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Rethinking Polynesian Origins: Human Settlement of the Pacific

Michal Denny, and Lisa Matisoo-Smith

Our Polynesian ancestors are renowned as some of the world's most successful and innovative navigators. Using their knowledge of tides and stars, Polynesian seafarers explored vast areas of the Pacific. They discovered and settled nearly every inhabitable island in the Pacific Ocean well before European explorers got here in the 16th century.

Māori oral legends tell us that Hawaiki is the legendary homeland from which Māori and Polynesian people explored and colonised the islands of the Pacific and Aotearoa New Zealand. There is also increasing scientific evidence that Polynesians reached South America well before the first Europeans.

The question of humans origins and the mapping of human movement around the world is one that has long interested science. Scientists use both biological, linguistic and cultural evidence to investigate the origins of human populations.

Allan Wilson Centre anthropologists Lisa Matisoo-Smith, is part of a team of researchers investigating questions about the origins of Polynesians such as:

- Where did the ancestors of Polynesians come from?
- What route did the settlers take through the Pacific?

Answering questions like this is the role of a field of science called biological anthropology.

Anthropology traces the evolution of culture from its primate origins, through over five million years of prehistory, to historical and contemporary societies.

Lisa Matisoo-Smith is Professor of Biological Anthropology at the University of Otago and Principal Investigator in the Allan Wilson Centre. Her research focuses on identifying the origins of Pacific peoples and the plants and animals that travelled with them, in order to better understand the settlement, history and prehistory of the Pacific and New Zealand. Her research utilises both ancient and modern DNA methods to answer a range of anthropological questions regarding population histories, dispersals and interactions.

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The research process

All research starts by finding out what is already known about the topic. In this case human dispersal out of Africa and human settlement of the Pacific. This process is called a literature search and involves identifying all relevant published research in the field. This is used to decide on the research questions that will underpin new research.

What is already known about human migration?

- There was a migration of anatomically modern humans out of Africa around 150,000 – 100,000 BP (Years Before Present), moving east towards Asia and north into Europe.
- Part of this migration reached South-East Asia by 60,000 BP.
- Populations of these stone-age hunter gatherers then expanded from Southeast Asia into the Pacific through New Guinea to Australia and the Bismarck Archipelago by about 45,000 BP
- Once in Southeast Asia and Australia the movement of humans into new areas stopped for nearly 30,000 years.
- A later wave of expansion out into the rest of the Pacific took place began around 3,500 BP.
- In this migration the people went east to Samoa and Tonga and from there north to Hawaii, further east to Easter Island and south to New Zealand.
- This was the last major human migration event.

