Chapter 2
The Skies Over Aotearoa/New Zealand: Astronomy from a Maori Perspective

Abstract In this chapter, which is largely based on Orchiston (2000), we critically examine the sources of information on Maori astronomy available to us, briefly describe the archaeological evidence for the settlement of Aotearoa/New Zealand and hence the origins of Maori astronomical knowledge, and examine the life of the Maori astronomer. We then detail the range of astronomical objects and events that graced the Maori sky between AD 1200 and 1768, and see what evidence of these is preserved in the oral histories and early literature recorded by Elsdon Best. We then query whether astronomical motifs are represented in Maori rock art, summarise Maori concepts of time, and conclude with some comments about what the future may hold for those wishing to carry out further studies of Maori astronomical lore.

2.1 Introduction

To the Maori of Aotearoa/New Zealand, astronomy used to be an integral part of everyday life. Before the arrival of the Europeans, it foretold the seasons and the weather, dictated a variety of food-quest activities, and played a vital role in oceanic voyaging. Thus, the Maori had names for the Sun, the Moon, all of the naked eye planets, some of the brighter stars, the Milky Way, the Coal Sack, both Magellanic Clouds, and even the Zodiacal Light. There also were names for comets and meteors. But Kingsley-Smith (1967: 5) reminds us that

> The Maori, like other races, endowed the stars and constellations with human attributes and wove fantastic stories about their conflicts, loves, hatreds, and achievements … They possessed great potency for good or ill to the human family.

Yet our knowledge of Maori astronomy is superficial and plagued by severe source limitations.

W. Orchiston, *Exploring the History of New Zealand Astronomy*,
Astrophysics and Space Science Library 422,
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2.2 Source Limitations: The Nature of the Evidence

This study is concerned with ethnoastronomy,

> … that peculiar intermingling of astronomy, history, anthropology and folklore … Ethnoastronomy is a fascinating discipline on two counts, its novelty and its potential … [and] remains largely underexplored and underdeveloped. Consequently, it is full of promise. (Snedegar 1992: 41).

The special place of ethnoastronomy within the discipline of astronomy is discussed by Erny (1992).

The study of Maori astronomy is endowed with its own special problems and challenges. Like many other indigenous peoples of the world, the Maori were non-literate, and so we had to await the arrival of the first European explorers for written accounts of their knowledge systems. Although Cook, Surville and Du Fresne were all in Aotearoa/New Zealand waters between 1769 and 1777 and recorded a great deal of detail about Maori culture in different coastal localities (see Salmond 1991), their various logs, journals and published accounts say almost nothing about Maori astronomy.

Personally, I find this especially sad in the case of the Cook voyages, for astronomers were on all three voyages, and spent considerable periods ashore, particularly at Queen Charlotte Sound, carrying out astronomical observations (see Orchiston 1998, and Chaps. 4, 5 and 6 in this book). For the most part there were very amiable Maori-European relations, and some of the Maoris who visited the Europeans would have learnt what the astronomers were doing. Yet none of the Maoris thought to discuss their own astronomical activities and beliefs and compare them with those of the visiting Europeans. This may have been because such knowledge was jealously guarded and was not to be shared with Europeans, or because such knowledge was the domain of specialists and Maori astronomers were not among those interacting with the Europeans at this time.

Although there are snippets of information on Maori astronomy included in a number of books and research papers published during the nineteenth century, much of this material is superficial, contradictory or downright unreliable, and it was only towards the end of that century that a detailed study was carried out. The scholar responsible for this was Elsdon Best (1856–1931; Fig. 2.1), who was later to work as Ethnologist at the Dominion Museum in Wellington (Craig 1964). During the last decade of the nineteenth century and first decade of the twentieth, he carried out fieldwork, particularly in the Ureweras in the East Coast region of the North Island (see Fig. 2.2 for Aotearoa/New Zealand localities mentioned in the text). Best subsequently published a succession of Monographs and Bulletins of the Dominion Museum (as it was then known) on aspects of Maori culture, and in 1922 his 80-page Monograph No. 3, *The Astronomical Knowledge of the Maori*, appeared in print (Fig. 2.3). This contained a synthesis of information drawn from his own fieldwork and that culled from earlier published accounts. Subsequently, Best included astronomical material in two other Monographs, *The Maori Division of Time* (No. 4) and *Polynesian Voyagers. The Maori as a Deep-sea Navigator,*

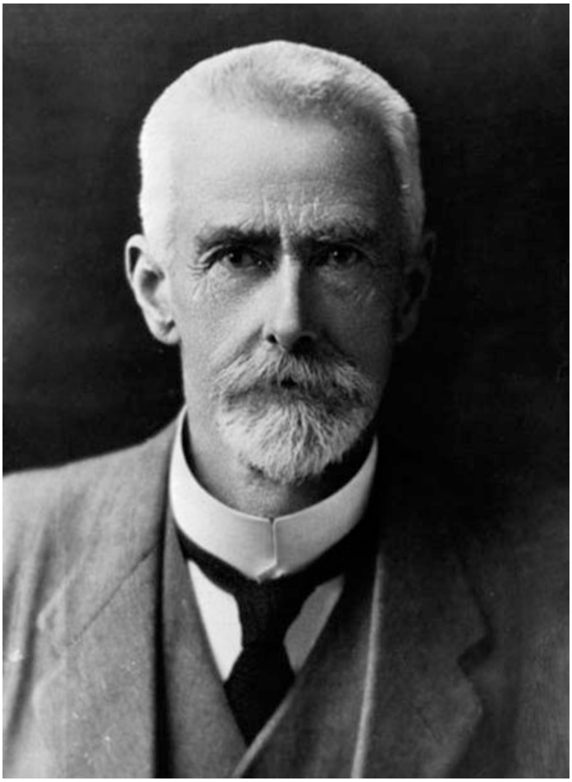

Fig. 2.1 A photograph of Elsdon Best by Stanley Polkinghorne Andrew (*Courtesy* Alexander Turnbull Library, Ref. 1/1-018778-F)

Explorer, & Colonizer (No. 5). To this day, these remain the only substantive works written on the 'traditional' astronomical systems of the Maori, and they have been through numerous reprintings; I made use of copies printed in the 1950s for this study (i.e. Best 1954, 1955, 1959).

Invaluable as these books may be, we cannot ignore their serious limitations (Orchiston 1986). All of the published sources he drew on date to the nineteenth century, and Best carried out his fieldwork at the very end of that century, more than one hundred years after initial European contact. In the interim, *major* changes had taken place in 'traditional' Maori culture. This was particularly so of Maori religious systems, which invited the wrath of the early evangelical missionaries, and we must not forget that Maori astronomy was intricately inter-woven with mythology and religion. In other words, the 'Maori astronomy' that Best recorded may have differed significantly from the practises and beliefs in vogue in 1768, before the arrival of Cook and other Europeans.

Another important consideration is that Best's astronomical field data were geographically biased in that they came—in the main—from just the one area of the North Island of Aotearoa/New Zealand. Studies have shown that at any one point in time there were major regional variations in Maori culture and material culture

Fig. 2.2 Aotearoa/New Zealand topography, with localities mentioned in the text shown in *red*

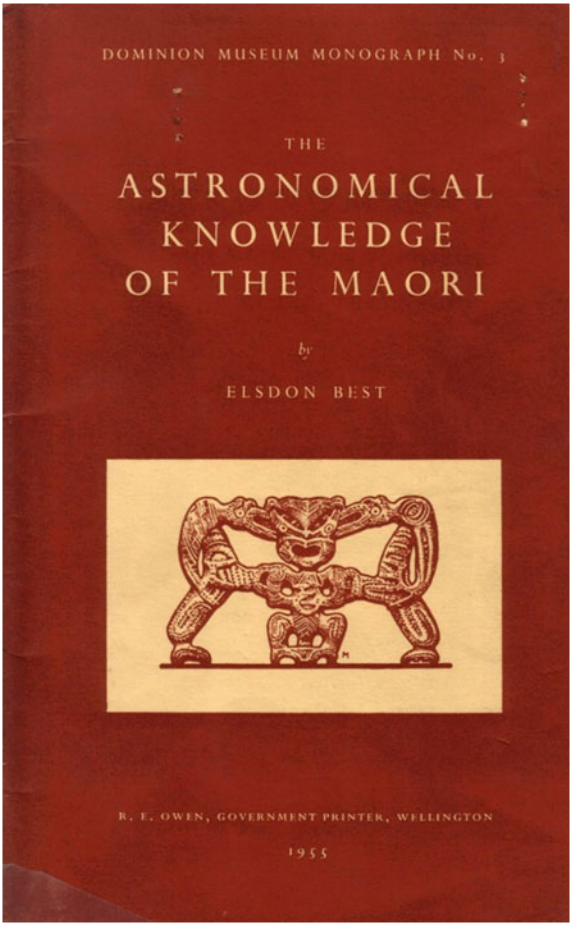

Fig. 2.3 Front cover of the 1955 edition of *The Astronomical Knowledge of the Maori* (*Photograph* Wayne Orchiston)

(e.g. see Skinner 1974: 18–26), and that significant changes occurred through time. Given the data at his disposal, all that Best could do was attempt to provide an overview of Maori astronomy based on his own fieldwork and supplementary data provided by earlier writers. The result is a synthesis, which indicates the general trends and patterns prevalent in the nineteenth century. This may be fine for basic astronomical knowledge, but when it comes to the Maori perception of the cosmos, its creation and its evolution, how much is truly 'traditional' and how much is an amalgamation of pre-European concepts and elements of Christian-based religion and European scientific precepts?

2.3 The Initial Settlement of Aotearoa/New Zealand and the Origin of Maori Astronomy

Cultural, linguistic, floral and faunal evidence reveals that most Polynesian peoples are genetically related, and this is also reflected in the similarities of the various astronomical knowledge systems found in the different island groups at the time of initial European settlement (see Best 1955).

The present-day Polynesians can be traced back to the first settlers of Samoa and Tonga, who made their initial appearance on the western boundary of the 'Polynesian Triangle' by 1000 BC. They were associated with the distinctive Lapita pottery tradition, also found further to the west, in Fiji, New Caledonia, the New Hebrides, the Solomon Islands and islands in the Bismarck Archipelago off New Guinea (see Green 1992: Fig. 1.3).

The evolution of this 'Lapita cultural complex' into a distinctly 'Polynesian' culture occurred in the Samoa-Tonga region. As the late Professor Roger Curtis Green (1932–2009) pointed out long ago, Polynesian

> … language, biological make-up, and culture was not brought from elsewhere already fully formed, but rather evolved in that region from a proto-language (Central Pacific) ancestral to the present-day daughter languages of Fiji, Rotuma and Polynesia (Pawley and Green 1973, pp. 42–43, 53), from a pre-Polynesian parental stock … and from the Eastern Lapita cultural complex which can be associated with this language and population. (Green 1992: 41).

By the first few centuries BC an ancestral Polynesian culture was recognisable, and it was people from this region, armed with what we may call an Ancestral Polynesian astronomical knowledge system, who then colonised the Cook, Society and Marquesas Islands. These, in their turn, became the primary dispersal points from which the remaining island groups of Polynesia were settled.

Aotearoa/New Zealand is situated in the far southwestern corner of the Pacific Ocean at one apex of the 'Polynesian triangle' (see Fig. 2.4). Current evidence favours an initial settlement during the thirteenth century AD (Anderson 1991; Davidson 1987; Higham et al. 1999; Holdaway and Jacomb 2000), while archaeological and linguistic evidence points clearly to the general region of the Cook, Society and Marquesas Islands as the source of the initial settlers (see various papers in Sutton 1992).

When they arrived in Aotearoa/New Zealand the ancestral Maori discovered a pristine alien environment that was very different indeed from the small high islands of central or eastern Polynesia whence they came. They found two very large islands and many smaller ones, extending from sub-tropical north to sub-antarctic south. Both islands were bisected longitudinally by high mountains, and in the central North Island some of these were volcanically active. Most of the land was forested, and the principal terrestrial inhabitants were a range of giant birds, most of them flightless (e.g. see Fig. 2.5) and nearly all of them now extinct (Cumberland 1962; McGlone et al. 1992).

