Rat Colonization and Polynesian Voyaging: another hypothesis

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Robert Langdon (1995:77) disputes the long-standing proposition that *Rattus exulans* was dispersed by Polynesian voyaging and suggests that over hundreds of thousands or millions of years it "succeeded in getting from one island to another without any human aid at all." Between this and the conventional view lies the possibility, not yet explored in detail, that some rats were transported on canoes that had lost their human crew. I discuss this is relation to New Zealand, but the principles are the same for Easter Island.

The New Zealand case is especially pertinent because *Rattus exulans* remains from non-cultural sites have been dated to as early as about 2000 b.p. (Holdaway, Worthy, Anderson and McGlone n.d.), some 1200 years earlier than any reliable radiocarbon dates on archaeological sites (Anderson 1991). The status of these results is still uncertain and, in addition, there are several dates of similar age on *Rattus exulans* remains from the Shag River Mouth archaeological site where the cultural remains are otherwise securely dated to 620 b.p. (Anderson, Allingham and Smith 1996). Nevertheless, the initial results are sufficiently provocative to encourage speculation about the plausibility of rat colonization in the effective absence of people.

Drift voyaging to distant lands

Unaided dispersal of rodents on mats of vegetation that originated in Ecuadorian rivers is argued for the Galapagos Islands. Steadman and Ray (1982:19), say this happened on at least three occasions, with two genera arriving long before human colonization of the Americas, and *Oryzomys* more recently (possibly with prehistoric people, although that is thought unlikely by Terrell 1986:94-106). The absence of *Megaoryzomys* from the more isolated Galapagos islands (Steadman 1986), also suggests a non-cultural mechanism, if it is assumed that watercraft would tend to spread taxa throughout the archipelago.

The eastern islands of the Galapagos lie about 1000 km from the mainland, but currents off the Ecuadorian coast are relatively weak and variable. The more powerful Humboldt current, which runs through the Galapagos, sweeps away from the mainland coast of Peru at about 3000 km distant from the islands, the maximum likely distance involved. There are no other cases of natural over-water dispersal of cursorial mammals to match that of the Galapagos, although some placental rodents were rafted across narrow water-gaps to Australia and the Philippines (Diamond 1987).

For New Zealand, the over-water distance is within the parameters of the Galapagos example (1000-3000 km), but *Rattus exulans* had almost certainly not reached the nearest potential source islands, Norfolk Island at 800 km distant and New Caledonia at 1400 km distant, prior to about 3000 b.p.—distribution in the western Pacific is largely covariant with Lapita expansion. Since there is no current comparable to the Humboldt connecting these islands with New Zealand, and few large rafts of vegetation are debauched by their rivers (there could have been logs, but these are highly unstable in a seaway), the probability of a successful natural drift event occurring during a maximum timespan of 2000 years before demonstrated human settlement of New Zealand, cannot be high. Nevertheless, the disposition of wind and current is quite favorable to a drift crossing by canoe.

Oceanic circulation in the south Pacific forms a vast anticyclonic vortex or gyre which extends from the Coral sea to the vicinity of Easter Island. "The southern border of the gyre consists of an easterly current which flows in the subtropical zone (25-35°S), favored by the dominant westerly winds" (Rougerie and Rancher 1994:15). Thus one potential drift route clips the northern extremity of New Zealand. During El Niño conditions, the surface current flow slackens but there is a marked increase in winds from the westerly quarter and therefore in the speed and breadth of the eastward surface flow.

