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The mammal fauna of the Sir Edward Pellew island group, Northern Territory, Australia: refuge and death-trap

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Abstract

Context. Australian islands have provided a major conservation refuge for many native mammals; however, conversely, island populations may also be highly susceptible to the introduction of novel threats. Nearby islands subject to different arrays of threats or different timing of arrival of those threats may provide a natural experiment, offering particular insight into the relative impacts of different threats to Australian mammals more generally.

Aims. The present study sought to document the native mammal fauna occurring on the main islands of the Sir Edward Pellew group, Northern Territory, and the changes in that fauna over a ~50-year period, and to seek to identify those factors that have contributed to such change.

Methods. In different combinations, the five main islands (and three smaller islands) were subject to standard wildlife survey methods in 1966–67, 1988, 2003, 2004–05, and 2009–10. Sampling procedures were not identical in all periods; however, a measure of abundance (trap success rate) could be calculated for all sampling. This conventional survey approach was complemented by documentation of ethno-biological knowledge.

Key results. For many species, these islands held populations of biogeographic or conservation significance. However, there has been a major loss or decline of mammal species from most islands. Extirpation is difficult to prove; however, we consider it most likely that the important regional populations of brush-tailed rabbit-rat (*Conilurus penicillatus*), northern quoll (*Dasyurus hallucatus*), northern brush-tailed phascogale (*Phascogale pirata*), common brushtail possum (*Trichosurus vulpecula*) and canefield rat (*Rattus sordidus*) have been lost from these islands, and that northern brown bandicoot (*Isoodon macrourus*), western chestnut mouse (*Pseudomys nanus*), pale field-rat (*Rattus tunneyi*) and long-haired rat (*Rattus villosissimus*) have been lost from most of the islands on which they formerly occurred. Some species–island combinations are known only from the ethno-biological record, and the loss of these populations probably mostly occurred in the period 30–50 years ago. Many other declines and losses occurred in the period between the second (1988) and third (2003) survey. The loss of the northern quoll from Vanderlin Island occurred in 2008. No single factor unambiguously accounts for the declines, although the introduction of cats (*Felis catus*) provides the best fit to the pattern of decline. A notable exception is the extirpation of northern quoll on Vanderlin Island, which is closely linked to the colonisation of that island by cane toads (*Rhinella marina*).

Conclusions. The Sir Edward Pellew group of islands have lost much of their formerly high conservation significance for native mammals over the past 50 years, mostly because of introductions of cats, and to a lesser extent, natural colonisation of the islands by cane toads.

Implications. The present study has provided some insight into the relative impacts of a range of factors that have been considered as possibly implicated in the decline of native mammals on the northern Australian mainland, with most support being offered here for a primary role for predation by feral cats. The study has also demonstrated the need for better quarantining of islands with significant conservation values. The comprehensive natural colonisation of these islands by cane toads offers a further lesson, of most importance to managers of islands in north-western Australia currently just beyond the range of toads.

Additional keywords: cane toad, conservation management, ethno-biology, extinction, feral cat, island biogeography.

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Introduction

Australian islands have provided a remarkable refuge for native mammals, harbouring many species that have been extirpated across their formerly extensive mainland range (Burbidge *et al.* 1997, 2008; Burbidge 1999; Smith and Quin 1996; Burbidge and Manly 2002; McKenzie *et al.* 2007). The persistence of some species on islands but not on the mainland is seen as one of the strongest strands of correlative evidence that demonstrates the relationship between particular threats and particular biodiversity consequences (Burbidge *et al.* 1997, 2008). In some (mostly unfortunate) cases, the evidence has been more of a natural experiment than correlative, when a threatening factor has been newly introduced to an island, and the response of the mammal fauna has been documented (Burbidge 1999; Burbidge and Manly 2002).

In the present paper, we describe the terrestrial mammal fauna of the Sir Edward Pellew island group in the Gulf of Carpentaria, Northern Territory, and its changes over the past 40–50 years. This period has coincided with some changes to the management of the islands, but also with the introduction of feral cats (*Felis catus*) to some of these islands and the colonisation of many of the islands by the cane toads (*Rhinella marina*). The individual islands of the Pellew group have been subjected to variable histories and combinations of factors that may affect their native mammal fauna. This variability provides some scope for teasing apart the relative impacts of different factors that have been considered to be implicated in the decline of native mammals more broadly in northern Australia (e.g. Woinarski *et al.* 2001, 2010, 2011). However, in considering such extrapolation of results from these islands to the mainland, we note the reservation that island populations may be particularly susceptible to new threats, given that populations on islands may have very low genetic diversity, small population size, limited experience with predators, and little scope for juggling habitat use (Woinarski 2010).

The present paper collates information from a small series of surveys extending intermittently since 1966. Notably, results from these surveys have been described hitherto only in a series of 'grey literature' reports, and it is a specific purpose of the present paper to introduce the information from these reports to the more formal scientific record. The paper also seeks to complement the intermittent 'hard data' record from wildlife surveys with ethno-biological information from the far more continuous perspective of Yanyuwa understanding of this country (Bradley *et al.* 2006). The Yanyuwa, traditional Aboriginal owners of these islands and neighbouring mainland, have an extremely rich store of knowledge about these islands, and the biota of these islands is an integral part of their culture and being. Bradley *et al.* (2006, p. 73) stated the following: 'The short-eared rock-wallaby (*Petrogale brachyotis*) is associated with the islands and is mythologically seen to have been a fiercely independent and quarrelsome creature who resented any other creatures coming onto the islands . . . Some older Yanyuwa men and women often used this creature to explain why the Yanyuwa people are like they are, that is, fiercely independent and solitary island dwellers. The twisted western coastline of Vanderlin Island was created by a Rock Wallaby Spirit Ancestor running up and down in anger to stop other Spirit Ancestors from entering the islands'.

Methods

The Sir Edward Pellew island group

The Sir Edward Pellew island group (hereafter 'Pellew islands') comprises a mostly tightly aggregated set of islands in the south-west of the Gulf of Carpentaria, northern Australia (Fig. 1). The group includes five main islands (North, Centre, South West, West and Vanderlin; area 55–263 km^2), and 66 smaller islands and rock stacks (Table 1).

The islands are positioned near the mouth of the McArthur River, and extend from <0.1 to 40 km (at most distant point) from the mainland. Some islands are poorly differentiated dynamic deltaic units, characterised by mangroves, saltmarsh and colluvial muds. However, most islands include or are dominated by more rugged sandstones, and were isolated by rising sea levels from 10 000 to 6000 years ago (Torgersen *et al.* 1988). For each island, we used digital elevational models and GIS to calculate distance of the closest point to the mainland, island size, maximum elevation and topographic ruggedness (the latter following the methodology of Riley *et al.* 1999). Johnson and Kerle (1991) described vegetation composition of the islands, comprising sandstone woodlands and heathlands, sandplain woodlands and shrublands, dune communities, freshwater wetlands, rainforests and mangrove communities.

The climate of the Pellew islands is monsoonal, with a distinct wet season between October and April. Median annual rainfall is between 765 and 980 mm (Johnson and Kerle 1991). Severe cyclones occur occasionally, and may radically transform vegetation structure. The most intense cyclones affecting the Pellew islands in recent decades were Cyclones Kathy in 1984 (Johnson and Kerle 1991), Steve in 2000 and Winsome in 2001.

The islands are the traditional home of the Yanyuwa people, who now (particularly since the 1940s) mostly live in the nearby mainland town of Borroloola, but continue to visit the islands frequently. Small outstations, comprising one to few houses permanently or intermittently inhabited, are present on Vanderlin, South West, Centre, West and Black Craggy Islands. The Pellew islands were visited annually by Macassan trepang-collectors from at least the early 1700s to early 1900s, and they developed freshwater wells at several seasonal camp sites and introduced tamarinds (*Tamarindus indica*) to supply food and as shade trees (Macknight 1976). There has been limited European use and modification of the islands, although notably a small pastoral property was established on Vanderlin Island in the 1940s; largely unmanaged, cattle, horses, donkeys and goats became feral on that island (PWCNT 2004). The township of Pellew was established on Centre Island in 1983, with a small number of permanent dwellings visited frequently to infrequently. The waters around the Pellew islands attract many recreational and professional fishers, and the islands receive some visitation by tourists. North Island was designated as Barranyi National Park in 1992 (PWCNT 2004).

