

The eradication of the black rat (*Rattus rattus*) on Barrow and adjacent islands off the north-west coast of Western Australia

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Abstract The black rat (*Rattus rattus*) has been introduced to many islands around the world and has been shown to have a detrimental impact on a wide range of fauna. It is known from about 1% of Australian Islands, of which many are adjacent to the Western Australian Pilbara or Kimberley coasts. Rats were accidentally introduced to these islands in the late 1800s by the pearling industry. Barrow and adjacent islands are nature reserves with significant conservation value, particularly for threatened mammals. Rats were known to inhabit the six smaller adjacent islands, but it was not until 1990 that they were located on the south end of Barrow Island. Eradication programmes on North and South Double, Boomerang, Pasco and Boodie Islands in 1983-1986 have been successful, but most of these islands had no non-target mammals. Seven mammals were considered to be at risk from an oat-based baiting programme on Barrow Island. Barrow Island was also considerably larger than other islands where successful eradication had occurred (23,000 ha vs 5 ha - 1000 ha). The rats on the smaller islands, without non-target mammals, were successfully eradicated using oats impregnated with the anticoagulant Pindone. Baits were laid on the ground in a 25 m grid. On Boodie Island unsuccessful attempts were made at covering the oat baits to prevent access by the threatened burrowing bettong (*Bettongia lesueur*). While the rats were eradicated, the bettongs also disappeared. They have since been successfully re-introduced and their abundance is well above pre-baiting levels. Fortunately on Barrow Island, the rats were present only in 245 ha at the south end of the large island. A bait station was designed that allowed climbing access by the black rats (and native rodents) but prevented access by other native mammals. These bait stations were set on a 25m grid throughout the area where the rats occurred. This eradication programme has been successful and the native rodents have since re-invaded the area. These bait stations were also used to eradicate rats on Middle Island where the threatened golden bandicoot (*Isodon auratus barrowensis*) occurs. Abundances of golden bandicoots increased following rat eradication suggesting that rats may have suppressed bandicoot numbers. Monitoring of these reserves is continuing.

Keywords Barrow Island; black rat, *Rattus rattus*; eradication; non-target mammals; island management.

INTRODUCTION

The black rat (*Rattus rattus*) has been introduced to many islands around the world and has been shown to have a detrimental impact on a wide range of fauna, including native birds (Atkinson 1977, 1985; Taylor 1979; Moller 1983), reptiles and invertebrates (Ramsay 1978; Whitaker 1978). It is the most widely distributed introduced rodent on Australian islands, being recorded on 78 of the 8296 islands identified in Abbott and Burbidge (1995). In Western Australia it is known from 40 islands, most of which are near the Pilbara and Kimberley coasts. Black rats were accidentally introduced to many of these after the 1860s from shipwrecks, and the pearling industry, which made extensive use of the islands' bays for camping and careening vessels. Burbidge *et al.* (1997) did not find a relationship between the presence of rats and mammal extinctions; however, a more recent analysis (Burbidge and Manly 2002) does support such a link. Mammal declines and extinctions in the presence of rats include the burrowing bettong (*Bettongia lesueur*) on Boodie Island, nabarlek (*Petrogale concinna*) on Sunday Island, and the bush rat (*Rattus fuscipes*) and a native rodent (*Pseudomys* sp.) on Woody Island (Burbidge and Manly 2002). Black rats are also well-known as an exterminator of small ground-nesting seabirds - examples from Western Australia include the common noddy (*Anous stolidus*) and sooty tern (*Sterna*

