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## **Distribution, Present and Past, of *Rattus praetor* in the Pacific and Its Implications<sup>1</sup>**

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**ABSTRACT:** We outline the current distribution of *Rattus praetor* in Near Oceania and present new evidence for its association with prehistoric human settlement on some islands in Remote Oceania. We discuss the problems of determining intentionality in the human transport of this animal, with reference to other examples of animal translocation in the Pacific. Current and prehistoric disjunct distributions of all domestic and nearly all wild mammals in both Near and Remote Oceania point to a common pattern of human behavior and in particular the deliberate translocation of *R. praetor* into Remote Oceania.

HUMAN SETTLEMENT OF Remote Oceania, the islands of the Pacific east and south of the Solomons (Green 1991a), was accompanied by a range of humanly transported landscapes, both material and conceptual. Within these, animals played a considerable role, whether their human bearers were conscious of it or not. Some animals (e.g., pigs) were so large that they can only have arrived in new homelands as the result of deliberate transport; with others (e.g., microscopic snails), intentional carriage is unlikely. Rats lie between these size extremes and are thus useful in considering the logic by which the intentionality of transport has been determined.

Not all the transported landscapes of Remote Oceania were actually stocked with the same range of animals, and consideration of the absences is another avenue for investigating intentional translocation. Presence of large animals is clear evidence of intentionality, but is their absence accident or design? Answers to such a question bear also on wider discussions, such as the frequency and duration of voyages between islands and groups.

Here we discuss the discovery of *Rattus praetor* in several archaeological sites in Remote Oceania. The limited and disjunct distribution of this species raises the question of intentionality. Allen et al. (1989:555) and Green and Kirch (1997:25) have already suggested that its distribution to the two relatively isolated islands of Nissan and Tikopia implies intentional translocation. We agree with them, and further contend that a widespread pattern of deliberate decision making concerning the transport of many animals is implied by their disjunct distributions in both Near and Remote Oceania. Also implied is little or no distinction in this matter between domestic and wild animals.

We outline first the current distribution of *R. praetor*, then the changes to this distribution during the past 3000 yr. We next outline the metrical basis for our identification of *R. praetor* and finally discuss our findings in the context of known current and past animal translocations.

### *Current Distribution*

*Rattus praetor* (Thomas, 1888), the Large Spiny Rat, is some 20 cm long and weighs around 200 g. It is called spiny because of its spinous hair, especially in the ventral region. It is currently regarded as a native of New Guinea, where it is widespread on both sides of the central cordillera in Irian Jaya. Only on the north side does it extend into Papua

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New Guinea, being found as far east as the Sepik-Ramu drainage (Flannery 1990). Although found at altitudes of up to 1900 m, it is more common in lowland areas. Flannery (1995) reported that it is also found on several small islands off New Guinea's coasts (Bat, Blup Blup, Karkar), in Salawati and Gebe west of New Guinea, and in the Bismarck Archipelago and some Solomon Islands (Bougainville, Guadalcanal, ?Choiseul) to the east.

Its habitats are diverse. Taylor et al. (1982) noted that it can be a strong burrower and has been seen climbing over rocks and logs. It is also an opportunist, having been captured in food supplies and in buildings made of traditional materials as well as around concrete dugouts. However, "that it travels in man's cargo across ocean straits is undocumented" (Taylor et al. 1982: 217 [the context implies adventitious travel, see also 221]). Flannery (1995:159) said that *R. praetor* "is common in disturbed habitats throughout most of its range," a rather less-specific statement about its association with humans than an earlier description of it as "a commensal murid" (Flannery et al. 1988: 93). Taylor et al. (1982: 217, 222) also noted that *R. praetor* is sympatric with *R. exulans* and *R. rattus* throughout its current range.

#### *Prehistoric Evidence within the Area of Current Distribution*

As a result of archaeological research during the last two decades, it is now apparent that *R. praetor* is almost certainly a native only of the main island of New Guinea, its presence on other large islands deriving from its association with humans. The primary basis of the claim is that the species is never found in the earliest settlement levels, but sometimes occurs subsequently. (There is no archaeology of the small offshore islands.)

The relatively recent arrival of *R. praetor* is best documented at present in New Ireland, where a series of cave and rockshelter sites, dating back more than 30,000 <sup>14</sup>C yr B.P. in some cases, has been excavated (Allen and Gosden 1991, Allen et al. 1989). At Balof 2 (Flannery and White 1991, White

et al. 1991), identification of mandibles and maxillae has shown that *R. praetor* is found only in the top two horizons, which date at most to the last 3000–4000 yr. It is contemporaneous with *R. exulans* and does not overlap with *R. mordax*, which is found in earlier Holocene and Late Pleistocene levels.