Record of surveys

There were remarkably few records of fauna from the Pellew islands before the first systematic survey. Johnson and Kerle (1991) provided a brief summary of early records, including reports of kangaroo and dog tracks by Matthew Flinders in 1802, and reports of rock-wallabies on Vanderlin and North Islands, by

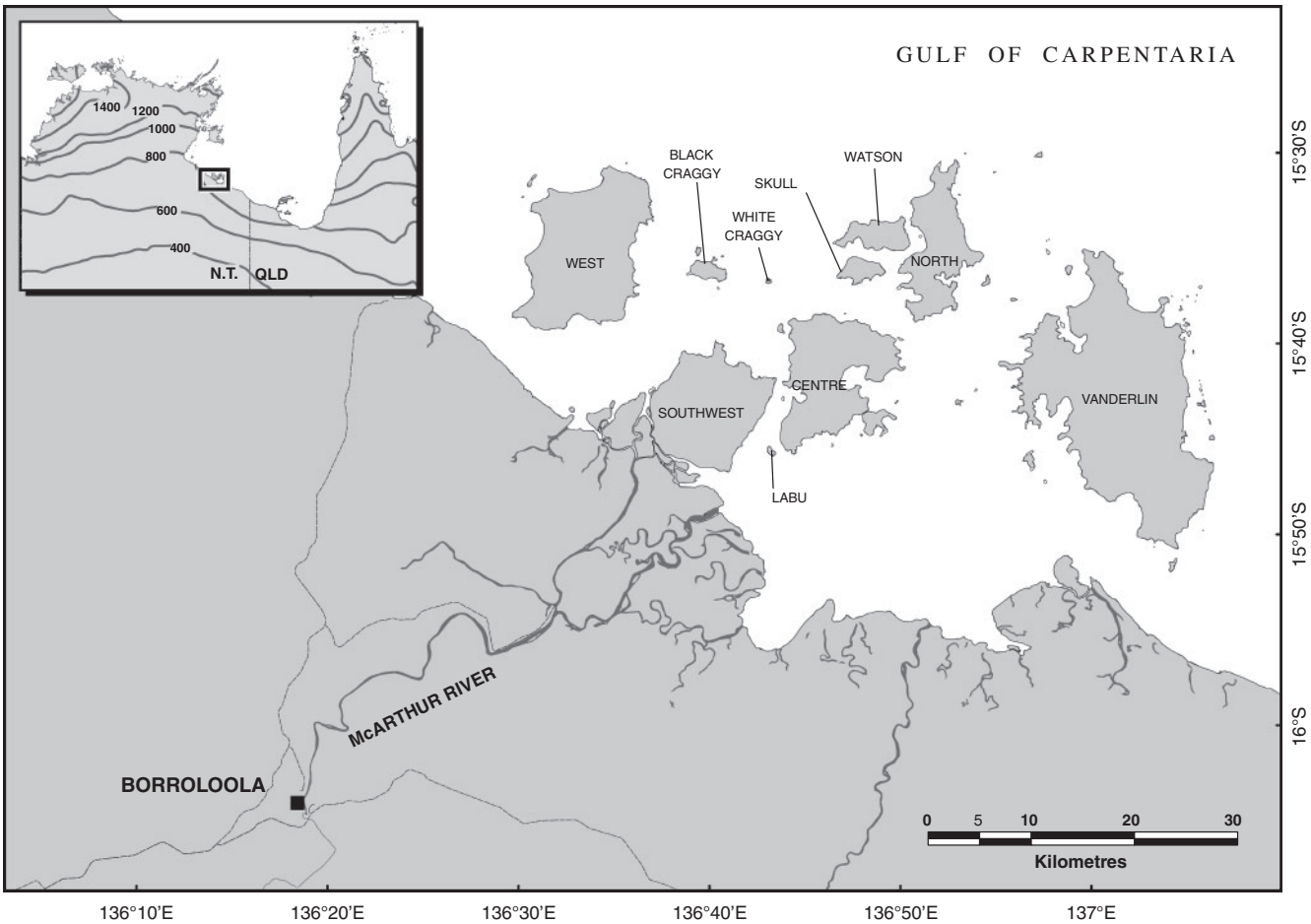


Fig. 1. Location of (*A*) the Sir Edward Pellew and (*B*) the Wessel island groups, with more detailed map of locations for individual islands in the Pellew group.

Paradice in 1923–24. In 1942, Donald Thomson collected three short-eared rock-wallabies from Vanderlin Island (Dixon and Huxley 1985).

The first systematic survey was undertaken by CSIRO from July 1966 to December 1967 and then in the wet season of 1975–76 (Calaby 1976); that fieldwork included trapping in main habitats on Centre, West, South West and North Islands. All five main islands, and the smaller Black Craggy (4.6 km^2), Watson (14.1 km^2) and Skull (6.7 km^2) Islands, were sampled by the Conservation Commission of the Northern Territory (CCNT) in 1988 (Johnson and Kerle 1991). Additional to the results reported in Johnson and Kerle (1991) for the 1988 survey, we here also include results from brief sampling (171 trap-nights) undertaken in May 1988 on Centre Island by D. Gibson (reported in CCNT file notes; Johnson and Kerle 1991). The Northern Territory Department of Natural Resources Environment the Arts and Sport (NRETAS) has since undertaken several surveys, in collaboration with the li-Anthawirriyarra ranger group (comprising Yanyuwa owners). In 2003, all five main islands were sampled (Taylor *et al*. 2004). In 2004 and 2005, all main islands were sampled by systematic trapping, and a series of nest boxes was established (to attempt to detect brush-tailed rabbit-rat (*Conilurus penicillatus*) and northern brush-tailed phascogale (*Phascogale pirata*)) on trees on Centre (19 boxes) and West Islands (40 boxes), and rechecked intermittently over a 6-month period (Ward *et al*. 2006). In 2009, Vanderlin, West, Black Craggy, Watson and Skull Islands were sampled (Mahney *et al*. 2009). In 2010, North Island was sampled (NRETAS, unpubl. data). In addition, 10 cat faeces collected on West Island in 2008 and 2010 were examined for the presence of native mammal prey (Paltridge 2010).

Table 2 gives trapping effort for each island for each survey; however, note that these figures may not be strictly comparable because the proportion of different trap types may have varied (albeit not substantially) among surveys and islands. The sampling effort has been broadly comparable across all surveys, with the total trap effort (including that on the three smaller sampled islands) for 1966–67 being 2664 trap-nights, for 1988 being 4696 trap-nights, for 2003 being 4042 trap-nights, for 2004–05 being 7431 trap-nights, and for 2009–10 being 3360 trap-nights.

Compared with sampling of small terrestrial mammals, sampling of bats has been unsystematic and non-comprehensive, and these are not a focus of the present paper.

Indigenous knowledge

Most ethno-biological information reported here derives from Bradley *et al*. (2006), and is based on decades of collaboration and

Table 1. Summary characteristics of the islands of the Sir Edward Pellew group

Islands are listed in order of decreasing size; only islands >1 km^2 are listed. Islands for which some mammal records are reported here are indicated with an asterisk. Index numbers (square brackets) for unnamed islands refer to maps presented in Woinarski *et al*. (2007*b*)

Island	Area (km^2)	Closest distance to mainland (km)	Max. elevation (m)	Ruggedness
* Vanderlin	262.5	5.7	82	2.94
* West	128.9	3.6	52	0.89
* South West	91.3	0.6	90	2.62
* Centre	84.4	7.6	89	4.35
* North	55.4	24.7	74	4.35
* Watson	14.1	26.1	45	3.14
Unnamed deltaic [216]	11.3	<0.1	3	0.02
* Skull	6.7	23.4	46	3.33
Unnamed deltaic [230]	6.3	0.1	4	0.04
Hobler	5.2	<0.1	7	0.08
* Black Craggy	4.6	17.2	48	4.87
Unnamed [221]	4.0	14.7	29	3.82
Unnamed deltaic [219]	2.6	0.3	4	0.08
Unnamed deltaic [229]	1.8	0.2	4	0.21
Unnamed deltaic [224]	1.2	<0.1	4	0
Unnamed deltaic [199]	1.1	0.2	0	0
Unnamed deltaic [233]	1.1	<0.1	2	0.04
Jolly	1.0	10.7	10	1.65

knowledge exchange chronicled by Bradley, a highly proficient Yanyuwa speaker. In some cases, this information was prompted or corroborated by a direct reference to specimens or live animals.

The survey reports of Johnson and Kerle (1991), Taylor *et al*. (2004), Ward *et al*. (2006) and Mahney *et al*. (2009) all recorded information provided by Indigenous landowners in addition to data derived from trapping. The latter three surveys were undertaken in close collaboration with Indigenous landowners and rangers, and provided an opportunity for much dialogue about different animal species, based on captures of live animals. During these surveys, Archie Johnston and Steve Johnston (now both deceased) provided particularly perceptive and detailed commentary about wildlife of the Pellew islands, deriving mostly from many decades of their residence on Vanderlin Island, and their travel around the other islands.

Semi-formal interviews focussed on past and present status of mammals were conducted with Indigenous landowners in Borroloola and the Pellew islands by M. Ziembicki in 2009, with the aid of a large series of mounted mammal specimens (based on the protocols described in Burbidge *et al*. 1988).

Regional comparisons

For geographic context, we map distributional records for some species. These records derive from a large aggregated dataset of museum specimens, survey records and incidental observations, for the Northern Territory, maintained by NRETAS.

The mammal species composition on the Pellew islands is compared simply to that on the islands of the Wessel group (Woinarski *et al*. 1999), a comprehensively sampled island chain off north-eastern Arnhem Land, ~400 km to the north (Fig. 1).

Analysis

The present paper is largely descriptive. There are too few islands sampled in the Pellew group to warrant or support detailed analysis of the factors underpinning species richness patterns, although richness–island size tallies are graphed, and counterpointed against comparable information for the Wessel island group, by using analysis of covariance of species richness against island size.

