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Limited Bio-Diversity and Other Defects of the Immune System in the Inhabitants of the Islands of St Kilda, Scotland

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1. Introduction

Intra-species variations in *Homo sapiens* can contribute to health and resistance to infection, or alternatively to death and disease. The small isolated population of the St Kilda archipelago in the Scottish Hebrides suffered severely from many infectious diseases in the seventeenth to nineteenth centuries, with greater morbidity and mortality than the inhabitants of similar Scottish communities on other remote islands.



Fig. 1. Map of Scotland



Fig. 2. Map of St Kilda



Fig. 3. Picture of St Kilda

These infections were one of the factors leading to the failure of the island society, culminating in its final evacuation in 1930. Limited population genetic biodiversity and other factors predisposing to infectious diseases including low herd immunity and isolation, the absence of any 'healthcare professionals', malnutrition, social conditions, climatic factors and dioxin toxicity are discussed.

St Kilda, located at 57° 48' N, 8° 34' W, is an inaccessible and isolated archipelago in the Scottish Hebrides, previously inhabited for approximately 2,000 years by a small struggling community until evacuated in 1930 as a non-sustainable society. Today it has been re-occupied by the National Trust of Scotland, and the Ministry of Defence.

The 430 metre cliffs of St Kilda can be seen on clear days from the nearest islands in the Outer Hebrides, Harris and North Uist, which have themselves been occupied continually for six thousand years, according to archaeological evidence. Simple stone tools found on the main St Kilda island of Hirte, suggest that travellers visited St Kilda some 4,000 to 5,000 years ago.^{1, 2, 3} The other smaller islands composing the St Kilda archipelago are Boreray, Soay and Dun.

The date of the first permanent settlement on St Kilda is not clear, but evidence suggests at least transient occupation from prehistoric times, harvesting the abundant stocks of fish and the sea birds, growing crops and keeping animals. A souterrain, an Iron Age earth house store about 2,000 years old, with a central long passage, and shorter passages or cells branching off, was discovered in 1844. A possible Bronze Age burial structure was excavated in 1995.



Fig. 4. Souterrain



Fig. 5. Village bay

The presence of three early chapels and two incised stone crosses of early Christian style were recorded by the Rev. Kenneth Macaulay.^{4,5} The continued use of Norse place names, such as Oiseval – the east hill – and Ruaival – the red hill, and archaeological finds of Norse brooches and steatite, are strong evidence of continual occupation by the Norsemen and their descendents until the 20th century. However, prior to the steamship era, the inclement climate and the small exposed rocky harbour restricted access by visiting sailing vessels.

2. Genetic origins

The inhabitants of St Kilda were predominantly of Celtic origin. The Vikings from Scandinavia occupied the Scottish islands until the 13th century. Control of the Hebrides was largely transferred from the Scandinavians to the Scots after the battle of Largs in 1263, but many settlers of Viking origin remained in the Hebrides. Studies of mitochondrial and Y chromosome DNA reveal that 30% of Orcadians and Shetland Islanders have Norse maternal and paternal ancestors, but in the Hebrides the male DNA remains around 30%, but Norse mitochondrial DNA falls to 8%, indicating that the Scandinavians took their women to the Northern Isles of Orkney and Shetland, but predominantly took local Celtic females as their partners in the Hebrides.⁶ The degree of consent cannot be determined. There have been no specific studies of the DNA of the current single survivor and the descendents of the evacuees from St Kilda, but the persistence of Norse names suggests at least some perhaps only male genetic biodiversity on St Kilda.

The St Kilda population up to the epidemic of 1727 were predominantly from two families of Morrisons and McDonalds generating inbred families with limited genetic diversity. St Kilda, as a 'virgin soil' environment, also had a non-immune adult population, with increased morbidity and mortality from most infections. Subsequent to that episode in 1727 which left one adult survivor on Hirte, the island was repopulated from neighbouring islands, though the inhabitants numbering over a hundred were essentially derived from only five resident families, the Gillies, MacQueens, MacDonalds, MacKinnons and Fergusons, for the remaining 200 years.⁷ Close consanguineous marriages were carefully avoided, and an external review of insanity caused by close intermarriages found no evidence of this problem. Consanguinity may, however, have been closer than suspected following the 'religious' leadership of a self-appointed predatory character known as Roderick for six years at the end of the 17th century. Seduction formed part of his 'instruction' of women attending counselling before marriage or childbirth.⁸

Comparisons with pre-Columbian North America indigenous population who had not encountered European viruses are interesting and relevant. ⁷ Their genetic biodiversity of histocompatibility leukocyte antigens (HLA), the genetic key to immunological defence against viruses, was 64 times less than that of the Europeans. The indigenous North American population declined from perhaps 100 million to a few million in 300 years. Smallpox is incriminated, without indisputable evidence, as causing the death of 90% of non-immune indigenous Americans in the sixteenth and seventeenth centuries.

