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RESEARCH ARTICLE

Patterns of population decline following European contact and colonization: The cases of Tahiti and the Marquesas

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Abstract

Recent archaeological data assess that Tahiti and the Marquesas Islands were densely populated at contact with the Europeans and then experienced a tremendous decline. This phenomenon is most often attributed to epidemics, while a steady negative increase is rarely mentioned. This paper shows that the population of Tahiti was most probably around 110,000 – or even reached 180,000 – at contact, based on a retrodiction from the 1881 census using data on epidemic mortality and annual decline rates observed in the second half of the nineteenth century in Tahiti, the Marquesas, and other Eastern Polynesian islands in similar situations, according to missionary, administrative, and medical reports. Our 'model', or reconstitution, provides estimates on the impact of both types of mortality. Due to no exposure to childhood and other diseases common on the continents, the Polynesians had low immunity, as shown by age-specific death rates until the 1918 flu and the 1951 measles epidemics. Following the European contact, sexually transmitted diseases (STDs), tuberculosis (TB), and other introduced infectious diseases resulted in a steady population decline due to reduced birth rates and very high death rates. Health services were available for the Europeans soon after the takeover, however the natives got access to health services much later with their sporadic and fragmental provision. The constant negative increase extended far beyond the colonial period, including after effective drugs were discovered in the 1880s, becoming the main contributor to the overall demographic decline in the Marquesas, where health services were missing most of the time before 1924, mostly in the South-Eastern group.

Keywords

population decline, epidemics, infertility, colonization, Tahiti, the Marquesas

JEL codes: I14, I18, J15

The debate on the size of indigenous populations at contact in Eastern Polynesia, particularly in Tahiti, the Marquesas, and Hawai'i[1], has somewhat receded; because recent archaeological research (Kirch and Rallu 2007) provides evidence of high population density before the European contact, obliterating estimates of small populations (Oliver 1974; McArthur 1968), which were criticized as early as the late 1980s (Stannard 1989; Rallu 1990). Then, the debate was re-oriented towards causes of this phenomenon. Stannard (1989) sees epidemics and new diseases as the main causes of the demographic decline, while Kunitz (1994) emphasizes social factors, an approach dating back to the early twentieth century (Rivers 1922), which was soon contradicted by Baker (1928). Recently, the focus has returned to higher estimates of indigenous populations at contact[2] and, consequently, a higher post-contact decline in the late 18th and the 19th centuries. However, there has been more focus on epidemics than endemic diseases. The former mostly occurred in the early post-contact period and were characterized by extremely high mortality peaks, and the latter increased progressively following the dissemination of germs and resulting, within a few decades, in abnormally high mortality and low fertility, leading to a constant population decline.

This paper presents a model/reconstitution of the population trends since the European contact to estimate the population decline and impact of epidemic mortality due to low immunity, as well as constant annual decline, mostly due to the introduced endemic diseases in the context of poor medicine and little health care or social services. We will compare the situation in Tahiti and the Marquesas, which have different colonial histories. After a brief review of the recent archaeological data on pre-contact population density and trends, we will analyze the age patterns of epidemic mortality in relation to immunity, and constant decline in relation to the new endemic diseases, using birth and death rates recorded by civil registration. Analysis of the rule of law situation in the first decades after contact and efficiency of colonial administrations, as well as availability of health services for indigenous populations, based on the French archives and missionaries' and physicians' reports, will provide for a social context of such a long-lasting decline.

Thus, we will shift the focus of the debate about factors, biological or social, with the higher impact on population decline, towards different types of diseases, sudden epidemics and constant decline due to endemic diseases. The latter impeded post-epidemic recovery and lasted until the 20th century, whereas it could have been reduced with better social and health services in the late 19th century, even if it were only basic medical supplies of the late 19th century. Assessing a major impact of constant decline to the overall collapse of the Eastern Polynesian populations will enable us to consider much larger populations at contact rather than estimates published around 1970 (see above) and in our previous papers (Rallu 1990, 2007).

Theoretical Framework

The estimates of populations at contact are the bases for assessing post-contact declines. Archaeological data show that the population stabilized one or two centuries prior to contact in Hawai'i and that some islands and valleys in the Society Islands, the Cook Islands, and the Marquesas (Fig. 1) reached a high population density. The population size at contact, related to density, will be compared with navigators' early estimates.

1 Discovered in 1767, 1774, and 1778, respectively.

2 With two projects on estimates of size and demographic trends in the Pacific islands' populations, by UNSW and ANU.

Figure 1. French Polynesia. *Source*: https://liquid-blue.com/photos/tour/french-polynesia/

Then, we will carry out retrodictions from the first official censuses in the second half of the nineteenth century, using available statistical data on epidemics and annual birth, death, and growth rates, and check consistency with estimates of population at contact. If no statistical data are available for Tahiti or the Marquesas, we will use data on other islands experiencing similar situations reported by missionaries, colonial administrators, or doctors in journals and archives. Epidemic mortality data are randomly available from 1850 (see below); intercensal trends in Tahiti can be analyzed; and civil registration is complete enough to estimate age-specific birth and death rates from 1886 in the Marquesas (Rallu 1990: 44).

The contact has occurred in a situation of stabilized populations following several centuries of growth and isolation, resulting in low immunity. Therefore, we will also consider low immunity and patterns of the acquired immunity by the Polynesians, comparing data on measles and the 1918 flu in Tahiti and mainland France.

We will also emphasize, based on archives and various reports, the poor social and health policies following the takeover of Tahiti and the Marquesas in the early 1840s and the associated causes of the long-lasting annual decline that is hardly considered, as most of the focus in the decline has so far been on epidemics.

We have designed a reconstitution of population trends in Tahiti and the Marquesas based on registered epidemics and periods of decline at various rates mentioned by statistical and qualitative reports. Thus, we separate two types of decline, i.e., the only statistical data that can be reconstituted in the long-term perspective: *a*) mortality during years of epidemics and *b*) steady annual decline. We assume that the former is primarily due to low immunity of the Polynesians to the diseases introduced by the Europeans, as little could be done to prevent epidemic mortality peaks, while the latter, due to the lack of social and health services for indigenous populations despite the fact that more and more efficient drugs became available from the late 19th century. Comparing population trends after the takeover in Tahiti

and the Marquesas will clearly show the impact of availability of health care services – even a doctor with basic medical supplies – on the population decline.

