one mortality (five days post-release), one located in a reptile scat (probable sand monitor (*Varanus gouldii*) (six days post-release)) and one removed from a live animal 13 days post-release (the latter having lost 11g in weight). A post-mortem examination was performed and despite having slipped a limb through its collar, this was found to have had minimal impact and the cause of death was confirmed as haemochromatosis (iron accumulation disease), a disease not previously identified in dibblers.

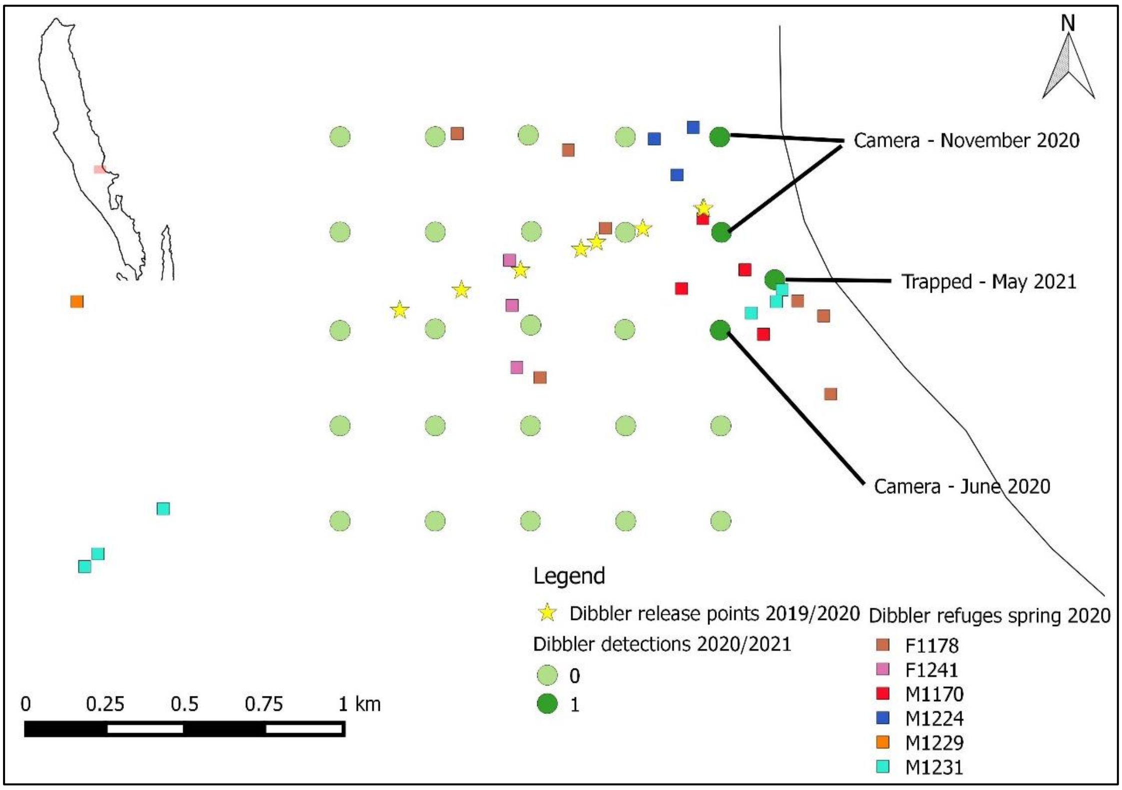


Figure 4. Map of dibbler detections on camera and in traps in 2020 and 2021, as well as the location of refuges for six of the seven collared individuals in October 2020.

Of the three remaining animals, two were not located at all following release despite a radio-tracking flight being completed on the 17 October, and the third continued to be located until 16 October. All collars were fitted with 'weak-links' which were expected to degrade over time. During the radio-tracking period, 24 individual refuges were located (Figure 4).

3.2.2 Cameras

Dibblers were recorded once at three camera locations on the grid around the release area: one in June 2020 and two in November 2020 (Figure 4).

3.2.3 Trapping

Trapping of Barge Landing and Weather Station grids in November 2020 resulted in no dibbler captures. However, when the same grids were trapped in May 2021, a female (1238) was recaptured on the Barge Landing grid on 13 May, with 8 pouch young and having increased 63% in body weight since release. This animal was released as a captive bred sub-adult in October 2020 and was the second smallest animal in this cohort.

4 Shark Bay mouse

Shark Bay mice (djoongari) (*Pseudomys fieldi*) were translocated to DHI in April 2021 for the first time. The initial founder cohort was taken from Northwest Island in the Montebello Islands off the Pilbara coast, with a reinforcement from the original natural population on Bernier Island planned for 2022. The Translocation Proposal for the reintroduction to DHI was approved in April 2021 and the translocation was undertaken under DBCA Animal Ethics Committee Approval AEC 2021-03A.

4.1 Methods

4.1.1 Translocation

Shark Bay mice were released on DHI between 20 and 22 April 2021. A total of 80 mice were translocated, with a female-biased sex ratio of 3:2.

Table 4. Numbers of Shark Bay mice translocated and released on Dirk Hartog Island on between in April 2021.

Release date	Source	Female	Male	Total
20 April	Northwest Island	28	21	49
21 April		13	11	24
22 April		7	0	7
Total		48	32	80

Seventeen release points were used in the release area of *Spinifex longifolius* habitat near Tetradon Loop along a north-south transect at 50m intervals. At ten of these points, two artificial refuges (one 'V' and one 'U') were established to provide additional refuges for the released animals. These artificial refuges ('Pseud-homys') were designed based on schematics of burrows excavated on Bernier Island by

Peter Speldewinde during studies undertaken as a part of the Shark Bay Mouse Recovery Plan in the 1990s. Refuges were created using flexible, perforated piping and plumbing joins. Half of each design also included a 'blind ending', a feature identified in burrows excavated on Bernier Island. The 'V' designs consisted of two 110cm lengths of 50mm pipe, while the three sections that made up the 'U' design were 80, 50 and 80cm lengths (Appendix 2). One Shark Bay mouse was released directly into each of the artificial refuges and the remaining mice were 'hard' released (i.e. released directly from their transport container (a medium Elliott trap) into cover).

4.1.2 Radio-tracking

Twelve Shark Bay mice were collared under isofluorane general anaesthesia following the same methods used on dibblers and similar to those described in Sims *et al.* (2020), using Holohil BD-2C transmitters and a weak link made from cotton sewing thread. Five transmitters had an expected battery life of 42 days (1.1g) and the remainder had an expected battery life of 28 days (0.95g). These transmitters did not have a mortality function, so an attempt to track animals to their refuges was made daily. Nocturnal tracking to confirm movement was undertaken once every three nights.

A passive VHF logger tower was also erected in the release area to test systems planned for the greater stick-nest rat release. This unit recorded signal strength from any collars that were in range of the VHF antennae (mounted on a 6.5m high pole) 24 hours a day. As well as providing another method to confirm the presence of animals in the release area and that those animals were moving, some additional information was also collected on activity periods and patterns. Data were collected and analysed using software from radio-tracking.eu (Gottwald *et al.* 2019).

Animals were recaptured by partially fencing off refuges using a drift fence created from plastic shower curtain ('Pseudo-no-roamys'). Several Elliott traps baited with universal bait (peanut butter, oats and sardines) were then placed inside the fence and in the vegetation surrounding the refuge site.

4.1.3 Cameras

One remote camera was set on each of the artificial refuge sites the day prior to the first night of releases. These cameras were deployed for the immediate post release period (~30 days) before being collected. Given the size of Shark Bay mice (>40g) and presence of a known size object (50mm pipe), the expectation was that the translocated Shark Bay mice could be readily distinguishable from the other, smaller, rodent species also present in the area.

4.1.4 Other monitoring methods

Tracking tunnels were deployed with ink cards between 20 and 26 May 2021 at the 10 release sites where cameras were deployed on artificial refuges and were baited with universal bait. It was hoped that the tracks of Shark Bay mice would be readily distinguishable from other rodent species due to their larger size.

4.2 Results

4.2.1 Radio-tracking

Eight of the twelve radio-collared Shark Bay mice survived the initial release period (Table 5) with mortalities recorded between one and 10 days post-release. Mortalities were attributed to birds (possibly nankeen kestrel (*Falco cenchroides*) (one)) and snakes (three), one of which was confirmed as a Stimson's python (*Antaresia stimsoni*) (Table 5). Collars were removed from all the remaining animals between 19 and 28 days post-release. An additional six uncollared Shark Bay mice were captured during this process. Average weight change for animals with radio-collars was -24% and for those without collars it was -12%.

Table 5. Results of post-release monitoring of collared cohort of Shark Bay mice on DHI (April-May 2021).

