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PROBABLE LOCAL EXTINCTION OF THE BUSH RAT, *RATTUS FUSCIPES* ON EAST WALLABI ISLAND IN THE HOUTMAN ABROLHOS

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ABSTRACT

The Bush Rat, *Rattus fuscipes*, has not been trapped on East Wallabi Island in the Houtman Abrolhos, Western Australia, since 1967. Recent surveys on both East and West Wallabi have suggested that though there is a significant population of Bush Rats present on the latter, there is a possibility that the population on East Wallabi is either very small or extinct. Further survey work to establish the status of Bush Rats on East Wallabi is necessary.

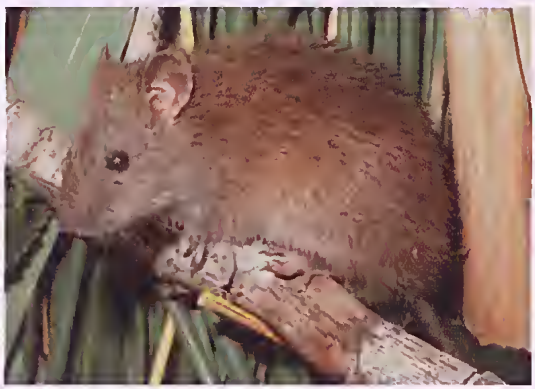

Figure 1. Photo of *R. fuscipes*. (Photo Greg Barron).

This paper is dedicated to the memory of Greg Barron (1952-2005), who was a noted naturalist, photographer and Western Australian Museum staff member from 1977 to 1985.

INTRODUCTION

The common and widespread Bush Rat, *Rattus fuscipes*, is a medium sized native Australian rodent (Figurel) with weights ranging between 40–225 g throughout its distribution around the coast of southern and eastern Australia and on near-coastal islands. There are four currently recognised subspecies (Lunney 1998). In Western Australia, it is present in coastal forests and shrublands from Jurien Bay southeast to Point Dempster with outlying populations on the Wallabi Islands of the Houtman Abrolhos (Figure 2).

Rattus fuscipes was first collected during the Voyage of the Beagle [1832–1836] and described by Waterhouse in 1839. The holotype (the specimen designated as the type specimen of the nominal species) was collected at King George's Sound, Western Australia in March 1836 and has since been lost. A neotype (a newly designated type specimen selected in the absence of the holotype) was designated by Taylor and Horner in 1967 (Western Australian Museum specimen M6634) as a female collected at "Princess Royal Harbour, approximately 4 miles due south of Mount Melville

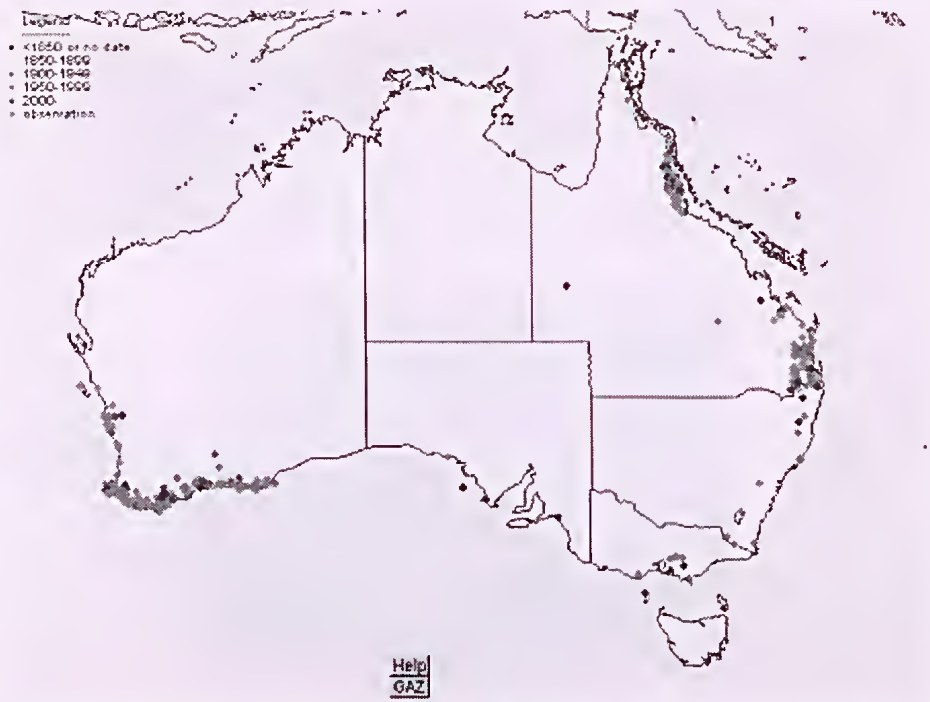

Figure 2. Map of distribution of *R. fuscipes* across Australia from www.museum.wa.gov.au/faunabase

Albany, WA". This locality is approximately four miles from where H.M.S. "Beagle" is thought to have anchored in 1836.

In 1926 Thomas named a specimen from East Wallabi Island (British Museum, BMNH 26.7.12.2 original Western Australian Museum registration number 9103) as *Rattus glauerti* because the teeth were "so conspicuously smaller than those of the mainland animal as to indicate specific distinctness". The name *R. glauerti* was subsequently synonymised with *R. fuscipes.*

Given the remoteness and isolation of this population of *R. fuscipes* from mainland ones and the fact that isolated reptile species on the Abrolhos islands are taxonomically distinct, (the Abrolhos Dwarf Bearded Dragon, *Pogona minor minima* and Abrolhos Spiny-tailed Skink, *Egernia stokesii stokesii*), there is a need to determine the taxonomic status of *R. fuscipes* on the islands.

The Houtman Abrolhos is an archipelago of over 170 islands, islets and rocks (Harvey *et al.* 2001) lying some 55–70 km off the mid west coast of Australia and it is the site of the earliest European habitation of the continent in 1629. The Archipelago comprises four island groups, the southern Pelsaert Group, the central Easter Group, the northern Wallabi Group and even further to the north, North Island. All these groups are separated from one another by sea depths of over 40 m and by similar depths from the adjacent mainland.

West and East Wallabi Islands (Figure 3a and 3b), are the largest islands in the archipelago and consist of Cretaceous and Tertiary limestone, siltstone and marl of continental origin, and have been isolated by rising sea levels for between 6000–8000 years from the adjacent mainland (Harvey *et al.* 2001). They are currently separated from each other by nearly 2 km of ocean at a depth of less than 2 m. Important geological features on East and West Wallabi include pavement limestone, sand dunes and consolidated dunes which are unusual, easily disturbed structures that have a slow rate of regeneration (AIMAC & Fisheries WA 1998.)

East Wallabi has an area of 307 ha while West Wallabi is 587 ha. Both have an average annual rainfall of 400mm (Abbott &Burbidge 1995). The flora, vegetation structure and geological associations of the islands are described in Harvey *et al.* (2001; Table 11), who report that 97 species occur on West Wallabi and 74 on East Wallabi of which 79% and 64% are native, respectively. Storr *et al.* (1986) have described the birds of the Abrolhos. There are 27 species of bird recorded from East Wallabi, 24 landbirds and 3 seabirds; on West Wallabi there are 48 species, 35 species (including waders) and 13 seabirds (*pers. comm.* Ron

Johnstone). Nineteen species of reptiles, (How *et al.*, 2004) have been recorded from West Wallabi and 16 species from East Wallabi. A further two taxa have been added to the East Wallabi reptile assemblage as a result of the November 2005 survey (Maryan 2005).

According to Abbott and Burbidge (1995) neither island was accessible to Aborigines prior to European settlement. However, this does not indicate that

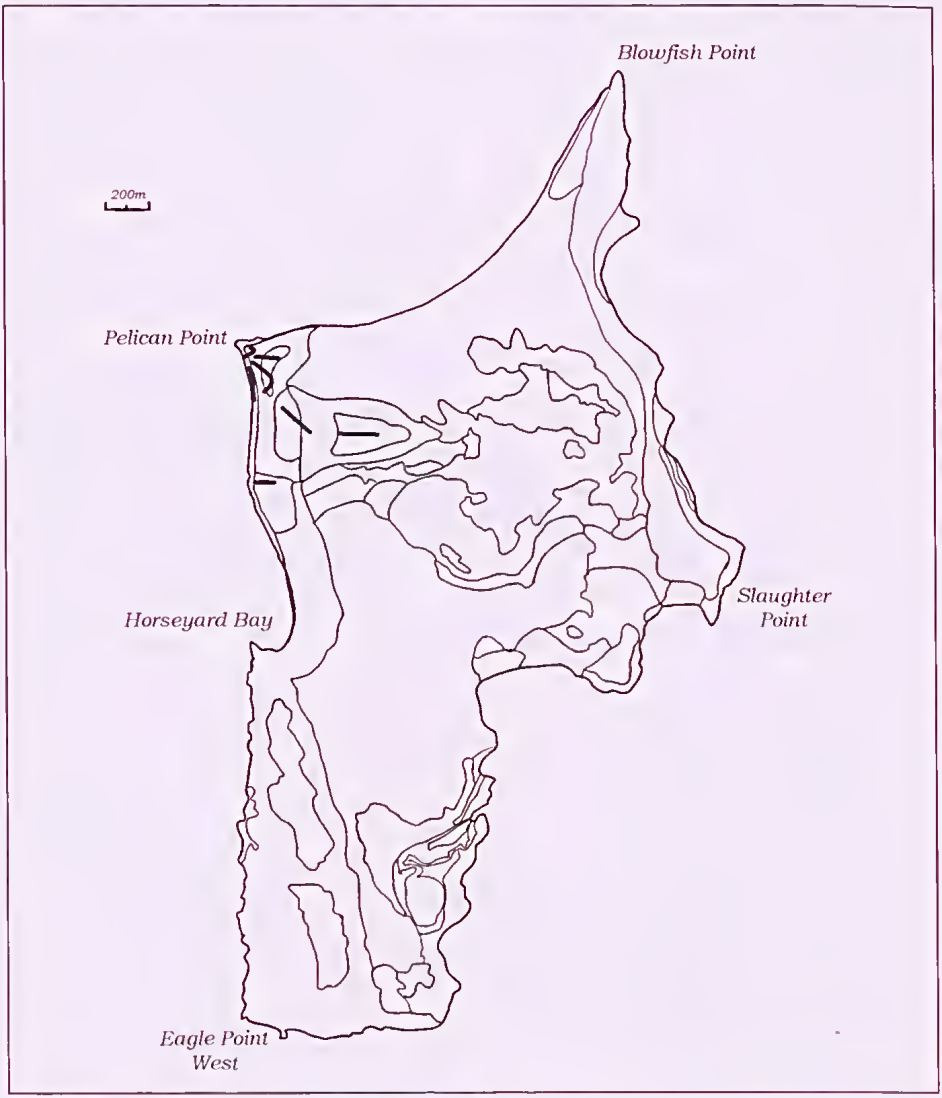

Figure 3a. Map of West Wallabi Island with trap lines marked in bold. Contour lines representing habitat types (after Harvey *et al.* 2001).

Aboriginal people did not access the land when it was connected to the mainland (M. Smith *pers. comm.*). West Wallabi is historically famous for the landing of the soldiers shipwrecked from the Batavia, in June 1629 looking for water, and their subsequent stranding and attacks by J. Cornelisz, the mutineer. Presently, East Wallabi is uninhabited but has an airstrip that gives access to tourists and visitors travelling to other islands. Rock lobster fishers have a settlement at Pelican Point, West Wallabi which they seasonally occupy. Both islands are under the control of the W.A. Department of Fisheries.

The history of trapping of *R. fuscipes* on the islands strongly suggests that the population on East Wallabi is either very low or now extinct, with the last known record being from 1967. In November 2005, a field survey of West and East Wallabi Islands in the Houtman Abrolhos was organised between the Western Australian Museum and the Department of Conservation and Land Management to document the reptile fauna and evaluate the populations of *R. fuscipes* on the Wallabi Islands.

MATERIALS AND METHODS

Information on the presence of *R. fuscipes* on East and West Wallabi Islands was extracted from the mammal database of the Western Australian Museum, Western Australian Museum catalogues and the field notebooks of Glen Storr, Alex Baynes and Ric How.

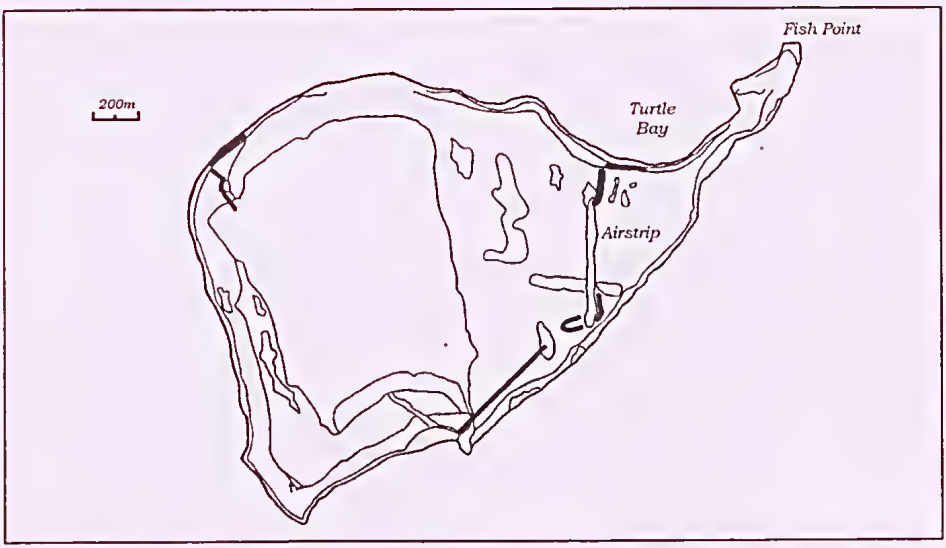

Figure 3b. Map of East Wallabi Island with trap lines marked in bold. Contour lines representing habitat types (after Harvey *et al.* 2001).

Many individuals who have worked on the Wallabi Islands or who have visited them were contacted for any information regarding evidence of *R. fuscipes* sighted or trapped in the last three decades on the islands.

Collections of *R. fuscipes* from the islands were made either by hand or using mammal traps of various types. Early trapping involved the use of Break-back traps (like large mousetraps), however, these have not been used since the 1980s for ethical reasons. Baynes used Sherman traps (large collapsible metal box traps) while recent trapping has involved the use of Elliott traps (collapsible aluminium box traps) and pit-fall traps with fence lines.

The notebooks confirm that trapping generally occurred in several vegetation types and at numerous locations on the two Wallabi islands (Figure 3a and 3b). It was not possible to differentiate trapping effort into the various habitat types identified by Harvey *et al.* (2001), although trapping by Baynes and How is known to cover several habitat types on both islands.

During the November 2005 survey all individuals trapped were examined to determine their sex; measured for nose-vent length, tail–vent length and weighed.

RESULTS

TRAPPING HISTORY

The specimen named *R. glauerti* by Thomas in 1926, was collected from East Wallabi Island on 17 November 1907, (original Western Australian Museum registration number is 9103). The specimen was received in exchange by the British Museum from the Western Australian Museum. In 1926, Thomas donated New Guinea and Queensland specimens to the Western Australian Museum and these may have been the exchange specimens for the *Rattus* type.

From data in the notebooks and the mammal database of the Western Australian Museum, *R. fuscipes* was observed and collected on East Wallabi Islands in April 1959 by G. Storr, who also collected two individuals in September of that year using Break-back traps. In December 1966, J. Kirsch collected specimens from East Wallabi and in August 1967 A. Baynes and M. Archer trapped the last known individuals from East Wallabi (Table 1). In September 1977, R. How trapped in the same location as Baynes, from the southeastern beach through to the eucalypt patch, and failed to record the species (Figure 3b). In October 2002 Pearson and How again failed to trap individuals on East Wallabi Island while trapping on the southwestern dunes and limestone pavement.

Individual *R. fuscipes* were collected on West Wallabi Island in April 1959 by G. Storr who was again successful in June and September 1959. Individuals were

Table 1. Summary Table of trapping data for *R. fuscipes* on East and West Wallabi Islands, including Date, Trap type (E, Elliott; BB, Break Back; P, Pit fall), number of individuals trapped and the collectors names. An asterisk denotes observations only.

West Wallabi			East Wallabi			Collector
Date	Traps	Individuals	Date	Traps	Individuals	
20/04/1959		3	20-21/04/1959	observed	2*	Storr
22/06/1959		3+5*				Storr
26/06/1959		2				Storr
12/09/1959		2	08/09/1959	BB	2	Storr
22/04/1960		4				Kelsall
23/04/1960	by hand	1				Storr
			00/12/1966		2	Kirsch
			06/12/1966		2	Kirsch
			27-31/08/1967	205S	9	Baynes & Archer
28-29/08/1977	50E + 38BB	4	2/09/1977	25E + 12BB	0	How
12-14/10/1999	75E	2				Pearson & How
29-30/10/2002	100E	3	31/10/2002	48E	0	Pearson & How
8-11/11/2005	160E	22	7-10/11/2005	199E	0	Cooper & How
8-11/11/2005	140P	21	7-10/11/2005	92P	0	Cooper & How

trapped or caught by hand in April 1960 by J. Kelsall and G. Storr, while in August 1977, R. How successfully trapped individuals on West Wallabi (Table 1). The species was again trapped on West Wallabi by D. Pearson and R. How in October 1999 and October 2002.

No further records or sightings of *R. fuscipes* on the islands were obtained by the authors.

NOVEMBER 2005 SURVEY

During the November 2005 survey no *R. fuscipes* were caught on East Wallabi, although 291 trap nights using both Elliott and pit fall traps were employed. During the same survey period 43 *R. fuscipes* were caught on West Wallabi Island after 300 trap nights using both trap types, with no difference in capture rates between either trap type (Table 1). Active Bush Rats were also observed during the cool overcast days during this survey.