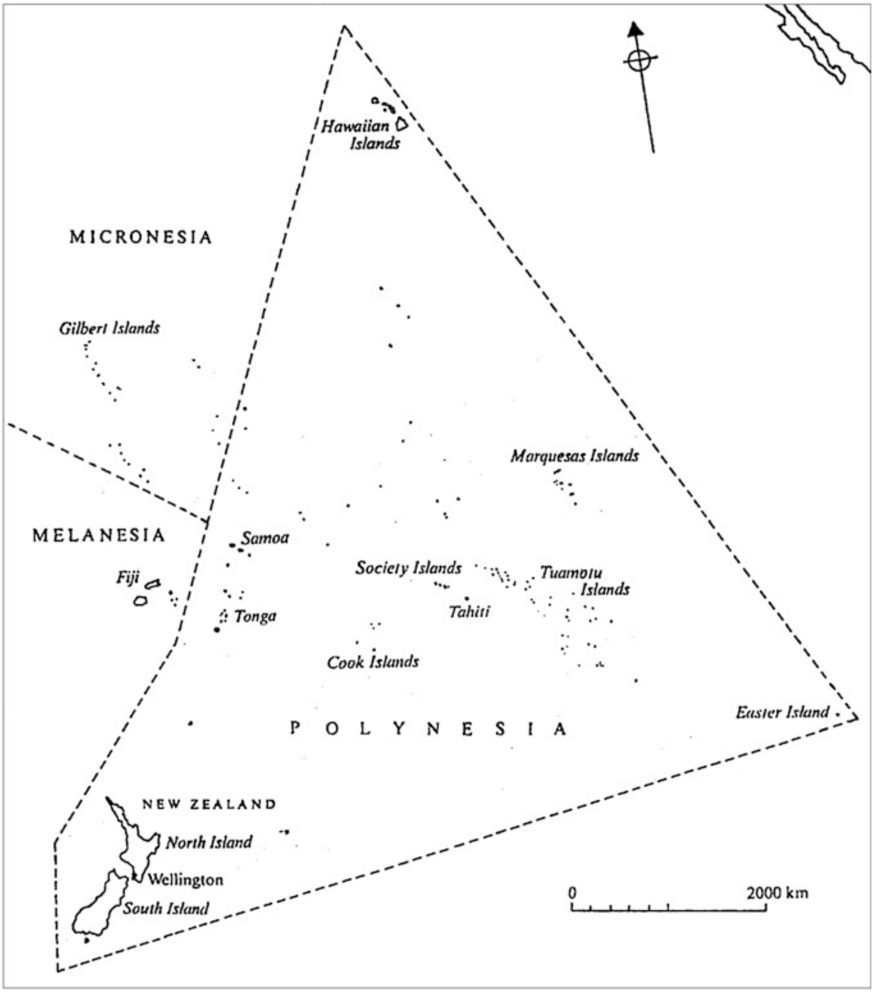

Fig. 2.4 The main islands of Polynesia and eastern Micronesia and Melanesia

Yet the earlier settlers were not totally unprepared for this new environment, for they

> … brought plants and other material from their tropical home that were needed for the successful colonization (Davidson 1987; Anderson 1991; Higham et al. 1999; Holdaway and Jacomb 2000). These included kumara (*Ipomoea batatus*), yam (*Dioscorea* sp.), taro (*Colocasia esculanta*), gourd (Family Cucurbitaceae), paper mulberry (*Broussonetia terminalis*), banana (*Musa* sp.), breadfruit (*Artocarpus communis*), tropical cabbage tree (*Cordyline terminalis*), and coconuts (*Cocos nucifera*) (Best 1925). The cooler, seasonal temperate climate of New Zealand meant that many of these crops failed to thrive, or, as in the case of coconuts, bananas, and breadfruit, did not grow at all. Taro, paper mulberry, and yam growing were restricted to the warmer North Island. (Bassett et al. 2004).

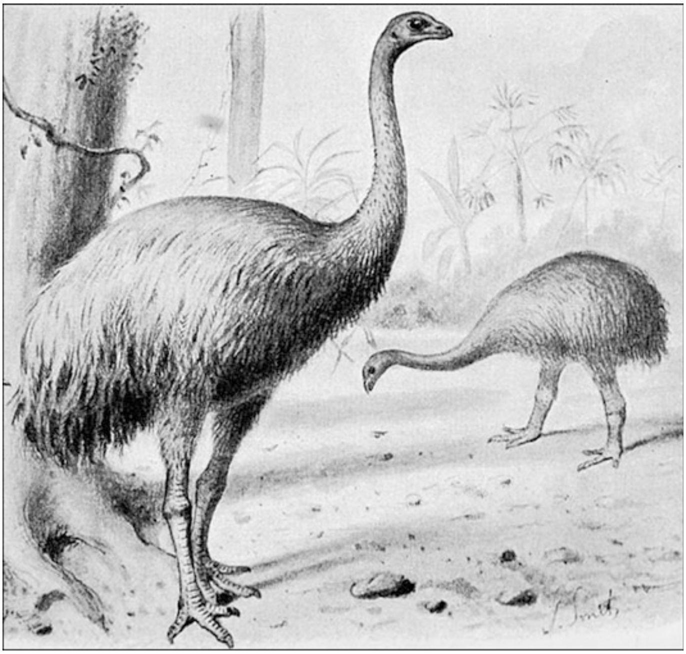

Fig. 2.5 The range of flightless birds that occupied Aotearoa/New Zealand at the time of the initial Maori settlement included several different species of moas (https://en.wikipedia.org)

The ancestral Maori responded to this horticultural challenge by focusing some of their attention on the moa and other large flightless birds, and soon drove most of these to extinction (e.g. see Anderson 1989; Holdaway and Jacomb 2000). They also used fire to rapidly change the landscape in the course of their exploration (McGlone 1983), and to clear areas for cultivation once they developed the ability to over-winter the *kumara* and discovered that it could then grow successfully as far south as the sheltered microclimates found on Banks Peninsula (Bassett et al. 2004). The *kumara* then became a dietary staple over large areas of Aotearoa/New Zealand (Yen 1961), supplemented on a seasonal basis by the ubiquitous fernroot tubers; various edible fruits and berries; a myriad of forest and shore birds; endless supplies of shellfish, fish and crayfish; and an abundance of seals and dolphins.

The astronomical knowledge base that reached Aotearoa/New Zealand with the first settlers was the one then current in central Polynesia, and was part of their prevailing ‘world view’. However, it had its roots further to the west, and was derived from an earlier Lapita prototype. In this regard, it is important to realise that the major stars and constellations visible from Aotearoa/New Zealand, and other prominent features such as the Magellanic Clouds, had been equally visible from island Polynesia *and* the islands of Melanesia occupied by the Lapita people. So although they moved to a more southerly land, the ancestral Maori settled under a familiar sky—even if the Magellanic Clouds and Milky Way rose higher in the sky at culmination. In other words, there was no need to instantly develop a totally new or even substantially revised astronomical system specifically for Aotearoa/New Zealand.

Yet no knowledge base is unchanging, for cultures are dynamic and automatically evolve (or devolve) with time. The archaeological record clearly documents that the initial Maori culture underwent substantial modification in the course of the next 800 years (Davidson 1987; Golson 1959; Green 1975; Trotter and McCulloch 1997). This is best seen in elements of material culture, but it is reasonable to suppose that the astronomical knowledge base also would have shared in this process, especially as the economic basis of Maori society evolved with time.

2.4 The World of the Maori Astronomer

In pre-European Maori society, membership of various social groups—as elsewhere in Polynesia—was based on kinship and descent. Three different groupings are conventionally recognised: the *whanau* (extended family), the *hapu* (clan) and the *iwi* (tribe). However, Davidson (1987) provides a timely reminder:

> It is important to realise, however, that this is a generalised (and idealised) summary based on nineteenth century studies. The system encompassed considerable individual and regional variations.

Nonetheless, the local group usually comprised the *whanau*, typically 20–50 individuals who lived together in a hamlet or village. Only in times of threat would members of several *whanau* flee to a common *pa* (or fortified settlement), but at other times the *whanau* was the group involved in day-to-day activities (Orchiston 1979).

If astronomy underpinned not only horticulture, but also other food-quest activities—as documented by Best (1955)—then every local group would have needed one or more individuals with specialist celestial knowledge. These Maori astronomers were always men of high rank, and were termed *tohunga kokorangi*. Their duty was to study the heavens, and utilize their astronomical knowledge for the welfare of the community. Best (1955: 6) recounts how

> One famed old wise man of the Wairarapa district, of last century, devoted much of his time to studying the stars and planets. His contemporaries have told me that they have often known him to pass the greater part of the night on the summit of a hillock near his hut, gazing continuously at the heavens.

Like other Maori astronomers, he had to rely solely on the naked eye for his studies. The only reference I could find to any sort of observing aid—if it may be termed that—comes from Beattie (1918: 145), who was told by an informant that "When he was a lad at Temuka [during the nineteenth century] he had seen his father put sticks in the ground and observe the stars." This would appear to have been an isolated incident, or perhaps an idiosyncrasy of that particular astronomer. It certainly was not the norm.

Training to be a *tohunga kokorangi* was no trivial task. It involved years of study to acquire the full gamut of celestial lore, which was passed down from generation to generation by word of mouth. Consequently, most Maori astronomers were respected senior members of their local groups, but to think of them as 'elderly' in the context of present-day populations is misleading, for Houghton (1980: 95–97) has shown that in pre-European Maori society the average lifespan was only 31–32 years, and that very few individuals lived beyond 50 years of age. It would seem that most Maori astronomers were 'venerable old men' in their late twenties or in their thirties!

Although astronomy was the domain of experts, in 1922 Best believed that "It is assuredly a fact that in former times the average Maori knew much more about the stars than does the average man among us [today]." (Best 1955: 8).

2.5 The Creation of the Maori Universe

Best (1955: 5–6) stresses that

> Maori beliefs concerning the heavenly bodies were very different from our own … much of the star-lore of the Maori was empirical - astronomy and astrology were intermingled in his beliefs and teachings … there was much of sentiment in the Maori mind in connection with the stars …

Mythological accounts were used to explain various astronomical objects and events, and these myths were passed down by word of mouth, and in songs, charms, chants, and as sayings.

To the East Coast Maoris there was a system of twelve separate and distinct heavens, which were termed *nga rangi tuhaha* (the bespaced heavens). Some other tribes reported just ten heavens, while two earlier writers, White and Davis, mention twenty heavens. Despite these variations, Best (1955: 8) gives greatest credence to the East Coast accounts.

Of these twelve heavens, closest to the Earth's surface was the mythological *Ranginui*, and it was upon his body that the stars and other celestial objects moved. East Coast accounts reveal that it was *Turangi* and *Moe-ahura*, two of the offspring of *Ranginui* (the Sky Father) and *Papatuanuku* (the Earth Mother), who gave birth to the Sun, the Moon and the stars, as depicted in the following genealogy (see Fig. 2.6). The stars were produced after the Sun and Moon, and were referred to as the 'younger members' of the family (Best 1955: 9–10).

Variations on this genealogy occur throughout Aotearoa/New Zealand, generally in the names assigned to the parents of the Sun, Moon and stars [e.g. see (Orchiston 1996: 326) for another version of this genealogy]. To the Te Awa people of the Bay of Plenty they were *Tangotango* and *Wainui*, respectively, while other tribes claim the father's name was *Tongatonga*. The mother's name has also been given as

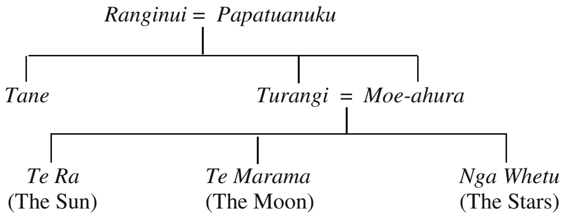

Fig. 2.6 Genealogy documenting the Maori origins of the Sun, Moon and stars (after Best 1955)

Moe-te-ahura and *Hine-te-ahura*. Regardless of the names used, the offspring were generally the same, except that the Te Awa included *Hinetore* (phosphorescence) as a fourth sibling (ibid.).

One interesting variant, supplied to Best by Nepia Pohutu (d. 1882) from the Wairarapa, substitutes *Uru-te-ngangana* for *Turangi* and has him marrying two different women. From the first, *Hine-te-ahura*, he begot *Te Ra-kura* (the red Sun) and *Te Marama-i-whanake* (the waxing Moon), and from the other, *Hine-turama*, came the stars (Best 1955: 10–11).

