

Mammals of the Bungle Bungle Area

by

John Woinarski, Karina Menkhorst, Nick Gambold and Richard Braithwaite.

ANNOTATED SPECIES LIST

Nomenclature and order follow Strahan (1988).

'A' indicates species recorded from Argyle (Dames and Moore 1982).

'O' indicates species recorded from the Ord River survey (Kitchener 1978).

indicates introduced species.

The survey sites where we recorded the species are given in parentheses after the scientific name. The land unit and floristic group in which the highest mean abundance was recorded is listed, except for those species where this mean maximum abundance was less than 0.1 animals per quadrat (see Tables 5 and 6).

Species not definitely recorded from the Bungle Bungle area are enclosed in square brackets.

Measurements for bats caught during the survey are listed in Table 7.

All specimens retained are now housed in the Western Australian Museum.

O. ECHIDNA *Tachyglossus aculeatus*.
(3,6,7,8).

Common and widespread throughout the Bungle Bungle area, including the Osmand Valley, though presence was more often detected by scats than by sightings of animals.

[NORTHERN QUOLL *Dasyurus hallucatus*.]
Not recorded during this survey. Nick Gambold observed a quoll on two nights in November 1986, near Piccaninny Gorge. McGonigal (1989) noted anecdotally that quolls were found in the Bungle Bungle area. Local Aborigines knew this species from the Park area, though they could not confirm its continued presence.

NINGBING ANTECHINUS *Pseudantechinus ningbing*.
(8,10).

Preferred land unit: Buchanan frontage.

Preferred floristic group: *E.aspera* low woodland-*Acacia-Triodia*.

1 trapped, 1 specimen.

One animal collected in Cathedral Gorge, one seen also in Bream Gorge, and may be widespread but in low numbers throughout the sandstone ranges.

OA. STRIPE-FACED DUNNART *Sminthopsis macroura*.
(1,3,5,9).

Preferred land unit: Nelson cracking clay plains.

Preferred floristic group: *E.brevifolia* open woodland-*Cassia-Plectrachne*.

6 trapped, 5 specimens.

Uncommon, mostly in sandplains with spinifex, but also recorded on cracking clays.

OA. LONG-TAILED PLANIGALE *Planigale ingrami*.
COMMON PLANIGALE *Planigale maculata*.
(1,4,6,7,8,10).

Preferred land unit: Antrim rugged uplands.

Preferred floristic group: *E.brevifolia* low open woodland-*Acacia-Triodia*.

19 trapped, 14 specimens.

Planigales were reasonably common on both rocky ridges with spinifex and loamy clay soils with tussock grasses. Apparently mature male specimens varied in weight from 3 g to 9.7 g, and exhibited a range of pelage colours. All specimens have been identified (N. Cooper and D. Kitchener, Western Australian Museum) as *P. maculata*, in contrast to the usual identification of planigales in the Kimberley as *P. ingrami* (e.g. Kitchener 1978; Dames and Moore 1982). *P. maculata* was not recorded from the east Kimberley by McKenzie (1981a).

[BILBY *Macrotis lagotis*.]

Not definitely recorded during this survey. A burrow unit thought to be of this species was found on a sandplain near a rocky breakaway just north of Goosehole (site 3), but had been abandoned for probably two to five years. Known by Raymond Wallaby for the Bungle Bungle area, though he was not able to confirm its continued presence.

ROCK RINGTAIL POSSUM *Pseudocheirus dahli*.
(4,8).

Preferred floristic group: *Livistona* open forest-*Acacia-Germania*.

One animal and scats seen at Bream Gorge and occasional scats on the plateau of the Bungle Bungle massif. Probably widespread in gorges and rock outcrops, but at very low density. This species has not hitherto been recorded in the east Kimberley (McKenzie 1981a).

[SPECTACLED HARE-WALLABY *Lagorchestes conspicillatus*.]

Not definitely recorded. We noted a runway unit and heard a small macropod in very dense old spinifex on a low limestone ridge at site 6, but were unable to secure a specimen or locate any more substantial signs. A hare-wallaby was thought to once occur in the Park area by Raymond Wallaby.

OA. NORTHERN NAIL-TAIL WALLABY *Onychogalea unguifera*. (3,5,9).

Preferred land unit: Nelson cracking clay plains.

Preferred floristic group: *Melaleuca* low open woodland-*Acacia-Aerva*.

Common on blacksoil plains and tussock grasslands near the Ord River.

OA. SHORT-EARED ROCK-WALLABY *Petrogale brachyotis*.

(6,8,10).

Patchily common on massif (e.g. 'Frog Hole' Gorge, 'Mini Palm' Gorge), Osmand Range (e.g. near 'Fowlhouse') and ranges in the south of the Park (site 6). No specimen was secured, so identification is based on detailed sight records (vouched by Mr. Norm McKenzie).

OA. AGILE (SANDY) WALLABY *Macropus agilis*. (6).

We did not see this common Kimberley species in the survey area. It is mentioned as occurring in the Bungle Bungle area in the CALM Park brochure (one of only two animal species listed) and 'thought to occur in the park' by Colreavy *et al.* (1989). Our closest sight record was near the Negri (about 20 km north of the north-east corner of the Park). A dingo scat collected at site 6 contained hairs of this species.

OA. COMMON WALLAROO (EURO) *Macropus robustus*.

(3,4,5,6,7,8,10).

Preferred land unit: Headley lower slopes.

Preferred floristic group: *Livistona* open forest-*Acacia-Germania*.

Common in most habitats of the Park, other than the degraded blacksoil of the Ord River plains.

O. LITTLE RED FLYING-FOX *Pteropus scapulatus*. (7).

Uncommon in the Park during our survey but may be seasonally common. One individual was observed by spotlight on a tributary of Osmand Creek near Mt. John and several mummified remains were found caught on barbed wire of the ninety kilometre fence. A large colony of approximately 10 000 individuals occurred in closed riparian forest at Winnama Gorge during November.

O. DUSKY HORSESHOE-BAT *Hipposideros ater*. (6).

3 trapped, 3 specimens.

Uncommon, recorded only from the south of the Conservation Reserve at Site 6. This species uses warm humid caves and possibly also occurs in Osmand Valley.

OA. COMMON SHEATHTAIL-BAT *Taphozous georgianus*.

(4,6,10).

13 trapped, 3 specimens.

Common in sandstone caves in the Bungle Bungle massif, Osmand Valley and ranges in the south of the Park.

O. YELLOW-BELLIED SHEATHTAIL-BAT *Taphozous flaviventris*.

(9).

Uncommon, several individuals were observed by spotlight over broad plains at Kitty's Knob. This species is probably more widespread in the Park, however, its foraging strategy of flying fast above the tree canopy makes it difficult to collect.

A. NORTHERN MASTIFF-BAT *Chaerophon jobensis*. (8).

2 trapped.

Uncommon, recorded only from Bream Gorge where a pregnant female was mist-netted at an open waterhole in November.

BECCARI'S MASTIFF-BAT *Mormopterus beccarii*. (8).

