

# The mammals of Cape Range peninsula, north-western Australia

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## Abstract

Since the mammal material from the cave deposits of Cape Range was last studied two decades ago, the results of two collections of modern mammals, archaeological excavations in rock shelters in the western terraces and mammal remains collected as a by-product of surveys of the Cape Range cave invertebrates, have become available. The taxonomy of several mammal species has also been revised during that time, providing solutions to a number of outstanding problems of identification. The new material almost doubles the number of mammal species recorded from the peninsula to 49, comprising 38 native ground mammals, five bats and six introduced species.

Much of the small mammal material was probably accumulated by owls, some medium-sized species used the caves as shelters and their bones were probably contributed directly, and large mammal remains were accumulated by pitfall.

The original (i.e. immediately pre-European) mammal fauna of the peninsula consisted of the echidna, 12 or 13 dasyurids, three bandicoots, one rat-kangaroo, two kangaroos, one rock-wallaby, a possum, five bats, 13 rats and mice and the Dingo. The numbers of caves from which species are recorded are generally consistent with known habitat preferences in indicating whether the marsupials originally occurred in the range or on the surrounding plains. For example, remains of the hill kangaroo *Macropus robustus* are common in caves, whereas the plains kangaroo *M. rufus* is not recorded from any caves but has been collected on the plains on both the eastern and western sides of the peninsula. Speculative assignment of the other non-volant mammals suggests a total of 17 species originally inhabited the range and 22 originally occurred on the plains, with three species common to both. No species filling a probable plains wallaby niche is currently recorded.

Biogeographically, the Cape Range peninsula mammal fauna is composed principally of species that were originally widely distributed across the arid zone. There is a small component of northern species, for which the peninsula represents a western range limit, and a few north-western endemics. A southern element is lacking from the fauna, and no currently recognized mammal species is restricted to the peninsula.

The mammal fauna of Barrow Island is a subset of the Cape Range peninsula fauna. Once thought to be fully representative of the adjacent mainland, the Barrow Island fauna is shown to be restricted, lacking the vast majority of regional small mammals.

At least half of the original Cape Range peninsula mammal fauna appears to have become extinct since European colonization of Australia. The Central Rock-rat, of which no living population is known, is more abundant in the cave deposits in Cape Range than anywhere else in its original distribution, suggesting that the Range may have provided particularly favourable habitat. It is possible that it still survives there. A survey of the vertebrates of Cape Range should be a high priority.

## Introduction

The colonization of Australia by Europeans has been followed by the extinction of most or all populations of a substantial proportion of the native mammal fauna. This has been particularly severe in the arid zone and has occurred almost equally in areas which have and

have not been subjected to pastoral exploitation. Most native non-volant species intermediate in weight between mice and kangaroos have become either locally or totally extinct in most of the mainland arid zone (e.g. Baynes 1984, Morton and Baynes 1985, Burbidge and McKenzie 1989, Baynes and Baird 1992). As a result, remains on the surfaces of cave deposits have become a very important source of information on original (i.e. immediately pre-European) mammal faunas.

As a major karst area, Cape Range contains a large number of caves, ranging in form from sink holes to open rock shelters. Some contain substantial accumulations of bones. Mammal remains have been collected by cave explorers since 1962 and donated to the Western Australian Museum. Kendrick and Porter (1974) reported on material received up to 1968. They recorded 29 mammal taxa from the deposits, 26 native and three introduced. Of the native taxa, two were only tentatively identified to species level, six were not identified below generic level and one was of uncertain genus.

Subsequently, archaeological investigations of rock shelters in the western limestone terraces of the peninsula have been carried out by Morse (1988, this volume), and a substantial project to investigate the invertebrate fauna of the Cape Range caves has been initiated by W.F. Humphreys (e.g. Humphreys this volume). It is the mammal specimens collected from caves as a byproduct of the Humphreys project, together with mammal remains from the Morse excavations identified by one of us (A.B.), which provide the materials for this study.

### Systematics

In the two decades since Kendrick and Porter carried out their study, the taxonomy of a substantial proportion of Cape Range peninsula mammals has been revised. One new genus (*Ningaui*) and three new species (*N. timealeyi*, *Sminthopsis youngsoni*, and *Pseudomys chapmani*) have been described; *Sminthopsis ooldea* has been raised from subspecies to full species level; the generic assignment of several species has been reorganized; and altered species concepts have resulted in two further name changes. Most of these variations are summarized in Walton (1988), but the nomenclature used here differs in the case of five names.

Mahoney and Ride (1988) reduced *Dasykaluta* and *Pseudantechninus* to synonymy with *Parantechninus*. However, the phylogenetic study by Kitchener and Caputi (1988) indicated that *Pseudantechninus* differs from *Parantechninus* at the generic level. *Dasykaluta* differs from these two genera by as great a distance as they differ from each other. *Pseudantechninus* and *Dasykaluta* are therefore treated as full genera in this paper.

In a recent study, Kerle *et al.* (1991) concluded that the northern populations of *Trichosurus*, regarded since 1970 as a separate species, *T. arnhemensis*, differ at only the subspecific level from the *T. vulpecula* populations occurring throughout most of the rest of the continent.

The taxonomic revision of the genus *Eptesicus* by Kitchener *et al.* (1987) was not published in time for its conclusions to be included in the taxonomic survey of the Vespertilionidae by Mahoney and Walton (1988), who were nevertheless aware of the need for revision in many of the genera in this family. The Cape Range peninsula populations of *E. finlaysoni* are a case in point, belonging to one of the previously unnamed species revealed by that study.

Synonymy of *Pseudomys praeconis* with *P. fieldi* follows the opinion of Baynes (e.g. 1990); although full supporting data are still lacking.

### Materials and Methods

All cave mammal fossils reported upon by Kendrick and Porter (1974) have been located, and their identifications checked, except the *Ovis aries* specimen whose identification is assumed to be correct. Fieldwork directed by W.F. Humphreys from 1987 through 1992 has produced substantial further material from many additional caves in Cape Range, all of which has been included in this study. A full list of the fossil material is given in Appendix I. Most specimens have been collected on an opportunistic basis, introducing major bias towards specimens of the larger species whose remains are more noticeable. In only two cases were small bulk samples obtained. It has not therefore been possible to quantify species simply by counting individuals. A simple, though still biased, measure of relative abundance was obtained by counting the number of caves from which a species had been recorded. These results are shown in Table 1 below.

Further mammal material became available as a product of archaeological excavations carried out in limestone caves in the western limestone terraces of the peninsula by K. Morse (1988, and this volume). Although sparse, it contributes to understanding of the Quaternary history of the area because it originates from radiocarbon dated profiles and includes at least one additional species of biogeographic significance.

Records of modern (i.e. live-caught) mammals were provided from the W.A. Museum mammal collection data base. Specimen identifications were only checked in cases where they represented species not recorded from the cave deposits, e.g. the *Macropus rufus*, or where problems were apparent, e.g. specimens of *Eptesicus* still listed under names that indicated that they had not been included in the study by Kitchener *et al.* (1987). The accession numbers of the modern specimens from Cape Range peninsula are included in Appendix I.

All identifications were made by comparison with specimens in the modern mammal or vertebrate palaeontological collections of the Western Australian Museum. Modern specimens were used wherever possible.

### Results

Out of the roughly 350 Cape Range karst features investigated by the end of the 1992 field season, 46 had yielded mammal bones. Bone material has only been collected systematically from the earliest known caves (with the lowest karst feature registration [C-] numbers). Collection of bone from more recently discovered caves has depended more upon chance observations, or the particular investigator, than the presence of bone in the site.