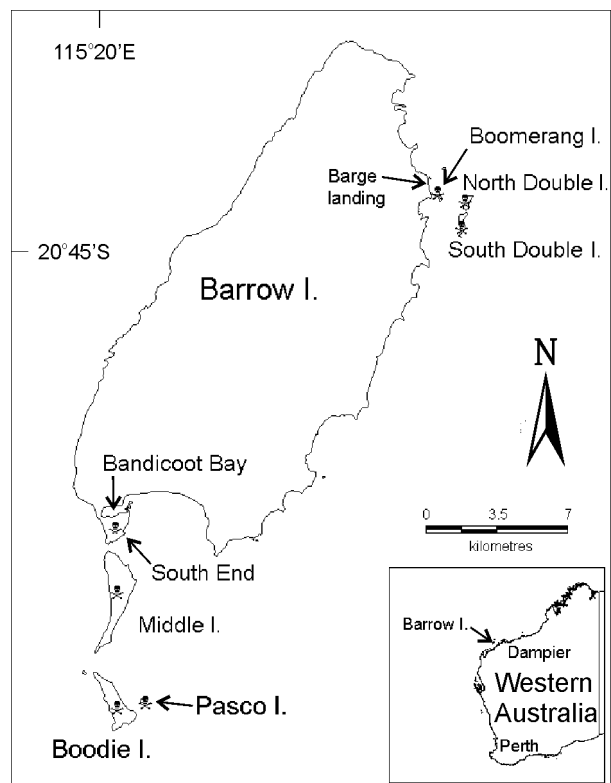


Fig. 1 The location of Barrow and adjacent islands off the north-west coast of Western Australia.

fuscata) from Rat Island (Houtman Abrolhos), and common noddy from Bedout Island and the Lacepede Islands (Tunney 1902; A.A. Burbidge pers. comm.).

Barrow Island and the adjacent six islands (Fig. 1) are nature reserves with significant conservation value, particularly for threatened mammals, and turtle and seabird nesting. Eleven terrestrial mammals are known from Barrow Island, with six of these listed as threatened species under the WA *Wildlife Conservation Act 1950* (Abbott and Burbidge 1995; Butler 1970, 1975). Three species of marine turtle and at least twelve species of seabird nest on Barrow and adjacent Islands. Seventeen species of migratory wader use the beaches and shallows for feeding and resting. In the 1890s the waters around Barrow Island were fished extensively for pearls and pearl shell, and the beaches and bays were used for camps and careening of vessels. Since 1964, Barrow Island has been a producing oilfield and up to 150 people now live and work on the island.

Black rats were first recorded on Double Island in 1918 (Whitlock 1918) and on Barrow Island in 1976 (Kitchener and Vicker 1981). However, the Barrow Island record was from a white-bellied sea eagle nest adjacent to Double Island and it was believed to have come from Double Island rather than Barrow Island. In 1983, an inspection of the islands adjacent to Barrow confirmed the presence of black rats on North and South Double, Boomerang (which connects to Barrow at low tide), Pasco, Boodie and Middle islands. Extensive trapping on Barrow along the east coast near Boomerang did not find evidence that black rats occurred on that part of Barrow Island. However, in 1990 a black rat was trapped at the south end of Barrow, near Middle Island. Given that there were pearling camps in this area (H. Butler pers. comm.), it is likely that the rats were introduced from careened pearling vessels 100 years earlier.

Following the successful eradication of black rats on Bedout Island in 1981, using pindone-impregnated oat baits (Morris 1989), an eradication programme commenced on the smaller islands around Barrow Island in 1983. The islands without non-target mammals (North and South Double Islands and Pasco Islands) were baited first. Boomerang Island, which did have brushtail possums (*Trichosurus vulpecula arnhemensis*) and golden bandicoots (*Isodon auratus barrowensis*), was also baited at this time. Because of its low tide connection to Barrow Island, mammals can move between the two islands and readily recolonise the island after baiting. Boodie and Middle Islands, off the south end of Barrow Island had populations of threatened mammals (boodie (*Bettongia lesueur*) and golden bandicoot (*Isodon auratus barrowensis*) respectively) that were at risk from any rat-poisoning programme. However, in 1985 an attempt at selective baiting of the rats on Boodie Island was undertaken. After rats were discovered on Barrow in 1990, immediate plans were made to develop a rat baiting strategy that excluded as many of the non-target mammals on Barrow as possible. Seven mammals were considered to

Table 1 The area of islands and names of non-target mammals on Barrow and adjacent islands (* denotes threatened species under the WA *Wildlife Conservation Act 1950*).