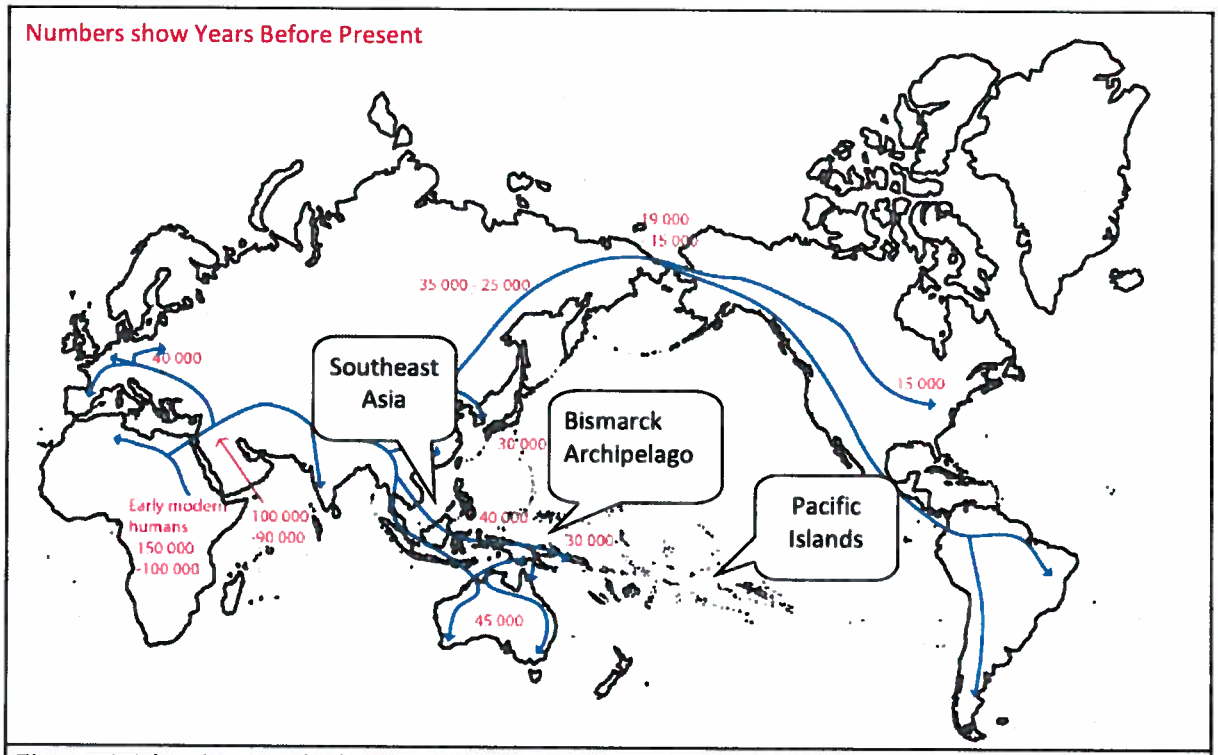


Figure 1. The dispersal of anatomically modern humans from Africa

Research Questions

These are the types of questions that came out of the background research:

1. Who are the ancestors of modern Pacific peoples?
2. Where were the geographic origins of these ancestors?
3. What route or routes did they take in their migration through the Pacific?

Molecular biotechnological techniques are now an important tool in collecting data to answer these questions, particularly for looking at mitochondrial DNA (mtDNA) and the Y chromosome. mtDNA and the Y chromosome are used in this type of research because they are inherited from only one parent and they do not recombine (or mix) with DNA from the other parent. Scientists are interested in variation or differences in the mtDNA or Y chromosome between different populations in different areas as these can

The origins of Polynesian Peoples

Polynesia is defined as the islands found roughly in a triangle formed by Hawaii, Aotearoa-New Zealand and Easter Island (Rapa Nui) (See Figure 2).