4 trapped.

Uncommon, recorded only from an open waterhole at Bream Gorge.

LESSER LONG-EARED BAT *Nyctophilus geoffroyi*. (7,8,9).

11 trapped, 2 specimens.

This bat was widespread and reasonably common. It was trapped most frequently in riparian forests. Females with enlarged nipples and juveniles were both recorded in late November.

NORTH QUEENSLAND LONG-EARED BAT *Nyctophilus bifax*.

(8,9)

3 trapped, 2 specimens.

Uncommon but probably widespread, this species was trapped at open waterholes fringed by riparian forest at Bream Gorge and on the Ord River at Kitty's Knob. Females collected in late November had enlarged nipples. This species has not been recorded before in the east Kimberley (McKenzie 1981a).

O. ARNHEMLAND LONG-EARED BAT *Nyctophilus arnhemensis*.

(2,5,6,8,9).

21 trapped, 4 specimens.

Common in riparian vegetation ranging from closed forests to dense *Acacia* shrublands. Females with enlarged nipples were recorded in late November.

COMMON BENT-WING BAT *Miniopterus schreibersii*.
(1,4,5,6,8,10).

26 trapped, 3 specimens.

Common in sandstone habitats, especially the Bungle Bungle massif, where it roosts in caves. Males with descended testes were collected in mid-July and pregnant females in late November.

O. GOULD'S WATTLED BAT *Chalinolobus gouldii*.
(1,2,5,6,7,8,9,10)

16 trapped, 5 specimens.

Common, most frequently trapped on the edge of riparian forests. Males with descended testes were collected in June and July, females with enlarged nipples in early December.

LARGE-FOOTED MOUSE-EARED BAT *Myotis adversus*.

(10).

3 trapped, 3 specimens.

Rare. One specimen was mist-netted over a permanent creek fringed by closed forest in Winnama Gorge. Two individuals were caught in Cathedral Gorge. One male with descended testes was recorded in early December. This species was not recorded for the east Kimberley by McKenzie (1981a).

O. LITTLE BROAD-NOSED BAT *Scotorepens greyi*.

LITTLE NORTHERN BROAD-NOSED BAT *Scotorepens sanborni*.

(1,5,6,8,9,10)

114 trapped, 5 specimens.

These two taxa were not separated in the field. We collected one specimen of *S. greyi* and four of *S. sanborni*. Abundant in a wide variety of habitats throughout the Park. Males with descended testes were recorded in June and July, pregnant females in early December. *S. sanborni* was not recorded for the east Kimberley by McKenzie (1981a).

O. LITTLE CAVE BAT *Eptesicus caurinus*.

(1,4,5,6,8,10).

121 trapped, 16 specimens.

Most commonly trapped on the sandplains surrounding the Bungle Bungle massif, this species is widespread and abundant in the Park. It was observed roosting in caves and fissures in rock walls. Males with descended testes were collected throughout the survey period, females with enlarged nipples in late November and juveniles in early December.

WATER-RAT *Hydromys chrysogaster*.

(7).

Recorded only in large pools of the Mt. John tributary of the Osmand Creek.

OA. COMMON ROCK-RAT *Zyromys argurus*.

(4,6,7,8,9,10).

Preferred land unit: Wickham rugged uplands.

Preferred floristic group: *E.cliftoniana* low woodland-*Cajanus-Plectrachne*.

167 trapped, 7 specimens.

Patchily very common in gorges and rocky ranges of the massif (e.g. 'Frog Hole' Gorge, plateau), Osmand Range (e.g. Winnama Gorge, Bream Gorge, Mt. John site), and scattered rocky hills in the south-west of the Park.

OA. WESTERN CHESTNUT MOUSE *Pseudomys nanus*.

(1,2,9).

Preferred land unit: Buchanan sandplain.

Preferred floristic group: *E.collina* woodland-*Acacia-Triodia*.

26 trapped, 3 specimens.

Patchily common, especially on plains with sandy soils supporting woodlands and dense shrub or tussock grass cover.

DESERT MOUSE *Pseudomys desertor*.

(4,6,10).

Preferred land unit: Elder uplands.

Preferred floristic group: *E.brevifolia* low open woodland-*Acacia-Triodia*.

11 trapped, 4 specimens.

Patchily common, especially on gravelly sandy loam soils, with extensive rock cover, dense spinifex and low open tree layer. Also trapped in dense old spinifex just south of Three-ways. This species has not been recorded in the east Kimberley before (McKenzie 1981a).

OA. DELICATE MOUSE *Pseudomys delicatulus*.

(1,2,3,5,8,9).

Preferred land unit: Buchanan sandplain.

Preferred floristic group: *E.collina* woodland-*Acacia-Triodia*.

25 trapped, 7 specimens.

Patchily common, especially on alluvial sands and deep sand plains, with relatively tall woodlands and dense cover of tussock grasses or spinifex.

A. KIMBERLEY MOUSE *Pseudomys laborifex*.

(6,8).

Preferred land unit: Wickham rugged uplands.

Preferred floristic group: *Lysiphyllum* woodland-*Carissa-Heteropogon*, *E.brevifolia* low open woodland-*Acacia-Triodia*.

4 trapped, 4 specimens.

Uncommon, recorded in slopes and gullies on sandy loam soils with extensive cover of gravel, stones or rocks and with low open woodlands above relatively dense spinifex or tussock grasses.

OA. SHORT-TAILED MOUSE *Leggadina forresti*.
(8).

Preferred floristic group: *Lysiphyllum* woodland-*Carissa-Heteropogon*.

1 trapped, 1 specimen.

Although quite common at Argyle and Ord, especially in tussock grasslands, only one was recorded in this survey. Bone fragments attributable to this species were recorded by Muir (1983) from limestone near the Bungle Bungle outcamp.

PALE FIELD-RAT *Rattus tunneyi*.
(8).

Preferred land unit: Wickham rugged uplands.

Preferred floristic group: *Livistona* open forest-*Acacia-Germania*.

33 trapped, 6 specimens.

Common in wet gorges, springs and dense riparian vegetation of the Osmand Valley (e.g. Bream Gorge, Winnama Gorge, Wulwuldji Spring); not recorded in the drier gorges of the massif, nor in fringing vegetation of the Ord River. The Osmand Valley may be the local southern range limit for this now mainly Torresian species. Bone fragments of this species were recorded by Muir (1983) from limestone near the Bungle Bungle outcamp. This species has been recorded rarely before from the east Kimberley (McKenzie 1981a), and Burbidge and McKenzie (1989) consider it to be declining there.

OA. DINGO *Canis familiaris dingo*.
(1,2,3,5,6,10).

Preferred land unit: Elder cuestas.

Preferred floristic group: *E.brevifolia* open woodland-*Cassia-Plectrachne*.

Reasonably common and widespread, occurring throughout the Park other than the plateau of the massif.

#OA. FERAL CAT *Felis catus*.
(1,2,3,8,10).