Estimates of Indigenous Populations at Contact

Large samples of the 14-th century dated housing structures are now available for assessing pre-contact population trends in Hawai'i, which is likely to apply to Tahiti and the Marquesas settled earlier by the Polynesians. In the fifteenth and sixteenth centuries, growth rates were close to 0.5 percent (Rallu 2007: 20), following agricultural innovations such as irrigated taro terraces and the appearance of large chiefdoms in the late Expansion Period[1] (1100–1650) (Kirch 1984, 2000). At the same time, semi-arid zones that are ecological limits for human settlement, like Kahikinui on the slopes of Maui volcano, started to be settled, reaching densities between 43 p/km^2 and 57 p/km^2 in the lowland zone (below 900 m) in the eighteenth century (Kirch 2007: 102). Then, the population stabilized and started to decline (Rallu 2007: 21) along with the extension of wars, displacement of commoners to build monumental 'heiau' (open religious structures), new customs like abortions and infanticides (Ellis 1831: 249–253)[2], and human sacrifices (Kirch 1984: 2000). Trends in the Society Islands and the Marquesas have probably been similar, with earlier stabilization than in Hawai'i due to the smaller island size.

After several decades of archaeological research, fieldworks cover nearly whole valleys, providing population density estimates prior to contact for some Pacific islands. Hamilton and Kahn (2007: 155) estimate population density in the Opunohu valley of Moorea, an island close to Tahiti, at 87 p/km^2 in coastal and intermediate (Opunohu DROP) valley and 52 p/km^2 for the whole valley in the late 18th century, which they think are very conservative estimates, as most of the lower caste people's houses were not built on stone platforms.

McArthur (1968: 167) estimates the population of Rarotonga (the Cook Islands) at "between six and seven thousand before 1830", or a density around 97 p/km^2. Such density is likely to apply to Tahiti, as these islands have similar geographical features, yielding 101,000 inhabitants. This figure is consistent with the estimates by Robertson (1948: 139, 221) in 1767: "*over 100,000*" (after staying five weeks in Matavai Bay and reporting plantations and innumerable houses on the coastal plain and several miles back into the valley) and Forster in 1773: 120,000. Cook's attempt at a statistically based estimate at his third voyage in 1774, after having spent more than six months on the island, yields a much higher figure, 204,000 (Beaglehole 1961: 409). Spanish missionaries' and Boenechea's estimates of 15,000 inhabitants or less and recent estimates by McArthur (1968) and Oliver (1974) of 30,000 and 35,000, respectively, are inconsistent with the current archaeological data.

Early population estimates of the Marquesas indicate a high population density, but they are unreliable, as the first Europeans to reach this archipelago failed to visit all islands. However, the density was probably lower than in the Society Islands due to a sizeable semi-arid area (Terre Deserte) in Nuku-Hiva and dry north-western parts of the most islands. Molle and Conte (2015: 267) estimate the Ua Uka's population at between 1,660 and 2,550 in the late eighteenth century with the density per arable land at between 66 p/km^2 and 99 p/km^2 or be-

1 The period of population growth and increasing complexity of the socio-political system.

2 Infanticide was very frequent according to missionary reports based on a few informants in the Leeward Islands that may not be representative.

tween 56 p/km^2 and 83 p/km^2, respectively, with low and high estimates of the arable land. The whole island's density is estimated at between 20 p/km^2 and 31 p/km^2. Such low figures compared to the average densities in the Marquesas (Kirch 1984), Tahiti, Kahikinui, and Rarotonga are due to the fact that most of the Ua Uka's north and north-west coasts are uninhabited.

Thus, the recent archaeological research shows that population numbers in the Society Islands at contact were much closer to the first navigators' estimates rather than to the 1830 missionary 'census,' carried out without adequate methodology and following several epidemics, which has enumerated 8,674 Tahitians (McArthur 1968: 249).

Dramatic Epidemic Mortality

The immunization process fits well into the reports of catastrophic epidemics among the Pacific islanders following the introduction of diseases, such as flu, that hardly affect the Europeans. Although reports on epidemics in the late eighteenth and early nineteenth century may be incomplete, some provide for interesting information. In 1773, the Tahitians complained to Cook about a dreadful fatal disease (probably flu) following Boenechea's visit in 1772 (Beaglehole 1961: 215). At that time, flu was an entirely new virus to the Polynesians (like the new strain of flu virus in 1918 that affected people worldwide), and the death toll was certainly very high. Martin and Combes (1996: 360) also report a "disastrous influenza" in 1820. As circulation around Tahiti was easy in the lagoon, these epidemics have probably affected the whole island. Reports on later epidemics cast light on the enormous toll among the island populations. In 1844, Comeiras, a doctor on La Boussole, reported flu in Tahuata that killed so many people that there were less than sixty warriors left on the island (Testard de Marans 2005: 46). The same year, an epidemic occurred in the Taio Hae valley of Nuku Hiva (Lesson 1981: 924–927). The Marquesans called it disease of the belly (*mate i te kopu*) and said that the affected people died quickly from convulsions. Dr. Lesson saw many empty houses and exposed dead bodies and assumed it was an encephalomeningitis, most probably due to adulterated alcohol sold by the French colonists. The 1863 smallpox epidemic was reported to have killed "half of the population of Nuku Hiva and two-thirds of that of Ua Pou," with 968 and 600 deaths, respectively (Bailleul 2001: 107); however, deaths rates based on our population estimates are somewhat lower (Table 1).

Statistical Data on Epidemics

Scarce Pacific islands data for the second half of the nineteenth and early twentieth century show very high epidemic death rates. Death rates due to smallpox range from 430 p.1000 to 500 p.1000 in Nuku Hiva, Guam, and Ua Pou. Whooping cough killed about 230 p.1000 children under five years old in 1855 and 140 p.1000 in 1898. These figures are consistent with the earlier visitors' reports on large sections of the population being swept off.

In the Society Islands, civil registration data show that the 1918 flu death rate was close to 200 p.1000, and Western Samoa and Nauru show similar figures. Such high rates have nothing in common with a (comparatively) slight increase that occurred in the Western countries or among the Europeans in the Pacific. In New Zealand, death rates in 1918 were 5.8 p.1000 among the Europeans and 42 p.1000 among the Maoris, reaching 80 p.1000 in the most affected communities (Rice 2005: 52; Wilson and al. 2012: 71–77), while deaths were still partly unrecorded for the latter.