A much earlier presence of *R. praetor* has been recorded by Marshall and Allen (1991:78) at Panakiwuk cave, at the north end of the island. There it appears first in Unit 11, dated to ca. 13,000 yr B.P., and is said to be "common" in the site from then until the present. According to their Table 16, however, the next identified specimen is in Unit 8, which dates to the early Holocene. No counts are given. At this site *R. praetor* and *R. mordax* are contemporaries for a considerable period. The lowest level of human occupation is dated to ca. 15,000 yr B.P. (Marshall and Allen 1991: 66).

A single left humerus has been recorded from the Dori site at Lasigi, dated probably to ca. 2000 yr B.P. (Golson 1991: 251).

Moving farther south, Leavesley and Allen (1998: 74) noted that *R. praetor* might be present among the small number of large rat bones that could not be more precisely identified at the site of Buang Marabek. They reported that it is not present in Matenbek (1998: 77). The fauna from the other Pleistocene site in New Ireland, Matenkupkum, has not been reported in detail.

The variation in apparent occurrence along the length of New Ireland is curious because of its presence throughout the island today. The explanation probably lies in the chances of deposition and excavation. For example, it seems very likely that some of the 246 "large rats" (i.e., *R. praetor* and *R. mordax*) identified at Panakiwuk derive from owl pellets, as do the very large number of *Melomys rufescens* bones (Marshall and Allen 1991: 83–84). The use by owls of caves used by humans, and thus the depositing of bones, is presumably haphazard. We note also that many of these excavations are of quite small volumes.

On Manus, at the site of Pamwak, Williams (1997) reported that *R. praetor* is found in levels dated between 9000 and 5000 yr B.P.

Human use of the site begins earlier than 14,000 yr ago.

The only published report of *R. praetor* in prehistoric sites in the Solomons is a single left dentary from site DAI on Buka Island, dated to ca. 1800–2000 yr B.P. (Flannery et al. 1988:90). Flannery et al. attributed the absence to the use of 5-mm sieves. But *R. praetor* does not occur among the 126 mandibles and maxillae from five rodent species excavated by S. Wickler from site DJA (Test Pit 3) on Buka (White, 1989, unpubl. reports in author's possession on faunal identifications of Buka sites; Wickler 1995), although Wickler used 3.2-mm sieves. The earliest levels of this 2.4-m-deep site date to 29,000 yr B.P. The top 40 cm was laid down after 2500 yr B.P. and contains the only examples of *R. exulans* (Wickler and Spriggs 1990). Roe (1993, vol. 1:96) recovered some *R. praetor* bones from level 4 of Havatu III site on northwestern Guadalcanal, just above a basal level dated to ca. 390 yr B.P. There are a few specimens of a size comparable with that of *R. praetor* in sites DBE, DJO-A, DJO-B, and DJO-D, also on Buka, but more precise identifications have not been possible and the bones may belong to other contemporary species. The DJO sites date to less than 3000 yr ago, and DBE is Holocene.

This overview shows that it is difficult to draw more than general conclusions about the history of *R. praetor* in this area. It appears only after human presence has been maintained for some time—so far, terminal Pleistocene is the earliest date claimed for it. In this regard, *R. praetor*'s history is remarkably parallel to that of several other "wild" animals that also appear in archaeological

sites well after human arrival. These arrivals are discussed further below.

#### *Range Extension into Remote Oceania in Prehistoric Times*

The occurrence of rat bones larger than the common *R. exulans* previously has been noted on Tikopia (Kirch and Yen 1982:278) and Reefs–Santa Cruz (Green and Cresswell 1976:256). In the latter case two size ranges of rats larger than *R. exulans* were identified by A. Zeigler from site SE-RF-2. The larger of these two species Zeigler thought to be *R. rattus* or *R. norvegicus*, and the smaller was said to be possibly *R. ruber*. Subsequent research by B. Marshall (in litt. to R. Green, 25 August 1989) showed that the larger species in fact matched the *R. praetor* reference material from New Ireland in size and tooth configuration. These specimens come from levels dated to ca. 3000 yr B.P. (R. Green, in litt., 16 June 1998; see also Green 1991b:200). But the first definite identification of *R. praetor* in Remote Oceania was by Flannery et al. (1988) of bones from Tikopia, where it was dated to 2300 yr B.P. *Rattus praetor* was not associated with the earliest settlements, and the animal now seems to be extinct, as it is on Nissan and Santa Cruz. Mandible M/1–3 lengths of the prehistoric animals are given in Table 1.