Animal ID	Sex	Release date	Collar retrieved	Outcome	Days elapsed	No. refuges	Weight change (%)
PF2129	F	20/04/21	30/04/21	Mortality (snake)	10	5	n/a
PF2131	M	20/04/21	21/04/21	Mortality (bird)	1	0	n/a
PF2132	M	20/04/21	19/05/21	Live	29	7	-23
PF2146	M	20/04/21	09/05/21	Live	19	4	-31
PF2148	F	20/04/21	17/05/21	Live	27	6	-22
PF2149	F	20/04/21	09/05/21	Live	19	3	-21
PF2157	F	21/04/21	30/04/21	Mortality (snake)	9	7	n/a
PF2164	M	21/04/21	19/05/21	Live	28	10	-24
PF2166	F	21/04/21	13/05/21	Live	22	3	-27
PF2167	M	21/04/21	10/05/21	Live	19	4	-23
PF2172	F	21/04/21	25/04/21	Mortality (*A. stimsoni*)	4	4	n/a
PF2177	F	22/04/21	17/05/21	Live	25	5	-21

Fifty-eight refuge sites were recorded, with all but five located under tussocks of *Spinifex longifolius* which ranged in size from small, singular tussocks (<50cm) to portions of large, dense, continuous swathes (>100m). Four of the remaining refuges were only used once and these were located under *Acacia ligulata, Thryptomene dampieri*, *Acanthocarpus preissii* and *Salsola australis*. The fifth refuge was a sinkhole in the intertidal zone (later inundated), that was used by two different mice, on one occasion each. While some animals exhibited exploratory behaviour, covering large areas and using several different refuge sites, other animals persisted at a single refuge (or refuges in the same area) for most of the monitoring period.

Radio-collared animals demonstrated the mobility of this species, with one animal found 975m from its refuge within one hour of sunset, but located at the previous refuge the following day. Three animals (2M:1F) moved outside the immediate release area. The males were located within the same habitat system as the release sites and one of these was recaptured with a uncollared female at the time of collar removal. The third animal (a female), moved outside the immediate release area, but returned after a period of 16 days and was recaptured there for collar removal.

The logger tower gave just under three weeks' worth of data and indicated that animals were becoming active approximately one hour prior to sunset and remaining active until about an hour after sunrise. Apparent quiet periods of low or no activity in the early hours of the morning were also noted (Appendix 3).

4.2.2 Cameras

Of the 10 release sites with artificial refuges, cameras at all sites recorded Shark Bay mice. Multiple individuals were recorded at seven sites. Artificial refuges were recorded being used by Shark Bay mice (i.e. entering or exiting pipes) at five sites and were inspected at an additional three sites, often on multiple occasions. The latest record of Shark Bay mice on camera varied between 22 April and 19 May and some artificial refuges were being at least until three days before camera retrieval.

4.2.3 Other monitoring methods

During attempts to capture collared greater stick-nest rats (see Section 5.1.2) at Quoin Bluff and Garys Beach, two male Shark Bay mice were captured, six- and seven-weeks post-release. These locations are approximately 8.5km (minimum distance by land) from the release area, but have appropriate refuge habitat nearby and these animals were both in apparently good health.

Tracks resembling those of Shark Bay mice were recorded on at least five out of 10 tracking tunnel ink cards (e.g. Figure 5). However, the high rodent activity at this time meant the ink cards quickly became saturated with tracks and this was exacerbated by rodents harvesting paper from the ink cards, presumably as nesting material. Therefore, Shark Bay mice tracks may have been present on more ink cards but could not be distinguished.

Tracks of Shark Bay mice were often encountered in the vicinity of the release area (Figure 5). The larger size of the tracks compared to other rodent species, combined with the sand substrate in the release area, made discrimination easier than it may have been otherwise.

Figure 5. Tracks believed to be from a Shark Bay mouse, left on sand in release area and right on tracking tunnel ink pad.

We have a reasonable degree of confidence that these tracks were not from ash-grey mice (*Pseudomys albocinereus*) as few if any were recorded on camera traps in this area during the first month after the translocation. However, further trials are required to assess the feasibility of discerning tracks of this species from those of Shark Bay mice.

5 Greater stick-nest rat

Greater stick-nest rats (wopilkara) (*Leporillus conditor*) were translocated to DHI for the first time in May 2021. The first founder cohort was taken from Salutation Island in Shark Bay, with a reinforcement planned for 2022 from the original natural population on East and West Franklin Islands in South Australia. The Translocation Proposal for this reintroduction was approved in May 2021 and the translocation was undertaken under DBCA Animal Ethics Committee Approval AEC 2021-08A.

5.1 Methods

5.1.1 Translocation

Greater stick-nest rats were translocated to DHI between 18 and 21 May 2021, with a total of 58 individuals released in a sex ratio of approximately 1M:1.5F (Table 6). Approximately half of the released cohort were captured from individual nests and were translocated and released as ‘family’ groups (acknowledging that animals caught in the vicinity of a nest were not necessarily kin). The remainder were translocated and released as individuals. Five groups were released as ‘families’, with 32 animals released as individuals. A captive pair from Salutation Island, currently held at purpose-built facility at Peron Homestead for collar-fitting trials, are planned for release on DHI in July 2021 along with their captive-born offspring.

Table 6. Numbers of greater stick-nest rats translocated and released on Dirk Hartog Island on between in May 2021.

Release date	Source	Female	Male	Total
18 May	Salutation Island	1	3	4
19 May		1	3	4
20 May		15	9	24
21 May		18	8	26
Total		**35**	**23**	**58**

Prior to release, artificial refuges (or ‘protonests’) were constructed in the release area, using a pre-existing scaffold such as dead shrub and consisting mostly of *A. ligulata* branches arranged in a tepee-like fashion, with a collection of smaller woody sticks making up the shelter underneath. Animals were transported in purpose-built wooden boxes, with sliding doors at either end, secured with a screw. ‘Families’ were translocated together in larger boxes with six chambers, accompanied by some nest material from the source nest. Animals were released directly into protonests as calmly and quietly as possible by placing transport boxes into/under the protonests and the doors gently slid open, allowing animals to quietly emerge in their own time.

The transport boxes were left as an extra refuge that would retain the animal's scent and encourage fidelity to the release site. Animals were released at 39 protonests.

5.1.2 Radio-tracking

A total of 15 individuals were fitted with Holohil RI-2DM transmitters and a weak link made from multi-strand embroidery thread (of identical design to those used on Shark Bay bandicoots) on 13, with two others fitted with brass-loop style collars without a weak link. Collars were planned for deployment for four to six weeks post-release, with collar checks planned between two- and three- weeks post-release. Collared animals were recaptured using a combination of Elliott and Sheffield traps and hand-netting. Pre-baiting was attempted at several sites to increase the likelihood of a successful capture.

As per 4.1.2, a total of eight passive VHF logger towers were erected around the Herald Bay area, at maximum distance of 8.5km from the release area at Garys Beach. Modelling showed that six of these towers would provide coverage of much of the eastern part of the island between the management fence and the Tetradon Loop dunes. Data from these towers could be used to ascertain which collared greater stick-nest rats had been in the vicinity, providing a first step to locating any 'missing' collars of dispersing individuals. Towers were also erected at Garys Beach and near Quoin Bluff to provide information on behaviour of less mobile collared individuals. Data were collected and analysed using software from radio-tracking.eu (Gottwald *et al.* 2019).

5.1.3 Cameras

Cameras were deployed on 22 protonests prior to animals being released and were serviced on 28 June 2021.

5.2 Results

5.2.1 Radio-tracking

A summary of the outcomes for the 15 collared greater stick-nest rats is presented in Table 7. Two mortalities were recorded, one at two days and another at 14 days post-release and post-mortems were performed in the field laboratory at the Fauna Camp. In both cases there was evidence of predation, with the first suspected to be an unknown large raptor and the second a sand monitor based on the nature of the carcasses. However, neither carcass had been consumed and it could not be determined if the animals died of another cause and had been scavenged. Both individuals were in apparently good health and had full gastro-intestinal tracts. Samples were taken for subsequent histopathology analysis to determine if there were any underlying conditions (e.g. capture myopathy) that may have predisposed these animals to predation. No changes were found that were consistent with capture myopathy, but the second animal did have a cortical cataract in the eyeball that was examined.

Collar checks for most animals occurred between two and three weeks post-release. Collar fit varied between good and loose, with one collar removed due to being too loose. Another collar was removed after the collar check due to the difficulty in recapturing that individual. Of the remaining collared animals, two had their collars chewed off by conspecifics (both males) indicating these individuals were engaging in social behaviours (i.e. allo-grooming). Both occurred close to their original release sites (<400m) and all were released as individuals, indicating they had established social bonds after release. Another collar broke off the animal after becoming caught in an Elliott trap which, while not the desired outcome, was a good indication that the weak links included in the collar design were functioning as intended.

Table 7. Results of post-release monitoring of collared cohort of greater stick-nest rats on DHI (May-June 2021) (suspected sand monitor predation; ** weak link broke in trap door; † animal was refuging in protonest; ‡ tracked as far as 11.9km north of release area, then returned; ᶱ suspected raptor predation; ^ 19 days post-release)*

Animal ID	Sex	Release date	Collar retrieved	Individual (I) or Family (F)	Outcome	Days elapsed	Distance from release (m)	Weight change (%)
LC2106	F	19/05/21	02/06/21	F	Mortality*	14	61	n/a
LC2112	F	20/05/21	24/06/21	F	Live	35	10,100	+3
LC2114	F	20/05/21	19/06/21	F	Live	30	170	+12
LC2115	F	20/05/21	05/06/21	F	Broke**	16	314	n/a
LC2119	F	20/05/21	22/06/21	I	Live	33	314†	+1
LC2125	M	20/05/21	07/06/21	F	Live	18	31	-1
LC2128	M	20/05/21	02/06/21	I	Chewed	13	376	n/a
LC2129	F	20/05/21	21/06/21	I	Live	32	1,750‡	-17
LC2135	F	21/05/21	23/05/21	I	Mortalityᶱ	2	253	n/a
LC2136	F	21/05/21	24/06/21	I	Live	34	10,900	+5
LC2141	F	21/05/21	16/06/21	I	Live	26	2,160	-3
LC2143	M	21/05/21	31/05/21	I	Chewed	10	30	+4^
LC2148	M	21/05/21	12/06/21	I	Live	22	13	-9
LC2157	F	21/05/21	18/06/21	I	Live	28	1,930	-11
LC2158	F	21/05/21	25/06/21	I	Live	35	4,870	+1

The remaining eight collars were removed between four and five weeks post-release. Collar fit was again variable with some loose and others snug, but no negative effects (injury, entrapment, rubbing) were observed except some minor fur loss under the collar.