Various other options are mentioned by Best (1955: 11–13), providing just grounds for claiming that regional variations in Maori ‘star lore’ did indeed occur in pre-European times.

Originally, *Tane*, *Turangi* and *Moe-ahura* lived in darkness, but through the birth of the *whanau marama* (children of the light) he brought night and day to the world. It was *Tane* who was responsible for placing his nieces and nephews up in the sky, across the body of their grandfather, *Ranginui*. In a Bay of Plenty version of the myth, *Tane* began by positioning *Hinatore* on *Ranginui’s* chest, but

> Feeble indeed was the light emitted … and darkness held fast. Tane procured the stars, and now dim light was seen. He next brought the moon, and light became stronger. Then Tane placed the sun on high, and bright light entered the world. (Best 1955: 13).

Other myths assign different ancestors with the important task of placing the stars in the sky. In one of these, *Tama-rereti* took them aboard his canoe for transportation. The basket for the stars was named *Te Ikaroa* (the Milky Way), and instead of going into a basket with all the other stars, *Atutahi* (Canopus) clung to the outside. This explains why it now resides beyond the bounds of the Milky Way (Best 1955: 14).

Because of the conflicting accounts, the precise identity of the Milky Way is unclear. In some accounts *Te Ikaroa* is equated with *Turangi*, and in others is identified as his younger brother (Best 1955: 10–15). But in all versions, *Te Ikaroa* was charged with their well-being and “… was placed in the middle of the little suns (stars) in order that he might protect and cherish them.” (Best 1955: 14).

The Milky Way and two guardians of the seasons were then appointed to lay down the courses of the different heavenly bodies in order to regulate the seasons, and so that they would not end up interfering with one another. *Te Ikaroa* was responsible for guarding the *ara matua* (the main road), which is the path followed by the Sun, Moon and the planets (Best 1955: 15).

2.6 Celestial Objects and Events, and Documentation of Maori Astronomical Knowledge

2.6.1 Introduction

In this section, we examine the range of objects and events that were known to have been visible in the skies over Aotearoa/New Zealand between AD 1200 and 1768, and then examine Best's account for any evidence of these.

We also look for evidence of regional variations in Maori astronomical practices and beliefs, to determine whether these would have been a feature of the geographically-discrete 'culture areas' that the late Dr Henry Devenish Skinner (1886–1978), long-time Director of the Otago Museum, found were typical of Maori culture at the time of early European settlement (see Skinner 1974: 18–26).

2.6.2 The Sun

The Sun is the most conspicuous star visible from the Earth, and is seen as vital for human survival. This was also the view of the Maori astronomer, who referred to the Sun as *Te Ra*, an ancient term found throughout Polynesia (and even further afield, in Egypt, though this should not be seen to imply cultural links between these two regions). Best (1955: 9) also mentions the terms *Komaru* and *Mamaru* for the Sun, but notes that they are seldom heard. *Ra kura*, the 'red Sun', is a term that was sometimes used to describe the Sun, and would have been most applicable at sunset. When the Sun was on the meridian it was known as *Poutumaro*, and two different personified names for the Sun were *Tama-nui-te-ra* and *Tama-uawhiti* (Best 1955: 16–17). Various songs included reference to the Sun. For example:

> *E whiti, e te ra, e maene ki te kiri*. (Shine, oh Sun, in pleasing manner at the skin [of man]). (Best 1955: 7).

Alternatively:

> *E to, e te ra, rehurehu ki te rua*. (Decline, oh Sun, and set in the abyss.) (ibid.).

Sunspots are a well-known photospheric phenomenon, and vary in abundance with a mean period of 11.1 years between successive maxima (Fig. 2.7). By systematically observing the Sun through thin cloud or when it was near the horizon, Mossman (1989) has empirically established that near sunspot maximum, experienced observers should be able to see naked eye sunspots almost every day, and

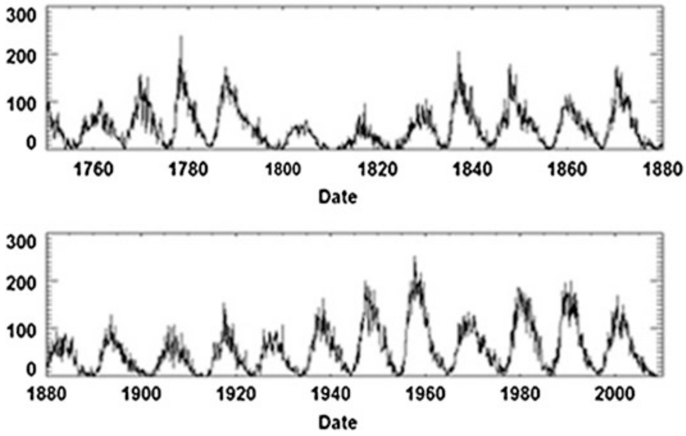

Fig. 2.7 A plot of monthly average sunspot numbers over the past 250 years illustrating the 11.1-year solar cycle (www.solarsystemcentral.com/sunspot_cycles_page.html)

even an inexperienced person would easily notice large spots (cf. Keller and Friedli 1992). Moreover, the general shapes of large individual sunspots or groups of smaller spots were discernible, which provides confirmation for some of the descriptions contained in Oriental records (see Clark and Stevenson 1978; Willis et al. 1996; Yau and Stephenson 1988), even if the actual numbers of spots reported greatly understated their actual abundance (Eddy 1987). Mossman (1989: 62) also found that spots were most conspicuous at sunset, "… when viewed against a naturally reddened disk …" Upon applying Mossman's parameters to Oriental records, Eddy et al. (1989) believe that sunspots were visible within ±3 years of each solar maximum. Assuming an average cycle period of 11.1 years, this would imply that there were about 52 solar maxima between AD 1200 and 1768, and that naked eye spots would have been obvious to the Maori astronomer.

This, of course, assumes that the sunspot cycle has not changed appreciably during the last 800 years, but we now know that such was not the case and that during the Maunder Minimum (from about AD 1645 to 1715) sunspots were absent or very rare (Eddy 1983; Hoyt and Schatten 1996; Ribes and Nesme-Ribes 1993). On the basis of Chinese and Korean sunspot records, Clark and Stephenson (1978) suggest that reduced sunspot numbers may also characterise the Spörer Minimum and the Medieval Minor Minimum, both of which also occurred during Maori times (see Fig. 2.8). Even so, there would still have been numerous occasions during the following intervals when Maori astronomers could have observed naked eye sunspots: AD 1200–1280, 1350–1420, 1550–1645 and 1710–1768. Yet no evidence of spotty imperfections or blemishes—of sunspots—exists in Best's account of Maori astronomy. *Te Ra* was perfection personified!

Grant (1992) has combined data drawn from the sunspot record, speleothems, tree-rings and erosional-alluviational sequences to reconstruct the palaeoclimate of Aotearoa/New Zealand for the last 2000 years, and he identifies two different

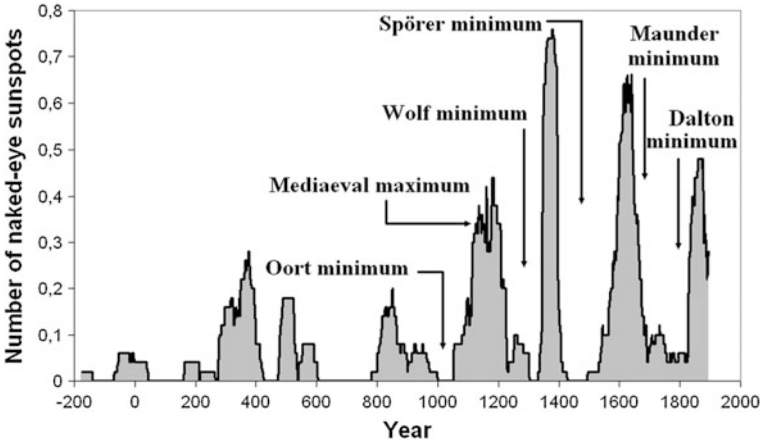

Fig. 2.8 A plot showing the incidence of naked eye sunspots and intervals with low to zero sunspot activity (after Vaquero et al. 1997)

periods of warmer weather during the pre-European Maori occupation of Aotearoa/New Zealand. They are the Warm Waihirere Period (immediately prior to the Medieval Minor Minimum) and the Warm Matawhero Period (between the Spörer Minimum and the Maunder Minimum). Each of these Periods was characterised by higher temperatures than at present, stormy weather that caused widespread gale damage to forests and coastlines, heavy rainfall and associated flooding. Maori mythology contains an account that could conceivably have been inspired by one, or both, of these warm Periods. Soon after the Sun was placed in the sky

> It was now found that the heat of the sun was unbearable. The body of the Earth Mother dried up and became dust; the eye of man could see naught. For at that period the body of Papa, the Earth Mother, was without covering. So now Tane said to Te Ikaroa (Milky Way), "Space out the courses of the little suns and the moon that we may obtain sleep. Move the sun forward, there to traverse his course, while you and the younger ones follow behind …" This was done … But the heat of the red sun was still intolerable, and all the offspring of the Earth Mother wailed aloud. Rangi was afflicted sorely by the great heat, and moaned in anguish; his head was scorched by the fierce rays of the sun … So the sun was removed to the back of Rangi, and all things were content. (Best 1955: 15).

Judging from Chinese analogies (see Xu 1987) and more recent statistics (Neidig and Cliver 1983), another naked eye phenomenon which a dedicated Maori astronomer was bound to see sooner or later was a white light flare. Data from the last century and a half suggest that during those intervals with sunspots, about 50 white light flares were potentially visible each century, but because no mention of them appears in Best's account there is no way of knowing whether any were witnessed by Maori astronomers.

Solar eclipses are rare and spectacular events (Fig. 2.9), and no fewer than 10 total eclipses and 16 annular eclipses were potentially visible from

Fig. 2.9 A drawing of a solar eclipse showing the pearly-white corona and four red/orange-coloured prominences (after Sands 1871)

Table 2.1 Total and annular solar eclipses visible from Aotearoa/New Zealand, AD 1200–1768

Total eclipse		Annular eclipse	
1301	August 5	1270	September 17
1409	October 9	1275	December
1430	February 23	1293	December 29
1463	November 11	1330	January 20
1491	November 2	1359	June 26
1545	December 4	1368	June 16
1610	June 21	1384	February 22
1735	April 23	1424	January 2
1739	February 8	1433	December 12
1748	January 30	1444	May 18
		1485	September 9
		1488	January 14
		1507	July 10
		1516	June 30
		1581	December 26
		1666	December 26

Aotearoa/New Zealand between AD 1200 and 1768. These are listed in Table 2.1 (after J. Meeus, personal communication, 1999), and each event would only have been visible for a few minutes, and in every case from a very localized region of the country. In addition to these 35 eclipses, a large number of partial solar eclipses were visible from Aotearoa/New Zealand in pre-European times.

In perusing Table 2.1, the century and a half from 1400 to 1550 stands out as being particularly rich in such events (there were 5 total eclipses and 7 annular eclipses), with less than one generation in each case separating the 4 different eclipses that occurred between 1424 and 1444, and between 1485 and 1507. Inclement weather probably prevented observation of some of these eclipses, but it is reasonable to expect that information about those that were observed, and others that occurred during the fifteenth century, would have spread by word of mouth.

Collectively, the eclipses listed in Table 2.1 would have provided Maori astronomers with ample examples of each type of phenomenon, yet Best (1955: 20) only records a single term for a solar eclipse, which is *Ra Kutia*. There is no indication whether this applies solely to total eclipses, or whether it also was intended to include annular, and even partial, solar eclipses.

Nor does the standard Maori explanation of solar eclipses provide any clarification: "An eclipse of the sun was caused by its being attacked and devoured by demons, from which attacks, however, it invariably recovers." (ibid.). Obviously these demons were not always successful in their attacks, given the comparative prevalence of partial solar eclipses. In this regard, it is interesting to note that there is considerable debate as to just how obvious partial solar eclipses would have been to people without optical aid (e.g. see Mostert 1989).