Crosby defines the term 'virgin soil' epidemics as '*those in which the populations at risk have had no previous contact with the diseases that strike them and are therefore immunologically almost defenceless*'. John Morgan, a Manchester physician, used the term when writing about his visit to St Kilda in 1860: '*May we not explain the accumulated fatality in all these cases by supposing that in the same manner as the different cereals flourish best when planted in virgin soil, or at longer intervals of time, so it is with infectious disease? The more distant their visitation, the richer the pabulum supplied for the epidemic.*'⁷

3. Animal evolution²

The islands of St Kilda were sufficiently isolated for animals to evolve different characteristics over a few centuries. The common house mouse probably introduced by the Vikings evolved into the now extinct, but larger subspecies of the St Kilda House Mouse (*Mus musculus muralis*), which was found only on St Kilda. The mouse was dependent on human habitation and died out after the evacuation in 1930.

Another local genetically different animal is the Soay sheep (*Ovis aries*). The name Soay derives from the Viking name of island of sheep. This breed is thought to be the descendents of the earliest domesticated sheep of Northern Europe, and is physically similar to the other wild ancestors of domestic sheep like the horned urial sheep of Central Asia and the Mediterranean mouflon. Soay sheep are hardy and extremely agile animals well adapted for survival on the high cliffs of St Kilda, though they are smaller than modern domesticated sheep. Unattended, their numbers tend to build up to peak, followed by a crash, perhaps due to over-grazing or parasite infection. In the autumn of 1960 for example, 1344 sheep were counted, yet by the following spring 820 had died.

They have a reduced genetic mechanism to select their coat colour compared to other sheep. Two genetic loci determine the colour which is limited to black, brown or, less commonly, white. The population of Soay sheep are a fascinating subject for researching evolution and



Fig. 6. Soay sheep



Fig. 7. St Kilda wren

population dynamics, as the numbers are unmanaged, closed to migration in or out, and without competitors or predators.

The third different local sub-species is the St Kilda Wren, *Troglodytes troglodytes hirtensis*, which differs from the common mainland wren by its larger size, its long strong bill and its colour which is more pale grey and less rufous.

Even the humans were rumoured to have evolved differently. The men over several centuries were hunter-gatherers of the birds and birds' eggs, which became their staple diet, from the sheer cliffs of St Kilda. They climbed barefoot and were said to have developed the 'St Kilda toe', an elongated big toe to give them more traction on the rocks. While this story is not substantiated, some tourists in 2008 were astonished by the size of the big toe of a man whose mother was a native of St Kilda.

4. Plant diversity²

St Kilda partially escaped the intense glaciations of the Great Ice Age, hence pre-glacial plants are found in its peaty soil. Two hundred varieties of lichen and a hundred and thirty different flowering plants have been discovered on the island. Some of these are extremely rare or ancient, such that a study of these plants helps to explain the distribution and origin of plants in the United Kingdom.



Fig. 8. St Kilda mouse



Fig. 9. Deserted house

5. Diet, vitamins and infections⁹

Malnutrition was clearly another factor contributing to the immune problems of St Kildans. The church ministers, who were usually the only literate members of the society, gave broad details of the islanders' food sources and diet, although none gave a detailed year-round description of their daily consumption of vegetables or other food, so the average daily intake of vitamins is uncertain. There are no laboratory studies that assessed nutrient levels in the islanders. Staff-Surgeon Scott, who visited St Kilda in 1887, detected rheumatism, dyspepsia, anaemia, childhood palpitations and incipient scurvy. The islanders' diet of flesh and eggs, with a lack of fruit and vegetables, was deficient in vitamin C and probably in the B group vitamins.

In 1912, after a severe winter Dougal MacLean, the island missionary, reported that the population had survived on tea, bread and butter for months. The islanders devoted time mainly to catching seabirds and collecting their eggs, secondly to attending to cattle and sheep and lastly to tending the limited arable land. Sheep and a few cattle were slaughtered for food only on special occasions. The St Kildans did not rotate crops nor leave areas fallow for a season. The arable land was a maximum of eighty acres and naturally poor, with thin stony topsoil and poor drainage. They destroyed large areas of potential farm land by stripping turf near the village for fires, rather than collecting peat from further away. Crops were mainly barley, oats and potatoes, but also sea-plants, dulse, (an edible seaweed),

silverweed roots, dock, sorrel, scurvy-grass, rhubarb, turnips and cabbages. Peas and beans flowered without produce. Fruits were clearly a rarity.