Movements of collared animals varied considerably. The majority (nine) remained close to the release site at Garys Beach (<400m), with two others moving ~2km to Quoin Bluff. Another five uncollared individuals (4M:1F) were also captured in the vicinity of these latter two animals' refuges. Four animals dispersed further afield, three of which settled after two weeks (two at Tetradon Loop (nine to 11km from release) and another 4.8km south-west of Herald Bay) and the fourth remained mobile up until the point of collar removal. This individual initially travelled south towards Tetradon Loop before crossing to the west coast of the island and then headed north of the management fence. However, by the time its collar was removed, it was back within 2km of the release site again, 1km south-west of the Herald Bay camp. All four individuals were in average to above average condition when recaptured and refuging in suitable locations. Of the four that dispersed widely, only one was released as part of a ‘family’, but it was suspected that this individual was not originally part of this social group.

Refuge choice of collared animals varied, with some animals in the release area continuing to use protonests and others refuged under large shrubs, e.g. *Acacia ligulata*, *Nitraria billardieri* and one under *Eucalyptus obtusiflora*. Some individuals consistently refuged in small cave-like structures under limestone cliffs or rocks, sometimes more than 4m deep. All refuge locations were in the vicinity of known or likely food plants for the species.

Data from the passive VHF logger towers are yet to be analysed in detail. However, these towers proved valuable when trying to locate ‘missing’ collared animals on several occasions, providing a time and location when the collar was last ‘seen’, allowing the search area to be greatly reduced.

5.2.2 Cameras

Camera traps captured images of greater stick-nest rats at 19 of the 22 protonests at which cameras were deployed. Last detections varied from 24 May (≥3 days post-release) to the date of servicing (28 June; >5 weeks post-release), with nine detections occurring within a week prior to servicing. Animals were seen entering/exiting at 12 sites. More than one individual was observed at 12 protonests, with at least three at five sites. Other behaviour observed on cameras included nest-building, feeding, fighting, allo-grooming, climbing on top of the nest and a possible attempted mating. Interestingly, a sand monitor was recorded on top of a protonest two days post-release, which remained occupied by rats until at least the week before camera servicing. This protonest was the closest to where a presumed sand monitor predation of a collared animals occurred. In addition, two protonests where cameras were not deployed showed evidence of occupancy, one with an entrance tunnel, another with structure added to the top of the transport box.

6 Extant vertebrate fauna

Since 2017, extant vertebrate fauna has been monitored on DHI, to evaluate the impact of the eradications on populations of these species, as well as the potential effect of restoring populations of locally extinct fauna. These data can then be compared with baseline monitoring data, obtained using identical methods at the same sites prior to the commencement of the eradication programs. This monitoring was undertaken under DBCA Animal Ethics Committee Approval AEC 2020-12.

Incidental observation and camera trap data (obtained through monitoring for other translocated species) for vertebrate fauna on DHI were also collected.

6.1 Methods

6.1.1 Trapping

The trapping methodology used was a combination of Elliott traps and pitfalls at eight sites in the centre of the island for seven nights, as per Cowen *et al.* (2020).

6.1.2 Cameras and incidental observations

Captures of 'non-target' incidental species on camera traps for surveys of translocated fauna were recorded and entered in the CPW Photo Warehouse (Ivan and Newkirk 2016) database. Some taxa (e.g. rodents and hare-wallabies) were often not able to be identified to species level and entered as e.g. 'small mammal' or 'hare-wallaby'.

Incidental observations were recorded on a weekly basis on a communal list and entered into a Microsoft Access database at the end of each week.

6.2 Results

6.2.1 Trapping

Across a total of 658 pitfall and 672 Elliott trap nights, 765 individual animals were captured representing a 19% decrease on capture rates compared to 2019. Individual species totals are shown in Appendix 3, but one new species for the trapping program (since 2017) was recorded: black-necked whipsnake (*Demansia calodera*). The overall number of captures (excluding sandy inland mice (*Pseudomys hermannsburgensis*)) increased from 387 in 2017 to 476 in 2020. Capture rates of all extant rodents decreased between 2019 and 2020, with sandy inland mice, ash-grey mice and house mice (*Mus musculus*) decreasing by 42%, 20% and 34% respectively. Little long-tailed dunnart (*Sminthopsis dolichura*) captures increased for the third year in a row, from 35 individuals in 2019 to 61 in 2020, representing a 75% increase.

6.2.2 Cameras and incidental observations

A total of 123 species were either observed, captured on remote camera or captured in traps in the reporting period. These species have been collated in Appendix 4. Western netted dragon (*Ctenophorus reticulatus*) was detected for the first time since observations of this species in spring 2017, with a single individual encountered whilst radio-tracking Shark Bay mice north-west of Tetradon loop.

7 Banded and rufous hare-wallabies

Banded hare-wallabies (*Lagostrophus fasciatus*) and rufous hare-wallabies (*Lagorchestes hirsutus*) were first translocated to DHI in August-September 2017, with further translocations in 2018 (banded and rufous) and 2019 (rufous only). So far, these translocations appear to have been successful with all short- and medium-term success criteria having been met. However, since these species are both 'trapshy' (i.e. reluctant to enter conventional live-capture traps), monitoring them effectively presents a challenge.

Trials to assess the efficacy of faecal DNA as a monitoring technique were conducted in 2018 and 2019. It was found that isolating epithelial cells on the outside of faecal pellets (scats) (to extract DNA and subsequently genotype individual hare-wallabies) was not only feasible but proved effective in discriminating both species and individuals. Consequently, a full-scale monitoring effort took place in 2020 as the first step in a long-term monitoring program for these species on DHI.

In addition, camera traps proved useful in monitoring the increasing extents of occurrence of both species as their establishment on the island continues.

7.1 Methods

7.1.1 Scat surveys

A total of 34 transects running east-west, 200m apart, at three different locations were searched for hare-wallaby scats. Two additional transects were nested into the 200m-spaced transects to provide a total of five transects at 100m spacings, to test if these made any difference to the results of the subsequent analysis. Transect length varied between 1.3 and 2.7km, with a total of 62.6km combined for the 200m-spaced transects only.

Transects were walked in pairs and any scats encountered that were assessed as being fresh (≤21 days old) were collected in plastic vials containing silica gel desiccant and cotton wool. Scats that had a glossy surface were assumed to be fresh and preferred over ones that had lost their gloss and were visually desiccated and losing integrity. Locations were recorded by waypoint in a handheld GPS unit and vials were labelled with date, transect and waypoint ID and collectors' initials. Vials were frozen at the end of each day and upon completion of the survey, vials were transferred to Dr Kym Ottewell at DBCA Kensington in Perth.

7.1.2 Camera and incidental observations

During monitoring for other translocated fauna using camera traps, images of both species of hare-wallaby were also recorded. Observations of animals and tracks and/or scats were recorded on an ad-hoc basis.

7.2 Results

7.2.1 Scat surveys

Between 11 and 15 November 2020, over 400 scat samples were collected along survey transects. These samples are awaiting subsequent DNA extraction and analysis, the results of which will be used to estimate population density and abundance in the survey areas.

7.2.2 Camera and incidental observations

The 2km camera grid of 24 units, used to monitor Shark Bay bandicoots (see 2.1.2), was also used to monitor for the presence of hare-wallabies. Figure 6 shows the locations and number of independent events of rufous hare-wallabies between September 2020 and March 2021. In addition to rufous hare-wallabies, there were three records on banded hare-wallabies on this camera grid, two on the north-west of the grid and one south-west of Herald Bay. These are the first records of banded hare-wallabies north of the Tetradon Loop dunes.