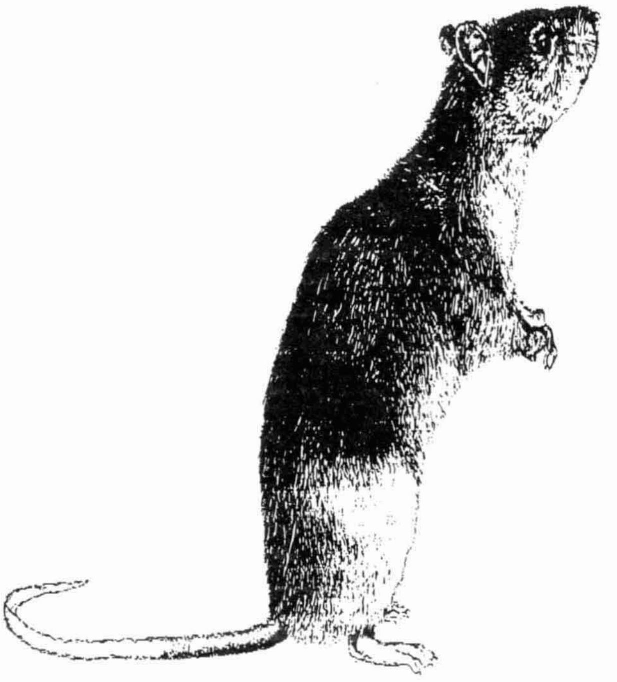
For most of New Zealand, the more important waters are those originating in the South Equatorial Current. These flow through Polynesia and East Melanesia and then swing south at about 20° latitude, as they reach the continental shelf, to become the East Australian Current. Off the coast of New South Wales, slow-moving gyres are spun off towards Tasmania and New Zealand, while the remainder of the water is turned eastward to New Zealand along the Tasman Front at the Subtropical Convergence Zone, usually located 37-42°S. So, there are several drift routes which could bring material southeast towards New Zealand. The landmass stretches across an arc of 33 degrees from New Caledonia, and 50 degrees from either Norfolk Island or a point 100 km off Sydney and is, therefore, a very large target in Oceanic terms.

In addition, there is no doubt that material is deposited on the western New Zealand coasts from tropical sources. There have been no recent studies of the quantity or distribution of such exotic flotsam in New Zealand generally but local observations show that it occurred frequently on Northland beaches (Smith et al., 1990:16) and both natural debris of tropical origin and several artifacts of apparent Melanesian origin have been recovered from one short stretch of coastline west of Wellington (Keyes and Hall 1967).

For the transportation of rats, however, much more is required than drifting debris. Anything floating very low in the water will move at the speed of the currents and that is probably too slow for survival of rats between New Zealand and the tropical Pacific. Material drifting under the influence of the South Equatorial Current, for instance, takes two to six months to cross from Fiji to Australia, about 2600 km (Smith et al., 1990:7, Smith 1992:59), at an average speed of 0.6-1.8 km per hour. As a "western boundary current", comparable to the Gulf Stream, the East Australian Current moves at up to

9 km per hour (Cresswell 1987), but the speed drops substantially as it dissipates eastward in the Tasman Sea where the main influence on surface drift becomes the persistent westerlies which are predominant south of 30°S. Material from the Coral Sea would probably drift in a broad arc towards Australia, down the east coast and then across the Tasman, a distance of about 4000 km. At a current speed of 20-30 km per day it would take 133-200 days to reach New Zealand.

A more crucial factor in the drift rate and direction of immobilized objects is the influence of the wind. Sea surface-layer drift speeds can be predicted at 1-6% of wind speed at 10 m (Brown 1991:Table 1). So, for example, in a Fresh Breeze (17-21 knots), which is a common range for trade winds in the open ocean, the surface layer will move downwind (deflected slightly to the left in the southern hemisphere), at a speed of 7.4-9.4 km/day at 1% to 44.6-56.2 km/day at 6%. Material which sticks above the water is subject to additional wind pressure and will "sail" faster than the surface-layer drift speed. How much faster is dependent on a range of factors (height, surface area to wind, draft, weight and so on), of which the proportion of an object's height above water level is the most crucial.



Mats of vegetation generally have low windage, but voyaging canoes, with their shallow draft and long broadside rising 0.75 m (or more with some of the superstructure and spars intact), would be responsive to the wind even when partly swamped. Evidence of drift voyages in the tropical Pacific (Table 1) shows a broad range of net drift speeds (the mean speed for a shortest distance passage between origin and destination irrespective of the actual distance covered) with the higher speed attained where vessels are known to have drifted before constant winds—as in the drift from Rurutu to Maurua (Parsonson 1963:33). These data as a whole show a mean drift speed of 34 km per day, but Hilder's (1963:92) analysis suggested a mean speed of about 1 knot (44 km per day). He also pointed out that many of the drifts were eastward against the prevailing westerly currents, or southward, and had occurred as the result of summer westerlies.