Table 1 lists all the mammal species recorded from Cape Range peninsula. The number of cave deposits from which each species has been recorded as surface material is given, and modern records from the peninsula are also indicated. Three of the species which are recorded from many cave sites, *Isoodon auratus*, *Rattus tunneyi* and *Zyomys pedunculatus*, also have high relative abundance in the small bulk samples from caves C-4 and C-207, supporting the validity of that measure of abundance. Details of source caves for mammal fossils and accession numbers of these and the modern material are catalogued by species in Appendix I, and mammal species lists for each cave are provided in Appendix II. The modern mammal fauna of Barrow Island is also given in Table 1 for comparison. This is based upon Butler (1970), with the addition of the *Planigale maculata* obtained by Butler and Smith in 1973.

The new material from Cape Range caves, and specimens added to the modern mammal collection, identified in the light of the taxonomic advances noted in the Systematics section,

**Table 1.** The mammal faunas of the Cape Range peninsula and Barrow Island. The numbers of caves from which remains of each species have been obtained are shown in the "Cave" column. Modern = live caught / observed. X = recorded, - = not recorded. The number in brackets indicates the species is restricted to Pleistocene levels.

Species	Cape		Barrow I.
	Cave	Modern	
<i>Tachyglossus aculeatus</i> (Short-beaked Echidna)	1	X	-
<i>Thylacinus cynocephalus</i> (Thylacine)	2	-	-
<i>Antechinomys laniger</i> (Kultarr)	1	-	-
<i>Dasyercus cristicauda</i> (Mulgara)	2	-	-
<i>Dasykaluta rosamondae</i> (Little Red Antechinus)	2	X	-
<i>Dasyurus geoffroyi</i> (Western Quoll)	1	-	-
<i>Dasyurus hallucatus</i> (Northern Quoll)	12	-	-
<i>Ningauia timealeyi</i> (Pilbara Ningauia)	-	X	-
<i>Phascogale calura</i> (Red-tailed Phascogale)	3	-	-
<i>Planigale maculata</i> (Common Planigale)	3	X	X
<i>Pseudantechinus macdonnellensis</i> (Fat-tailed Antechinus)	6	X	X
<i>Sminthopsis longicaudata</i> (Long-tailed Dunnart)	7	-	-
<i>Sminthopsis macroura</i> (Stripe-faced Dunnart)	2	X	-
<i>Sminthopsis ooldea</i> (Ooldea Dunnart) ?	1	-	-
<i>Sminthopsis youngsoni</i> (Lesser Hairy-footed Dunnart)	1	-	-
<i>Isodon auratus</i> (Golden Bandicoot)	18	-	-
<i>Perameles</i> sp. cf. <i>P. bougainville</i> (Western Barred Bandicoot)	1	-	-
<i>Macrotis lagotis</i> (Bilby, or rabbit-eared bandicoot)	2	-	-
<i>Bettongia lesueur</i> (Burrowing Bettong)	2	-	X
<i>Lagorchestes conspicillatus</i> (Spectacled Hare-wallaby)	-	-	X
<i>Macropus agilis</i> (Agile Wallaby)	(1)	-	-
<i>Macropus robustus</i> (Common Wallaroo, or euro)	8	X	X
<i>Macropus rufus</i> (Red Kangaroo)	-	X	-
<i>Petrogale lateralis</i> (Black-footed Rock-Wallaby)	21	-	X
<i>Trichosurus vulpecula</i> (Common Brushtail Possum)	11	-	X
<i>Pteropus scapulatus</i> (Little Red Flying-fox)	-	X	-
<i>Taphozous georgianus</i> (Common Sheathtail-bat)	-	X	X
<i>Chalinolobus gouldii</i> (Gould's Wattled Bat)	-	X	-
<i>Eptesicus finlaysoni</i> (Finlayson's Eptesicus)	1	X	X
<i>Nyctinomys australis</i> (White-striped Mastiff-bat)	-	X	X
<i>Hydromys chrysogaster</i> (Water-rat)	-	-	X
<i>Leggadina forresti</i> (Forrest's Mouse)	1	-	-
<i>Leporillus apicalis</i> (Lesser Sticknest-rat)	6	-	-
<i>Mesembriomys macrurus</i> (Golden-backed Tree-rat)	5	-	-
<i>Mus musculus</i> (House Mouse)	3	X	-
<i>Notomys alexis</i> (Spinifex Hopping-mouse)	9	X	-
<i>Notomys amplius</i> (Short-tailed Hopping-mouse)	6	-	-
<i>Notomys longicaudatus</i> (Long-tailed Hopping-mouse)	8	-	-
<i>Pseudomys chapmani</i> (Pebble-mound Mouse)	1	-	-
<i>Pseudomys desertor</i> (Desert Mouse)	5	-	-
<i>Pseudomys fieldi</i> (Alice Springs Mouse)	7	-	-
<i>Pseudomys hermannsburgensis</i> (Sandy Inland Mouse)	6	X	-
<i>Pseudomys nanus</i> (Western Chestnut Mouse)	7	-	X
<i>Rattus rattus</i> (Black Rat)	2	-	-
<i>Rattus tunneyi</i> (Pale Field-rat)	18	-	-
<i>Zyzomys argurus</i> (Common Rock-rat)	-	-	X
<i>Zyzomys pedunculatus</i> (Central Rock-rat)	12	-	-

Table 1. (cont.)

Species	Cape		Barrow I.
	Cave	Modern	
<i>Canis familiaris</i> (Dingo)	7	-	-
<i>Vulpes vulpes</i> (Fox)	2	-	-
<i>Felis catus</i> (Cat)	1	-	-
<i>Capra hircus</i> (Goat)	1	-	-
<i>Ovis aries</i> (Sheep)	1	-	-

have enabled us to better define the ranges of morphological variation in the local populations and resolve most of the problems of identification recognized by Kendrick and Porter (1974). Their “*Planigale* sp. or *Sminthopsis* sp.” material from cave C-19 (specimens 71.6.56 and 71.6.57) is identified as *Planigale maculata*. The specimen from cave C-6 (68.7.73) listed as “*Sminthopsis* sp.” is here referred to *S. longicaudata*. The *Perameles* specimen (66.4.17), which is still unique, is tentatively assigned to *P. bougainville*. The *Isoodon* are identified as *I. auratus*. All specimens of *Petrogale* that retain diagnostic characters (the majority of a large sample) are identifiable as *P. lateralis*, and in presenting the results in Table 1 the assumption is made that all *Petrogale* material from the Cape Range caves is that species. (However, in Appendix I the level of identification is differentiated.) The single tooth (68.7.102) from cave C-6, tentatively referred to *Potorous platyops*, is here reidentified as almost certainly a small last lower molar of *Trichosurus vulpecula*.

Kendrick and Porter (1974) reported a single maxilla (71.10.197) from cave C-4 representing either *Notomys longicaudatus* or *N. amplius*. That particular specimen is here identified as *N. longicaudatus*, although recently collected material shows remains of both species to be present in the caves. The small species (“*Notomys* sp.”) is here identified as *N. alexis*. New material confirms the presence of *Pseudomys fieldi*, including specimens 71.6.92 from cave C-19 and 71.6.144 from C-21, which, on the basis of a tentative identification by A. Baynes, were listed by Kendrick and Porter (1974) as “*Pseudomys ?praeconis*”, the then-current name of the taxon (see Systematics section above).

Compared to the fauna listed by Kendrick and Porter (1974), an additional 16 species of mammals are now known from the Cape Range cave deposits. Of these, *Sminthopsis ooldea* is only tentatively identified, *Macropus agilis* is restricted to Pleistocene sediments and three of the species are introduced. Modern material adds a further two ground mammals, *Ningaui timealeyi* and *Macropus rufus*, and four bats to the fauna recorded from the Cape Range peninsula, for a total of 49 species comprising 38 native ground mammals, six introduced ground mammals and five species of bats (all native).