Results

Species list

Records of individual species from individual islands are summarised in Table 3. Across all sources, 27 native terrestrial mammal species (excluding dingo/dog, and the more speculative ethno-biological records of golden bandicoot (*Isoodon auratus*) and northern hopping-mouse (*Notomys aquilo*)) and seven non-native mammal species (including dingo/dog) have been recorded from the Pellew islands.

Species richness is plotted against island area in Fig. 2. For islands >1 km^2, there is a very strong relationship between species richness and island size ($F = 32.8$, $P < 0.001$), and there are more mammal species on the Pellew islands than on similarly sized islands of the Wessel group ($F = 34.6$, $P < 0.001$).

There are some striking similarities and differences in the mammal composition of the Wessel and Pellew island chains (Table 4). A small number of species are widespread on both island groups (notably short-eared rock-wallaby, common rock-rat (*Zyzomys argurus*), grassland melomys (*Melomys burtoni*) and common water-rat (*Hydromys chrysogaster*)). There are two cases of species-pairs with complementary distributions: Carpentarian

Table 2. Total trap success (and total no. of trap-nights) reported across surveys of the five main islands of the Sir Edward Pellew group

Note that the smaller islands Black Craggy, Watson and Skull were also sampled in 1988 and 2009. Trap success rates were not reported for these islands in 1988, and were 10.2%, 5.1% and 9.0%, respectively, in 2009 (from 432 trap-nights for each of these islands). The 1988 tallies include the results of Gibson (file note), not otherwise reported in Johnson and Kerle (1991). Note that the latter reference reports inconsistent tallies among their tables 6.1, 6.3 and 6.4. We here report the tallies given in table 6.4 of Johnson and Kerle (1991). n.s. = not sampled

Year	Vanderlin	West	South West	Centre	North	Total
1966–67	n.s.	6.3 (233)	12.2 (450)	14.9 (1706)	18.9 (275)	14.1 (2664)
1988	10.4 (925)	11.5 (825)	14.5 (1050)	15.2 (546)	35.4 (850)	17.3 (4196)
2003	13.5 (1050)	0 (495)	0.2 (521)	8.3 (919)	5.7 (1057)	7.0 (4042)
2004–05	11.9 (1200)	0 (1260)	0.4 (1571)	3.8 (2350)	8.1 (1050)	4.4 (7431)
2009–10	6.0 (864)	0 (336)	n.s.	n.s.	1.5 (864)	3.1 (2064)

Table 3. List of all mammal species recorded from all islands

Source of records: a = 1966 survey (Calaby 1976), b = 1988 survey (Johnson and Kerle 1991), c = 2003 survey (Taylor *et al*. 2004), d = 2004–05 survey (Ward *et al*. 2006), e = 2009–10 surveys (Mahney *et al*. 2009; NRETAS, unpubl. data), f = Paltridge (2010) and g = additional information from Yanyuwa sources, but note that the more uncertain records of golden bandicoot and northern hopping-mouse are excluded from the table. Table includes some records from two islands not otherwise referred to in text, namely Labu Islet (area = 0.4 km^2) and White Craggy Island (0.2 km^2). Asterisk indicates introduced species

Common name	Scientific name	Vanderlin	North	Centre	South West	West	Skull	Watson	Black Craggy	White Craggy	Labu	Other ethno-biological information
Short-beaked echidna	*Tachyglossus aculeatus*	g			d							
Carpentarian antechinus	*Pseudantechinus mimulus*	cde	abcd	bd	bd							
Northern quoll	*Dasyurus hallucatus*	bc										‘On the islands’
Brush-tailed phascogale	*Phascogale pirata*					b						‘On the islands’
Common planigale	*Planigale ?maculata*	b										
Northern brown bandicoot	*Isoodon macrourus*	g	g	abcd	g							
Common brushtail possum	*Trichosurus vulpecula*											‘On the islands’
Sugar glider	*Petaurus breviceps*					g						
Agile wallaby	*Macropus agilis*	abce	abce	abcd	abcd		e				bg	
Euro	*Macropus robustus*							e				
Short-eared rock-wallaby	*Petrogale brachyotis*	bce	abce	ac								
Northern blossom-bat	*Macroglossus minimus*											‘On the islands’
Black flying-fox	*Pteropus alecto*	ce					e					
Little red flying-fox	*Pteropus scapulatus*	c				d						
Common sheathtail bat	*Taphozous georgianus*	b	ac	a				e	a			
Ghost bat	*Macroderma gigas*		bg							g		
Norhern long-eared bat	*Nyctophilus arnhemensis*	b	ab									
Central cave eptesicus	*Vespadelus finlaysoni*		b									
Brush-tailed rabbit-rat	*Conilurus penicillatus*			a								
Water-rat	*Hydromys chrysogaster*	be	b	ab	a							
Grassland melomys	*Melomys burtoni*	be	ab	abc	ac	ab	be					
Delicate mouse	*Pseudomys delicatulus*	bce	b		d	abf						
Western chestnut mouse	*Pseudomys nanus*				ab							
Canefield rat	*Rattus sordidus*				b							
Pale field-rat	*Rattus tunneyi*		ae	abc	ab	ab	e	e	e			
Long-haired rat	*Rattus villosissimus*		bce		ab		be	b	b			
Common rock-rat	*Zyzomys argurus*	bcde	abcde	abcd	abc	a		e	b			
* Dingo/dog	*Canis lupus*	a		b	abc	de						
*Cat	*Felis catus*	b			c	cd						
*Horse	*Equus caballus*	bc										
*Donkey	*Equus asinus*	a										
*Goat	*Capra hircus*	abce				de			b			
*Cattle	*Bos taurus*	be							b			
*Pig	*Sus scrofa*				d							

and sandstone antechinus (*Pseudantechinus mimulus* and *P. bilarni*) and northern brown and golden bandicoot (*Isoodon macrourus* and *I. auratus*). Some species occur on only one (or two) islands in both groups (brush-tailed rabbit-rat, northern quoll (*Dasyurus hallucatus*), sugar glider (*Petaurus breviceps*) and common brushtail possum (*Trichosurus vulpecula*)). However, there is a substantially richer rodent (particularly *Rattus* spp.) and macropod (particularly agile wallaby (*Macropus agilis*)) fauna on the Pellew islands.

Note that identification of native *Rattus* species may have been inconsistent among surveys. Johnson and Kerle (1991) cited genetic evidence to confirm the record of canefield rat (*Rattus sordidus*; previously unrecorded from the Northern Territory) from South West Island, and considered that the three *Rattus* species present there (*R. sordidus*, pale field-rat (*R. tunneyi*) and long-haired rat (*R. villosissimus*)) showed distinct habitat segregation. Mahney *et al*. (2009) also used genetic evidence to confirm the occurrence of both long-haired rat and pale field-rat on Skull Island in 2009.

Survey data and trap success

No mammals were recorded from the nest boxes established by Ward *et al*. (2006) on West and Centre Islands. Of 10 cat faecal samples collected on West Island in 2008 and 2010, one contained native mammal fragments (bones of delicate mice in a 2010 sample) (Paltridge 2010).

Estimates of abundance (trap success rates) from repeated sampling of individual islands are summarised for all species combined in Table 2 and for individual species in Table 5. Note that Calaby (1976) provided values only for total trapping success, that Johnson and Kerle (1991) did not report trap success rates for the three small islands sampled (Black Craggy, Watson and Skull), and that we calculated trap success

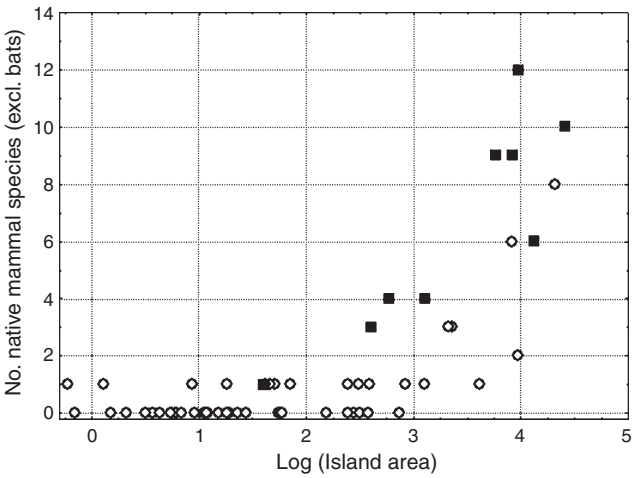


Fig. 2. Island area (km^2)–species-richness tallies for the islands of the Sir Edward Pellew (filled square) and Wessel (open circle) island groups, for non-volant terrestrial native mammals. Information for the islands of the Wessel island group from Woinarski *et al*. (1999).

rates for individual species on their larger sampled islands from primary data not fully reported in Johnson and Kerle (1991). Note that this comparison is indicative only because different surveys used different combinations of trap types and may have sampled different locations and habitats.

Overall trap success rates declined substantially across the surveys. The decline was particularly dramatic for West and South West Islands, particularly between the 1988 and 2003 surveys. However, declines were evident on all five large islands. Overall trap success rate remained high for the most recent period on the three smaller sampled islands.