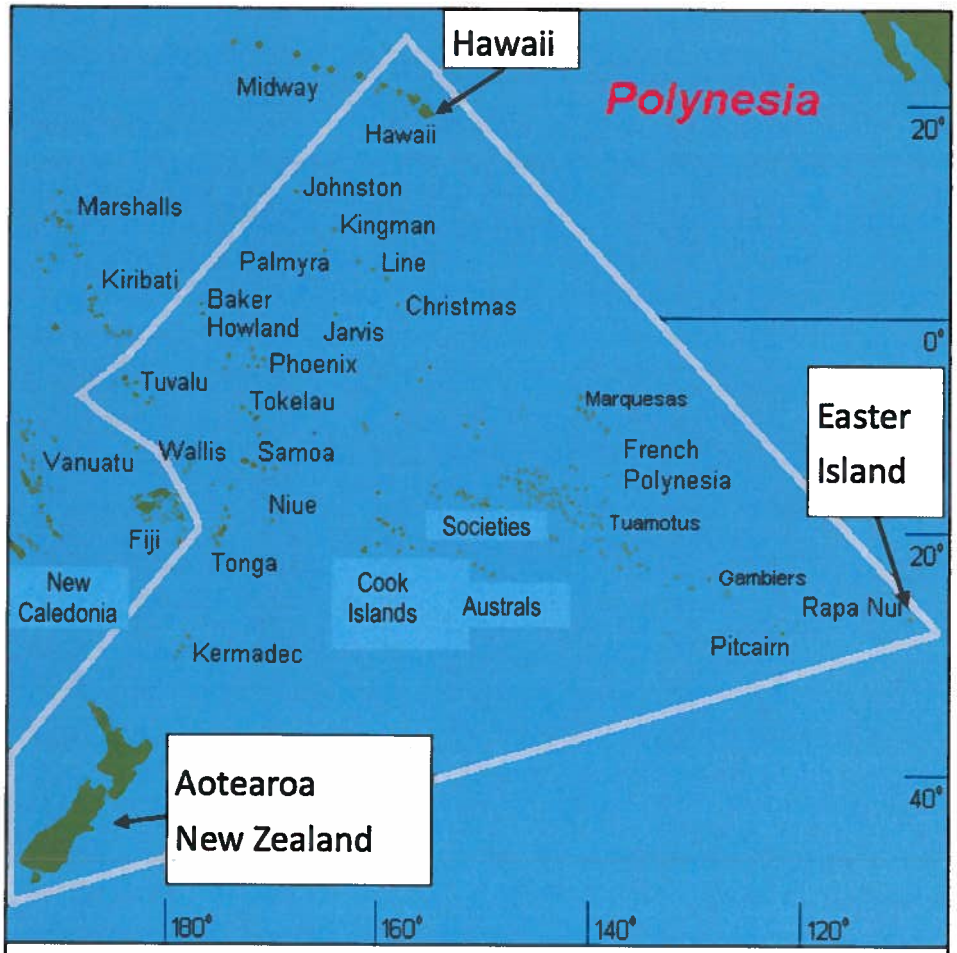
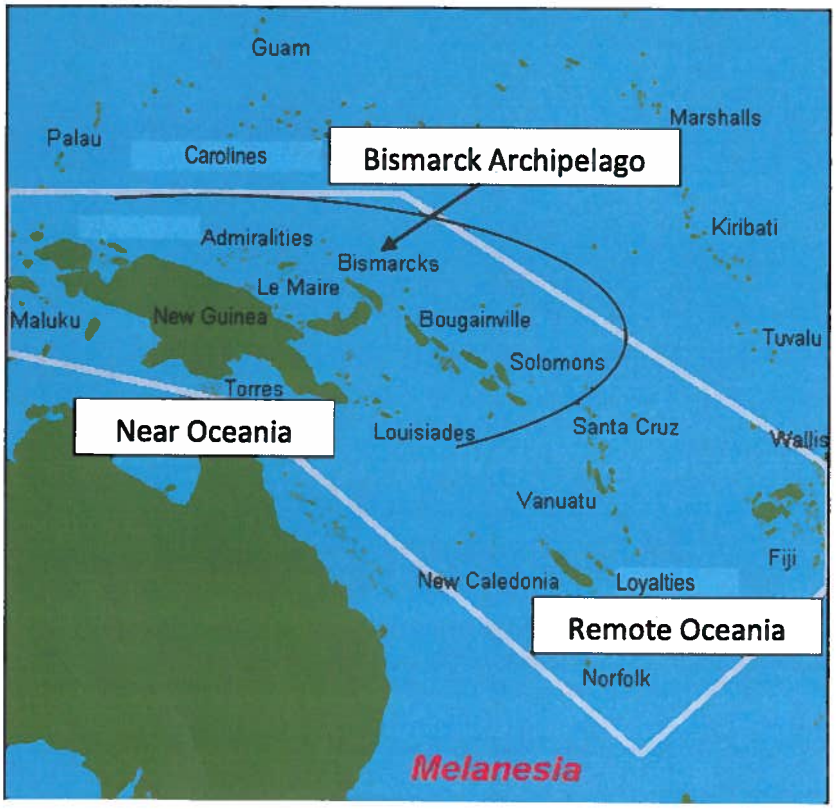


Figure 2: The Islands of Polynesia



When looking at human settlement of the Pacific, anthropologists divide the Pacific into two regions (See Figure 3):

- Near Oceania, which was settled by humans by 30,000 BP.
- Remote Oceania, which was not settled until around 3000 BP. Notice that Polynesia is in Remote Oceania

Figure 4: Pieces of Lapita pottery
Source: Department of Anthropology, University of Auckland.

