

A review of the rodent fauna of Seram, Moluccas, with the description of a new subspecies of mosaic-tailed rat, *Melomys rufescens paveli*

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Abstract

With five previously described native species, all of them endemic, and at least four introduced species, the murid rodent fauna of Seram is more diverse than that catalogued from any other Moluccan island. Here, the rodent fauna of Seram is briefly reviewed, and a newly recorded rodent from the island is described as *Melomys rufescens paveli*, a new subspecies of a species otherwise known from New Guinea and the Bismarck Archipelago. Other non-volant mammals from Seram and the nearby islands of Ambon and Buru are briefly discussed.

Key words: *Melomys*, Seram, Ambon, Buru, Moluccas

INTRODUCTION, MATERIALS AND METHODS

Given the rich rodent faunas that have been catalogued from the islands of the Philippines (Musser & Heaney, 1992; Heaney *et al.*, 1998; Musser, Heaney & Tabaranza, 1998), from Sulawesi (Musser & Holden, 1991; Musser & Durden, 2002), and from New Guinea (Tate, 1951; Taylor, Calaby & van Deusen, 1982; Flannery, 1995a; Menzies, 1996), rodent assemblages on islands in the Moluccas (including Seram, Ambon, Buru, and the Sula, Talaud, Halmahera, Obi, Banda, Kai and Tanimbar island groups; Fig. 1) seem strikingly depauperate in comparison (Table 1). For example, despite reasonable collecting efforts (Kellogg, 1945; Flannery, 1995b; Hasagawa & Syaffrudin, 1995a,b) only one living native rodent species, *Rattus morotaiensis*, is known from the major islands of the Halmahera group (Halmahera, Morotai and Bacan), although two additional, undescribed species of *Rattus* are recorded as Holocene subfossils from Morotai (Flannery, Bellwood *et al.*, 1998). Similarly, *Rattus elaphinus* is the only native rodent described to date from the Sula group (Musser & Holden, 1991), although two currently undescribed species of *Rattus* are also represented by museum specimens from the large island of Taliabu (Musser, 1981: 168; Musser & Newcomb, 1983: 572). The Obi group has a somewhat richer fauna, with three endemic species, including *Melomys obiensis*, *Hydromys* (undescribed sp.), and a currently undescribed genus and species known by

a single museum specimen ('*Rattus* sp.' of Flannery, 1995b: 162).

Elsewhere in the Moluccas, *Melomys* is the most common and widespread genus of native rodents. Two endemic species of *Melomys* occur sympatrically on the islands of Salebabu and Karakelang in the Talaud group (*M. caurinus* and *M. talaudium*; see Thomas, 1921a,b; Tate, 1951; Flannery, 1995a; Riley, 2002), and two others have recently been described from the islands of Yamdena and Riama in the Tanimbar group (*M. cooperae* and *M. howi*; see Kitchener & Maryanto, 1995; Kitchener & Suyanto, 1996). Three rodent species occur in the Kai Islands: the endemic *Melomys bannisteri*, closely related to *M. lutillus* of New Guinea (Kitchener & Maryanto, 1993; Flannery, 1995b, Menzies, 1996), and the widespread Australo-Papuan rodents *Hydromys chrysogaster* and *Uromys caudimaculatus* (Groves & Flannery, 1994; Flannery, 1995b). Surprisingly, no native rodents are yet known from the large, mountainous and long-isolated island of Buru (the third largest island of the Moluccas), or from Ambon, an island with a long history of European occupation.

Within the Moluccas, only the island of Seram (the largest and highest of the Moluccan islands (area 17 148 km², maximum elevation 3027 m) supports a relatively diverse assemblage of rodents. Five native rodent species, all of them endemic, have previously been described from Seram (Thomas, 1920; Flannery, 1995b). Each of these five species is briefly discussed below (following recent examination of all museum specimens), and a new rodent from the island is described. Together, these six native rodents of Seram are known from a total of 27 museum specimens (see Discussion), deposited

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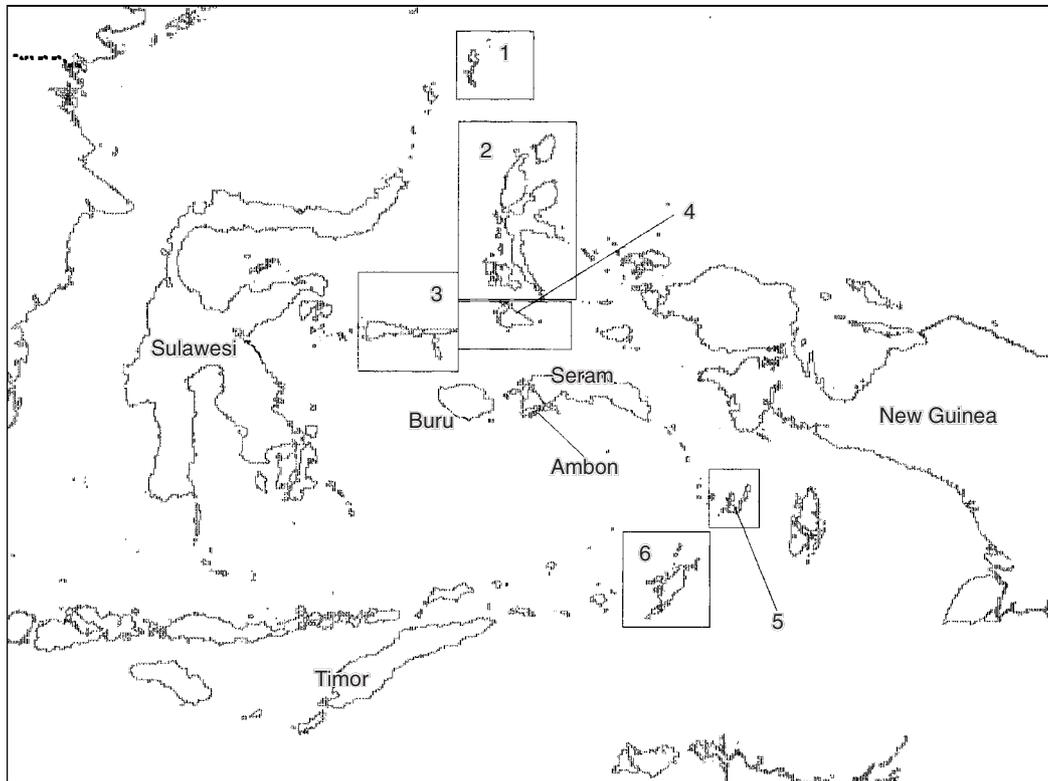