Fig. 10. Cultivated land



Fig. 11. St Kilda cliffs, a food source

The major source of food was the gannet and fulmar, caught on the cliffs and consumed either as eggs or as young birds, both fresh and cured. Boiling was the usual method of cooking all meals, which would have further reduced the vitamin C content.

Fishing was important, but at times was impossible due to the unpredictable weather and heavy seas. Much of the St Kildans' food produce, including most of their agricultural crops, was paid as rent and taken to Harris or consumed by visitors, leaving a nutritionally limited diet of seabirds, eggs, fish and the less nutritious vegetables for the islanders.

Studies of Ascorbic acid supplements have shown some benefit in the treatment of respiratory infections, particularly in patients with more severe illness and pre-existing low vitamin C levels. Tetanus was another serious problem on St Kilda, and vitamin C deficiency may have contributed to the high death rate. A study has shown that the addition of 1,000 mg ascorbic acid to the standard therapy of anti-tetanus serum, sedatives and antibiotics reduced the mortality in children aged one to 12 years.⁹

6. Infectious diseases on St Kilda

The island population suffered from many diseases caused by micro-organisms including leprosy and tuberculosis, the more common conditions are discussed.

7. Neonatal tetanus¹⁰

The best known health problem of these islanders was neonatal tetanus, causing the desperately distressing and tragic death of up-to two thirds of the babies born on St Kilda for at least a hundred and fifty years, between 1750 and 1900.

A visit to the island for three weeks was made by Martin Martin MD in 1695. He was an astute observer of all facets of life, yet noted:

'They are not infested with several diseases which are so predominant in the other parts of the world'.

The first mention of *trismus nascentium* or *tetanus neonatorum* was made by the Rev. Kenneth Macaulay, minister of Ardnamurchan, after a visit to the island of St Kilda in 1758, 61 years after Martin's visit. His 278 page book contains less than one page, quoted in full below, about these tragic neonatal deaths for which he had no explanation.

'The St Kilda infants are peculiarly subject to an extraordinary kind of sickness; on the fourth, fifth or sixth night after their birth, many of them give up suckling; on the seventh day their gums are so clenched together that it is impossible to get anything down their throats; soon after this symptom appears, they are seized with convulsive fits, and after struggling against excessive torments, till their little strength is exhausted die generally on the eighth day. I have seen two of them expire after such agonies. It is surprising that Martin, who was himself bred to physic, and a person of unbounded curiosity, should have passed over in silence a circumstance so very striking, supposing that this very uncommon distemper had got any footing on Hirta in his time.'

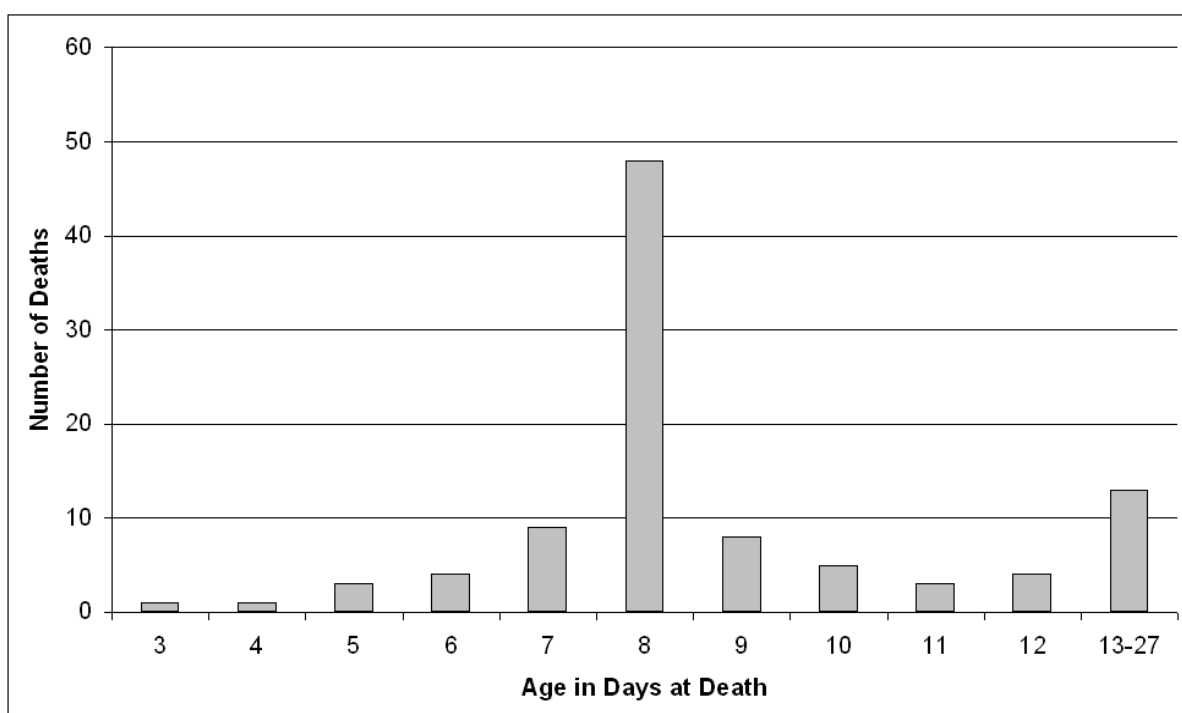
It seems highly improbable that Martin could have overlooked this classical description of neonatal tetanus. Possibly some important sterile technique was not passed on from one village midwife to her successor early in the 18th century, unfortunately the delivery methods were never documented or observed by a doctor or indeed any other male. Handover remains an imperfect process in current medical circles. The deaths continued and were documented by Dr John Morgan MA, MB, MRCP, on his visit to St Kilda in 1860 from the parochial Island Register kept by the resident missionary, the Rev. Neil Mackenzie.