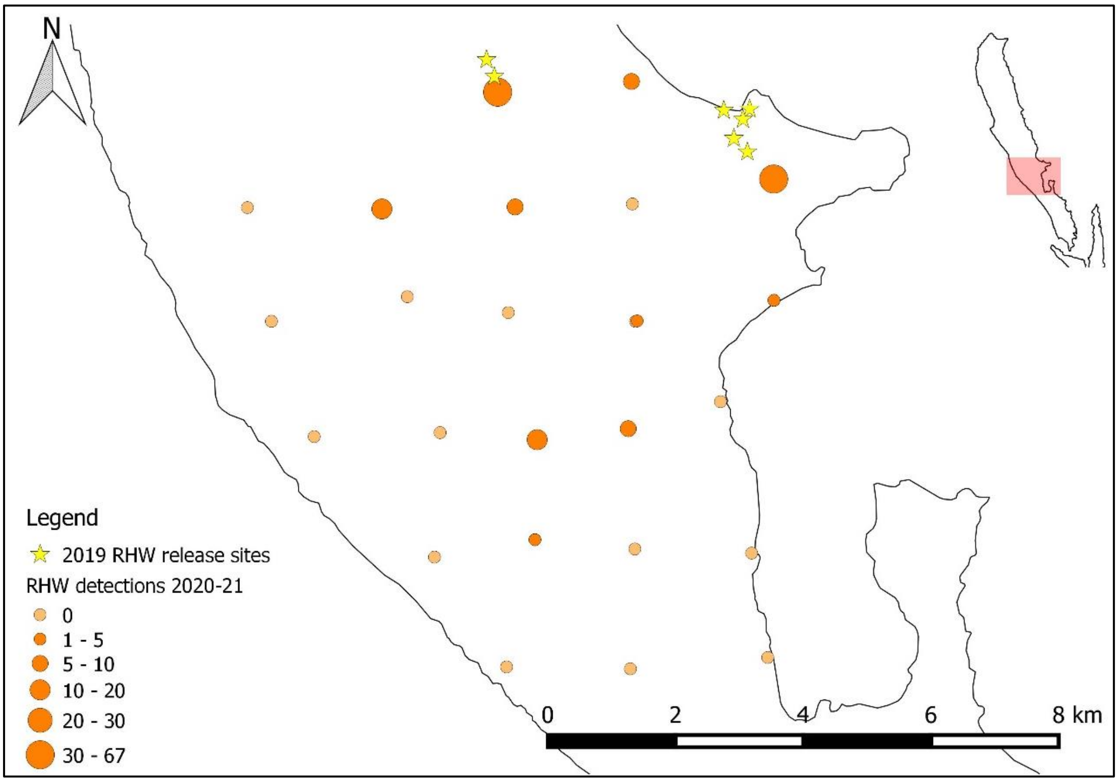


Figure 6. Map of independent detections of rufous hare-wallabies on camera traps between management fence and Tetradon Loop dunes between September 2020 and March 2021.

8 Discussion

8.1 Shark Bay bandicoot

The supplementation translocation of Shark Bay bandicoots from Bernier Island to DHI in September 2020 resulted in 100% survival of the collared cohort in the first four weeks post-release, as well as new reproductive activity and condition maintenance or improvement. Based on the results of live-capture and camera traps surveys, Shark Bay bandicoots appear to have increased in abundance and extent of occurrence on DHI since the first translocation in 2019. Capture rates increased substantially between November 2020 and May 2021, despite the coincidental increase in captures of native rodents. All captured adult females were reproductively active and this, combined with the high reproductive rate and large percentage of new individuals (20 of 28 individuals captured in May 2021), indicates that recruitment into the population is also high.

Two possible instances of BPCV1 symptoms were noted and swabs taken for analysis. Both sets of swabs subsequently tested negative but there is an ongoing need for vigilance and precautionary hygiene measures to avoid accidental transmission.

8.2 Dibbler

A supplementation translocation of 31 individuals from the Perth Zoo captive population took place in October 2020 and, although results of post-release monitoring were mixed, improvements were made compared to 2019. Two mortalities were noted: one by a reptile predator and another from a previously unknown disease in this species. Unfortunately, due to the weight loss in the first week of the post-release period (not unexpected in translocations) collars became loose and either were slipped off or limbs were slipped through. Fortunately, partly due to the soft collar material, there was no evidence of injury caused by this. Regardless, this outcome was undesirable for animal welfare and collaring of captive-bred Dibblers will now cease. Three collars of seven deployed also appeared to have failed and despite extensive searching from the air, could not be relocated. The occurrence of a predation mortality was not unexpected, but the confirmation of haemochromatosis as the cause of death in the other mortality was surprising, as this disease is not previously known in dibblers. The underlying cause could not be identified but may relate to a number of factors including diet in captivity, or starvation after release.

Dibblers were detected occasionally on camera in the release area, indicating multiple individuals were persisting in this area, despite going undetected for long periods. Further confirmation of this came with the capture of a captive-bred female with eight pouch young in May 2021. This was a notable event, since it indicated survival and reproduction amongst the captive-bred cohort, although it is hoped that future surveys will result in more evidence of this. That the female was healthy enough to produce a full complement of eight offspring can also be taken as a promising sign.

8.3 Shark Bay mouse

The translocation of Shark Bay mice to DHI showed some initially positive signs, with a 67% survival rate amongst the radio-collared cohort up to four weeks post-release The majority of these animals remained in the release area and quickly established refuges in *Spinifex longifolius*, which was expected to be core habitat for this species. Some individuals did disperse away from the release area (between 2.5-8.5km) but established refuges in, or were caught in proximity to, good quality habitat.

Unfortunately, the short-term success criteria of ≤30% mortality rate was exceeded (albeit by 3%), with three predations by snakes a major factor in this. Despite planning the translocation for autumn, when reptiles were expected to be less active, weather conditions during the first two weeks post-release were unseasonably warm and humid, which may have promoted reptile activity. After examining data from the

DHI weather station it was found that maximum temperatures for the two-week period from 17 April were, on average, between 2.7 and 3.9°C higher in 2021 than between 2015-2020 (excluding 2019, no data available). There was no evidence of predation by sand monitors (*Varanus gouldii*), which have previously been identified as a predator of translocated Shark Bay mice (Morris and Speldewinde 1995, Speldewinde 1999). Sand monitors are present at the source location on Northwest Island, but no snakes occur there. It is possible that the translocated mice were somewhat naïve to snakes, which may have led to the observed levels of predation. However, no predation of the collared cohort occurred after 10 days post-release, which may indicate a reduction in reptile activity and/or improved predator awareness as animals established home ranges and regular refuge sites. Since several snake species are present on Bernier Island, naivety to these predators in the planned supplementation from this population may be less of a problem.

During the course of the post-release monitoring, new information came to light about the behaviour of Shark Bay mice. Despite rapidly establishing regular refuges, some animals still moved relatively large distances in short periods when (presumably) foraging. In addition, activity periods appear to have a bimodal distribution, with peaks early and late in the night and periods of low activity during the middle of the night. Often activity began before sunset and ceased after sunrise, indicating some individuals are somewhat crepuscular in their activity.

Shark Bay mice were recorded on camera traps using the artificial refuges that were installed in the release area at least four weeks post-release. Some animals that were not observed actually entering or exiting the refuges were recorded regularly in their vicinity. Furthermore, the refuges also provided an indicator of size, allowing easier discrimination of Shark Bay mice from other rodent species that were also recorded. Tracking tunnels showed some promise for monitoring this species but the technique requires some refinement to ensure that tracks of other *Pseudomys* species can be easily discriminated from Shark Bay mouse tracks.

8.4 Greater stick-nest rat

Based on the translocation history of this species, the two main concerns for the translocation of greater stick-nest rats to DHI were ‘hyper-dispersal’ and predation. Aside from releasing in autumn when reptile predators are less active, to mitigate these risks, two novel elements were introduced to the release strategy: 1) capturing all individuals in a nest and releasing them together and 2) releasing animals into an artificial refuge or ‘protonest’ in the box they were transported in. While further investigation is needed to learn how effective these strategies were in their own right, the overall outcome of the translocation so far indicated that there had been some success. There were two mortalities of collared animals, with predators implicated in both and no evidence of capture myopathy found after histopathology analysis. Both animals had full stomachs and were in reasonable body condition when they died, indicating predation as the primary cause. However, one animal was found to have a cataract in at least one of its eyes, which may have predisposed it to predation by a presumed sand monitor.

Four individuals dispersed substantially further from the release area than the other 11. However, all but one had settled after two weeks and all were in good health when recaptured at four to five weeks post-release. Only one of these was released as part of a ‘family’ and was possibly not part of the social group with which it was released. Overall, while the release strategies were not totally successful in eliminating predation and long-distance dispersal, the occurrences were low enough to ensure short-term success criteria around these factors were met.

Protonests were originally established as temporary refuges to assist with predator avoidance and to help promote site fidelity. However, camera traps deployed next to protonests found that many continued to be used and augmented by rats some time after release and these animals were seen displaying a range of social behaviours. Many of these were released as individuals, but usage of ‘family’ protonests beyond the initial release was also high. Cameras recorded a sand monitor on top of one protonest two days post-release, demonstrating why the protonests were constructed, and this same nest continued to be occupied by at least three animals until the week the cameras were serviced. Protonests will continue to be monitored with cameras to see if this behaviour persists. It is hoped that by spring (when reptiles will become more active again), translocated greater stick-nest rats will have established refuges that will offer adequate protection from these potential predators.

Aside from observations of social behaviour on camera, there was other evidence that animals captured and released as individuals quickly established social bonds with conspecifics. Two animals had their collars chewed off and the suggestion (given the condition of one animal captured with a chewed collar) is that this was not due to aggression, but rather social interactions. Given the close capture locations and high density of animals on Salutation Island, it is possible that some individuals were able to re-establish connections with animals from their original social group.