Table 1. Death rates (p.1000) in epidemic years

Epidemic type	Year	Place	Source of data	Death rate p.1000
		Rough estimates		
Smallpox	1856	Guam	Underwood*	around 450
Smallpox	1863	Nuku Hiva	968 deaths (Bailleul)	around 430
Smallpox	1863	Ua Pou	600 deaths (Bailleul)	around 500
Measles	187	Fiji	administrative report	'1/3 of the population'
		Administrative report or registration data		
Measles	1854	Tahiti	civil registration**	97
Flu	1849	Guam	administrative report*	25[(b)]
Whooping cough	1855	Guam	administrative report*	229[(a)(b)]
Whooping cough	1898	Guam (Agana)	administrative report*	141[(a)(b)]
Unspecified	1914	S–E Marquesas	civil registration**	126
1918 flu	1918	Society Islands	civil registration**	191
1918 flu	1918	Samoa	administrative report	196
1918 flu	1918	Nauru	administrative report	180

* Underwood. Based on the estimate that the epidemic 'reduced [the population] nearly in half' (Underwood 1973: 22)

** Rallu, 1990.

(a) Rate for children 0–4 (calculated based on Underwood data).

(b) Deaths due to epidemics only (Underwood).

Impact of low immunity

Comparing age-specific death rates in the Society Islands and France in 1917–1918 before and during the epidemic evidences the role of immunity. The most striking difference lies in the age pattern of the flu mortality. Death rates among young children were higher in the Society Islands (Figure 2) than in France, and they increased much more rapidly from age 10–14 years. At ages 30–34, the rates were 14 times higher than in France among males and 24 times among females (Rallu 1990: 256). In France, the rates leveled off at 25–34 years and declined thereafter. But they rose until the oldest age groups in the Society Islands reaching very high levels: at ages 40–49, the difference with France was by a factor of 60 and, at 50–54 – by a factor of 100. At older ages, every other Polynesian died.

In Europe, severe flu epidemics have periodically occurred in the past, about every 40 or 50 years, due to new strains of the virus. The affected people develop immunity against the new virus, mostly if it shares most of its DNA with previous ones (Mathews and al. 2009: 143); this explains why death rates declined among the Europeans over 35 years, whereas they increased until older ages among the Polynesians. The previous flu epidemics in May, August, and September 1918 did not increase the Tahitians' immunity against the Spanish flu virus, a different strain. However, many deaths were probably related to complications that could not be treated as sick people sometimes were brought to hospitals in a desperate state. With most of its staff including two of its three doctors being sick and little medicine supplies, the colonial administration has set up a Comité Exécutif d'Hygiène et de

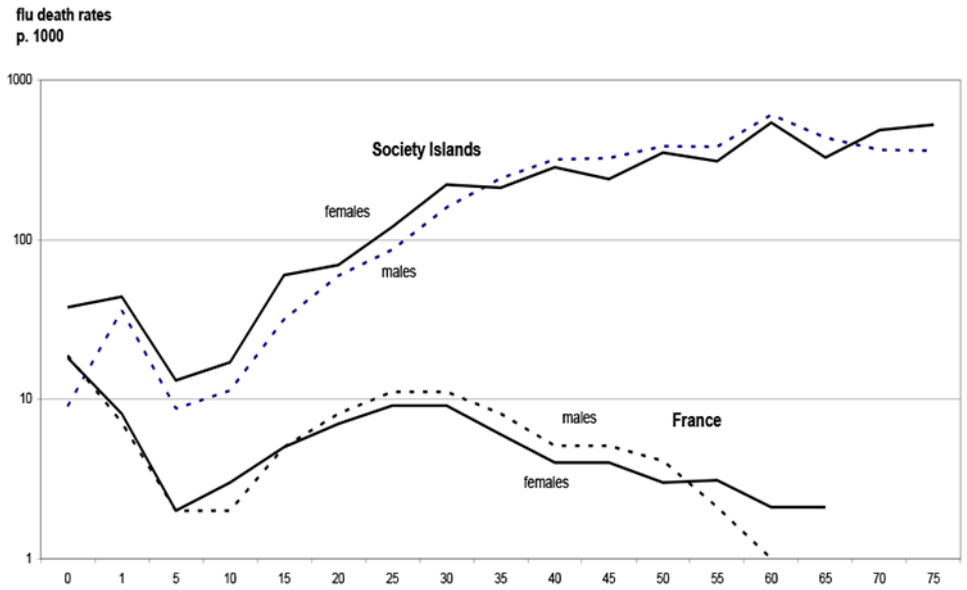

Figure 2. The '1918 flu' death rates (p.1000) by age-groups, Society Islands and France (logarithmic scale). *Source*: (Rallu 1990)

Santé Publique that mostly broadcasted news in French and sometimes in Tahitian (Leriche 1964: 759), advising people not to gather (ceremonies for the armistice were interrupted and schools closed), practice a frequent mouthwash, and avoid bathing in cold water, a common practice of the Tahitians when they have a fever. Pastors and nuns distributed an ineffective anti-flu potion. When all family members were sick, no one was able to go out and prepare food, and some people might have died of starvation.

A similar low immunity is seen for measles. In 1951, a measles epidemic affected people of all ages in French Polynesia. Mortality due to the epidemic alone was high among children aged 0–1 and 1–4 years with rates of 132 p.1000 and 44 p.1000, respectively. Then, rates increased from age 5–9 years, reaching 100 p.1000 at age 30–39 years and above 250 p.1000 at 60 years and over (Rallu 1980: 400). Measles was rarely introduced in Tahiti, and most people were not exposed to the virus when they were children. A previous measles epidemic occurred in 1854 in Tahiti and Moorea with a death rate of 97 p.1000, at a time when civil registration was still incomplete. Such a high death rate implies that many adults have died: if only children were affected, the whole population under seven or eight would have been swept off.

In 1914, an epidemic hit Hiva Oa and Fatu Hiva with the death rate reaching 126 p.1000. Adults were affected the most with rates increasing by 50 percent to 200 percent at ages 20 and over compared with the previous years. However, it was unreported by the administration and missions, therefore we have no clues about causes of the epidemic.

Thus, the age-specific death rates of the 1918 flu, the 1854 and 1951 measles in Tahiti, and the 1914 epidemic in the Marquesas assess the impacts of the first contacts with new viruses in the isolated populations. Such high mortality levels affecting nearly all ages were most probably common during early epidemics due to "reduced genetic polymorphism of the nineteenth-century Polynesians" (Martin and Combes 1996: 360).