Island	Area (ha)	Non-target mammals
Barrow	23,590	<i>Isodon auratus barrowensis</i> * <i>Bettongia lesueur</i> * <i>Lagorchestes c. conspicillatus</i> * <i>Macropus robustus isabellinus</i> * <i>Petrogale lateralis lateralis</i> * <i>Trichosurus vulpecula arnhemensis</i> <i>Pseudomys nanus ferculinus</i> * <i>Zygomys argurus</i> <i>Hydromys chrysogaster</i>
Middle	350	<i>Isodon auratus barrowensis</i> *
Boodie	170	<i>Bettongia lesueur</i> *
South Double	23	none
North Double	12	none
Boomerang ¹	5	<i>Isodon auratus barrowensis</i> * <i>Trichosurus v. arnhemensis</i>
Pasco	2	none

¹ Connected to Barrow at low tide.

be at risk from an oat-based baiting programme (Table 1). This paper describes the techniques used for rat baiting programmes on Barrow and adjacent islands, and the results obtained.

METHODS

Barrow Island lies approximately 60 km off the Pilbara coast of Western Australia (Fig. 1) and has been a nature reserve since 1910. It is also covered by a Petroleum Lease issued to West Australian Petroleum (WAPET, now part of Chevron) that has been an operating oilfield since 1964. Boomerang, and North and South Double Islands lie close to the east coast of Barrow, near the barge landing (Fig. 1). Middle, Boodie and Pasco Islands lie close to the south end of Barrow Island. These islands have been nature reserves since 1975.

The bait used for rat eradication on all islands consisted of husked oats impregnated with the anticoagulant pindone (2 pivalyl 1,3-indandione) at the rate of 0.17 mg per oat seed (2.8 g per kg of oats). Each bait station consisted of 150 g of pindone-impregnated oats contained in a palm-sized plastic bag. However, the method of bait deployment varied depending on whether non-target mammals were present or not. These methods are described below.

North and South Double, Boomerang and Pasco Islands.

In April 1983, baits were laid on Boomerang Island on the ground in a 25 m grid pattern with no covering (approximately 16 bait stations per hectare). A small tear was made in each plastic bag to facilitate access by the rats. Baits

were also thrown into the low coastal cliffs from a dinghy. Baits were inspected every day for a week and replaced if more than two thirds of the oats had been consumed. A similar method was used to bait North and South Double Islands in October 1983 and Pasco Island in May 1985. Monitoring of success was by track and scat observations on all these islands at various times since the baiting occurred. The most recent monitoring of North and South Double, and Boomerang Islands was in October 2000, and Pasco Island in November 1998. Trapping (10 Sheffield cage traps and 10 Elliott traps set at 10 - 15 m intervals for two nights) was also undertaken on Boomerang Island in October 2000. Monitoring of these islands will continue as part of the Department of Conservation and Land Management's (CALM) fauna monitoring programme on Barrow Island.

Because Boomerang Island connects to Barrow Island at low tide, there was concern that black rats may have colonised the adjacent coastal parts of Barrow Island. In April 1983, an extensive trapping programme was undertaken using small and medium sized Elliott traps. Two more-or-less continuous lines of traps were run along the coastal dunes and cliffs from Mattress Point (1 km south of the barge landing) to Ant Point (1 km north of the barge landing). A total of 960 trap-nights were set. Another 329 trap-nights were set around incinerators and the warehouses near the centre of the island where all equipment is stored after being landed on the island.

Boodie Island

The black rat baiting programme was undertaken on Boodie Island in May 1985. Baits were laid in a 25 m grid, however the presence of the burrowing bettong on a small part of this island necessitated covering some of the bait stations. We used an upturned plastic wash basin with access holes cut into the sides. These were designed to be large enough to allow access to rats, but small enough to prevent access by the bettongs. A previous survey of Boodie Island in October 1983 found that bettongs only occurred either on, or close to, the limestone outcropping at the south-east end of the island (approximately 15% of the 170 ha island). The 427 bait stations set in this area were covered. The remaining 994 bait stations were set uncovered in vegetated (*Spinifex longifolius*) areas on the remaining sandy part of the island. Large tidal inlets penetrate the north side of the island and baits were not set in these areas. All bait stations were checked daily for 10 days and baits replaced if necessary.