8.5 Extant vertebrate fauna

As in 2019, captures of extant vertebrates were mostly just one species, sandy inland mouse. However, overall capture rates for this species and other rodents were lower than in 2019, indicating that the population had declined after a ‘boom’. With natural population fluctuations such as these, it is hard to draw conclusions on the overall dynamics of the populations and the underlying causes. However, the consistently increasing numbers of little long-tailed dunnarts may be a better indication that the island’s ecosystems are recovering after the eradications of sheep, goats and feral cats. Monitoring will continue in October 2021, which will provide five years’ data, that can be compared with five years’ pre-eradication data.

Previous fauna reconstruction reports have recommended ongoing monitoring of large raptors on the island (Cowen *et al.* 2018, Cowen *et al.* 2019, Cowen *et al.* 2020). Both wedge-tailed eagles (*Aquila audax*) and white-bellied sea-eagles (*Haliaeetus leucogaster*) were recorded on DHI in 2020-21 but their abundance does not appear to have changed discernibly and wedge-tailed eagles in particular do not seem to be resident anywhere on the island. General monitoring of these species in particular will continue to see if any changes emerge in abundance and behaviour but at present these species do not seem to represent a major risk to translocated fauna populations. Owls have been implicated as predators of both Shark Bay mice and greater stick-nest rats (Short *et al.* (2019); Australian Wildlife Conservancy (unpublished report)) but were not recorded at all on DHI in 2020-21, although it is possible that Australian boobooks (*Ninox boobook*) and eastern barn owls (*Tyto javanica*) are present in low densities.

8.6 Hare-wallabies

Extraction and analysis of faecal DNA needs to be completed before estimates of density and abundance of banded and rufous hare-wallabies on DHI can be derived. However, based on the large number of scats collected during surveys in 2020, these species appear to be doing well. Incidental records indicate that the extent of occurrence for rufous hare-wallabies is approximately 75% of the island's area, while the approximate extent of occurrence for banded hare-wallabies is >35%. The discovery that banded hare-wallabies have now dispersed well north of the Tetradon Loop dune system is another positive indication about the health of this species' population on the island.

Rufous hare-wallabies are often encountered on the island's roads at night, putting these individuals at risk of vehicle strikes. In 2020-21, four occurrences of vehicle strikes were recorded, but many more may have gone unnoticed. Signage is present south of the management fence to encourage road users to slow down and be aware of hare-wallabies between dusk and dawn and more signs are to be installed elsewhere. However, there may be a need to provide more information to visitors to the island about the need to drive slowly at night or to avoid doing it altogether. It is probably impractical to try and avoid vehicle strikes entirely, but during a period of peak visitation to the island (at least partly due to the COVID-19 pandemic inhibiting overseas travel) it is important to ensure the risk is minimised, not least because of the conservation status of this taxon (Vulnerable under both WA and Commonwealth legislation). It appears that the population of rufous hare-wallabies on DHI is doing well but as the population continues to increase, vehicle strikes are likely to become more frequent and may also affect other species such as banded hare-wallabies, Shark Bay bandicoots, boodies and woylies. Establishing an effective management strategy for traffic on the island early on will hopefully avoid more problems in future.

8.7 Planning for 2021-22

Three translocations are planned for 2021-22, all of them supplementations. A third cohort of dibblers from the Perth Zoo breeding program is planned for release in October 2021, including a trial 'delayed release' to improve site fidelity at the release site. Release sites will focus on the coastal vegetation community at Herald Bay where all recent detections have occurred.

Further supplementations of Shark Bay mice and greater stick-nest rats are planned from Bernier Island, and East and West Franklin Islands (South Australia), respectively. The Shark Bay mouse supplementation in April 2022 will be dependent on the success of spring monitoring on DHI and the results of pre-harvest monitoring on Bernier Island. Based on the results of the greater stick-nest rat translocation from Salutation Island, a new Translocation Proposal will be drafted for approval by both WA and South Australian state government signatories. Assuming approval is obtained and source numbers are sufficient, this translocation is planned for May 2022.

A provisional schedule for translocation and monitoring work is outlined in Table 8.

Table 8. Provisional program for translocations and monitoring on DHI in 2021-22.

Year	Month	Activity on DHI
2021	Jul	
	Aug	
	Sep	monitoring of GSNR and SBM
	Oct	translocation of Dibblers; small vertebrate monitoring
	Nov	monitoring of Dibblers
	Dec	
2022	Jan	
	Feb	
	Mar	
	Apr	monitoring, translocation and post-release monitoring of SBM
	May	translocation of GSNR; monitoring of SBB and Dibblers
	Jun	post-release monitoring of GSNR

Appendices

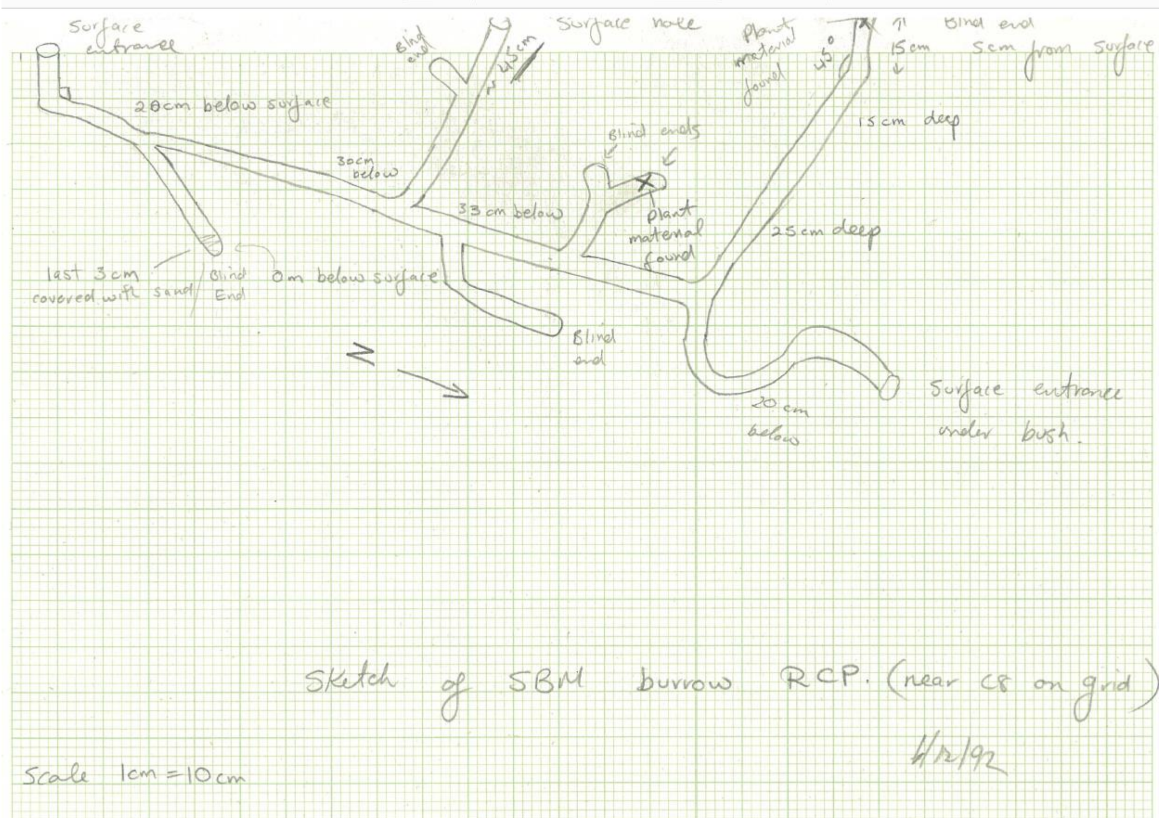
Appendix 1

Results of trapping sessions in November 2020 and May 2021 for Shark Bay bandicoots

Session		Barge Landing	Weather Station	Garys Beach	**Total**
November 2020	Total captures	49	43	19	**111**
	Trap success	10.2%	8.9%	11.8%	**9.9%**
	Total SBB captures	0	9	6	**15**
	Trap success SBB	0	1.9%	3.7%	**1.3%**
	No. new SBB	0	2	1	**3**
	% adult female reproductively active (lactating or with pouch young)	0	100	100	**100**
	Average weight of adult males	n/a	228.3	242.7	**235.5**
May 2021	Total captures	404	317	101	**822**
	Trap success	84.2%	66%	63.1	**73.4%**
	No. SBB individuals	0	18	10	**28**
	Trap success SBB	0	8.5%	12.5%	**5.4%**
	No. new SBB	0	12	8	**20**
	% adult female reproductively active (lactating or with pouch young)	0	100	100	**100**
	Average weight of adult males	n/a	218.1	231.6	**223.8**

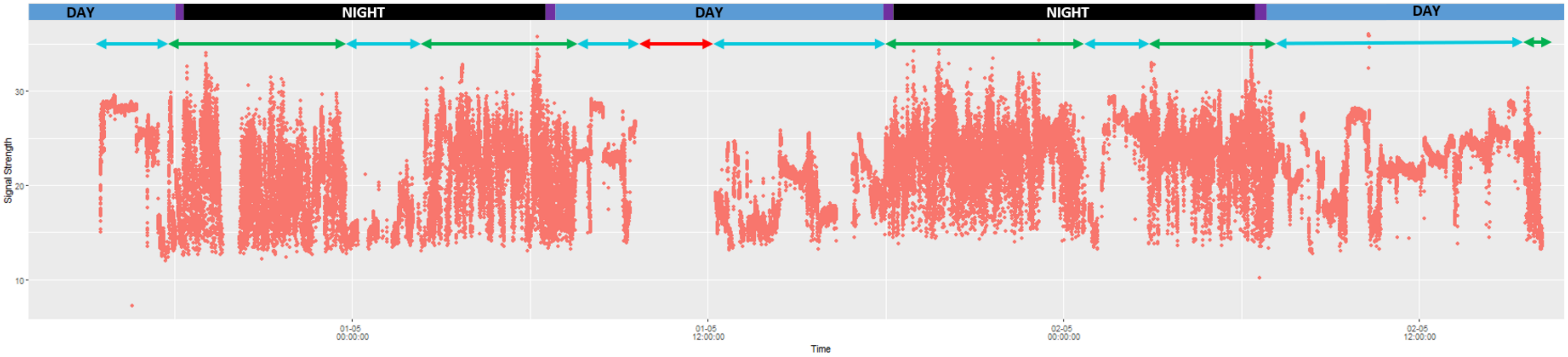
Appendix 2

Images of artificial refuges for Shark Bay mice ('Pseud-homys') and diagram of excavated burrow on Bernier Island (from P. Speldewinde, unpublished data).