Recovery after Epidemics

The speed of recovery after epidemics is related to mortality age patterns. Epidemics mainly affecting the elderly result in a younger age structure of the population and lower death rates thereafter, however, this effect lowers with time. Such beneficial effect does not occur after epidemics that mostly affect children (measles, whooping cough), and the age structure of the population becomes older. Later, when depleted cohorts reach reproductive ages, birth rates decline. However, due to low immunity in the early post-contact period, both types of epidemics have affected adults to some extent.

In the Society Islands, the 1919 death rate was not much below its 1917 level with 33.6 p.1000 versus 35.3 p.1000 because high flu death rates among young and middle-aged adults limited the population's rejuvenation and adult mortality was still high in "normal" years (Rallu 1990: 248–264). But the birth rate was only 32 p.1000 in 1919 versus 42 p.1000 in 1917, due to a drop in the number of conceptions, and increase in the number of spontaneous abortions and deaths of pregnant women during the epidemic. There was a strong fertility recovery in 1920 and 1921 with 48 p.1000 and 45 p.1000, respectively, but the death rates increased to 38 p.1000. As a result, growth rates were -0.1 percent in 1919, 1.0 percent in 1920, and 0.8 percent in 1921, close to the 1917 levels (0.7 percent). With such a rate, full recovery would have taken 20 years. However, growth rates increased due to improvements in health services following the pandemic, and mostly due to migration to Tahiti. But, in the early post-contact period, epidemics were too frequent, with five in 1772–1820 in Tahiti, to allow a full recovery. There was probably not much, if any, recovery after the early epidemics because infanticide and human sacrifices continued to be practiced until the 1810s (Ellis 1831), wars had periodically occurred until Pomare unified the island in 1815 and, mostly because the introduced new diseases started to reduce fertility and increase mortality at adult ages.

Steady Population Decline

Early reports on constant decline

STDs and tuberculosis were more frequently introduced by the increasing numbers of visitors. They sold alcohol and taught the Marquesans how to make palm wine (Denning 1974), causing digestive diseases, sudden deaths due to excess drinking, murders, and affecting indigenous people's health and reducing their resistance to germs. Alcoholism is well acknowledged for its negative effect on the course of tuberculosis. Marestang (1886: 363) noticed that young adults died eight to twelve months after the onset of coughing. Thus, peaks of epidemic mortality in the first decades after contact were followed by continuously high mortality resulting, in conjunction with the reduced fertility, in a steady population decline.

Such a situation was reported by missionaries in Tahiti as early as in 1803: "As to the Island, the inhabitants are diminished every year" (Newbury 1961: 75), and in the 1820s, in Taiarapu: "the people are dying very fast. There are not half the inhabitants […] that there were ten years ago" (McArthur 1968: 248), such a decline implies an average annual rate of 6.5 percent. These reports show that some 25-30 years after the increased frequency of contacts in the 1770s the new diseases have become widespread.

In the Marquesas in 1842, about 30 years after intensification of contacts, Dr. Lesson noticed that syphilis was widespread and tuberculosis was the most common pulmonary disease, rapidly resulting in deaths of young adults (Lesson 1981: 938, 923). These diseases were reported as major causes of rapid population decline in the archipelago until the mid-1920s (see below).

Census and Civil Registration Data

Since the civil registration was incomplete, covering mainly deaths until the 1910s, we have used the 1848 and 1881 Tahiti censuses to estimate that the population declined at an average rate of 1 percent yearly, excluding epidemics (Rallu 1990: 233), with stabilization in the 1880s.

On the Marquesas, death rates were high in 1886–1900; however, they were declining in the North-West (N–W) Marquesas and increasing in the South-East (S–E) Marquesas (Fig. 3), mostly in Hiva Oa where contacts had increased since the early 1880s following pacification (see below). In 1911–1923, about thirty years later (a period close to that observed in Tahiti), a mortality peak was registered in the S–E group; death rates reached 80 p.1000 in Hiva Oa (and even higher in Hanaiapa, Puamau, and Hekeani valleys) and the island's population was reduced to 41 percent of its 1911 size due to an average annual rate of 5.7 percent. Such rates are close to those implied by missionary reports dated around 1800 and in the 1820s in Tahiti (see above).

Remarkably, the mortality crisis in Hiva Oa followed the opening of missionary schools. Similar events occurred in Maui, where a big mission school opened in the early 1830s, with an annual decline in population of 7 percent in 1831-1835, reaching 11 percent in Lahaina, where the school was located (Schmitt 1977: 12); in Rarotonga (the Cook Islands) in 1838-1843, following nearly a complete conversion of the population; and in Tahiti in the 1820s, after promulgation of the Pomare Code in 1819 (see below), that forbid ancient cult and traditional ceremonies. Conversions resulted in large church attendance on Sundays with daily collective prayers – the only gatherings allowed at that time. Anthem singing widely spreads diseases, such as tuberculosis, which is transmitted through droplets. In Tahiti, it resulted in the creation of the Mamaia sect that picked up momentum in 1826. The Tahitians left missionary villages to avoid high mortality and returned to traditional cults and practices, such as tattooing.

In 1886–1900, death rates (corrected for under-registration[1]) in the Marquesas were not much higher than in France in 1740–1750, with around 45 p.1000 versus 40 p.1000, and life expectancy was lower: 22 years versus 25 years (Meslé and Vallin 1989: 1122–1123). In France, the death rate fell to 27 p.1000, and life expectancy reached 36 years in 1800. Life expectancy did not increase much in the nineteenth-century France, from 38.6 years in the early 1820s (after the Napoleonic wars) to 43.0 years in 1880. Then, the increase became faster, mainly after 1890, following the discovery of new drugs with life expectancy adding up to 46.5 years by the end of the century.

The increase in life expectancy in France before 1880 has no equivalent in the post-contact Tahiti and the Marquesas, affected by epidemics and mortality crises until the 1830s. Missionaries were mostly witnessing the tremendous population decline unable to help. From the takeover by France in 1843 to the 1870s, the mortality decline in Tahiti was mostly due to a progressive increase in immunity of the population, as health services for the Polynesians were hardly available until late 1870s. Since 1880, birth rates have been on the rise, and death rates declined slowly, however, the latter remained much higher than in mainland France, with 36 p.1000 in early 1900s (despite still incomplete registration of deaths) versus 22 p.1000 because new drugs were not available in the island.