Three transects were established to monitor bettong and black rat numbers during and after the baiting. Transect 1 ran along the WAPET track from the beach and across the limestone to the Pasco # 3 oil well. Transect 2 ran along a sandy track between the limestone outcropping and a large sand dune to the north-west of the limestone. Transect 3 ran along the sandy beach on the north side of the island. Each transect was 500 m in length and it was walked by an observer with a head torch twice in an evening; once out and once back. The numbers of bettongs and rats seen on each leg of the transect were recorded and averaged. These transects were used again in September 1985, four months after the baits had been laid.

Trapping using 20 Sheffield cage traps and 25 Elliott traps set at 10-15 m intervals for two nights was undertaken in November 1998. In October 2000, 10 Sheffield cage traps set at 10 m intervals were set for one night.

Barrow and Middle Islands

Black rats were detected at the south end of Barrow Island in July 1990. In August/September the extent of the black rat distribution was determined and a bait station developed to reduce the take of poison bait by non-target mammals. In October 1990 a trial area of approximately 75 ha at the northern end of the known rat distribution was baited (to prevent possible colonisation of the rest of Barrow Island) with bait stations set at 25 m spacings. Using the same bait station spacings, the remainder of the south end (approximately 170 ha) was baited in May 1991, and Middle Island baited in September 1991 (Fig. 2).

The presence of large numbers of non-target mammals on Barrow Island necessitated the development of a bait station that allowed access by rats but prevented access by other mammals ranging in size from 30 g to 10 kg. The ability of rats to climb and to move through small holes was taken advantage of.

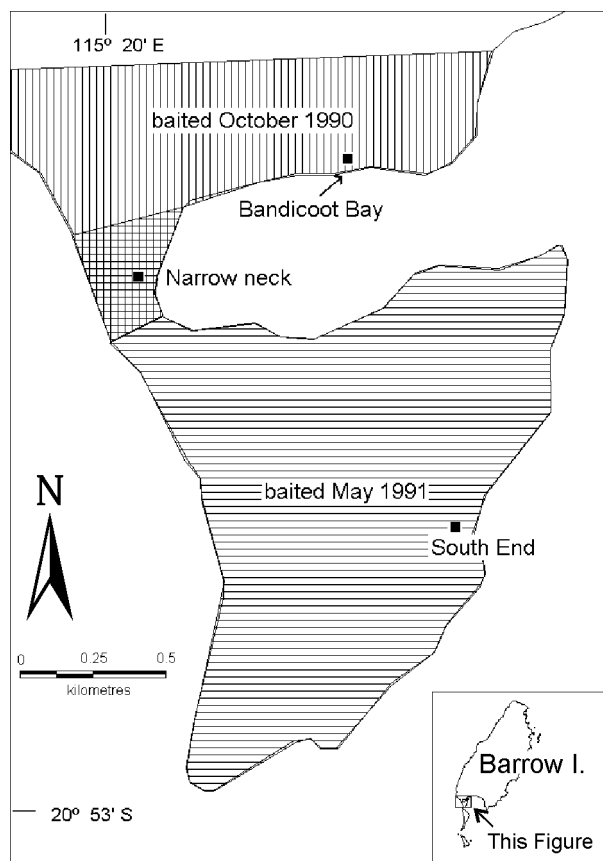


Fig. 2 The south end of Barrow Island showing baited area and the locations of trapping grids.

Table 2 Results of trapping along the coast of Barrow Island adjacent to Boomerang Island.