Four of the 43 individuals were recaptures while one escaped and two were killed by shearwaters in pitfall traps. The weight and measurements of the individuals are presented in Table 2. Adults and sub-adults were represented in the samples of both sexes.

DISCUSSION

The last *R. fuscipes* caught on East Wallabi Island was in August 1967 and, despite additional surveys in September 1977, October 2002 and November 2005, no captures have subsequently been made. The direct temporal comparison during this study of trapping success for *R. fuscipes* on both East and West Wallabi Island clearly indicates that while a healthy population persists on West Wallabi Island, no individuals were found on East Wallabi Island. During extensive diurnal searches for reptiles on each of the Wallabi Islands during the November survey, *R. fuscipes* was seen on West Wallabi but no observations or signs were recorded on East Wallabi. This absence of sightings and differences in the trapping success on East Wallabi Island contrasts with the success of captures for the species on West Wallabi over the same time span and suggests that there is a strong possibility that the *R. fuscipes* population on East Wallabi is extinct.

Eastern populations of *R. fuscipes* are known to be larger in summer and autumn when young are weaned and the

Table 2. Summary of Mean, Standard Deviation, Minimum and Maximum measurements for Nose-vent Length, Tail-vent length and Weight for 18 female and 13 male *R. fuscipes* trapped on West Wallabi Island in November 2005.

	Nose-Vent Length (mm)	Tail-Vent Length (mm)	WEIGHT (g)
Females (18)	114.4±18.5, 75–145	100.2±14.3, 70–123	53.4±15.1, 23–75
Males (13)	114.5±15.7, 95–150	100.2±13.5, 80–120	52.9±17.8, 29–96

population numbers are lowest in winter. In the present spring study, November 2005, small sub-adults (animals which are not reproductively mature), were present in the West Wallabi population. However, the presence of sub-adults, does not explain the far higher trapping success of *R. fuscipes* on West Wallabi for this survey than in any previous one on the island undertaken during the winter and spring.

Island populations have exhibited much higher densities than on the adjacent mainland for Glennie Island in Bass Strait (Hobbs 1971; Robinson 1975), and comparatively high densities of Bush Rats have been recorded by Wheeler (1970) on Kangaroo Island and Schmitt (1975) on Pearson Island off South Australia.

Bush rats are omnivorous, eating seeds, fruits, grasses and insects (Watts and Aslin 1981) and are opportunistic in their diet. They were also observed during the present study eating small reptiles (geckos) caught in the same pit trap.

In 1976, Baverstock found that the water requirements of Bush Rats in captivity were the highest of any native rat yet studied. Despite this, it lives in the driest habitats of any native true rat except the Longhaired Rat (*R. villosissimus*) and Tunney's Rat (*R. tunneyi*), suggesting that physiological adaptations that allow survival without water are not necessary for successful exploitation of an arid environment. Behavioural adaptations and adoption of a specialised diet may be equally important (Watts and Aslin 1981).

Several factors probably influence the population size of *R. fuscipes* on the two islands. East Wallabi is about half the size of West Wallabi, has fewer plant species and is less diverse in landform and vegetation types (Harvey *et al.* 2001). It is apparent from our survey that populations of the Carpet Python (*Morelia spilota*) and Tammar Wallaby (*Macropus eugenii*) are markedly less abundant on East Wallabi and the size of adult skink lizards *Ctenotus fallens* are smaller on East Wallabi than West and this probably reflects lower productivity on the former.

There are an estimated 1 030 000 pairs of Wedge-tailed Shearwater, *Puffinus pacificus* and the Little Shearwater, *Puffinus assimilis assimilis* breeding on West Wallabi (Fuller *et al.* 1994), the burrows providing shelter and the eggs a possible food source for *R. fuscipes*. There are very few nests of either species of shearwater on East Wallabi (C. Surman *pers. comm.*).

Fisheries WA (2001 p36) suggested that a detailed assessment should be made of the potential for East Wallabi Island for tourism development, however, until there are further seasonal studies to assess the population status of *R. fuscipes* and to determine the activity

patterns and structure of the reptile assemblage on the island this should not be considered.

With *Rattus glauerti* having been synonymised with *R. fuscipes*, material collected from the Wallabi islands is being analysed by Steve Donnellan of the Evolutionary Biology Unit, South Australian Museum to determine the genetic relationships of *Rattus* on the Wallabi islands and to clarify their taxonomic status.

ACKNOWLEDGEMENTS

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The October 1999 and 2002 surveys were funded by CALM funds to David Pearson. Alex Baynes provide helpful advice and access to his early notebooks and Ron Johnstone assisted in locating information from his notebooks and from those of Glen Storr.

We also thank Mr Russell Dyson, Regional Manager, and Andy Darbyshire of the Fisheries Department, Geraldton, for permission to undertake the survey on the Wallabi Islands. The Western Australian Museum currently works under a CALM Permit No SF004816 to collect fauna and has ethics approval through the CALM Animal Ethics Committee [*License to Use Animals for Scientific Purposes No.* U18/2005] to take tissue from individuals.

We also thank Claire Stevenson who produced Figures 3a and 3b.

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BIRDS OF THE COCOS (KEELING) ISLANDS, INDIAN OCEAN

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SUMMARY

This paper reports on bird observations made on two trips to the Cocos (Keeling) Islands including the remote and difficult-to-access Pulu Keeling National Park in May and June/July 2003. Although additional species new to the island that I recorded as well as some of my other sightings have been included in Johnstone and Storr (2004), this paper expands on my observations during my time on the islands. I have included a list of all previous species sighted on the islands although a review of all previous records can be found in Johnstone and Storr (2004).

INTRODUCTION

The Cocos (Keeling) Islands are situated in the north-eastern Indian Ocean (12° 12' S, 96° 54' E). The closest island is Christmas Island (see Figure 211 in Johnstone and Storr 2004), which is 975km to the east-north-east. Java Head is just over 1,000 km to the northeast while Perth is 2900km to the southeast (Parks Australia 1999). The annual climate is tropical with an average rainfall of 1976 mm. The islands have an average daily maximum of 28.9 C, high humidity and a predominant wind direction of east to south-east with average daily speeds of 16 to 30 km/hr for most of the year (Director of National Parks 2004).

The southern atoll consists of 26 islands surrounding a lagoon. North Keeling Island (only 1.2 square kilometres in size) is 24 km to the north. The total land area of the two atolls is 14 square kilometres. A narrow submarine bank at a depth of 700–800m connects the atolls while the depth of the surrounding ocean is approximately 5000m. There is no fresh water on North Keeling Island. Bechet Besar freshwater swamp on West Island is the only fresh water above ground on the islands, although Horsburgh Island has a small brackish lake on its northern side. The islanders rely on the freshwater lenses on the two largest islands, West Island and Home Island, for water.

There are about five hundred Cocos-Malay people living on Home Island and one hundred people, mostly public servants, live on West Island (Parks Australia 1999). The islands are very low lying, the highest point being on South Island where a sand dune reaches 9m above sea level.

Even before settlement in the early nineteenth century Coconuts (*Cocos nucifera*) were abundant on the islands. However, since then coconut plantations have replaced most of the original vegetation on the southern atoll. The vegetation on North Keeling Island remains pristine due mainly to its inaccessibility (Parks Australia 1999).

North Keeling Island was proclaimed Pulu Keeling National Park in 1995 and is Australia's smallest Commonwealth national park. The island is 2km long and 1.3km wide. The shore rises steeply to a height of 3–5 m and then slopes gradually to the central lagoon. The Park includes the land area of the island as well as a marine area extending 1.5km around the perimeter. As well as the Park's value as an unspoiled coral atoll ecosystem it supports one of the largest breeding colonies in the world of the Red-footed Booby (*Sula sula*) (Parks Australia 1999). The mouth of the lagoon on the east coast has been blocked for the last few years and the water level in the lagoon is falling.

Pisonia (*Pisonia grandis*) forest and Coconut dominate the vegetation on North Keeling Island. Octopus Bush (*Argusia argentea*) shrublands are common on the eastern shore while Tea Shrub (*Pemphis acidula*) and smaller patches of Ironwood (*Cordia subcordata*) form dense thickets around the margin of the lagoon, interspersed with open grassy areas (Parks Australia 1999).

The vegetation is affected by cyclones that pass through the area occasionally. The shallow rooted Pisonia trees are easily blown over and reshoot where they fall. Cyclone Walter, which passed through the area on 5 April 2001, felled 14 percent of the trees on North Keeling and destroyed 61 percent of the canopy (Director of National Parks 2004). The resulting regrowth and original root systems and old trunks form formidable barriers as well as ideal habitat for the endemic Cocos Buff-banded Rail (*Gallirallus philippensis andrewsi*).

Apart from birds a few other vertebrates occur on the Cocos (Keeling) Islands.

The Mourning Gecko (*Lepidodactylus lugubris*) occurs on North Keeling Island while on the southern atoll the introduced House Gecko (*Hemidactylus frenatus*) and a blind snake (*Ramphotyphlops* sp.) also occur (Director of National Parks 2004). Green Turtles (*Chelonia mydas*) and Hawksbill Turtles (*Eretmochelys imbricata*) are common, the Green Turtle

nesting on the northern atoll (Director of National Parks 2004). A Dugong (*Dugong dugon*) has been resident in the lagoon since May 2002 (Director of National Parks 2004). Rabbits were introduced to the islands some time ago and there are still occasional reports of sightings by locals on Direction Island (W. Murray pers. comm.).

Gibson-Hill (1949) cited an "immense number" of marine birds on the main atoll in 1828–29 and stated that Charles Darwin, visiting the area in April 1836, referred to the trees on the main atoll as being "occupied by many nests of seabirds".

Most of the birds had been eliminated from the southern atoll by 1885 because of habitat change, density of human habitation, intense hunting pressure and predation by cats and rats. Today there are still very few birds on the southern atoll (Stokes 1982).

Carter (1994) recorded approximately sixty species of birds from the islands, however, the number was increased to 72 species (Johnstone & Storr 2004). The inclusion of the Northern Giant Petrel recorded by Park staff in 2003 (Murray, pers. comm) now increases the number to 73.

METHODS

My bird observations were made over two separate periods, 4–15 May 2003 and 26 June–14 July 2003. During the first period I searched the entire outer perimeter of the southern atoll and a small portion of the inner lagoon area as well as accessible areas within the islands. During the second period I was employed by Parks Australia to undertake a bird survey of Pulu Keeling National Park. I visited the National Park twice, in the company of park staff, from 30 June 2 July and from 7–10 July. The trip from the southern atoll to Pulu Keeling takes one hour by boat. There is only one landing place on the island, reached by a 50m swim.

On both trips the island and the lagoon were circumnavigated. Approximately 5 hours was also spent searching the forested areas, mainly using set transect lines, which are used for Red-footed Booby counts. The lagoon area was also thoroughly investigated.

The Wedge-tailed Shearwater nesting area was checked three times in the evenings with the intent of determining the presence of the Herald Petrel (*Pterodroma arminjoniana*), which was observed in this area once before. The area was observed for a period of one hour on each occasion until fading light made bird identification impossible. The taxonomy and nomenclature of this list generally follows Christidis and Boles (1994).

Green Junglefowl *Gallus varius*

The former owner of the Cocos Keeling Islands, George Clunies-Ross, introduced these birds to the southern atoll, probably around 1800 (Gibson-Hill 1950). I found these birds common along the roads and the runway on West Island. Some were observed with one to three chicks. On one occasion 42 individuals were counted from the northern end of the runway.

Green Junglefowl are decreasing in number in their own home range in Indonesia due to habitat loss and capture for the pet trade but as an introduced species on West Island appear to be doing well. While considered a pest by locals in gardens and farms this population could become an important gene pool for the species. This species does not occur in Pulu Keeling National Park.

Red Junglefowl *Gallus gallus*

Chickens derived from this species are kept by many of the islanders and many escape their cages or are deliberately let loose around the pondoks (local shacks). I noticed the occasional bird around dwellings and also along the road on West Island as well as on Home, South and Horsburgh Islands.

The domestic chicken is capable of interbreeding with the Green Junglefowl and in some countries is deliberately crossed to breed birds for cock fighting. I saw no obvious evidence of crossbreds occurring on the islands although given the number of both feral chickens and Green Junglefowl seen this would seem to be likely to occur.

Feral chickens are restricted to the southern atoll and are not found in Pulu Keeling National Park.

Helmeted Guineafowl *Numida meleagris*

Stokes *et al.* (1984) stated that a pair had been seen in the transmitter area on West Island for a number of years probably derived from domestic stock from the Clunies-Ross estate. These birds have not been seen recently.

Hardhead *Aythya australis*

I observed one adult male in the brackish lake on Horsburgh Island on 11 May 2003. This was the first record for the Cocos (Keeling) Islands. The bird was not sighted on my second visit.

Northern Giant-Petrel *Macronectes halli*

A Northern Giant Petrel was found on Home Island and handed to park staff in May/June 2003 in an emaciated condition. It died but unfortunately the bird was not kept as a specimen (Murray, pers. comm.).

Herald Petrel *Pterodroma arminjoniana*

Approximately ten birds were

seen on North Keeling around the Wedge-tailed Shearwater colony, possibly breeding, from April to June in 1986 (Stokes and Goh 1987). No petrels were sighted during my visit despite checking the area on three evenings. Previous attempts at sighting this species by park staff have also been unsuccessful. Visits to the island are limited and as this species can only be sighted at dusk and observers are few there may be a possibility that this species still visits the island.

Wedge-tailed Shearwater *Puffinus pacificus*

I observed these birds entering burrows in the early evenings in the area adjacent to the inlet on Pulu Keeling National Park. The fact that they were still present in July when breeding should be well completed was interesting. Previous records indicate breeding occurs between October and November (Gibson-Hill 1950) (Carter 1994) and possibly up to January (Stokes *et al.* 1984). Four birds were seen to circle, land and enter burrows one evening and on subsequent evenings two and then one bird were observed. About 20 active or recently used burrows were in the area. A few breeding birds have also been recorded from West Island (Johnstone and Storr 2004).

Yellow-nosed Albatross *Diomedea chlororhynchos*

One bird was found in an emaciated condition, 2 July 1941 (Gibson-Hill 1949). This specimen was later identified as *D. c. bassii* (Johnstone and Storr 2004).

Red-tailed Tropicbird *Phaethon rubricauda*

Breeding birds have been recorded on South Island, West Island and on North Keeling Island (previous records summarised by Johnstone and Storr 2004).

White-tailed Tropicbird *Phaethon lepturus*

I observed up to 14 birds at a time in Pulu Keeling National Park usually high above the other birds and always late in the day. One bird was observed possibly leaving a nesting hollow in an ironwood and others were observed flying among trees in the centre of the forest. I also observed one individual at Trannies Beach on West Island. Small numbers have been recorded on West Island (Johnstone and Storr 2004).

Masked Booby *Sula dactylatra*

This species breeds throughout the year in Pulu Keeling National Park but winter is the prime nesting time. Birds are only occasionally recorded from the southern atoll (Johnstone and Storr 2004). During my visit I observed approximately 50 pairs nesting on the coast on south-eastern Pulu Keeling National Park and two birds were observed nesting in the open grassy area near the inlet. Most nests contained eggs although

there was one large chick at the inlet near the Wedge-tailed Shearwater nesting area.

Red-footed Booby *Sula sula*

In 1941, 3,500–4,000 pairs were estimated to be present (Gibson-Hill 1950), 30 000 individuals were recorded in 1982 (Stokes *et al.* 1994) and 'tens of thousands' breeding birds were sighted in 1999 (Johnstone and Storr 2004). The resident population of this species on the northern atoll is now estimated by park staff to number 30 000 pairs (Director of National Parks 2004). The population of Red-footed Booby appears to have grown under protection.

On both my visits to Pulu Keeling National Park, the birds I observed nesting were mainly in the lagoon area and Pisonia trees in the centre of the island but many were also nesting over other areas of the island, even in low bushes. Some birds were collecting nesting material while others had eggs or chicks up to approximately eight weeks old. Dark plumaged immature birds were also common. Many birds were nesting close to the frigatebirds. I also observed a few birds out to sea from Home Island.

Brown Booby *Sula leucogaster*

Evidently this species fluctuates widely in numbers (Johnstone and Storr 2004) but during my visit approximately 20 pairs were nesting along the coast in Pulu Keeling National Park. Nests were at various stages, eggs to large chicks being present. Birds are occasionally sighted near the southern atoll.

Little Pied Cormorant
Phalacrocorax melanoleucos

I observed one bird at the northern end of the runway, West Island on 7 May 2003. This was the first sighting for the islands of this species.

Little Black Cormorant
Phalacrocorax sulcirostris

Four birds were observed on the edge of the lagoon on the southern end of the runway on 29 June 2003. This was another first record for the island.

Great Frigatebird *Fregata minor*

During my visits to Pulu Keeling National Park, a number of small pockets of nesting birds were observed between the Lesser Frigatebirds and many birds were roosting in the trees on the eastern side of the lagoon. Only eggs were observed. Although I made no estimation of numbers they were noticeably less common than the Lesser Frigatebird. At the time of my visit the Lesser Frigatebirds outnumbered Greater Frigatebirds by about ten to one. This was considerably less than Carter's (1994) estimation in 1994 of two to one. Breeding is confined to the northern atoll although birds are occasionally sighted around the southern atoll (Johnstone and Storr 2004).

Lesser Frigatebird *Fregata ariel*

Estimations in 1999 by park staff

from surveys indicate a resident population of approximately 3000 pairs (Parks Australia 1999). In November 1999 J. Reid estimated 10000 birds on the island (Johnstone and Storr 2004). I found these birds were very abundant in Pulu Keeling National Park; nests were located in loose groups mainly around the lagoon area in tea shrub or ironwood and most contained eggs. Some birds were also observed off the coast on the southern atoll.