Uncommon but widespread. Specimens are occasionally trapped and removed by rangers around Kurrajong camp.

#OA. HORSE *Equus caballus*.
(6,8).

Preferred land unit: Wickham rugged uplands.

Preferred floristic group: *Lysiphyllum* woodland-*Carissa-Heteropogon*.

Uncommon in the National Park, at least partly because of recent culling. Reasonably common in the Osmand Valley, and present also in the south-west of the Park.

#OA. DONKEY *Equus asinus*.
(1,2,3,5,6,7,8,9,10).

Preferred land unit: Headley lower slopes.

Preferred floristic group: *Hakea* low woodland-*Dodonea-Triodia*.

Still reasonably common and widespread in the Park; extremely common in Osmand Valley Station and the south-west of the Conservation Reserve. Culling, especially in the Park area, has reduced numbers substantially over the last five years. Nonetheless, donkeys are still responsible for pronounced environmental degradation, especially in the Osmand Valley.

FERAL PIG *Sus scrofa*.
(7).

Uncommon and patchily distributed. Recorded in this survey from dense riparian vegetation of Winnama Gorge and the Mt. John tributary of the Osmand Creek. Reported also in the south-east of the Park (between the Ninety-Kilometre fence and Ord River Station). Apparently these populations are recent invaders from escaped Turkey Creek stock. Any increase in the population or range of this species may lead to serious damage of the limited dense riparian vegetation (e.g. the taro swamps of the Osmand Valley).

#A. ONE-HUMPED CAMEL *Camelus dromedarius*.

Not recorded during this survey, but a small population is known from the Park area - a group of 4 or 5 individuals was reported from between Three-ways and Bellburn Creek in December 1985 (Bob Taylor) and odd individuals have been reported since along the Ninety-Kilometre fence.

#OA. FERAL CATTLE *Bos taurus*.
(1,2,3,5,6,7,8,9).

Preferred land unit: Antrim lowlands.

Preferred floristic group: *E.opaca* low open woodland-*Grevillea-Triodia*.

Still reasonably common and widespread throughout the Park (except for the more rugged Bungle Bungle massif and other ranges), although much of the population has been culled over the last 5 years. A relatively high stocking rate of cattle in the Osmand Valley Station continues to contribute to environmental degradation.

#. FERAL WATER BUFFALO *Bubalus bubalis*.

Not recorded during this survey, though odd individuals have been reported from the Ord and Osmand units by Paul Novelty and local rangers, including one individual shot during 1989.

Notable species

Like many other medium-sized mammals, the Northern Quoll and Bilby have suffered drastic reductions in range and population size over the last century (McKenzie 1981a; Burbidge and McKenzie 1990). Custodians of the Bungle Bungle area regarded both species as formerly occurring in the region, though they had seen neither for some years. Relatively recent signs of Bilbies and sightings of Quolls (see Annotated Species List) suggest that both species were present within the last five years. However, we found no evidence for the continued survival of either species in our intensive surveys. For the Quoll, extensive areas of apparently suitable habitat persist in reasonable condition in rocky areas of the Bungle Bungle massif, Osmand Plateau and the south-west of the Conservation Reserve. For the Bilby, most of the previously suitable habitat is now degraded. These two species are probably on the brink of local extinction in the Park, if they have not already totally disappeared.

The Ningbing Antechinus was described only recently (Kitchener 1988) from sandstone outcrops and limestone ridges in the Kimberley, and its ecology remains poorly known.

The Rock Ringtail Possum has a patchy distribution in sandstone outcrops from Arnhem Land to the west Kimberley, and it is generally regarded as rare (e.g. Sawle 1988).

The Northern Nail-tail Wallaby has a wide distribution in savanna woodlands of the northern semi-arid reserve from Queensland to Western Australia, but is generally uncommon within this range. Purnululu National Park is one of the few conservation reserves or national parks where it occurs in reasonable numbers.

The Kimberley Mouse (*Pseudomys laborifex*) was described recently (Kitchener and Humphreys 1986) from Mitchell Plateau, and has since been shown to have a reasonably wide distribution in the Kimberley region, though it characteristically occurs at very low densities. Its ecological requirements remain poorly known.

The occurrence of the Desert Mouse (*Pseudomys desertor*) in the Bungle Bungle area is particularly noteworthy, as it extends the known range considerably (from the Great Sandy Desert and Tanami; Burbidge and McKenzie 1983; Gibson 1986), and it overlaps the distribution of its close relative the Western Chestnut Mouse. Little is known of the ecology of the Desert Mouse, but it has apparently undergone a dramatic reduction in range over the last century (Strahan 1988). All our records for this species were from on or adjacent to the Bungle Bungle massif or on rugged stony hills with spinifex in the south-west of the Conservation Reserve,

and these relatively inaccessible areas may have escaped the massive environmental degradation of the surrounding lowlands. This stony habitat is dissimilar to habitats previously reported for this species (Finlayson 1941; Gibson 1986).

The Large-footed Mouse-eared Bat (*Myotis adversus*) occurs in a broad coastal belt from South Australia, along the east coast of Australia to the Kimberley in the west. Strahan (1988) regards this species as comparatively rare over its limited range. The distribution of *Myotis* in Australia is limited by the aridity and lack of permanent bodies of freshwater over much of the continent. Western Australian Museum records of this species are restricted to the northern Kimberley (Kitchener and Vicker 1981). *Myotis* uses its large feet to rake the surface of water to catch aquatic insects which make up the majority of its diet. The occurrence of this species in the Park is particularly notable both for its distance from the coast and its comparative aridity. One specimen was mist-netted over a permanent watercourse fringed by closed forest at Winnama Gorge, however, the other two individuals were trapped in an ephemeral watercourse of the Bungle Bungle massif. All watercourses of the Bungle Bungle massif are ephemeral and small pools of water occurring in rocky basins are relatively rare. The presence of *Myotis* in the Park represents both an inland range extension and an extension of its previously known habitat.

Six species recorded in this survey have not been recorded in the east Kimberley before (Kitchener 1978; McKenzie 1981a; Dames and Moore 1982): *Planigale maculata*, *Pseudocheirus dahli*, *Nyctophilus bifax*, *Scotorepens sanborni*, *Myotis adversus* and *Pseudomys desertor*.

Additional species

Five bat species known from the Ord River (Kitchener 1978) and/or Argyle (Dames and Moore 1982) areas were not recorded in this survey of the Bungle Bungle area: Black Flying-Fox *Pteropus alecto*, Ghost Bat (*Macroderma gigas*), Orange Horseshoe Bat (*Rhinonictis aurantius*), Hoary Bat (*Chalinolobus nigrogriseus*) and Little Northern Mastiff-bat (*Mormopterus loriae*). The Black Flying-Fox is a partly nomadic species and may at times follow the fruiting or flowering of plants along watercourses into the Bungle Bungle area. The Ghost Bat and Orange Horseshoe Bat are cave-dwelling species and regarded as rare or declining (Churchill *et al.* 1988; Jolly 1988; Churchill and Helman 1990). Although we visited many caves in the Bungle Bungle massif and Osmand Valley, many others proved inaccessible and may well be inhabited by these species. The Hoary Bat is a common species across northern Australia and its absence from our survey is surprising.