Fig. 1. Map of the Moluccan islands, between Sulawesi and New Guinea, showing the position of Seram, Ambon, and Buru. 1, Talaud group; 2, Halmahera group; 3, Sula group; 4, Obi group; 5, Kai group; 6, Tanimbar group.

Table 1. Native rodents recorded from Moluccan islands other than Seram. Asterisk, species endemic to the island or island group

Species	Island
Talaud group	
* <i>Melomys caurinus</i> (Thomas, 1921)	Karakelang (MZB), Salebabu (MZB)
* <i>Melomys talaudium</i> (Thomas, 1921)	Karakelang (MZB), Salebabu (BMNH)
Sula group	
* <i>Rattus elaphinus</i> Sody, 1941	Taliabu (AMNH, MD, MZB, ZMB), Mangole (AM)
* <i>Rattus</i> undescribed species A	Taliabu (AMNH; Musser, 1981)
* <i>Rattus</i> undescribed species B	Taliabu (AMNH; Musser, 1981)
Halmahera group	
* <i>Rattus morotaiensis</i> Kellogg, 1945	Halmahera (AM), Morotai (AM, USNM), Bacan (AM)
* <i>Rattus</i> undescribed species C	Morotai (subfossil, AM)
* <i>Rattus</i> undescribed species D	Morotai (subfossil, AM)
Obi group	
* <i>Melomys obiensis</i> (Thomas, 1911)	Obi (BMNH), Bisa (AM)
* <i>Hydromys</i> undescribed species	Obi (AM)
*Undescribed genus and species	Bisa (AM)
Kai group	
* <i>Melomys bannisteri</i> Kitchener & Maryanto, 1993	Kai Besar (AM, WAM), Taam (CSIRO)
<i>Hydromys chrysogaster beccarii</i> Peters, 1875	Kai Besar (ZMB, WAM)
<i>Uromys caudimaculatus siebersi</i> Thomas, 1923	Kai Besar (BMNH)
Tanimbar group	
* <i>Melomys cooperae</i> Kitchener, 1995	Yamdena (MZB, WAM)
* <i>Melomys howi</i> Kitchener, 1996	Riama (MZB, WAM)

in the Australian Museum in Sydney (AM), the Natural History Museum in London (BMNH), and the Western Australian Museum in Perth (WAM). Other specimens discussed here are deposited in the American Museum of Natural History, New York (AMNH), the Australian Na-

tional Wildlife Collection, Canberra (CSIRO), the Staatliches Museum für Tierkunde, Dresden (MD), the Museum Zoologicum Bogoriensis, Bogor (MZB), the United States National Museum, Washington (USNM), and the Museum für Naturkunde, Berlin (ZMB). External

Table 2. Vouchered elevational data for the six native murids of Seram

Species	Elevation (m a.s.l.)
<i>Melomys fulgens</i>	Sea level (BMNH)
<i>Melomys rufescens paveli</i>	400 (AM)
<i>Melomys aerosus</i>	650 (WAM) 850 (BMNH) 1200 (BMNH) 1500 (BMNH) 1830 (BMNH)
<i>Melomys fraterculus</i>	1830 (BMNH)
<i>Rattus feliceus</i>	Sea level (BMNH) 350 (AM) 400 (AM) 1200 (BMNH) 1830 (BMNH)
<i>Rattus ceramicus</i>	1500 (WAM) 1830 (BMNH)

dimensions were measured in the field by the original collector or by the author from intact alcohol specimens. Craniodental dimensions were measured by the author with digital callipers to the nearest 0.01 mm. Definitions of craniodental measurements follow Musser & Heaney (1992). See Table 2 for elevational data on these six species.