Christmas Frigatebird *Fregata andrewsi*

An adult female was recorded from North Keeling in 1986 (Stokes and Goh 1987) and two more birds were seen on North Keeling in 1993 (Carter 1994). I observed three adult female birds near South Island flying with Lesser Frigatebirds on my first visit.

White-faced Heron *Egretta novaehollandiae*

One bird was recorded in January 1992 (Stokes *et al.* 1982).

Little Egret *Egretta garzetta*

A specimen taken in 1879 from West Island was identified as the Indonesian race *nigripes* (Forbes 1885). Carter (1994) observed a bird with yellow feet on West Island on 4 November 1993. J. Reid recorded two birds in November 1999 with nuchal plumes and bare part colouring consistent with the subspecies *nigripes* (Johnstone and Storr 2004).

I observed Little Egrets opposite the meteorological station on the edge of the lagoon, in the North Park area and on the oval on Home Island. Up to four birds were observed at a time and all were longer legged and more upright and slender than the Eastern Reef Egrets. They had blackish bills grading to greenish/yellow at the base. Those that I observed closely had dark legs with yellow feet. There is a possibility that these birds may be the subspecies *E. garzetta garzetta*. The Australian subspecies *E. g. nigripes* has black feet with yellow to grey soles while the subspecies *garzetta*, which occurs in Europe, Asia, Japan, Philippines and Africa, has yellow feet (Marchant and Higgins 1990). A specimen would be needed for confirmation of subspecies.

Eastern Reef Egret *Egretta sacra*

Reef egrets are reported to breed on the southern atoll in coconut trees around January (Gibson-Hill 1949, Stokes *et al.* 1994). I encountered these birds often on the rocky shore, inland lagoon and grassy areas on West Island as well as most of the smaller islands. They were often in the company of the Little Egrets. Mainly white morphs were seen. Few were seen on Pulu Keeling National Park probably due to lack of suitable habitat.

On 5 July 2003 I observed a light ash grey bird in the company of two dark phase birds and four white phase birds in the swampy

area around the towers just south of North Park. This particular bird had a pale coloured bill, white head and neck, pale ash grey body and wings, darker towards the primaries. The legs were darkish. On 11 July 2003 a light ash grey bird in company of one dark phase and five white phase birds was observed on the lagoon side of central South Island. This bird appeared similar to the bird seen on West Island. I am fairly confident that this was an Eastern Reef Egret but have never before heard of this colour variation.

Great Egret *Ardea alba*

On 6 July 2003 I flushed three birds from Beshet Besar freshwater swamp. The yellow bills, dark legs (trailing in flight), long kinked neck and large size of these birds, compared to the two reef herons also in the swamp, clearly identified these birds. The birds were seen again on 13 July 2003. This was a new record for the islands.

Cattle Egret *Ardea ibis*

Two birds were observed in breeding plumage on 14 January 1982 (Stokes *et al.* 1982).

Black-crowned Night Heron *Nycticorax nycticorax*

One specimen was taken on 13 October 1941 (Gibson-Hill 1950).

Nankeen Night Heron *Nycticorax caledonicus*

Observed nesting on the islands as early as 1879 but regarded as a visitor in 1949 (Forbes 1885, Gibson-Hill 1949). I found these birds common on West Island especially in open grassy areas. They are also commonly seen on lawns around buildings. On 29 June 2003 I observed 34 birds from the northern end of the runway. They nest in the Pemphis shrubs on the small offshore islands of the southern atoll (Murray, pers. comm.). Three birds were also observed roosting in Pulu Keeling National Park amongst nesting frigatebirds and Red-footed Boobies and four birds were seen on Home Island.

Glossy Ibis *Plegadis falcinellus*

Four birds were recorded on the airstrip in May 1990 (Stokes 1994). J. Reid recorded three birds at Bechet Besar swamp on 18 November 1999 (Johnstone and Storr 2004).

On 6 May 2003 I observed seven birds on the northern end of the runway. Probably the same birds were present in various places including Bechet Besar freshwater swamp on my second visit.

Greater Flamingo *Phoenicopterus ruber*

One bird was seen on North Keeling during 26 April to 15 June 1988 (Marchant and Higgens 1990).

Swamp Harrier *Circus approximans*

One specimen was taken on 6 July 1941 (Gibson-Hill 1950).

Nankeen Kestrel *Falco cenchroides*

A pair was seen for several weeks on West Island on 5 June 1990 (Stokes 1994).

Buff-banded Rail *Gallirallus philippensis*

This endemic subspecies *G. philippensis andrewsi* was once common on all islands in the group but now is almost confined to Pulu Keeling National Park where it is said to have been introduced in the late 1800s, although it may already have been present (Gibson-Hill 1948). It appears that a small population may be surviving on West Island as an adult with five chicks was seen at the southern end of the runway in July 2002 (Director of National Parks 2004).

On my visit to Pulu Keeling National Park I found these birds very common along the edge of the lagoon with up to 20–30 individuals within sight simultaneously. They were also encountered frequently in the forested area. Fewer were encountered around the coast. One chick, only a few days old, was observed in the large grassy area opposite the inlet in the central lagoon region. Four half-grown chicks were also present in the same area.

White-breasted Waterhen *Amaurornis phoenicurus*

Local rangers have previously recorded this species on the islands and have seen adults with chicks (Murray, pers. comm.). The species has been on the islands at least since 1998 when a specimen was hit by a plane on the runway and eventually identified in May 2000 by J. Reid (Johnstone and Storr 2004). I observed single birds on West Island at the northern end of runway, in a swampy area on the lagoon side of West Island, as well as near the Quarantine Station and just south of North Park.

Pin-tailed Snipe *Gallinago stenura*

This species is considered an uncommon visitor (Johnstone and Storr 2004).

Little Curlew *Numenius minutus*

One bird seen near the airstrip on West Island on 12 and 15 March 1983 and three birds on 26 March 1983 (Stokes *et al.* 1984).

Whimbrel *Numenius phaeopus*

Recorded as an uncommon visitor from both atolls (Johnstone and Storr 2004). Park staff regularly see this species on the coastal side of South Island, however, during my visit no birds were seen there on 9 May 2003, the birds probably having migrated north.

Common Redshank *Tringa totanus*

Johnstone and Storr (2004) considers this species to be a rare visitor.

Common Greenshank *Tringa nebularia*

This species is considered an uncommon visitor (Johnstone and Storr 2004).

Common Sandpiper *Actitis hypoleucos*

This species is considered a regular visitor (Johnstone and Storr 2004).

Ruddy Turnstone *Arenaria interpres*

Ruddy Turnstones are regular visitors to the islands (Johnstone and Storr 2004). Up to 12 birds in breeding or part breeding plumage were observed by me in the central lagoon area near inlet on Pulu Keeling National Park and on the rocky eastern shore near the inlet on both visits.

Sanderling *Calidris alba*

This species is considered an irregular visitor (Johnstone and Storr 2004).

Sharp-tailed Sandpiper *Calidris acuminata*

One bird seen on West Island on 4 November 1993 (Carter 1994).

Curlew Sandpiper *Calidris ferruginea*

J. Reid observed a single bird on the shore of Pulu Keeling National Park on 9 November 1999 (Johnstone & Storr 2004).

Black-winged Stilt *Himantopus himantopus*

E. Alfred recorded a bird of the nominate subspecies from Afro-Eurasia at Bechet Besar swamp on 28 November 1958 (Johnstone and Storr 2004). On 14 May 2003 I observed one bird at the southern end of runway in a shallow salt-water pond. The black nape was clearly visible identifying it as the Australian subspecies *leucocephalus*. Possibly the same bird was observed several times at the northern end of the runway on my second visit.

Pacific Golden Plover *Pluvialis fulva*

This species is considered an irregular visitor (Johnstone and Storr 2004).

Grey Plover *Pluvialis squatarola*

One was seen on the airstrip on 4 November 1993 (Carter 1994).

Greater Sand Plover *Charadrius leschenaultii*

This species is considered a regular visitor (Johnstone and Storr 2004).

Oriental Plover *Charadrius veredus*

One bird was seen on 17 October 1941 (Gibson-Hill 1950).

Oriental Pratincole *Glareola maldivarum*

This species is considered a regular visitor (Johnstone and Storr 2004). Park staff have noted their annual visits in the late dry season each year (Director of National Parks 2004).

Lesser Black-backed Gull *Larus fuscus*

A bird was banded as a chick at Simo, Lapland, Finland on 13 July 1957 and recovered freshly dead, presumedly killed by islanders, on South Island at the end of September 1959 (Johnstone and Storr 2004).

Common Tern *Sterna hirundo*

One of two birds present was collected from the lagoon area on the main atoll on 11 February 1941 (Gibson-Hill 1950).

Bridled Tern *Sterna anaethetus*

One was collected from North Keeling on 5 July 1941 (Gibson-Hill 1950).

Sooty Tern *Sterna fuscata*

The variation in nesting dates in this species is interesting. In January 1983 30–40 nests with eggs were recorded (Stokes *et al.* 1984). Carter (1994) saw no evidence of breeding in November 1993. However, in November 1999 120–150 pairs with mainly 2–3 week old chicks were recorded, while nests with eggs were also present (Johnstone and Storr 2004). Gibson-Hill (1950) recorded the nesting season here to be in November or early December in 1940, although he suggested that this species might follow a nine to ten month rotation instead of twelve. During my visit approximately 200–300 birds roosted in the southeastern corner of the lagoon in Pulu Keeling National Park. At least two nests contained eggs. Birds are also occasionally recorded from the waters around the southern atoll (Johnstone and Storr 2004).

White-winged Black Tern *Chlidonias leucopterus*

Considered an irregular visitor (Johnstone and Storr 2004).

Common Noddy *Anous stolidus*

I observed this numerous species nesting in a variety of situations on Pulu Keeling National Park including on the beach, amongst old coral in the central lagoon area as well as in trees. Nests in the lagoon area contained eggs and one chick was present on coral shingle on the coastal edge of island. On the second visit I observed eight birds nesting in coconut trees near the south end of West Island. Gibson-Hill (1950) stated that this species lays its eggs from late December to early March on the islands and suggested the difference in nesting times to other islands near the same latitude may be associated with changes in ocean currents.

White Tern *Gygis alba*

I observed approximately ten birds at Trannies Beach on West Island. One half grown chick was observed in *Calophyllum inophyllum* on the broken end of an upright branch, during the first visit. A newly hatched chick was present in July. These birds were abundant in Pulu Keeling National Park. Nests can be found over most of the island but generally away from other nesting seabirds. A number of birds were incubating eggs while a couple of newly hatched chicks were also observed.

Small numbers were nesting on Home Island, and a few were sighted on South and Horsburgh Islands.

Lesser Noddy *Anous tenuirostris*

A report of up to 40 pairs of this species breeding in Pulu Keeling National Park in November 1999, is detailed in Johnstone and Storr (2004).

Christmas Island Imperial Pigeon *Ducula whartoni*

Introduced between 1890–95. Now considered extinct (Johnstone and Storr 2004).

Buffy Fish-Owl *Ketupa ketupa*

One collected 23 October 1941 (Gibson-Hill 1950).

Fork-tailed Swift *Apus pacificus*

On 11 May 2003 I observed two birds flying over and around the brackish lake on Horsburgh Island. This was the first record for these islands.

Rainbow Bee-eater *Merops ornatus*

I heard and observed one bird flying overhead at the northern end of the runway on 29 June 2003. This bird, which appeared to be a juvenile, was closely observed in the tower area just south of North Park on 12 and 13 July 2003. This was the first record for the islands.

Dollarbird *Eurystomus orientalis*

There are two reports of single birds from the islands (Johnstone and Storr 2004).

Yellow Wagtail *Motacilla flava simillima*

J. Reid observed a first year bird on Horsburgh Island swamp on 15 November 1999 and another bird on North Keeling Island on 23 November 1999 (Johnstone and Storr 2004). There are also unconfirmed reports such as a wagtail with yellowish underparts observed on Home Island in December 1981 (Stokes *et al.* 1984).

On 9 May 2003 I sighted one bird along a shallow creek at northern end of runway. This bird was observed for about ten minutes and as close as 4m. It was olive green above and yellow below (including underneath throat). The crown was also olive green. It had a very prominent white eyebrow and white edging to tail and black eye-stripe. The wing feathers had lighter edging but not prominent. The bird was flushed several times to reveal the olive green rump. It was identified as a Yellow Wagtail in the field using MacKinnon and Phillips (1995). Using various other references I have since identified this bird as being a male of the subspecies *simillima* using my field notes. The very prominent white eyebrow and yellow throat were the main identifying features. The fact that this bird did not exhibit the bluish-slate crown typical of a breeding male of this subspecies may indicate a change to non-breeding plumage.

Grey Wagtail *Motacilla cinerea*

These birds have been sighted by park staff in August and September in most years since 1996 (Director of National Parks 2004).

Double-barred Finch *Taeniopygia bichenovii*

Originally thought to be aviary escapees this species is now considered extinct on the islands (Johnstone and Storr 2004).

Asian Golden Weaver *Ploceus hypoxanthus*

This species was also probably introduced around 1800 but is now considered extinct (Johnstone and Storr 2004).

Java Sparrow *Padda oryzivora*

The former owner of the Cocos Keeling Islands, George Clunies-Ross, introduced this species around 1800. It is now considered extinct (Johnstone and Storr 2004).

Barn Swallow *Hirundo rustica*

I observed three birds during my second visit. Two were seen near the runway and one was observed in the lagoon area opposite the inlet in Pulu Keeling National Park. This species is considered a regular visitor and local rangers have often seen the species on Home Island.

Christmas Island White-eye *Zosterops natalis*

George Clunies-Ross introduced these birds to Horsburgh Island between 1885 and 1900 (Stokes *et al.* 1984). They are now reasonably common on this one island. I observed approximately 25 individuals mainly in the ironwood growing around the small lagoon.

Island Thrush *Turdus poliocephalus erythropleurus*

The former owner of the Cocos Keeling Islands, George Clunies-Ross, introduced this species around 1800. It is now considered extinct (Johnstone and Storr 2004).

UNCONFIRMED SPECIES

Duck species

Wood-Jones (1909) and Forbes (1885) both refer to a flock of ducks resident on West Island but did not identify them.

Western Reef Heron *Egretta gularis*

I observed an unusual bird on 27 June 2003 in the swampy region around the towers, on the northern end of West Island (just south of North Park). This all white bird had the two distinct breeding plumes on the nape present although the darkish bill had a distinct yellow/orange tinge at the base. The legs did not appear very dark but more grey/green and the yellow colouring on the feet extended part way up the tarsus. The description and photographs were shown to John Darnell of the Western Australian Museum who suggested the possibility of the Western Reef Heron *Egretta gularis*. The description in Brown *et al.* (1982) of the white morph of *E. gularis dimorpha* comes very close to what I saw with "yellow feet with yellow extending part way up the tarsus" and "bill

black, similar to that of Little Egret *E. garzetta*, but some yellow at base". It also states that the bill is longer, heavier and down curved at tip, not straight and slender like *garzetta*. On careful scrutiny of the photographs that I managed to take, the bill does appear longer and heavier than expected for *E. garzetta* but they were not clear enough to be absolutely certain. In my mind it does appear to be likely to be this species. I am not confident enough, however, with my description to be certain.

During his visit to the islands Julian Reid also saw a bird closely matching the above description but without the breeding plumes. The bird recorded on November 1999 on Pulu Blan had "bright yellow bill, dark long legs with yellow feet (noted in flight) facial skin greenish and had a longer neck than attendant Reef and Little Egrets" (Johnstone and Storr 2004).

From these observations I would suggest that the egrets on Cocos (Keeling) Islands require further investigation. The procurement of specimens would be the best way to verify species/subspecies.

Hawk species

A small unidentified hawk was seen on 29 May 1983 (Stokes *et al.* 1982).

Dove species

A possible dove species was seen on Horsburgh Island in November 1982 (Stokes *et al.* 1982).

Common Koel *Eudynams scolopacea*

A bird recorded by J. Reid on West Island on 14 November 1999 has been identified as this species (Johnstone and Storr 2004).

Nightjar species

One unidentified bird seen on the airstrip on 26 March 1983 (Stokes *et al.* 1982).

Edible-nest Swiftlet *Collocalia fuciphaga*

On 13 May 2003 I observed one bird flying around the quarantine station and adjacent coconut palms. This bird was observed for approximately ten minutes with some good views. It was very much smaller than the fork-tailed swifts, which were observed only two days previously. Plumage was dark brown all over with a paler brown rump. Tail shallowly forked. Using a field guide (MacKinnon and Phillips 1995) on site this bird was identified from the Black-nest Swiftlet and Mossy-nest Swiftlet by the pale rump and shallowly forked tail. These birds are notoriously difficult to identify in the field, however, and not being familiar with this species I am not one hundred percent certain of this identification. If confirmed this would be another first for the islands.

White-throated Needletail *Hirundapus caudacutus*

Twenty to thirty birds believed to be this species seen over

Bechet Besar Lagoon on West Island on 14 January 1982 and two unidentified swifts seen near West Island in June 1982 (Stokes *et al.* 1982).

Arctic Warbler *Phylloscopus borealis*

A small brown passerine was observed closely by a local at North Park shortly before my second visit. On being queried and shown a field guide, an Arctic Warbler was singled out as the most likely species. Park staff were unable to relocate the bird and unfortunately the species was not verified.

DISCUSSION

Of the confirmed 73 species of birds recorded on the Cocos (Keeling) Islands only 20 have been recorded as breeding while 43 are recorded as vagrants or irregular visitors. Of the 9 introduced species 6 are listed as extinct on the islands (refer to Table 1).

The small colony of Common Noddies at the southern end of West Island and the small White Tern colonies at Trannies Beach and Home Island are an encouraging sign that bird numbers may increase with protection. However, poaching is an ongoing problem on both atolls. Even the northern atoll's remoteness and difficult access does not deter poachers.