We did not record the House Mouse (*Mus musculus*) during this survey, although it is known from around homesteads and pastures in the Ord River area (Kitchener 1978) and much of the Kimberley (e.g. McKenzie 1981a, 1983). The Long-haired Rat (*Rattus villosissimus*), which has a mainly inland distribution, has been recorded from recent skeletal material in the Ord River area (Kitchener 1978) and may occur in the Bungle Bungle area during outbreaks.

The Scaly-tailed Possum (*Wyulda squamicaudata*) was described from an animal from Violet Valley Aboriginal Reserve near Turkey Creek, though the provenance of this specimen is perhaps dubious as it appears now to be restricted to higher rainfall areas of near coastal north Kimberley (Strahan 1988).

Red Kangaroos (*Macropus rufus*) have been reported from just south of Ord River Station (Hadden² personal communication), and may occasionally occur on sandy plains in the south of the Park and Conservation Reserve.

The Antilopine Wallaroo (*Macropus antilopinus*) is known from the east Kimberley as far south as the Negri (Parker 1973), a record omitted by McKenzie (1981a). It may well occur in the taller open forests of Texas Downs and the north of the National Park.

Bandicoots were known from the Bungle Bungle area (Wallaby³ personal communication; Colreavy *et al.* 1989), but their continued presence is uncertain. Either or both Golden Bandicoot (*Isodon auratus*) and Northern Brown Bandicoot (*Isodon macrourus*) could have occurred in the area. These species have declined or disappeared from much of northern Australia over the last century (McKenzie 1981a), at least partly because of the effects of the grazing industry (Kitchener 1978).

The arboreal Brush-tailed Phascogale (*Phascogale tapoatafa*), Sugar Glider (*Petaurus breviceps*) and Northern Brushtail Possum (*Trichosurus arnhemensis*) may also be present in the taller open forests of the Bungle Bungle area, particularly of the Osmand Valley, or have existed there until recent times. These species have apparently disappeared from the south-west Kimberley over the last century (McKenzie 1981a).

Patterns within the Bungle Bungles

The number of species of mammal recorded per site varied from eight to 21 (Table 8). The richest sites were those adjacent to the massif or other rocky ranges (Bream Gorge, the south-west of the Conservation Reserve, and Piccaninny

Gorge). The plateau of the massif (site 4) had relatively few species. Bream Gorge had the most species which were restricted to only one site.

The diversity of mammal species varied widely between land units (Table 9). Headley lower slopes, Wickham uplands, Antrim uplands and Elder cuestas had the highest average number of native mammal species per quadrat. The lowland units Nelson low rises and Antrim lowlands had few mammal species per quadrat, and Nelson low slopes and frontages had no native mammal species, although few quadrats in these units were sampled.

Mammal species with a predominantly Eyrean distribution were restricted mostly to Antrim, Buchanan and Elder land units. Introduced species were most abundant and diverse in Nelson, Headley and Wickham units.

The upland land units - Elder uplands, Buchanan uplands and Wickham uplands - and Buchanan frontage had a distinctive mammal fauna including Desert Mouse, Common Planigale, Ningbing Antechinus, Common Rock-rat, Kimberley Mouse, Rock Ringtail Possum and Short-eared Rock Wallaby (Table 5). Lush vegetation along watercourses and gorges of the Wickham unit also contained Feral Pig and Pale Field-Rat. Euros were also relatively abundant in these upland units, but occurred also in the lower slopes of Headley, Antrim and Elder units. Feral donkeys and cattle were distributed throughout most land units, though were comparatively rare in the upland units. The Delicate Mouse and Western Chestnut Mouse were most abundant in the Buchanan sandplains. The Northern Nail-tail Wallaby was most abundant on Nelson cracking clay plains, but occurred also on tussock grasslands of Nelson low rises and on lower slopes of the Antrim and Elder units.

Mammal species diversity also varied substantially between floristic groups (Table 10). Floristic groups *Livistona* open forest-*Acacia-Germania*, *E. ptychocarpa* forest-*Pandanus-Heteropogon*, *Lysiphyllum* woodland-*Carissa-Heteropogon* and *Hakea* low woodland-*Dodonea-Triodia* had the most mammal species per quadrat: groups *E. cliftoniana* low open woodland-*Acacia-Triodia*, *E. collina* woodland-*Acacia-Triodia* and *E. collina* woodland-*Acacia-Plectrachne* had the fewest. Introduced species were especially abundant and diverse in floristic groups *E. ptychocarpa* forest-*Pandanus-Heteropogon*, *Lysiphyllum* woodland-*Carissa-Heteropogon*, *E. opaca* low open woodland-*Grevillea-Triodia*, *Hakea* low woodland-*Dodonea-Triodia*, *Lysiphyllum* low woodland-*Acacia-Cenchrus* and *Melaleuca* low open woodland-*Acacia-Aerva*. Eyrean species were most diverse in floristic groups *E. brevifolia* low open woodland-*Acacia-Triodia*, *E. brevifolia* open woodland-*Cassia-Plectrachne*, *E. cliftoniana* low open woodland-*Acacia-Triodia* and

² D. Hadden - Western Australian Department of Agriculture, Ord River Station

³ R. Wallaby - Pumululu Aboriginal Corporation

Acacia spp. tall shrubland-*Triodia*, but were absent from most floristic groups. The highest numbers of Torresian mammal species were in floristic groups *Livistona* open forest-*Acacia-Germania*, *E. brevifolia* low open woodland-*Acacia-Triodia*, *E. aspera* low woodland-*Acacia-Triodia* and *E. cliftoniana* low woodland-*Cajanus-Plectrachne*.

The distribution of mammal species across floristic groups (Table 6) largely recapitulated the distribution across land units (Table 5).

The occurrence of four species of *Pseudomys* (and the closely related *Leggadina*) in one area is unusual. The two smaller species (Delicate Mouse and Kimberley Mouse) and the two larger species (Western Chestnut Mouse and Desert Mouse) appear to be segregated by habitat (Table 11). The Desert Mouse and Kimberley Mouse occurred in low woodlands or shrublands with extensive spinifex, rock and gravel cover. The Western Chestnut Mouse and Delicate Mouse preferred open forest or woodland flats with sandy soil, relatively abundant tussock grass and little cover of rocks or gravel.

Biogeographic patterns

Thirty-four native mammal species and seven introduced mammal species are now known from the Bungle Bungle area. This is a rich assemblage, being surpassed by only Mitchell Plateau, Kakadu Stages I and II, and Kakadu Stage III of the 16 other regional surveys available in north-western Australia (Fig. 8). Torresian species and species with relatively widespread distributions dominate the mammal fauna, with only two native species (Desert Mouse and Stripe-faced Dunnart) having a principally Eyrean distribution.