### Taphonomy

#### Agents of accumulation of mammal remains

Cape Range peninsula caves which have yielded mammal bone material vary from open shelters to deep sink holes. Among this range will have been suitable shelters for a variety of animals, including both mammal predators and mammals which themselves used the caves as dens.

No species of mammal was a true member of the cave fauna, spending its entire life there.

On the other hand suitable caves probably provided vital shelter from conditions beyond the physiological tolerance of several species, including rock-wallabies and all the microchiropteran bats.

Nearly all of the material of smaller mammals, ranging in size up to the bandicoots and *Dasyurus hallucatus*, consists of unbroken but mainly dissociated bones. This is consistent with owls, probably *Tyto alba*, being the principal accumulating agents of mammals in this size range. The main exception to this generalization is *Rattus rattus*, collected specimens of which usually consist of either intact skulls or complete skeletons. This is probably because the *R. rattus* used the caves as shelters and died there. As such this species is comparable to *Petrogale lateralis* and *Trichosurus vulpecula*, medium-sized species whose remains are relatively abundant in the Cape Range caves (Table 1) and often consist of fairly complete skulls suggesting that they died in the caves which they used as shelters.

Some caves, mainly the sink holes, will have acted as pitfall traps, particularly for the largest species such as *Macropus robustus* which have been unable to climb up the walls to escape.

### Age of mammal remains

Only in the case of the mammal remains from the archaeological excavation in Mandu Mandu Creek rockshelter, is there direct evidence, in the form of radiocarbon dates, on the age of the mammal material from the Cape Range caves. All the other specimens considered in this study are from the surface of deposits and have no stratigraphic context and no dates. However, the absence of *Mus musculus* from most of the samples suggests that they predate severe local effects of European colonization: i.e. they may be considered representative of the original fauna.

As discussed by Kendrick and Porter (1974), the thylacine specimens from Monajee Cave (C-21) originated from deposits whose lithology indicated considerable age in at least one case. Since their 'lithified "cave earth"' contained remains of both *Thylacinus* and *Canis* it probably accumulated around or after 3,500 years BP, the currently accepted date of replacement of *Thylacinus* by *Canis* on the Australian mainland (Milham and Thompson 1976). The thylacine calcaneum found in the 'unlithified "cave earth"' may have been derived from the lithified deposit (Kendrick and Porter 1974).

The sediments began to accumulate in Mandu Mandu Creek rock shelter at least 30,000 years ago (Morse this volume). The *Thylacinus cynocephalus* and *Macropus agilis* specimens were found in the lowest spit, and are mineralized. They could be as little as 30,000 years old, on the other hand they could have been lying on the cave floor for a very long time before sediment accumulation began. They are clearly Pleistocene in age, but it is not possible to date them more precisely at this stage.

## Discussion

### Mammal habitats

As noted above, use of the caves by mammals was confined to shelter, and no species was restricted to caves as a habitat.

Payne *et al.* (1988) distinguished five land systems, each divided into several units, on Cape Range peninsula. Keighery and Gibson (this volume) find that floristic patterns occur on a much finer scale than the land system units. On the other hand, the state of knowledge of the

mammals is such that any attempt to allocate species to habitats can only be made at the crudest level.

The relative abundances of species (see Table 1) are generally consistent with habitat preference data from the literature in suggesting that range and plains species are distinguishable within the Cape Range peninsula mammal fauna. Range species would be expected to be more abundant in the cave deposits and/or present in more caves than the plains species. There would have been a greater number of opportunities for the remains of range species to be incorporated into caves either because they climbed or fell into them as live animals, or because they occurred close to a predator's shelter. Species that remained strictly in the plains would have no opportunity to fall into a cave and would be beyond the hunting range of predators using most of the caves as shelters. In interpreting the relative abundance data used here it is necessary to also take into account biases introduced by predators and collectors. Small dasyurid remains are usually several times less abundant than those of rodents in cave deposits in arid areas (e.g. Smith 1977, Baynes 1984, Copley *et al.* 1989, Baynes and Baird 1992). This probably does not truly reflect the long term proportions in the communities from which the prey are drawn, but rather, a bias introduced by the owl predators which are nomadic (Schodde and Mason 1980) — being present at times of high rodent populations but typically absent during droughts when rodent numbers probably fall to a greater extent than those of dasyurids. For example, in Uluru National Park rodent numbers

**Table 2.** Estimated original distribution of the native ground mammals between range and plains habitats on Cape Range peninsula. Species are paired as approximate ecological equivalents. § indicates that a species is allocated to habitat type on the basis of habitat data with modern specimens from Cape Range peninsula or observations of living animals on the peninsula.

Range	Plains
<i>Tachyglossus aculeatus</i> §	<i>Tachyglossus aculeatus</i> §
<i>Dasyurus hallucatus</i>	<i>Dasyurus geoffroi</i>
<i>Phascogale calura</i>	<i>Dasyercus cristicauda</i>
<i>Pseudantechinus macdonnellensis</i> §	<i>Dasykaluta rosamondae</i> §
<i>Planigale maculata</i> §	<i>Ningau timealeyi</i> §
<i>Sminthopsis longicauda</i>	<i>Antechinomys laniger</i>
<i>Sminthopsis macroura</i> §	<i>Sminthopsis youngsoni</i>
•	<i>Sminthopsis ooldea</i>
<i>Isodon auratus</i>	<i>Perameles</i> sp.
•	<i>Macrotis lagotis</i>
<i>Macropus robustus</i> §	<i>Macropus rufus</i> §
<i>Petrogale lateralis</i> §	•
<i>Trichosurus vulpecula</i>	<i>Bettongia lesueur</i>
<i>Mesembriomys macrurus</i>	<i>Notomys amplus</i>
<i>Leporillus apicalis</i>	<i>Notomys longicaudatus</i>
•	<i>Notomys alexis</i> §
•	<i>Leggadina forresti</i>
•	<i>Pseudomys chapmani</i>
•	<i>Pseudomys hermannsburgensis</i> §
<i>Pseudomys nanus</i>	<i>Pseudomys desertor</i>
•	<i>Pseudomys fieldi</i>
<i>Zyomys pedunculatus</i>	•
<i>Rattus tunneyi</i>	<i>Rattus tunneyi</i>
<i>Canis familiaris</i>	<i>Canis familiaris</i>

fluctuate violently compared to those of the dasyurids (Reid *et al.* 1991, 1993). Collector bias is generally related to size: bones of medium to large-sized species are more often noticed and collected by non-specialists than the minute jaws of small dasyurids and rodents.

Table 2 shows the general habitat type in which members of the Cape Range peninsula mammal fauna are inferred to have occurred, or have been recorded on the basis of modern specimens. For the purpose of this exercise, the "range" habitat is restricted to the Range Land System of Payne *et al.* (1988) and the "plains" habitat includes their other four systems. The range habitat thus comprises the limestone plateaux, gorges and escarpments, upper and lower slopes and creek lines and drainage basins of Cape Range and the western limestone terraces of the peninsula. The plains habitat comprises the mainly sandy plains and linear dune fields of the Cardabia Land System, principally to the south of Cape Range; the outwash plains of the Learmonth Land System on the eastern and western margins of Cape Range; and the coastal dunes, swales and plains of the Coast Land System on the west coast and Littoral Land System on the east coast. This division generally corresponds to rocky and stony substrates in the range habitat and sandy or loam substrates in the plains habitat. The main exception to this is the stony footslopes of the ranges which, as Unit 1 of the Learmonth Land System, are here treated as part of the plains habitat. Future investigations may show that this unit is continuous with range habitat for mammals.