If westerly currents and winds are assumed to move disabled canoes in the Tasman Sea southeast at a net rate of 1 knot, then the following drift times can be estimated: 16 days from Norfolk Island and 31 days from New Caledonia to northern New Zealand, and 34 days to southern New Zealand from a point 100 km east of Sydney. One particular scenario that seems quite plausible is that vessels sailing in light northerlies, common conditions in the Coral Sea during summer (Smith 1992:58) strayed too far south into the strong, persistent northwesterly conditions of the northern Tasman Sea, became disabled and were driven on to New Zealand. There is, of course, no need to propose that a vessel was overtaken by disaster only at a point close to the origin of a voyage. Much of a passage might have been sailed quite rapidly, leaving only a brief period of drift.

In any event, drift times from the nearest archipelagoes northwest of New Zealand-Norfolk Islands, New Caledonia and southern Vanuatu—are well within the range (mean of 81 days, 2000 km, in Table 1) of those that have been successfully accomplished historically. This is much less the case to the north and northeast. The disposition of current and weather systems changes unfavorably for drifting to New Zealand and the distances lengthen substantially eastward. Rarotonga, for example is 2500 km away, or 73 days drift at the mean speed of the historical data in Table 1, and it is unlikely that a successful drift from that direction could attain that rate.

Vulnerability of Watercraft

Unballasted wooden vessels are relatively immune to sinking and canoe hulls continue to float when swamped. However, they could not continue to sail. So how likely was disablement of prehistoric ocean-going canoes? This is a crucial matter in estimating the probability of voyaging success as some have acknowledged (e.g. Doran 1976:45) but it is one which has been little studied. Stays, sheets and sails on facsimile canoes are generally of modern fibers so little is known of the resilience of traditional sailing rigs under stress. The sea-keeping qualities of the hulls are slightly better known.

Finney's (1979:49) comments on an early swamping of the *Hokule'a* are especially pertinent: "unlike outrigger canoes, big double-canoes are virtually impossible to bail out, particularly in heavy seas. Even if only one hull is flooded, the buoyancy of the other hull keeps the flooded one depressed at or below the water level, or so near it that waves push in faster than it can be bailed out." Although *Hokule'a* had been fitted with bulkheads and canvas covers it was apparent that these provide insufficient protection, so watertight decks and compartment were constructed because, "our primary object was to test sailing performance and navigational accuracy, *not survivability*" (Finney 1979:53, my emphasis, and see Anderson 1996). In all subsequent construction of large experimental voyaging canoes, so far as I can tell, there have been watertight bulkheads or other installed buoyancy devices. With the major threat of irretrievable swamping thus minimized, and with rigs of modern materials, the experiences of experimental voyages provide little guidance to the seaworthiness of prehistoric canoes, and therefore to the former probability of survival at sea.

It is, then, a matter of conjecture as to whether swamping or other disablement of double-canoes in prehistory was a common event. Modern experience perhaps favors the former point of view. To western eyes, Pacific islanders often appear appalling casual in their attitudes toward safety at sea. They go to sea in dangerous conditions for small craft, often overloaded, no safety equipment on board, with poorly-maintained engines, no alternative means of propulsion and no means of navigation. Not surprisingly, accident rates are high, estimated at 360 small boats reported missing every year in the tropical south Pacific, of which 60 are never seen again and some hundreds of people lost, according to the South Pacific Commission (Dominion (New Zealand) 10.5.95). The risks are higher beyond the trade wind zone. As canoes pushed south of the Tropic of Capricorn and into latitudes where westerlies were increasingly dominant, wind speeds higher and seas more threatening, there must have been an increasing risk of disablement and the loss of crew. No direct observations of Pacific canoes fetching up on the New Zealand coast are recorded historically, but several canoes without crew, one containing wooden artifacts thought to be from either Tonga or New Zealand, were seen beached on Norfolk Island in 1788-1790 (Specht 1984:38), and that is the sort of event that might have occurred in New Zealand prior to European discovery.