RESULTS

The five native rodents of Seram

Melomys aerosus Thomas, 1920

Melomys aerosus, a medium-sized, short-tailed *Melomys* is distinctive within the genus because of its nearly black coloration. It has been collected on several occasions, and is known from a total of 10 museum specimens. The type series of five individuals was collected in 'heavy

jungle' (i.e. primary rainforest) between 1500 and 1800 m a.s.l. in central Seram by Felix, Charles and Joseph Pratt in January–February 1920 (Thomas, 1920). Four of these specimens came from Gunung Manusela, as noted by Thomas (1920) and Flannery (1995b). However, the fifth specimen (BMNH 20.7.26.23 collected January 1920) is labelled 'Mt. Hoale, C. Ceram, 5000 ft' (probably = Hoaulu, 3°00'S, 129°20'E), a locality for the species overlooked by previous authors. The Pratt brothers trapped *M. aerosus* in low trees, and noted on specimen labels that according to local informants it is an arboreal species that descends to the ground to forage at night (see Flannery, 1995b). An earlier specimen of *M. aerosus* (BMNH 13.3.6.22, an immature male, skin and skull) was collected by E. Stresemann on 3 July 1911 at 2800 ft a.s.l. (850 m), also on Gunung Manusela (this same specimen was erroneously reported by Flannery, 1995b to have been collected at 750 m a.s.l. by Evelyn Cheesman in 1922). *Melomys aerosus* was most recently collected in August 1987, when D. J. Kitchener trapped four individuals (WAM 33491–33494, including two adults weighing 97 and 123 g) in a banana plantation near Kanikeh (c. 3°06'S, 129°28'E). These last specimens reveal that the species is not restricted to undisturbed habitats. External measurements for *M. aerosus* are given in Table 3.

Melomys fulgens (Thomas, 1920)

Melomys fulgens is a large, brilliant orange-coloured *Melomys* known from only two museum specimens (both adult males): the holotype (BMNH 20.7.26.20, skin and skull) and paratype (BMNH 19.7.26.20, skin and skull) collected by the Pratt brothers in February 1920 at Teloeti Bay (Teluk Taluti), on the southern coast of Seram. *Melomys fulgens* is closely allied to the less brightly coloured and shorter-tailed *M. leucogaster* of central New Guinea (Tate, 1951; Musser & Carleton, 1993; Flannery, 1995b; Menzies, 1996) but is none the less highly distinctive. In its bright coloration and very long, prehensile tail it is superficially convergent on species

Table 3. Selected measurements (mean and range, mm) for all available adult specimens of mosaic-tailed rats (genus *Melomys*) from the north and central Moluccas, including the Talauds (Karakelang and Salebabu), north-central Moluccas (Obi and Bisa), and Seram, showing clear diagnostic differences in external dimensions between named forms

	<i>aerosus</i>	<i>obiensis</i>	<i>paveli</i>	<i>fulgens</i>	<i>caurinus</i>	<i>talaudium</i>	<i>fraterculus</i>
	Seram	Obi, Bisa	Seram	Seram	Talauds	Talauds	Seram
Head-body length	153 150–160 (5)	126.5 123.2–128.5 (3)	123 123 (1)	150 150–150 (2)	176 176 (1)	174 173–174 (2)	115 115–115 (2)
Tail length	132.2 125–138 (8)	161.6 148.2–175.0 (2)	128 128 (1)	202.5 200–205 (2)	136.5 136–137 (2)	171 150–183 (3)	154 153–155 (2)
Hindfoot length	32.8 31–34 (8)	27.5 26.7–29.0 (4)	26.2 26.2 (1)	34 34–34 (2)	30 30–30 (2)	– Unknown	26 26–26 (2)
Ear length	17.4 16–18 (8)	15.4 14.0–17.2 (4)	14.6 14.6 (1)	18 17–19 (2)	15 15 (1)	14.7 13–16 (3)	17.5 17–18 (2)
Occipitonasal length	36.6 35.0–37.4 (7)	34.1 33.4–34.4 (3)	– (Broken)	39.3 39.3–39.4 (2)	38.6 38.6 (1)	38.3 36.9–39.7 (6)	32.4 31.7–33.0 (2)
Zygomatic breadth	18.6 18.0–19.8 (8)	17.4 17.3–17.6 (3)	14.7 (Estimate)	21.1 20.2–22.0 (2)	20 20.0 (1)	19.6 18.1–20.8 (6)	16.1 15.9–16.4 (2)
Mammary formula	0+2=4	0+2=4	0+2=4	Unknown	0+2=4	0+2=4	Unknown

of *Chiruromys*, and it is assumed to be highly arboreal (Thomas, 1920; Flannery, 1995b). External measurements for *fulgens* are given in Table 3.

***Melomys fraterculus* (Thomas, 1920)**

Melomys fraterculus is the most enigmatic of the Seramese murids. It is a small-bodied rat with a light reddish-brown back, a buff-coloured venter with grey fur-bases, and a long, white, and relatively well-haired tail with variable brown mottling. Flannery (1995b: 133) stated that *fraterculus* is known by a single specimen, but the type series actually consists of two individuals: the holotype (BMNH 20.7.26.26, adult male, skin and skull) and a paratype (BMNH 20.7.26.27, adult male, skin and skull). Both specimens were trapped by the Pratt brothers in January 1920 at c. 1800 m a.s.l. on Gunung Manusela. As both known specimens are male, the mammary formula remains unknown. The label on the paratype skin states 'said by natives to live in trees; trapped in heavy jungle in limestone country.' Previous authors have placed this species in *Uromys*, *Melomys* or *Pogonomelomys* (Thomas, 1920; Rümmler, 1938; Tate, 1951; Laurie & Hill, 1954; Menzies, 1991; Musser & Carleton, 1993; Flannery, 1995b); its correct generic position is still unclear and will be reviewed in a forthcoming work. External measurements for *M. fraterculus* are given in Table 3.