In general, habitat preferences of the marsupials are more clearly defined than those of the rodents. Thus, for example, *Dasyurus hallucatus* is recorded from a substantial number of caves, often being represented by several specimens, and is known to prefer rocky habitats (e.g. Begg p. 23 in Strahan 1983), while *D. geoffroii* is represented by a single cave specimen and is a generalist in habitat preference. Similarly, *Pseudantechinus macdonnellensis* and *Dasykaluta rosamondae*, *Planigale maculata* and *Ningau timealeyi* and *Macropus robustus* and *Macropus rufus* make complementary range and plains ecological pairs, in their cases supported by habitat data with modern specimens from the peninsula. Other pairings made in Table 2 equate less comfortably and/or represent situations with less information. *Phascogale calura* and *Dasyercus cristicauda* are only equivalent in being similar-sized small vertebrate and insect predators. *P. calura* is arboreal (e.g. Kitchener p. 36 in Strahan 1983) and, although only modestly represented in the cave deposits, probably occurred in the ranges where trees and tall shrubs principally grow (Payne *et al.* 1988), whereas *Dasyercus cristicauda* is restricted to friable substrates in which it can burrow (e.g. Woolley p. 26 in Strahan 1983) and is recorded from only two caves, so was almost certainly a member of the plains fauna. It is correspondingly difficult to find plains ecological equivalents of species which are highly adapted to rocky habitats such as *Sminthopsis longicaudata* and *Zyomys pedunculatus*.

For many of the other rodents there are few data on habitat preferences, and their cave relative abundances are equivocal. *Mesembriomys macrurus* is listed in Table 2 as having occurred in the ranges on the basis that it has relatively high abundance in the caves and is arboreal (e.g. McKenzie pp. 385-386 in Strahan 1983). *Notomys amplius* is equivalent only in having comparably broad incisors: the broadest among the plains rodents. Nothing is known of its natural history. *Leporillus apicalis* built stick nests in caves and overhangs of ranges (e.g. Robinson p. 425 in Strahan 1983), while *Notomys longicaudatus* was a species of open plains, preferring clay soils for its burrows (Dixon p. 435 in Strahan 1983). They have very similar-sized relatively narrow incisors, though rather different molars. *Notomys alexis* is a plains species with a preference for sandy substrates, though it is also found on loams (e.g.



Breed pp. 428-429 in Strahan 1983). Inclusion of *Leggadina forresti* in the plains fauna of Cape Range peninsula is consistent with it being represented by only a single cave specimen, and its preference for tussock grassland or low shrubland on loam, clay or stony soils (Morton p. 419 in Strahan 1983). *Pseudomys chapmani* is also represented by only a single cave deposit specimen, but it is one of the few rodents with clearly defined habitat requirements, being restricted to rises and slopes, particularly outwash fans, where small stones are sufficiently dense on the surface for it to construct its characteristic pebble mounds and the ground vegetation is composed of hummock grasses (Dunlop and Pound 1981). Its habitat on the Cape Range peninsula is likely to be the stony footslopes around the base of Cape Range. *Pseudomys hermannsburgensis* has similar habitat preferences to *Notomys alexis* (e.g. Breed p. 407 in Strahan 1983).

*Pseudomys nanus* and *Pseudomys desertor* are very probably ecological vicars: both have relatively broad incisors and strongly sloping cusps on their molar teeth indicating a similar diet, probably grasses. Their distributions are generally mutually exclusive, with *P. desertor* occurring in the deserts, including the Great Sandy Desert, and *P. nanus* in the grassy woodlands of wet-dry tropical northern Australia. However, remains of both species are found in the same cave deposits in north-western Australia, including the Cape and Hamersley Ranges. Ecological separation between them in this area is likely to have been by habitat. Unfortunately their abundances in the Cape Range cave deposits (Table 1) are similar and do not provide a clear indication of which species occurred where. Data with specimens in the modern mammal collection of the W.A. Museum show that *Pseudomys nanus* has been collected in Western Australia in a number of habitat types including hummock grasses on substrates ranging from clay through sand plain to boulder piles. *Pseudomys desertor* reaches high densities in mature *Triodia* on both desert sand dunes and loam swales during favourable seasons (Reid *et al.* 1991). On the balance of probabilities *P. nanus* appears more likely to have occurred in the range habitats and *P. desertor* on the plains, but the data are not clear cut for either this pair or the following species. The only habitat data for *Pseudomys fieldi* are derived from observations of the population that persists on Bernier Island in Shark Bay, where it is consistently found in thickly vegetated coastal dunes rather than the heath which occurs on the limestone platform that forms the bulk of the island. It appears more likely to have occurred in plains rather than range habitat on Cape Range peninsula, but its moderate abundance in cave deposits suggests it was not restricted to the distant coastal dunes. *Rattus tunneyi* has been recorded from a wide variety of habitats ranging from mobile coastal dunes to rocky hills. It is one of the most abundant species in the caves and probably occurred in both range and plains habitats.

In spite of the speculative nature of much of the habitat allocation, one missing point stands out as probably significant. There is no wallaby equivalent to *Petrogale lateralis* recorded for the plains habitats. A species of *Lagorchestes* is likely to have filled the niche. The question of which is considered in the biogeographic section below.

Cape Range caves could potentially provide the material for a large scale study leading to a much more precise inference of the original distribution of the mammal species between the available habitat types. Many more bulk samples of mammal remains originating from caves situated at variable distances from the main habitats would be needed. Such sites may eventually be found in the open rock shelters which have not so far received such detailed examination because they contain few of the cave invertebrates that have been the focus of the recent investigations.

## Biogeography

The biogeographic patterns of the mammals recorded from the Cape Range peninsula are entirely explicable in terms of the late Quaternary physiography and climate of north-western Australia. This would be expected for such comparatively large animals which cannot complete their entire life cycles within relatively uniform microclimates such as caves, but must always remain adapted to regional macroclimatic conditions in order to persist.

The patterns considered here are those that obtained immediately before there was any impact from European colonization of Australia. Cave deposit material has not only made a vital contribution to knowledge of these original faunas on the Cape Range peninsula, but also throughout the areas with which they are compared. For example, three out of the six larger rodents recorded from the Cape Range peninsula at the north-western extremity of the continent, *Leporillus apicalis*, *Notomys amplus* and *Zyzomys pedunculatus*, have never been collected as living animals in the state of Western Australia, and a fourth, *Notomys longicaudatus*, was collected at only a single locality. Yet cave material shows that all four originally occurred over huge ranges in the central and western arid zone — ranges from which they have probably entirely disappeared since the arrival of European man (e.g. Baynes 1984, Baynes and Baird 1992). It is unfortunate in the context of the biogeography of the Cape Range peninsula mammals, that the one area that has yielded very little in the way of mammal remains, in spite of the high number of caves present in the ranges, is the Pilbara.

Drawing upon the distributions published in Strahan (1983) modified in the light of cave material, both published and unpublished, modern records in the collections of the Western Australian Museum, and the taxonomic papers mentioned in the Systematics section, it is possible to divide the mammal fauna of the Cape Range peninsula into five groups:

1. Species generally widespread throughout most of Australia: *Tachyglossus aculeatus*, *Thylacinus cynocephalus* (formerly) and its replacement *Canis familiaris*, and *Trichosurus vulpecula*.
2. Species with extensive original distributions across the arid zone, but not recorded from the Pilbara: *Antechinomys laniger*, *Dasyurus geoffroii*, *Phascogale calura*, *Sminthopsis youngsoni*, *Perameles bougainville*, *Bettonia lesueur*, *Petrogale lateralis*, *Leggadina forresti*, *Leporillus apicalis*, *Notomys amplus*, *Pseudomys fieldi* and *Zyzomys pedunculatus*.
3. Species with extensive original distributions across the arid zone including the Pilbara: *Dasyarcus cristicauda*, *Pseudantechinus macdonnellensis*, *Sminthopsis longicaudata*, *S. macroura*, *S. ooldea*, *Isodon auratus*, *Macrotis lagotis*, *Macropus robustus*, *M. rufus*, *Taphozous georgianus*, *Chalinolobus gouldii*, *Eptesicus finlaysoni*, *Nyctinomys australis*, *Notomys alexis*, *N. longicaudatus*, *Pseudomys desertor*, *P. hermannsburgensis*, *P. nanus* and *Rattus tunneyi*.
4. Species with extensive distributions across northern Australia, including the Pilbara: *Dasyurus hallucatus*, *Planigale maculata*, *Pteropus scapulatus* and *Mesembriomys macrurus*. Another species with a similar northern distribution, *Macropus agilis*, is recorded from the base of Pleistocene levels in the Mandu Mandu Creek rockshelter deposit.
5. Species restricted to north-western Australia (defined as stretching from the eastern Pilbara to North West Cape): *Dasykaluta rosamondae*, *Ningaui timealeyi* and *Pseudomys chapmani*.