Declines were most pronounced for some individual mammal species. *Rattus* species were abundant on four large islands (but not Vanderlin Island) in the earlier surveys, whereas they were unrecorded from three of those islands (Centre, West and South-West) and had declined very substantially from the other (North) in the more recent surveys. However, they remained abundant on the three small islands sampled. The western chestnut mouse (*Pseudomys nanus*), brush-tailed rabbit-rat and brush-tailed phascogale were recorded only in the 1966 and/or 1988 surveys (each from one island), but were not recorded in more recent surveys (despite the targeted use of nest boxes for the latter two species). The grassland melomys declined on most large islands, but remained abundant on one of the small islands sampled. The rock-dwelling Carpentarian antechinus and common rock-rat showed no appreciable change in abundance for most islands across the surveys.

Ethno-biological information

Reflecting either change that occurred before the commencement of the systematic surveys, or the incompleteness of these surveys, information in Bradley *et al*. (2006) and that collected during the surveys reported here adds considerable additional detail about mammal occurrence from Yanyuwa sources to the survey-based inventory (Table 6).

Discussion

Significance of the mammal fauna of the Pellew islands

Interpreting his 1966–67 survey results, Calaby (1976: p. 1) noted that the trap success rate for mammals on the Pellew islands (14.1%) 'compares favourably with other regions of Australia where small mammals are considered to be common'. Calaby (1976) contrasted the abundance and diversity of the Pellew

Table 4. Broad comparison of mammal species composition on the islands of the Sir Edward Pellew and Wessel island groups

Only islands >1 km^2 are considered. Values in parentheses are the number of islands from which reported

Taxonomic group	Sir Edward Pellew group (n = 8 islands)	Wessel group (n = 17 islands)
Echidna	*Tachyglossus aculeatus* (2)	–
Dasyurids	*Dasyurus hallucatus* (1)	*Dasyurus hallucatus* (1)
	Pseudantechinus mimulus (4)	*Pseudantechinus bilarni* (1)
	Planigale maculate (1)	
	Phascogale pirata (1)	
Bandicoots	*Isoodon macrourus* (3)	*Isoodon auratus* (1)
Possums and gliders	*Trichosurus vulpecula* (?1)	*Trichosurus vulpecula* (?1)
	Petaurus breviceps (1)	*Petaurus breviceps* (1)
Macropods	*Petrogale brachyotis* (3)	*Petrogale brachyotis* (4)
	Macropus agilis (5)	
	M. robustus (1)	
Rodents	*Hydromys chrysogaster* (4)	*Hydromys chrysogaster* (6)
	Zyzomys argurus (7)	*Zyzomys argurus* (6)
	Melomys burtonis (6)	*Melomys burtonis* (4)
	Conilurus penicillatus (1)	*Conilurus penicillatus* (1)
	Pseudomys delicatulus (4)	*Pseudomys delicatulus* (1)
	P. nanus (1)	
	Rattus tunneyi (7)	
	R. villosissimus (5)	
	R. sordidus (1)	

Table 5. Trap success rate in different surveys for individual small mammal species on individual islands

'66 = 1966 survey (Calaby 1976), '88 = 1988 survey (Johnson and Kerle 1991), '03 = 2003 survey (Taylor *et al*. 2004), '04 or '05 = 2004–05 survey (Ward *et al*. 2006), '09 = 2009 survey (Mahney *et al*. 2009) and '10 = 2010 survey (NRETAS, unpubl. data). Except where indicated in some specific accounts, Calaby (1976) did not indicate trap success for individual species, noting instead only whether the species was common (C) or uncommon (U). Johnson and Kerle (1991) did not indicate trap success for individual species for Black Craggy, Watson or Skull Islands, but noted whether the species was common (C) or present (P). The table does not include the 1988 record of *Planigale maculata* from Vanderlin Island (Johnson and Kerle 1991), because this species is typically detected from pitfall trapping, and pitfall trapping was notably carried out inconsistently among surveys and islands

Species	Island							
	Vanderlin	North	Centre	West	South West	Black Craggy	Watson	Skull
Brush-tailed rabbit-rat, *Conilurus penicillatus*			'66: 0.1					
			'88: 0					
			'03: 0					
			'05: 0					
Northern quoll, *Dasyurus hallucatus*	'88: 0.40							
	'03: 0.50							
	'04: 0							
	'09: 0							
Northern brown bandicoot, *Isoodon macrourus*			'66: U					
			'88: 0[A]					
			'03: 0.1					
			'05: <0.1					
Grassland melomys, *Melomys burtonii*		'66: C	'66: C	'66: C	'66: C			
	'88: 0.7	'88: 0	'88: 2.7	'88: 1.2	'88: 0			'88: P
	'03: 0	'03: 0	'03: 0.7	'03: 0	'03: 0.2			
	'04: 0	'04: 0	'05: 0	'05: 0	'05: 0			
	'09: 0.2	'10: 0		'09: 0				'09: 8.1
Northern brush-tailed phascogale, *Phascogale pirata*				'66: 0				
				'88: 0.2				
				'03: 0				
				'05: 0				
				'09: 0				
Carpentarian antechinus, *Pseudantechinus mimulus*		'66: 1.1	'66: 0		'66: 0			
	'88: 0	'88: 0.2	'88: 0.7		'88: 0.3			
	'03: 0.4	'03: 0.2	'03: 0		'03: 0			
	'04: 0.3	'04: 0.3	'05: S[A]		'05: 0.1			
	'09: 0.1	'10: 0						
Delicate mouse, *Pseudomys delicatulus*				'66: U	'66: 0			
	'88: 1.3			'88: 2.3	'88: 0			
	'03: 0.3			'03: 0	'03: 0			
	'04: 0			'05: 0	'05: 1.2			
	'09: 0.3			'09: 0[B]				
Western chestnut mouse, *Pseudomys nanus*					'66: C			
					'88: 1.2			
					'03: 0			
					'05: 0			
Canefield rat, *Rattus sordidus*					'66: 0			
					'88: 4.2			
					'03: 0			
					'05: 0			
Pale field-rat, *Rattus tunneyi*		'66: C	'66: C	'66: C	'66: C			
		'88: 0	'88: 8.2	'88: 7.3	'88: 13.7	'88: 0	'88: 0	'88: 0
		'03: 0	'03: 3.2	'03: 0	'03: 0			
		'04: 0	'05: 0	'05: 0	'05: 0			
		'10: 0.3		'09: 0		'09: 10.2	'09: 2.1	'09: 0.7
Long-haired rat, *Rattus villosissimus*		'66: 0			'66: 0.2			
		'88: 18.0			'88: 0	'88: C	'88: C	'88: C
		'03: 1.0			'03: 0			
		'04: 0			'05: 0			
		'10: 0.2				'09: 0	'09: 0	'09: 0.3
Combined *Rattus*		'66: C	'66: C	'66: C	'66: C			
		'88: 18.0	'88: 8.2	'88: 7.3	'88: 17.9	'88: C	'88: C	'88: C
		'03: 1.0	'03: 3.2	'03: 0	'03: 0			

(*continued next page*)

Table 5. (*continued*)

Species	Island							
	Vanderlin	North	Centre	West	South West	Black Craggy	Watson	Skull
		’04: 0	’05: 0	’05: 0	’05: 0			
		’10: 0.4		’09: 0		’09: 10.2	’09: 2.1	’09: 1.0
Common rock-rat, *Zyzomys argurus*		’66: C	’66: C		’66: C			
	’88: 7.2	’88: 11.2	’88: 3.6		’88: 4.2	’88: P	’88: 0	
	’03: 12.4	’03: 4.4	’03: 4.5		’03: 0.2			
	’04: 11.6	’04: 7.9	’05: 3.8		’05: 0			
	’09: 5.3	’10: 0.9				’09: 0	’09: 13	
No. of trap-nights		’66: 275	’66: 1706	’66: 233	’66: 450			
	’88: 925	’88: 950	’88: 546	’88: 825	’88: 1050	’88: 100	’88: 200	’88: 200
	’03: 1050	’03: 1057	’03: 919	’03: 495	’03: 521			
	’04: 1200	’04: 1050	’05: 2350	’05: 1260	’05: 1571			
	’09: 864	’10: 864		’09: 336		’09: 432	’09: 432	’09: 432

[A]One Carpentarian antechinus was seen on Centre Island, but none was caught in traps.
[B]Reported from cat faeces in 2010 (Paltridge 2010).

mammal fauna with that of the adjacent mainland (where he recorded trap success of 1.9% from comparable sampling), for which he considered the mammal fauna to have suffered very substantial loss because of environmental degradation resulting from the impacts of pastoralism and fire.

Both Calaby (1976) and Johnson and Kerle (1991) considered that the Pellew islands were of outstanding conservation significance, in large part because of their provision of refuge to many mammal species that were nationally threatened and/or that had declined severely across their mainland range. The ethno-biological information suggests that the islands had even greater conservation significance than that reported by Calaby (1976) and Johnson and Kerle (1991).