***Rattus feliceus* Thomas, 1920**

Rattus feliceus is a large reddish-brown rat with spiny fur, a relatively short tail with very large tail scales, a white venter, and eight mammae (2+2=8). It has a broad elevational range (Table 2) and seems to be largely terrestrial. It is known by eight specimens (at BMNH and AM), and has been trapped at three localities: (1) from sea level at Teloeti Bay on the south coast of Seram (see Musser & Holden, 1991); (2) between 350 and 400 m a.s.l. near Piliiana Village in south-central Seram (AM 30342, 30807, and 30808); (3) from 1200 to 1800 m a.s.l. on Gunung Manusela (the type series, collected by the Pratt brothers in January–February 1920). *Rattus feliceus* is a distinctive species that is probably allied to native *Rattus* species from New Guinea (Taylor *et al.*, 1982); however, its immediate systematic relationships have yet to be conclusively demonstrated (Musser & Holden, 1991). In all known adult specimens, head and body length measures 200–230 mm ($n=6$), tail length 153–185 mm ($n=6$), hindfoot length 44–47.5 mm ($n=7$), ear length 20.5–23 mm ($n=7$), and weight 272–345 g ($n=3$). Flannery (1995b) provided additional brief biological notes on the species.

***Rattus ceramicus* (Thomas, 1920)**

Like the other exclusively montane Seramese murid *M. fraterculus*, *R. ceramicus* is poorly-known. It is a small brown rat with long, very soft fur, a black nearly naked

tail equal to head and body length, well-haired toes, a relatively long rostrum, and an unusually long bony palate. It is known by four museum specimens. Three of these (BMNH 20.7.26.28–30, two adult males and one adult female, skins and skulls) were collected by the Pratt brothers in January–February 1920 at c. 1830 m a.s.l. on Gunung Manusela. Notes accompanying the paratypes state 'trapped in heavy jungle in precipitous limestone country' and 'said by natives to live in trees.' A fourth specimen (WAM M33490, adult male, with well-developed testes) was collected by D. J. Kitchener on 23 August 1987 in oak forest near Kanikeh, Seram, at an elevation of 1500 m. The generic position of *ceramicus* is uncertain and requires additional study; it was initially described as a species of *Stenomys* (Thomas, 1920), later designated as the type species of a monotypic genus *Nesoromys* (Thomas, 1922), and is now generally included within *Rattus* (Musser & Carleton, 1993). Compared to other *Rattus*, it exhibits an intriguing mosaic of both 'archaic' traits (see Aplin, Chesser & ten Have, 2003) and highly-derived features, the latter including the unique configuration of the palate (Thomas, 1922; Ellerman, 1941). In all known specimens, head and body length measures 118–135 mm ($n=3$), tail length 126–140 mm ($n=4$), hindfoot length 28–30 mm ($n=4$), ear length 17–18 mm ($n=4$), and weight 66.5 g ($n=1$). The mammary formula is not known.

A new Seramese rodent

During an expedition to Seram in May 1993, researchers from the Australian Museum trapped a single rat that is not referable to any of the species discussed above. This specimen represents a previously undescribed subspecies of the widespread Melanesian rodent *Melomys rufescens*.

***Melomys rufescens paveli* new subspecies**

Holotype: AM M31923, adult female, skin and skull, from near the village of Piliiana (c. 3°15'S, 129°30'E, elevation c. 400 m) on the south coast of Seram, collected 30 May 1993 by P. German and E. Tasker. The holotype is the only known specimen.

Diagnosis: body size very small, as for *M. r. niviventer* of the southern New Guinean lowlands (cf. Tate, 1951; Menzies, 1996); length of head–body approximately equal to tail length (96% of tail length in the holotype); dorsal pelage soft and brightly coloured (fur rufescent red-brown, with grey bases); venter pure white; dorsal surfaces of forefeet and hindfeet dark grey; tail unicoloured black, with one hair per tail scale; teeth very small; skull relatively narrow; nasal profile flat.

Distribution: known only from the type locality.

Etymology: for Pavel German, collector of the holotype and of many other important mammal specimens from throughout the Melanesian region.

Description: *M. r. paveli* possesses nearly all the features considered diagnostic of *Melomys rufescens* by Menzies

(1996), including the following external traits: (1) small body-size (*paveli* is smaller than all races of *M. rufescens* except *M. r. niviventer*; see Menzies, 1996); (2) a unicoloured black tail, slightly longer than the head and body, with tail scales raised, one hair per scale, and scale hairs very short; (3) rufescent red-brown dorsal coloration with a pure white venter; (4) broad hindfeet with a long first digit (hindfoot breadth/hindfoot length = 0.21 in *paveli*; vs a mean value of 0.24 in New Guinean *M. rufescens*; Menzies, 1996). It differs from other taxa placed in *M. rufescens* by Menzies (1996) in that the dorsal surfaces of the feet are darker, the teeth are smaller, the nasal profile is flat rather than convex, and the skull is relatively narrower (nasal length/zygomatic width is *c.* 0.80 in *M. r. paveli*, vs a mean value of 0.64 in New Guinean *rufescens*).

The holotype of *paveli* is an older adult with well-worn teeth. The cranium (broken by a break-back trap) is completely fragmented posterior to the frontals, maxillary zygomatic roots, and palate. The zygomatic plate is nearly vertical, thrown forward slightly toward its base. The teeth are small (Table 5); lower teeth measure as follows (length \times width, mm): M_1 (2.27 \times 1.46), M_2 (1.31 \times 1.54), M_3 (1.28 \times 1.19); width across incisor tips is 1.98 (maxillary) and 1.39 (mandibular). The palate terminates roughly at the posterior border of M^3 . Fur is richly rufescent red-brown on the dorsum (with dark grey fur bases), fading in brilliance on the sides of the body. The middle of the venter is pure white (with white bases) from chin to tail base. The tail is relatively short (as in lowland New Guinean subspecies, for which the ratio of head and body to tail length averages 0.98 according to Menzies, 1996), with 16 tail scales/mm in the midsection, as in *M. r. niviventer* (cf. Tate, 1951). A dark grey stripe covers the dorsal surfaces of the forefeet and hindfeet, the forefeet are much more heavily furred than the hindfeet, and the claws are white and very small. The mammae formula is 0 + 2 = 4, as in all other *Melomys* (*sensu stricto*) and closely related genera (excluding *Mammelomys*; Menzies, 1996). Weight (65.0 g), tibia length (32.2 mm), and forearm (= ulna) length (22.7 mm) for the holotype were measured in the field.