A much larger collection of *R. praetor* has now been identified from Vanuatu, from Bedford's excavations in Navaprah cave, near Lekken village in northwest Malakula (Bedford et al. 1998). A total of 138 rodent dentaries was recovered. Our measures of M/1–3 fell into two clear groups, one ranging

TABLE 1  
M/1–3 LENGTHS (mm) FOR PREHISTORIC *Rattus praetor*

| SITE                | NO. | MEAN | MEDIAN | RANGE   | REFERENCE                          |
|---------------------|-----|------|--------|---------|------------------------------------|
| Tikopia             | 4   | 8.0  | na     | 7.7–8.5 | Flannery et al. (1988)             |
| SE-RF-2, Santa Cruz | 4   | 8.0  | na     | 7.8–8.1 | Marshall (in litt., 1989), table 2 |
| Navaprah, Malakula  | 41  | 7.3  | 7.2    | 6.7–8.1 | J.P.W., laboratory notes           |
| 101/7/197, Fiji     | 7   | 8.2  | 8.4    | 7.4–8.6 | J.P.W., laboratory notes           |
| Sovanibeka, Fiji    | 5   | 7.7  | 7.6    | 7.3–8.0 | J.P.W., laboratory notes           |

from 4.5 to 6.0 mm (median 5.3 mm) and the other from 6.7 to 8.1 mm (median 7.2 mm) (Table 1). The former is *R. exulans*. The latter is attributed to *R. praetor* on the basis of specimen size and the morphology of molars, notably their lack of accessory cuspules and simplicity. Comparisons were also made with *R. rattus*, *R. tanezumi*, and *R. mordax* material in the Australian Museum collections.

*Rattus praetor* is concentrated in 1 m<sup>2</sup> of the excavation, and the condition of the bones shows they must derive from owl pellets. *Rattus praetor* occurs through the Navaprah deposit, from the lowest levels dated to ca. 2700–2500 yr B.P., to levels dated to ca. 470–630 yr B.P. It is not found in levels above 60 cm below datum, though there is very little bone in these.

Bones of similar size, although not in such quantity, have been recovered from Yalu and Womplamplam, two other cave sites in the same area of Malakula. These sites demonstrate a ceramic chronology similar to that of Navaprah and can be assumed to be of a similar date. Recent excavations at the Mangaasi site on Efate (Bedford et al. 1998; cf. Garanger 1971) have also produced rodent long bones and a mandible, all of which fall within the measurement range of *R. praetor*.

No *R. praetor* has been found in cave or open sites on Erromanga, even though some date from an early period of human occupation. *Rattus praetor* is not extant anywhere in Vanuatu.

Two sites on Fiji have recently produced rat bones that we attribute to *R. praetor*. On Lakeba, site 101/7/197, excavated by S. Best (Best 1984), produced seven large rodent dentaries in levels N–S, dated to >2200 yr B.P. Best originally noted that these bones were large, but was inclined to attribute them to *R. norvegicus*. Their size and the morphology of the molars, however, places them firmly with *R. praetor*. Their position in the deposit also makes *R. norvegicus* improbable, because there are no other pre-European records of this species and the deposit is not disturbed, so intrusion is unlikely.

The presence of *R. praetor* in Fiji is supported by 12 dentaries from a test pit dug by G. Hope and C. Ollier in the limestone over-

hang Sovanibeka on Mago Island (Clark and Hope 1997). As at Navaprah the dentaries fall into two size groups. One is clearly *R. exulans* (M/1–3: 4.8–5.8 mm,  $n = 7$ ), but the other is much larger (7.3–8.0 mm,  $n = 5$ ) (Table 1). The larger dentaries were checked against *R. praetor*, *R. rattus*, *R. tanezumi*, and *R. norvegicus* specimens at the Australian Museum and proved to be most like *R. praetor* in terms of size and morphology. The nearby open site of Votua (Anderson and Clark 1999) produced three postcranial rat bones with measurements within the Vanuatu *R. praetor* range (Table 2), but these could not be further identified.

Fiji is so far the most easterly extension of *R. praetor* in prehistoric times, but it is no longer found there.

No large rat bones have been reported from prehistoric sites in New Caledonia, nor is *R. praetor* present there today (Rageau 1957, Flannery 1995).

Poulsen (1987:247) reported three large rodent bones from site Tol on the main island of Tongatapu, but the site includes both early and late elements and *R. rattus* appears to be a possible source. J.P.W.'s check of thousands of rat bones from the Tongoleleka site in the Ha'apai group, dated to ca. 2700 yr B.P. (Shutler et al. 1994), revealed only animals in the size range of *R. exulans*.