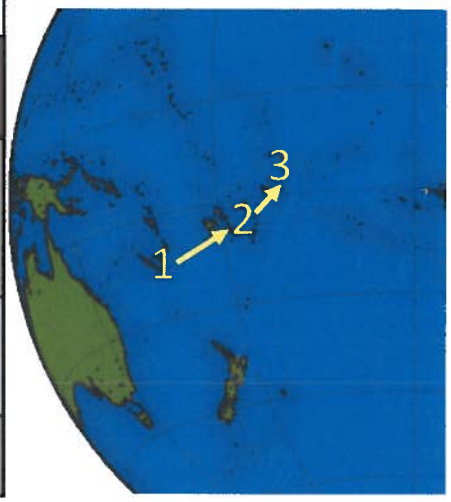
The first human settlers of Remote Oceania are associated with the Lapita culture, which first appeared in the Bismarck Archipelago in Near Oceania around 3500 BP. (An archipelago is a chain or cluster of islands formed from volcanic activity).

The Lapita culture is named after the distinctive patterned pottery seen in Figure 4, which was first found at a site called Lapita in New Caledonia. Anthropologists are very interested in who the Lapita people were and what role they played in the settlement of the Pacific.

Remnants of Lapita pottery are now found throughout many areas of Remote Oceania, which suggests that the Lapita people were the first to settle this area. Table 1 shows how the age of the pottery remains found in each area supports the idea that this settlement spread from west to east from Melanesia into Polynesia.

Table 1: Location and dates of Lapita Archaeological sites

Location of Lapita Archaeological sites	Date (years before present)
1. Reef and Santa Cruz Islands Vanuatu New Caledonia	~3000 BP
2. Fiji Tonga	~2900 BP
3. Samoa	~2700 BP



Evidence such as this suggests that the Lapita people are the ancestors of modern Pacific peoples, but questions remain about whether there could also have been contributions from other populations from Asia and Micronesia at later times.

Models for human settlement of the Pacific

Prior to the development of molecular biotechnological techniques, scientific understanding of human settlement in the Pacific was developed by collecting evidence from archaeological studies (remains of Lapita pottery and Polynesian pottery), language, physical and cultural comparisons, and studies of blood groups and the limited genetic data available at the time. By the early 1990's it was commonly accepted by anthropologists that the only ancestors of the Polynesians were the Lapita peoples. Evidence for this hypothesis (or model) came from:

- Archaeological remains like the pottery in Table 1, suggested that Lapita were the first humans in the region,
- relatively limited variation in culture and languages between Polynesians, and
- a unique Polynesian phenotype i.e. little variation in physical appearance between the different populations, particularly in comparison to the biological variation found in Melanesia.

This model is often called the **Lapita-only** model of human settlement of the Pacific.

Like all scientific models and hypotheses, scientists collect further evidence to either strengthen or modify the model. One of the key researchers in this area has been Lisa Matisoo-Smith from the Allan

Using molecular biotechnologies, Lisa and her fellow researchers have found evidence which suggests that the hypothesis that the Lapita were the only ancestors of Polynesians may not be the completely explain the situation.

Research carried out by Lisa and her team has focussed on determining the genetic origins of animals and plants that are known to be associated with human settlements in the Pacific. These are known as commensal plants and animals because they have a close relationship with humans – as food items, companions, or because they are important for other cultural reasons. Examples of these animals include rats, pigs, dogs, and chickens. Importantly these animals cannot get from one island to another unless they are taken there by humans, therefore scientists can track the movements of the humans by tracking the movements of these commensal animals that travelled with the humans.