DISCUSSION

Melomys r. paveli can be immediately distinguished from other Seramese mosaic-tailed rats by both colour and external dimensions. Compared to *M. r. paveli*, *Melomys aerosus* is larger and much darker in overall coloration, with a relatively shorter tail and longer hindfoot (Table 3). With its striking orange-brown dorsal pelage, *Melomys fulgens* is most similar to *M. r. paveli* in colour, but is considerably larger-bodied, with a much longer tail (140% of head-body length). *Melomys fraterculus* is smaller-bodied, with a relatively longer tail (about 135% of head-body length) and relatively larger ear (Table 3). Among all Moluccan rodents, *M. r. paveli* most resembles *Melomys obiensis* of Obi and Bisa in the north-central Moluccas in body size and overall coloration (see Thomas, 1911;

Flannery, 1995b). However, compared to *M. obiensis*, *M. r. paveli* can be distinguished by its more brightly coloured dorsum, darker hindfeet, relatively shorter and unicoloured tail, smaller teeth, flatter nasal profile, and straighter zygomatic plate. The two species are probably not closely related.

Of the subspecies of *M. rufescens* (cf. Menzies, 1996), *M. r. paveli* most closely resembles *M. r. niviventer*, a small-bodied, short-tailed, and brightly coloured rat from the woodlands and grasslands of the lower Fly and Digul rivers of southern New Guinea (see Tate, 1951; Menzies, 1996) rather than the geographically nearer but larger-bodied *M. r. calidior* from the lowlands of south-western New Guinea (the vicinity of the Mimika River), or any of the other, larger lowland subspecies of northern New Guinea (reviewed by Menzies, 1996). It does not closely resemble *Melomys gracilis*, a larger, longer-tailed, and more densely furred species of the New Guinea highlands. *Melomys gracilis* (including *Melomys dollmani* Rümmler) was included in *Melomys rufescens* by Menzies (1996), but the two are easily diagnosed by morphological differences, and Flannery (1995a) cited evidence that they occur widely in sympatry. They are clearly separate biological species.

The single known specimen of *M. r. paveli* was a pregnant female collected in moderately disturbed mid-elevation rainforest in precipitous limestone country (see habitat figured by Flannery, 1995b: 31) with a break-back trap baited with roast coconut set on the ground at night. It was trapped at the same locality and in the same habitat as *Rattus feliceus*, the largest of the native Seramese murids, and *Rattus exulans*, a widespread and common south-east Asian commensal rodent. It is probably also sympatric with *Melomys fulgens*, also known only from lowland south Seram. *Melomys rufescens* is a good climber but is often trapped on the ground in New Guinea and the Bismarck Archipelago (Flannery, 1995a,b); it is rarely encountered in undisturbed forest, and probably favours modified habitats such as village gardens and secondary forest. It has a broad altitudinal range in New Guinea, occurring from sea level to about 2400 m (Flannery, 1995a).

The presence of *M. rufescens* in Seram is not particularly surprising, as the species is known from many other islands close to New Guinea, including Salawati and Waigeo (West Papuan Islands), Karkar (off the northern New Guinea coast), Sideia (off the south-eastern tip of New Guinea), and New Britain, New Ireland, and the Duke of York Group in the lower Bismarck Archipelago. In addition, closely allied species occur on the remote island of Manus in the Admiralty Islands (*M. matambuai*; see Flannery, Colgan & Trimble, 1994) and on Buka, Bougainville, and Choiseul in the northern Solomon Islands (*M. bougainville*; see Troughton, 1936; Flannery & Wickler, 1990). The ancestors of all of these populations (including that of Seram) presumably reached these oceanic islands all except Salawati and Sideia, land-bridge islands, by sweepstake dispersal over water.

As noted above, *M. r. paveli* differs in several ways from other mosaic-tailed rats placed in *M. rufescens* and

Table 4. Selected measurements for the holotypes of *Melomys rufescens niviventer* (as published by Tate, 1951) and *M. r. paveli*

	<i>niviventer</i> Lower Fly River AMNH 105431	<i>paveli</i> SC Seram AM M31923
Head and body length	121	123
Tail length	125	128
Hindfoot length	26	26.2
Ear length	14	14.6
Least interorbital width	5.6	5.3
Nasal length	11.1	12.2
Crown length M ¹⁻³	5.9	5.5
Zygomatic breadth	16	c. 14.7
M ¹ length × width	3.0 × 1.8	2.6 × 1.5
M ² length × width	2.0 × 1.8	1.8 × 1.8
M ³ length × width	1.0 × 1.1	1.1 × 1.1

can probably be considered as distinctive as *M. matambuiai* or *M. bougainville*, both of which are currently separated from *M. rufescens* as distinct species (Flannery, 1995b; Menzies, 1996). All these taxa are intimately related, and undoubtedly share a recent common ancestry; here we retain *paveli* within *rufescens* primarily on account of its very close resemblance to *M. r. niviventer* in colour and body size (Table 4).