He noted thirty-three of the recorded 64 island deaths between July 1830 and September 1840 were attributed to the 'eight-day sickness'. Morgan spoke to the midwife, Betty Scott, who had herself lost 12 out of 14 of her own children to this condition about the clinical features. Scott excluded any obvious congenital problem stating:-

'At the time of birth, there was no appreciable physical inferiority on the part of those infants who were so prematurely and suddenly selected as a prey. They were all proper bairns, and so continued till about the fifth or sixth day. The mother's eye might then not infrequently observe on the part of her child a strange indisposition to take the breast.'

Date	Live births	No of Neonatal deaths in 28 days	mortality rate %
1830-39	61	35	57%
1840-49	5	-	-
1850-59	11	5	45%
1860-69	29	20	69%
1870-79	28	14	50%
1880-89	27	14	52%
1890-99	25	6	24%
1900-09	15	2	13%
1910-19	17	1	6%
1920-29	7	0	0%

Table 1. Figures from the Island and District Registers (incomplete 1840-56)



Graph 1. day of death

The problem persisted late in the 19th century, with frequent deaths, personal and family tragedies, and a failure to replenish the society with children who would ultimately sustain the workforce. George Murray, the island's schoolteacher, wrote in his diary on 12th December 1886:

'Last night at 10.30, after six days' intense suffering, the child departed this life. Every one expressed great wonder how it lived so long after being seized with the illness, as they generally succumb at the end of a week after they are born. This one was 13 days except one and a half hours. It had a frequent cry since it was born; but the first signs of its being dangerously ill was at the end of a week, when it ceased to suck the breast, but still sucked the bottle. The following day, the jaws fell (thuit na gilán), when all hope of its recovery were given up. From that time until its death it occasionally took a little milk in a spoon or out of a bottle. The last two days a little wine in water was given once or twice. It often yawned and sometimes looked hard at you. It was pitiful to see the poor little things in the pangs of death. May God prepare us all for the same end.'

When the child was buried, Murray wrote, showing significant insight into the cause of neonatal tetanus in the last sentence:

'In the grave which was opened, I saw the coffins of its two little brothers that died in the same way. The one coffin was quite whole, there being only about 16 months since it was interred. On looking through the churchyard, I felt sad at the sight of so many infant graves. One man, not yet 50 years old, I should say, pointed to the place to me where he buried nine children. He is left with four of a family. Another buried no less than a dozen infants and is left with two now grown up. Sad to think of the like. Bad treatment at birth must have been the cause of so many dying.'