The Pellew mammal fauna includes (or included) the following four species listed as threatened at Australian (under the *Environment Protection and Biodiversity Conservation Act*) and Northern Territory (under the *Territory Parks and Wildlife Conservation Act*) levels: Carpentarian antechinus, northern quoll, northern brush-trailed phascogale and brush-tailed rabbit-rat. In addition, the canefield rat is known in the Northern Territory only from the Pellew islands, and is considered vulnerable under Northern Territory legislation (Woinarski *et al.* 2007*a*). As well as this species-level significance, isolation of mammals on these islands may have led to genetic divergence and distinction from mainland populations, and hence some conservation significance for these populations (as comparably reported for northern quolls on some islands of the Kimberley: How *et al*. 2009).

Furthermore, the mammal fauna of the Pellew islands is rich (overall and per island) relative to that of the similarly well sampled islands of the Wessel group (Fig. 2, Table 4). This may be because the closer proximity of islands in the Pellew group to the mainland may permit a higher rate of colonisations.

The mammal fauna is also of biogeographic importance. For several species (notably northern brush-tailed phascogale, northern quoll, brush-tailed rabbit-rat), the Pellew populations are (or were) notably disjunct from the current Northern Territory mainland range, now largely restricted to taller forests of the higher-rainfall northern fringe of the Northern Territory (Fig. 3). This current disjunction may reflect relatively recent gradational decline of these species from lower-rainfall mainland areas (as reported elsewhere in northern Australia; e.g. Kitchener 1978; McKenzie 1981; Braithwaite and Griffiths 1994, 1996), or a response to more gradual climatic and vegetation change in the 6000–10 000 years since the islands’ isolation.

The mammal fauna of the Pellew islands is not only a marooned remnant of that now typical of northern tall open forests, but it also includes representation of a species confined to these islands and a small number of sites in the southern Gulf of Carpentaria hinterland (Carpentarian antechinus), a species characteristic of semiarid grasslands of inland Australia (long-haired rat) and a species otherwise restricted to eastern Queensland (canefield rat). This is an eclectic mix, and may reflect the composition at the time of the islands’ isolation, or occasional episodes of overseas dispersal from the nearby mainland. With respect to the latter, the ethno-biological evidence is clear that agile wallabies swim between islands, and the recent comprehensive natural colonisation of islands by cane toads is evidence of the limited isolation of these islands. The 2009 record of euro (*Macropus robustus*) from the small Watson Island (Mahney *et al*. 2009), but no larger islands, may be further evidence of the ability of some mammal species to swim to these islands.

Decline and its causes

One of the objectives of the present paper was to attempt to relate changes in the status of mammals to factors that may have caused such change. For the Pellew islands, this is a difficult exercise because the timing of the introduction of particular potentially threatening factors may be imprecisely known, because the period between surveys has been irregular, and because the sampling intensity in some visits may have been insufficient to interpret absence of records for some species as either local extirpation or ‘pseudo-absence’ (that is, the species was present but not detected).

The ethno-biological information reported here suggests that the earliest surveys (Calaby 1976; Johnson and Kerle 1991) either

Table 6. Summary of ethno-biological information recorded for the Sir Edward Pellew group of islands

Species	Information from Bradley *et al*. (2006: pp. 73–88)	Additional information from interviews conducted during mammal surveys
Northern quoll	Older Yanyuwa people noted that they 'were common on the islands' but that 'most people of middle age and below were not familiar with the species'.	
Northern brown bandicoot	Once a favoured food source for the Yanyuwa 'on the islands'; old people reported explicitly that they were formerly abundant around the large springs on South West and on Vanderlin Islands; there were two distinct names, referring to a smaller and larger type, and the smaller one may have referred to the golden bandicoot.	Formerly abundant around the large springs on Vanderlin Islands (Johnny Johnston in 2009 interview). However, Steve Johnston noted that he had not seen bandicoots on Vanderlin Island during his long residence there, but had been told stories by his elders that they were (formerly) present on South West, North and Centre Islands.
Northern brushtail possum	Possums are (or were) important for aspects of Yanyuwa culture; the common brushtail possum occurred 'on the islands', but 'the possum population has dropped dramatically in all locations where they were once well-known'.	In interviews in 2009, neither Steve Johnston nor Johnny Johnston knew of possum records from the islands, although both reported that possums were abundant in mangroves at a site on the nearby mainland, as reported also by Bradley *et al*. (2006).
Northern brush-tailed phascogale	Old Yanyuwa people knew this species 'that lived only on the islands'.	This species was not known from Vanderlin Island by Steve Johnston or Johnny Johnston.
Northern blossom-bat	This bat was known from paperbark forests and rainforest thickets 'on the islands' (with identification based on description, and recognition of the species seen in a captive population).	
Ghost bat	Known from cave systems on North and White Craggy Islands.	
Agile wallaby	'Sometimes encountered floating on the tidal currents between islands', and reported an occurrence of an agile wallaby emerging from the sea onto the beach at Centre Island.	Archie Johnston (in Taylor *et al*. 2004) reported that agile wallabies had been introduced to, or colonised, Vanderlin Island only in the past 30–50 years.
Sugar glider		Ward *et al*. (2006) noted that several former Yanyuwa residents from West Island reported its occurrence. In interview in 2009, neither Johnny Johnston nor Steve Johnston knew of this species on Vanderlin Island.
Northern hopping-mouse		Ward *et al*. (2006) noted that several former Yanyuwa residents from West Island reported 'chasing hopping-mice' on the dunes. In interview in 2009, neither Johnny Johnston nor Steve Johnston knew of this species on Vanderlin Island.
Echidna	The echidna is only sung in one song line and it is on Vanderlin island up in the rocky ledge country, I have asked people about the echidnas on the island and people said they were once there, mostly on Vanderlin. When I pushed what happened to them, old people just said, when the old people die, the animal can go away too. Of course this is an interesting but common way to talk about species loss. Old Steve Johnston remembered his mum getting 'one or two' over the years.[A]	On the basis of presentation of stuffed museum specimens in structured interview, neither Johnny Johnston nor Steve Johnston knew of this species from the Pellew islands.
Black-footed tree-rat		On the basis of presentation of stuffed museum specimens in structured interview, neither Johnny Johnston nor Steve Johnston knew of this species from the Pellew islands.
Other rodent		Steve Johnston reported the (former) presence on Vanderlin Island of a large rat.

[A]This paragraph from J. Bradley (pers. comm.).

failed to detect some significant species then still present on the islands, or that these species had disappeared before these surveys. The most significant of the ethno-biological records are of common brushtail possum from one or more islands, northern brown bandicoot (and possibly golden bandicoot) from Vanderlin and South West Islands (and possibly others), sugar glider from West Island, and possibly northern hopping-mouse from West Island. The record also suggests that northern quoll occurred on more than the one island (Vanderlin) from which it was reported in surveys. Some of these records are very precise (such as the occurrence of bandicoots around springs on South West and Vanderlin Islands); however, others are