The non-volant mammal faunas of Seram, Ambon and Buru

In addition to the six native rodent species reviewed above, 12 other wild-living non-volant mammals are known from Seram. These include an endemic genus and species of bandicoot *Rhynchomeles prattorum* (see Thomas, 1920; Groves & Flannery, 1990), two cuscuses (*Phalanger orientalis* and *Spilocuscus maculatus*), two civets (*Viverra tangalunga* and *Paradoxurus hermaphroditus*), a deer *Rusa timoriensis*, a wild pig (derived from hybridization between *Sus scrofa* and *Sus celebensis* according to Groves, 1981), and five widespread and common south-east Asian commensals and agricultural pests, i.e. the Asian house shrew *Suncus murinus* and the rodents *Rattus exulans* (the most common rodent in Seram), *Rattus nitidus*, *Rattus argentiventer* and *Rattus rattus* (Corbet & Hill, 1992; Kitchener *et al.*, 1993; Macdonald *et al.*, 1993). *Rattus exulans* and *R. nitidus* (which may have been introduced to Seram several millennia ago) have become naturalized there and apparently occur widely in many habitat types over a broad altitudinal range (Table 5), whereas *R. rattus* and *R. argentiventer* (which probably arrived much later, also with human assistance) are seemingly restricted to the lowlands and seem from collection records to remain largely dependent on human habitation and agriculture on Seram. Notably, a rat collected on Gunung Binaiya, Seram and recently referred to as '*Rattus cf. moluccarius*' (a synonym of *Rattus rattus*; see Musser, 1970) by Verneau, Catzeflis & Furano (1997) probably represents *R. nitidus* rather than *R. rattus*.

Table 5. Vouchered elevational records of introduced murids collected higher than sea level on Seram

Species	Elevation (m a.s.l.)
<i>Rattus exulans</i>	350 (AM)
	400 (AM)
	650 (WAM)
	760
	800 (AM)
	900 (AM)
	1400 (BMNH)
<i>Rattus nitidus</i>	1500 (WAM)
	1830 (BMNH)
	350 (AM)
	650 (WAM)
	1200 (BMNH)
<i>Rattus rattus</i>	1350 (WAM)
	1830 (BMNH)
	350 (AM)
	650 (WAM)

Aside from rodents, the Seramese bandicoot (known only by the type series collected at 1800 m a.s.l. on Gunung Manusela in 1920) is the only other non-volant mammal endemic to Seram. The civets, deer and pig were probably introduced by people in ancient times from Sulawesi (or in some cases, ultimately from islands on the Sunda Shelf; see Corbet & Hill, 1992). Flannery (1994, 1995b) suggested that both cuscuses may have been introduced to Seram (and other Moluccan islands) from New Guinea, but judging from the wide natural distribution of these genera on other islands in the vicinity of New Guinea (Flannery, 1995b), *Spilocuscus* and *Phalanger* could certainly be native to Seram. Recourse to Seramese subfossil deposits will be necessary to resolve this issue.

Undiscovered mammals probably occur on Seram. For example, Thomas (1920) recorded the possible presence of a triok ('judging from accounts given to Messrs Pratt by their native hunters, it seems probable that a species of *Dactylopsila* is also found in Ceram'). Macdonald *et al.* (1993: 163) additionally noted that 'two species of phalanger have been scientifically reported from the island although the local people seem to recognize three or four species; sexual and developmental dimorphism in coat colour may account for these differences in species number.' Although this explanation is probable, I have also seen a single trophy skin of an unidentified cuscus with an entirely dark chocolate-brown dorsum and a white venter, similar in appearance to *Phalanger sericeus* of New Guinea (MZB 14710, collected by Boeadi at Kelo, Seram in August 1987). Clearly additional trapping and collecting efforts are necessary, especially at higher altitudes, to complete the inventory of the mammal fauna of this large island.

The non-volant mammal faunas of Ambon and Buru merit brief discussion in comparison to Seram. Both cuscuses, the deer, the pig, and the civet *V. tangalunga* of Seram occur also on Ambon and Buru. The babirusa *Babyrousa babyrussa* additionally occurs on Buru, where

it was presumably introduced from Sulawesi or the Sula Islands in ancient times (Groves, 1980). *Suncus murinus*, *Rattus exulans* and *R. rattus* have been collected on both Ambon and Buru, and the introduced shrews *Crocidura maxi* and *Crocidura monticola* and the house mouse *Mus musculus* are also recorded from Ambon (Laurie & Hill, 1954; Corbet & Hill, 1992). Although Ambon and Seram were joined at times as a single Pleistocene landmass, and remain in close geographic proximity today, none of the seven endemic non-volant mammals of Seram (six rodents and a bandicoot) seems to occur on Ambon. This is probably explained by Ambon's considerably smaller size (761 km²) and much lower maximum elevation (only 1038 m), as well as the nearly complete modification of the island's native vegetation for agricultural cultivation (Coates & Bishop, 1997; Ellen, 1997), which has cleared most of the primary forest and probably increased the ubiquity of introduced predators (such as dogs, cats and viverrids) and commensal rats.