The Marquesas, the N–W group, where a physician was available, experienced a slight increase in life expectancy: from 20 years in 1886–1895 to 22 years in 1896–1905 (maybe

1 Birth and death registration was nearly complete starting from 1886, except for stillbirths and births followed by early deaths; rates have been corrected at the Marquesas level, but small numbers at the island level do not allow for data correction (Rallu, 1990).

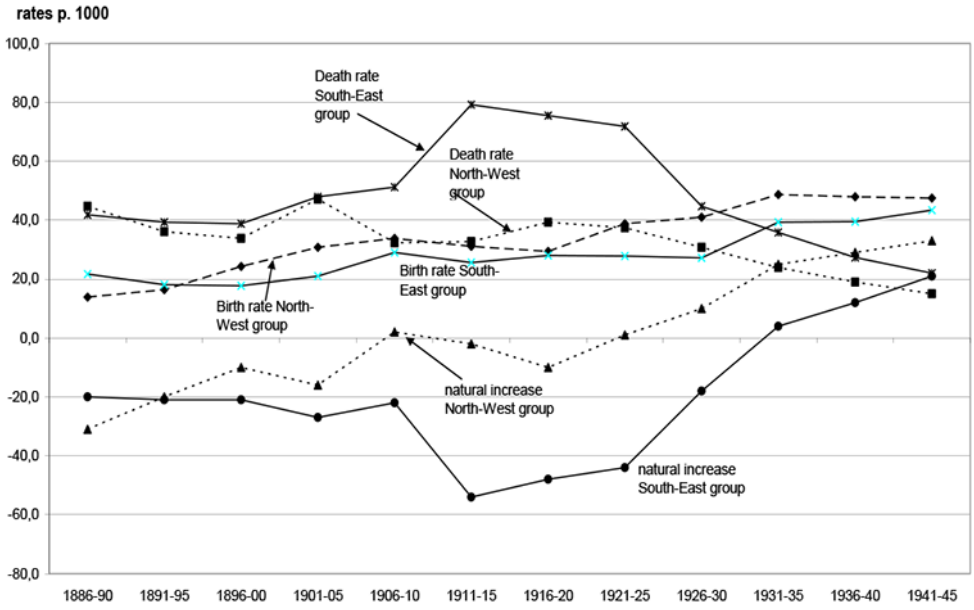

Figure 3. Observed birth, death, and natural increase rates (p. 1000), the Marquesas Islands, 1886–1945. *Source*: (Rallu 1990)

due to the increased medical supplies like in Tahiti), followed by a stall in life expectancy (Rallu 1990). But the S–E group with no doctor available except in 1898–1901, was affected by a very severe mortality crisis in 1911–1923, with a life expectancy of around 15 years. Since 1924, when a physician was appointed in Atuona, declines in mortality have become substantial with life expectancy adding up to 23 years in 1926–1935s. In the N–W group it has reached 30 years by that time.

In general, demographic trends on the islands in the second half of the nineteenth century mirror the ones observed in France with slower progress or reverse trends in the former being consistent with low availability or complete lack of health services. However, part of the gap in life expectancy is certainly related to higher prevalence rates of infectious diseases in Tahiti and the Marquesas than in France, the impact of which cannot be precisely assessed due to lack of data on morbidity and causes of death. These islands have been far behind mainland France in terms of mortality indicators until the twentieth century. Life expectancy in French Polynesia failed to reach 44 years until 1946–1950, a level observed in France in the early 1880s.

STDs and Low Fertility

In the Marquesas (and probably also in Tahiti, where civil registration shows low birth rates until 1880), fertility was low, with TFR (total fertility rate) of only 3.2 (children per woman) in the late nineteenth century (Rallu 1990: 78; 1992), due to extremely high share of women never giving birth (or pregnancies resulting in unregistered stillborn babies – see below), reaching 27 percent in the 1876–1890 birth cohorts. Moreover, infertility was rapidly increasing with age: among women of these cohorts who already had children and were still in union, 49 percent no longer gave birth after their 25th birthday and 58 percent after their

30th birthday (Rallu 1990: 133). However, it is noticeable that, in 1886–1890, birth rates were still higher in Hiva Oa (19 p.1000) than in Nuku-Hiva: 15 p.000, but Tahuata, where most of the ships were called before the pacification of Hiva Oa, had almost the same rate as Nuku-Hiva: 16 p.1000. The less frequently visited small bays of Puamau and Hekeani in the East of Hiva Oa had the highest birth rates, 22 p.1000. The same pattern was seen in Nuku Hiva in the 1840s; Radiguet (1882: 148) noted that depopulation was more substantial in Taio Hae than in less frequently visited Taipi Vai. Such low birth rates and high infertility are related to widespread STDs. Gonorrhea causes lesions resulting in sterility, and syphilis is a cause of abortions and stillbirths. The share of stillbirths accounts for 10 to 15 percent of deliveries, two- to three-fold normal levels, however, it is still underestimated as up to 40 percent of babies born to women with untreated syphilis can be stillborn or die from the infection as a newborn. Dr. Tautain reported:

"Stillbirths are frequent, and only stillbirths from full-term deliveries are recorded. Chiefs of stations[1] are recommended to register stillbirths from six-month or older pregnancies. But this is not enough because many stillbirths occur in the first and second trimesters." (Rapport du Commandant... 1844[2]; see also Clavel 1884: 497).

Yaws, a disease frequent in the Pacific islands, immunizes against syphilis, but it has no effect on fertility. However, some colonial administrators, military doctors, and even scholars used, and are still using, yaws to reject the impact of syphilis on birth rates – it is actually a follow-up of the denial of the introduction of syphilis in the Pacific islands by the Europeans. However, high levels of early spontaneous abortions and stillbirths suggest a widespread syphilis, co-existing with yaws, because not everybody was affected by the latter.

In 1886–1895, birth rates were hardly half the death rates, and they reached only 60 percent in 1896–1905. With a normal birth rate of 40 p.1000[3], the Marquesan population would have declined by an average annual rate of 0.5 percent in 1886–1900 instead of 2.0 percent. During the 1911-1923 mortality crisis in the S–E group, the annual decline would still have been 3.6 percent, however much lower than the observed rate of 5.1 percent, and in Hiva Oa, the most affected island, 4.2 percent versus 5.7 percent. This shows the important impact of low fertility on population trends in the Marquesas, and probably also in Tahiti, given the high prevalence of syphilis out there (see below). The Marquesan population of the N–W group stabilized in the 1920s and the S–E group – in the 1930s when the birth rates reached 40 p.1000 and mortality declined to a similar level; the population growth resumed about five years later, following a further decline in mortality (Figure 3).