We conclude this section by noting that in 1991 Roberts' review of the distribution of *R. exulans* suggested the existence of an "exulans only" boundary at Tikopia. Beyond this, *R. exulans* is "the only rat species known to have been introduced prehistorically" (Roberts 1991:126). That boundary can now be seen to have varied with time. At its maximum extent it lay south and east of Vanuatu and Fiji, whereas its current limit is the southern end of the Solomons (Flannery 1995). Further research may produce other changes.

#### *Identification of Rattus praetor*

The claims made above for an extension in the prehistoric distribution of *R. praetor* into Remote Oceania require a demonstration

TABLE 2  
MANDIBULAR AND POSTCRANIAL DIMENSIONS<sup>a</sup> OF POLYNESIAN AND VANUATU *Rattus exulans* AND VANUATU *Rattus praetor*

| MANDIBLE | Rattus exulans—POLYNESIA |          |         |  | Rattus exulans—VANUATU |          |          |  | Rattus praetor—VANUATU |          |  |          |
|----------|--------------------------|----------|---------|--|------------------------|----------|----------|--|------------------------|----------|--|----------|
|          | Mand. L.                 | M1—M3 L. | Mand H. |  | Mand. L.               | M1—M3 L. | Mand. H. |  | Mand. L.               | M1—M3 L. |  | Mand. H. |
| Number   | 90                       | 178      | 195     |  | 39                     | 76       | 64       |  | 15                     | 45       |  | 26       |
| Mean     | 16.1                     | 6.0      | 4.5     |  | 15.5                   | 5.3      | 4.0      |  | 20.4                   | 7.3      |  | 5.7      |
| Min.     | 13.4                     | 4.9      | 3.5     |  | 13.2                   | 4.5      | 2.9      |  | 16.9                   | 6.5      |  | 4.8      |
| Max.     | 19.0                     | 7.2      | 5.3     |  | 16.6                   | 5.9      | 4.7      |  | 22.2                   | 7.9      |  | 6.7      |
| SD       | 1.1                      | 0.5      | 0.4     |  | 0.8                    | 0.3      | 0.4      |  | 1.5                    | 0.3      |  | 0.5      |
| CV       | 6.1                      | 7.8      | 8.9     |  | 5.2                    | 5.2      | 9.6      |  | 7.1                    | 4.6      |  | 8.2      |

| HUMERUS | Rattus exulans—POLYNESIA |     |         |         | Rattus exulans—VANUATU |      |     |         | Rattus praetor—VANUATU |     |      |     |         |         |     |
|---------|--------------------------|-----|---------|---------|------------------------|------|-----|---------|------------------------|-----|------|-----|---------|---------|-----|
|         | GL                       | BP  | MS(m-l) | MS(a-p) | BD                     | GL   | BP  | MS(m-l) | MS(a-p)                | BD  | GL   | BP  | MS(m-l) | MS(a-p) | BD  |
| Number  | 79                       | 91  | 156     | 152     | 147                    | 57   | 19  | 27      | 27                     | 60  | 31   | 3   | 25      | 25      | 45  |
| Mean    | 18.6                     | 3.5 | 1.4     | 1.6     | 4.2                    | 16.7 | 3.2 | 1.6     | 1.8                    | 3.8 | 20.9 | 4.9 | 2.0     | 2.4     | 5.4 |
| Min.    | 14.6                     | 3.0 | 1.0     | 1.1     | 3.1                    | 14.2 | 3.0 | 1.3     | 1.6                    | 1.7 | 16.0 | 4.8 | 1.7     | 2.0     | 4.4 |
| Max.    | 20.8                     | 4.1 | 1.8     | 2.3     | 5.0                    | 18.3 | 3.6 | 1.9     | 2.2                    | 4.3 | 26.1 | 5.2 | 2.4     | 2.9     | 6.3 |
| SD      | 1.2                      | 0.3 | 0.1     | 0.3     | 0.4                    | 0.9  | 0.1 | 0.2     | 0.2                    | 0.3 | 2.6  | 0.2 | 0.2     | 0.2     | 0.5 |
| CV      | 6.2                      | 7.4 | 10.3    | 16.2    | 9.8                    | 5.7  | 4.4 | 12.6    | 9.5                    | 9.1 | 12.5 | 4.4 | 8.1     | 8.7     | 8.9 |