More surprising is the fact that no endemic non-volant mammals (or even any assuredly native non-volant mammals) have yet been documented from Buru. This is without doubt an artefact of insufficient collecting efforts; given its size (9505 km²), elevation (up to 2428 m), and geographic position, Buru can be expected to support a moderately diverse but highly endemic assemblage of native non-volant mammals, including rodents and marsupials. As a point of comparison, the similarly sized Philippine islands of Leyte (7370 km²) and Mindoro (10 570 km²) support five and seven native murids, respectively (Heaney *et al.*, 1998). Other vertebrate groups are not unusually depauperate on Buru, for example, the island supports 10 endemic bird species, including one endemic bird genus (Coates & Bishop, 1997). In particular, the highlands of Buru, which are particularly rich in endemic birds (White & Bruce, 1986; Jepson, 1993), are completely unsurveyed for mammals, and remain an outstanding priority for inventory work of mammals in the region.

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REFERENCES

- Aplin, K. P., Chesser, T. & ten Have, J. (2003). Evolutionary biology of the genus *Rattus*: profile of an archetypal rodent pest. In *Rats, mice, and people: rodent biology and management*: 487–498. Singleton, G. R., Hinds, L. A., Krebs, C. J. & Spratt, D. M. (Eds). Canberra: Australian Centre for International Agricultural Research.
- Coates, B. J. & Bishop, K. D. (1997). *A guide to the birds of Wallacea*. Alderley, Queensland: Dove.
- Corbet, G. B. & Hill, J. E. (1992). *The mammals of the Indomalayan region*. Oxford: Oxford University Press.
- Ellen, R. (1997). The human consequences of deforestation in the Moluccas. *Civilisations* **44**: 176–193.
- Ellerman, J. R. (1941). *The families and genera of living rodents II. Family Muridae*. London: British Museum (Natural History).
- Flannery, T. F. (1994). *Possums of the world: a monograph of the Phalangeroidea*. Sydney: GEO Productions.
- Flannery, T. F. (1995a). *Mammals of New Guinea*. Ithaca, NY: Cornell University Press.
- Flannery, T. F. (1995b). *Mammals of the south-west Pacific and Moluccan Islands*. Ithaca, NY: Cornell University Press.
- Flannery, T. F. & Wickler, S. (1990). Quaternary murids (Rodentia: Muridae) from Buka Island, Papua New Guinea, with descriptions of two new species. *Aust. Mammal.* **13**: 127–139.
- Flannery, T. F., Bellwood, P., White, J. P., Ennis, T., Irwin, G., Schubert, K. & Balasubramaniam, S. (1998). Mammals from Holocene archaeological deposits on Gebe and Morotai Islands, Northern Moluccas, Indonesia. *Aust. Mammal.* **20**: 391–400.
- Flannery, T. F., Colgan, D. & Trimble, J. (1994). A new species of *Melomys* from Manus Island, Papua New Guinea, with notes on the systematics of the *M. rufescens* complex (Muridae: Rodentia). *Proc. Linn. Soc. N. S. W.* **114**: 29–43.
- Groves, C. P. (1980). Notes on the systematics of *Babyrousa* (Artiodactyla, Suidae). *Zoologische Mededelingen Leiden* **55**: 29–46.
- Groves, C. P. (1981). Ancestors for the pigs: taxonomy and phylogeny of the genus *Sus*. *Aust. Natl. Univ. Res. School Pacific Stud., Dept. Prehist. Tech. Bull.* **3**: i–vii, 1–96.
- Groves, C. P. & Flannery, T. F. (1990). Revision of the families and genera of bandicoots. In *Bandicoots and bilbies*: 1–11. Seebeck, J. H., Brown, P. R., Wallis, R. L. & Kemper, C. M. (Eds). Norton, New South Wales: Surrey Beatty.
- Groves, C. P. & Flannery, T. F. (1994). A revision of the genus *Uromys* Peters, 1867 (Muridae: Mammalia) with descriptions of two new species. *Rec. Aust. Mus.* **46**: 145–169.
- Hasagawa, H. & Syafrudin (1995a). Nematode fauna of the two sympatric rats *Rattus rattus* and *R. exulans*, in Kao District, Halmahera Island, Indonesia. *J. Helminth. Soc. Wash.* **62**: 27–31.
- Hasagawa, H. & Syafrudin (1995b). *Nippostrongylus marhaeniae* sp. n. and other nematodes collected from *Rattus* cf. *morotaiensis* in North Halmahera, Molucca Islands, Indonesia. *J. Helminthol. Soc. Wash.* **62**: 111–116.
- Heaney, L. R., Balete, D. S., Dolar, M. L., Alcalá, A. C., Dans, A. T. L., Gonzales, P. C., Ingle, N. R., Lepiten, M. V., Oliver, W. L. R., Ong, P. S., Rickart, E. A., Tabaranza, B. R. Jr & Uzzurum, R. C. B. (1998). A synopsis of the mammalian fauna of the Philippine Islands. *Fieldiana Zool.* **88**: 1–61.
- Jepson, P. (1993). Recent ornithological observations from Buru. *Kukila* **6**: 85–109.
- Kellogg, R. (1945). Two rats from Morotai Island. *Proc. Biol. Soc. Wash.* **58**: 65–68.
- Kitchener, A. C., Clegg, T., Thompson, N. M. J., Wilk, H. & MacDonald, A. A. (1993). First records of the Malay civet, *Viverra zibetha* Gray, 1832, on Seram, with notes on the Seram bandicoot *Rhynchomeles pratorum* Thomas, 1920. *Z. Säugetierkd.* **58**: 378–380.
- Kitchener, D. J. & Maryanto, I. (1993). A new species of *Melomys* (Rodentia, Muridae) from Kai Besar Island, Maluku Tengah, Indonesia. *Rec. West. Aust. Mus.* **16**: 427–436.