Post-Contact and Colonial Contexts

It is always difficult to precisely link population trends with historical events and changes in health care, especially without data on morbidity and causes of death. However, the history of contact and French colonization in Tahiti and the Marquesas accurately translates the general context and underlying causes of population trends presented above.

1 Small administration offices on the islands.

2 Archives Nationales d'Outre-mer, Océanie. All references to these archives in the paper are under 'FM SG OCEA'.

3 A level observed in the pre-transitional populations in Europe in the eighteenth and nineteenth centuries and in most developing countries in the 1950-1970s.

From Discovery to the French Takeover

Tahiti was discovered by Wallis in 1767 and visited by Bougainville (1768), Boenechea (1772, 1774), and Cook (1769, 1773, 1774, 1777). From the late 1770s to the early 1790s, ships called at Tahiti nearly every year, sometimes twice a year, and stayed for a few weeks, sometimes for two or three months, while Bligh in 1788 stayed for even much longer. In the 1790s, whalers used to resupply in Tahiti in exchange for alcohol and firearms. English missionaries settled in 1797 and reported frequent wars and a steady population decline. However, following the victory of Pomare III in 1815, the situation has become more controllable. There was already the rule of law with the Pomare Code. Well before the takeover by France in 1843, the English missionaries had prepared for an English colony, and Pritchard was appointed Consul of the United Kingdom in Tahiti in 1837.

Cook visited Tahuata and Hiva Oa in 1774 and Ingraham and Marchand visited the N–W group in 1791. The English missionaries arrived in 1797; Crook stayed for a year only, discouraged by sexual license. Whalers, sea cucumber and sandalwood traders frequently called in the islands, the former enrolling the Marquesans to join their crew. Alcohol and firearms were the usual items in exchange for fresh supplies and recruits. The first colonizers were stowaways. They became advisers in warfare with firearms, and chiefs frequently engaged in tribal wars. There was no rule of law. In 1838, the catholic missionaries settled permanently in Nuku Hiva, and in 1842 France took possession of the Tahuata and Du Petit Thouars islands.

In the Marquesas, information on epidemics, mostly typhoid fever and flu, is sporadic and with little details until 1842. They have probably affected only one or two islands, like in the 1850s and 1860s. Three famines occurred in 1797–1798, 1804 (lasting for several years), and 1820 (Kellum-Ottino 1971: 26). Robarts estimated that between 200 and 300 people died over a year in the valley where he stayed, and in Ua Pou, whole valleys were deprived of inhabitants (Denning 1974: 274). However, there may have been temporary migrations to other valleys. Tolls from frequent tribal wars, excess drinking, murders – sometimes revenged with cannibalism, which lasted until 1880 in Hiva Oa (Eggiman. Situation…), and mostly infectious diseases, particularly tuberculosis, also caused many deaths. Moreover, women used to swim to ships as soon as they anchored, and fertility was strongly reduced by STDs.

Colonial Period

Tahiti was already pacified in 1843 (however, fights with opponents to the French takeover caused a few hundred deaths) and was easier to administrate than the Marquesan archipelago. After the 1842 takeover, repeated skirmishes and fights made the French to pull out from the position in Tahuata (Testard de Marans 2005: 6–24; see also Rapport du Commandant... 1844). Nuku Hiva was also to be abandoned, however, the decision was canceled following a project to build a deportation center in 1851. However, the French administration was almost ineffective outside Taio Hae valley. In 1859, following a rebellion of the Taipis (next valley east of Taio Hae), the position was abandoned, and the buildings and the flag were left to the missionaries' care. The French administration returned to Taio Hae the following year, and to the S–E group in Atuona (Hiva Oa) in 1880 only. However, the colonial control of the islands was still limited. The Chinese working on cotton plantations bought opium from the Chinese in Tahiti and sold it to the Marquesans. Brewing and selling alcohol to the Marquesans was declared illegal in 1894, with little effect, and again in 1903. However,

the Europeans were allowed to buy spirits that finally ended in the natives' hands, and the colony gave an impression of abandonment due to the lack of boats for inter-island administration and isolation from Tahiti (Lettre du Gouverneur … 1903).

Health Services

Before the takeover, vaccination of the Tahitians against smallpox was rapidly carried out by the missionaries in 1841. Members of the Mamaia sect had refused injections, and the sect disappeared, however mortality was not high in the areas where vaccination was accepted. Since 1845, despite occasional vaccine shortages, the colonial administration has conducted smallpox vaccination campaigns, the impact of which cannot be estimated as there was no new introduction of disease on the island (Rapports sur les campagnes…).

A military hospital was opened in Papeete in 1845 for the navy, police forces, other Europeans, and eventually members of the Pomare royal family. A dispensary for common Tahitian was opened much later, in the late 1850s. It was known as a place of abuse and was closed in 1865. Despite numerous claims to reopen it since 1868, the Tahitians had to wait until the late 1870s to have a new dispensary (Conseil Supérieur … 1876). From the takeover until the 1880s, syphilis was a major concern of navy doctors with regard to the troops' and civilian Europeans' health (Lettre du Commandant… 1868; Note pour la Direction… 1875); the same situation has probably affected the Marquesas, given very low fertility rates out there.

Health services were practically non-existent in the Marquesas. From the takeover by France, there was only one – almost resident – navy medical doctor in Taio Hae (Nuku Hiva), most often without any boat fit to visit other islands (Testard de Marans 2005: 50, 56, 165–166). Unlike in Tahiti, no vaccination campaign was carried out in the Marquesas. The Papeete hospital sent vaccines when the smallpox epidemic broke out in 1863, but it was too late. While doctors reported that birth rates were reduced by high levels of stillbirths, the administration considered kava as a cause of male sterility. From the 1880s, drinking kava was sanctioned by the French police. As a result, people drank more alcohol and smoked opium, a combination that causes irreversible physiological damage.

Concerned about the constant decline in the Marquesan population, the administration started civil registration of the Marquesans in 1882 and decided to carry out five-year censuses. In 1887, Vice-president of the most populated S–E group had to act as a doctor. He was given a pharmacy and medical guidelines. A physician was appointed in Atuona in 1898, but the position was closed in 1901 due to the lack of funds. Despite several claims to restore it, among which by Governor Petit (Lettre du Gouverneur… 1902; Lettre du Gouverneur… 1903), the S–E group had to wait until 1923 to have a resident physician.