| FEMUR  | Rattus exulans—POLYNESIA |     |         |         | Rattus exulans—VANUATU |      |     |         | Rattus praetor—VANUATU |     |      |      |         |         |     |
|--------|--------------------------|-----|---------|---------|------------------------|------|-----|---------|------------------------|-----|------|------|---------|---------|-----|
|        | GL                       | BP  | MS(m-l) | MS(a-p) | BD                     | GL   | BP  | MS(m-l) | MS(a-p)                | BD  | GL   | BP   | MS(m-l) | MS(a-p) | BD  |
| Number | 89                       | 87  | 88      | 88      | 85                     | 137  | 96  | 155     | 155                    | 68  | 18   | 17   | 24      | 24      | 7   |
| Mean   | 25.6                     | 5.3 | 2.6     | 2.1     | 4.4                    | 22.1 | 4.6 | 2.4     | 1.9                    | 4.0 | 27.2 | 6.5  | 3.4     | 2.6     | 6.1 |
| Min.   | 22.6                     | 4.5 | 2.1     | 1.8     | 3.8                    | 16.0 | 3.6 | 1.9     | 1.5                    | 3.6 | 22.1 | 5.2  | 3.1     | 2.3     | 5.8 |
| Max.   | 29.6                     | 6.1 | 3.3     | 2.7     | 4.9                    | 27.8 | 5.6 | 3.1     | 2.6                    | 4.6 | 34.3 | 8.0  | 4.1     | 3.1     | 6.4 |
| SD     | 1.6                      | 0.4 | 0.2     | 0.2     | 0.2                    | 2.4  | 0.4 | 0.2     | 0.2                    | 0.2 | 3.6  | 0.7  | 0.3     | 0.2     | 0.3 |
| CV     | 6.2                      | 6.7 | 8.8     | 8.3     | 5.2                    | 10.8 | 7.9 | 9.5     | 10.2                   | 5.1 | 13.2 | 11.2 | 7.8     | 7.5     | 4.2 |

TABLE 2 (continued)

| TIBIA  | <i>Rattus exulans</i> —POLYNESIA |         |         |      |     | <i>Rattus exulans</i> —VANUATU |         |         |     |     | <i>Rattus praetor</i> —VANUATU |         |         |     |     |
|--------|----------------------------------|---------|---------|------|-----|--------------------------------|---------|---------|-----|-----|--------------------------------|---------|---------|-----|-----|
|        | GL                               | MS(m-l) | MS(a-p) | BD   | DD  | GL                             | MS(m-l) | MS(a-p) | BD  | DD  | GL                             | MS(m-l) | MS(a-p) | BD  | DD  |
| Number | 60                               | 214     | 214     | 132  | 134 | 155                            | 26      | 26      | 240 | 240 | 23                             | 26      | 26      | 55  | 55  |
| Mean   | 30.0                             | 1.7     | 1.7     | 2.7  | 2.2 | 25.8                           | 1.7     | 1.8     | 2.5 | 2.0 | 33.4                           | 2.4     | 2.6     | 3.4 | 2.8 |
| Min.   | 27.8                             | 1.3     | 1.3     | 2.2  | 1.6 | 19.8                           | 1.4     | 1.6     | 1.9 | 1.4 | 25.2                           | 2.0     | 2.2     | 2.7 | 2.2 |
| Max.   | 32.6                             | 2.3     | 2.3     | 4.0  | 3.0 | 29.9                           | 2.1     | 2.2     | 2.8 | 2.3 | 37.4                           | 2.8     | 3.1     | 4.0 | 3.3 |
| SD     | 1.2                              | 0.2     | 0.2     | 0.4  | 0.2 | 1.6                            | 0.2     | 0.2     | 0.2 | 0.1 | 3.7                            | 0.2     | 0.3     | 0.3 | 0.3 |
| CV     | 4.1                              | 12.4    | 11.6    | 12.9 | 8.3 | 6.1                            | 9.4     | 8.9     | 6.5 | 7.6 | 10.9                           | 7.7     | 10.8    | 7.7 | 9.8 |

<sup>a</sup> *Measurement description:* Mandible length (Mand. L.): midpoint of the arc between the condyloid process and the angular process to the anterodorsal edge of the infradentale. Tooth row length (M1-M3 L.): posterior to anterior border of the dental alveoli. Mandible height (Mand. H.): corpus height from the anterodorsal border of M1 to the ventral corpus. Postcranial measures: GL, greatest limb length; BP, proximal breadth; BD, distal breadth; DD, distal breadth, after von den Dreisch (1976). MS(m-l), midshaft diameter in the mediolateral plane; MS(a-p), midshaft diameter in the anteroposterior plane.

that we can there distinguish *R. praetor* remains from the more widely distributed *R. exulans* (Roberts 1991). Our ability to do so is complicated by two factors:

1. Within *Rattus* there is considerable intraspecific variation attributable to a range of influences, among which altitude, latitude, level of interspecies competition, diet, and population insularity are important (Taylor et al. 1982, Atkinson and Moller 1998). We can therefore anticipate that species with extensive geographical ranges will demonstrate considerable amounts of skeletal variation. Support for hypervariability in the physical characters and skeleton of *R. exulans* has been noted by various authorities (e.g., Moller 1977) and most recently by Matisoo-Smith and Allen (in press), who noted some overlap with *R. praetor* in the length of the mandibular tooth row.