- Kitchener, D. J. & Maryanto, I. (1995). A new species of *Melomys* (Rodentia, Muridae) from Yamdena Island, Tanimbar group, Eastern Indonesia. *Rec. West. Aust. Mus.* **17**: 43–50.
- Kitchener, D. J. & Suyanto, A. (1996). A new species of *Melomys* (Rodentia, Muridae) from Riama Island, Tanimbar group, Maluku Tenggara, Indonesia. *Rec. West. Aust. Mus.* **18**: 113–119.
- Laurie, E. M. O. & Hill, J. E. (1954). *List of land mammals of New Guinea, Celebes, and adjacent islands, 1758–1952*. London: British Museum (Natural History).
- Macdonald, A. A., Hill, J. E., Boeadi & Cox, R. (1993). The mammals of Seram, with notes on their biology and local usage. In *Natural history of Seram, Maluku, Indonesia*: 161–190. Edwards, I. D., Macdonald, A. A. & Procter, J. (Eds). Andover: Intercept.
- Menzies, J. I. (1990). A systematic revision of *Pogonomelomys* (Rodentia: Muridae) of New Guinea. *Sci. New Guinea* **16**: 118–137.
- Menzies, J. I. (1996). A systematic revision of *Melomys* (Rodentia: Muridae) of New Guinea. *Aust. J. Zool.* **44**: 367–426.
- Musser, G. G. (1970). *Rattus masarettes*: a synonym of *Rattus rattus moluccarius*. *J. Mammal.* **51**: 606–609.
- Musser, G. G. (1981). The giant rat of Flores and its relatives east of Borneo and Bali. *Bull. Am. Mus. nat. Hist.* **169**: 67–176.
- Musser, G. G. & Carleton, M. D. (1993). Family Muridae. In *Mammal species of the world: a taxonomic and geographic reference*: 501–755. 2nd edn. Wilson, D. E. & Reeder, D. R. (Eds). Washington, DC: Smithsonian Institution Press.
- Musser, G. G. & Durden, L. A. (2002). Sulawesi rodents: description of a new genus and species of Murinae (Muridae, Rodentia) and its parasitic new species of sucking louse (Insecta, Anoplura). *Am. Mus. Novit.* **3368**: 1–50.
- Musser, G. G. & Heaney, L. R. (1992). Philippine rodents: definitions of *Tarsomys* and *Limnomys* plus a preliminary assessment of phylogenetic patterns among native Philippine murines (Murinae, Muridae). *Bull. Am. Mus. nat. Hist.* **211**: 1–138.
- Musser, G. G., Heaney, L. R. & Tabaranza, B. R., Jr (1998). Philippine rodents: redefinitions of known species of *Batomys* (Muridae, Murinae) and descriptions of a new species from Dinagat Island. *Am. Mus. Novit.* **3237**: 1–51.
- Musser, G. G. & Holden, M. E. (1991). Sulawesi rodents (Muridae: Murinae): morphological and geographical boundaries of species in the *Rattus hoffmanni* group and a new species from Pulau Peleng. *Bull. Am. Mus. nat. Hist.* **206**: 322–413.
- Musser, G. G. & Newcomb, C. (1983). Malaysian murids and the giant rat of Sumatra. *Bull. Am. Mus. nat. Hist.* **174**: 327–598.
- Riley, J. (2002). Mammals on the Sangihe and Talaud Islands, Indonesia, and the impact of hunting and habitat loss. *Oryx* **36**: 288–296.
- Rümmler, H. (1938). Die Systematik und Verbreitung der Muriden Neuguineas. *Mitt. Zool. Mus. Berl.* **23**: 1–298.
- Tate, G. H. H. (1951). Results of the Archbold Expeditions. No. 65. The rodents of Australia and New Guinea. *Bull. Am. Mus. nat. Hist.* **97**: 183–430.
- Taylor, J. M., Calaby, J. H. & van Deusen, H. M. (1982). A revision of the genus *Rattus* (Rodentia: Muridae) in the New Guinean region. *Bull. Am. Mus. nat. Hist.* **173**: 177–336.
- Thomas, O. (1911). New Asiatic Muridae. *Ann. Mag. nat. Hist.* (ser. 8) **7**: 205–209.
- Thomas, O. (1920). On mammals from Ceram. *Ann. Mag. nat. Hist.* (ser. 9) **6**: 422–431.
- Thomas, O. (1921a). On a collection of rats and shrews from the Dutch East Indian Islands. *Treubia* **2**: 109–114.
- Thomas, O. (1921b). On a new genus and species of shrew, and some new Muridae from the East-Indian Archipelago. *Ann. Mag. nat. Hist.* (ser. 9) **7**: 241–250.
- Thomas, O. (1922). New mammals from New Guinea and neighbouring islands. *Ann. Mag. nat. Hist.* (ser. 9) **9**: 261–265.
- Troughton, E. le G. (1936). The mammalian fauna of Bougainville Island, Solomons Group. *Rec. Aust. Mus.* **19**: 341–353.
- Verneau, O., Catzeflis, F. & Furano, A. V. (1997). Determination of the evolutionary relationships in *Rattus* sensu lato (Rodentia: Muridae) using L1 (LINE-1) amplification events. *J. mol. Evol.* **45**: 424–436.
- White, C. M. N. & Bruce, M. D. (1986). *The birds of Wallacea. B. O. U. Checklist No. 7*. London: British Ornithologists' Union.