Placement within these groups does, of course, depend upon current taxonomic judgements.

For example, if a future revision of *Planigale* divides the northern populations now regarded as the one widespread species *P. maculata*, into separate species as in the *Pseudomys chapmani* group (Kitchener 1980, Kitchener and Humphreys 1986, 1987, Woinarski 1992), then the planigale taxon recorded from the Cape Range peninsula would move from Group 4 to Group 5. The lack of information about the original mammal fauna of the Pilbara is a particular problem in assigning species between Groups 3 and 4. Remains of *Bettongia lesueur* might yet be found in that region as there are valley flats which could have been suitable for it. Woodlands in some of the gorges might also have provided habitat for *Phascogale calura*.

The Cape Range peninsula does provide the most northerly records of *Leporillus apicalis*, *Pseudomys fieldi* and *Zyzomys pedunculatus*, but these are only by about 2° of latitude. A southern element is lacking from the mammal fauna, having reached its most northerly extremity at Shark Bay (e.g. Baynes 1990). There are no endemics and most of the fauna is composed of mammals that were originally widespread in the arid zone. More notably, Cape Range marked the south-western range limit of the northern forms *Dasyurus hallucatus* and *Planigale maculata* in precontact times and the probable western limit of *Macropus agilis* in the late Pleistocene.

The mammal groupings do not show strong patterns. Group 5 contains only plains species and the Cape Range representatives of the specialized rocky range adapted genera *Petrogale* and *Zyzomys* are the general arid zone species *P. lateralis* and *Z. pedunculatus* rather than the Pilbara species *P. rothschildi* and *Z. argurus*. On the other hand *Dasyurus hallucatus* and *Planigale maculata* are common to the original faunas of Cape Range and the Pilbara.

It was noted in the Mammal habitat section above that no species of plains wallaby had been recorded for Cape Range peninsula. An animal occupying the niche that uses hummock grass as a shelter is likely to have occurred there and would probably have been a species of *Lagorchestes*. It is much less simple to predict whether it would have been *L. hirsutus*, which would be a member of Group 2, or *L. conspicillatus*, which would be a member of Group 4. This currently unanswerable question will probably be resolved by future collection of material from a cave deposit or dune blow-out.

### Comparison of mammal faunas of Cape Range peninsula and Barrow Island

The mammal fauna of Barrow Island (Table 1) can be seen as basically a subset of the original fauna of Cape Range peninsula, which also suggests that the peninsula is an appropriate area of mainland for comparison. The island fauna includes species that probably preferred range and plains habitats on the peninsula (Table 2), in approximately even proportions. This is predictable: both Cape Range and the limestone platform of Barrow Island formed rocky islands surrounded by sandy plains at times of low sea level during Pleistocene glacials. With the rise of sea level the area of plains was reduced so that now limestone ridges form the most extensive substrate on the island (Butler 1970), but sand sheets and dunes are still major habitats.

The differences between the faunas are the presence on Barrow Island of *Lagorchestes conspicillatus* (which might also have been on the peninsula, see above) and *Hydromys chrysogaster*, and the substitution of *Zyzomys argurus* for *Z. pedunculatus*. It is possible that *H. chrysogaster* may yet be shown to be or have been present in the mangrove habitats fringing Exmouth Gulf. (Although *H. chrysogaster* is mapped by Olsen, pp. 367-368 in Strahan 1983, as extant all along the north-west coast, the only specimens from the area are

those from Barrow Island and one skull, W.A. Museum M6849, picked up on Depuch Island in 1961).

Main and Yadav (1971) developed an argument, based on the macropodoids, that Barrow Island is sufficiently diverse topographically to hold an almost complete isolate of the local coastal fauna and flora, and hence that any physiographically diverse reserve of about the same size on the mainland could be expected to retain a representative sample of regional fauna and flora without management. They were aware of the absence of *Macropus rufus*, but comparison with the much larger peninsula fauna revealed by this study suggests that the Barrow Island mammal fauna is actually far more restricted. It consists mainly of medium-sized species, several of which are members of other island faunas. Most are "K-strategists" in terms of classical island biogeographic theory. Clearly, the greatest differences are in the small mammals, with only two out of at least 12 dasyurids and only two out of 14 native rodents present on Barrow Island.

### Conservation

Invaluable though such reserves as Barrow Island are for the conservation of individual species, the conclusions above indicate that much larger areas than those of any Western Australian islands are needed for the maintenance of what remains of Australian mammal communities.

Estimates of the survival status of the original native ground mammals of the Cape Range

**Table 3.** Survival status of original native ground mammals of Cape Range peninsula.

EXTINCT	SURVIVING
<b>Totally</b>	<b>Possibly</b>
<i>Leporillus apicalis</i>	<i>Antechinomys laniger</i>
<i>Notomys amplus</i>	<i>Sminthopsis longicauda</i>
<i>Notomys longicaudatus</i>	<i>Sminthopsis ooldea</i>
Total 3	<i>Sminthopsis youngsoni</i>
	<i>Leggadina forresti</i>
<b>On mainland</b>	<i>Pseudomys desertor</i>
<i>Perameles bougainville</i>	<i>Pseudomys chapmani</i>
<i>Bettongia lesueur</i>	<i>Zyzomys pedunculatus</i>
<i>Pseudomys fieldi</i>	Total 8
Total 3	
<b>Locally</b>	<b>So far</b>
<i>Dasyercus cristicauda</i>	<i>Tachyglossus aculeatus</i>
<i>Dasyurus geoffroii</i>	<i>Dasykaluta rosamondae</i>
<i>Dasyurus hallucatus</i>	<i>Ningau timealeyi</i>
<i>Phascogale calura</i>	<i>Planigale maculata</i>
<i>Isodon auratus</i>	<i>Pseudantechinus macdonnellensis</i>
<i>Macrotis lagotis</i>	<i>Sminthopsis macroura</i>
<i>Trichosurus vulpecula</i>	<i>Macropus robustus</i>
<i>Mesembriomys macrurus</i>	<i>Macropus rufus</i>
<i>Pseudomys nanus</i>	<i>Petrogale lateralis</i>
<i>Rattus tunneyi</i>	<i>Notomys alexis</i>
<i>Canis familiaris</i>	<i>Pseudomys hermannsburgensis</i>
Total 11	Total 11
17-25	11-19

peninsula are given in Table 3. Many species are included in the "Extinct" column as much on the basis of a lack of survival throughout their original ranges as absence of a recent record from the area. Species placed in the "Surviving so far" group have been collected or observed on the peninsula in the last two decades. The "Possibly surviving" group is relatively large because no comprehensive survey of the living vertebrates of Cape Range has yet been made. *Zyzomys pedunculatus* is included in this group because the species appears to have been more abundant in Cape Range than anywhere else in its original distribution. Its great rarity as a live caught animal (e.g. Begg p. 390 in Strahan 1983), is consistent with the generally extremely low numbers of its remains found in cave deposits. If Cape Range does indeed provide particularly favourable habitat, it is possible that it has survived there. In which case, it would be the only known living population. A survey should be given a high priority.