Currently, the most prominent naked eye feature of a total solar eclipse is undoubtedly the corona (see Fig. 2.9), and its form and extent varies in the course of a solar cycle. However, Eddy (1983) has shown that the corona was absent during periods without sunspots. Therefore, coronae would only have accompanied 5 or at most 6 total solar eclipses visible from Aotearoa/New Zealand between AD 1200 and 1769, and if weather conditions prevented observation of some of these events the corona would have been viewed but rarely. It is therefore no surprise that Best fails to mention the existence of the corona in his account.

Prominences (Fig. 2.9) were another conspicuous feature of total solar eclipses, but most would have been invisible or at very best inconspicuous to the naked eye, despite their distinctive red colour. Nor are they mentioned by Best.

A comparatively rare terrestrial atmospheric phenomenon was a solar halo (Fig. 2.10), and one form of this (Best suggests a sun-dog of several colours) was know to the Maori as *kura hau awatea*. Such haloes were believed to portend approaching bad weather. If the different colours were bright and distinct then the storm was nearby; a dim halo showed that the storm was still some way off. It was also believed that certain gifted men could generate solar haloes at will and use these as a means of communication with other Maori (Best 1955: 19).

The Sun was originally important in everyday Maori life. To quote Best (1955: 20–21):

> A considerable amount of respect was paid to the sun in Maori ritual performances … All higher classes of knowledge are connected with the sun; they emanated from Tane. The cultus of Tane represents the Maori form of sun-worship. It is marked by deference to Tane as representing the fertilizing-qualities of the sun, and by placatory gifts made to him. Thus all ritual formulae and offerings were made to the personified form of the sun.

Fig. 2.10 Example of a solar halo seen from Brocken (Harz), Germany on December 28, 2012 (https://en.wikipedia.org)

2.6.3 The Moon

The Moon is our nearest natural celestial neighbour, and its highlands and plains (*maria*) are obvious to the naked eye, as are its changing phases.

In everyday speech the Moon was known to the Maori as *Te Marama*, although the terms *Ahoroa*, *Atarau* and *Mahina* were occasionally used (Best 1955: 23). From time to time, the Moon appeared in the songs of the Maori, as in the opening lines of these two songs:

> *Tera te marama e ata haere ana* (Yonder the Moon drifts slowly along) (Best 1955: 7).

and

> *Tera te marama ka mahuta ake i te pae* (Yonder the Moon rises over the horizon). (ibid.).

Different terms were used to distinguish the phases of the Moon: *kua toriwha te marama* described the crescent Moon; *marama taiahoaho* the full moon; and *kua tohi te marama* the waning Moon. Best also lists other terms for unspecified phases of the Moon. Maori mythology provides a logical explanation for the phases. Unlike men, the Moon never dies but at certain times it

> … approaches its elder brother, the sun, and the two move together for a period. The moon belittles itself in the presence of its more important elder; its importance (brightness) is lost in the superior magnificence of the sun. After a time the moon leaves the sun behind; then it is said by men, 'The moon is again seen'. Best (1955: 25–26).

When the Moon reappears in crescent form, she has just re-enervated herself by bathing in the life-giving waters of *Tane*, and returns to view young and beautiful!

The personified form of the Moon was *Hina* or *Hine-te-iwaiwa*, and other variants were *Hina-uri*, *Hina-te-iwaiwa*, *Hine-nui-te-po* and *Hine-to-otaota* (Best 1955: 22). *Hina*

> … is said to have flourished in the days of the gods, and to have been a kind of patroness of the female sex and of all labours peculiar to women, such a weaving. Female children were dedicated to her, and, most significant of all, she presided over childbirth. (Best 1955: 22).

Best (1955: 22–23) specifically refers to "… the cult of Hine-te-iwaiwa …", and mentions that the Moon was believed to exert considerable influence on the birth of a child (Best 1955: 27). Meanwhile, Taylor relates that when the new moon appeared, women assembled and used the following lament to bewail those relatives who had died during the previous month:

> Alas! O moon! Thou has returned to life, but our departed beloved ones have not. Thou has bathed in the *waiora a Tane*, and had thy life renewed, but there is no such fount to restore life to our departed ones. Alas! (ibid.).

Our 'Man in the Moon' to the Maori was a 'Woman in the Moon' called *Rona*. One myth recounts that *Rona*

> … was originally a woman of this world … She was going to a spring for water one night with her gourd water-vessels when the moon became obscured, which caused her to apply a most offensive epithet to it. She was at once taken away by the moon, and she is still seen in it with *rururu taha*, or bundle of gourd vessels. (Best 1955: 25).

Sometimes *Rona* also was known by her longer name, *Rona-whakamau-tai* (*Rona* the tide-controller), which would indicate that the Maori knew of the connection between the Moon and the tides. Whether or not this reflects pre-European knowledge is a moot point.

Compared to eclipses of the Sun, total lunar eclipses were common, and hundreds of them were observed by Maori astronomers prior to the arrival of Europeans. Moreover, they were easily explained:

> The common view of an eclipse of the moon is that Rona, a malignant being, is attacking and destroying it. When the moon does not appear the twain are battling with each other, and so cannot be seen. After the combat, the moon bathes in the *waiora a Tane*, and so returns to us young and beautiful. (Best 1955: 24–25).

There are some similarities here to the disappearance of the Moon near the new moon phase.

One of the remarkable features of a totally eclipsed Moon is its colour, and it is interesting that Best does not allude to this. Those of us who have witnessed many lunar eclipses never know which particular hue the Moon will take on at totality. Red, pink, orange, golden and coppery-coloured Moons all occur (e.g. see Fig. 2.11), each of which may have had a different significance to the Maori astronomer.

Fig. 2.11 Examples of orange and pink moons during the lunar eclipses of August 28, 2007 and December 21, 2010 respectively (*Courtesy* John Drummond, Patutahi, New Zealand and https://en.wikipedia.org respectively)

Partial lunar eclipses were far less prominent than their solar counterparts, but Stephenson and Fatoohi (1994) found that they were regularly observed by Chinese and Arab astronomers nonetheless. There is no reason to suppose that they would not have elicited the same attention from the pre-European Maori astronomer. In their study, Stephenson and Fatoohi (1994: 93) noted an interesting feature, that "The magnitudes of small eclipses are consistently overestimated, while for large eclipses the reverse is generally true." (and they define "magnitude" as the maximum degree of obscuration of the Moon's disk). Since this seems to have been a universal phenomenon, it should also characterise the observations of the Maori astronomer.

One other Moon-related phenomenon which deserves to be mentioned is the lunar occultation. Typically between ten and twenty of these would be visible to the naked eye in any one year. Lunar occultations were observed by the Maori, and were reputed to have portended the outcome of military action. Best (1898: 233) was told by one of his informants that

> The moon represents a pa and the star a war party attacking that fort. The star knows all about the coming trouble. Should it pass to the other side of the moon [i.e. be occulted] the pa will fall. Just before the battle of Orakau we saw this sign, and we saw the star reappear at the other side of the moon. As we were a war party of course our warriors made much of this omen.

Much rarer were lunar occultations of planets. Although these would have been even more notable phenomena, Best is not forthcoming on how these were explained by the Maori.

2.6.4 The Planets

Apart from the Earth, five different planets were known to ancient peoples (Mercury, Venus, Mars, Jupiter and Saturn), and they stood out from the background stars by their motion along the ecliptic. Mars was also conspicuous because

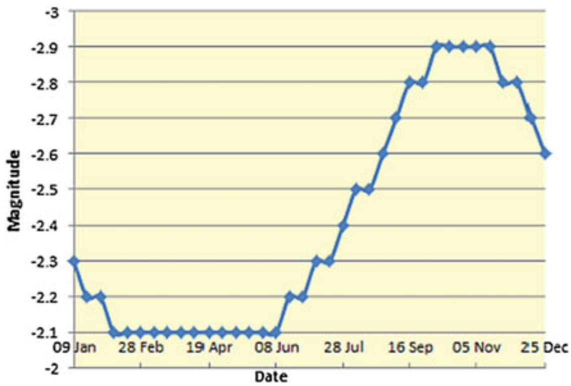

Fig. 2.12 This plot shows the way in which the magnitude of Jupiter varied in the course of just one year (in this case 2011), between −2.1 and −2.9 (www.sydneyobservatory.com.au/wp-content/…)

of its red colour. In addition, all five planets underwent noticeable changes in brightness in the course of a year (Fig. 2.12). Jupiter and Venus were always brighter than the brightest stars, and Mars sometimes was. Venus spent part of a year as the 'Evening Star' and the remainder as the 'Morning Star', while Mercury never seemed to be far from the Sun, low in the western sky at sunset or similarly positioned in the east before sunrise.

Among the myriads of stars in the night sky, the Maori astronomers also recognised these same five 'deviant' stars, which were referred to as *Whetu Ao* (Best 1955: 9). Mercury was called *Whiro*, while Mars was generally known as *Matawhero* although the name *Maru* has also been proposed (Best 1955: 49). Given the significance of the colour red in Maori society, it is remarkable that Mars' distinctive red hue had no particular meaning to the Maori.

Jupiter was generally known as *Kopu-nui* and perhaps *Parearau* (Best 1955: 40–42), but there is some controversy surrounding the latter name. Four Bay of Plenty Maori assigned it to Jupiter, but

> … Stowell says that it is Saturn; that Parearau is a descriptive name for that planet, and describes its appearance, surrounded by a ring. The word *pare* denotes a fillet or head-band; *arau* means "entangled" - perhaps "surrounded" in this case, if natives really can see the *pare* of Saturn with the naked eye. If so, then the name seems a suitable one. (Best 1955: 43).

In fact, Saturn's ring is not visible to the naked eye, even to those with acute vision, so if this name does indeed refer to Saturn and its rings then it must be of nineteenth century derivation, when telescopic studies of the planet and its rings were very much in vogue (e.g. see Proctor 1882).

Parearau, whatever her true identity, was also sometimes known as *Hine-i-tiweka*, and was often spoken of as a companion of *Kopu* (Venus) and in one version as the wife of *Kopu* (Best 1955: 43–44). In another variant, far from being a wife, she is a widow! Best (1955: 44) recounts that "Seafarers consulted *Parearau* when a storm was threatening, for if she appeared to be of a light misty aspect the storm would pass by."

When the Italian astronomer Galileo Galilei (1564–1642) first viewed Jupiter through a telescope on 7 January 1610 he was amazed to observe four small adjacent stars which he quickly came to realise were satellites of the giant planet (Fig. 2.13). They are now termed the 'Galilean satellites'. During the nineteenth century, William Colenso (1811–1899) was told that some Maori astronomers had such phenomenal eyesight that they could see these four moons of Jupiter (Best 1955: 35). Peak (1958: 256) gives the mean visual magnitudes of Io (I), Europa (II), Ganymede (III) and Callisto (IV) at opposition as 5.5, 6.1, 5.1 and 6.2 respectively, and notes that "… I and III would be comparatively easy naked eye objects, were it not for the proximity of the brilliant planet; II and IV would be near the limit but might be seen on occasions …" (ibid.). These comments by an authority on visual observations of Jupiter must throw doubt on Colenso's account—which, after all, was obtained long after the existence of the Galilean moons had become common knowledge.

Best known and brightest of all the planets was Venus, which unlike the other *whetu ao* was blessed with a number of names. A Tuhoe informant from the Ureweras told Best (1955: 50):

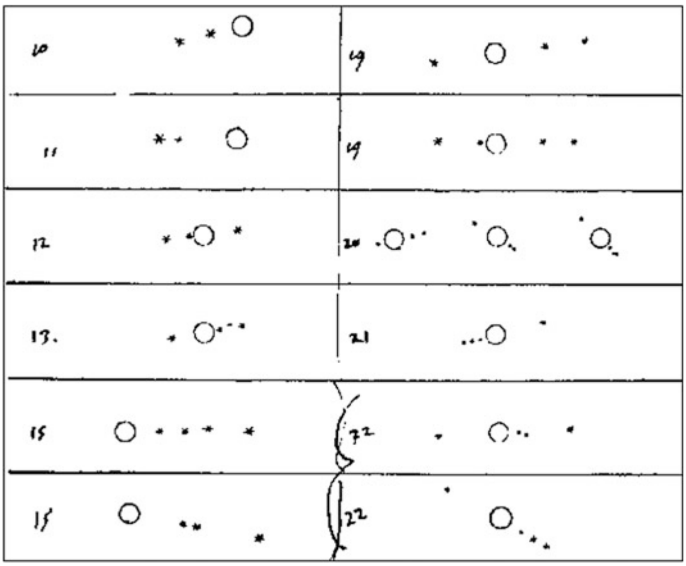

Fig. 2.13 Sketches that Galileo made of Jupiter and the changing positions of its four (Galilean) moons from night to night (www.astro.umontreal.ca/~paulchar/grps/site/images/galileo.4.html)

> … Venus has three names - Kopu, Tawera, and Meremere. As an evening star in summer it is called Meremere-tu-ahiahi; in the winter, as a morning star, it is Kopu. In other districts Venus as a morning star is called Tawera; as an evening star, Meremere and Meremere-tu-ahiahi.