Appendix 3

Plots of time vs. signal strength for an individual collared Shark Bay mouse, showing variation in activity with time of day. Data derived from passive VHF logger tower using the Analysis Web App (radio-tracking.eu, (Gottwald *et al.* 2019)).



Appendix 4

List of small vertebrate captures during trapping surveys conducted in October 2020.

Family	Species	Common name	Individual captures
Agamidae	*Ctenophorus butlerorum*	Shark Bay heath dragon	7
	Ctenophorus maculatus	Spotted military dragon	16
Carphodactylidae	*Nephurus levis*	Smooth knob-tailed gecko	26
Diplodactylidae	*Crenadactylus ocellatus*	South-western clawless gecko	1
	Diplodactylus ornatus	Ornate gecko	28
	Strophurus spinigerus	Soft spiny-tailed gecko	34
Gekkonidae	*Gehyra variegata*	Variegated dtella	9
	Heteronotia binoei	Bynoe's gecko	1
Pygopodidae	*Aprasia haroldi*	Shark Bay worm-lizard	12
	Delma butleri	Spinifex delma	3
	Lialis burtoni	Burton's legless lizard	2
Scincidae	*Ctenotus australis*	West coast long-tailed ctenotus	9
	Ctenotus fallens	West coast ctenotus	17
	Ctenotus sp.		1
	Cyclodomorphus celatus	Western slender blue-tongue	1
	Lerista elegans	Elegant slider	32
	Lerista lineopunctulata	Line-spotted robust slider	5
	Lerista planiventralis	Keeled slider	24
	Lerista praepedita	West coast worm-slider	7
	Lerista varia	Variable-striped robust slider	10
	Morethia lineoocellata	Pale-flecked snake-eyed skink	24
Varanidae	*Varanus gouldii*	Sand monitor	2
Elapidae	*Demansia calodera*	Black-necked whipsnake	1
	Neelaps bimaculatus	Black-naped snake	2
	Pseudechis australis	Mulga snake	1
	Pseudonaja mengdeni	Western brown snake	1
	Simoselaps littoralis	West coast banded snake	17
Pythonidae	*Antaresia stimsoni*	Stimson's python	1
Typhlopidae	*Anilios australis*	Southern blind snake	4
Dasyuridae	*Sminthopsis dolichura*	Little long-tailed dunnart	61
Muridae	*Pseudomys albocinereus*	Ash-grey mouse	97
	Pseudomys hermannsburgensis	Sandy inland mouse	290
	Mus musculus	House mouse	19

Appendix 5

List of incidental sightings between July 2020 and June 2021, in addition to those collated through remote cameras and trapping.

Common name	Scientific name	Incidental sighting	Remote camera	Trapped
Shield shrimp	*Triops australiensis*	X		
Loggerhead turtle	*Caretta caretta*	X		
Green turtle	*Chelonia mydas*	X		
South-western clawless gecko	*Crenadactylus ocellatus*	X		X
Ornate gecko	*Diplodactylus ornatus*			X
Variegated dtella	*Gehyra variegata*	X		X
Bynoe's gecko	*Heteronotia binoei*	X		X
Smooth knob-tailed gecko	*Nephrurus levis*	X	X	X
Soft spiny-tailed gecko	*Strophurus spinigerus*	X		X
Barking gecko	*Underwoodisaurus milii*	X		
Shark Bay worm-lizard	*Aprasia haroldi*			X
Spinifex delma	*Delma butleri*			X
Burton's legless lizard	*Lialis burtonis*	X		X
Keeled legless lizard	*Pletholax gracilis*	X		
Peron's snake-eyed skink	*Cryptoblepharus plagiocephalus*	X		
West Coast long-tailed ctenotus	*Ctenotus australis*	X		X
West Coast ctenotus	*Ctenotus fallens*	X		X
Western Slender blue-tongue	*Cyclodomorphus celatus*			X
Western spiny-tailed skink	*Egernia stokesii subsp. badia*	X		
Elegant slider	*Lerista elegans*	X		X
Line-spotted robust slider	*Lerista lineopunctulata*			X
Keeled slider	*Lerista planiventralis*			X
West coast worm-slider	*Lerista praepedita*			X
Variable-striped robust slider	*Lerista varia*			X
Pale-flecked snake-eyed skink	*Morethia lineoocellata*			X
Bobtail	*Tiliqua rugosa*	X	X	
Shark Bay heath dragon	*Ctenophorus butlerorum*	X		X
Spotted military dragon	*Ctenophorus maculatus*	X		X
Western netted dragon	*Ctenophorus reticulatus*	X		
Dwarf bearded dragon	*Pogona minor*	X	X	
Sand monitor	*Varanus gouldii*	X	X	X
Black-necked whipsnake	*Demansia calodera*	X		X
Yellow-faced whipsnake	*Demansia psammophis*	X		
Black-naped snake	*Neelaps bimaculatus*			X
Mulga snake	*Pseudechis australis*	X		X
Western brown snake	*Pseudonaja mengdeni*			X
West Coast banded snake	*Simoselaps littoralis*	X		X
Stimson's python	*Antaresia stimsoni*	X		X
Southern blind snake	*Anilios australis*			X
Brown quail	*Coturnix ypsilophora*	X		
Grey teal	*Anas gracilis*	X		
Pacific black duck	*Anas superciliosa*	X		
Australian shelduck	*Tadorna tadornoides*	X		
Wedge-tailed shearwater	*Puffinus pacificus*	X		
Australasian gannet	*Sula serrator*	X		
Little pied cormorant	*Phalacrocorax melanoleucos*	X		
Little black cormorant	*Phalacrocorax sulcirostris*	X		
Pied cormorant	*Phalacrocorax varius*	X		
Australian pelican	*Pelecanus conspicillatus*	X		
White-faced heron	*Ardea novaehollandiae*	X		
Eastern reef egret	*Ardea sacra*	X		
Eastern osprey	*Pandion cristatus*	X	X	
White-bellied sea-eagle	*Haliaeetus leucogaster*	X		

Common name	Scientific name	Incidental sighting	Remote camera	Trapped
Wedge-tailed eagle	*Aquila audax*	X		
Little eagle	*Aquila morphnoides*	X		
Nankeen kestrel	*Falco cenchroides*	X	X	
Buff-banded rail	*Gallirallus philippensis*	X		
Australian bustard	*Ardeotis australis*	X	X	
Bush stone-curlew	*Burhinus grallarius*	X		
Painted button-quail	*Turnix varia*	X	X	
Bar-tailed godwit	*Limosa lapponica*	X		
Eastern curlew	*Numenius madagascariensis*	X		
Eurasian whimbrel	*Numenius phaeopus*	X		
Grey-tailed tattler	*Tringa brevipes*	X		
Common greenshank	*Tringa nebularia*	X		
Ruddy turnstone	*Arenaria interpres*	X		
Common sandpiper	*Actitis hypoleucos*	X		
Sharp-tailed sandpiper	*Calidris acuminata*	X		
Sanderling	*Calidris alba*	X		
Red-necked stint	*Calidris ruficollis*	X		
Sooty oystercatcher	*Haematopus fuliginosus*	X		
Pied oystercatcher	*Haematopus longirostris*	X		
White-headed stilt	*Himantopus leucocephalus*	X		
Red-capped plover	*Charadrius ruficapillus*	X		
Red-kneed dotterel	*Erythrogonys cinctus*	X		
Banded lapwing	*Vanellus tricolor*	X		
Silver gull	*Larus novaehollandiae*	X		
Pacific gull	*Larus pacificus*	X		
Lesser crested tern	*Sterna bengalensis*	X		
Crested tern	*Sterna bergii*	X		
Caspian tern	*Sterna caspia*	X		
Gull-billed tern	*Sterna nilotica*	X		
Laughing dove	*Spilopelia senegalensis*	X	X	
Horsfield's bronze-cuckoo	*Chrysococcyx basalis*	X		
Spotted nightjar	*Eurostopodus argus*		X	
Purple-backed fairywren	*Malurus assimilis*	X	X	
White-winged fairywren	*Malurus leucopterus* subsp. *leucopterus*	X	X	
Southern emu-wren	*Stipiturus malachurus* subsp. *hartogi*	X		
Rufous fieldwren	*Calamanthus campestris* subsp. *hartogi*	X	X	
Spotted scrubwren	*Sericornis maculatus*	X	X	
Spiny-cheeked honeyeater	*Acanthagenys rufogularis*	X		
Singing honeyeater	*Lichenostomus virescens*	X	X	
Pied honeyeater	*Certhionyx variegatus*	X		
White-fronted chat	*Epthianura albifrons*	X	X	
Crested bellbird	*Oreoica gutturalis*	X		
Willie wagtail	*Rhipidura leucophrys*	X		
Black-faced cuckoo-shrike	*Coracina novaehollandiae*	X		
Black-faced woodswallow	*Artamus cinereus*	X	X	
Little woodswallow	*Artamus minor*	X		
Pied butcherbird	*Cracticus nigrogularis*	X		
Grey butcherbird	*Cracticus torquatus*	X	X	
Little crow	*Corvus bennetti*	X	X	
Australian pipit	*Anthus australis*	X	X	
Zebra finch	*Taeniopygia guttata*	X		
Welcome swallow	*Hirundo neoxena*	X		
Tree martin	*Hirundo nigricans*	X		
Brown songlark	*Cincloramphus cruralis*	X		
Silvereye	*Zosterops lateralis*	X		
Dibbler	*Parantechinus apicalis*	X	X	X
Little long-tailed dunnart	*Sminthopsis dolichura*		X	X
Shark Bay bandicoot	*Perameles bougainville*	X	X	X
Rufous hare wallaby	*Lagorchestes hirsutus*	X	X	