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## Appendix I: specimen data for Cape Range peninsula mammals.

Bold C- numbers, e.g. **C-201**, are Cape Range karst feature numbers. Accession numbers are from the Western Australian Museum vertebrate palaeontological collection (e.g. 93.1.81) or modern mammal collection (e.g. M18140). Those prefixed by a question mark, e.g. ?69.7.417, indicate less certain identifications.

*Tachyglossus aculeatus* Cave: **C-201** 93.1.81, 93.1.82. Modern — observations of living animals: 1.8 km S. of Central Hill, 8 Aug 1987 (H. Tomlinson, M.R. East); near Trealla Hill, Aug 1988 (R.D. Brooks); 2 km E. of Central Hill, 10 Aug 1989 (R.D. Brooks, M.R. East and R.D. Wood); main road 4 km S. of Exmouth, winter 1991 (R.D. Brooks).

*Thylacinus cynocephalus* Cave: **C-21** 71.6.103, 71.6.137; **Mandu Mandu Creek rockshelter** basal level Morse excavation Square C1 (Morse this volume). Modern: - .

*Antechinomys laniger* Cave: **C-207** 93.1.84. Modern: - .

*Dasyercus cristicauda* Cave: **C-4** 87.12.6; **C-207** 93.1.85. Modern: - .

*Dasykaluta rosamondae* Cave: **C-4** 68.5.30(?locality); **C-119** 93.1.45. Modern: M18140, M18141.

*Dasyurus geoffroii* Cave: **C-200** 93.1.69. Modern: - .

*Dasyurus hallucatus* Cave: **C-4** 69.7.426-69.7.430, 87.12.1, 93.1.1, 93.1.2; **C-6** 68.7.70, 68.7.71; **C-19** 71.6.63, 71.6.64, 71.6.75; **C-21** 66.4.41, 66.4.60, 66.4.61, 71.6.118; **C-91** 93.1.39; **C-144** 93.1.58; **C-163** 93.1.62; **C-207** 93.1.86, 93.1.112, 93.1.199; **C-246** 93.1.129; **C-251** 93.1.135; **C-252** 93.1.147, 93.1.148; **C-402** 93.1.187. Modern: - .

*Ningau timealeyi* Cave: - . Modern: M18142-M18144.

*Phascogale calura* Cave: **C-4** 77.11.19, 77.11.20; **C-19** 71.6.62; **C-207** 93.1.87, 93.1.113. Modern: - .

*Planigale maculata* Cave: **C-4** 87.12.3; **C-19** 71.6.56, 71.6.57, 93.1.29; **C-231** 93.1.125; Modern: M8729.

*Pseudantechinus macdonnellensis* Cave: **C-4** 69.7.415a, 69.7.415b, 69.7.415c, 69.7.417a, 77.11.21-77.11.23, 87.12.2, 93.1.3; **C-6** 68.7.72, 68.7.82; **C-18** M34122; **C-19** 71.6.58, 71.6.59, 71.6.61; **C-21** 66.4.63; **C-119** 93.1.46. Modern: M18139.

*Sminthopsis longicaudata* Cave: **C-4** 69.7.417b, ?69.7.417c, 77.11.24-77.11.27, 87.12.4; **C-6** 68.7.73; **C-19** 71.6.60; **C-21** 66.4.64, 71.6.117; **C-163** 93.1.63; **C-207** 93.1.88, 93.1.200; **C-402** 93.1.188. Modern: - .

*Sminthopsis macroura* Cave: "Ningaloo Cave" M7960; **C-4** 93.1.4. Modern: M7159, M11215, M13876, M19670.

*Sminthopsis ooldea* Cave: **C-207** ?93.1.89. Modern: - .

*Sminthopsis youngsoni* Cave: **C-207** 93.1.90. Modern: - .

*Isodon auratus* Cave: **C-4** 68.5.29 (?locality), 69.7.420-69.7.425, 81.8.1, 87.12.5, 93.1.5-93.1.7; **C-6** 68.7.56-68.7.69; **C-19** 71.6.65-71.6.74; **C-21** 66.4.18-66.4.40, 66.4.42, 66.4.43, 66.4.62, 71.6.102, 71.6.104, 71.6.115, 71.6.116, 71.6.119-71.6.121, 71.6.129, 71.6.139, 71.6.140, 71.6.150; **C-119** 93.1.47-93.1.50; **C-144** 93.1.59, 93.1.60; **C-163** 93.1.64; **C-192** 93.1.67; **C-200** 93.1.70; **C-207** 93.1.92, 93.1.114; **C-213** 93.1.117; **C-248** 93.1.130; **C-251** 93.1.136, 93.1.137; **C-252** 93.1.149, 93.1.150; **C-256** 93.1.156; **C-299** 93.1.164; **C-310** 93.1.181; **C-402** 93.1.189; **unknown cave** 62.9.13, 62.9.17, 62.9.20, 93.1.210. Modern: - .

*Perameles* sp. cf. *P. bougainville* Cave: **C-21** 66.4.17. Modern: - .

*Macrotis lagotis* Cave: **C-200** 93.1.71; **C-207** 93.1.93. Modern: - .

*Bettongia lesueur* Cave: **C-21** 66.4.58; **C-207** 93.1.94. Sand dunes (pickup): M4372. Modern: - .

*Macropus agilis* Cave: **Mandu Mandu Creek rockshelter** basal level Morse excavation Square C1 (Morse this volume). Modern: - .

*Macropus robustus* Cave: **C-4** 69.7.760; **C-15** 93.1.27; **C-21** 66.4.72, 66.4.73a, 66.4.73b, 66.4.74-66.4.83, 66.4.77a-66.4.77c, 66.4.81a, 66.4.81b; **C-56** 93.1.31; **C-215** 93.1.120; **C-300** 93.1.172; **C-310** 93.1.182; **C-460** Padjari Manu (formerly Bunbury Cave) 62.9.3; **unknown cave** 62.9.9, 62.9.10, 68.7.53, 68.7.54. Modern: M3300, M3862, M3866, M3873, M3996, M4377, M5307, M6566, M6731, M19939.1, M19939.2, M19940-M19942.

*Macropus rufus* Cave: - . Learmonth airfield surface (pickup): 68.5.33. Modern: M24214.

*Macropus* sp. indet. (either *M. robustus* or *M. rufus*) Cave: **C-6** 68.7.101; **C-18** 93.1.28; **C-21** 68.7.108; **C-78** 93.1.38; **C-207** 93.1.115.

*Petrogale lateralis* (accession numbers of specimens identifiable as *Petrogale* but lacking specific diagnostic characters are bracketed) Cave: **C-4** 62.9.6, 62.9.7, (69.7.757), (69.7.758), 69.7.759, (69.7.761); **C-6** 68.7.89-68.7.100, 68.7.103-68.7.107; **C-7** 69.6.403; **C-19** 71.6.77-71.6.82, (71.6.83-71.6.86), 71.6.133-71.6.136; **C-21** (66.4.44), (66.4.45), 66.4.46-66.4.51, (66.4.52), 66.4.53, 66.4.54, (66.4.55-66.4.57), (71.6.105), (71.6.106), (71.6.122), (71.6.152); **C-78** 93.1.37; **C-91** (93.1.40); **C-103** 93.1.209; **C-113** 93.1.155; **C-126** (93.1.56); **C-135** 93.1.57; **C-169** (93.1.66); **C-198** 93.1.68; **C-207** 93.1.95, 93.1.110, 93.1.116; **C-215** (93.1.123), 93.1.124, 93.1.180; **C-252** (93.1.151); **C-280** 93.1.160; **C-299** 93.1.165; **C-300** 93.1.173-93.1.175; **C-312** 93.1.185, (93.1.186), (93.1.201); **C-402** 93.1.190; **unknown cave** 62.9.1, 62.9.16b, (62.9.22a-d), 62.9.22e,f, (93.1.208), (93.1.211). Modern: - .