Other terms listed by Best (1955: 40) are *Rangi-tu-ahiahi*, *Rere-ahiahi*, *Tu-ahiahi*, and possibly *Puaroa*—although Best (1955: 50–51) has some doubts regarding this last name. The first three names all relate to Venus as an evening star.

Of all the planets, Venus was most revered for her beauty, and what better way of complimenting an attractive woman than to describe her by way of the following popular saying:

> *Me te mea ko Kopu e rere i te pae*. (Like Venus as she appears above the horizon.) (Best 1955: 50).

Yet in Maori mythology, Venus as a morning star is a male (Best 1955: 51).

Conjunctions of two or three of the five naked eye planets are beautiful events (especially if the Moon also is in the region), and many of these must have been observed by Maori astronomers.

Much rarer were quintuple planetary groupings, when all five known planets were visible together in the sky within a circle of 25° diameter or less. These events were seen as portends of disaster in Europe, and the spectacle would also have drawn Maori concern and comment (though Best is silent on this topic). Quintuple planetary groupings that occurred during pre-European Maori times are listed in Table 2.2 (after de Meis and Meeus 1994).

Although these dates relate to the closest approaches of the planets, all five planets would have been in comparatively close proximity for several successive days—certainly long enough to guarantee their observation regardless of prevailing weather conditions. It is a safe assumption that all seven planetary groupings would have been seen, marvelled at, and remarked upon by Maori astronomers.

However, given the spacing of these apparitions, and assuming an average Maori lifespan of 31–32 years, most quintuple planetary groupings would have been once-in-a-lifetime events, except for those lucky enough to witness the 1564–1584 pair of events.

Table 2.2 Quintuple planetary groupings, AD 1200–1768

1284	December 23
1483	October 23
1524	February 19
1564	June 21
1584	May 1
1624	August 26
1662	December 6

2.6.5 Comets

Comets, those dreaded 'bearded stars' to some ancients, are commonly referred to in the historical records (e.g. see Hasegawa 1980), but precisely which ones were observed by Maori astronomers is not known. Burnham (2000), Hughes (1987), Seargent (2009) have written about 'great' or 'remarkable' comets, which passed close to the Sun and the Earth, and consequently were conspicuous to the naked eye for several successive weeks or months.

By drawing on Hughes' paper, Guillemin's (1877) book and data in Hasegawa (1980), Hughes (1985), Jansen (1991), Kronk (1984), Marsden and Williams (1996), Vsekhsvyatskii (1964) and Yeomans (2007), I have been able to assemble a list of all naked eye comets with maximum apparent visual magnitudes brighter than +2 that were definitely visible from Aotearoa/New Zealand between AD 1200 and 1769 (Table 2.3). A minor shortcoming of this list is that not all of these comets may have still been in Aotearoa/New Zealand skies when at their brightest or when their tails were of maximal length, although those of 1577, 1652, 1668, 1686, 1689, 1695 and 1758 certainly were. However, Masse (1995: 465) reminds us that

> The incredible variable nature of comets cannot be overstated in terms of impact on early culture. A single comet can change from being short-tailed (or even non-tailed) to long-tailed … from single straight tails to branching, twisting, chain-like or even multiple tails … and from dull to brilliant over the course of a few days or even hours of time.

As well as the comets listed above, there would have been others of comparable brightness visible from Aotearoa/New Zealand which had faded beyond Hughes' magnitude threshold by the time they were detected by northern observers and so were omitted from his list—and hence from Table 2.3.

In addition, other fainter comets of less spectacular appearance would also have been visible to Maori astronomers. It is significant that Marsden and Williams (1996) list no fewer than 46 different non-periodic comets that were visible from the northern hemisphere between AD 1200 and the advent of the telescope, which gives some idea of the occurrence frequency of naked eye comets (as opposed only to 'remarkable' comets, of which there are just 11 in Table 2.3). Of the 46 comets, 15 (33 %) were observed for more than one month.

Naked eye comets certainly were known to the Maori, who generally referred to them as *Auahi-roa* or *Auahi-turoa*. The former translates literally as 'long smoke', and according to one legend, *Auahi-roa* was the son of *Te Ra* (the Sun) and was sent down to the Earth to supply the people there with fire. After reaching the Earth *Auahi-roa* married, and his wife subsequently gave birth to five mythical 'Fire Children' who produced fire for mankind. Best (1955: 66) succinctly summarises the connection:

> So when you see the comet in the heavens, know that it is Auahi-turoa, he who brought fire to mankind. And fire is often called Te Tama a Auahi-roa, or Te Tama a Upoko-roa (the son of Auahi-roa, or of Upoko-roa), because it is the offspring of a comet.

Table 2.3 'Great Comets' visible from Aotearoa/New Zealand, AD 1200–1768

Name	Designation	Maximum magnitude	Naked eye visibility (days)	Maximum tail length (°)
1222	1P/Halley	1–2	Visible in daylight	30
1264	C/1264 N1	0–1	~110	100
1301	1P/Halley	1–2		15
1378	1P/Halley	+1.2	44	>20
1402	C/1402 D1	−5	~82; visible in daylight	>15
1456	1P/Halley	−0.2	43	57
1468	C/1468 S1	1–2	82	30
1471	C/1471 Y1	−3	59; visible in daylight	>30
1500	C/1500 H1		>72; visible in daylight	10
1531	1P/Halley	+1.4	36	>15
1532	C/1532 R1	+1	120; visible in daylight	15
1533	C/1533 M1	0	78	15
1556	C/1556 D1	−2	73	4
1577	C/1577 V1	–7	87; visible in daylight	80
1585	C/1585 T1	–4	46	2
1607	1P/Halley	+1.6	23	Long
1618	C/1618 W1	+1 to +3	69; visible in daylight	104
1652	C/1652 Y1		26	8
1664	C/1664 W1	+1	~90	37
1665	C/1665 F1	−2 to −3	25	30
1668	C/1668 E1	1–2	28	37
1680	C/1680 V1	+1.5	~90	90
1682	1P/Halley	+1.6	26	30
1686	C/1686 R1	+1	>37	18
1689	C/1689 X1		~31	68
1695	C/1695 U1		22	40
1744	C/1743 X1	−5	~112; visible in daylight	90
1758	C/1758 K1	−3	~67	Short
1759	1P/Halley	−0.9	69	47

Best also gives a number of other names for comets, namely *Auroa*, *Manu-i-te-ra*, *Meto*, *Puaroa*, *Puihiihi-rere*, *Purereahu*, *Tiramaroa*, *Tunui-a-te-ika*, *Taketake-hikuoa*, *Upoko-roa*, *Wahieroa*, *Whetu* and *Whetu-kaupo*. Some of these probably were generic names of regional rather than national relevance; others were descriptive, for particular kinds of comets (e.g. those with prominent tails); and others again probably referred to specific comets. Hongi (1920: 27) is most likely referring specifically to its spectacular apparition in 1910 when he says that Comet 1P/Halley (Fig. 2.14) was known as *Awa-nui-a-rangi*, or the 'celestial river of light'.

Fig. 2.14 Halley's Comet photographed at the Yerkes Observatory on May 29, 1910 (https://en.wikipedia.org)

Two features of all bright comets which excite present-day observers are the nature and behaviour of the head (that is, the nucleus and the coma), and the form and evolution of the dust and ion tails. While the head does not seem to have been of much interest to the Maori astronomer, four of the different 'comet' names listed above specifically refer to their tails. *Meto* denoted a *whetu puhihi*, a star which emitted 'rays' (a tail), and Best (1955: 67) was told that "The rays or tail of Meto extend upwards … if its body be below the horizon, as a range of hills, its *puhihi* extend up above the horizon (*Ka hihi ake nga puhihi*)." The second term is *Puaroa*, which Best (ibid.) tells us, "… is said to possess or emit mist-like emanations, referred to by the name of *hiku makohurangi*, or misty tail." *Tiramaroa* referred to a comet with long *puhihi* (rays), which sometimes pointed upwards and sometimes downwards (Best 1955: 65), while *Tunui-a-te-ika* reputedly possessed a long tail (Best 1955: 68). The Great Comet of 1843 (C/1843 D1) certainly possessed a long tail (see Fig. 2.15) and was readily visible from Aotearoa/New Zealand. Maoris in the Wellington region "… hailed it as an evil omen, and commenced howling very pathetically." (*New Zealand Gazette and Wellington Spectator* 1843), but whether they—or other Maoris—specifically referred to it as *Tunui-a-te-ika* is not known.

Finally, for centuries comets were seen by the lay public in many areas of the world as ill omens—as 'harbingers of doom' (e.g. see Chambers 1910;

Fig. 2.15 A painting of the Great Comet of 1843 (C/1843 D1) by Charles Piazzi Smyth (https://en.wikipedia.org)

Proctor 1896). Generally, the Maori also saw comets as signs of impending doom. Thus, when *Taketake-hikuroa* was seen in the sky "… it was viewed as an evil portent for the tribe." (Best 1955: 68), and the appearance of *Tunui-a-te-ika* announced the death or impending death of some person so "… priestly adepts performed the *matapuru* rite, in order to avert the threatened evil, whatever it may be." (ibid.). But apparently not all comets portended disaster, for the appearance of *Meto* gave forewarning of a hot summer (Best 1955: 67).

2.6.6 Meteors and Meteorites

Meteors, those sand-sized pieces of cometary debris that light up when they penetrate the Earth's atmosphere, are visible on every clear night, more so if the Moon is absent. To the Maori, these transient celestial visitors were commonly referred to as *Kotiri*, *Kotiri-tiri*, *Matakokiri* or *Tumatakokiri*, and Best (1955: 69) states that the Bay of Plenty Maori used the name *Tamarau*.

Meteors were explained as wayward stars which wandered from their places in the sky, and were struck by their elder siblings, the Sun and Moon. Some Maori regarded the appearance of a meteor as portending the death of a chief, but others thought that if a meteor appeared to fly towards them this was a good sign. One old informant told Best (1955: 70) that

> Another ancestor is Tumatakokiri, who is seen darting at night. His appearance is that of a star flying through space. His task, as he so flies, is to foretell the aspect and conditions of the heavenly bodies, of winds, and of seasons. If he swoops downwards, the following season will be a windy one. If he just flies through space, a fruitful season follows; a season of plenty lies before the people.

Sporadic meteors (Fig. 2.16) were present throughout the year, but at certain times they paled into insignificance in the presence of shower meteors. A meteor shower occurs when the Earth passes through debris that has been ejected by a comet and spread around the orbital path of that comet (Jenniskens 2006). There are a relatively small number of very active meteor showers that occur every year, and a great many minor showers. When a meteor shower occurs, the associated meteors are seen to radiate from a common point, known as the 'radiant'. Major meteor showers are usually named after the constellations in which these radiants are located. In pre-European times, many showers would have been visible from Aotearoa/New Zealand in the course of any one year (e.g. see Rada and Stevenson 1992) and the major ones are listed below in Table 2.4. Most meteor showers typically had zenith hourly rates of between 5 and 50 meteors, but judging from twentieth century experiences, certain showers (such as the Pi Puppids and the Phoenicids) occasionally exhibited greatly enhanced activity (e.g. see Jenniskens and Lyytinen 2005).