Species	Trapping Date / (# trap nights)					Overall trap success (%)
	19/4/83 (140)	20/4/83 (240)	21/4/83 (240)	22/4/83 (240)	23/4/83 (100)	
<i>Isoodon auratus</i>	29	45	43	34	12	17.0
<i>Pseudomys nanus</i>	4	17	17	23	5	6.9
<i>Zyzomys argurus</i>	0	1	6	8	3	1.9
<i>Bettongia lesueur</i>	8	4	4	4	3	2.4
<i>Pseudantechinus sp.</i>	2	0	1	0	0	0.3
<i>Rattus rattus</i>	0	0	0	0	0	0.0

The bait was enclosed in a 20 litre plastic bucket (Rheem) with 38 mm holes cut in the lid. Two external timber planks (90 cm long x 5 cm wide) ran from the lid to the ground. Two internal planks led from the holes in the lid to the bait on the sand (Fig. 3). The lid prevented access by the larger macropods (Barrow Island euro (*Macropus robustus isabellinus*), spectacled hare-wallaby (*Lagorchestes conspicillatus conspicillatus*), and burrowing bettong). The brushtail possum was prevented from reaching the bait by placing the poisoned oats on sand at least 13 cm below the lid. This was further than the maximum reach of a possum's forearm. The golden bandicoot was prevented from climbing to the top of the bait station by making the angle of the external planks greater than approximately 60 degrees. The native rodents (*Pseudomys nanus ferculinus* and *Zyzomys argurus*) could not be excluded from this bait station. However these species were widespread on Barrow Island and it was believed that they would be able to recolonise the baited area once the rats had been eradicated.

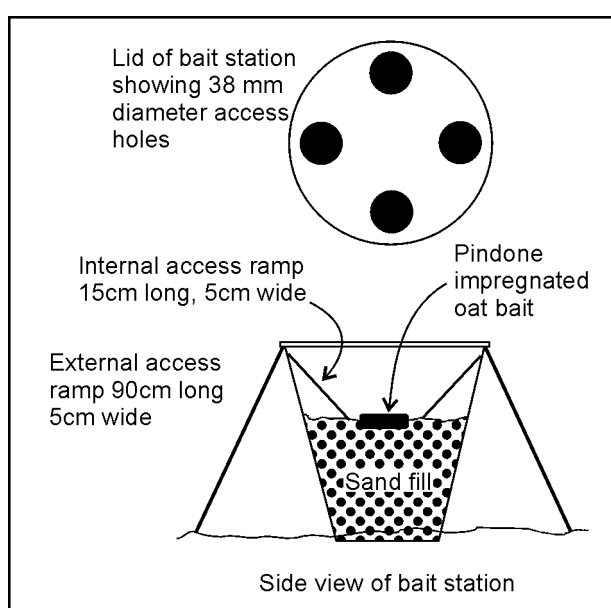


Fig. 3 Diagrammatic view of the bait station developed for black rat eradication on Barrow and Middle Islands.

Monitoring of baiting success was by trapping at three sites on the south end of Barrow Island (Bandicoot Bay, Narrow Neck and South End – Fig. 2), two sites on Middle Island, and searching for black rat tracks. On Barrow Island, each trapping site consisted of a 10 x 5 Elliott trap grid, with 20 m spacings between traps. In November 1998, the Bandicoot Bay site was changed to a 5 x 5 grid and cage traps and pit traps included at each trap point. Monitoring of this grid is ongoing as part of CALM's Barrow Island fauna monitoring programme.

RESULTS

North and South Double, Boomerang, and Pasco Islands

No rats were trapped on Barrow Island adjacent to Boomerang Island in April 1983 (Table 2) and none were detected around the warehouses.

Monitoring of Boomerang Island four months and six months after baiting (in August and October 1983) found no evidence of black rats, and this island has been visited opportunistically several times since. The latest was in October 2000 and no sign of black rats was detected. The brushtail possum and golden bandicoot have successfully recolonised Boomerang Island. Two possums were trapped in October 2000 and bandicoot tracks were seen on the island.

North and South Double Island were inspected 15 months after baiting (in February 1985) and again in September 1991 and no signs of rats were found. These islands were last visited in October 2000 and there was no sign of rats.