The first commensal animal that Lisa's team studied was the Pacific rat or Kiore (*Rattus exulans)*. Kiore is a good animal for this because:

Figure 6: Pacific Rat.
Picture from Cook Islands Biodiversity Database: http://cookislands.bishopmuseum.org/species.asp?id=8745

- it was often intentionally transported in colonising canoes as a source of food
- it cannot swim so can only get to new islands by being carried in canoes with people,
- it reproduces rapidly and thus accumulates mutations faster than humans,
- it is a different species from the European rats that were introduced later and therefore can not interbreed with them. This means any current populations of Pacific rats are direct descendants of the original populations and
- remains of Pacific rats appear in the earliest layers of archaeological sites associated with Lapita people and are found in all sites associated with Lapita and later Polynesian settlement.

Molecular biotechnologies offer advances in understanding

The first study looked at the variation in the mitochondrial DNA (mtDNA) of living populations of Pacific rats from islands around the Pacific. mtDNA is inherited only from the mother, therefore there is no mixing with the father's DNA or recombination during meiosis. This means that differences in the mtDNA due to mutation can be traced back through the generations. Scientists use the variation in the mtDNA to work out the relationships between different populations.

The results of this study suggested that it is highly likely that there were multiple introductions of the Pacific rat to the Pacific Islands. This raised the question, "did these introductions all occur at the same time or at different times?" If they were at different times then this suggests that another group of people migrated into the Pacific sometime after the Lapita people.

This question cannot be answered by studying modern mtDNA, as variation in modern mtDNA only shows different origins,—it doesn't show the timing. Ancient DNA, however, could be used to answer this question. Ancient DNA is any DNA extracted from tissues such as bone that are not fresh or preserved for DNA extraction later. When an organism dies, the DNA molecules immediately start to break down, which makes it difficult to extract good quality DNA for analysis. The hot and wet environment found in most of the Pacific makes it just about the worst area for DNA preservation. Despite this Lisa and other Allan Wilson Centre researchers have been able to obtain DNA from Pacific samples as old as 3000—4000 years[(2)].

If the age of the remains is known then the likely date of the introduction of new genetic material can be estimated. The team next investigated ancient DNA from the remains of Kiore found in different archaeological sites around the Pacific looking for patterns in the haplotypes in mtDNA. A haplotype is a

Lisa found three distinct groups of haplotypes, - shown as Groups I, II and III in Figure 7. Three clearly different haplotypes (or genetic groups) is an indication that these populations of rats are likely to have quite different ancestral origins.