The mammal fauna of the Bungle Bungle area is most similar to that of the Ord River region, Drysdale and Stage III of Kakadu (Fig. 8). It has little similarity with the mammal faunas of the Great Sandy Desert, Tanami, Hamersley and three Top End areas where the survey was least detailed - Umbrawara, Katherine Gorge and Coburg Peninsula. Indeed, survey procedure (trapping techniques and effort, especially for bats) has a gross influence on the composition and comprehensiveness of any mammal species list.

Ordination of the available mammal species lists shows the dominant influence of the rainfall gradient (Fig. 9). The four sites with lowest rainfall - Tanami, Great Sandy Desert, Hamersley and Edgar Ranges - are clearly segregated from all other sites. The mammal species composition undergoes its most substantial change with the rainfall drop from the Bungle Bungle area (c 600 mm) to the Edgar Ranges (c 500 mm). Within the higher rainfall sites, the Bungle Bungle area is grouped with Argyle, Ord and Drysdale. The second axis of the ordination loosely

separates Kimberley sites from those of the Top End, although the positions of Katherine Gorge and Dampier Peninsula are anomalous.

As foreshadowed by McKenzie (1981a), the fauna of the east Kimberley region has very strong affinities with that of the Phanerozoic south-west Kimberley, matching in part the similarity between these two areas in climate, topography and geological history. Re-analysing his data to include our records from the Bungle Bungle area, and using the similarity index we describe earlier, the extant south-west Kimberley fauna is more similar to that of the geographically distant east Kimberley (S.I.=72.7) than to the adjacent north Kimberley (68.0) or Sandy Deserts (53.8). Both the south-west Kimberley and the Bungle Bungle area occupy transition zones between the Torresian and Eyrean biogeographic regions, although both contain more Torresian mammal species.

Related to the change in mammal species composition along this moisture gradient, the Bungle Bungle area marks an approximate inland (southern) local range limit for several Torresian species: Pale Field Rat (although this species had a much more extensive distribution in the recent past), Ningbing Antechinus, Short-eared Rock-wallaby, Rock Ringtail Possum, Agile Wallaby, Dusky Horseshoe Bat, Common Bent-wing Bat, Large-footed Mouse-eared Bat, North Queensland Long-eared Bat, Arnhem Land Long-eared Bat, Common Rock-Rat and Kimberley Mouse. The occurrence of the Desert Mouse also represents a northern range limit for this inland species.

The overall trapping success for small mammals was low (1.4 per cent per trapnight for Elliott and cage traps, and 2.8 per cent per pitfall trapnight), compared with other surveyed areas in north-western Australia (e.g. Great Sandy Desert (Burbidge and McKenzie 1983) 0.8 per cent for Elliotts and 69.4 per cent for pitfalls; Tanami (Gibson 1986) 3.9 per cent for Elliotts and 35.8 per cent for pitfalls; Mitchell Plateau (Bradley *et al.* 1987) 3.1 per cent for Elliotts and cage-traps). This low abundance of small mammals was particularly marked for the more degraded land units: Antrim lower slopes (0 and 1.2 per cent), Nelson low rises (0 and 0 per cent), Nelson lower slopes (0 and 0 per cent), Nelson frontages (0 and 0 per cent), Headley lower slopes (1.0 and 0 per cent), Buchanan uplands (0.2 and 0 per cent) and Buchanan frontage (0.5 and 1.1 per cent). Trapping success for small mammals was better in Wickham (6.1 and 1.0 per cent), Elder cuestas (0 and 4.2 per cent), Buchanan sandplains (1.8 and 11.3 per cent), Antrim uplands (1.9 and 6.9 per cent) and Elder uplands (1.8 and 2.1 per cent). The mean number of small mammals caught per quadrat was significantly correlated with degradation score across land units ($r=0.60$, $p<0.05$, $N=13$): small mammals become increasingly rare in more degraded land units.