The rangers of Pulu Keeling National Park face the unenviable task of trying to manage a National Park 24km away by sea. Access is difficult, the weather fickle and legislation inadequate. The number of shotgun shells encountered on the Southern Atoll during my visit was also an indication of what the rangers are up against. During my first visit an immature Lesser Frigatebird was handed in to park staff with a shattered wing joint apparently caused by a shotgun pellet. I was told by park staff that even the diminutive White Tern is not safe from the poachers gun. A shooting hide was discovered on my last trip to Horsburgh Island, adjacent to the lagoon. There were many shotgun shells in the area. This hide was not there on the previous visit and was immediately dismantled by park staff.

The lagoon habitat encountered in both Pulu Keeling National Park and the southern atoll appears to be ideal for many species of migratory wader, however only Ruddy Turnstones were encountered. Migratory wader numbers would be expected to be higher around November to February when these birds are more prevalent in the Southern Hemisphere.

Vagrant seabirds and migratory waders would be expected from these islands, possibly blown off course by the strong south-east trade winds or cyclones. The chances, however, of any small vagrant species reaching such a remote set of islands are still slim

Table 1. List of birds recorded on Cocos (Keeling) Islands. Br = breeding recorded, R = resident, S = regular visitor, I = irregular visitor, V = vagrant, * = introduced, E = considered extinct.

Common Name	Scientific Name	Status	North Keeling	Southern Atoll	Observed by author
Green Junglefowl	*Gallus varius*	* R		Br	+
Red Junglefowl	*Gallus gallus*	* R		Br	+
Guinea Fowl	*Numida meleagris*	* E		+	
Hardhead	*Aythya australis*	V		+	+
Northern Giant Petrel	*Macronectes halli*	V		+	
Herald Petrel	*Pterodroma arminjoniana*	I	Br		
Wedge-tailed Shearwater	*Puffinus pacificus*	S	Br	Br	+
Yellow-nosed Albatross	*Diomedea chlorohynchos*	V		+	
Red-tailed Tropicbird	*Phaethon rubricauda*	I	Br	Br	
White-tailed Tropicbird	*Phaethon lepturus*	S	Br	Br	+
Masked Booby	*Sula dactylatra*	R	Br	+	+
Red-footed Booby	*Sula sula*	R	Br	+	+
Brown Booby	*Sula leucogaster*	R	Br	+	+
Little Pied Cormorant	*Phalacrocorax melanoleucos*	V		+	+
Little Black Cormorant	*Phalacrocorax sulcirostris*	V		+	+
Great Frigatebird	*Fregata minor*	R	Br	+	+
Lesser Frigatebird	*Fregata ariel*	R	Br	+	+
Christmas Frigatebird	*Fregata andrewsi*	V	+	+	+
White-faced Heron	*Egretta novaehollandiae*	V		+	
Little Egret	*Egretta garzetta*	I		+	+
Eastern Reef Egret	*Egretta sacra*	R	+	Br	+
Western Reef Egret	*Ardea gularis*	V		+	+
Great Egret	*Ardea alba*	V		+	+
Cattle Egret	*Ardea ibis*	V		+	
Black-crowned Night Heron	*Nycticorax nycticorax*	V		+	
Rufous Night Heron	*Nycticorax caledonicus*	R	+	Br	+
Glossy Ibis	*Plegadis falcinellus*	I		+	+

Table 1 (cont.)

Common Name	Scientific Name	Status	North Keeling	Southern Atoll	Observed by author
Greater Flamingo	*Phoenicopterus ruber*	V	+		
Swamp Harrier	*Circus approximans*	V		+	
Nankeen Kestrel	*Falco cenchroides*	V		+	
Cocos Buff-banded Rail	*Gallirallus philippensis andrewsi*	R	Br	Br	+
White-breasted Waterhen	*Amaurornis phoenicurus*	R		Br	+
Pin-tailed Snipe	*Gallinago stenura*	I		+	
Little Curlew	*Numenius minutus*	V		+	
Whimbrel	*Numenius phaeopus*	S	+	+	
Common Redshank	*Tringa totanus*	I		+	
Common Greenshank	*Tringa nebularia*	I		+	
Common Sandpiper	*Actitis hypoleucos*	S	+	+	
Ruddy Turnstone	*Arenaria interpres*	S	+	+	+
Sanderling	*Calidris alba*	I	+	+	
Sharp-tailed Sandpiper	*Calidris acuminata*	V		+	
Curlew Sandpiper	*Calidris ferruginea*	V	+		
Black-winged Stilt	*Himantopus himantopus*	V		+	+
Pacific Golden Plover	*Pluvialis fulva*	I		+	
Grey Plover	*Pluvialis squatarola*	V		+	
Greater Sand Plover	*Charadrius leschenaultii*	I	+	+	
Oriental Plover	*Charadrius veredus*	V		+	
Oriental Pratincole	*Glareola maldivarum*	S		+	
Lesser Black-backed Gull	*Larus fuscus*	V		+	
Common Tern	*Sterna hirundo*	V		+	
Bridled Tern	*Sterna anaethetus*	V	+		
Sooty Tern	*Sterna fuscata*	S	Br	+	+
White-winged Black Tern	*Chilidonias leucopterus*	S	+	+	
Common Brown Noddy	*Anous stolidus*	R	Br	Br	+
Lesser Noddy	*Anous tenuirostris*	V	Br		

White Tern	*Gygis alba*	R	Br	Br	+
Christmas Island Imperial Pigeon	*Ducula whartoni*	* E		+	
Common Koel	*Eudynamys scolopacea*	V		+	
Buffy Fish-Owl	*Ketupa ketupa*	V		+	
Nightjar sp		V		+	
Swiftlet sp		V		+	+
White-throated Needletail	*Hirundapus caudacutus*	V		+	
Fork-tailed Swift	*Apus pacificus*	V		+	+
Rainbow Bee-eater	*Merops ornatus*	V		+	+
Dollarbird	*Eurystomus orientalis*	V		+	
Yellow Wagtail	*Motacilla flava simillima*	I		+	+
Grey Wagtail	*Motacilla cinerea*	S		+	
Double-barred Finch	*Taeniopygia bichenovii*	* E		+	
Asian Golden Weaver	*Ploceus hypoxanthus*	* E		+	
Java Sparrow	*Padda oryzivora*	* E		+	
Barn Swallow	*Hirundo rustica*	S	+	+	+
Christmas Island White-eye	*Zosterops natalis*	* R		Br	+
Christmas Island Thrush	*Turdus poliocephalus erythropleurus*	* E		+	

and the habitat may not be suitable for many species. The prospects of these displaced species are probably bleak. The Yellow-nosed Albatross and Northern Giant Petrel for example arrived at the islands in extremely poor condition. However, before 1941 the Rufous Night Heron was considered a vagrant but is now a common resident. The White-breasted Waterhen, a recent colonist of the islands appears to be breeding there and increasing in numbers.

Another factor to consider, however, may be the large number of frigatebirds around the northern atoll. While on Christmas Island I witnessed several frigatebirds attack and kill a smaller bird (identity unknown due to distance out to sea). Frigatebird aggressive tendencies are well known and it is likely that any small vagrant species would quickly be eliminated if it chanced to reach Pulu Keeling National Park. This may explain why all small vagrant birds have been recorded only from the southern atoll where these aggressive species do not occur. The lack of observers on the northern atoll, however, makes this difficult to determine.

The breeding of seabirds on North Keeling Island appeared to be in variance with dates indicated by other authors. Breeding patterns vary from locality to locality and the latitude would have some bearing on breeding times. The local weather patterns such as the onset of the monsoons would probably be the final determining factor in the breeding times on these islands.

While birdwatchers visiting the southern atoll may not be overrun by a choice of birds the possibility of finding something new and unusual on these beautiful and unique islands makes birding the Cocos (Keeling) Islands an enjoyable challenge.

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APPRAISING VERTEBRATE DIVERSITY ON BONAPARTE ISLANDS, KIMBERLEY, WESTERN AUSTRALIA

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ABSTRACT

Three expeditions examining 35 islands in the Bonaparte Archipelago along the northwest Kimberley coast were undertaken between August 2002 and June 2005. These documented numerous new records of mammal and reptile species for the islands with the fauna of 27 islands being examined for the first time. Mammals were usually confined to the larger islands adjacent to the mainland and only on East Montalivet and Coronation were populations recorded on more distant islands. Two mammal species were trapped on an unnamed island that was only 23 ha in extent. Reptiles occurred on all islands examined from the smallest (4ha Low Rocks) to the largest (18121ha Bigge Island). The 29 reptile species recorded represent several new records for the Bonaparte Archipelago and includes new localities for many species. Populations of Olive Pythons were recorded on islands as small as 73ha. No frogs were recorded although climatic conditions and the poor wet seasons preceding the expeditions were not conducive to amphibian activity.

INTRODUCTION

Kimberley islands have been isolated from the mainland for up to 10 000 years as a result of increasing sea levels after the last Pleistocene glacial maximum at about 18 000 years before present (Nix and Kalma 1972, Hopper *et al.* 1996). Such extended periods of isolation of

islands elsewhere has lead to many populations differentiating into new taxa as evidenced by the islands of the Indonesian archipelago, lying immediately to the north of the Kimberley coast (Schmitt *et al.* 1995, Kitchener and Suyanto 1996), Pilbara coastal islands (Abbott and Burbidge 1995, Smith 1976) and Bernier, Dorre and the Houtman Abrolhos off the west coast (Ride and Tyndale-Biscoe 1962; How *et al.* 2004).

The documentation of the mammals, birds, amphibians, and reptiles of the Kimberley region of Western Australia has progressed at very different rates. Storr (1980) regarded the quarter century beginning in 1886 as the 'golden age' of Kimberley ornithology. All but a few of the birds now known from the region were made known to science in that period. The first, and relatively complete, list of mammals from the Kimberley was compiled by Dahl (1897) within two decades of the first European exploration of the region. While our understanding of the diversity of the birds and mammals of the Kimberley was largely complete by the end of the 19th Century, an understanding of the herpetofauna had barely begun. Most of the herpetofauna was described in the 20th Century and over a third has been described since 1960.

The extensive array of biological surveys conducted during the 1970's (Miles and Burbidge 1975; Kabay and Burbidge 1977; Kitchener 1978; Burbidge and McKenzie 1978; Western Australian Museum 1981) added substantially to our understanding of the distribution of the north Kimberley vertebrate fauna. These surveys lead to a far better understanding of the composition, habitat preferences and biogeography (McKenzie 1981) of most vertebrate groups of this tropical area, particularly mammals, and permitted a reappraisal of the taxonomy of numerous species (Kitchener and Humphreys 1986, Kitchener and Sanson 1978, Kitchener and Caputi 1988, Kitchener 1976, 1989, Storr 1975). The major rainforest survey of the late 1980s (McKenzie *et al.* 1991) and continued sampling activity in the region has shown that the area covered by the 1:250 000 map sheets of Cambridge Gulf, Montague Sound and Prince Regent in the north Kimberley are the richest for frogs, mammals and reptiles in all Western Australia (How and Cowan 2006).

In contrast, the fauna of Kimberley islands is poorly documented and there has been only one published survey of these islands (Burbidge and McKenzie 1978). This reported on some 20 islands in the Bonaparte Archipelagos of the northwest Kimberley that were surveyed for between 1 and 11 days. Islands in the Buccaneer Archipelago in the west Kimberley were also surveyed by government

biologists briefly between 1980 and 1982 and results remain mostly un-published (but see Abbott and Burbidge 1995), however, the fauna of Koolan Island, also in the Buccaneer archipelago, has been documented in detail by McKenzie *et al.* (1995). Information gathered on these island surveys, later visitations by individuals and the major rainforest survey (McKenzie *et al.* 1991) as well as specimens in the collections of the Western Australian Museum, indicate that at least 5 frog, 34 mammal and 58 reptile species are present on the offshore islands along the Kimberley coast. This is in marked contrast with the 26 frogs, 72 mammals and 109 reptiles known from adjacent areas of the mainland. None of the offshore island populations have been examined systematically and all populations, except *Ramphotyphlops* sp. and *Lerista praefrontalis*, have been referred to mainland taxa in published reports.

Our understanding of the identity of vertebrate faunas on the Kimberley islands also stands in sharp contrast with the detailed knowledge of island archipelagos off the Pilbara and western and southern coasts of Western Australia, all of which have been separated from the mainland for similar periods of time. Many of Western Australia's more southern islands have vertebrate populations that are distinctive at the subspecific level, and in some cases at the species level, from populations on the adjacent mainland. All endemic insular taxa are recognised as threatened fauna either by legislation (Government of Western Australia 2005) or by Department of Conservation and Land Management authorities under the Priority Species List.

This paper reports on the outcomes of three expeditions to 35 Kimberley islands in the Bonaparte Archipelago undertaken between August 2002 and June 2005. These surveys were designed to make collections and document the frogs, mammals and reptiles from selected islands in order to determine the morphological and genetic attributes of island and mainland populations. These studies will permit an evaluation of the systematic status of many insular populations and contrast these data with published information available on vertebrates from cognate archipelagos off the Pilbara and west coast of Western Australia. The project will also appraise the evolutionary processes involved in differentiating island forms and assist in determining whether populations are relictual or derived from colonisers from adjacent islands or the mainland.

ISLANDS AND METHODS

Islands were selected on the basis of their geographic location with islands representing those both distant from and adjacent to the mainland being selected.

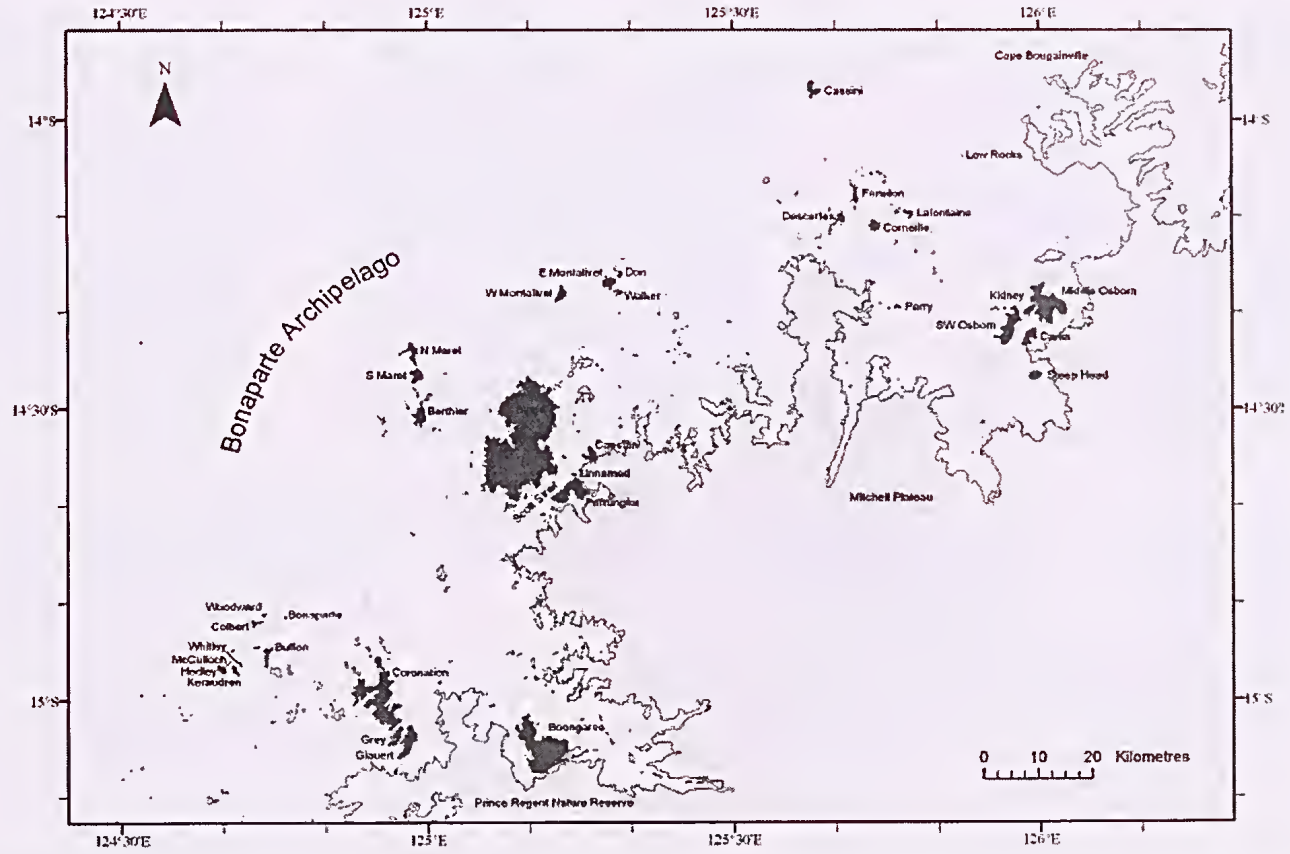

Figure 1. Map of island and mainland locations sampled during the survey of the Bonaparte Archipelago between 2002 and 2005.

Likewise, islands of different sizes were selected as well as those consisting of the main sandstone, volcanic or laterite geological substrates. Wherever possible, a wide variety of vegetation types were sampled on each island with both woodlands and vine forest being targeted.

Thirty-five islands were examined over the three expeditions along with two locations on the mainland; one with three sites adjacent to Scott Strait during the June 2004 survey, the other with three sites opposite Glauert and Boongaree Islands, during the June 2005 survey. For each of these locations, the data for the sites have been aggregated.

The islands sampled are shown in Figure 1, while their area, broad geographical co-ordinates, principal geological formations and duration of sampling are presented in Table 1. Nine of the islands sampled during this project [South West Osborn, Middle Osborn, Carlia, Low Rocks, East Montalivet, South Maret, Bigge, Coronation, Boongaree] were also sampled in the early 1970s (Burbidge and McKenzie 1978) with specific information on their geology, vegetation and vertebrate fauna presented then. On South West Osborn, Bigge and Boongaree Islands, sampling during this survey was carried out on both volcanic and sandstone substrates, while on Carlia Island only sandstone substrates were sampled.