Common name	Scientific name	Incidental sighting	Remote camera	Trapped
Banded hare-wallaby	*Lagostrophus fasciatus*	X	X	
Greater stick-nest rat	*Leporillus conditor*	X		X
House mouse	*Mus musculus*	X		X
Ash-grey mouse	*Pseudomys albocinereus*	X	X	X
Shark Bay mouse	*Pseudomys fieldi*	X	X	X
Sandy inland mouse	*Pseudomys hermannsburgensis*	X	X	X
Dugong	*Dugong dugon*	X		
Humpback whale	*Megaptera novaeangliae*	X		
Orca	*Orcinus orca*	X		
Bottlenose dolphin	*Tursiops aduncus*	X		

Appendix 6

Algar, D., K. Morris, J. Asher and S. Cowen (2020). Dirk Hartog Island 'Return to 1616' Project – The first six years (2014 to 2019). *Ecological Management & Restoration* **21**(3): 173-183 https://doi.org/10.1111/emr.12424

doi: 10.1111/emr.12424

FEATURE

Dirk Hartog Island 'Return to 1616' Project – The first six years (2014 to 2019)

By Dave Algar, Keith Morris, John Asher and Saul Cowen

Early European land use of Dirk Hartog Island left a legacy of cats, sheep and goats that led to the local extinction of 10 of the Dirk Hartog Island's 13 mammal species. A successful programme of eradication of these introduced species has resulted in improved habitat quality and is allowing the translocation of the island's locally extinct native mammals. The island could potentially support one of the most diverse small-medium-sized terrestrial mammal assemblages in Australia and contribute significantly to their long-term conservation.

Key words: *ecological restoration, feral cats, goats, island eradication, native species reintroductions, sheep.*

***Dave Algar, Keith Morris** and **Saul Cowen** are scientists in the Animal Science Program with the Department of Biodiversity, Conservation and Attractions (Locked Bag 104, Bentley Delivery Centre, Western Australia 6983, Email: dave.algar@dbca.wa.gov.au; Tel: +61 (0) 8 94055145). **John Asher** is the Manager, Ecosystem Health Branch with the Department of Biodiversity, Conservation and Attractions (PO Box 1693, Bunbury, Western Australia 6231). This paper provides an overview of a successful eradication campaign for feral cats, sheep and goats on Dirk Hartog Island, Western Australia, which has enabled the reintroduction of a number of locally extinct native mammals..*

Figure 1. Tetrodon Loop, a bay on the east coast, encircled by Quoin Bluff South and Notch Point. (Photo John Asher). [Colour figure can be viewed at wileyonlinelibrary.com]

Introduction

Dirk Hartog Island (DHI) is Western Australia's largest island, located within the Shark Bay World Heritage Area on the far western edge of the Australian continent (Fig. 1). It covers an area of 633 km^2 measuring almost 80 km long and 11 km wide, with the southern point of the island located 1.5 km from the Australian mainland (Fig. 2).

The climate of the region is semi-desert Mediterranean with a mean annual rainfall approximately 224 mm. Most rain usually falls in winter, when mid-winter mean maximum temperatures can be a little over 20°C with a mid-summer mean maximum of 31.8°C (Bureau of Meteorology 2018; long-term records 1893–2018).

Land use history

Given the island's rich fauna and diverse flora (Boxes 1 and 2), Indigenous occupation (or at least visitation) of the island may have occurred prior to 3000 BP when it is thought the island may have been connected to the mainland, although no occupation sites have been located post-contact (Abbott & Wills 2016).

Appendix 7

Sims, C., K. Rayner, F. Knox and S. Cowen (2020). A trial of transmitter attachment methods for Shark Bay bandicoots (*Perameles bougainville*). Australian Mammalogy https://doi.org/10.1071/AM20035

CSIRO PUBLISHING

Australian Mammalogy
https://doi.org/10.1071/AM20035

Research Note

A trial of transmitter attachment methods for Shark Bay bandicoots (*Perameles bougainville*)

Colleen Sims[A], *Kelly Rayner*[A], *Fiona Knox*[B] and *Saul Cowen*[A,C,D]

[A]Department of Biodiversity, Conservation and Attractions, Biodiversity and Conservation Science, Locked Bag 104, Bentley, WA 6983, Australia.
[B]School of Veterinary Medicine, College of Science, Health, Engineering and Education, Murdoch University, Murdoch, WA 6150, Australia.
[C]School of Biological Sciences, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia.
[D]Corresponding author. Email: saul.cowen@dbca.wa.gov.au

Abstract. In mammal reintroductions, effective post-release monitoring often relies on the use of radio-transmitters. Collars are a popular attachment technique but are not necessarily appropriate for all taxa. However, other attachment methods may result in substantially reduced monitoring durations. We assessed several transmitter types for the Shark Bay bandicoot (*Perameles bougainville*), aiming to optimise animal welfare and attachment duration. Collars (fitted under general anaesthetic) were considered the optimal method and 12 bandicoots were collared and monitored as part of a reintroduction program. We found that our collars permitted monitoring for up to seven weeks, while causing minimal harm to the animals.

Keywords: animal welfare, attachment duration, collar attachment, collar design, *Perameles bougainville*, radio-transmitter, Shark Bay bandicoots, wildlife monitoring.

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Introduction

The IUCN/SSC (2013) guidelines for wildlife reintroductions highlight the importance of effective monitoring, including behavioural, ecological and mortality monitoring, to assess whether reintroduction objectives are being achieved. Radio transmitter systems are tools that have commonly been used to achieve these monitoring goals (White and Garrott 1990; Short *et al.* 1992; Mech and Barber 2002; Matthews *et al.* 2013). Attachment of these devices using collars is a popular technique, but for some species this method can be challenging. In the case of the ≤1000-g eastern barred bandicoot (*Perameles gunnii*), collars have proven problematic for animal welfare and survival (Seebeck and Booth 1996) and extensive trials of attachment techniques have been conducted to establish the optimal method (Coetsee *et al.* 2016).

The closely related Shark Bay bandicoot (*Perameles bougainville*) (SBB) (formerly western barred bandicoot: Travouillon and Phillips 2018) is substantially smaller, weighing just 219 g, on average (Short *et al.* 1998). Collars have been used to monitor wild SBB in the past but with adverse results such as entanglement, capture myopathy and neck ulceration (Moseby 2001; Richards and Short 2003; Moseby *et al.* 2018). However, others have collared SBB with few apparent issues (Friend and Beecham 2004).

The aim of this trial was to identify an optimal method of transmitter attachment for SBB in captivity and then apply this during the intensive monitoring program of a full-scale reintroduction to assess its efficacy.

Methods

Two adult male SBB were captured at White Beach on Dorre Island, Western Australia, on 4 May 2019 and transferred by charter vessel to Carnarvon, then by road to Native Animal Rescue in Malaga, Perth. They were housed separately in concrete-floored enclosures (3.0 × 2.0 × 1.8–2.2 m), fully covered on three sides and roof, with one wire mesh side and managed under strict quarantine protocols. Enclosure setup included clean 'washed' sand, fresh cut branches, and a wooden nest box (20 × 20 × 40 cm). Bandicoots were given four weeks to adjust to captivity and stabilise body weight (BW) before trials commenced. Two Bushnell Trophy cameras were placed in each enclosure and set to record 20–30 s of video per trigger from 1730 to 0730 hours each night.