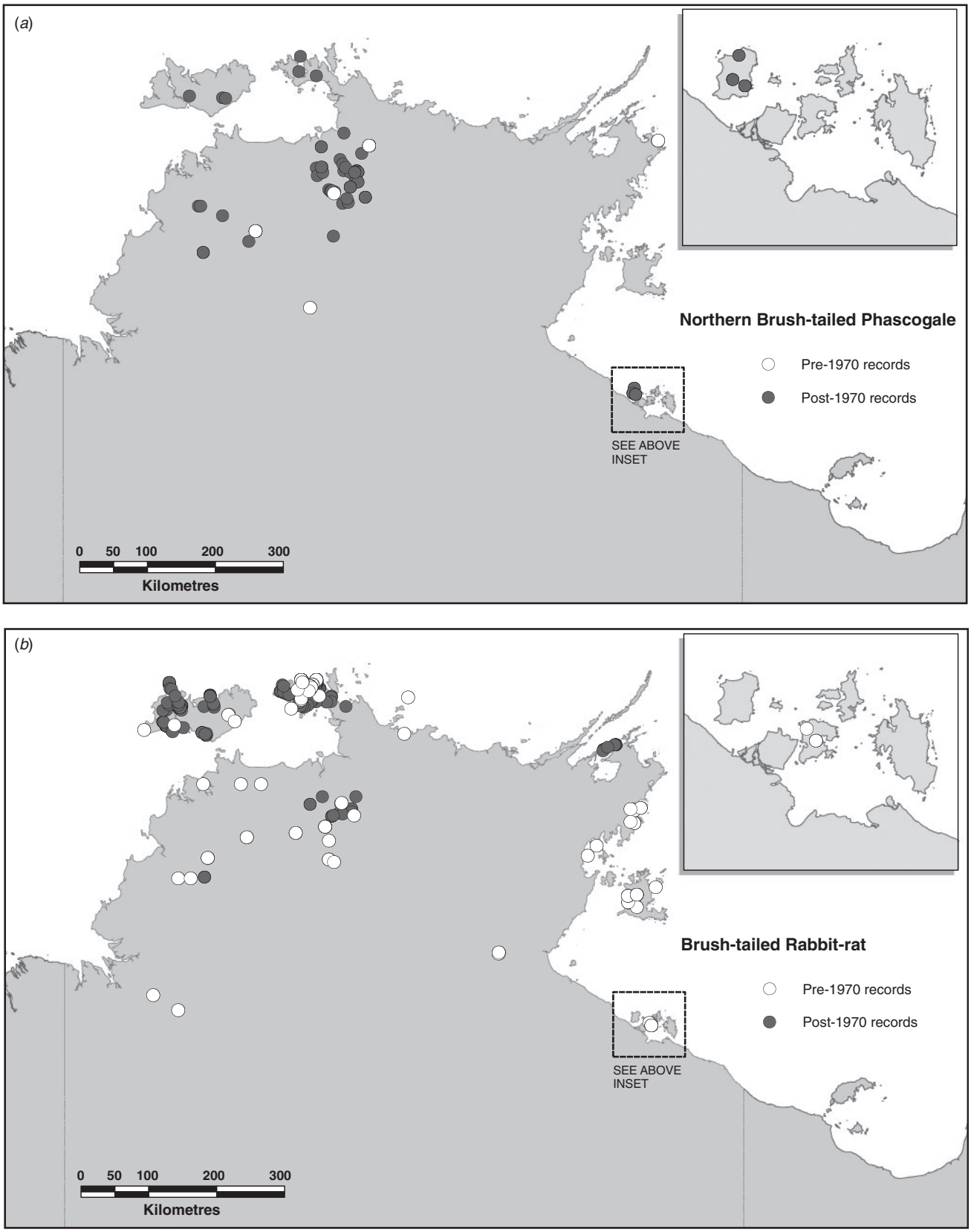
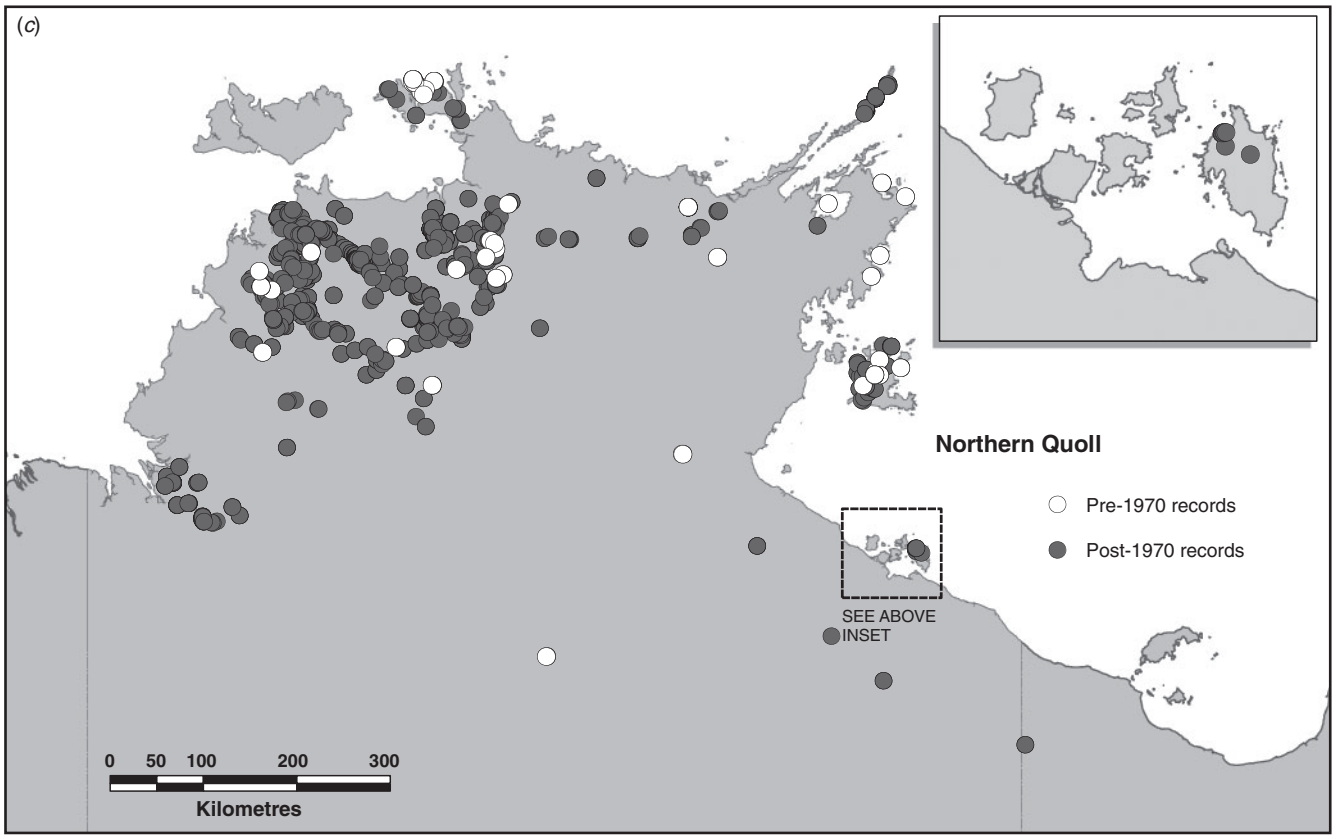


Fig. 3. Broader Northern Territory distribution for some mammal species for which the records from Pellew islands represent conservation or biogeographic note.



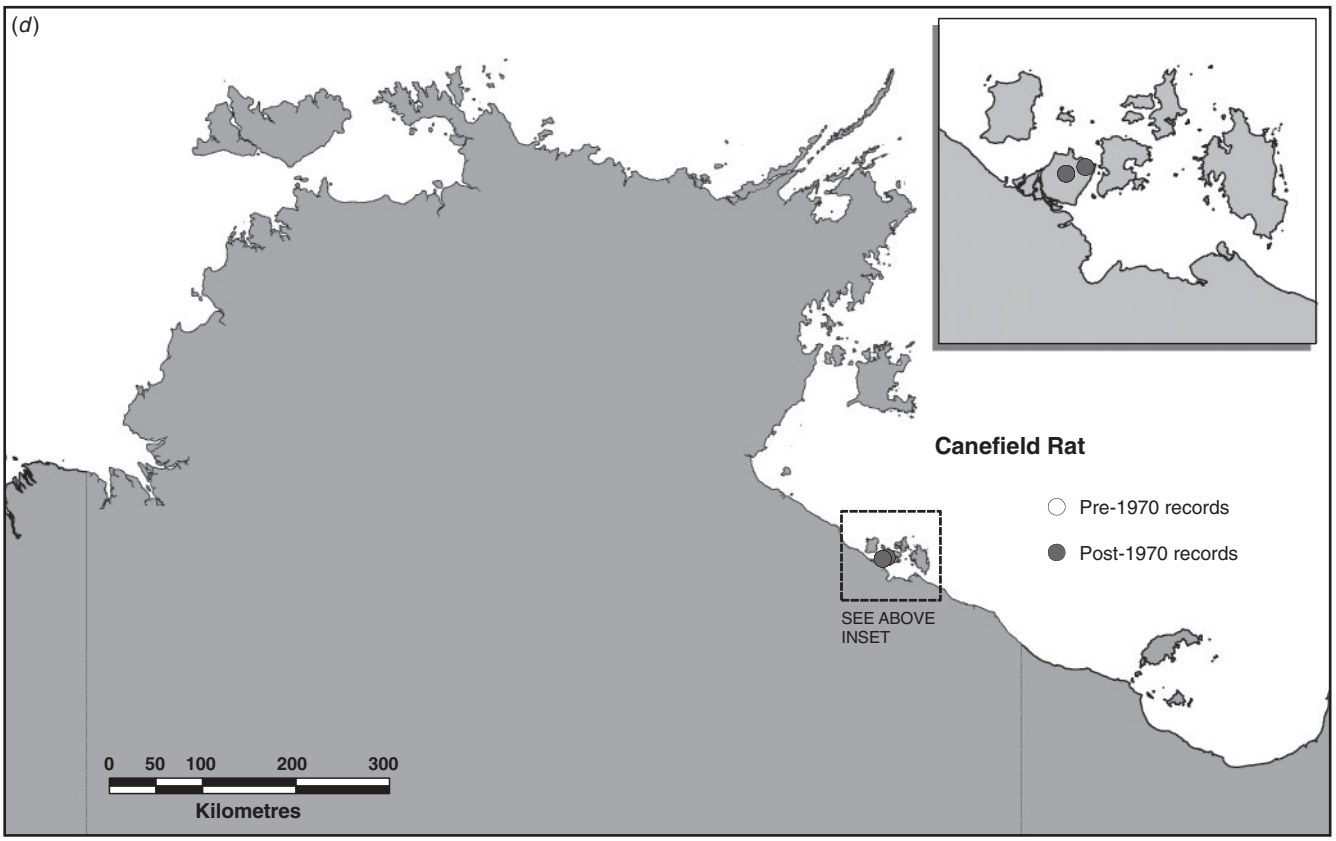


Fig. 3. (*continued*)