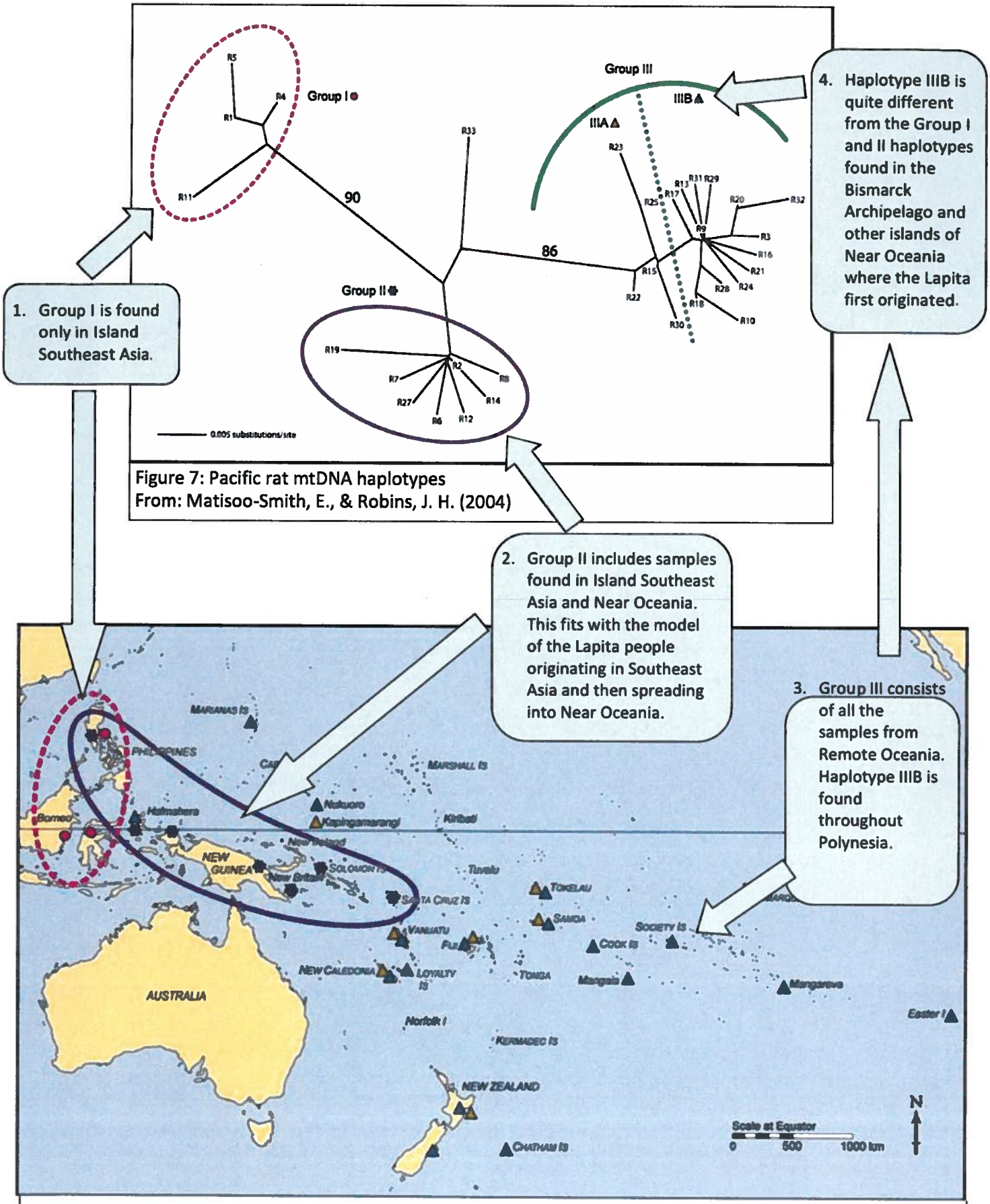


Figure 7: Pacific rat mtDNA haplotypes
From: Matisoo-Smith, E., & Robins, J. H. (2004)

Figure 8: Distribution of the three groups of Pacific Rat haplotypes in Near and Remote Oceania.
From: Matisoo-Smith, E., & Robins, J. H. (2004)

Group III does not fit the expected pattern. It shows no genetic link with the haplotypes found in Near Oceania. This suggests that this haplotype may be the result of a later introduction of the Pacific Rat into Polynesia sometime after the Lapita introduction.