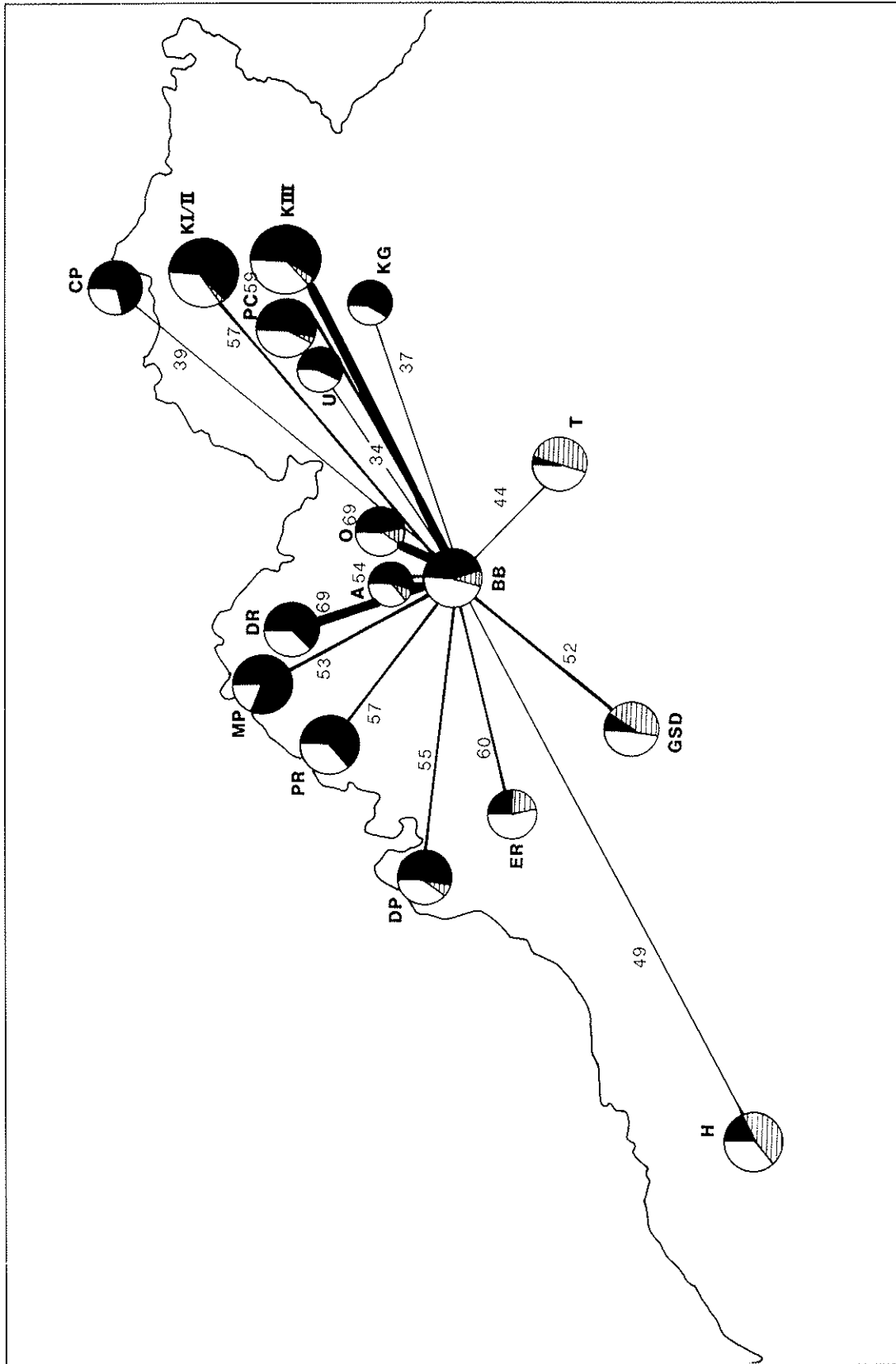


Figure 8

Network diagram showing similarity of the native mammal fauna of the Bungles Bungle area to other surveyed regions of north-western Australia. Similarity values are given and represented by the thickness of connecting lines. The proportion of Eyrean species recorded is represented by black, of Eyrean species by horizontal lines, and widespread species are unshaded. The size of the circle is proportional to the number of species recorded: H (Hamersley) = 33; DP (Dampier Peninsula) = 29; ER (Edgar Range) = 24; GSD (Great Sandy Desert) = 29; PR (Prince Regent River) = 34; MP (Mitchell Plateau) = 39; DR (Drysedale) = 28; BB (Bungles Bungle) = 34; A (Atgyle) = 15; O (Ord) = 25; T (Tanami) = 30; U (Umbravara) = 14; KG (Katherine Gorge) = 16; PC (Pine Creek) = 32; KIII (Stage III of Kakadu) = 55; KI/II (Stages I & II of Kakadu) = 58; CP (Cobourge Peninsula) = 27.

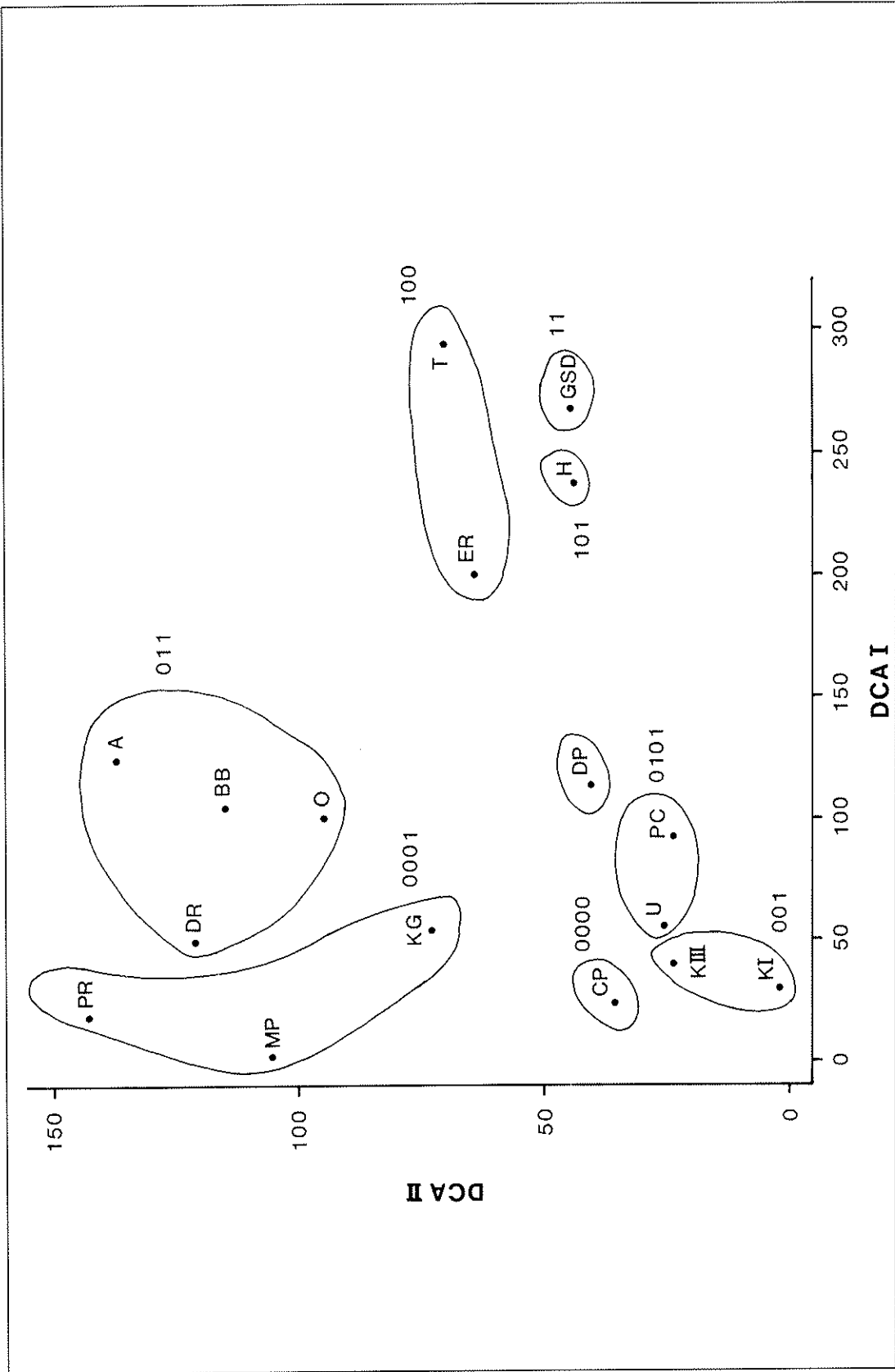


Figure 9

Ordination of the native mammal faunas of 17 areas surveyed in north-western Australia. Lines enclosing points represent TWINSpan groups. Symbols as for Figure 8. Eigenvalues for DCA 1 0.48, for DCA 2 0.13.

Table 5

Distribution of mammal species across land systems (a). Values in body of table are average abundance per quadrat. Asterisks denote proportion of quadrats per unit in which the species was recorded: *>25%, **>50%, ***>75%.