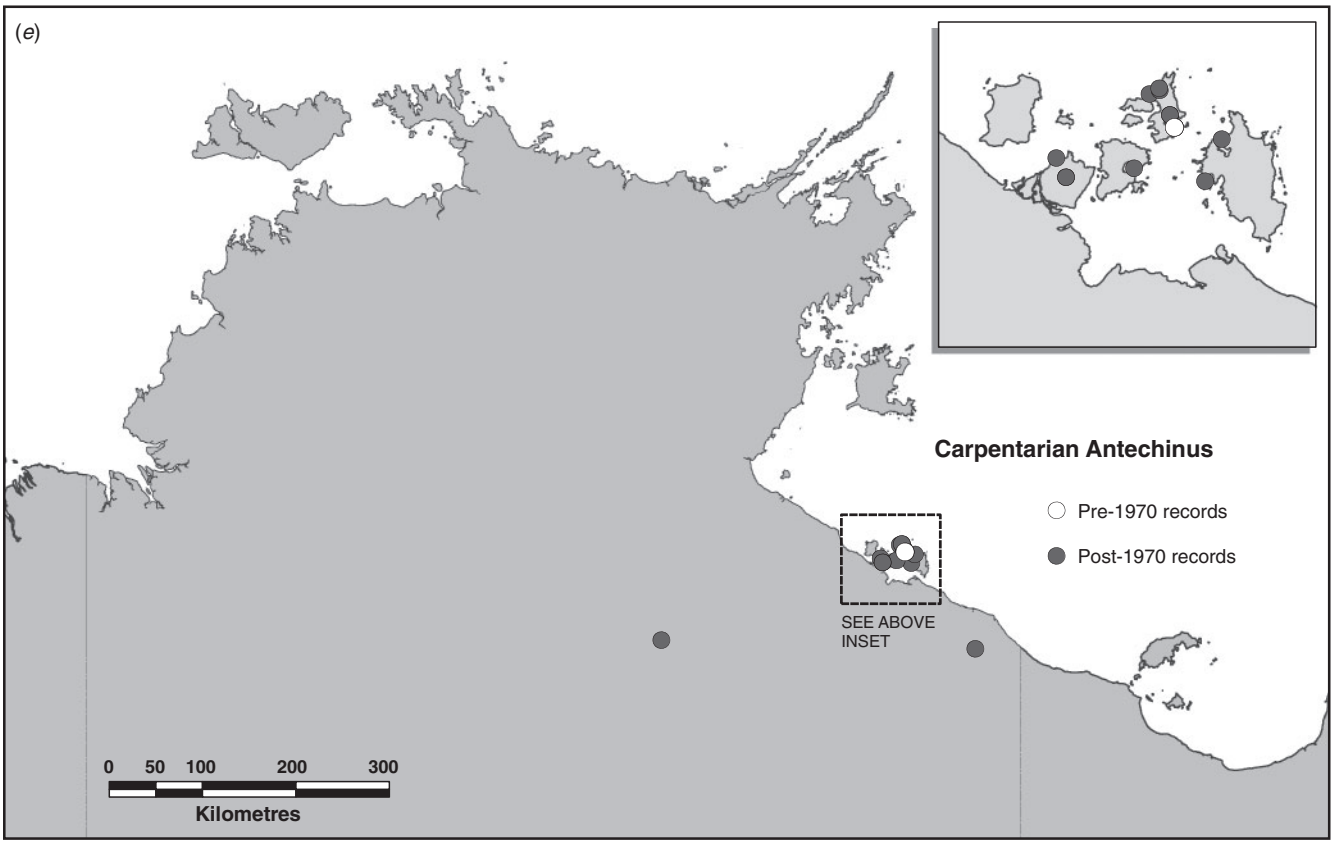


Fig. 3. (*continued*)

imprecise in dating, location or identity (e.g. golden bandicoot, northern hopping-mouse). With respect to the possible golden bandicoot record, M. Ziembicki (unpubl. data) noted that many Indigenous communities across the monsoonal tropics of the Northern Territory used separate names for larger and smaller bandicoots, and that this does not necessarily mean that two bandicoot species were present. The Yanyuwa informants reported in Bradley *et al*. (2006) were specific that possums, quolls and bandicoots had declined from the islands, and suggested that this decline was within the lifetime of older people, with younger people being relatively unfamiliar with these species; broadly, this means that these species may have declined during the period of about 1960–80.

Several other studies have demonstrated recent decline in the mammal fauna in northern Australia, but have not provided definite proof for causes (Kitchener 1978; McKenzie 1981; Woinarski *et al*. 2001, 2010, 2011). Four major factors have been suggested, including changed fire regimes, habitat degradation as a result of grazing pressure, predation by feral cats and poisoning by cane toads (with this latter restricted to carnivorous or omnivorous mammal species). The extent to which the fate of the mammal fauna of the Pellew islands provides evidence relating to these possible causes is summarised in Fig. 4, and the following paragraphs.

The present study provided little evidence about the role of fire. It is plausible that fire regimes changed across all islands in association with the general movement of Yanyuwa people from

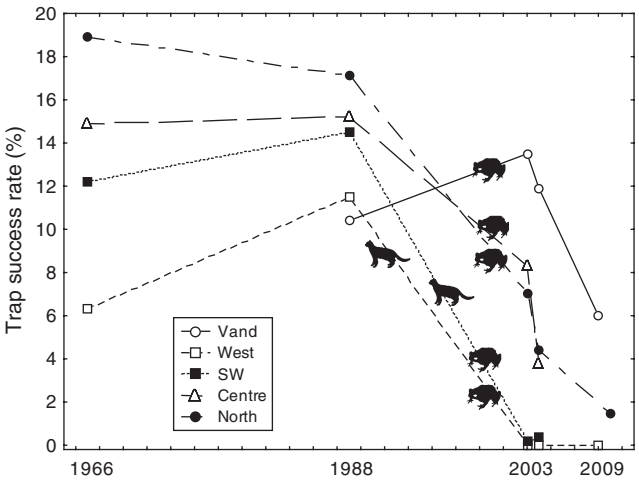


Fig. 4. Overall trap success rates on the five main islands of the Sir Edward Pellew group over time, with indication of dates of arrival of cats and toads. Note that cats were present on Vanderlin Island ('Vand') before the first survey period, and that this island was not sampled in 1966.

living on the islands to living mostly on the mainland, mostly in the 1940s and 1950s. Such change may be characterised as from the presumed ordered regime of fine-scale burning under traditional Indigenous management to a more anarchic regime of irregular intense and extensive fires (Yibarbuk *et al*. 2001).

However, in the 1960s and 1970s, Calaby (1976) interpreted the fire regime of the Pellew islands to be more benign than that on the nearby mainland. For the 1980s, Johnson and Kerle (1991: p. 21) stated that 'fire appears to have severely reduced the fire sensitive pine and jungle communities on most of the islands'. The northern cypress-pine (*Callitris intratropica*) is known to be fire sensitive, and a prevalence of dead stems, as reported by Johnson and Kerle (1991), typically marks the environmental consequences of a change from intensive traditional fire management, of fine-scale 'cool' fires, to less regular extensive 'hot' fires (Bowman and Panton 1993; Bowman *et al*. 2001; Yibarbuk *et al*. 2001). However, the most recent survey reported here (Mahney *et al*. 2009) interpreted a history of fire imagery and vegetation patterning to conclude that the current fire regime on the Pellew islands was relatively benign, with fires more infrequent and smaller than on the nearby mainland. Marked changes in fire regimes elsewhere in northern Australia have typically led to reduction in habitat quality for some mammal species (such as brushtail possum), through reduction in the abundance of tree hollows and hollow logs (used for shelter) and of shrubby understorey (that provides fruit and other important dietary items) (Kerle 1985; Firth *et al*. 2005, 2006). However, the case for fire as the primary driver of the mammal declines reported here is not strong, because fire-mediated vegetation change would most likely have been gradual and relatively consistent across islands (although feasibly fire impacts would be greater on the less rugged West and South West Islands, consistent with the greater intensity of mammal loss on those), and changed fire management does not really coincide with the relatively rapid marked mammal decline from 1988 to 2003.

For the 1960s and 1970s, Calaby (1976) considered that most of the Pellew islands were notable in lacking the environmental degradation due to pastoralism that characterised the nearby mainland. The exception was Vanderlin Island, which has been subject to largely unregulated browsing by goats (since the 1930s), and grazing by cattle (since the 1940s) and horses and donkeys (since the 1960s) (S. Johnston, pers. comm.). (Unfortunately, for cause attribution, it is also the only island for which there has been a similarly long period of feral cats.) Johnson and Kerle (1991) linked this grazing pressure to some environmental degradation. Somewhat contrarily, Archie Johnston (in conversation in 2003) asserted that much of the environmental change that he had observed over decades on Vanderlin Island was attributable to a proliferation of the agile wallaby (*Macropus agilis*) over that period, arising in part from the extirpation there of dingoes.

More recently (early 1980s: Ward *et al*. 2006), goats were introduced to West Island, and have subsequently become abundant there, although intermittent management actions have led to some periods of population decline. Johnson and Kerle (1991) reported that there was a small herd of goats on Black Craggy Island, and cattle had been present there 'in the past', but numbers and persistence were limited by lack of fresh water. Taylor *et al*. (2004) reported that the goat population on this island had subsequently perished. Feral pigs (*Sus scrofa*) were first reported for the Pellew islands in 2005 by Ward *et al*. (2006), who noted their presence on South West Island in 2005, presumably from a recent natural colonisation from the nearby mainland. Their continued presence on, or visitation to, this island was confirmed in 2009 by J. Bradley (pers. obs.).