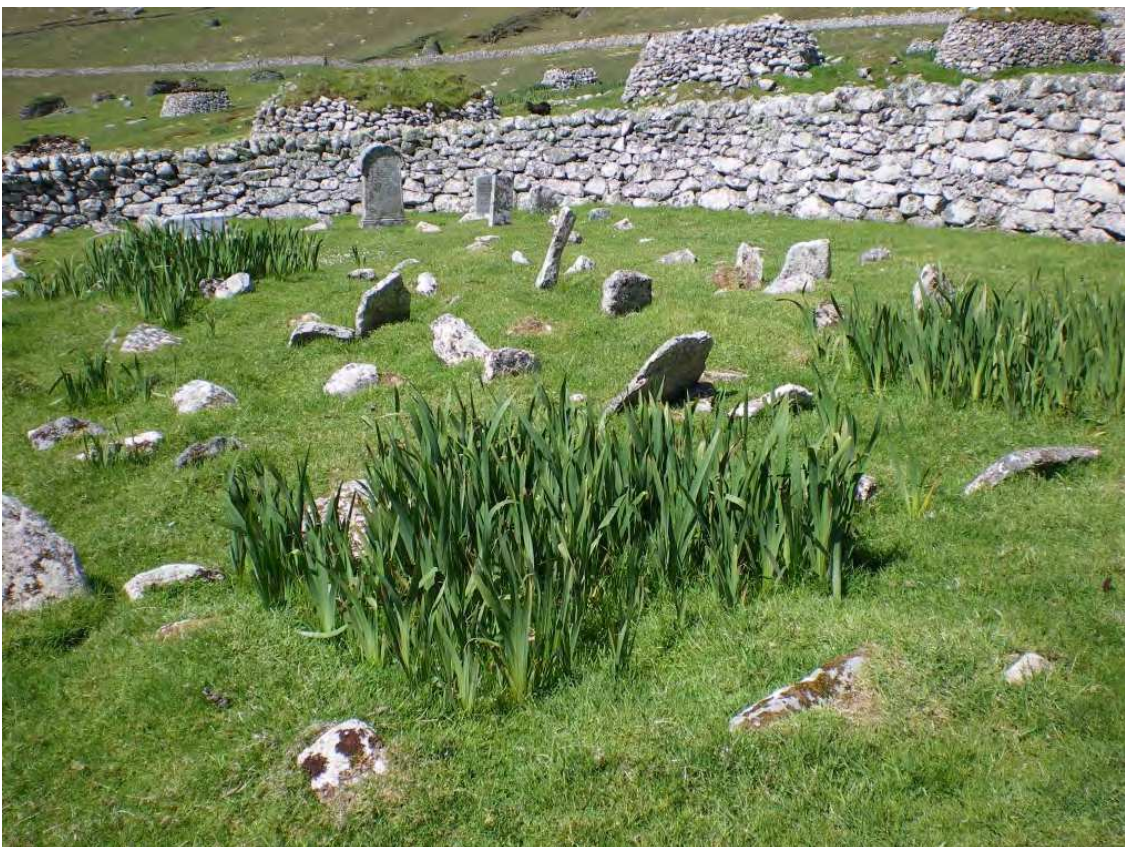


Fig. 12. Graveyard

The solution was finally discovered in 1890 by the Rev. Angus Fiddes, a Free Church clergyman and scientist, who lived and worked on St Kilda. He visited the leading obstetricians in Glasgow, identified the problem as neonatal tetanus, and learned the latest delivery techniques, which when correctly applied prevented any further deaths, though some of the island women were initially opposed to new ideas and to a new midwife from outside.

The precipitating cause remained unknown, and for some 80 years, the unsubstantiated view of Dr George Gibson FRCPEdin, that anointing the umbilical cord with oil from the fulmar gull caused the infection, held sway. Clearly some unhygienic midwifery practice was the cause, and recent bacteriological studies revealing the gull oil to be sterile, yet the soil, inside and outside the house and storage cleits, to be heavily infected with tetanus, suggests cutting the umbilical cord with an unsterilized blade, such as the dirty rusting lancet still used on St Kilda for bloodletting in the early 20th century, a much more probable cause.

Biodiversity appears to play no part in the neonatal tetanus tragedy; however St Kildans were also susceptible to common viral contagious diseases which had severe effects.



Fig. 13. Fulmar gull

8. The Smallpox epidemic in St Kilda⁷

Smallpox outbreaks were common on the Scottish Islands in the eighteenth and nineteenth centuries. All the islands had a similar hostile climate, and varying degrees of isolation and malnutrition. Ten outbreaks occurred on the Shetland Islands between 1700 and 1830. The 1740 diary of Thomas Gifford of Busta, from Greig's *Annals of a Shetland parish*,⁷ recorded that two of his daughters became unwell and bed-bound, developed a rash five days later and died a further eight and nine days respectively after that. Some of Gifford's 11 other children developed a rash but all survived, thus illustrating the typical features of smallpox:

- Severe symptoms preceding the infectious rash, with isolation preceding infectivity.
- Deterioration and death of only a few of those infected with smallpox.
- Greater vulnerability in children than adults
- Relatively slow spread to household contacts
- Most of those infected survive mild but obvious disease

In contrast to such episodes, in 1727 an outbreak of possible smallpox on St Kilda killed nearly the entire population. Ninety-four deaths in a population of 132 were recorded, leaving four adult and twenty-six children as the survivors.