*Trichosurus vulpecula* Cave: **C-4** 69.7.418, 87.12.7; **C-6** 68.7.85-68.7.88, (68.7.102); **C-19** 71.6.76; **C-21** 66.4.59, 71.6.141; **C-60** 93.1.32; **C-91** 93.1.41; **C-207** 93.1.96; **C-248** 93.1.131; **C-291** 93.1.161, 93.1.162, 93.1.163; **C-299** 93.1.166, 93.1.167; **C-402** 93.1.191; **unknown cave** 62.9.2, 62.9.15, 62.9.21, 68.5.28. Modern: - .

*Pteropus scapulatus* Cave: - . Modern: M4981, M4989.

*Taphozous georgianus* Cave (live caught): **C-96** M20914; **C-460** Padjari Manu (formerly Bunbury Cave) M7476; **unknown cave** M5148, M18146-M18149, M20940, M20964-M20966, M21040, M21042.

*Chalinolobus gouldii* Cave: - . Modern: M5040.1-M5040.4.

*Eptesicus finlaysoni* Cave: **C-200** 93.1.72. Cave (live caught): **C-460** Padjari Manu (formerly Bunbury Cave) M5147, M19370-M19384, M19773, M19774; **unnumbered cave 1** M14562; **unnumbered cave 2** M20933-M20936; **unnumbered cave 3** M20963, M21041. Modern: M5042, M5493, M8719-M8728, (M3234).

*Nyctinomus australis* Cave: - . Modern: M3233, M5037.1-M5037.3.

*Leggadina forresti* Cave: **C-207** 93.1.97. Modern: - .

*Leporillus apicalis* Cave: **C-4** 69.7.414, 71.10.203, 87.12.11; **C-200** 93.1.73; **C-207** 93.1.98; **C-251** 93.1.138; **C-299** 93.1.168; **C-402** 93.1.192; **unknown cave** 62.9.8b. Modern: - .

*Mesembriomys macrurus* Cave: **C-4** 69.7.431, 71.10.198, 87.12.15, 93.1.8; **C-6** 68.7.74; **C-21** 66.4.68, 71.6.126; **C-207** 93.1.99; **C-402** 93.1.193; **unknown cave** 62.9.19. Modern: - .

*Mus musculus* Cave: **C-200** 93.1.80; **C-231** 93.1.126; **unnumbered overhang** in mouth of Pilgonaman Gorge 93.1.202. Modern: e.g. M18132.

*Notomys alexis* Cave: **C-4** 71.6.112, 71.6.125, 71.6.147, 71.9.3, 71.10.202, 87.12.9, 93.1.9, 93.1.10; **C-19** 71.6.93; **C-119** 93.1.51; **C-200** 93.1.74, 93.1.75; **C-205** 93.1.83; **C-207** 93.1.100; **C-231** 93.1.127; **C-251** 93.1.139; **unnumbered overhang** in mouth of Pilgonaman Gorge 93.1.203. Modern: M5038.1-M5038.3, M5043.1-M5043.3, M5044, M5490, M8144, M18138, M24272.



- Notomys amplus* Cave: C-4 93.1.18; C-119 93.1.55; C-200 93.1.76; C-207 93.1.101; C-251 93.1.140; unnumbered overhang in mouth of Pilgonaman Gorge 93.1.204; unknown cave 93.1.212. Modern: - .
- Notomys longicaudatus* Cave: C-4 71.10.197, 87.12.10, 93.1.11; C-6 68.7.76; C-91 93.1.42; C-200 93.1.77; C-207 93.1.102; C-251 93.1.141; C-310 93.1.183; C-402 93.1.194. Modern: - .
- Pseudomys chapmani* Cave: C-207 93.1.103. Modern: - .
- Pseudomys desertor* Cave: C-4 71.9.1, 87.12.12, 93.1.12-93.1.14; C-19 71.6.91, 71.10.200; C-21 71.5.71, 71.6.145, 71.6.153; C-207 93.1.104; unnumbered overhang in mouth of Pilgonaman Gorge 93.1.205; unknown cave 93.1.213. Modern: - .
- Pseudomys fieldi* Cave: C-4 93.1.17; C-19 71.6.92; C-21 71.6.144; C-207 93.1.105; C-251 93.1.142; C-252 93.1.152; unnumbered overhang in mouth of Pilgonaman Gorge 93.1.206. Modern: - .
- Pseudomys hermannsburgensis* Cave: C-4 71.9.2, 87.12.13; C-19 71.6.94, 71.6.95; C-21 71.6.127, 71.6.138, 71.6.146; C-200 93.1.78, C-207 93.1.106; C-231 93.1.128. Modern: M3754, M7752-M7754, M18136, M18137, M24275, M24381.
- Pseudomys nanus* Cave: C-4 71.10.204, 87.12.14, 93.1.15, 93.1.16; C-19 71.6.93; C-21 71.6.111, 71.6.113, 71.6.157, 71.10.199; C-207 93.1.107; C-215 93.1.121; C-251 93.1.143; unknown cave 62.9.14, 71.9.4. Modern: - .
- Rattus rattus* Cave: C-6 68.7.81; C-60 93.1.33-93.1.36; unknown cave 71.6.44. Modern: - .
- Rattus tunneyi* Cave: C-4 69.7.412, 71.10.205, 81.8.2, 87.12.17, 93.1.19-93.1.21; C-6 68.7.75, 68.7.7-68.7.80; C-19 71.6.88, 71.6.96; C-21 71.6.109, 71.6.123, 71.6.130, 71.6.142, 71.6.155, 93.1.30; C-91 93.1.43; C-119 93.1.52; C-163 93.1.65; C-200 93.1.79; C-207 93.1.108; C-213 93.1.118; C-215 93.1.122; C-248 93.1.132; C-251 93.1.144, 93.1.145; C-252 93.1.153; C-266 93.1.159; C-299 93.1.169; C-402 93.1.195; unnumbered overhang in mouth of Pilgonaman Gorge 93.1.207; unknown cave 62.9.8, 62.9.14, 62.9.18, 62.9.20. Modern: - .
- Zyzomys pedunculatus* Cave: C-4 68.5.31(?locality), 69.7.411, 71.10.206, 71.10.207, 87.12.16, 93.1.22-93.1.26; C-19 71.6.89, 71.6.90; C-21 66.4.67, 66.4.69, 71.6.110, 71.6.124, 71.6.143, 74.5.27; C-119 93.1.53, 93.1.54; C-207 93.1.109; C-213 93.1.119; C-248 93.1.133; C-251 93.1.146; C-252 93.1.154; C-299 93.1.170, 93.1.171; C-310 93.1.184; C-402 93.1.196; unknown cave 62.9.18, 93.1.214. Modern: - .
- Canis familiaris* Cave: C-4 62.9.5; C-19 71.6.98; C-21 66.4.84, 67.7.2; C-113 93.1.44; C-215 93.1.158; C-256 93.1.157; C-300 93.1.176. Modern: - .
- Vulpes vulpes* Cave: C-300 93.1.177, 93.1.178; C-452 93.1.198. Modern: - .
- Felis catus* Cave: C-452 93.1.197; Modern: - .
- Capra hircus* Cave: C-300 93.1.179. Modern: - .
- Ovis aries* Cave: C-21 Kendrick and Porter (1974); Modern: - .