SPECIES	LAND SYSTEM												
	Eu	Bf	Bu	Au	Bp	HI	Ns	Al	El	Nr	Wk	NI	Nf
<i>Pseudantechinus ningbing</i>	.14												
<i>Pseudomys desertor</i>	.38	.14	.14	.17									
<i>Planigale maculata</i>	.25	.14		.42*	.29						.11		
<i>Zyzomys argurus</i>	1.00*	.29*		1.33		.80**	.25*				2.40**		
<i>Macropus robustus</i>	.09*	.03*	.09***	.08**		.10***	.01	.09***					
<i>Equus asinus</i>			.04*	.05*	.06	1.28***	.10***	.03*		.10***	.19**	.10***	.10***
<i>Bos taurus</i>				.03*		.10***	.10***	.35	.02	.06**	.05**	.10***	.10***
<i>Smithopsis macroura</i>				.08	.06		.25*	.05	.20				
<i>Pseudomys delicatulus</i>				.13	1.00*		.10	.30					
<i>Pseudomys nanus</i>					1.47*		.25*						
<i>Canis familiaris</i>						.08***		.02	.22*				
<i>Onychogalea unguifera</i>							.05*	.01	.01	.03*			
<i>Felis catus</i>							.01	.03*	.02				
<i>Pseudomys laborifex</i>			.08								.09		
<i>Tachyglossus aculeatus</i>											.02		
<i>Leggadina forresti</i>									.01		.03		
<i>Rattus tunneyi</i>											.54		
<i>Equus caballus</i>											.15		
<i>Sus scrofa</i>											.01		
<i>Petrogale brachyotis</i>											.01		
<i>Pseudocheirus dahti</i>											.03		

(a) Land systems: Eu = Elder uplands, Bf = Buchanan frontage, Bu = Buchanan uplands, Au = Antrim rugged uplands, Bp = Buchanan Sandplain, HI = Headley lower slopes, Ns = Nelson cracking clay plains, Al = Antrim lowlands, El = Elder cuestas, Nr = Nelson low rises, Wk = Wikham rugged uplands, NI = Nelson interfluvial lower slopes, Nf = Nelson frontage

Table 6

Distribution of mammal species across floristic groups^(a). Values in body of table are average abundance per quadrat. Asterisks denote proportion of quadrats per group in which the species was recorded: * >25%, ** >50%, *** >75%.

SPECIES	FLORISTIC GROUP																
	1	14	13	2	5	11	16	15	17	12	4	7	6	10	8	9	3
<i>Rattus tunneyi</i>	3.0**			0.4	0.2												
<i>Pseudocheirus dahli</i>	0.2																
<i>Petrogale brachyotis</i>	p			p	p												
<i>Zyromys argurus</i>	4.8***	6.8***	3.2*	0.6*	1.0*	0.8**	0.9*	1.3***	0.1	0.1	0.1		0.1				
<i>Planigale maculata</i>	0.2	0.2	1.0**		0.2			0.1							0.3*	0.5*	
<i>Tachyglossus aculeatus</i>	p	p*		p	p									p			
<i>Macropus robustus</i>	0.8***	0.1***	0.1**	0.1**		0.4***	0.1***	0.1*	0.1***	0.1**	0.1**	0.1	p		0.1**		p
<i>Equus asinus</i>	p			p*	0.5***	1.3***			p*	0.1***	p*	0.1***	0.1***				0.1 p*
<i>Pseudomys desertor</i>			0.4*				0.4		0.3*								
<i>Pseudomys laborifex</i>			0.2		0.2			0.1									
<i>Equus caballus</i>				p	0.4*												
<i>Bos taurus</i>				0.1**	0.1**	0.1**		0.6**	p*	p*	p*	p	0.1***	p			p
<i>Sus scrofa</i>				p*													
<i>Leggadinia forrestii</i>					0.1												
<i>Canis familiaris</i>						0.1***				p	p	p	p	0.2*			
<i>Parantechinus ningbing</i>								0.3*									
<i>Onychogalea unguifera</i>										p			0.1**	p*			
<i>Pseudomys delicatulus</i>										0.1	0.1			0.5*	1.1*	0.5*	
<i>Smithopsis macroura</i>										0.1			0.1	0.2	0.1		
<i>Felis catus</i>											p	p	p	p			
<i>Pseudomys nanus</i>													0.1	0.2	1.9*	0.9*	

^(a) Descriptions of floristic groups: 1 = *Livistona - Acacia - Germania*, 14 = *E. cliffortiana - Cajanus - Plectrachne*, 13 = *E. brevifolia - Acacia - Triodia*, 2 = *E. psychocarpa - Pandanus - Heteropogon*, 5 = *Lysiphyllum - Carissa - Heteropogon*, 11 = *Hakea - Dodonea - Triodia*, 16 = *E. cliffortiana - Acacia - Triodia*, 15 = *E. aspera - Acacia - Triodia*, 17 = *Acacia - Triodia*, 12 = *E. opaca - Grevillea - Triodia*, 4 = *Melaleuca - Acacia - Aristida*, 7 = *Acacia - Aerva - Aristida*, 6 = *Lysiphyllum - Acacia - Cenchrus*, 10 = *E. brevifolia - Cassia - Plectrachne*, 8 = *E. collina - Acacia - Triodia*, 9 = *E. collina - Acacia - Plectrachne*, 3 = *E. camaldulensis/Melaleuca - Aerva - Aristida*.

Table 7

Forearm measurements (mm) of bat species trapped during the survey; giving mean (number measured; range).

<i>Species</i>	<i>Female</i>	<i>Male</i>
<i>Hipposideros ater</i>	36.4(2;36.2-36.6)	37.4 (1)
<i>Taphozous georgianus</i>	65.2(2;64.6-65.7)	65.5 (1)
<i>Chaerophon jobensis</i>	50.5(1)	-
<i>Mormopterus beccarii</i>	37.8(2;37.4-38.2)	37.0(2;36.7-37.2)
<i>Nyctophilus geoffroyi</i>	35.2(5;32.8-37.4)	34.2(4;33.3-35.0)
<i>Nyctophilus bifax</i>	41.2(3;40.5-41.6)	-
<i>Nyctophilus arnhemensis</i>	39.0(10;37.7-41.0)	37.6(10;36.0-39.2)
<i>Miniopterus schreibersii</i>	44.0(4;43.3-44.8)	44.5(7;43.6-45.6)
<i>Chalinolobus gouldii</i>	38.8(4;37.4-39.5)	37.5(11;35.4-39.4)
<i>Myotis adversus</i>	38.8 (1)	38.0(2;37.5-38.5)
<i>Scotorepens greyii</i> sanborni	31.1(63;28.5-33.5)	30.8(38;27.1-32.8)
<i>Eptesicus caurinus</i>	30.4(56;28.0-33.2)	29.3(62;27.4-30.9)

Table 8

The number of mammal species recorded per study site, and the number of these recorded from only one site (i.e. restricted species). Introduced species are included in parentheses.

<i>Site</i>	<i>No. mammal species</i>	<i>No. restricted species</i>
1	12 (3)	0
2	8 (3)	0
3	9 (3)	0
4	8 (0)	0
5	12 (2)	0
6	18 (3)	1 <i>Hipposideros ater</i>
7	11 (3)	2 <i>Sus scrofa</i> , <i>Hydromys chrysogaster</i>
8	21 (3)	4 <i>Leggadina forresti</i> , <i>Rattus tunneyi</i> , <i>Chaerophon jobensis</i> , <i>Mormopterus beccarii</i>
9	12 (2)	0
10	15 (2)	2 <i>Pseudantechinus ningbing</i> , <i>Myotis adversus</i>

Table 9

Average number of mammal species per quadrat for the land systems surveyed.