Previously assessed distributional data for the amphibians, reptiles and mammals were obtained from the literature (Burbidge and McKenzie 1978; Abbott and Burbidge 1995) and the State's collections housed in the WA Museum.

General rainfall and climate patterns in the northwest Kimberley are presented in Burbidge and McKenzie (1978), an area characterized typically by a 'wet' season extending from December to April and a 'dry' season from May to November. Rainfall averages over 1500mm at Mitchell Plateau and is concentrated in the 'wet' season. During the present expeditions, the wet season of early 2002 was one of the driest on record, and those for 2004 and 2005 were also well below average.

The charter vessel 'Barra B' was used as a base for visitation to all islands sampled. Access to the islands was by outboard runabout and predicated by both shoreline type, weather conditions and tidal activity that ranged up to ten metres.

SAMPLING

Sampling occurred on three separate expeditions between 25 August – 6 September 2002, 26 May – 8 June 2004 and 19 May – 3 June 2005.

On each island where one or more nights trapping occurred (Table 1), sample sites were trapped using a line of between 20 and 25 Elliott Type A traps, baited with

universal bait. These were set around 10 metres apart. A few Elliott Type B traps were used on some lines and wire mesh Tomahawk cat traps were also employed where sampling continued for several days and there was the prospect of catching larger mammals. Traps were checked during the morning each day. No concerted effort was made to trap bats by mist netting or harp trapping. Opportunistic collecting of vertebrates was undertaken on all islands visited and involved active searching in litter and dead wood as well as under rocks and logs. Head-torching for nocturnal species was conducted on several islands and small pitfall traps were employed on Cassini, Descartes, North Maret, Buffon Islands and the mainland opposite Scott Strait.

Voucher specimens were taken of all taxa for use in later analyses of morphological and genetic variation of vertebrates from the Bonaparte archipelago. Numerous individuals, particularly mammals, were released after weighing and removal of tail or ear tip for later genetic examination.

RESULTS AND DISCUSSION

Sampling on the islands and adjacent mainland sites during the three expeditions documented 2 amphibian, 12 mammal and 29 reptile species.

AMPHIBIANS

Two species of frogs were collected, *Litoria copelandi*, *L. meiriana*, both from the mainland on Prince Regent Nature Reserve adjacent to Glauert Island. None of the islands examined had frogs present and a general lack of freestanding water on the vast majority of islands and the 'poor' wet seasons associated with the sampling time probably account for this low documentation of amphibians.

Previous surveys have identified four species of frog in the Bonaparte Archipelago, *Notaden weigeli*, *Litoria rubella* and *L. inermis* from Bigge Island and *Cyclorana* sp. from Katers Island (Smith and Johnstone 1978).

Frogs are particularly poor survivors on small islands and ineffective dispersers across sea-barriers.

MAMMALS

Mammals were collected from 11 of the islands and the two mainland locations during the survey (Table 2). In total, 394 individuals of twelve species were captured and identified. The sighting of a small rock wallaby on Boongaree Island probably represents the previously recorded and collected *Petrogale burbidgei*, while scats and diggings of echidna, *Tachyglossus aculeatus*, were very common on Boongaree but only one positive sighting was made.

None of the species recorded by this project are new records for mammals on the Bonaparte

Table 1. The island and mainland locations and their co-ordinates sampled during the Bonaparte Archipelago surveys of 2002–2005. The island areas, dates and duration of sampling, number of trap days and broad geological substrates are listed.

ISLAND	AREA (ha)	DATES	Days	Trap days	Latitude	Longitude	Geology
Berthier	556	28/5–1/06/2004	5	500	14°31'	124°59'	Volcanic
Bigge	18121	3–8/06/2004	6	750	14°36'	125°12'	Sandstone/Volcanic
Bonaparte	19	20/05/2005	1	50	14°51'	124°46'	Sandstone
Boongaree	4840	29–3/06/2005	6	1110	15°05'	125°10'	Sandstone/Volcanic
Buffon	283	22–23/05/2005	2	226	14°54'	124°44'	Volcanic
Capstan	394	2–5/06/2004	4	350	14°35'	125°15'	Sandstone
Carlia	457	3–6/09/2002	4	330	14°22'	126°00'	Sandstone/Volcanic
Cassini	370	25–26/08/2002	2	400	13°57'	125°38'	Laterite/Volcanic
Colbert	100	19–20/05/2005	2	200	14°52'	124°43'	Sandstone
Corneille	299	27–30/08/2002	4	400	14°11'	125°44'	Laterite/Volcanic
Coronation	4125	24–28/05/2005	5	716	15°02'	124°57'	Volcanic
Descartes	159	29–30/08/2002	2	120	14°10'	125°41'	Volcanic
Don	73	26–27/05/2004	2	80	14°16'	125°19'	Volcanic
Fenelon	253	27–30/08/2002	4	400	14°08'	125°42'	Laterite/Volcanic
Glauert	1023	24–26/05/2006	3	225	15°03'	124°57'	Volcanic
Grey	399	24–26/05/2005	3	225	15°02'	124°57'	Volcanic
Hedley	172	21–23/05/2005	3	300	14°57'	124°40'	Sandstone
Keraudren	129	21–23/05/2006	3	300	14°56'	124°41'	Volcanic
Kidney	227	2–4/09/2002	3	137	14°20'	125°59'	Volcanic
La Fontaine	158	26–28/08/2002	3	120	14°09'	125°47'	Sandstone
Low Rocks	4	28/08/2002	0.5		14°03'	125°52'	
Mainland – Scott Strait		2–8/06/2004	6	1000	14°36'	125°15'	
Mainland – Prince Regent NR		25/5–3/06/2005	9	1063	15°05'	125°07'	
Maret North	400	28–1/06/2004	5	660	14°23'	124°59'	Laterite/Volcanic

Maret South	384	29–1/06/2004	4	400	14°27'	124°59'	Laterite/Volcanic
McCulloch	6	21/05/2005	0.5		14°56'	124°40'	Volcanic
Montalivet East	366	26–27/05/2004	2	300	14°17'	125°18'	Laterite/Volcanic
Montalivet West	337	26–27/05/2004	2	200	14°18'	125°13'	Laterite/Volcanic
Osborn Middle	2455	2–5/09/2002	4	304	14°21'	126°01'	Volcanic
Osborn South-West	1315	31–5/09/2002	6	659	14°23'	125°57'	Sandstone/Volcanic
Parry	52	31/08/2002	0.5		14°20'	125°46'	Sandstone
Purrungku	1389	6–8/06/2004	3	150	14°37'	125°14'	Sandstone
Steep Head	278	6/09/2002	1	20	14°27'	126°00'	Sandstone
Unnamed	23	6–8/06/2004	3	150	14°36'	125°14'	Volcanic
Walker	62	26–27/05/2004	2	80	14°17'	125°19'	Volcanic
Whitley	41	22–23/05/2005	2	80	14°56'	124°41'	Volcanic
Woodward	29	19–20/05/2005	2	100	14°51'	124°44'	Sandstone

Archipelago, although these findings represent the first records of mammals for Cassini, Capstan, East Montalivet, 'unnamed' and Purrungku Islands. The documentation of *Melomys burtoni* and *Taphozous georgianus* on Coronation and *Zyzomys woodwardi* on Carlia Islands are also first records.

The capture of two individuals of *Z. woodwardi* on Coronation Island will allow a thorough examination of the systematic identity of this aberrant population. McKenzie *et al.* (1978) identified this population as 'unusually large' and distinctively coloured *Zyzomys argurus* when compared to adjacent mainland populations and stated that the population warranted further systematic examination. Subsequent examination of those individuals by Norah Cooper (pers comm.) clearly demonstrates that they are a small form of *Z. woodwardi*. The two *Isoodon* species were recorded only on mainland sampling locations. One mummified skeleton of *Pteropus scapulatus* was located on Cassini Island and probably represents a vagrant, as no roosting site was evident in the very low Eucalypt woodland that occupies the south-eastern part of the island.

The Federal Government recently listed the Northern Quoll, *Dasyurus hallucatus*, as a threatened taxon. This species remains relatively widespread and abundant in the northwest

Table 2. Mammal individuals captured (including those vouchered in brackets) from the Bonaparte Archipelago surveys 2002–2005 and the confirmed sightings (S) of larger species.

Species	BIGGE	BOONGAREE	CAPSTAN	CARLIA	CASSINI	CORONATION	MAINLAND SCOTT STRAIT	MAINLAND PRINCE REGENT	EAST MONTALIVET	MIDDLE OSBORN	SOUTH WEST OSBORN	PURRUNGKU	"UNNAMED"	TOTAL
Tachyglossus aculeatus		S												S
Dasyurus hallucatus	12(2)	14(0)	6(1)				11(1)	9(1)				2(1)		54(6)
Isoodon auratus							1(1)							1(1)
Isoodon macrourus								7(3)						7(3)
Petrogale sp		S												S
Melomys burtoni		3(3)				1(1)		1(1)						5(5)
Mesembriomys macrurus								2(2)					1(1)	3(3)
Rattus tunneyi		6(5)					17(10)	93(12)					1(1)	107(28)
Zyzomys woodwardi	12(9)	31(17)	9(8)	5(5)		2(2)	12(8)	10(10)	1(1)	6(4)	63(14)	17(12)		168(90)
Zyzomys argurus							26(23)	12(11)				3(2)		41(36)
Pteropus scapulatus					1(1)									1(1)
Vespadelus douglasorum		1(1)												1(1)
Taphozous georgianus		6(6)				2(2)								6(6)

Kimberley and occurs on several larger near-shore islands (Abbott and Burbidge 1995). During the current expeditions there were six instances of the Northern Quoll being captured in traps with partially eaten rodent species that indicate the quolls entered the traps in order to eat the rodent. The rodents involved were *Rattus tunneyi*, *Zyzomys argurus* and *Z. woodwardi*.

Larger islands generally had more species while smaller islands usually lacked mammal populations, although of particular interest is the discovery of two mammal species on 'unnamed' island in Scott Straight. This island is just over 23 hectares and its ability to support both *Rattus tunneyi* and *Mesembriomys macrurus* is surprising. Four islands with mammal species, Carlia, Boongaree, Capstan and Purrungku, are separated from the mainland by less than 100 metres of water and the latter two may be connected to the mainland at extreme spring low tides. It is remarkable that a population of *Zyzomys* was found on East Montalivet, given its large distance from the mainland (30 km), as there appears little likelihood that this population represents anything other than a long-isolated relictual one. Augustus Island is the only offshore location where both species of *Zyzomys* co-occur and gives credence to the statement that 'Wetter conditions at the time of isolation of the Kimberley islands may have influenced the distribution of the two species of *Zyzomys*' (McKenzie *et al.* 1978).

The survey of the Bonaparte Archipelago in the early 1970s (McKenzie *et al.* 1978) recorded 22 native mammal species from 20 islands. Foremost amongst the islands for mammal diversity was Augustus Island, the largest, on which 11 species were recorded, while Bigge had eight species and Boongaree nine. Although six days were spent sampling on Bigge during the present project, only two species of mammal were recorded (Table 2). No attempt was made to systematically sample bats throughout the expeditions and these accounted for 5 of the native species recorded by McKenzie *et al.* (1978).

There has been continuing interest in the extinction rates of Australian mammal species in the temperate and arid areas of the continent. It has been postulated that mammals in a 'critical weight range' of 35g–5.5kg have higher extinction rates than those outside this range (Burbidge and McKenzie 1989). However, mammals that are both smaller and larger than those in the 'critical weight range' do not appear to persist well on offshore Kimberley Islands. The North Kimberley bioregion of Western Australia is one of the few areas where the original mammal fauna remains intact with no recorded extinctions. Excluding bats and

all exotic species, one of the five (20%) ground mammals above the critical weight range in the North Kimberley bioregion [*Canis lupus*] has been recorded on several islands of the Bonaparte Archipelago and two of the eight (25%) mammals below the 'critical weight range' are also known on Bonaparte islands [*Pseudantechinus ningbing* on Augustus and South Heywood and *Pseudomys delicatulus* on Bigge]. The six other smaller mammal species known from the North Kimberley mainland but not the islands are, *Planigale maculata, P. ingrami, Sminthopsis virginae, S. butleri, Leggadina lakedownensis* and *Pseudomys laborifex* (Kitchener *et al.* 1981, McKenzie *et al.* 1975). Fourteen of the 21 (66%) terrestrial mainland North Kimberley mammals within the 'critical weight range' occur on Bonaparte islands (McKenzie *et al.* 1978). Given the supposedly greater persistence amongst smaller mammal species in other parts of mainland Australia, it is surprising that so few survive on Bonaparte islands compared with those known from the adjacent north Kimberley mainland. A recent re-examination of the purported higher extinction rates amongst 'critical weight range' mammals (Cardillo and Bromham 2001) suggests that this is not supported statistically and indicates a more significant issue is the higher persistence of smaller mammal species across mainland Australia in the face of a general decline in mammal species. Such is not the case in the Bonaparte Archipelago.

The present and previous island surveys in the Kimberley occupied limited timeframes and were often constrained by the difficult and remote terrain. Intensive ecological studies of the Mitchell Plateau mammal fauna in the north Kimberley (Bradley *et al.* 1987) showed the advantages of a longer-term seasonal and habitat focussed approach to regional survey by adding several species to the previously known vertebrate assemblages of an intensively sampled mainland location (Kitchener *et al.* 1981). It is highly probable that additional species of mammals will be located on islands that have already been sampled as evidenced by the discovery of *Z. woodwardi* on East Montalivet and several additional species recorded for Bigge by a CALM survey in 2003. The long occupancy of Koolan Island for mining purposes has also shown that continued sampling and observation results in higher diversity of mammals with 18 mammals now known to occur there.

REPTILES

Reptile species were recorded on all 35 islands and the two adjacent mainland locations. None of the 29 species recorded were found only at the mainland locations, which are omitted from Table 3. All 1200 individuals captured and identified had tissue sampled.

These data represent the first

sampling of reptiles on Berthier, Bonaparte, Buffon, Capstan, Cassini, Colbert, Corneille, Descartes, Don, Glauert, Grey, Hedley, Keraudren, Kidney, La Fontaine, Low Rocks, McCulloch, North Maret, Parry, Purrungku, South Maret, Steep Head, 'unnamed', Walker, West Montalivet, Whitley and Woodward Islands.

Several species were collected that had not previously been recorded from islands in the Bonaparte Archipelago, *Heteronotia planiceps*, *Cyclodomorphus maximus*, *Lerista* sp., *Tiliqua scincoides*, and *Dendrelaphis punctulata* (Smith and Johnstone 1978; WA Museum records). All these taxa have been recorded from islands in the Buccaneer Archipelago but represent the first recorded island populations in the Bonaparte Archipelago. Clearly, there is still need for detailed biodiversity survey initiatives on islands in this diverse archipelago.

One of the most important 'finds' of the sampling has been the discovery of an undescribed *Lerista* species from Berthier Island. The closest taxon to this in the WA Museum collections is *Lerista praefrontalis*, a unique population on King Hall Island in the Buccaneer Archipelago. The *Lerista* specimens from Berthier Island are in need of detailed systematic assessment (Maryan pers comm.). Offshore island populations of the Olive Python *Liasis olivaceus*, were discovered on Descartes (159 ha) and Don (73 ha) Islands, indicating the species is far more widespread than previously thought and that it can persist on relatively small islands in the absence of mammals; presumably both reptiles and birds comprise their entire diet. The King Brown or Mulga Snake, *Pseudechis australis*, was captured on several islands (Table 3) and were noticeably different in patterning from mainland forms. One individual of this species was captured in a trap and regurgitated a recently killed *Ctenotus inornatus*, also indicating willingness by this predator to enter traps to feed on prey.

Forty-two reptile species were recorded from the Bonaparte archipelago islands by Smith and Johnstone (1978) during the major survey of the early 1970s, however their data included four species only located on Koolan Island, in the Buccaneer Archipelago. The lower number of reptile species on islands compared to adjacent mainland locations (Storr and Smith 1975; Smith and Johnstone 1981) may reflect a true impoverishment of island reptile faunas or a decreased sampling effort on islands. Inadequate sampling effort is best exemplified by the fact that 13 sampling days on Augustus Island, covering 19 023 hectares, yielded 21 reptile species, while long-term records from Koolan Island, covering just 2580 hectares, yielded 35 reptile taxa (McKenzie *et al.* 1995).

Table 3. Reptiles recorded from islands sampled in the Bonaparte Archipelago between August 2002 and June 2003.