Pasco Island was visited four months after baiting (in September 1985) and again in October 1998 and no sign of rats was found.

Boodie Island

Within seven days of baits being deployed on Boodie Island, black rat numbers started to decline (Table 3), and

Table 3 The number of bettongs and black rats seen (average of two surveys) along 1 km transects on Boodie Island.

Date	Transect 1 (Limestone track)		Transect 2 (Sand dune track)		Transect 3 (Beach)	
	Bettongs		Bettongs		Bettongs	
	Rats	Rats	Rats	Rats	Rats	Rats
20/10/83	2	26	-	-	-	-
18/5/85	0	20.5	1	2.5	0	0.5
19/5/85	4.5	26.5	0	1.5	0	1
20/5/85	1	23.5	0	2.5	0	1
21/5/85	1	12.5	0	1.5	0	1
22/5/85	3.5	14	0	2	0	1.5
23/5/85	2	14	0	1	0	1
24/5/85	2.5	4	0	0	0	0.5
25/5/85	3.5	4	0	0	0	0
26/5/85	1	3	0	0	0	0
27/5/85	2	1.5	0	0	0	0
28/5/85	1.5	1.5	0	0	0	0
29/5/85	1	1	0	1	0	0
17/9/85	1	0	0	0	0	0
18/9/85	1	0	0	0	0	0

subsequent visits have confirmed that the rats have been eradicated. Rats pulled some of the oats out from under the cover allowing access by the bettongs, which also declined and subsequently became locally extinct. In 1993, 36 burrowing bettongs were re-introduced from Barrow Island, and the population is now thriving. In the presence of black rats, the bettongs were restricted to the limestone portion of Boodie Island and there was evidence of rats sharing and competing for burrows with the bettongs. There were probably no more than 20 - 50 bettongs on the island when the rat eradication programme commenced. Trapping in October 1998 and October 2000 produced an 80% trap success rate for bettongs (no rats were trapped), and they have now colonised the entire island.

Table 5 Trap success rates (%) for golden bandicoots and black rats on Middle Island. Baiting was undertaken in September 1991.

	Sept. 1990	June. 1991	May 1992	Oct. 1992	Nov. 1998
Bandicoot	6.8	4.3	21.5	36.0	35.0
Black rat	3.0	1.8	0	0	0

Barrow and Middle Islands

The baiting programme undertaken in 1990/91 was successful in eradicating black rats from the south end of Barrow Island, and Middle Island. On Barrow Island, none have been trapped and no tracks have been seen since May 1991. Golden bandicoots and Barrow Island mice were also impacted and abundances declined during and immediately after the baiting programme (Table 4). However within 12 months, abundances of these native species had returned to pre-baiting levels. On Middle Island pre-baiting rat trap success rates were two to three times higher than on the south end of Barrow Island, suggesting higher rat densities on Middle Island (Table 5). Golden bandicoot abundance on Middle Island also increased five-fold following rat eradication.

DISCUSSION

An effective method has been developed for eradicating black rats in the presence of non-target mammal species on semi-arid islands up to 350 ha. The black rat eradication programme on Barrow and the adjacent islands has been successful and Barrow Island remains one of the largest landmasses on Earth without introduced mammals. This follows the successful eradication of black rats from the smaller Bedout, and Middle and West Lacepede Islands (Morris 1989; Abbott and Burbidge 1995). In other parts of Australia, only two other successful black rat eradication programmes have been reported (Abbott and Burbidge 1995) and these were on small islands of 1 ha and 42 ha.

Table 4 Trap success rates (%) for golden bandicoots, Barrow Island mice and black rats on Barrow Island. Rat control was undertaken at Bandicoot Bay and Narrow Neck in October 1990 and at the South End in May 1991 (- denotes no trapping undertaken).