Neil MacKenzie, minister on St Kilda from 1829 to 1843, writing a hundred years later stated *'Death after death followed. At last there were scarcely sufficient to bury the dead... There were 94 deaths... those who had been left on Stac an Armin returned mostly to empty houses'*.



Fig. 14. Stac an Armin

A small party of three men and eight boys were marooned on Stac an Armin, a 196-metre high sea stack, where they had been taken to collect birds and birds eggs, but also survived through an Atlantic winter till rescued on 13 May 1728 in a little known epic tale of endurance in adversity. A small bothy gave limited shelter, and the group lived off the stack's fresh water supply, birds and their eggs and fish caught with a bent nail, though they were noted to have lost weight. They patched their clothes as well as possible with birds' skins. Although the greater resources of Boreray Island were 100 yards away, the vertical rock face prevented ascent from the water.

A decade earlier Lady Mary Wortley Montagu, wife of the ambassador to Turkey discovered there the procedure of variolation, or intradermal inoculation of smallpox scabs. This caused a moderate infection with a mortality rate of 0.5–2%, compared with a death rate of 10% from the actual disease, She variolated her own children, and though sceptical of physicians there, hoped to introduce the process into England, writing

'I am patriot enough to take pains to bring this useful invention into fashion in England, and I should not fail to write to some of our doctors very particularly about it if I knew any one of them that I thought had virtue enough to destroy such a considerable branch of their revenue for the good of mankind'.

Montagu has an extraordinary coincidental connection with St Kilda. Her sister, Lady Frances Pierrepont, married John Erskine, the 22nd Earl of Mar, a Jacobite general in the 1715 battle of Sherriffmuir. John's brother, Lord Grange married Rachel Chiesley, who soon, perhaps correctly, suspected her husband's infidelity and Jacobite loyalties. Grange imprisoned her, initially on the Monarch Islands, west of North Uist in the Outer Hebrides, and then on St Kilda from 1734 to 1742, where she became the celebrated Lady Grange of St. Kilda. Had Chiesley heard of vaccination from Lady Montagu, her brother-in-law's sister-in-law, and arrived seven years earlier, she may have prevented the epidemic if indeed it was smallpox.

William Heberden differentiated chickenpox from smallpox in 1767; hence 'smallpox' epidemics prior to that date cannot be accepted as indisputable.

Limited biodiversity may well have reduced the population's resistance to this infection, which could equally have been chicken pox. The 1727 epidemic has always been labelled smallpox; however the following points suggest the alternative of chickenpox:

- No clinical features of the 1727 St Kilda epidemic are available;
- The similar exantheas of smallpox and chickenpox were not distinguished at that time;
- The epidemic spread widely and rapidly among the inhabitants, more like chickenpox than smallpox;
- The epidemic caused a higher death rate among adults than children – again, more like chickenpox than smallpox;
- Chickenpox probably had a high mortality in the 'virgin soil' of the Americas, in a non-immune society, with limited genetic biodiversity of the HLA system, though there are no data on the comparative mortality of smallpox and chickenpox;
- The viability of the smallpox virus is inversely related to its infectivity. Smallpox is only highly contagious in the aerosolised form. Smallpox virions have a low survival rate and smallpox scabs an even lower infectivity in fomites.

9. The boat cough¹¹

Another well documented infection peculiar to the inhabitants of St Kilda was called by the native Gaelic speakers '*cnatan-nagall*' or the strangers' cough.¹⁰

Martin during his visit to the island in 1697, did record details of this boat cough. He wrote:

*'They [the islanders] contract a cough as often as any strangers land and stay among them, and it continues for some eight or ten days; they say the very infants on the breast are affected by it.'*⁸

The Reverend Macaulay arrived in St Kilda in 1758, and related his experience as follows:

*'When I landed, all the inhabitants, except two women in child-bed enjoyed perfect health.... On the third day after I landed, some of the inhabitants discovered evident symptoms of a violent cold, such as hoarseness, coughing, discharging of phlegm, etc. and in eight days, they were all infected with this un-common disease, attended in some with severe head-aches and feverish disorders.'*⁵

Macaulay noted that once this epidemic had resolved it did not recur without further visitors. Three episodes were once noted to occur within eight weeks following three separate visits from other islands, making the usual suggestion of influenza unlikely, as this organism does not mutate into a new infecting subtypes as quickly as this.