GENUS	SPECIES	BETHIER	BIGGE	BONAPARTE	BOONGAREE	BUFFON	CAPSTAN	CARLIA	CASSINI	COLBERT	CORNEILLE	CORONATION	DESCARTES	DON
Diporiphora	*superba*				X									
Pogona	*microlepidota*		X											
Gehyra	*nana*		X								X		X	
Gehyra	*xenopus*						X							
Heteronotia	*binoei*	X	X	X					X	X			X	
Heteronotia	*planiceps*				X									
Oedura	*obscura*				X									
Oedura	*rhombifera*													
Delma	*borea*				X							X		
Lialis	*burtonis*				X									
Carlia	*johnstonei*	X	X		X	X	X	X			X	X	X	
Carlia	sp.						X	X	X		X		X	X
Carlia	*triacantha*		X			X				X				X
Cryptoblepharus	*megastictus*													
Cryptoblepharus	*plagiocephalus*		X									X		
Ctenotus	*inornatus*	X	X	X	X	X	X	X	X	X	X	X	X	X
Cyclodomorphus	*maximus*													
Glaphyromorphus	*isolepis*	X		X		X			X			X		
Lerista	sp.									X				
Lerista	*walkeri*		X											
Morethia	*ruficauda*											X	X	
Notoscincus	*ornatus*		X											
Tiliqua	*scincoides*													
Varanus	*acanthurus*		X			X					X			
Varanus	*glauerti*						X							
Antaresia	*childreni*	X							X					
Liasis	*olivaceus*												X	X
Dendrelaphis	*punctulata*										X			
Pseudechis	*australis*					X		X			X			
TOTAL TAXA		5	10	3	7	6	5	4	5	4	7	6	7	4

	8	7	3	3	5	8	5	1	1	1	8	12	1	3	3	8	2	2	4	6	3	1
EAST MONTALIVET																X						
FENELON	X	X			X	X						X			X				X			
GLAUERT						X					X	X										
GREY				X														X				
HEDLEY			X	X	X		X					X		X			X			X		
KERAUDREN	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X
KIDNEY						X					X					X						
LA FONTAINE											X											
LOW ROCKS											X											
MCCULLOCH											X											
MIDDLE OSBORN	X	X	X		X	X	X				X	X		X		X			X	X		
NORTH MARET	X	X			X	X						X	X									
PARRY													X									
PURRUNHKU														X								
SOUTH MARET															X							
SOUTH WEST OSBORN	X	X	X		X	X						X		X		X			X	X		
STEEP HEAD																	X					
"UNNAMED"																		X				
WALKER	X																		X			
WEST MONTALIVET												X								X		
WHITLEY		X													X						X	
WOODWARD																						

CONCLUSIONS

While the three expeditions to numerous islands in the Bonaparte Archipelago have provided important new records of species on islands, their vertebrate fauna remain poorly documented when compared to Koolan Island in the adjacent Buccaneer Archipelago. Most island populations have not been evaluated systematically and all have the potential to provide important new information on evolutionary effects of isolation since the Pleistocene. Future molecular studies of island populations will document genetic variability though the Archipelago and contrast that with adjacent mainland populations as well as examine the effect of distance from potential source populations.

It has been postulated that the recent population declines of several vertebrate groups in tropical Australia are the result of environmental modifications caused by climate change and lowered groundwater levels (Braithwaite and Muller 1997). This has been questioned by Woinarski *et al.* (2001) who suggested a combination of habitat modification resulting from grazing, altered fire regimes, particularly changing the shrublayer of tropical savannas, as well as predation from feral cats was probably responsible. There is growing evidence that there are long-term changes occurring in mammal populations in the remote Kimberley mainland in Western Australia (Kenneally *et al.* 2003; Lochman pers comm.).

Islands are likely to be the refugia of the same or closely related taxa on the mainland but are less subjected to anthropogenic influences such as changed fire regimes, cattle grazing and feral cat predation. However, the marked increase in ecotourism of the region has the potential to dramatically alter island species richness. Anecdotal evidence from a professional fisherman suggests there has been a three-fold increase in the number of tour boats cruising the Kimberley coast since 2002 (Macintosh pers comm.).

The most significant threat to island populations may come from the colonisation of the Kimberley by *Bufo marinus*, the Cane Toad. This threat will occur either naturally, by the colonisation of the islands by this invasive pest, or by misguided introductions to islands of mainland forms that are perceived to be threatened by the spread of *Bufo* across the mainland.

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Museum Honorary Associate Jeff Lodge and his wife Di organised the logistics of working in the northwest Kimberley and were the driving forces behind us being able to mount the expeditions. They also brought their 7-metre boat the 'Sea Eagle' to all islands and provided specialist and invaluable support to the expeditions. The skipper of the 17m 'Barra B', Robbie Macintosh, and his able crew of Mark Ainsworth, David Gittings and Roxy Wicherts were exceptional in providing for all the expeditions requests and needs. Their decades of experience in Barramundi fishing around the Kimberley coastline was essential to the productivity and success of the expeditions.

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FLORISTICS OF THE SHARK BAY WORLD HERITAGE SITE, WESTERN AUSTRALIA: VEGETATION AND FLORA OF 34 SMALL ISLANDS

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ABSTRACT

Thirty-four small islands within the Freycinet Estuary, Freyeinet Reach and Disappointment Reach of the Shark Bay World Heritage area were surveyed for vegetation and flora. Only Eagle and "South West" Eagle Islands had been previously studied. All the other islands were surveyed for the first time during this survey.

Island areas ranged from <0.1 to 161 hectares. Five islands (North Smith, Briggs Rocks, two of the Wild Islets and Smith Rocks) lacked any vascular plants. Heath, shrublands and herbfields were the common vegetation formations.

A eombined total of 169 species (135 native and 34 naturalised) of vascular plants were recorded. The largest families recorded were the Poaceae (22 species), Asteraceae (20 species) and Chenopodiaceae (18 species). The largest islands, Salutation, Baudin and Three Bays, supported 109, 92 and 80 species respectively. The most ubiquitous species was *Nitraria billardierei*. One species, *Calandrinia* sp. nov. (J. Alford 1376) has only been recorded from these islands.

Naturalised species were reasonably common, especially on islands mined for guano. Guano mining appears to have occurred on 15 islands (North and South Smith, Three Bays, North and South Guano, Maryanne, North and South Depuch, Freyeinet, White, Charlie, North and South Kangaroo, Lefebre and Friday) and probably on Wild-Central Islet and Double island. The vegetation has not recovered from this activity.

INTRODUCTION

Most of the islands (Salutation, Three Bays, North and South Guano, Maryanne, Freycinet, Baudin, White, Wild, Double, Sunday, Egg, and Pelican) are part of Reserve 26004 for Conservation of Flora and Fauna and collection of Guano. Friday and Charlie Islands are separate

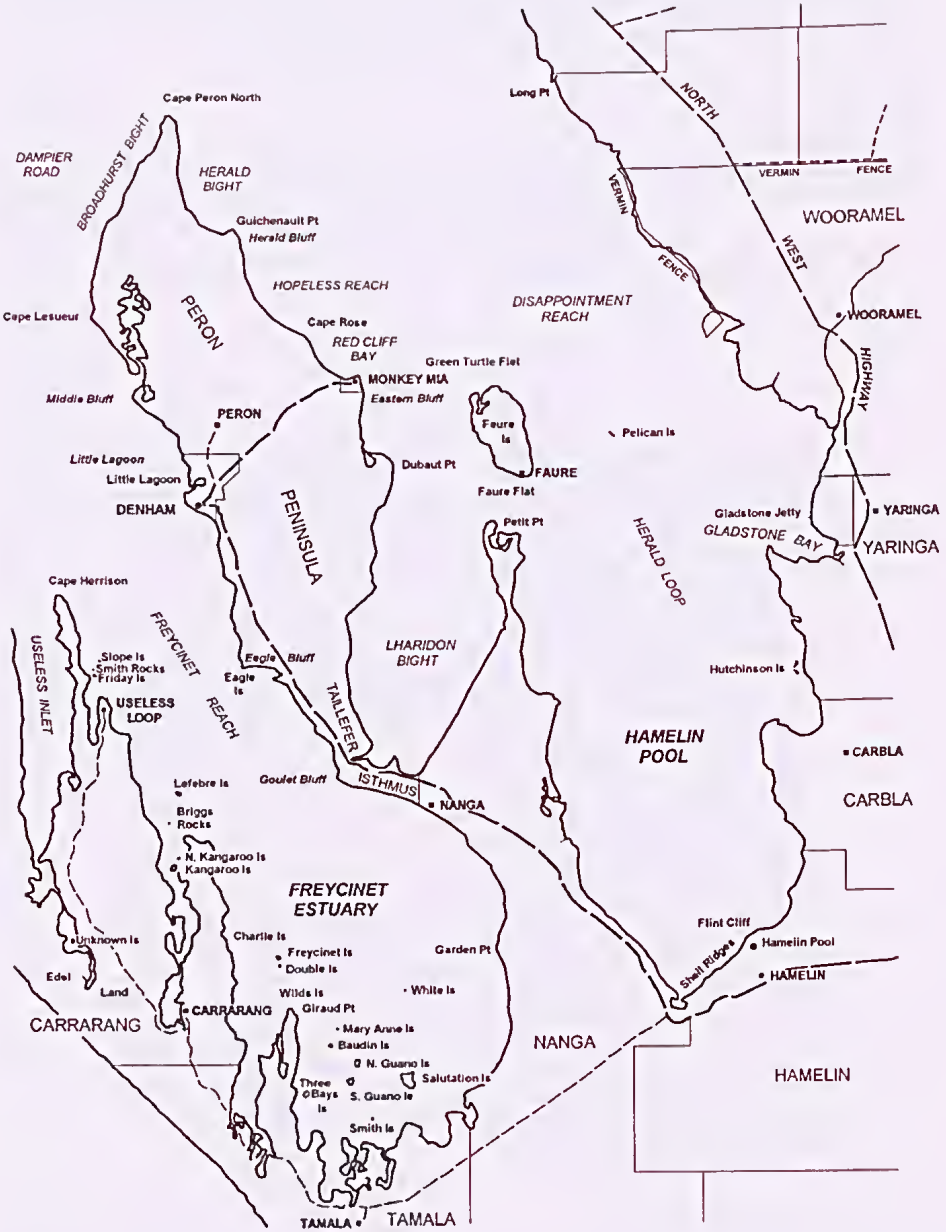

Figure 1. Location of islands surveyed, with the exception of Meade, Sunday and Egg.

reserves for the Conservation of Flora and Fauna. All of the fore mentioned islands and most of the remainder are proposed to become nature reserves, within the Shark Bay World Heritage Area.

The purpose of this report is to provide baseline data on the floristics of these islands. All the islands were visited in Spring 1989 or 1997 and surveyed where possible by foot traverse. A complete list of flora present was obtained. Structural vegetation forms were mapped, but an absence of aerial photographs meant that these were only collated as hand drawn maps, presented with a set of photographs in a report to the Australian Heritage Commission. Voucher collections are deposited in PERTH Herbarium.

Several of the islands are unnamed. In general they are named informally in this publication in relation to the nearest named island ie: NW (North-West) or SW (South-West).

A general location map of all the islands, except for Sunday, Meade and Egg (which lie just off the east shore of Dirk Hartog Island) is given in Figure 1. A total vascular flora list is presented in Table 1 with the records for each island under the numbering system listed below.

ISLAND BY ISLAND FLORA AND VEGETATION DESCRIPTIONS:

All the islands are ordered from south to north. The number of vascular plants recorded is summarised. The area of the island is given, normally from that listed in the CALM terrestrial reserves management plan (Hancock *et al.* 2000) to high water mark. However, the area of all islands was also estimated from the CALM lands and survey coastal data set and where there was no area available these estimates are shown in parenthesis. Most of the islands have boulder slopes and beaches, which make area estimates above high water mark difficult. Vegetation communities present are summarised and a complete flora list presented in Table 1.

1. SOUTH SMITH ISLAND
26° 35' S 113° 43' E

Number of plant species recorded: 3, 0 aliens.
Area: 1.350 ha.
Vegetation:
The island consists of a rugged limestone boulder slope with guano rich pockets of sand. *Nitraria billardierei* shrubland is the only vegetation formation present.

2. NORTH SMITH ISLAND
26° 35' S 113° 43' E

Number of plant species recorded: 0.
Area: 891m².
Vegetation:
A limestone rock– no vegetation recorded.

3. THREE BAYS ISLAND
26° 33' S 113° 39' E

Number of species recorded 80, 12 aliens.
Area: 5.2609 ha.
Vegetation:
Low sand covered island with sandy beaches, backed by grasslands of *Spinifex longifolius*, then a band of *Nitraria billardierei* shrubs. The remainder of the island is covered with low heath of varying composition depending on depth of the sand over the limestone. Limestone outcrops have a heath dominated by *Atriplex cinerea* or *Sarcostemma viminale*. Sandy areas have heath dominated by *Scaevola crassifolia*, with mixtures of *Nitraria billardierei*, *Diplolaena grandiflora*, *Rhagodia latifolia* and *Carpobrotus* aff. *rossii* (Keighery & Gibson 1615).
Seabird rookeries on the northern end of the island have herbfields of *Calandrinia polyandra*, and populations of the weeds **Sisymbrium erysimoides*, **Hordeum leporinum*, **Chenopodium murale* and **Spergularia diandra*.

4. "SOUTH GUANO" ISLAND
26° 32' 46" S 113° 41' 25"E

Number of plant species recorded: 22, 3 aliens.
Area: 450 m².
Vegetation:
A small island consisting of a "plateau" with surrounding talus of rugged limestone. Shallow dark brown sandy loam with white stones, pebbles and shells over limestone. A tall shrubland of *Nitraria billardierei* is found on the talus slopes. The plateau has herbfields of *Calandrinia polyandra* or **Chenopodium murale* with patches of *Bromus arenarius* and emergent *Lavatera pleibea* var *tomentosa*, with a small area of very low succulent shrubland dominated by *Disphyma crassifolium*. These plateau vegetation formations result from the loss of *Nitraria* shrubland due to guano mining.

5. "NORTH GUANO" ISLAND
26° 33' 15" S 113° 41' 25"E

Number of plant species: 17, 3 aliens.

Area: 405 m².

Vegetation:

An island consisting of a central plateau, ledge like areas and steep talus slopes surrounding the plateau. The talus slopes have *Nitraria billardierei* shrubland. Ledges have a prostrate closed succulent shrubland of *Disphyma crassifolium*. The plateau area is dominated by a grassland of *Setaria dielsii* and *Bromus arenarius* with two small areas dominated by a low succulent shrubland of *Carpobrotus* aff. *rossii* (Keighery & Gibson 1615). These plateau vegetation formations result from guano mining and were probably *Nitraria* shrubland.

6. "LITTLE GUANO" ROCK
26° 33' 15" S, 113° 41' 34"E

Number of plant species recorded: 8, 0 aliens.
Area: 405 m².
Vegetation:
Located approximately 200 metres east of North Guano

Island. This island is a rugged limestone rock with *Nitraria billardierei* shrubland to 1.5 metres. The population of the succulent herb, *Calandrinia polyandra* on this island has plants with either pink or white flowers in equal numbers.

7. SALUTATION ISLAND
26° 32' S 113° 46' E

Number of plant species recorded: 109, 14 aliens.
Area: 161.8743 ha.
Vegetation:
The largest island of the group, is covered by extensive areas of sand.

Around the island's periphery, on sandy beaches a low heath of *Calocephalus brownii* and/or *Sporobolus virginicus* grassland occurs. Behind the strand line on the primary dunes there is normally a shrubland of *Nitraria billardierei* over *Frankenia pauciflora* low shrubs or a *Sporobolus virginicus* grassland. On beaches with outcropping limestone there is a narrow band of succulent shrubland at the waters edge consisting of *Halosarcia halocnemoides* and *H. indica*. These areas are backed by a low heath of *Scaevola crassifolia* and *Frankenia pauciflora*. Limestone cliffs are covered by patchy succulent shrublands of *Disphyma crassifolium* over *Calandrinia polyandra* herbfields.

Inland the common vegetation on sandy soils is low open shrubland of *Acacia rostellifera* (occasionally replaced by *Acacia ligulata* or *A. galeata*) over *Ptilotus obovatus*, *Rhagodia latifolia*, *Scaevola crassifolia*, *Carpobrotus* aff *rossii* and *Diplolaena grandiflora*. Dunes may be dominated by *Diplolaena grandiflora* or *Atriplex cinerea*.

Areas of outcropping limestone overlain by thin sands have low heaths dominated by *Atriplex cinerea*, *Scaevola crassifolia* or *Ptilotus divaricatus* over numerous shrubs, grasses and herbs. Exposed limestone has an open low succulent heath of *Sarcostemma viminale* over herbs. A seabird rookery had a mid dense herbfield of **Chenopodium murale*.

A population of the potentially serious weed Boxthorn (**Lycium ferocissimum*) was located on this island and should be eradicated, The population of *Swainsona* on this island keys to *S. longicarinata* (*Swainsona ? longicarinata* (J. ALFORD 1330), is the voucher collection) but is poorly placed in this species

8. BAUDIN ISLAND
26° 31' S 113° 39' E

Number of plant species recorded: 92, 9 aliens.
Area: 19.0202 hectares.
Vegetation:
A low sand covered island with several sandy beaches separated by limestone headlands, and high points of exposed limestone. Beaches have a strand vegetation of low shrubs of *Calocephalus brownii*, backed by grasslands of *Spinifex longifolius*, or sparse open shrublands of *Scaevola crassifolia* and *Nitraria billardierei*. The

remainder of the island is covergd with low heath of varying composition depending on depth of the sand over the limestone. Dominants of these areas are *Scaevola crassifolia, Alyxia buxifolia, Acanthocarpus preissii, Diplolaena grandiflora* and *Acacia rostellifera*. Limestone outcrops have a heath dominated by *Sarcostemma viminale*. Talus slopes below limestone headlands are dominated by *Nitraria billardierei* shrubland.

9. MARYANNE ISLAND
26° 29' S 113° 41' E

Number of plant species recorded: 16, 4 aliens.
Area: 2.8328 ha.
Vegetation:
This island consists of a central plateau and surrounding talus slopes. The talus slopes are dominated by *Nitraria billardierei* very open shrubland. The plateau was mined for guano, and contains herbfields, instead of shrublands. These herbfields are dominated either by *Calandrinia polyandra, *Sagina apetala, *Chenopodium murale* or **Mesembryanthemum crystallinum*. Patches of *Disphyma crassifolium* succulent prostrate shrubland are found on ledges at the edge of the plateau.

WILDS ISLANDS
26° 27' 05" S, 113° 36' 53" E

These are a group of four islets, with the central and first islet joined by a tombolo.
(Total area estimated at 1.241 ha of which the central islet is 950m².)