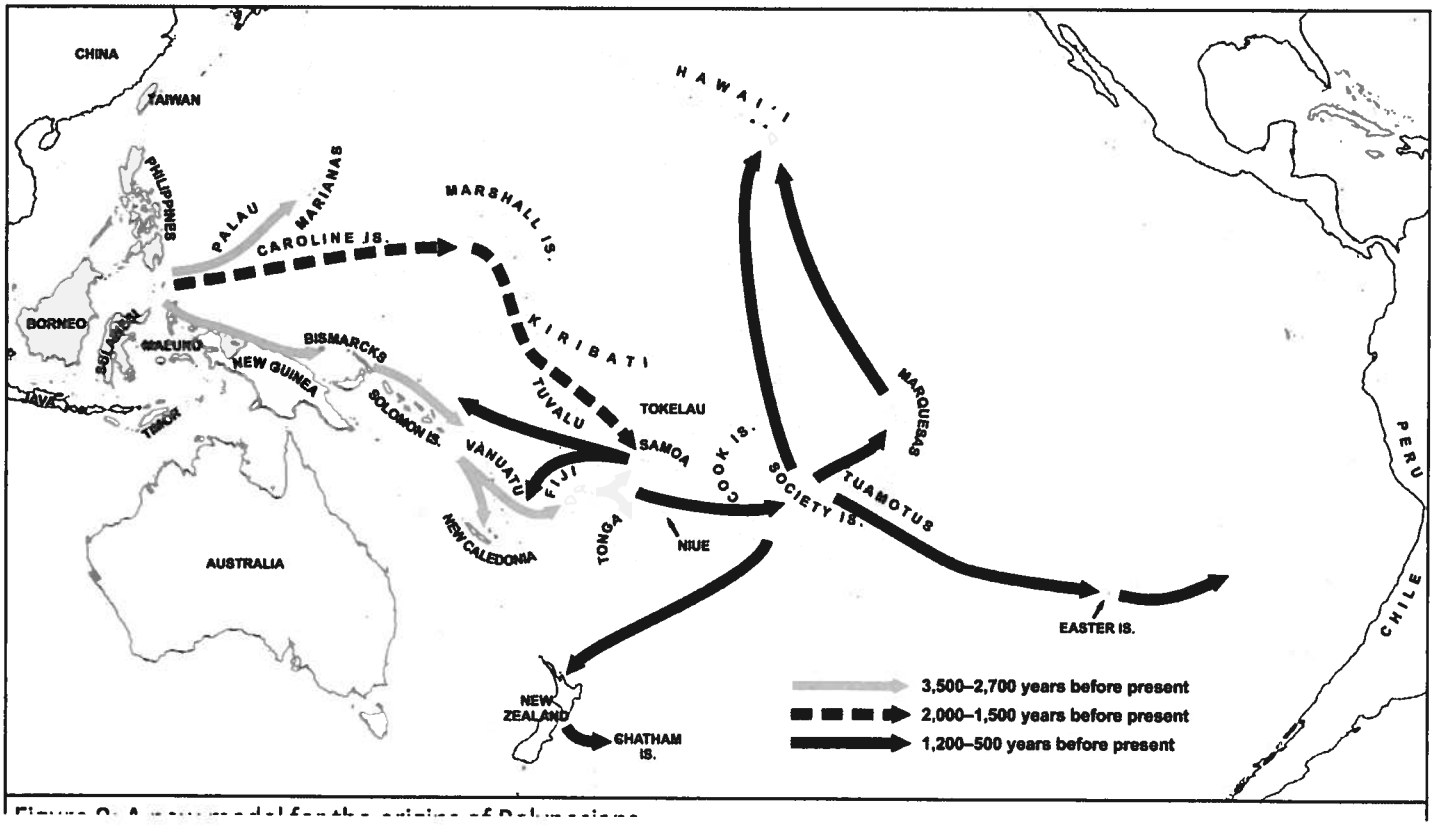
To test this hypothesis Lisa and her team carried out similar studies of variation in both modern and ancient mtDNA in pigs and chickens. In both of these animals the results showed there are introductions that are consistent in geographic distribution and time of appearance in the archaeological record with a Lapita introduction. But other mtDNA studies on dogs of the Pacific, plus the rat and chicken data all indicate a second introduction. This suggests a second population migration out of Asia sometime after 2000 BP.

Conclusion

These results have led Lisa and her colleagues to suggest a new model for Polynesian origins[1]. It is based on an existing framework for Lapita origins suggested by Roger Green in 1991. Here are the key ideas:

1. The Lapita colonists in West Polynesia and the rest of Remote Oceania look very much like the current indigenous populations of Vanuatu, New Caledonia and western Fiji
2. Around 1500 BP a new population arrived in Western Polynesia with new and more typically Asian derived physical characteristics, and mtDNA lineages.
3. These new people also introduced new mtDNA lineages of commensal rats, dogs and chickens.
4. There was intense and complex interactions with the existing Lapita-descended populations as they spread over West Polynesia.
5. This resulted in the formation of the Ancestral Polynesian culture, who then dispersed east, and north into the rest of Polynesia.