LAND SYSTEM	SYMBOL	NO. QUADRATS	NO. MAMMAL SPP.	Total	NO. NATIVE MAMMAL SPP. <i>Torresian</i>	<i>Eyrean</i>
ANTRIM	rugged uplands	12	2.42	1.67	0.67 (40.1%)	0.25 (15.0%)
ANTRIM	lowlands	21	1.10	0.52	0.24 (46.2%)	0.05 (9.6%)
BUCHANAN	uplands	7	1.43	1.00	0	0.14 (14.0%)
BUCHANAN	sandplain	17	1.24	1.18	0.71 (60.2%)	0.06 (5.1%)
BUCHANAN	frontage	7	1.00	1.00	0.57 (57.0%)	0.14 (14.0%)
ELDER	uplands	16	1.13	1.13	0.63 (55.8%)	0.19 (16.8%)
ELDER	cuestas	10	2.40	1.90	0.30 (15.8%)	0.20 (10.5%)
HEADLEY	lower slopes	5	4.40	2.40	0.60 (25.0%)	0
NELSON	cracking clay plains	4	3.25	1.25	0.75 (60.0%)	0.25 (20.0%)
NELSON	interfluvial lower slopes	1	2.00	0	0	0
NELSON	frontage	3	2.00	0	0	0
NELSON	low rises	12	2.08	0.33	0.33 (100%)	0
WICKHAM	rugged uplands	35	3.54	2.20	0.89 (40.5%)	0

Table 10

Average number of mammal species per quadrat for the floristic groups.

FLORISTIC GROUP	NO. MAMMAL SPP.	NO. NATIVE MAMMAL SPP.		
		<i>Total</i>	<i>Torresian</i>	<i>Eyrean</i>
1. <i>Livistona - Acacia holosericea - Germania</i>	3.6	3.6	1.6 (44%)	0
2. <i>E. ptychocarpa - Pandanus - Heteropogon</i>	3.4	1.6	0.4 (25%)	0
3. <i>E. camaldulensis / Melaleuca - Aerva - Aristida</i>	1.0	0.3	0	0
4. <i>Melaleuca leucadendra - Acacia eriopoda - Aristida</i>	1.2	0.4	0.2 (39%)	0
5. <i>Lysiphllum - Carissa - Heteropogon</i>	3.9	2.0	0.8 (38%)	0
6. <i>Lysiphllum - Acacia holosericea - Cenchrus</i>	2.5	0.6	0.3 (50%)	0.1 (13%)
7. <i>Acacia farnesiana - Aerva - Aristida</i>	2.4	1.0	0.8 (80%)	0
8. <i>E. collina - Acacia stipuligera - Triodia spicata</i>	1.1	1.1	0.6 (50%)	0.1 (12%)
9. <i>E. collina - Acacia tumida - Plectrachne pungens</i>	1.2	1.1	0.8 (75%)	0
10. <i>E. brevifolia - Cassia - Plectrachne pungens</i>	2.0	1.6	0.3 (16%)	0.2 (11%)
11. <i>Hakea arborescens - Dodonea - Triodia wiseana</i>	4.4	2.4	0.6 (25%)	0
12. <i>E. opaca - Grevillea pyramidalis - Triodia pungens</i>	2.6	1.2	0.4 (36%)	0.1 (12%)
13. <i>E. brevifolia - Acacia retivenia - Triodia intermedia</i>	2.6	2.6	1.4 (54%)	0.4 (15%)
14. <i>E. cliftoniana - Cajanus - Plectrachne pungens</i>	2.7	2.5	1.2 (47%)	0
15. <i>E. aspera - Acacia eriopoda - Triodia microstachya</i>	2.3	2.3	1.3 (57%)	0
16. <i>E. cliftoniana - Acacia spp - Triodia spicata</i>	1.0	1.0	0.5 (50%)	0.2 (20%)
17. <i>Acacia spp - Triodia spicata</i>	1.4	1.0	0	0.3 (29%)

Table 11

Environmental variables of quadrats where six small mammals were captured.

NO. OF QUADRATS	SPECIES					
	<i>Pseudomys delicatulus</i>	<i>Pseudomys laborifex</i>	<i>Pseudomys nanus</i>	<i>Pseudomys desertor</i>	<i>Sminthopsis macroura</i>	<i>Planigale maculata</i>
	13	4	8	7	6	14
% Rock cover:	: mean (s.d.) range	78.8 (25.9) 40-95	4.4 (10.5) 0-30	68.6 (40.5) 0-95	33.3 (45.9) 0-95	58.9 (40.7) 0-95
% Tree cover (>8m)	: mean (s.d.) range	1.3 (2.5) 0-5	7.5 (4.6) 0-15	0	5.0 (4.5) 0-10	4.3 (6.8) 0-20
% Tree cover (2-8m)	: mean (s.d.) range	3.8 (4.9) 0-15	7.5 (8.7) 0-20	2.5 (3.4) 0-10	3.2 (3.7) 1-10	3.0 (3.1) 0-10
% Shrub cover (>2m)	: mean (s.d.) range	7.0 (9.4) 0-30	1.5 (2.4) 0-5	14.4 (11.5) 0-30	6.0 (7.9) 0-20	6.3 (8.7) 0-30
% Shrub cover (<2m)	: mean (s.d.) range	4.2 (3.2) 1-10	9.0 (8.2) 1-20	7.0 (3.5) 1-10	10.9 (7.1) 1-20	6.9 (5.2) 1-20
% Tussock grass cover	: mean (s.d.) range	16.3 (16.6) 1-60	13.3 (24.5) 1-50	19.0 (20.9) 1-60	1 (-) 1	2.1 (2.7) 0-10
% Spinifex cover	: mean (s.d.) range	24.6 (16.6) 0-50	40.0 (21.6) 10-60	32.5 (15.8) 0-50	66.4 (14.9) 40-85	42.1 (20.1) 0-70
% Gravel cover	: mean (s.d.) range	1.7 (6.1) 0-22	24.8 (26.8) 0-56	0.3 (0.7) 0-2	3.9 (24.9) 0-61	28.8 (29.1) 0-70
No. plant spp/quadrat	: mean (s.d.) range	28.1 (8.1) 15-45	17.8 (8.8) 7-25	24.5 (7.5) 15-34	15.9 (10.6) 7-31	19.9 (8.8) 7-33
Soil texture (no. quadrats)						
sand	-	-	-	-	1	1
loamy sand	7	-	-	1	1	1
clayey sand	-	-	-	1	-	-
sandy loam	6	1	5	3	2	7
light sandy clay loam	-	2	-	1	-	3
sandy clay loam	-	1	1	1	2	2
Land form (no. quadrats)						
ridge	-	-	-	-	-	2
slope	1	2	-	2	1	4
flat	11	-	8	4	2	5
gully	1	2	-	1	3	3
Vegetation formation (no. quadrats)						
open forest	1	-	-	-	-	1
woodland	7	-	4	-	2	3
open woodland	3	-	3	-	1	1
low woodland	1	1	1	-	1	-
low open woodland	1	2	-	5	2	6
tall shrubland	-	-	-	1	-	2
shrubland	-	1	-	1	-	1