A totally different scale of activity, however, was sometimes associated with the Leonid meteor shower. This shower currently is active each November, and is associated with Comet 55P/Tempel-Tuttle. Every 33 years there is a chance of

Fig. 2.16 Photograph of an atypical meteor—most meteors are white (*Courtesy* John Drummond, Patutahi, New Zealand)

Table 2.4 Major meteor showers visible from Aotearoa/New Zealand in pre-European times (*Courtesy* American Meteor Society)

Name	Maximum activity	Radiant		Maximum zenith hourly rate	Parent body
		RA (h, min)	Dec (°)		
Pi Puppids	Late April	07:20	−45	Variable	Comet 26P/Grigg-Skjellerup
Eta Aquariids	Early May	22:36	−00.6	60	Comet 1P/Halley
Southern Delta Aquarids	Late July–early August	22:42	−16.4	20	Comet 96P/Machholz, Marsden and Kracht Comet group complex
Alpha Capricornids	Late July	20:20	−10.2	5	Comet 169P/NEAT
Orionids	Late October	06:24	+15.5	20	Comet 1P/Halley
Southern Taurids	Early November	02:06	+08.7	5	Comet 2P/Encke
Northern Taurids	Mid-November	03:54	+22.5	5	Minor planet 2004 TG10 and others
Alpha Monocerotids	Mid-November	07:48	+01	Variable	Unknown
Leonids	Mid-November	10:16	+21.6	Variable	Comet 55P/Tempel-Tuttle
Phoenicids	Early December	01:12	−53	Variable	Comet 289P/Blanpain

greatly enhanced meteor activity for just the one year or two successive years, with zenith hourly rates of 1000 s or even tens of 1000 s of meteors (Littman 1998). When this occurs the sky literally 'rains meteors', providing a truly unforgettable experience (e.g. see Fig. 2.17). These short-lived events are termed *meteor storms*, and are only visible for a few days in any one of these 'storm years'. By searching through historical sources Dick (1998) was able to identify the occurrence dates of such storms, and these are listed in Table 2.5.

All of these Leonid meteor storms would have been visible from Aotearoa/New Zealand, weather-permitting, and for many Maori would have afforded an unforgettable once-in-a-lifetime spectacle. Even at its best, the point from which the meteors were seen to emanate would have been very low in the northern sky, with most meteors shooting up into the sky from this radiant point, and others disappearing below the horizon. The presence of many bright and colourful meteors would have added to the drama of the occasion.

Very bright meteors—whether sporadics or shower-derived—are known as fireballs, while exploding fireballs are termed 'bolides'. Such meteors never fail to excite present-day confirmed meteor observers and would have provided the same appeal for Maori astronomers. To the Maori, fireballs were personified as *Rongomai*,

Fig. 2.17 A nineteenth century woodcut of the 1833 Leonid meteor storm (https://en.wikipedia.org)

Table 2.5 Leonid meteor storms, AD 1200–1768 (after Dick 1998)

Date range		Where documented
1202	October 18–19	Middle East and China
1237	October 18–19	Japan
1238	October 18–19	Japan
1366	October 21–22	Europe and China
1532	October 24–26	China and Korea
1533	October 24–26	Europe, China, Korea, Japan
1566	October 25–27	China and Korea
1601	November 5–6	China
1602	November 6–7	China
1666	November 6–7	China
1698	November 8–9	Europe and Japan
1766	November 11–12	South America

and occasionally one of these would escape from the sky and crash to the Earth as a meteorite. Evidence of these may be indicated by Maori place names, for there is a locality near Wellington named Te Hapua o Rongomai, where *Rongomai* is said to have descended to Earth at some time in the past (Best 1955: 67).

Known Aotearoa/New Zealand meteorites are listed in Table 2.6 (updated from Orchiston 1997). Those identified as 'falls' in the second column are recent phenomena, but most if not all of the remainder must date to Pleistocene or Holocene times given their proximity in each case to the land surface when recovered and the

Table 2.6 Known Aotearoa/New Zealand meteorites

Name[a]	Discovery year	Discovery mode	Type	Weight (kg)
Manaia (Masterton)	1863	Farming	Stony	5.8
Makarewa	1879	Railway construction	Stony	2.3
Mokoia	1908 (fall)	Search	Stony	~5
Waingaromia	1915	Farming	Iron	9.2
Berhampore (Wellington)	Early 1920s (fall)	Search	Stony	Cricket ball size
Morven	1925	Farming	Stony	7
View Hill	1952	Farming	Iron	33.6
Dunganville	1976	Prospecting	Iron	50.2
Kimbolton	1976	Farming	Stony	7.5
'Otago'	19??	Laboratory analysis	Stony	?
Opotiki	1989 (fall)	Search	Stony	Fusion crust only
Ellerslie (Auckland)	2004 June 12 (fall)	Search	Stony	?
Whakamarama	2013 May 13	Search	Iron	?

[a]For localities see Fig. 2.2

types of sediments in which they were found. It is very likely that some of these fell during Maori times and that their impacts were witnessed.

This table only lists recovered meteorites, yet we know of other meteorites that have definitely fallen in recent times but have not been recovered (despite systematic searches, including those carried out by the author of this book and his research associates). Moreover, the frequency of meteorite finds in agricultural areas of the USA, Canada and Europe and the areal extent of comparable agricultural land in Aotearoa/New Zealand indicates that Table 2.6 in no way reflects the true meteorite population. Clearly, many more meteorite impacts occurred between AD 1200 and 1768 than the mere handful reflected in this table.

Meanwhile, in more recent times, Maori oral histories record one example of what appears to be a meteorite impact:

> … when the Pakakutu *pa* at Otaki was being besieged [during the 1830s] Rongomai was seen in broad daylight, a fiery form rushing through space. It struck the ground and caused dust to rise. (Best, 1955: 67).

From Smith's (1910: 517) account of the hostilities between the Ati Awa tribe and the Ngati Raukawa and their allies from the Waikato and Taupo regions in 1834 we can pinpoint the precise location of Pakakutu Pa: "… on the north side of the Otaki river, not very far from the sea-coast, and between there and the Rangi-uru (or Whakarangirangi) stream." This location lies on a narrow coastal flat between the Tasman Sea and the escarpment marking the rise of the Tararua Range of mountains, and if a meteorite impact in fact took place during the siege of the *pa* and was visible from the vicinity of the *pa* then this most likely occurred somewhere on the triangular-shaped coastal flat which extends from the sea near Paraparaumu and Waikanae and becomes progressively broader as one proceeds to the northeast. At Otaki this coastal flat is only 5 km wide but when one reaches Levin, ~40 km from Waikanae, it has broadened to about 15 km. It is notable that there has been very extensive disturbance of the terrain throughout this whole area since 1834, in the form of farming, house and building construction, the forming of roads and a railway, etc., but as yet no discovery of a meteorite has been reported.

2.6.7 Stars and Asterisms

On a clear moonless night away from city lights, the average astronomer can nowadays see about 2500 stars (Moore 1985: 9), down to a limiting apparent visual magnitude of between 6 and 6.5 depending upon age, experience and visual acuity. But arriving at a proper understanding of Maori 'star-lore' is a considerable challenge. In the first place, Best (1955: 29–30) found accounts written by others of little use:

> There exists no monograph on the subject of Maori star-lore - no paper of any importance. Such matter as has been placed on record is in the form of brief or incomplete notes in a number of publications. Taylor's star-notes in *Te Ika a Maui* are sadly jumbled. Few men

> have been field-workers in Maori lore; thus many of the works dealing with such material simply contain rewritten data from previous publications.

And then when he tried to investigate Maori astronomy in the course of his own fieldwork, Best encountered serious difficulties:

> The fixing of Maori star-names is by no means always easy, for the average person among us needs a planisphere [or a star atlas] to refer to when making inquiries, and such is not always to hand. Nor is it often convenient to have one's native authority at one's side at night-time. (Best 1955: 29).

Compounding this was the fact that "Star-names differ, in some cases, among different tribes." (ibid.), reflecting the regional variations that occurred in Maori astronomical knowledge.

Despite these shortcomings, Best was able to assemble an interesting body of data. To the Maori, stars in general, were known as *Nga Whetu*, and occasionally as *Whanau Riki* and *Whanau Punga* (Best 1955: 9). All of the stars were collectively referred to as *kahui-o-te-rangi*, or "… the flock or assembly of the heavens …" (Best 1955: 42), and like the Sun, Moon and planets, the principal stars were assigned mythological attributes. Best (1898: 239) refers to these as 'high-born' stars, while "All the small stars were common people." High-born stars included Aldebaran, Altair, Antares, Arcturus, Canopus, Capella, Castor, Procyon, Rigel, Sirius, Spica and Vega, and all were known by one or more names (Best 1955: 38–42). Note that all of these are bright (first magnitude) stars.

In addition to naming individual stars, the Maori recognised various groupings of stars and assigned names to these. A few of these asterisms corresponded to our present-day constellations (e.g. the Southern Cross, Leo) or widely-recognised open clusters (such as the Hyades and the Pleiades—see Fig. 2.18), but others did not. Examples of the latter include part of Orion likened to a bird snare, a triangle of stars in Canis Major, and the tail of the scorpion in Scorpius (ibid.). According to

Fig. 2.18 The Maori grouping of stars known as *Matariki* (the Pleiades). The blue nebulosity round the brighter stars is common on photographs, but was not obvious to pre-European naked eye observers (*Courtesy* John Drummond, Patutahi, New Zealand)

Best, the Southern Cross had no fewer than six Maori names; Orion's Belt five; the Pleiades four; and the Hyades three. Some of these names were regional variants. The Maori recognised that stars in some of these groups were circumpolar and never set (Best 1955: 46).

Perhaps the most remarkable of all Maori constellations was the fabled 'Canoe of Tama-rereti' which *in toto* extended all the way from Taurus and Orion to Crux! More specifically:

> The Pleiades form the bow of this starry vessel, and the three bright stars in Orion's Belt represent the stern. The sail, the Ra o Tainui, is perhaps the Hyades. The cable is seen in the Pointers [Alpha and Beta Centauri], and the anchor is the Punga a Tama-rereti, the Southern Cross … The position of the cable in relation to the far-flung anchor is somewhat unusual. (Best 1955: 60).

This was the mythical ancestral canoe of the Tainui people.

Of all the stars known to the Maori, Canopus and Rigel had a special place, because of their intimate links with *kumara* cultivation, but they also were used to foretell the weather (Best 1955: 42, 48). Canopus was known variously as *Aotahi*, *Atutahi*, *Atutahi-ma-Rehua*, *Autahi*, *Kauanga*, *Paepae-poto*, and possibly *Makahea* (Best 1955: 38), and Best (1955: 42) was told that "… its appearance is a sign for the task of planting the crop to be commenced." Rigel was generally referred to as *Puanga*, but another name for it was *Pua-tawhiwhi o Tautoro*, and in the South Island it was known as *Poaka* or *Puaka* (Best 1955: 39). The *kumara* was a dietary staple throughout Aotearoa/New Zealand to the north of Banks Peninsula, and this is reflected in the combined geographical distributions of modified soils, borrow pits (which supplied the soil), stone structures and slope trenches. Meanwhile, covered pits like those shown in Fig. 2.19 where designed for the successful storage of *kumara*.

Two prominent asterisms also were associated with *kumara* cultivation, and they were the Pleiades and the three stars comprising Orion's Belt (see Fig. 2.20). The latter were known variously as *Tautoro*, *Tata o Tautoro*, *Te Tira o Puanga*, *Te Tuke o Maui* and *Te Tuke o Tautoro* (Best 1955: 39). But of all the asterisms recognised by the Maori, the Pleiades held pride of place, just as they did in Polynesia and in many other parts of the world (e.g. see Ammarell 1987; Ceci 1978; Hugh-Jones 1982; Snedegar 1995).

To the Maori, the Pleiades were generally referred to as *Matariki*, but they also were known by three other names, *Ao-kai*, *Hoho-kumara*, *Te Huihui o Matariki* (Best, 1955: 40)—and the first two of these alternatives clearly reflect their horticultural affinities. Whatever the name used, their role was to stay together and paddle their canoe across the sky (across the body of *Ranginui*), whilst ensuring that mankind was supplied with food. The primary 'food' was of course *kumara*, and Best was told that

> Our forebears consulted those sign-giving stars in connection with the planting of the *kumara* crop. The principal stars so relied on were Rigel, the Pleiades, Orion's Belt (Tautoro, and Whakaahu [Castor]. According to the manner of their rising, the crops would be planted early or late. (Best 1955: 48).