2. Because we are working with archaeological samples, which are often small in number and fragmented, the taxonomic concentration on crania and, to a lesser extent, the mandible in zoological studies (Taylor et al. 1982, Flannery 1990) limits our comparisons. Attempts to identify *R. exulans* using skeletal data display a similar focus on cranial elements (e.g., Miller 1924, Taylor et al. 1982), although some archaeologists have quantified some postcranial variation in the service of species attribution (Best 1984: 540–544, Spennemann 1989: vii, Matisoo-Smith and Allen in press).

Thus the recovery of large numbers of reasonably complete prehistoric rat bones from Vanuatu (notably from Navaprah, but also from Womplamplam and Yalu) gives us the opportunity to establish the osteometric parameters of *R. praetor* and *R. exulans* there.

Individual skeletal elements were initially ranked on the basis of size (length), when it was apparent that the majority were very similar with some larger. Measurements were restricted to the most numerous surviving elements and to those dimensions that could be recorded on the material. The sample was divided into two groups: all those larger than standard and a large sample of the standard-sized ones. Our sample does not reflect mini-

mum number of individuals (MNI) or any other abundance measure.

Eighteen measures based on von den Dreisch (1976) from four skeletal elements (mandible, humerus, femur, tibia) were taken on the two groups of Vanuatu rat remains and on a sample of prehistoric *R. exulans* from Polynesia (Easter Island, Marquesas, Hawai'i, Tonga, Norfolk Island). Descriptive statistics for the dimensions of the three groups and description of measurements are given in Table 2.

Table 2 shows that in most dimensions the means of the Polynesian *R. exulans* are slightly higher than those from Vanuatu. The smaller Vanuatu measures could be due to competition from the larger rat (cf. New Zealand data [Taylor 1975]) or be expressing a wider latitudinal effect, shown by smaller *R. exulans* in New Guinea and the largest in subtropical Polynesia (Moller 1977, Atkinson and Moller 1998, Matisoo-Smith and Allen in press).

We note that because dimensions of smaller or immature *R. praetor* are likely to overlap with those of the largest *R. exulans* in Vanuatu or elsewhere, no single set of measurements is likely to separate absolutely *R. praetor* from other similar-sized rat species. However, the variance statistics (standard deviation, coefficient of variation) clearly show that the measurements from the larger Vanuatu bones form a coherent group and this group is unlikely to represent very large individual *R. exulans*. We attribute this group to *R. praetor*. Variance statistics for the smaller animals also indicate a coherent group and are similar to those of the Polynesian sample of *R. exulans*.

Figures 1 and 2 are bivariate plots that demonstrate substantial separation between the two species using distal epiphysis and midshaft dimensions from the femur and tibia, respectively. These are loosely correlated with body weight (Anderson et al. 1985) and thus can be useful for separating the two species. The figures do not include the two sets of Fijian rat bones because they were few and considerably broken. However, their dimensions are consistent with the Vanuatu *R. praetor* series.



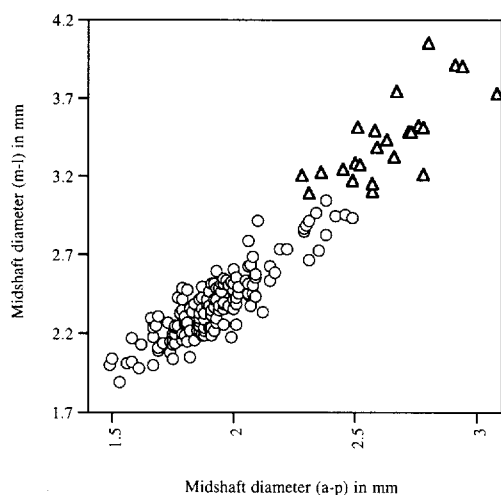


FIGURE 1. Bivariate plot of midshaft femur dimensions for *R. exulans* (circles) and inferred *R. praetor* (triangles) from Vanuatu.