Several different two-stage VHF transmitters with mortality function were evaluated to find the most appropriately designed package that could be obtained from various suppliers (Table 1). The two lightest and least bulky transmitters were chosen for trial and fitted under general anaesthesia (GA), which was induced and maintained (20–30-min duration) via face-mask using isoflurane in oxygen. The smaller animal (219 g) was fitted with the Holohil RI-2DM transmitter (8 g or 3.7% of BW) (Fig. 1). The second animal (238 g) was fitted with an Advanced Telemetry Systems M1515 transmitter (10 g or 4.2% of BW). Both transmitters were

Appendix 8

Cowen, S. and C. Sims (2021). Conservation translocation of banded and Shark Bay rufous hare-wallaby to Dirk Hartog Island, Western Australia. Global conservation translocation perspectives: 2021: Case studies from around the globe.https://iucn-ctsg.org/project/global-conservation-translocation-perspectives-2021/

Conservation translocation of banded and Shark Bay rufous hare-wallaby to Dirk Hartog Island, Western Australia

Saul Cowen & Colleen Sims

Biodiversity and Conservation Science, Western Australian Department of Biodiversity, Conservation and Attractions, 37 Wildlife Place, Woodvale, Western Australia, Australia
saul.cowen@dbca.wa.gov.au; colleen.sims@dbca.wa.gov.au

Introduction

The Banded hare-wallaby (*Lagostrophus fasciatus fasciatus*) and Shark Bay rufous hare-wallaby (*Lagorchestes hirsutus bernieri*) are two small macropodid marsupials, listed as Vulnerable by the IUCN and under Australian Commonwealth and Western Australian state legislation. Although similar in appearance and behavior, these species are not closely related, with banded hare-wallabies the sole-living representative of the subfamily Lagostrophinae. Both taxa disappeared from the Australian mainland after European occupation, at least partially as a result of predation by non-native Red foxes (*Vulpes vulpes*) and Feral cats (*Felis catus*) (Woinarski *et al.*, 2012), and the only remaining natural populations were found on Bernier and Dorre Islands in Shark Bay, Western Australia.

Subsequently, Banded hare-wallabies have been successfully translocated to Faure Island (also in Shark Bay) and Australian Wildlife Conservancy's Mt. Gibson Sanctuary, but the Shark Bay subspecies of Rufous hare-wallaby has never been translocated. Dirk Hartog Island is a large island (63,300 ha) in Shark Bay and while there are anecdotal reports that both taxa previously occurred there, no physical evidence (historical or subfossil specimens) were ever obtained. The successful eradication of Sheep (*Ovis aries*), Goats (*Capra hircus*) and Feral cats from Dirk Hartog Island by 2017 represented an opportunity to establish new populations of both taxa.

Banded hare-wallaby on Bernier Island © DBCA

Goals

- Establish new populations of both Banded and Rufous hare-wallabies.
- Maximize genetic

Appendix 9

Vaughan-Higgins, R. J., S. D. Vitali, C. Sims, M. Page and A. Reiss (2021). Streamlining Disease Risk Analysis for Wildlife Using the Shark Bay Bandicoot as a Model. *Ecohealth* https://doi.org/10.1007/s10393-021-01521-3

EcoHealth
https://doi.org/10.1007/s10393-021-01521-3

ECOHEALTH

Original Contribution

Streamlining Disease Risk Analysis for Wildlife Using the Shark Bay Bandicoot as a Model

Rebecca J. Vaughan-Higgins,[1,2] Simone D. Vitali,[2] Colleen Sims,[3] Manda Page,[4] and Andrea Reiss[5]

[1]*Conservation Medicine Program, College of Veterinary Medicine, School of Veterinary and Life Sciences, Murdoch University, South Street, Murdoch, WA 6150, Australia*
[2]*Veterinary Department, Perth Zoo, 20 Labouchere Rd, South Perth, WA 6151, Australia*
[3]*Biodiversity and Conservation Science Division, Department of Biodiversity Conservation and Attractions, Woodvale Wildlife Research Centre, Wildlife Place, Woodvale 6026, Australia*
[4]*Biodiversity and Conservation Science Division, Department of Biodiversity, Conservation and Attractions, 17 Dick Perry Avenue, Technology Park Western Precinct, Kensington 6151, Australia*
[5]*Wildlife Health Australia, Suite E, 34 Suakin Drive, Mosman, NSW 2088, Australia*

Abstract: Disease risk analysis (DRA) is a process for identifying significant disease risks and proposing measures to mitigate those risks. Although numerous methodologies for DRA exist, the IUCN Disease Risk Analysis Manual Jakob-Hoff et al. (World Organisation for Animal Health, Paris, pp 160, 2014) remains the gold standard for wild animal translocations. In some cases, however, constraints of time or resources demand compromises on the ideal methodology, and a cost–benefit assessment is required to determine the best approach. We propose a methodology modified from Jakob-Hoff et al. (World Organisation for Animal Health, Paris, pp 160, 2014) and Sainsbury and Vaughan-Higgins (Conserv Biol 26:442–452, 2012), using translocations of the Shark Bay bandicoot (SBB) (*Perameles bougainville)* as an example. In this study, 44 hazards were identified and described for *Peramelidae* species. We used hazard prioritization and "scoping" to develop a shortlist of hazards for detailed risk assessment, which excluded 35 of these hazards from further assessment. This approach enabled timely, efficient and cost-effective completion of the DRA while maintaining transparent evaluation of all disease risks. We developed a disease risk management strategy for SBB based on structured, evidence-based analysis of current information and established biosecurity practices and disease screening recommendations for future translocations. Our approach demonstrates a practical process for DRA and risk mitigation, which delivered management outcomes despite limited resources, variable knowledge of disease epidemiology and uncertain translocation pathways for the target species. Limitations are acknowledged, and further research will aim to objectively test this methodology compared to other available methods.

Keywords: Disease risk analysis, Risk assessment, Conservation, Translocation, Marsupial

Correspondence to: Rebecca J. Vaughan-Higgins, e-mail: R.Vaughan-Higgins@murdoch.edu.au

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Appendix 10

Peterson K., M. Barnes, C. Jeynes-Smith, S. Cowen S, L. Gibson, C. Sims, C. Baker and M. Bode (2021). Reconstructing lost ecosystems: a risk analysis framework for planning multispecies reintroductions under severe uncertainty. *Journal of Applied Ecology* https://doi.org/10.1111/1365-2664.13965

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RESEARCH ARTICLE

Journal of Applied Ecology

Reconstructing lost ecosystems: A risk analysis framework for planning multispecies reintroductions under severe uncertainty

Katie A. Peterson[1,2,3] | Megan D. Barnes[4] | Cailan Jeynes-Smith[1] | Saul Cowen[4,5] | Lesley Gibson[4,5] | Colleen Sims[4] | Christopher M. Baker[6,7,8] | Michael Bode[1]

[1]School of Mathematical Sciences, Queensland University of Technology, Brisbane, Qld, Australia
[2]ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Qld, Australia
[3]National Socio-Environmental Synthesis Center, University of Maryland, Annapolis, MD, USA
[4]Biodiversity and Conservation Science, Western Australian Department of Biodiversity, Conservation and Attractions, Perth, WA, Australia
[5]School of Biological Sciences, The University of Western Australia, Perth, WA, Australia
[6]School of Mathematics and Statistics, The University of Melbourne, Melbourne, Vic., Australia
[7]Melbourne Centre for Data Science, The University of Melbourne, Melbourne, Vic., Australia
[8]Centre of Excellence for Biosecurity Risk Analysis, The University of Melbourne, Melbourne, Vic., Australia

Correspondence
Katie A. Peterson and Megan D. Barnes
Email: katie.peterson@my.jcu.edu.au; megan.barnes@dbca.wa.gov.au

Handling Editor: Joseph Bennett

Abstract

1. Reintroduction projects, which are an important tool in threatened species conservation, are becoming more complex, often involving the translocation of multiple species. Ecological theory predicts that the sequence and timing of reintroductions will play an important role in their success or failure. Following the removal of sheep, goats and feral cats, the Western Australian government is sequentially reintroducing 13 native fauna species to restore the globally important natural and cultural values of Dirk Hartog Island (DHI).
2. We use ensembles of ecosystem models to compare 23 alternative reintroduction strategies on DHI, in Western Australia. The reintroduction strategies differ in the order, timing and location of releases on the island. Expert elicitation informed the model structure, allowing for use of different presumed species interaction networks which explicitly incorporated uncertainty in ecosystem dynamics.
3. Our model ensembles predict that almost all of the species (~12.5 of 13, on average) will successfully establish in the ecosystem studied, regardless of which reintroduction strategy is undertaken. The project can therefore proceed with greater confidence and flexibility regarding the reintroduction strategy. However, the identity of the at-risk species varies between strategies, and depends on the structure of the species interaction network, which is quite uncertain. The model ensembles also offer insights into why some species fail to establish on DHI, predicting that most unsuccessful reintroductions will be the result of competitive interactions with extant species.
4. *Synthesis and applications*. Our model ensembles allow for the comparison of outcomes between reintroduction strategies and between different species interaction networks. This framework allows for inclusion of high uncertainty in dynamics. Finally, an ensemble modelling approach also creates a foundation for formal adaptive management as reintroduction projects proceed.

KEYWORDS
ecological modelling, fauna reconstruction, island conservation, reintroduction ecology, species interaction networks, threatened species, translocation

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