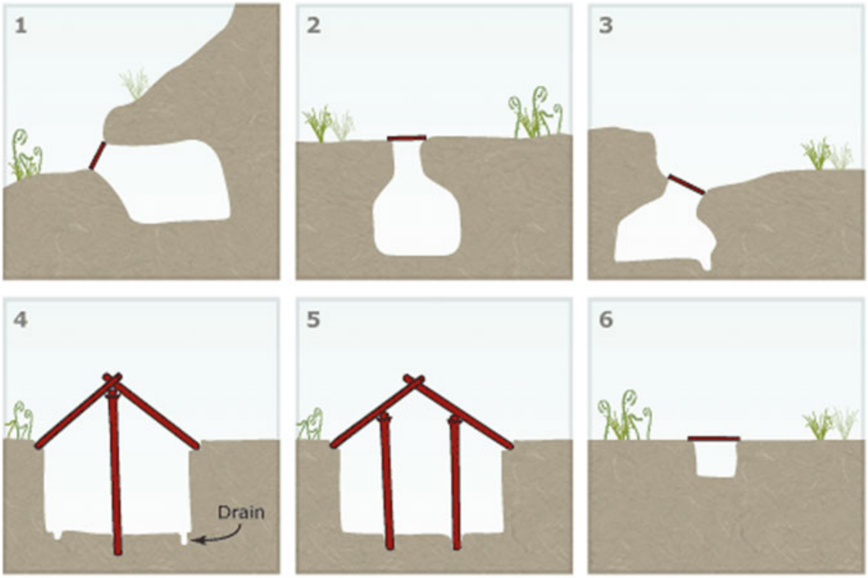

Fig. 2.19 Different types of *kumara* storage pits (after Davidson 1987)

As well as its horticultural connotations, the appearance of *Matariki* heralded the start of the birding season: "An old saying is, "When Matariki is seen, then game is preserved"; for it marked the season when such food-supplies have been procured and preserved in fat in certain vessels." (Best 1955: 53). In addition, the arrival of *Matariki* indicated that it was time to go in search of the lamprey, *Geotria Australia Gray* 1851. At first sight lampreys can be mistaken for eels (Fig. 2.21) except that they have a circular sucker *in lieu* of a regular mouth, lack a backbone and have seven gills behind the head. Lampreys spend most of their lives at sea, but when it is time to breed they return to rivers and especially areas near river mouths. If their current distribution (Fig. 2.22) reflects their availability in pre-European times, they would have been a popular seasonal food source for Maori people.

There is one further application of Maori astronomical knowledge which we must discuss, and this is oceanic voyaging. I have suggested elsewhere that "After the Vikings, they [the Polynesians] were the world's most accomplished mariners. Two-way voyaging was endemic throughout the central Polynesian region, and celestial objects were habitually used for navigation." (Orchiston 1996: 324). But just how closely the Polynesian norm applied to pre-contact Aotearoa/New Zealand is debatable. It is now apparent that the first settlement of Aotearoa/New Zealand occurred as a result of a planned voyage involving systematic exploration in a southwesterly direction, but there is considerable debate as to the extent of two-way voyaging between Aotearoa/New Zealand and island Polynesia following this initial settlement (e.g. see Finney 1992: 68–73). If two-way voyaging was rare—as some authors suggest—then much of the 'traditional navigational knowledge' of

Fig. 2.20 A photograph showing the two asterisms associated with *kumara* cultivation, *Matariki* (1 the Pleiades) and *Tautoro* (2 the three stars in Orion's Belt). Also included in this photograph are three 'high-born' stars, *Puanga* (3 Rigel), *Putara* (4 Betelgeuse) and *Taumata Kuku* (5 Aldebaran) (*Courtesy* John Drummond, Patutahi, New Zealand)

the Maori (e.g. see Best, 1954) could have been obtained from fellow-Polynesians by Maoris who served on whaling, sealing and other European vessels during the nineteenth century.

Fig. 2.21 The lamprey (www.niwa.conz/our-science/freshwater/tools/fishatlas/species/fish-species/lamprey)

This brings our account of Maori 'star-lore' to a close. What is remarkable is that so little was recorded, for of the 2500 naked eye stars that were visible to the Maori, Best was only able to supply names for 12! We have already alluded to the problems that non-astronomers faced in trying to identify different stars and asterisms, and Best (1955: 65) succinctly sums up the situation when he writes: "Such are the Maori star-names collected, and a poor showing it is, compared with what might have been obtained, for so few have been identified."

2.6.8 Variable Stars

To the Maori astronomer most stars were unchanging in relative position, brightness and colour from week to week or month to month, but they must have noticed that just a few altered appreciably in brightness. These are 'variable stars', and we now know that there are very large numbers of them in our Galaxy. There are various classes of variable stars (see Kholopov 1985), and most exhibit cyclic variations in brightness with well-defined periods and magnitude variations.

However, few variable stars remain within naked eye range throughout their full cycle, or if they do vary sufficiently in brightness for this to be apparent to a naked eye observer. Nowadays, variable stars are a favourite quarry of the amateur astronomer, and experienced observers are able to reliably discern a magnitude variation of 0.1.

Table 2.7 provides a list of naked eye variable stars whose magnitude variations would have been conspicuous to any observer (see Figs. 2.23 and 2.24), but on the basis of the limited information supplied by Best there is no evidence that Maori astronomers actually systematically monitored any of these stars. Indeed, Best is silent on the very existence of variable stars!

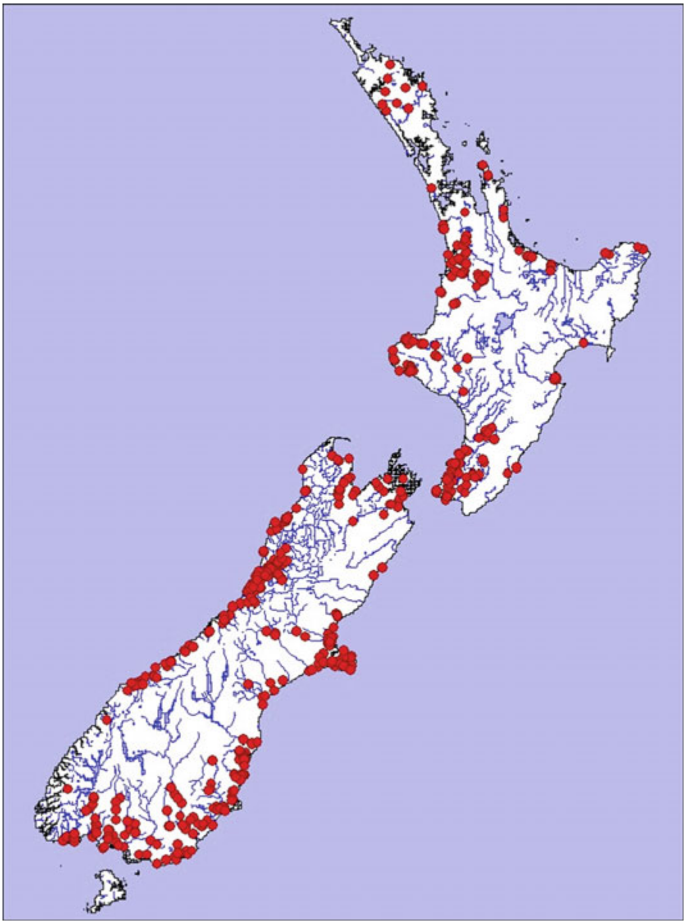

Fig. 2.22 Current distribution of lampreys (www.niwa.co.nz/our-science/freshwater/tools/fishatlas/species/fish-species/lamprey)

Apart from variable stars, which would have been constant companions of the Maori astronomer, from time to time he would have encountered two different types of temporary stars, or 'guest stars' as they were termed by the Chinese: supernovae and novae.

Liller (1992: 28) explains the cause of supernovae:

> The supernova explosion, catastrophic, or nearly so, to the star, results from the collapse of a very massive star that follows when it runs out of nuclear fuel … when there is no more energy being generated at the star's centre, the outer layers fall in. Some supernovae (Type II) appear to be isolated supergiant stars that evolve naturally to this brilliant flash finish; others (Type I) are theorised to follow the pattern of novae involving a white dwarf, but ones that grow disastrously from an immense over-accumulation of material from a close-by companion star. Whereas novae recur over and over again, a supernova is reduced, once and for all to a super-compact neutron star and a rapidly expanding cloud of gas that once made up the star. Sometimes no visible star is left at all.

Table 2.7 Examples of conspicuous naked eye variable stars visible from Aotearoa/New Zealand (after Norton 1957)

Star name	Magnitude variation	Period (days)	Popular name
η Aquilae	3.7–4.5	7.2	
l Carinae	3.6–5.0	35.5	
o Ceti	1.7–9.6	331	Mira
α Orionis	0.5–1.1	?	Betelgeuse
κ Pavonis	4.0–5.5	9.1	
L2 Puppis	4.6–6.2	140	
λ Tauri	3.3–4.2	3.9	

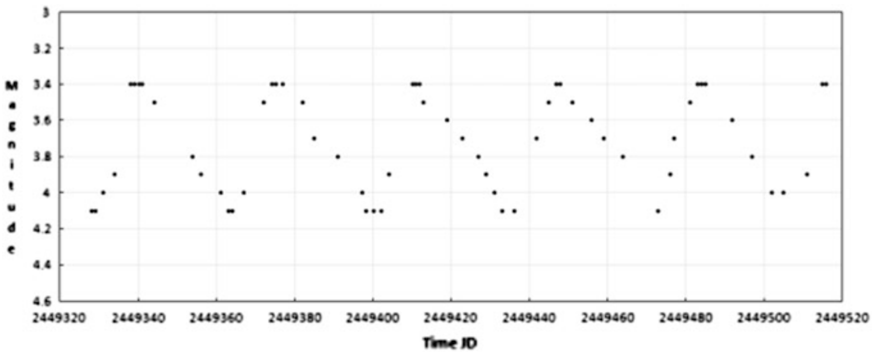

Fig. 2.23 Rod Stubbings' light curve of l Carinae (http://rodstubbbingsobservatory.wordpress.com/lightcurves/classical-cepheid/l-car)

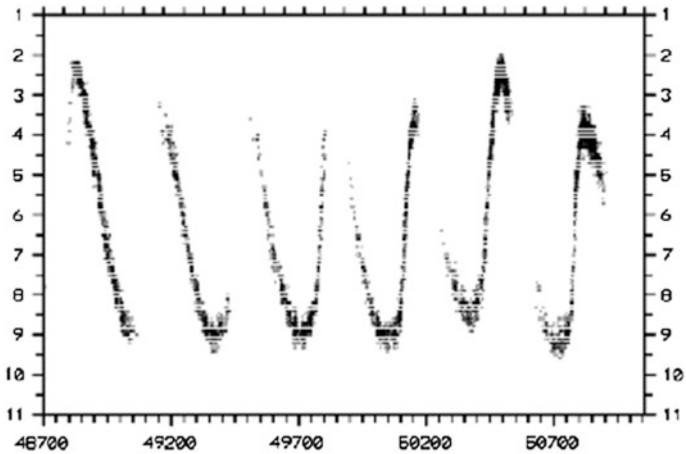

Fig. 2.24 The AAVSO light curve of o Ceti (www.hyperphysics.phy-astr.gsu.edu/hbase/starlog/ceti.html)

In all supernova explosions the total energy output is prodigious. In ancient times, not only were supernovae conspicuous by their brightness, but also by their longevity, for most remained visible to the naked eye for more than a year.

Because of their prominence, historic supernovae were widely observed by Chinese, Japanese, Korean and European astronomers, but only one of these is definitely known to have been visible from Aotearoa/New Zealand during the past 800 years. This was SN 1604 (also referred to as 'Kepler's Supernova') in Ophiuchus, which was first observed on 8 October 1604, and remained visible for 12 months. It was recorded by Chinese, Korean and European observers (Stephenson and Green 2002). However, in all probability SN 1604 was joined by a small number of far southern supernovae visible to the Maori, but for which no Arabic, Asian or European records exist.

Unlike a supernova, a nova is a star which rapidly increases in brightness over just a few hours and then slowly fades, usually over several months (see Fig. 2.25). Not all novae reach naked eye visibility, but the light curve follows the same pattern as for a supernova, although the magnitude increase is much less. It is believed that novae are associated with close binary stars, where one component is a white dwarf and the other a red giant. The two stars are so close together that matter can flow from the giant to the dwarf star, and after this has occurred for a time the accumulated material is ignited explosively and some of it is blasted into space. When this happens we see a nova (e.g. see Zeilik 1985).