This possible scenario is shown in Figure 9. The grey arrows show the initial Lapita expansion through Near Oceania and into Remote Oceania. The dotted arrows show the proposed arrival of new population (or populations) from Asia into West Polynesia. The black arrows show the settlement of East Polynesia and a back migration into Melanesia.



Implications of Founder Effects on Genetic Diversity

> Founder Effect - the loss of genetic variation that occurs when a new population is established by a very small number of individuals from a larger population.

Polynesian populations are relatively genetically homogenous i.e. they have little genetic variation. This is due in part to the fact the original settlers moved into unoccupied areas of the Pacific creating little opportunity for interbreeding with other populations. However, the major contributor to low genetic variability is most likely a founder effect. As canoes were the only method of transport around the Pacific, new islands would probably be settled by only a small number of people. It is also quite likely that these people were closely related and genetically not representative of the larger population that they came from. Numerous studies of mtDNA have shown that mtDNA variation decreases from east to west across the Pacific, which supports the idea of founding populations.

The settlement of Aotearoa New Zealand is a classic example of a founder effect. Māori oral traditions tell us that the ancestors of the Māori came to Aotearoa New Zealand in a series of canoe voyages, with up to 40 different canoes arriving over a long period of time[4]. It is thought that up to 500 settlers may have arrived in Aotearoa New Zealand over several generations. Even though this sounds a large number; in population terms it is quite small and therefore likely to result in a founder effect.

A genetic study in the late 1990's of 54 unrelated Māori identified only four different mtDNA lineages. This was the lowest of any human group studied. Out of those 54 people, 47 of them had the same mtDNA lineage. In addition while this lineage was also seen in other Pacific populations, it occurred at the highest frequency in Māori as shown in Figure 10[5].This shows that there is only limited mtDNA variation in Māori which is consistent with the founder effect.

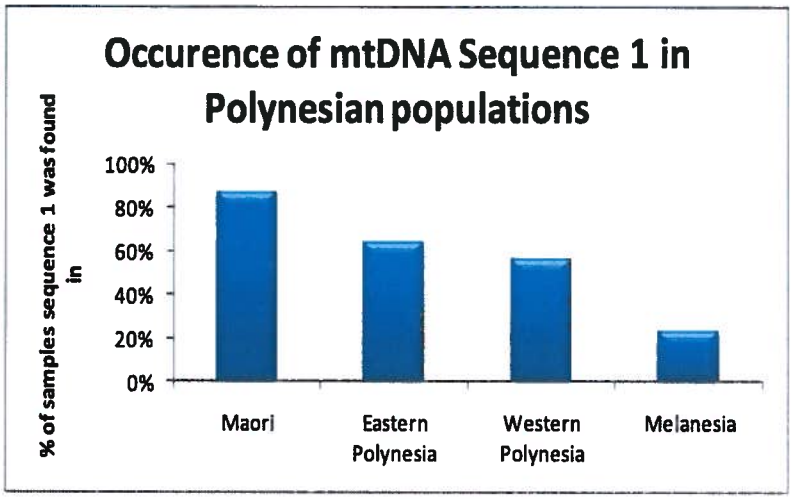


Figure 10.

Occurrence of mtDNA sequence 1 in Polynesian populations

Data from: Murray-McIntosh, R. P *et al* (1989)

The data from this study was then used to estimate the likely number of females in the founding population of New Zealand Māori . Computer simulations were run using the data and came up with a figure of between 50 and 100 women, which is consistent with Māori oral history.

The Genographic Project

The Genographic Project is a five-year research project involving a team of scientists from around the world. It aims to find out new information about the migratory history of the human species and in doing so answer questions like:

- Where do you **really** come from?
- How did you get to where you live today?

The researchers are using cutting-edge genetic and computational technologies to analyse historical patterns in DNA from participants around the world to better understand our human genetic roots. Lisa joined the Genographic project as a Principal Investigator in 2008 to further the project's work with Pacific Island communities.

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