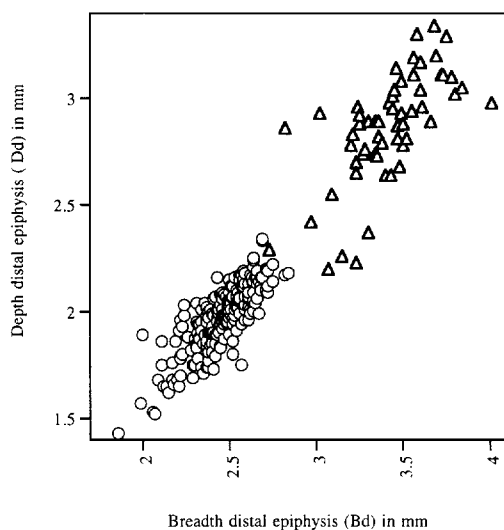


FIGURE 2. Bivariate plot of distal tibia dimensions for *R. exulans* (circles) and inferred *R. praetor* (triangles) from Vanuatu.

#### DISCUSSION

From its irregular distribution in time and space, it might be assumed that the adventitious nature of *R. praetor*'s diaspora is obvious, as Flannery (1995:43) claimed. But we

argue that such is not the case when this dispersal is looked at in the wider context of human-animal relationships in the Pacific.

We start by noting that the "spotty" distribution of *R. praetor* beyond the Bismarck Archipelago could be the simple artifact of an inadequate archaeological record. But we propose to accept it as real for the following reasons. First, we do not know the record is inadequate: we must build our models on available data. Second, as will be seen, the "spotty" distribution of *R. praetor* is similar to the distribution of other, better-documented, animals in the Pacific, suggesting that the distribution may be real. We now discuss some of these other distributions, excluding from our examples animals such as snails and skinks whose translocation is almost certainly unintentional (although even within this size range culturally appropriate exceptions are possible).

The translocation of a range of larger animals that would normally be considered "wild" is well documented throughout human history in Near Oceania. In New Ireland, the marsupials *Phalanger orientalis* and *Thylogale browni* appear in the Late Pleistocene and early Holocene (Flannery and White 1991, Leavesley and Allen 1998). *Spilogale maculatus*, today found throughout the northern part of the island, was introduced between A.D. 1929 and 1945 (Heinsohn 1998). In Manus another phalanger, *Spilogale kraemeri* (possibly a subspecies of *S. maculatus* [see Flannery 1995]), and the bandicoot *Echymipera kalubu* both appear in the archaeological record of Pamwak site in the terminal Pleistocene (Williams 1997). In Buka and more southerly Solomon Islands *Phalanger orientalis* is widespread today, but was introduced sometime after 6000 yr B.P. because it is not found in site DJA but occurs in other sites of more recent date. *Thylogale browni* is also found in some archaeological sites on Buka, where it was also introduced less than 6000 yr ago (Flannery and Wickler 1990).

It should be noted that extinctions also occur. *Thylogale browni* is not found anywhere in the Solomons today and is also extinct in the northern half of New Ireland.

Both extinctions probably result from human hunting.

Similar disjunct distributions, consisting of introductions and extinctions, also occur in some islands of Wallacea (Flannery et al. 1999).

The important point about these introductions is that although transport of these animals, if not their subsequent colonizing, can only have been intentional, their distribution is quite irregular. There is no obvious reason, for instance, why a bandicoot would have failed to colonize New Ireland or a wallaby Manus, had appropriate animals been transported there and allowed to multiply.

A similar pattern of disjunct distributions, both at the time of European contact and archaeologically, is observable with the three "domestic" animals of Remote Oceania—pig, dog, and fowl. These distributions have been discussed frequently (e.g., Cassels 1983, Baldwin 1990, Yen 1990, McGlone et al. 1994), and a few examples will suffice here. Pig, so important on some islands, has never been found in New Caledonian sites and was not there at European contact (Sand 2000); it arrived with early immigrants in Tikopia, but was deliberately given up later (Kirch and Yen 1982); it never reached New Zealand, Easter Island, or Micronesia (Yen 1990), except Palau. Dog was absent from some smaller islands at European contact and from New Caledonia, but reached New Zealand and possibly Norfolk Island (Anderson 1996). The history of fowl is less known, but like the pig it never reached New Zealand and was not present on Tikopia at European contact.

There is only one mammal, *Rattus exulans*, that occurs on every Pacific island that experienced human settlement (Roberts 1991).

Current explanations for the distributions of either domestic or "wild" animals are untheorized. Take the case of *R. exulans*. Many authors (e.g., Kirch 1985, 1997) regard its distribution as purely the result of chance, animals having "probably climbed aboard canoes at night, when they were loaded and ready for a daylight departure" (Kirch 1985: 291). Other researchers, such as David-

son (1984) and Roberts (1991), allow for the possibility of it being a "chosen companion" (an edible pet?), supporting this suggestion by reference to its universality of occurrence and frequent use as a food source (e.g., Tonga, Mangaia, and New Zealand). A few, such as Matisoo-Smith (1994, Matisoo-Smith et al. 1998), are strongly in favor of intentional transport, not only seeing its presence as the deliberate introduction of a food animal but also rejecting the possibility of constant unintentional transport of a mating pair, a pregnant female, or larger populations.