10. "CENTRAL" ISLAND
Number of plant species recorded: 13, 5 aliens.
Vegetation:
The central islet has a plateau surrounded by talus slopes. The vegetation of the plateau lacks any Nitraria shrubs but the presence of old stumps suggests that this island was mined for guano, but the slopes and ledges are also a large cormorant rookery. The talus slopes have a shrubland of *Nitraria billardierei*, with the plateau dominated by herbfields of **Chenopodium murale, *Sagina apetala* or **Mesembryanthemum crystallinum*.

11. "FIRST ISLET"
No vegetation recorded.

12. "SECOND ISLET"
No vegetation recorded.

13. "THIRD ISLET"
Number of plant species recorded: 9, 3 aliens.
Vegetation:
A rugged limestone rock with *Nitraria billardierei* shrubs mainly on ledges with low succulent shrubland of *Disphyma crassifolium* on northern end.

14. DEPUCH ISLAND "SOUTH"
26° 26' S 113° 33'E

Number of plant species recorded: 12, 5 aliens.
Area: 479 m².
Vegetation:
Located opposite the Wilds

Islands and 400 metres from the mainland. This island consists of rounded limestone boulders and guano (? an old mined patch). Vegetation consists of one patch of *Nitraria billardierei* shrubs, with the rest of the island having a sparse cover of a variety of scattered herbs.

15. DEPUCH ISLAND "NORTH"
26° 26' S, 113° 33'E

Number of plant species recorded: 15, 6 aliens.
Area: 0.896 ha.
Vegetation:
Located about 200 metres from the mainland. Centre of island completely bare of vegetation, a legacy of guano mining. Surrounding this area are scattered *Nitraria billardierei* shrubs over the succulent, *Disphyma crassifolium* and grasses and herbs.

16. WHITE ISLAND
26° 27' S 113° 46' E

Number of plant species recorded: 15, 5 aliens.
Area: 4.0469 ha.
Vegetation:
Primarily limestone covered in yellowish sandy guano. The centre of the island is devoid of vegetation – a legacy of guano mining. The steep rocky slopes below the centre are covered in scattered *Nitraria billardierei* shrubs over annuals. As the slope levels a band of *Atriplex isatidea* shrubs occurs.
Unusually this island contains two *Calandrinia* species, consisting of *Calandrinia polyandra* and a taxon that was not able to be allocated to any named or unnamed material of the genus in PERTH. *Calandrinia* sp (J. Alford 1376) is either very rare or a poorly collected taxon.

17. DOUBLE ISLAND
26° 25' S 113° 37' E

No of plant species recorded: 13, 2 aliens.
Area: 405 m².
Vegetation:
This island consists of two high plateaus with sharp rugged limestone talus surrounding the island. Soil, where present, is a light brown to pink/orange sandy loam over massive consolidated limestone. The talus slopes have scattered shrubs of *Nitraria billardierei* over herbs. The plateau vegetation consists of herbfields of **Chenopodium murale*, **Mesembryanthemum crystallinum* and *Calandrinia polyandra*. This vegetation type is the result of guano mining.

18. FREYCINET ISLAND
26° 24' S 113° 37' E

Number of plant species recorded: 34, 6 aliens.
Area: 3.6422 hectares.
Vegetation:
This island consists of a central plateau and surrounding talus slopes. The talus slopes are dominated by a low closed shrubland of *Nitraria billardierei*, over half of which are damaged by guano from roosting and nesting cormorants. The plateau was mined for guano, and contains herbfields, instead of shrublands. These herbfields are

dominated by *Calandrinia polyandra* with **Chenopodium murale* and **Sagina apetala*. Patches of *Disphyma crassifolium* succulent prostrate shrubland are at the edge of the plateau. Seedlings of *Nitraria billardierei* are found throughout this area. There is a swale in the centre of the plateau, with deeper sandy loam which has a very low, wind pruned shrubland of *Abutilon oxycarpum*, and *Ptilotus exaltatus* which contains patches of grasses and succulents. The grassland is dominated by *Bromus arenarius* to 30 cm and 1–60% cover. There is also one large patch on the talus slope below the west cliff. The succulent herbfields are dominated by *Calandrinia polyandra* (normally with pink, occasionally white flowers) varying from 10–60% cover. **Avena sterilis* is the dominant grass on a patch on the eastern dune with 60% cover.

19. CHARLIE ISLAND
26° 23' S 113° 34' E

A rock, with only scattered shrubs of *Nitraria billardierei* are present.

20. "SOUTH WEST CHARLIE"
26°23' S 113° 34' E

Number of plant species recorded: 7, 2 aliens.
Area: 0.92 ha.
Vegetation:
A limestone rock with a thick guano enriched plateau on top. A low shrubland of *Nitraria billardierei* occurs on the edges of the plateau with a few wind pruned specimens to 20 cm on the summit. The plateau has many old dead *Nitraria* stumps, a legacy of guano mining and cormorant colonies.

21. KANGAROO ISLAND
26° 19' S 113° 30' E

Number of plant species recorded: 11, 5 aliens.
Area: 1.177 ha.
Vegetation:
A platform island with tiny cliffs all around and shallow waters surrounding, being less than 100 metres from the mainland. Soils are very shallow grey/light brown sandy loams over ancient wave washed limestone. The margins and portions of the central dune are covered in a *Nitraria billardierei* shrubland. Where this has been removed by guano mining there is now a herbfield of **Chenopodium murale*, **Sonchus oleraceus* and **Sagina apetala* with emergent *Lavatera pleibea* var *tomentosa*.

22. NORTH KANGAROO ISLAND
26° 17' 59" S 113° 30' 11" E

Number of plant species recorded: 15, 3 aliens.
Area: 1.110 ha.
Vegetation:
A platform island with tiny cliffs all around and shallow waters surrounding, being less than 100 metres from the mainland. The margins are covered in *Nitraria billardierei* shrubland. Where this has been removed by guano mining in the centre of the island there is now a herbfield of *Calandrinia polyandra*.

23. BRIGGS ROCKS
26° 16' S 113° 29'E

No vegetation recorded.

24. LEFEBRE ISLAND
26° 14' S 113° 30' E

Number of plant species recorded: 5, 1 alien.
Island has 2 distinct limestone plateaus with a low dune between, total area: 1.985 ha.
Vegetation:
Only a few metres offshore, close to Useless Loop salt mining operations. Several hundred Pied Cormorants nest here. At the northern end there is a herbfield of **Chenopodium murale* with scattered emergent *Lavatera pleibea* var *tomentosa*. The rest of the island is mainly bare sand and guano. In places where gross disturbance has not occurred there is a fringing shrubland of *Nitraria billardierei*.

25. "EAGLE BLUFF" ISLAND
26° 06' S 113° 35' E

Number of plant species recorded: 7, 3 aliens.
Area: 2.456 ha.
Vegetation:
This island has low cliffs and a dune on the south-eastern end. Vegetation is mainly *Nitraria billardierei* shrubland of varying density over herbs, except for a large bare area on the dune.

Flora
Ian Abbott on 23.6.1976 recorded 8 plant species on this island (Abbott 1980). He did not record *Mesembryanthemum*, *Sagina*, *Nicotiana* or *Lavatera*. He recorded *Pelargonium* sp (?probably *Lavatera*), *Lawrencia* sp., *Sporobolus virginicus*, *Muellerlimonium salicorniaceum*, and *Poa* sp. These five species may have become extinct on the island or may have been missed due to the fact that Bridled Terns were nesting on the island during our visit and so some parts of the island were avoided so as not to scare adults off chicks, thereby exposing them to predation.

26. "SOUTH WEST EAGLE BLUFF" ISLAND
26° 06' S 113° 35' E

Number of plant species recorded: 3, 1 alien.
Area: 495 m².
Vegetation:
We did not land on this island, however, *Nitraria billardierei* shrubland is the dominant cover. This species and *Lavatera pleibea* var *tomentosa* were recorded from the boat. Ian Abbott recorded *Nitraria billardierei*, **Chenopodium* sp. and *Pelargonium* sp. on his visit on 23-6-1976.

27. FRIDAY ISLAND
26° 06' S 113° 24' E

Number of plant species recorded: 5, 1 alien.
Area: 819 m².
Vegetation:
This small flat topped island, close to shore, has been severely disturbed by guano mining in the past. The southern side has a small beach with a herbfield of **Chenopodium murale* and

scattered emergent *Lavatera pleibea* var *tomentosa*. The plateau of the island lacks vegetation and consists of a mantle of guano rich sand with numerous cormorant nests. The northern end of the island is a talus slope with a low shrubland of *Nitraria billardierei*, which probably occurred on the plateau prior to mining.

28. SLOPE ISLAND
26° 05' 47" S, 113° 24' 53" E

Number of plant species recorded: 4, 1 alien.
Area: 935 m².
This island is used as the end of the jetty for salt loading operations by Dampier Salt for their Useless Loop Operations. Most of the island surface has been destroyed or severely altered. Some remnant *Nitraria billardierei* shrubland is found on the talus slopes of the island.

29. SMITH ROCKS
26° 05' S 113° 24' E

No vegetation recorded.
Area: 185 m².

30. "NORTH-WEST"SLOPE ISLET
26° 03' 28" S 113° 24' 51" E

Number of plant species recorded: 11, 6 aliens.
Area: 915 m².
Vegetation:
This small flat topped island, close to shore, has been severely disturbed by guano mining in the past. Some remnant *Nitraria billardierei* shrubland is found on the talus slopes of the island.

31. SUNDAY ISLAND
26° 07' 33" S 113° 14' 07" E

Number of plant species recorded: 14, 4 aliens.
Area: 202 m².
Vegetation:
A small flat topped island, close to shore.
The plateau has a low shrubland of *Nitraria billardierei*, which is disturbed probably from localised or exploratory guano mining.

32. MEADE ISLAND
26° 00' 06" S 113° 11' 58" E

Number of plant species recorded: 15, 5 aliens.
Area: 405 m².
Vegetation:
A small flat topped island, close to shore.
The northern end of the island is a talus slope with a low shrubland of *Nitraria billardierei*, which probably occurred on the plateau prior to guano mining.

33. EGG ISLAND
25° 54' 35" S 113° 09' 21" E

Number of plant species recorded: 4, 2 aliens.
Area: 405 m².
Vegetation:
A small flat topped island, close to shore the island is a talus slope with a low shrubland of *Nitraria billardierei*.

34. PELICAN ISLAND
25° 51' 13" S 114° 00' 49" E

Number of plant species recorded: 5, 1 alien.
Area: 6.0703 hectares.

Vegetation:
This low sandy island, is covered with a low shrubland of *Nitraria billardierei*.

DISCUSSION

Heath, shrublands and herbfields were the common vegetation formations found on the islands. Species numbers ranged from 109 species recorded from the largest island, Salutation, through 92 species for Baudin and 80 on Three Bays Island (the other large diverse islands) to none recorded for 5 islands (North Smith, Briggs Rocks, two of the Wild Islets and Smith Rocks).

One hundred and sixty nine species of vascular plant were recorded during the survey from all 34 islands in the study (Table 1). These species comprised 33 Monocotyledons and 136 Dicotyledons. Thirty- four species of vascular plants were naturalised aliens, however, given the history of disturbance by guano mining and nesting seabirds, this is not surprising.

The largest families were the Poaceae (22 species – 13% of the total), Chenopodiaceae (18 – 11% of the total), Asteraceae (20 – 11% of the total) and Malvaceae (9 – 5.4% of the total). Annuals were very common comprising 69 species (most of the weeds are annuals), over 40% of the total.

The flora is of course a subset of the vascular flora of the World Heritage area, which contains ca 855 species (Trudgen and Keighery 1995). The largest families of this flora are the Asteraceae (95 taxa – 11% of total), Poaceae (62 – 7% of the total), Myrtaceae (69 – 8% of the total), Chenopodiaceae (63 – 7% of the total) and Proteaceae (40 – 4.7% of the total). Notable differences between the proportions of the island floras compared to the adjacent mainland are in the representation of the Myrtaceae and Proteaceae which are usually poorly represented in near shore environments in Western Australia.

One species, *Calandrinia* sp. nov. (J. Alford 1376) has only been recorded from a single collection made on White Island. As with most Western Australian limestone islands off the west coast the ubiquitous species was *Nitraria billardierei*, which was recorded from all vegetated islands. One serious weed, Boxthorn (*Lycium ferocissimum*) was recorded from Salutation Island and should be eradicated.

The small Shark Bay islands have floristic elements shared between all small offshore islands of the west coast lying north of Perth, viz: the Abrolhos (Harvey *et al.* 2001) and the Lancelin to Dongara Islands (Keighery *et al.* 2002). However, overlaying this widespread temperate element there is a significant arid element present on both the Abrolhos and the Shark Bay Islands. The flora of the islands is arid - temperate in nature, but impoverished compared to the adjacent peninsular of Edel Land or the larger Dirk Hartog Island.

Table 1. Vascular plants recorded on islands in the Freycinet Estuary

	1	2	3	4	5	6	7	8	9	10	11	12
MONOCOTYLEDONS	•											
ANTHERICACEAE												
Dichopogon tyleri N.H. Brittan			•									
Murchisonia volubilis N.H. Brittan			•					•				
Thysanotus patersonii R.Br.							•					
ASPHODELEACEAE												
Bulbine semibarbata (R.Br.) Haw.			•					•				
DASYPOGONACEAE												
Acanthocarpus preissii Endl.			•				•	•				
A. robustus A.S.George							•	•				
A. sp (Hopper 1367)			•					•				
Lomandra maritima T.S. Choo								•				
DIOSCOREACEAE												
Dioscorea hastifolia Endl.							•					
PHORMIACEAE												
Dianella revoluta R.Br.							•	•				
POACEAE												
**Avena barbata* Link												
**A. sterilis* L.												
Bromus arenarius Labill.			•	•	•	•	•	•				
Bromus diandrus Roth			•	•	•	•	•	•				
Cymbopogon ambiguus A.Camus							•	•				
Danthonia caespitosa Gaud.			•				•	•				
**Ehrharta longiflora* Smith								•				
**Eragrostis barrelieri* Daveau							•	•				
Eragrostis dielsii Pilger								•				
Eulalia fulva (R.Br.) Kuntze								•				
**Hordeum leporinum* Link			•							•		
**Lamarkia aurea* (L.) Moench							•	•				
Monachather paradoxa Steud.							•					
Paractaenum novae-hollandiae P.Beauv.								•				
Paspalidium sp												
**Phalaris minor* Retz.					•							
**Rostraria pumila* (Desf.) Tzvelev			•	•			•	•				
Setaria dielsii Herrm.			•	•	•	•	•	•				
Spinifex longifolius R.Br.			•				•	•				
Sporobolus virginicus (L.) Kunth			•				•	•				
Stipa crinita Gaud.			•				•	•		•		
S.elegantissima Labill.			•				•	•				
S.nitida Summerh.												

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34

Table 1 (cont.)

	1	2	3	4	5	6	7	8	9	10	11	12
DICOTYLEDONS												
AIZOACEAE												
Carpobrotus aff. *rossii* (Keighery et Gibson 1615)			•		•		•	•				
Disphyma crassifolium (L.) L.Bolus			•	•	•		•		•	•		
**Mesembryanthemum crystallinum* L.							•		•	•		
Tetragonia diptera F.Muell.			•	•	•		•		•			
Tetragonia implexicoma (Miq.) J.D.Hook.			•									
AMARANTHACEAE												
Ptilotus divaricatus (Gaud.) F.Muell. var *divaricatus*							•	•				
P. exaltatus Nees.							•	•				
P. gaudichaudii (Steud.) J.Black var *gaudichaudii*							•	•				
P. obovatus (Gaud.) F.Muell. var *obovatus*							•	•				
P. villosiflorus F.Muell.			•				•	•				
APOCYNACEAE												
Alyxia buxifolia R.Br.								•				
ASCLEPIADACEAE												
Gymnema granitica K.L.Wilson							•					
Sarcostemma viminale (L.) R.Br. ssp. *australe* (R.Br.) P.I.Forst.			•				•	•				
ASTERACEAE												
**Bidens bipinnata* L.							•					
Brachycome halophila P.S. Short							•					
B. iberidifolia Benth.			•				•					
B. latisquamea F.Muell.			•				•	•				
Calocephalus brownii (Cass.) F.Muell.			•				•	•				
**Centaurea melitensis* L.			•									
Cephalipterum drummondii A.Gray							•	•				
Millotia myosotidifolia.(Benth.) Steetz							•					
Olearia axillaris (DC.) F.Muell.								•				
Olearia dampieri (DC.) Lander							•	•				
Podolepis microcephala Benth.												
Podotheca angustifolia (Labill.) Less.							•					
**Pseudognaphalium luteo-album* (L.) Hilliard & B.L.Burtt.							•					
Rhodanthe humboltiana (Gaud.) P.G. Wils.			•				•	•				
R. oppositifolium (S.Moore) P.G. Wils.			•				•					
Senecio lautus G.Forst.			•	•			•	•				
**Sonchus oleraceus* L.			•	•	•		•	•	•	•		
**S. tenerrimus* L.									•	•		
**Urospermum picroides* (L.) Scop.			•				•	•				
Waitzia podolepis (Gaud.) Benth.							•	•				


13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

Table 1 (cont.)