Overall, the case is weak for mammal decline being caused by environmental degradation arising from non-native herbivores. On Vanderlin Island (the island with the longest history of, and most intensive, grazing), environmental degradation may have contributed to the known loss of bandicoots. Furthermore, it is striking that Vanderlin Island alone of the five large islands of the Pellew group has had no survey records of *Rattus* species, and it may be reasonable conjecture that at least one such species was present but has since disappeared. However, no livestock or feral stock are present on North, Centre or South West Islands, and hence habitat degradation through grazing cannot be the cause of the mammal declines demonstrated on these islands.

Feral cats have been present on Vanderlin Island for at least 30–50 years (PWCNT 2004), and hence may have caused the loss of the island's bandicoots and putative *Rattus*. In 1988, cats were not present on any other island (Johnson and Kerle 1991). Subsequently, their introduction to West (four cats introduced in 1993: Taylor *et al*. 2004; J. Bradley, pers. obs.) and South West (in 1998: Taylor *et al*. 2004) Islands coincided neatly with the marked decline (or extirpation) of *Rattus* species, western chestnut mouse, grassland melomys, northern brush-tailed phascogale and common rock-rat from either or both of these islands, sometime between 1988 and 2003. Unfortunately, we remain uncertain about whether or not feral cats occur on Centre Island (Taylor *et al*. 2004), and if they do, when they were introduced. This island also has suffered a marked decline or loss of *Rattus* species, brush-tailed rabbit-rat and grassland melomys, largely coincident with the comparable losses on West and South West Islands, but notably still retains a (probably small) population of bandicoots. The case for cat predation is weakened somewhat by the decline of *Rattus* species and grassland melomys from the presumed cat-free North Island, with timing largely coincident with comparable losses on other islands. In conversations in 2003, Steve and Archie Johnston reported that feral cats had recently become less common on Vanderlin Island (Taylor *et al*. 2004), broadly consistent with a relatively stable population of native mammals over this period (other than for northern quolls) on that island.

Elsewhere in Australia, rock-dwelling mammals have persisted better with feral cats than have similar mammals occurring in other habitats (Burbidge and McKenzie 1989; Burbidge and Manly 2002), presumably because the hunting efficiency of feral cats may be lower in rugged rocky areas. There is some indication in the data here that this pattern applies also in the Pellew islands, with typically better persistence of Carpentarian antechinus, common rock-rat and short-eared rock-wallaby than of other mammals, and higher rates of persistence generally on the more rugged North and Centre Islands than on the less rugged West and South West Islands. From our most recent surveys, native *Rattus* species are now known to persist only on North Island and on the three smaller islands of Black Craggy, Watson and Skull, none of which have populations of feral cats.

A significant impact of feral cats on the mammal fauna of the Pellew islands is consistent in part with a previous continental-scale analysis of patterns of mammal decline on Australian islands (Burbidge and Manly 2002), which concluded that

introductions of predators (foxes and cats) had been the major factor causing the extirpation of native mammals on islands. However, the above analysis indicated that predation by cats was likely to cause extinctions particularly on more arid islands, and was not characteristic of more mesic islands, such as the Pellew islands. The current study has suggested that native mammals on higher-rainfall islands should not be presumed safe from the impacts of feral cat predation.

Dogs may have impacts on native mammals that are either direct (through predation) or indirect (through potentially controlling the abundance of feral cats). Dogs (dingoes; *Canis lupus*) have almost certainly had a long history on the islands, with a rich Yanyuwa lore as companion animals (Bradley *et al*. 2006), corroborated by Flinders' record of them on the islands in 1802 (Johnson and Kerle 1991). Their status on individual islands over the past decades has been variable. Calaby (1976) noted that dingoes were absent from islands other than Vanderlin and South West. Johnson and Kerle (1991) reported dogs on Centre Island. A small pack of wild dogs was reported by Ward *et al*. (2006) on West Island. Steve Johnston (in Bradley *et al*. 2006: p. 73) reported that 'the original dingo population on Vanderlin Island became extinct in the 1930s due to trapping and baiting'.

Cane toads arrived on all islands from the nearby mainland by rafting on freshwater plumes and debris associated with a major flood of the McArthur River in February 2001 (Taylor *et al*. 2004). They have been reported on all islands sampled since then (Taylor *et al*. 2004; Ward *et al*. 2006; Mahney *et al*. 2009). The timing of their arrival coincided with the mammal declines observed on most islands between the 1988 and 2003 surveys. The evidence is very strong that they caused the extirpation of the northern quoll on Vanderlin Island. Three long-term residents and acute observers, Archie, Johnny and Steve Johnston, independently described to us its fate. All three agreed that it was an abundant species up to the arrival of cane toads on the island in 2001. All reported that they subsequently observed dead quolls with no apparent external injury, and that quolls rapidly became less common. Quolls were still present during our surveys of the island in 2003. But the Johnstons saw decreasingly few in subsequent years, with the last observation by Johnny Johnston in 2006 and Steve Johnston in 2008. This population is almost certainly now extirpated. This represents the clearest cause-and-effect case amongst the pattern of status change reported here, and is consistent with previous evidence, demonstrating marked susceptibility of northern quolls to poisoning by invading cane toads (Burnett 1997). However, notwithstanding that specific response, the ethno-biological record suggests that quolls were also lost from other islands before the arrival of toads.

It is plausible that toads may have also contributed to the presumed loss of the carnivorous northern brush-tailed phascogale from West Island. Elsewhere (notably in Kakadu National Park), recent rapid declines of *Rattus tunneyi* have followed soon after the arrival of cane toads, suggesting that toads may have contributed to this decline (Woinarski *et al*. 2010). Although the near simultaneous decline of *Rattus* species, and other native mammals, across the large islands in the Pellew group more or less in concert with the arrival of cane toads provides some support for this case, the argument is significantly weakened by the persistence (and indeed, continued high abundance) of *Rattus* species and other native rodents on the three smaller islands sampled in the Pellew group, all of which now also support large populations of cane toads.

The above paragraphs fail to demonstrate clear-cut convictable evidence. This is a frustrating conclusion. Without such intention, the Pellew islands have presented an exquisite setting for a fascinating set of natural experiments. The outcomes from those experiments have been catastrophic, with severe reduction in the value of the islands as an extremely significant refuge area. And yet, because of some imprecision in the timing and composition of the natural experiments, causation remains unproven. Given the arguments above, we consider that the most reasonable interpretation of the pattern of loss is predation by feral cats, exacerbated in some cases by changed fire regimes, and with one particular specific case of loss directly attributable to cane toads (Table 5, Fig. 4).

Extirpation is difficult to prove; however, we consider it most likely that, over the past 50 years, the important regional populations of brush-tailed rabbit-rat, northern quoll, northern brush-tailed phascogale, common brushtail possum and canefield rat have been lost from these islands, and that northern brown bandicoot, western chestnut mouse, pale field-rat and long-haired rat have been lost from most of the islands on which they formerly occurred. This represents a very high proportion of the terrestrial mammal fauna in these islands.

Management conclusions

Not all is lost. The Carpentarian antechinus persists in rocky areas on four of the islands. Given the paucity of records from the mainland, these represent important populations for this threatened species. It is most likely that this species has persisted far better than most other native mammals because it is largely restricted to rugged rocky areas (where cat predation may be the lowest, and feasibly, where fire impacts may be less pronounced) and is relatively solitary (which may make it less easy for cats to wipe out populations). Its persistence on islands with cane toads suggests that this predatory species may (learn to) avoid toads.

There are management lessons from this story. The residual remaining mammal conservation values of the Pellew islands may need to be bolstered and managed intensively. Searches should be instigated to determine whether of not cats occur on Centre Island. If present, attempt should be made to eradicate them. North Island may provide a translocation site for bandicoots (from the small and presumably highly vulnerable population on Centre Island).

Not all non-native species arriving on islands do so by human transport. In the case of the Pellew islands, cane toads were self-introduced, and are now abundant on all surveyed islands. The Pellew islands may have been particularly suited to such colonisation, given that they abut the mouth of a large river, mostly have some natural water sources, are close to the mainland and are separated from each other by typically small distances. However, such successful island colonisation should be heeded for regions, notably such as the Kimberley in north-western Australia, where the cane toad has not yet fully colonised and where some islands have high conservation values.

Islands offer the potential for great conservation value, although this potential is very easily subverted. Where islands have significant conservation assets, quarantine systems that control the deliberate or inadvertent introduction of pests should be designed appropriately. This is largely unexplored grounds for Aboriginal-owned islands, whose owners may not unreasonably assume the same rights for habitation, livelihoods, pets and freedom of movement as those living on the mainland. In response to some of the patterns of loss evident in the present study, conservation agencies and organisations, researchers, Aboriginal landowners and Indigenous ranger groups have recently consulted widely about the environmental impacts of cats and of the need for protection of the environments of the Pellew islands (Paltridge 2010).

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