A Rat Penumbra

When canoes were incapacitated and left drifting what were the relative chances of survival of the mammals that might have been on board? Pigs especially, and dogs also, probably had little chance of lengthy survival. They would have been eaten by surviving crew before rats were sought out, or died from starvation because they had no means of finding or catching suitable food without human assistance. So the two potential survivors on a drifting canoe long at sea were people and rats.

In one respect, the survivability of rats was enhanced by successful sailing. *Rattus exulans*, unlike *Rattus norvegicus* and to a lesser extent *Rattus rattus*, has an aversion to wet places. When its footing is entirely wet, as on a log at sea, then it will take to the water, swimming about as well as other rat species (Jackson and Strecker 1962) in an effort to find dry land. On a voyaging canoe under way *Rattus exulans* could probably find dry footing in many places, but once the vessel was disabled the choices might have been considerably reduced. Provided rats could find some dry refuges when the vessel was left adrift, then it was people who were at the disadvantage as survivors, in four respects.

1. People were more exposed to the elements and did not have the rat's advantage of being able to find shade in small places or warmth in a fur coat—and hypothermia is reckoned by Houghton (1990), amongst others, to be one of the great hazards of ocean voyaging. If that was generally true, it must have been especially so on passages in higher latitudes towards New Zealand. In heavy seas that would wash crew overboard, rats could find niches of safety under thwarts and in other places inaccessible to people.

2. While people could catch fish or seabirds occasionally, *Rattus exulans* had very much smaller energy requirements, and a wider omnivory to satisfy them. It could eat seeds, stalks and other fibrous material unpalatable to people, and insects, snails, other invertebrates, and small vertebrates such as lizards (Strecker and Jackson 1962:71-72, Atkinson and Moller 1995), all of which probably lived on large canoes but were difficult for people to catch and insignificant as sources of energy on a human scale. Sea-going canoes were also likely to contain packages of prepared food, coconuts and cultigen roots, and to become the roosting places of seabirds, not to mention the possibility of dead crew remaining aboard. Ten *Rattus exulans* of average size weigh 0.5 kg (Jackson 1962a:90), and could survive for more than a month on the food needed to keep one person alive for several days. Since there are instances in recent history of people surviving drift voyages of three months or more in the Pacific, it does not seem unreasonable to suppose that rats could do rather better.

3. Rats require much less fresh water than people, and given a moderately high water content in their food can do without free water for long periods. Experiments show that *Rattus exulans* can survive over 70 days on coconut meat alone, with no additional water source, or indeed food source (Strecker and Jackson 1962:73).

4. There are probably psychological factors of significance as well. People are able to assess their slim prospects of survival in extreme conditions and might simply give up, while rats, we may assume, are untroubled by such depressing thoughts. Rats, it hardly needs emphasizing, are great survivors.

Consequently, the longer a voyage proceeded, or the greater the difficulties into which it fell, the higher the relative survivability of rats compared with people. It follows that if rats embarked on all or most voyaging canoes, voluntarily or otherwise, then in respect of those canoes which did not make humanly-successful passages, there would generally be three successive stages of occupation: first, canoes with people and rats, then canoes with only rats surviving and lastly canoes with neither people nor rats. In geographical terms, this would amount to a *rat penumbra*—a moving zone of rat-only survival advancing in front of successful human colonization out into the Pacific.

It is in this light that we might interpret the New Zealand evidence. New Zealand, especially the South Island, lies well within the mid-latitude westerlies which probably deterred early Polynesian voyagers used to trade winds. Canoes that reached southern New Zealand at an early stage of Polynesian dispersal, therefore, probably did so accidentally—conceivably because they became unmanageable for one reason or another and then were caught in a combination of southeastward current and northwesterly wind that brought them into the mid-latitudes of the Tasman Sea, from where a landfall on New Zealand was all but unavoidable. Alternatively, the earlier means of navigation may not have been as sophisticated as they became during the settlement of East Polynesia so that some canoes which ventured too far south were unable to navigate out of difficulty before they were driven on to New Zealand. In any event, it is possible that there were only rats alive when the canoes reached land.