#### Appendix II: mammal species recorded from each cave.

- C-4 *Dasyercus cristicauda*, *Dasykaluta rosamondae*, *Dasyurus hallucatus*, *Phascogale calura*, *Planigale maculata*, *Pseudantechinus macdonnellensis*, *Sminthopsis longicaudata*, *Sminthopsis macroura*, *Isodon auratus*, *Macropus robustus*, *Petrogale lateralis*, *Trichosurus vulpecula*, *Leporillus apicalis*, *Mesembriomys macrurus*, *Notomys alexis*, *Notomys amplus*, *Notomys longicaudatus*, *Pseudomys desertor*, *Pseudomys fieldi*, *Pseudomys hermannsburgensis*, *Pseudomys nanus*, *Rattus tunneyi*, *Zyzomys pedunculatus*, *Canis familiaris*.

- C-6 *Dasyurus hallucatus*, *Pseudantechinus macdonnellensis*, *Sminthopsis longicaudata*, *Isoodon auratus*, *Macropus* sp. indet. (either *M. robustus* or *M. rufus*), *Petrogale lateralis*, *Trichosurus vulpecula*, *Mesembriomys macrurus*, *Notomys longicaudatus*, *Rattus rattus*, *Rattus tunneyi*.
- C-7 *Petrogale lateralis*.
- C-15 *Macropus robustus*.
- C-18 *Pseudantechinus macdonnellensis*, *Macropus* sp. indet. (either *M. robustus* or *M. rufus*).
- C-19 *Dasyurus hallucatus*, *Phascogale calura*, *Planigale maculata*, *Pseudantechinus macdonnellensis*, *Sminthopsis longicaudata*, *Isoodon auratus*, *Petrogale lateralis*, *Trichosurus vulpecula*, *Notomys alexis*, *Pseudomys desertor*, *Pseudomys fieldi*, *Pseudomys hermannsburgensis*, *Pseudomys nanus*, *Rattus tunneyi*, *Zyomys pedunculatus*, *Canis familiaris*.
- C-21 *Thylacinus cynocephalus*, *Dasyurus hallucatus*, *Pseudantechinus macdonnellensis*, *Sminthopsis longicaudata*, *Isoodon auratus*, *Perameles* sp. cf. *P. bougainville*, *Bettongia lesueur*, *Macropus robustus*, *Macropus* sp. indet. (either *M. robustus* or *M. rufus*), *Petrogale lateralis*, *Trichosurus vulpecula*, *Mesembriomys macrurus*, *Pseudomys desertor*, *Pseudomys fieldi*, *Pseudomys hermannsburgensis*, *Pseudomys nanus*, *Rattus tunneyi*, *Zyomys pedunculatus*, *Canis familiaris*, *Ovis aries*.
- C-56 *Macropus robustus*.
- C-60 *Trichosurus vulpecula*, *Rattus rattus*.
- C-78 *Petrogale lateralis*, *Macropus* sp. indet. (either *M. robustus* or *M. rufus*).
- C-91 *Dasyurus hallucatus*, *Petrogale lateralis*, *Trichosurus vulpecula*, *Notomys longicaudatus*, *Rattus tunneyi*.
- C-96 *Taphozous georgianus*.
- C-103 *Petrogale lateralis*.
- C-113 *Petrogale lateralis*, *Canis familiaris*.
- C-119 *Dasykaluta rosamondae*, *Pseudantechinus macdonnellensis*, *Isoodon auratus*, *Notomys alexis*, *Notomys amplus*, *Rattus tunneyi*, *Zyomys pedunculatus*.
- C-126 *Petrogale lateralis*.
- C-135 *Petrogale lateralis*.
- C-144 *Dasyurus hallucatus*, *Isoodon auratus*.
- C-163 *Dasyurus hallucatus*, *Sminthopsis longicaudata*, *Isoodon auratus*, *Rattus tunneyi*.
- C-169 *Petrogale lateralis*.
- C-192 *Isoodon auratus*.
- C-198 *Petrogale lateralis*.
- C-200 *Dasyurus geoffroii*, *Isoodon auratus*, *Macrotis lagotis*, *Eptesicus finlaysoni*, *Leporillus apicalis*, *Mus musculus*, *Notomys alexis*, *Notomys amplus*, *Notomys longicaudatus*, *Pseudomys hermannsburgensis*, *Rattus tunneyi*.
- C-201 *Tachyglossus aculeatus*.
- C-205 *Notomys alexis*.
- C-207 *Antechinomys laniger*, *Dasyercus cristicauda*, *Dasyurus hallucatus*, *Phascogale calura*, *Sminthopsis longicaudata*, *?Sminthopsis ooldea*, *Sminthopsis youngsoni*, *Isoodon*

*auratus*, *Macrotis lagotis*, *Bettongia lesueur*, *Macropus* sp. indet. (either *M. robustus* or *M. rufus*), *Petrogale lateralis*, *Trichosurus vulpecula*, *Leggadina forresti*, *Leporillus apicalis*, *Mesembriomys macrurus*, *Notomys alexis*, *Notomys amplus*, *Notomys longicaudatus*, *Pseudomys chapmani*, *Pseudomys desertor*, *Pseudomys fieldi*, *Pseudomys hermannsburgensis*, *Pseudomys nanus*, *Rattus tunneyi*, *Zyomys pedunculatus*.

- C-213 *Isoodon auratus*, *Rattus tunneyi*, *Zyomys pedunculatus*.
- C-215 *Macropus robustus*, *Petrogale lateralis*, *Pseudomys nanus*, *Rattus tunneyi*, *Canis familiaris*.
- C-231 *Planigale maculata*, *Mus musculus*, *Notomys alexis*, *Pseudomys hermannsburgensis*.
- C-246 *Dasyurus hallucatus*.
- C-248 *Isoodon auratus*, *Trichosurus vulpecula*, *Rattus tunneyi*, *Zyomys pedunculatus*.
- C-251 *Dasyurus hallucatus*, *Isoodon auratus*, *Leporillus apicalis*, *Notomys alexis*, *Notomys amplus*, *Notomys longicaudatus*, *Pseudomys fieldi*, *Pseudomys nanus*, *Rattus tunneyi*, *Zyomys pedunculatus*.
- C-252 *Dasyurus hallucatus*, *Isoodon auratus*, *Petrogale lateralis*, *Pseudomys fieldi*, *Rattus tunneyi*, *Zyomys pedunculatus*.
- C-256 *Isoodon auratus*, *Canis familiaris*.
- C-266 *Rattus tunneyi*.
- C-280 *Petrogale lateralis*.
- C-291 *Trichosurus vulpecula*.
- C-299 *Isoodon auratus*, *Petrogale lateralis*, *Trichosurus vulpecula*, *Leporillus apicalis*, *Rattus tunneyi*, *Zyomys pedunculatus*.
- C-300 *Macropus robustus*, *Petrogale lateralis*, *Canis familiaris*, *Vulpes vulpes*, *Capra hircus*.
- C-310 *Isoodon auratus*, *Macropus robustus*, *Notomys longicaudatus*, *Zyomys pedunculatus*.
- C-312 *Petrogale lateralis*.
- C-402 *Dasyurus hallucatus*, *Sminthopsis longicaudata*, *Isoodon auratus*, *Petrogale lateralis*, *Trichosurus vulpecula*, *Leporillus apicalis*, *Mesembriomys macrurus*, *Notomys longicaudatus*, *Rattus tunneyi*, *Zyomys pedunculatus*.
- C-452 *Vulpes vulpes*, *Felis catus*.
- C-460 *Padjari Manu* (formerly Bunbury Cave): *Macropus robustus*, *Taphozous georgianus*, *Eptesicus finlaysoni*.
- Unnumbered overhang in mouth of Pilgonaman Gorge *Mus musculus*, *Notomys alexis*, *Notomys amplus*, *Pseudomys desertor*, *Pseudomys fieldi*, *Rattus tunneyi*.