Human rhinoviruses (HRV), with 110 serological types, are the most common worldwide infective viral agents in humans, causing 30–50% of all cases of upper respiratory infection based on viral cultures, or an even higher percentage using improved detection techniques including reverse transcription-PCR. The short incubation period and recurrent infections with severe cough and profuse sputum, plus some cases of pneumonia and rare deaths, strongly support rhinovirus as the cause of the boat cough. Although adults with an averagely robust immune system usually experience one brief episode per year, the prolonged and recurrent bouts experienced by the St Kildans again support some problem in their immune systems.¹⁰

10. Migration

Unfortunately departure from the island to places of opportunities, a better climate and greater development failed to protect the people of St Kilda.

In 1852, thirty-six of the islanders migrated to Australia. Although they were among the youngest and fittest from the community, they suffered a 50% mortality on the voyage to Melbourne, mainly from measles. In the years immediately after the final evacuation in 1930, several of the young children died of tuberculosis. In these two examples, the factors of poor climate, malnutrition and isolation no longer applied as much, but the factors of low herd immunity and limited biodiversity were the main causes of death and disease in these migrants.

11. Dioxin

Dioxin is a specific organic unsaturated non-antiaromatic six-membered ring compound with a chemical formula of $C_4H_4O_2$. However, the term dioxin is used generically by most authorities to include chlorinated dioxins with furans and many derivative compounds as a complex of at least 75 ubiquitous and environmentally persistent organochlorine compounds, of variable toxicity.

The incomplete burning of sea water impregnated coastal peat in Scotland well before the industrial revolution has recently been shown to produce dioxins.⁹

Soil containing unburnt peat was taken both from the surface of the St Kilda arable area and excavated from houses down to the time strata of 1800–1850, has been found to contain 114 ng/kg of dioxin. Cultures for the tetanus bacillus at this depth would have been fascinating to ascertain the presence or absence of this micro-organism. Burning peat produced 643 ng/kg of dioxin in the peat smoke and ash. This would give a total dioxin production by the estimated 260,000–420,000 inhabitants of the Scottish highlands and islands in the eighteenth and nineteenth centuries of 1 kg/year, about one fifth of that produced by the whole of the UK in the industrial era.

St Kildans stored peat ash mixed with cow manure on the house floors over winter and in spring fertilised the island's arable land with the mixture, such that more than 70 years after the evacuation there are still high levels of TCDD in the arable area.¹¹

The mammalian immune system has been shown to be susceptible to direct damage by low doses of dioxin, and indirectly by damage to the immuno-modulating effect of the hormonal

system. Animal studies have also shown that dioxin toxicity can cause thymic involution, decreased antibody production with thymic dependent and independent antigens reduced function of the HLA system producing some lymphocyte subsets and reduced cytotoxic T-cell function.

The question therefore arises if the dioxin pollution was a contributory factor to the infections experienced by the inhabitants of St Kilda. Comparison with the major known leak of the dioxin, TCDD (2,3,7,8-Tetrachlorodibenzo-p-Dioxin) from Seveso near Milan in 1976, suggests this is unlikely. The soil levels of dioxin in Italy were considerably higher, yet careful follow up over many years in Seveso found no acute increase in the incidence of acute infections, but there was an increase in carcinomas of the gastrointestinal tract and lymphatic systems and an increase in the death rate from respiratory disease. Dioxins are believed to be carcinogenic, but cancers were not a common problem on St Kilda.



Fig. 15. Chloracne

Chloracne, an acne-like skin eruption, most marked behind the ears, on the cheeks and in the axilla and groin, affected a significant number of Seveso's inhabitants (42 of 214 children in the most contaminated Zone A.) Viktor Yushchenko, past President of the Ukraine, is considered to suffer from this condition, following an acute illness in 2004 in which his face became disfigured, scarred and pockmarked. Levels of dioxin in his blood were reported to be 6,000 times above the safe minimum, but the veracity of these tests are debated by toxicologists, and the possibility of deliberate poisoning is debated in political circles. Chloracne has become the '*sine qua non*' of dioxin poisoning.

Another dioxin leak, probably with TCDD, occurred Germany in 1953. Again chloracne occurred, and acute respiratory tract infections were more common only in the group with severe chloracne. Photographs on the St Kilda population from the late 19th century show no evidence of chloracne in the women and children. Although the men have heavy beards, there is no visible evidence on photographs of chloracne around the neck, nor reports suggesting this dermatological disease. Dioxin toxicity on St Kilda appears a most improbably contributory factor to the infections suffered by the islanders

12. Lord Howe Island – A comparison

The fortunate traveller who has visited both Lord Howe Island in the Pacific Ocean and the island archipelago of St Kilda in the Outer Hebrides will be struck by the many common features of these two remote islands; yet today one is a thriving society and the other was evacuated as a non-sustainable society in 1930.¹²

Lord Howe Island is situated in the Tasman Sea between Australia and New Zealand, 600 kms from the Australian west coast. Lord Howe Island has no detectable trace of human habitation prior to 1788 in spite of the extensive exploratory maritime voyages of the Polynesian people. Its first known sighting was by the HMS Supply captain Lieutenant Henry Lidgbird Ball and his crew on 17 February 1788 while sailing to Norfolk Island. They subsequently landed there on 13 March 1788 during the return journey to Sydney and named the island after Richard Howe, the First Lord of the Admiralty.