	Bandicoot Bay			Narrow Neck			South End		
	Bandicoot	Mouse	Rat	Bandicoot	Mouse	Rat	Bandicoot	Mouse	Rat
August 1990	18.0	11.0	1.4	26.3	12.0	0.9	9.5	21.0	1.5
November 1990	8.2	0.5	0	8.7	0.7	0	-	-	-
May 1991	9.7	6.1	0	5.5	1.0	0	14.0	22.0	2.0
September 1991	21.6	4.2	0	29.2	5.8	0	-	-	-
October 1992	29.5	11.7	0	-	-	-	-	-	-
December 1993	28.0	14.0	0	33.0	21.0	0	27.0	31.0	0
November 1998	29.4	2.8	0	44.0	13.0	0	-	-	-
October 1999	36.5	5.5	0	-	-	-	-	-	-
October 2000	21.5	6.0	0	-	-	-	-	-	-

The work on Boodie Island was the first attempt in Australia to eradicate black rats in the presence of a threatened, non-target mammal. This study, and that of Short and Turner (1993), confirmed that the method used was successful in eradicating the black rat (its primary aim) but that the burrowing bettong was also eradicated. While this was not a desirable outcome in itself, the assertion by Short and Turner (1993) that this threatened the overall conservation of burrowing bettongs is not warranted. The estimate they provide of pre-baiting bettong numbers of approximately 20 was probably accurate, and it was very likely that the population would have become extinct if the rats had remained on Boodie Island. The baiting programme was undertaken by CALM because it was recognised that if all the bettongs were eradicated, it would be a relatively-simple operation to re-introduce this species from Barrow Island: this is what has occurred. The population of bettongs is no longer restricted to the limestone areas of Boodie Island and there are substantially more than the 20 individuals estimated pre-baiting, and substantially more than the 70 predicted by Short and Turner (1993) to be the estimated carrying capacity of the island. It is likely that as many as 200-300 boodies now inhabit the island. This substantial increase in abundance, and that of the golden bandicoot on Middle Island following rat eradication, supports the contention of Burbidge and Manly (2002) that black rats are implicated in declines and extinctions of mammals on islands.

It is interesting to speculate on the source of the black rats on Barrow Island and why the species was restricted to the sandy southern part of the island, about 1.5 % of its total area. Had it been more widespread, the eradication programme would have been far more difficult.

WAPET (now part of Chevron Australia) has been operating on Barrow Island since 1964 and, despite rigorous quarantine procedures, there have been occasional introductions of the house mouse (*Mus domesticus*) to the island. These have been quickly eradicated. Most of the oilfield activity occurs in the central part of the island, and most equipment is barged to the island, landing near Boomerang and North and South Double Islands. However, Whitlock (1918) reported black rats on Double Island in 1918, prior to the development of Barrow as an oilfield. Pearlers used the area now known as 'The Landing' in the 1890s as a campsite (W. H. Butler pers. comm.) and it is reasonable to assume that the rats on Boomerang and Double Island originated from careened pearling luggers. An extensive trapping programme along the coast adjacent to Boomerang and Double Islands in 1983 did not find any sign of black rats. It is likely that the rats at the south end of Barrow Island also originated from pearling luggers in the 1890s.

Why didn't black rats invade other parts of Barrow Island? A possible explanation is that ecological processes kept Barrow rat free. While the adjacent islands have few or no native mammals, Barrow has a more complex guild

of fauna. Any rats landing on Barrow would have to contend with increased predation from perenties (*Varanus giganteus*), Stimson's python (*Morelia stimsoni*), mulga snake (*Pseudechis australis*) and golden bandicoots, and competition for food from two species of native rodent, a possum and three small wallabies. Bandicoot Bay at the south end of Barrow was also used as a pearling camp and rats on Boodie and Middle Islands and the south end of Barrow probably originated from this activity rather than the oilfield development. It is not clear why the black rats were only restricted to a small part of Barrow Island, despite having probably been on the island for 100 or so years. The south end is almost entirely sandy with sparse vegetation and generally lower numbers of native mammals and predatory reptiles. The reduced predation and competition may have allowed the rats to establish and maintain a low population size in this area, but they were not able to establish in the majority of the island which is composed of limestone and supports high densities of native mammals and reptiles.

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