Thus, except for vaccination campaigns, there were no health services for the Polynesians most of the time from 1843 to 1881 in Tahiti, nearly all the time in 1842–1923 in the S–E Marquesas, and only one doctor in the N–W group from 1842. In 1923, Dr. Rollin arrived in the S–E group with disinfectants and colloidal silver that kills a wide range of bacteria and germs and extends lives of TB patients. He was alone (there was no nurse) and did rounds of villages and trips to other islands almost every working day. He reported frequent tuberculosis and "cervical adenite scrofulas" (purulent infected ganglions in the neck related to a virulent form of TB) among the youth, together making four fifths of all deaths and that people frequently dying of infected wounds (Rollin 1929: 293). Thus, the sudden drop by 40 percent in death rates between 1923 and 1924 clearly shows that a large proportion of

deaths could have been easily prevented or at least delayed by drugs available from the late nineteenth century if there had been just one doctor with adequate supplies. The Marquesan population could have stabilized between 4,000 and 5,000. Moreover, given high death rates among adults of reproductive age, life extension would have also had a positive impact on birth rates.

Quarantine

It is well known that the introduced diseases (smallpox, dysentery, flu, etc.) have decimated indigenous populations in the Americas, and epidemics in the Pacific could have been prevented by a quarantine, already enforced in the first half of the eighteenth century in New York (Bedloe's Island) and Boston. Thus, the lack of quarantine, including after several epidemics reported by navigators and traders in the late 18th and early 19th centuries, is a major example of negligence on the part of early navigators, missionaries, and colonial administrations. In EFO (Etablissements français d'Océanie, now French Polynesia) quarantine and disinfection (by fumigation) procedures were not adopted before the 1860s, and often are still inadequate. In 1863, a French navy ship repatriated the Marquesans enslaved in Peru mines to Nuku Hiva and Ua Pou while some of them had smallpox. Only those who were already sick were isolated.

The 1918 flu in Tahiti could have easily been prevented. The Navua and The Roberta arrived from San Francisco, reporting two cases of influenza and two deaths, respectively. Although it was known that the Spanish flu was in California, the Papeete port authorities did not quarantine them. However, no boat was allowed to leave for the Marquesas, Australs, and Gambier (Leriche 1964: 752–758). American Samoa successfully implemented a quarantine in 1918.

The Impacts of Epidemics and Constant Decline

Tahiti

To estimate the impacts of epidemics and constant decline, we have revised our 2007 central estimate of 110,000 Tahitians in 1767 (Rallu 2007: 29–30)[1], taking into account missionaries' reports on the demographic situation in the first decades after contact. There were "at least 11 [epidemics] in Tahiti" from contact to 1877, of which five in 1772–1820: flu in 1772, 1774, and 1820, and dysentery in 1790 and 1807 (Martin and Combes 1996: 360). We assume the population declined on average by 17 percent[2] in epidemic years until 1820, by an average of 5 percent in each of the three epidemics in 1840–1843[3], and by 9.5 percent in the 1854 measles (Rallu 1990: 233). We assume no recovery in non-epidemic years due to infanticide, human sacrifices, and wars reconstitution, with annual decline since 1780 at a rate of

1 Comparatively to our previous model, there is no recovery between early epidemics for the reasons explained in the Recovery section; and trends are more consistent with the levels and timeline of missionary and other reports.

2 With birth and death rates of 30 p.1000 and 200 p.1000, respectively, as the birth rate was reduced by infanticide in the late eighteenth and early nineteenth centuries, and, the death rate about the same as in the 1918 flu, which seems acceptable for the early post-contact flu epidemics, because the Polynesians have never been infected by a similar virus before. However, death rates due todysentery are usually higher.

3 The 1841 smallpox being limited to the Mamaia sect.

0.5 percent, progressively increasing up to 3.0 percent in 1805–1820, when the missionaries report a very rapid constant decline. Then, the rates progressively returned to -1.5 percent in 1845 and -0.5 percent in 1880.

Under this scenario, the Tahiti's population in 1800 was 44.2 percent of its size at contact and 9.5 percent in 1843. Note that the missionary 'census' of 8,674 Tahitians in 1830 appears to be a gross underestimation as our reconstitution yields 15,300 for that year. Moreover, it implies an almost stable population from 1830 to 1848, while there were three epidemics in 1840–1843 and a constant ongoing decline. McArthur's estimate of 30,000 at contact leads to almost similar average annual rates in 1767–1848 (-1.43 percent) and 1849–1881 (-1.36 percent), which is inconsistent with the five major epidemics in the early post-contact period and rapid annual decline in the early 19th century.

From contact to 1800, epidemics were the main factor of decline, reducing the population by 41.7 percent versus 24.2 percent[1] for constant decline (related to endemic diseases introduced by the increasing contacts). But in 1801–1843, when the missionaries reported a very rapid depopulation, the main factor was a constant decline that reduced the population size by 67.2 percent due to widespread endemic diseases, versus 34.7 percent for epidemics (Table 2).

Table 2. Estimates of factors of decline and overall decline, in our reconstitutions (Tahiti 110K scenario)

	Trends[(a)] by period due to:		total*	Relative decline	
	epidemics	constant decline		year	population
1767-1800	0.417	0.242	0.442	1767	1000
1801-1843	0.347	0.672	0.214	1800	442
1844-1881	0.095	0.359	0.58	1843	95
1767-1881	0.655	0.843	0.054	1881	54
Marquesas					
1810-1842	n.a.**	n.a.**	0.399	1810	1000
1843-1886	0.163	0.672	0.275	1842	399
1887-1924	0.071	0.581	0.389	1886	107
1843-1924	0.201	0.861	0.111		
1810-1924	n.a.	n.a.	0.044	1924	44

(a) proportion of population remaining at end of periods

* Col. 3 = (1-col. 1)*(1-col. 2)

** no data to estimate factors

Source: author's estimates according to the reconstruction model (see above).

The annual decline continued at an average rate of 1 percent in 1844–1881 and, besides the 1854 measles, there were two moderate epidemics in 1847 and 1877 that, according to the civil registration data, had little impact on mortality (Rallu 1990). The population in

1 (1-0.417)*(1-0.242) = 0.442 (decline up to 44.2 percent of the initial number in 1767-1800) and so on.