Fig. 16. Map of LHI



Fig. 17. Picture of LHI

Both islands are remote even today. Although the distance from Glasgow to St Kilda (main island, Hirte) is only some 340 km as the crow flies, it can take three or four days to get there using sea, land and air transport, including a landing on the 'airstrip' at Barra –the beach at low tide. The journey from Brisbane to Lord Howe Island, a distance of 740 km, in the past took several days by sea, but now a return flight is possible in one day. Both islands are small and have sheer cliffs and high rainfall. Both have UNESCO World Heritage status in which ornithological significance plays a large part, an abundant supply of fish in the surrounding sea and a nearby sea stack renowned for unique bird life. The difference in latitude and ambient temperature were significant factors in the success of one society and the failure of the other.

The earliest settlers on Lord Howe Island had widespread genetic origins, coming from England, Portugal, America, South Africa, Micronesia, New Zealand and Australia, probably with a much greater biodiversity of histo-compatibility antigens creating more resistance to infections than that of the Hebridean people of St Kilda. One of the early settlers, Nathan Chase Thompson, from Somerset, Massachusetts, in the USA, arrived in 1853 with two business partners, George Campbell and Jack Brian, and two women and a girl from the Gilbert Islands (now Kiribati). Thompson initially married Boranga, one of the women, but their only child died aged 11 years and Boranga died soon after. Thompson subsequently married the Gilbertese girl, Bokue, who was by then aged 24. They had five children, two boys and three girls, whose descendants are an important part of today's island population.

Supporting evidence comes from an epidemic of measles, a disease with a mortality of up to 25% in the developing world. In 1868, some inhabitants of the Pitcairn Islands visited Lord Howe Island in the schooner *Pacific* while suffering an outbreak of measles. They landed and recovered on the island, causing an inevitable outbreak of the disease among the islanders. No more details are available, but no deaths in 1868 are to be discovered in the island records or graveyards, implying that poor herd immunity allowed the outbreak of measles but the genetic and environmental background resulted in uneventful recovery.

In contrast to St Kilda, Lord Howe Island appears a paradise of good health and longevity. Regular visits by whalers in the early years of settlement would have helped to reduce isolation and perhaps improve the herd immunity. William Clarkson, a visiting teacher, wrote in 1882 that 'sickness is almost unknown'.

A visit to the four island graveyards shows that most inhabitants born more than 100 years ago survived into their 80s, and today Lord Howe Island has 347 permanent residents, with a thriving tourism business.

Medical factors played a major role in the success of Lord Howe Island and the failure of St Kilda. Appendicitis became a manageable problem on Lord Howe Island, with recorded surgery on kitchen tables, but was a final straw leading to the evacuation of St Kilda, when two weeks passed before Mary Gillies with acute appendicitis could be notified and transported to a Glasgow hospital where she died within twenty-four hours. The climate and virgin soil allowed the Pacific islanders a much more beneficial varied diet with food rich in vitamin C. This fact plus the biodiversity of the early settlers and their improved obstetric care protected the young children of Lord Howe Island from infections and guaranteed the survival of the Pacific island society.

13. Conclusion

The inhabitants of St Kilda were an inbred population with limited genetic diversity. They suffered severely from infectious diseases, more than similar inhabitants of nearby islands,

who were also exposed to a climate noted for high rainfall, strong winds and cold winters, malnutrition with limited vitamin C intake, dioxin exposure, low herd immunity and lack of health care personnel. These factors are all in stark contrast to the successful society on Lord Howe Island. It is clearly not possible to tease out attributable percentages to each factor, but lack of biodiversity as in North America probably contributed to morbidity and mortality, and ultimately the failure of the society on St Kilda necessitating evacuation.

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Every ecosystem is a complex organization of carefully mixed life forms; a dynamic and particularly sensible system. Consequently, their progressive decline may accelerate climate change and vice versa, influencing flora and fauna composition and distribution, resulting in the loss of biodiversity. Climate changes effects are the principal topics of this volume. Written by internationally renowned contributors, Biodiversity loss in a changing planet offers attractive study cases focused on biodiversity evaluations and provisions in several different ecosystems, analysing the current life condition of many life forms, and covering very different biogeographic zones of the planet.

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