Rat Colonization Cycle

How frequently a breeding unit of rats occurred on voyaging canoes is a matter of conjecture, of course. Matissoo-Smith (1994), suggests that this was a common occurrence because *Rattus exulans* was a traditional food. Caged rats were deliberately taken aboard and any stowaways soon discovered and dispatched. This view is based upon some post-European Maori elaborations of voyaging traditions which in this and other respects appear to incorporate *ex post facto* rationalizations for the existence of various taxa in New Zealand. It seems at least as likely that rats simply boarded beached or moored canoes of their own volition, attracted by stored foods, and were able to conceal themselves effectively amongst sails and packages in the hulls, in the thatched walls and roof of the cabin and so on—in other words they were free rather than caged.

It might also have been the case that rats were more aggressive in this behavior early in the colonization period than later. Diamond (1978) argues that the behavior of colonizing taxa passes through several stages, in the earliest of which (expanding phase), there is heavy selection for dispersal and prolific breeding. By attracting bolder individuals, voyaging canoes in the period of rapid human expansion through Remote Oceania may have acted as a selection device favoring potentially successful colonists, and if canoes were long at sea they possibly also selected for more prolific and, or, faster breeding. Amongst some modern populations of *Rattus exulans*, annual production of young varied by 100% and the breeding cycle from 37 to 74 days (Jackson 1962b:102-106, Atkinson and Moller 1995).

Consequently, it is possible that there was a period of aggressive colonizing behavior by rats, as long range voyaging got under way, that ensured viable breeding units managed to get on, and frequently off, a high proportion of the voyaging canoes. As voyaging canoes departed in later times, and possibly less frequently, from island in which rat populations were by then well established, rat behavior patterns may have passed into less aggressive phases involving lower curiosity and productivity (Diamond 1978:251).

Discussion and Conclusions

In addition to New Zealand, there may be other cases which possibly represent successful rat voyaging in the south Pacific. On Norfolk Island, there is a horizon of burning, presumed anthropogenic, dated at about 800 b.p. at Cemetery Beach (Meredith et al., 1985). Bones of *Rattus exulans* occur within it but are also found up to 85 cm deeper in the sediments beneath. On Mangaia, remains of *Rattus exulans* occur beneath, and are dated earlier than, human occupation layers at Tangatatau (Kirch pers.comm.). That these three examples are on the southern margins of Oceania (23-43°S), may have some significance, since it can be expected that the probability of disaster at sea increased broadly with latitude.

I doubt that rat populations were naturally rafted between archipelagoes in Polynesia, although possibly sometimes within. The most probable mechanism in most cases remains transport on humanly-successful voyaging canoes. Yet, perhaps some populations were dispersed in the way conjectured here.

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Table 1. Drift voyaging between distant islands.

Passage	**Date**	**Approx. Distance (km)**	**Approx. Time (days)**	**Distance per day**	**Reference**
Kwajalein to New Hebrides	1951	2900	100	29	Parsonson 1963: 33
Vicinity Gilbert Islands	ca. 1937	1100	10	110	Parsonson 1963: 33
Rurutu to Maurua	1820	700	15	47	Parsonson 1963: 33
Aitutaki to Tonga	ca. 1829	1600	150	11	Dening 1963: 138
Raiatea to Atiu	ca. 1831	800	40	20	Dening 1963: 142
Raiatea to Australs	1921	700	20	35	Dening 1963: 142
Rotuma to Samoa	ca. 1829	1100	90	12	Dening 1963: 143
Rurutu to Manihiki	ca. 1837	1600	40	40	Dening 1963: 143
Tubuai to Manua	1832	2600	90	29	Dening 1963: 146
Salebabu to Witu	1947	2400	70	34	Dening 1963: 148
Pulau Siau to Guam	1960	2100	60	35	Dening 1963: 148
Marshalls to New Hebrides	1950	3000	105	29	Dening 1963:148*
Ocean Island to Ninigo	1944	3500	210	17	Levison et al. 1973: 20
Maupiti to Tau	1964	1500	155	10	Levison et al. 1973: 20
Tarawa to Truk	1981	2800	60	47	Terrell 1986: 71
Tanga (Lihir) to Niulakita	1995	3300	90	37	Canberra Times 18/3/95
Average		**1980**	**81**	**34**	

* Approx. nett drift, but Hilder (1963) estimated actual track as 12200 km, mean speed as 67 km/day.