	1	2	3	4	5	6	7	8	9	10	11	12
BRASSICACEAE												
**Brassica tournefortii* Gouan												
**Hymenobolus procumbens* (L.) Nutt. ex Shinz.			•									
Lepidium linifolium (Desv.) Steud.												
L. puberulum Bunge												
L. rotundum (Desv.) DC.							•					
**Sisymbrium erysimoides* Desf.			•				•					
Stenopetalum pedicellare F. Mueel. ex Benth.			•	•	•		•					
CAESALPINIACEAE												
Senna glutinosa (DC.) Randall ssp. *chatelainiana* (Gaud.) Randall			•				•					
CAPPARACEAE												
Capparis spinosa L. var *nummularia* (F.Muell.) Bailey			•				•	•				
CARYOPHYLLACEAE												
**Cerastium glomeratum* Thuill.			•									
**Polycarpon tetraphyllum* (L.) L.								•				
**Sagina apetala* Ard.									•	•		
**Silene gallica* L.			•					•				
**Silene nocturna* (Moench.) Garke							•					
**Spergularia diandra* Heldr et Sart.			•				•					
CHENOPODIACEAE												
Atriplex cinerea Poir.	•		•				•		•			
A. bunburyana F.Muell.								•				
A. isatidea Moq.			•	•			•		•			
**Chenopodium album* L.												
C. gaudichaudianum (Moq.) P.G.Wils.			•	•			•	•				
**C. murale* L.			•	•	•		•		•	•		
Dysphania plantaginella F.Muell.								•				
Dysphania sphaerosperma P.G. Wils.			•									
Enchylaena tomentosa R.Br.			•		•		•	•	•			
Halosarcia halocnemoides (Nees) P.G.Wils. ssp *tenuis* P.G. Wils.							•					
H. indica (Willd.) P.G. Wils.ssp. *bidens* (Nees) P.G. Wils.							•					
Rhagodia latifolia (Benth.) P.G. Wils.							•	•				
R. preissii Moq.				•								
*Salsola tragus*L.			•	•		•	•	•				
Sclerolaena diacantha (Nees) Benth.								•				
S. uniflora R.Br.			•				•	•				
Suaeda australis (R.Br.) Moq.			•									
Thrlekeldia diffusa R.Br.			•	•	•	•	•	•	•			


13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

Table 1 (cont.)

	1	2	3	4	5	6	7	8	9	10	11	12
CHLOANTHACEAE												
Dicrastylis maritima Rye & Trudgen							•					
CONVOLVULACEAE												
Convolvulus erubescens Sims			•									
**Cuscuta epithymum* (L.) L.								•				
Wilsonia humilis R.Br.							•					
CRASSULACEAE												
Crassula colorata (Nees) Ostenf. var *colorata*			•	•	•		•	•				
CUNONIACEAE												
Aphanopetalum clematideum (J. Drumm. ex Harv.) Domin			•				•					
EUPHORBIACEAE												
Euphorbia boopthona C.A. Gardn.			•				•	•				
E. drummondii Boiss.			•				•	•				
FRANKENIACEAE												
Frankenia pauciflora DC.			•				•	•				
GERANIACEAE												
Erodium cygnorum Nees							•					
**Erodium cicutarium* (L.) L'Her.			•									
GOODENIACEAE												
Goodenia berardiana (Gaud.) Carolin								•				
Scaevola crassifolia Labill.			•				•	•				
S. spinescens R.Br.							•	•				
S. tomentosa Gaud.							•	•				
LAURACEAE												
Cassytha aurea J.Z. Weber			•									
LOBELIACEAE												
Lobelia heterophylla Labill.							•	•				
MALVACEAE												
Abutilon geranioides (DC.) Benth.							•					
A. oxycarpum (F.Muell.) F.Muell.			•	•								
Hibiscus sturtii Hook.var *truncatus* Fryxell						•						
**Lavatera cretica* L.			•									
L. pleibeia Sims var *tomentosa* Hook.f.			•	•	•	•	•		•	•		
Lawrencia densiflora (E.G.Baker) Melville							•	•				
L. viridigrisea N.S.Lander	•						•	•				
Sida calyxhymenia Gay ex DC.			•				•					
S. corrugata Lindl.			•				•	•				

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34

Table 1 (cont.)

	1	2	3	4	5	6	7	8	9	10	11	12
MIMOSACEAE												
Acacia galeata Maslin							•					
A. ligulata Cunn. ex Benth.							•	•				
A. rostellifera Benth.							•	•				
A. victoriae Benth.												
MYOPORACEAE												
Eremophila glabra (R.Br.) Ostenf.							•	•				
E. maitlandii F.Muell. ex Benth.								•				
Myoporum desertii Cunn. ex Benth.			•				•	•				
M. insulare R.Br.								•				
MYRTACEAE												
Thryptomene baeckeacea F.Muell.							•					
T. sp "Carrarang" (J.Alford 1350)								•				
NYCTAGINACEAE												
Commicarpus australis Meikle			•				•					
OLEACEAE												
Jasminum calcareum F.Muell.							•	•				
OXALIDACEAE												
Oxalis perennans Haw.			•				•					
PAPILIONACEAE												
Glycine canescens F.J.Herm.			•				•					
G.tabacina (Labill.) Benth.								•				
Indigofera georgei E. Pritzel							•	•				
Lotus cruentus Court			•				•	•				
**Melilotis indica* (L.) All.							•					
Swainsona longicarinata J. Thomp.			•				•					
Templetonia retusa (Vent.) R.Br.								•				
PITTOSPORACEAE												
Pittosporum phylliraeoides DC. var *phylliraeoides*			•				•	•				
PLANTAGINACEAE												
Plantago drummondii Decne.								•				
PLUMBAGINACEAE												
Muellerlimon salicorniaceum (F.Muell.) Lincz.			•					•				
PORTULACCACEAE												
Calandrinia polyandra Benth.			•	•	•	•	•	•	•	•		
C. sp (J. Alford 1376)												
Portulacca oleracea L.							•					

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
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Table 1 (cont.)

	1	2	3	4	5	6	7	8	9	10	11	12
PRIMULACEAE												
Samolus repens (Forst. et Forst.G.) Pers.ssp nov. (J.Alford 1251)		•					•					
PROTEACEAE												
Grevillea candelabroides C.A.Gardn.			•									
RANNUNCULACEAE												
Clematis linearifolia Steudel							•					
RUTACEAE												
Diplolaena grandiflora Desf.			•				•	•				
SANTALACEAE												
Exocapus aphyllus R.Br.			•				•	•				
Santalum ?lanceolatum R.Br.								•				
SAPINDACEAE												
Alectryon oleifolius (Desf.) S.T. Reynolds ssp. oleifolius			•				•	•				
Dodonaea viscosa Jacq. ssp. angustissima (DC.) J.G. West							•					
SOLANACEAE												
**Lycium ferocissimum* Miers							•					
Nicotiana occidentalis Wheeler ssp. *hesperis* (N.T. Burb.) Horton			•	•	•	•	•	•	•	•		
**Solanum nigrum* L.												
SURIANACEAE												
Stylobasium spathulatum Desf.								•				
THYMELAEACEAE												
Pimelea gilgiana E.Pritzel			•					•				
Pimelea microcephala R.Br.							•					
URTICACEAE												
Parietaria debilis G.Forst.			•	•	•		•			•		
ZYGOPHYLLACEAE												
Nitraria billardierei DC.	•		•	•	•	•	•	•	•	•		
Zygophyllum apiculatum F.Muell.								•				
Z. fruticulosum DC.			•	•			•	•	•	•		

Guano mining appears to have occurred on 15 islands (North and South Smith, Three Bays, North and South Guano, Maryanne, North and South Depuch, Freycinet, White, Charlie, North and South Kangaroo, Lefebre and Friday) and probably on Wild-Central Islet and Double Island. Gauno

mining commenced on the islands rapidly after settlement in the 1840's, but was poorly documented or regulated. In most of these islands the original vegetation of *Nitraria* shrubland was cut down and the loose limestone rock placed in piles to facilitate collection of the guano (Wells 1955). This physical

evidence is still present on most of these islands. The plateau vegetation of the mined areas is now a herbfield, sometimes with *Nitraria* seedlings present, but on no island has the vegetation fully recovered from this activity.

ACKNOWLEDGEMENTS

Andrew Burbidge and Phil Fuller collected plants from Egg, Sunday, Meade and Pelican Islands during their seabird surveys of these islands. Their assistance made it possible to complete surveying all the small offshore islands of Shark Bay. Keith Morris and Robert Bromilow of the CALM Wildlife Research Centre assisted in accessing the islands during the survey.

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IN MEMORIAM

DORIS ISABEL JOHNSON

05 October 1911 – 24 September 2005

Doris Johnson, one of the Club's most loved members, passed away on 24 September 2005 just one week before her 94th birthday.

Doris joined the Club in June 1964 and was elected to Council in 1980 and served as Secretary in 1981–1983. By April 1983 she began coordinating the Retired and Leisured Group which she continued for nearly 20 years. She played a pivotal role in this group as well as helping out at most meetings of the main club. Her good cheer and support will be sorely missed.

Doris Johnson (second from left) at a Retired and Leisured Group excursion to Herdsman Lake in October 1996.

The following eulogy was read by Doris Johnson's nephew at her Memorial Service.

Welcome to this celebration of the life of my Aunt Doris, known more commonly in the family as AD, Dot or Dottie. It was a life so full of interest that I can indicate only briefly her essential biographical details in the time available.

She was born on 5 October 1911, the fourth child in a family of eight. Her parents were pioneering settlers in the Kalamunda district.

1900 - August Johannson and Maggie Ervin met in Bulong, in the WA goldfields. He was a Swedish seaman who, aged 19 and with seven shillings in his pocket, jumped ship in Rockingham in 1891, and by 1900 was prospecting in the Bulong area. Maggie was from a farming family in Victoria who had come to Bulong to keep house for her older brother Bob.

1902 - On becoming naturalized, August changed his name to Johnson.

1903 - August Johnson and Maggie Ervin married in Fremantle.

1904 - First child born.

1905 - They bought 12 acres of Crown land in Lesmurdie, built a shack with bush materials, hessian and iron, later a 3 roomed cottage with stone from the property. Grew annual crops, strawberries, peas etc.

1906 - Second child born. 1908 Third child born. 1911 Aunt Dot born. All four children so far were girls. With further clearing of the property an orchard was gradually established. Times were hard and money scarce. By the time Dot was ten, four more children had been born, two boys and two girls. Money still scarce!

1916 to 1926 - Dot attends Kalamunda School, a two mile walk each way through the bush. There was no high school in the area, and the remarkably dedicated schoolmaster simply extended the range of his classes to Junior High School level to give local kids the opportunity of a secondary education.

1926 - Dot passes the junior Certificate Examinations.

1927 - She attends Underwood Business College, tuition fees being paid for by Nora (sister no 2), then a teacher. In a

competition between the interstate Underwood colleges, Dot comes top in shorthand, and is a runner up in typing. At the end of that year she begins her long working life by joining TPA as a shorthand typist. The Depression begins to be felt. Her salary is reduced from 35 to 30 shillings per week, but she remains employed.

1929 - Travels to Sydney by ship (and who can blame her?). She remains in Sydney for the next 15 years, holding down some top secretarial jobs, with only one brief holiday back in WA.

1932 - Begins to study singing with Gertrude Hutton in Sydney. Joins the Sydney University Musical Society and sings in *Dido and Aeneus* and *oratoria:* is generally thrilled to bits by the experience.

1944 - Returns to WA to be present (and sing) at Frank and Maureen's wedding. Joins WM Adams and Co as secretary to the manager. Saves furiously for her first overseas trip. Joins University of WA Choral Soc.

1951 - AT LAST. Voyage to UK via Suez fortifies her view that sea travel is the only civilized way to go. Works in London, not discouraged by the persistence of food rationing, nevertheless glad of a food parcel from Australia when she returns from her first exploration

Doris Johnson's 90th birthday, 5 October 2001.

of continental Europe. Becomes a member of YHA and buys a rucksack (5 shillings and 11 pence at Army Disposals), then tours Scotland and the Lakes District.

1952 *highlights* - Standing for hours in the cold to view King George VI's lying in state in Westminster Hall, then watching the cortège going to Paddington station on its way to Windsor for the burial. Watching Queen Mary's funeral procession. What a lot of fun you can have in London. At Easter that year, did a bike tour of Cornwall with two of her buddies. Aug/Sept. by boat to Helsinki (saunas and cold plunges) and Stockholm (whole families of Swedish relatives).

1953 *highlights* - Sitting in an open seat in The Mall in pouring rain watching all comings and goings of the Coronation. Later that June, a YHA trip through North Wales, Derbyshire and other counties.

1954 - Major hitchhiking tour through France, Italy, Germany etc. between April and June. Knee groped by louche French truck driver. Side trip to Malta with aunts Sue and Bid to attend opening by the Queen of a memorial honouring RAF and RAAF crew members shot down whose bodies weren't recovered, including their brother Con. Parents getting old and frail. Saves furiously for trip home.

1955 - Completes circumnavigation of the globe by returning home via Panama, Tahiti, Fiji and New Zealand. Wonderful voyage, but understandably finds it a little hard to settle back in "Dullsville", WA.

1959 - After a couple of lacklustre jobs, finds one which is exactly her cup of tea: secretary to the executive officer of the FOP. Finds everything about the job congenial, not least being her allocation of two free tickets to most events, so during the Festival Season is seldom home. Life becomes rich and full again. She remains in this job until her retirement in 1976.

1961 - Her father dies in his 90th year. 1962 Her mother dies.

1963 - Buys a house – "Dot's Spot" – at 6 Meriwa St. Puts down roots? Not likely!

1966 - First long service leave. Visits Eva and me in the wild of the East Sepik District, New Guinea.

1974 - Second long service leave. Overseas world tour, by ship (the Marconi) to Greece, then with a Eurail Pass through Europe and Scandinavia, ending up in London, visiting friends not seen for 19 years.

1975 - Her richly-deserved retirement. Embroidery and afternoon telly? Again, not likely.

1976 - Globetrotting again for seven months. Norwegian cargo/passenger ship to SE Asia, Japan and Vancouver. Bus through the Rockies to Edmonton to visit her goddaughter and family, then by train to Ottawa, Niagara and New York. Flew to London, spent July with rellies in Scandinavia, August and September in UK with a short diversion to south of France to visit her best buddy.

May 1979 - Long range expedition to Beverley Springs Station, E Kimberley. 1983 N Qld safari to Cape York Peninsula. 1984 WA Nats club expedition to Prince Regent and Hunter Rivers. 1981 Tour of China with another best buddy. Easter 1987 WA Nats Club trip to the Abrolhos Island.

Doris Johnson had wonderful supportive neighbours. She was devoted to the Naturalists' Club and frequently talked about the comradeship and intellectual stimulation she derived from her long association with them over the years.

The following tribute was written by Kevin Coate

Doris Johnston was a long time member and stalwart of the Naturalists' Club, and one of those wonderful people from the older generation who in this modern age still retained old world values and kept up appearances no matter what. She had that happy knack, be it pottering around the garden, bush walking or just sitting at an office desk, of appearing neat and tidy with scarcely a hair out of place. Doris had a good sense of humour and was one of the hardy group of Naturalists' Club members, who embarked on a voyage of discovery along the Kimberley Coast in 1984. It was a trip she enjoyed immensely, and one which she often liked to recall when in company.

While based in Prince Frederick Harbour, having retraced Phillip Parker King's 1820 trip by whale boat to the upper reaches of the Hunter River, we went ashore near the confluence of the tidal section into the fresh water, to explore further upstream on foot. The tide dropped dramatically baring muddy banks while we were away, and the dinghies had to be relocated to the base of a large rock projecting out from the bank of the river in order to

board. It was a difficult spot to embark as it was fairly muddy and there was a drop of about six metres to the boat that could be negotiated with care. The dinghy nosed into the rock and Doris was first to clamber down to get aboard. In the process her foot slipped on a piece of mud clinging to the top of the rock.

Many of those there at the time, still talk in awe of how Doris appeared to bounce about three times on her bottom, picking up speed as she progressed down the rock. Luckily she landed on the covered in section of the bow of the dinghy, from where her momentum and the uplift of the dinghy propelled her to a sitting position facing forward in the back seat of the boat. Not having lost her composure for a moment, the instant she made contact with the seat, she produced a compact from her top pocket and adjusted her makeup. Some swear to this day, she had it out before landing.

The following tribute was written by Margo Bentley

At the meetings of the Retired and Leisured Group, Doris always welcomed us with great warmth and brought us all together in a very close friendship. One had to only miss a single meeting to receive a phone call from her to enquire if all was well. She maintained many contacts with members unable to come to meetings and brought their news to us.

She had made many trips with the Club and had travelled overseas and she had a deep interest and joy in hearing at our meetings about other member's travels and adventures, including the Long Range Excursions.

As a devoted gardener, both she and all of us were fascinated when members brought in and spoke about their wildflower amd garden specimens or their photographs pf them.

Music and the arts were very much to her taste and discussions about them enriched the time we spent together and we went to a number of exhibitions at the Museum, Art Gallery and State Library, including one on French exploration and another was the Ellis Rowan exhibition.

Our meetings have been a real pleasure due to Doris' interest in and love of the Group. We all have happy memories of them and of her.

CLUB NEWS

Programme

General Meetings and Branch Meetings are held at various venues in Nedlands, Kalamunda, Rockingham and North Beach.
The Retired and Leisured Group meets on alternate Wednesdays at 10a.m.
Excursions and field days are planned from time to time and will be advertised in the Club's monthly newsletter "The Naturalist News".

THE WESTERN AUSTRALIAN NATURALIST
(Journal of the W.A. Naturalists' Club)

Editor
MR JOHN DELL

The Western Australian Naturalist publishes original data on all branches of natural science pertaining to Western Australia. Originals and two copies of manuscripts should be submitted to the Editor for review by two referees. Authors are requested to follow current editorial style. If possible, manuscripts should be submitted on an IBM compatible 3½ disk in Word format. High quality illustrations suitable for some reductions in size are preferred.

DONATIONS TO THE CLUB

Members are reminded that they may make financial contributions to the club. This funding is very important from the Club's point of view, as it helps our publication activities, field station maintenance and other miscellaneous activities. Members are asked to remember the club and its needs when preparing their Wills and Testaments.

SUBSCRIPTIONS

Annual Membership: one adult, $60; Double Membership: $75; Family Membership: $65; Young members (6–17 years): $30. All Subscriptions include "The Western Australian Naturalist".
Further copies of "The Western Australian Naturalist" (or back copies) are available from the Treasurer.

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