1881 was only 58.0 percent of its number in 1843, with declines of 9.5 percent due to epidemics and 35.9 percent due to constant decline. The impact of epidemics becomes almost negligible due to lesser epidemics and progressively increasing immunity among the population, and annual decline is less severe as rates tend towards stabilization, health services becoming periodically available for the Tahitians (see above).

Altogether, the decline from contact to 1881 (when 5,960 Tahitians were enumerated) is by a ratio of 18.4 to 1 (5.4 percent of the initial population), epidemics alone causing a decline of 65.5 percent and an annual decline of 84.3 percent. The overall balance is strongly on the side of the constant decline in the early nineteenth century throughout, at lower rates, the 1880s. This exercise shows that records on epidemics (although probably incomplete) and moderate steady decline rates in the range of 1 percent to 3 percent are consistent with a population of about 110,000 (or a density of 106 p/km^2) at contact. This figure is well above our 1990 estimate of 66,150 in 1774, after Boenechea's flu in 1772, and, under our assumption of a 17 percent epidemic decline, 79,700 at contact[1]. This estimate was based on Tupaia's numbers of warriors by districts and the fleet seen by Cook in April 1774 (Rallu 1990: 221-222).

The Marquesas

Estimates of the Marquesan population by navigators are unreliable, and information on early epidemics is imprecise and probably incomplete. We also lack information on famine-related deaths. Therefore, unlike for Tahiti, it is not possible to reconstruct a vector of population change before the takeover, and we cannot estimate the impacts of both factors. We assume annual average decline rates of 2.0 percent in 1810–1819 following increasing contacts, and 3.2 percent in 1820–1842, a rate observed for the S–E group in 1886–1925, excluding the N-W group that have almost stabilized since 1906. These rates resulted in a decline to 39.9 percent of the population size in 1810 that, by retrodiction from our estimate of 18,000 at takeover (Rallu 1990: 50), would have been 45,000.

For the period 1843–1886, beside the 1855 bilious fever in Ua Uka (Jouan 1890: 19) and the 1863 smallpox in Nuku Hiva and Ua Pou (table 1), we assume an average annual decline of 2.5 percent (close to the 1886–1890 rate: -2.2 percent). In 1886, the population was only 27.5 percent of its size in 1842, with declines of 67.2 percent due to constant decline and 16.3 percent due to epidemics, the former being by far the most important.

The decline continued until 1924 adding up to 38.9 percent of the population size in 1886, with the 1914 epidemic, limited to the S-E Marquesas, accounting for a reduction of 7.1 percent versus 58.1 percent due to constant decline. With the Marquesan population of 2,002 in 1926 (Rallu 1990: 54), since 1810 the overall depopulation ratio has reached 22.7 to 1 or 4.4 percent of the initial population. A major part of the decline occurred in 1842–1924, when the population was reduced to 11.1 percent, with constant decline reducing the population by 86.1 percent, and epidemics – by 20.1 percent.

Depending on the impact of famine and unreported early epidemics, the population at contact in the late eighteenth century could have been well above 45,000, possibly around 65,000 based on Kirch's estimate of density, resulting in the overall decline to 3.1 percent.

1 It is noteworthy that Bernard Grossat, chairman of my thesis jury, requested that I drop this figure before publication because he considered it too high compared with McArthur's and Oliver's estimates, whereas most archaeologists think now that it is far too low.

Discussion

It appears that, in the overall depopulation process, the constant decline had the highest impact. Although there were no efficient drugs available for most of the decline period in Tahiti, it could have been averted if there had been some concern for the Polynesians' health, with the implementation of health care services – they were lacking most of the time after the takeover. The same situation resulted in a rapid decline until the mid-1920s in the Marquesas, while efficient drugs were available in Europe starting from the 1890s.

Thus, a retrodiction from the 1848 and 1881 censuses in Tahiti, based on available information on trends before the takeover by France, and relatively moderate decline rates observed from the second half of the nineteenth century, when the Polynesians' immunity was higher than in the first decades after contact, yields a Tahitian population of 110,000 at contact.

Many archaeologists working in Polynesia argue (personal communications) that the population of Tahiti in 1767 was most probably higher than 110,000, and some of them favor 200,000, a figure close to Cook's estimate because lower caste people's houses were not built on stone platforms.

Our 110,000 indigenous population at contact reconstruction for Tahiti is conservative, with an annual decline rate of 3 percent in 1805–1820 while missionaries' reports imply 6 percent, a rate close to those recorded in Hiva Oa in 1911–1923. The 1918 flu death rate may also underestimate the impact of the first flu epidemics, and dysentery is usually associated with higher mortality. There is also some uncertainty about the number of early epidemics. Assuming six epidemics, instead of five, from contact to 1820 (or epidemic death rates 20 percent higher) and a steady decline by 6 percent in 1810–1819 yields 180,000 inhabitants at contact. This scenario increases epidemics' impact in 1767–1800 by 20 percent and constant decline's impact in 1800–1843 by 25 percent. The population in 1800, 1843, and 1881 was 40.2 percent, 5.6 percent, and 3.3 percent of its size at contact or an overall depopulation ratio of 30 to 1. Thus, limited changes to make our scenario align with early missionary reports and higher, but still conservative, epidemic mortality shows that numbers at contact close to Cook's estimate can be consistent with the 1848 and 1881 censuses. Cook's estimate of 204,000 Tahitians was inflated because of an inaccurate number of districts: 43 instead of 19 or 21, but the fleet assembled in Faaa in April 1774 may not have included all the forces of the districts preparing to attack Moorea (Rallu 1990: 221-222). Such rapid early decline is also consistent with other cases of depopulation following the European contact worldwide (Stannard 1989: 50-59).

Although these exercises cannot assess the size of the Tahiti's population at contact, they show that the numbers between 110,000 and 180,000, or eventually higher, cannot be excluded as they are consistent with recent archaeological data on population density and are supported by most archaeologists working on these islands.

The history of the Pacific islands' population is still a work in progress. As archaeological techniques cannot find remains of wooden poles of houses without stone platforms (where lower status people were dwelling), further research in other Polynesian islands, including in areas that are ecological limits to human settlement, can improve our knowledge of pre-contact population density and size. Paleodemography, paleopathology, and osteoarcheology could also tell us more about the prevalence of diseases that affected the Polynesians after contact.

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