The absence of consensus in this matter shows that the association of *R. exulans* with humans on every island in the Pacific is not of itself a clear indication of the transportation relationship between the two.

What interpretation is then relevant to the disjunct distributions?

Many arguments have assumed that disjunct distributions must be due to failure during transport (animals died on the voyage), or failure to adapt to particular local environments (e.g., of Polynesian pigs in New Zealand [McGlone et al. 1994]), or to deleterious inbreeding leading to rapid extinction. But although chance plays a large part in the establishment of a viable population from any small initial colonizing propagule, this element decreases rapidly as either the size of the founding group increases or that group is reinforced by subsequent migrations (Yen 1990: 269). Thus any scenario that envisages multiple voyages between source and colony implies that there was some deliberation about the animals that were not transferred. Multiplicity of voyages is now commonly accepted, at least during the initial phase of colonization of Remote Oceania (Irwin 1992, Finney 1996, Kirch 1997), and subsequently in many cases (e.g., Dickinson et al. 1996 with references, Walter and Sheppard 1996, Weisler 1997), with many between islands that possessed some of these animals and islands that did not. For "visible" animals then, disjunct distributions are almost certainly the result of deliberate decisions by prehistoric people.

On the basis of the available data, the distribution of *R. praetor* is like the pattern

exhibited by both "wild" animals in Near Oceania and "domestic" animals in Remote Oceania, and we therefore consider its presences and absences in Remote Oceania as probably the result of deliberate human action.

Accepting this proposal raises two important issues that cannot be fully resolved at this time, namely function and extinction. We discuss these in turn.

Attribution of intentional translocation implies some function or purpose in the decision to translocate. What could this be in the case of *R. praetor*? When compared with other translocated animals, it is small, providing little food, and is not noted for fine fur or other useful products: Flannery (1994: 169) even described it as "a foul-smelling and spiny garden and house pest." On the other hand, bones of the full range of available rodents are found in archaeological sites in contexts that suggest that all species could have been part of human meals. We note above that eating rats is reported from a number of Pacific islands in the recent past. *Rattus praetor* may well have been just one of the animals that was available for translocation, with whether it was chosen being dependent on local factors. What we need to beware of here is overrationality. We might well think that larger and more "useful" domesticates should have been preferred, but that choice may not have seemed so obvious to prehistoric Pacific islanders.

It is also difficult to explain why *R. praetor* is not extant on any Remote Oceanic island or on Nissan. In 1988 Flannery et al. (1988:93) could question whether viable populations had ever existed on Nissan or Tikopia, or whether their few specimens had derived from a single transportational event. If the latter, then extinction of a population was not at issue. They left this matter open. In some of the new cases cited here, a viable breeding population seems a certainty. The large number of Malakula specimens, from three sites in close proximity, must derive from such a population. Other Vanuatu samples may do so. The Fiji samples are small but come from two islands. Although neither island is large, Lakeba is certainly as

big as some of the New Guinea offshore islands on which *R. praetor* exists today, so that a "feral" population seems highly probable.

Possible extinction mechanisms are easy to speculate about but hard to prove. Flannery (1996:402) referred to "stochastic extinction" on islands, but over a much longer time frame. Elimination by humans, whether deliberate or through habitat destruction, seems unlikely in the case of an animal with the abaptability of *R. praetor*. Direct interspecific competition, perhaps with the introduced *R. rattus* or *R. norvegicus*, is possible but also seems improbable given current sympatry, with the former at least, in the New Guinea region. A disease introduced by *R. rattus* is possible. Some greater precision may become possible as the period over which *R. praetor* existed in Remote Oceania is more precisely determined.

Most accounts of the human settlement of Remote Oceania distinguish clearly between the deliberate transport of domestic animals and the accidental transport of wild ones, with which *R. exulans* and *R. praetor* are grouped. Over the last decade, the distinction between the intentional transport of domestic animals and the inadvertent transport of wild ones has been negated in Near Oceania and Wallacea, with the documentation of deliberate transport of several species of wild animals since the Pleistocene. The disjunct distribution of *R. praetor* in several Remote Oceanic islands, similar to the pattern of distribution of domestic animals, suggests deliberate transport, as well as continuity since the Pleistocene in this aspect of human behavior toward animals.

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