Stephenson and Green (2002) surveyed the historical records of the past 2000 years, and found evidence of numerous 'new stars'. A few of these were supernovae, but the majority undoubtedly were novae. Those that were visible from Aotearoa/New Zealand are listed in Table 2.8, and all would have been obvious to the Maori astronomer even though the one at +20° declination would have been low in the northern sky.

This has to be regarded as a minimal list for Ho (1962) includes many more 'guest stars' and 'new stars' drawn from Korean and Japanese sources, but unfortunately he does not pinpoint their positions so it is not known how many of these would have been accessible to Aotearoa/New Zealand observers (although undoubtedly some were).

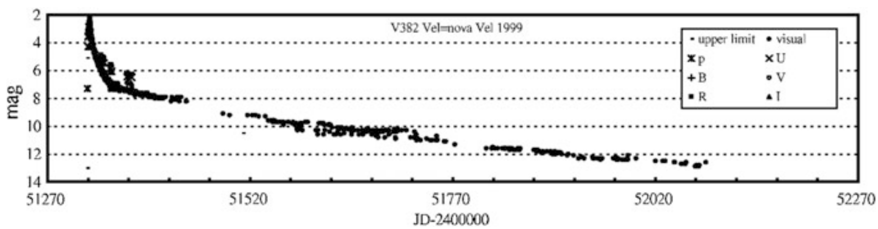

Fig. 2.25 The light curve of Nova Vel 1999, an example of a classical nova that was a naked eye object at maximum (after Kiyota et al. 2004: Fig. 1)

Table 2.8 Historic novae visible from Aotearoa/New Zealand, AD 1200–1700 (after Ho 1962; Hsi 1958)

Date recorded	Constellation	R.A.	Dec.
1224 July 17	Scorpius	17	−40
1240 August 17	Scorpius	17	−40
1388 March 29	Pegasus-Andromeda	00	+20
1430 September 9	Canis Minor	07 20	+07
1431 January 4–April 3	Eridanus	05	−10
1461 July 30–August 2	Ophiuchus	17 40	00
1584 July 11	Scorpius	15 40	−25
1676 February 18	Eridanus	04	−10
1690 October 18	Sagittarius	18	−30

In addition to these, and the novae listed in Table 2.8, it is certain that there were other novae that were visible from Aotearoa/New Zealand but were beyond the view of Chinese, Japanese and Korean astronomers. This is indicated by the fact that novae tend to be most abundant in the general region of the Milky Way (see Fig. 2.26), which is particularly conspicuous in the region of Carina, Crux and Centaurus.

Even without allowing for all these additional novae, the fifteenth century stand out for the relative abundance of these ‘new stars’, but more than this, the occurrence of the novae of 1430 and 1431 within just four months of one another would have been of special note to the Maori astronomer. Further, there are several other

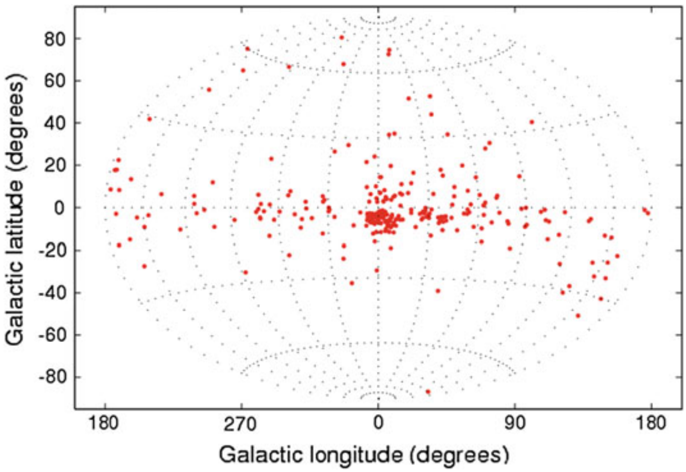

Fig. 2.26 A map showing the distribution of classical novae, and their concentration along or near the plane of our Galaxy (after Richmond 2007)

instances represented in the table where two or more novae would have been observed in the course of a typical human lifespan of 31–32 years.

Clearly novae, and to a much lesser extent supernovae, would have been notable intruders in an otherwise largely unchanging night sky, and would have featured in the star lore of the Maori. Yet the only possible references to 'temporary stars' or 'new stars' in Best's account of Maori astronomy relate to *Mahutonga*, which is described as "… a star of the south that remains invisible…" (Best 1955: 46). Other names which include the term *Mahu* refer to the Southern Cross and the Coal Sack, suggesting that this 'invisible star' was located in or near Crux (and therefore on the very southern visibility limit for Chinese, Japanese and Korean astronomers). Given the relative prevalence of novae, the Maori reference to *a single star* could suggest that a supernova was involved (see Green and Orchiston 2005, and Chap. 3).

2.6.9 Nebulae

The only gaseous nebulae *clearly* visible to the naked eye in the southern skies on a moonless night are the dark nebulae scattered throughout the Milky Way (Fisher 1963). The most conspicuous of these is undoubtedly the Coal Sack (Fig. 2.27), flanking Crux (the Southern Cross).

Best (1955: 39–41) lists six different Maori names for the Coal Sack, which are *Manako-uri*, *Naha*, *Te Patiki*, *Te Rua-patiki*, *Te Rua o Mahu* and *Te Whai-a-titipa*, but nowhere does he expound on how this feature was interpreted in Maori

Fig. 2.27 A photograph showing the Coal Sack, and the adjacent constellation of Crux, a recognised Maori asterism with multiple names (*Courtesy* John Drummond, Patutahi, New Zealand)

Fig. 2.28 *Mangaroa*, the Milky Way, also was known by a number of other Maori names (*Courtesy* John Drummond, Patutahi, New Zealand)

mythology. However, Sirius is said to have made his way into the sky "… *down through* the Coal Sack." (Hongi 1920: 26), which suggests that the Coal Sack was regarded as a hole in the heavens, similar to a viewpoint that at one time also was prevalent in Europe (e.g. see Pannekoek 1961: 476).

Other 'holes' or 'dark patches' in the sky were scattered along the length of the southern Milky Way (see Fig. 2.28), and had great importance to some indigenous cultures. For example, the Aboriginal Australians linked a succession of them mentally to identify an 'emu in the sky' (e.g. see Fuller et al. 2014). Unfortunately, there is no evidence that the Maoris interpreted dark nebulae in this way and saw 'a moa in the sky'!

2.6.10 The Milky Way and the Magellanic Clouds

The Milky Way, that amazing concentration of stars, dust and gas, is seen at its best in the southern sky, as beautifully depicted in John Drummond's photo mosaic presented in Fig. 2.28. Telescopic examination promptly reveals a plethora of star clusters and double stars, but pre-European Maori astronomers were not afforded this privilege.

Nonetheless, the Milky Way was a conspicuous feature in the Maori night sky, especially on clear moonless nights, and was known by numerous names (see Table 2.9). Of all of these options, Best (1955: 45) informs us that *Mangaroa* was the most commonly-used. Other names, like *Te Kupenga a Taramainuku* and *Whiti-kaupeka* were regional terms, and it is likely that a number of the other names listed also were regionally-specific. In addition, some similar terms may reflect regional dialect variations, that are found in Maori language (see Harlow 1979).

According to Maori legend, the Milky Way was one of the offspring of *Ranginui* and *Papatuanuku*, and its role—as we have seen—was to care for the stars.

The Large and Small Magellanic Clouds (see Fig. 2.29) were seen as separate entities to the Milky Way, despite their similar appearance, and a number of different names were applied to them. As Table 2.10 indicates, some of these terms

Table 2.9 Different Maori names for the Milky Way (after Best 1955)

Name	Region/source
Te Ika a Maui	
Te Ika-matua a Tangaroa	
Te Ika-o-te-rangi	
Te Ikaroa	
Te Ikaroa-o-te-rangi	
Te Ika-whenua-o-te-rangi	
Te Kupenga a Taramainuku	Ureweras
Te Mangoroa	
Mangoroiata	
Mokoroa-i-ata	
Te Paeroa o Whanui	
Te Tuahiwi-nui-o-rangi	
Tuahiwi o Rangi-nui	
Whiti-kaupeka	South Island

Fig. 2.29 Maori astronomers recognized the Large and Small Magellanic Clouds and many different names were assigned to them, as Table 2.10 indicates (*Courtesy* John Drummond, Patutahi, New Zealand)

applied collectively to both Magellanic Clouds and others to either the Large or the Small Magellanic Clouds. Again, there is evidence here of regional variations in terminology.

Table 2.10 Different Maori names for the Magellanic Clouds (after Best 1955)

Name	Association[a]	Source/region
Nga Patari	The MCs	
Nga Pataritari-hau	The MCs	
Nga Patari-kai-hau	The MCs	
Nga Patari-hau	The MCs	
Te Purangi	The MCs	Williams
Whakaruru-hau	The MCs	
Kokirikiri	LMC	White
Patari-rangi	LMC	Williams
Rangi-matanuku	LMC	White
Tioreore	LMC	
Patari-kaihau	SMC	Williams
Tikatakata	SMC	
Ao-tea	One of the MCs	Stowell
Ao-uri	One of the MCs	Stowell
Kokouri	One of the MCs	
Kokotea	One of the MCs	
Manako-tea	One of the MCs	White; Williams
Manako-uri	One of the MCs	White
Nonoko-tea	One of the MCs	Taranaki
Nonoko-uri	One of the MCs	Taranaki
Tiripua	One of the MCs	Williams
Tiritiripua	One of the MCs	
Tuputuputu	One of the MCs	
Pioriori	Upper MC	White

[a]Key MC = Magellanic Cloud; LMC = Large Magellanic Cloud; SMC = Small Magellanic Cloud

The large number of names employed for these two systems probably demonstrates the importance of the Magellanic Clouds in Maori society, but unfortunately, Best does not divulge precisely what their importance was.

2.7 The Astronomy-Meeting House Connection, and Astronomical Motifs in Maori Rock Art

Thus far, our account of Maori astronomy has been based solely upon the oral record, but in other pre-literate societies around the world astronomical information also was preserved in rock art, house design and orientation, portable artifacts, clothing, and even on personal tattoos or temporary body decoration. With the exceptions of meeting house design and possibly rock art, there is little if any evidence that the Maori made regular use of any of these options.

2.7.1 Meeting Houses and Astronomy

Harris et al. (2013: 331) explain that according to tradition

> Māori meeting houses [see Fig. 2.30] always face the rising Sun. Houses needed to be positioned so that the Sun encroached upon the porch, and if this did not occur it was considered an *aitua*, or a sign of miscalculation that could lead to death … Where the Sun rises and sets are two primary spatial designations from which all subsequent orientations and calculations regarding building construction are made.

The actual internal design and decoration of meeting houses (see Fig. 2.31) also had astronomical dimensions:

> … central to the construction of the meeting house is the Milky Way, which in traditions is often referenced by its shape as a fish … During the Māori New Year in mid-winter and at the time of the winter solstice the *tāhuhu* [ridge beam of the meeting house] lies in the same position as the 'great fish' … in the sky. This significant representation is adorned as patterns on the ridge-beam of the meeting house. Extending from the ridge-beam … are the rafters which connect to wall panels, which are sometimes carved to represent ancestors. In pre-colonial times the rafters were often painted in patterns that represented shapes of star groupings that were observed in the sky. These patterns also related to foods and resources that were accessed seasonally by the tribe. (ibid.).

Fig. 2.30 Example of a Maori meeting house, in this case Tamatekapua at Ohinemutu, Rotorua (https://en.wikipedia.org)

Fig. 2.31 This photograph of the interior of the Waitangi Meeting House at the Waitangi National Reserve at the Bay of Islands includes the following architectural features: the *tāhuhu* (ridge beam along the *top* of the meeting house), the decorated rafters and the carved wall panels. In pre-European times the *tāhuhu* and rafters sometimes were decorated with astronomical motifs (https://en.wikipedia.org)

2.7.2 Are There Astronomical Motifs in Maori Rock Art?

Rock art is an important feature of many cultures, and was executed for a number of reasons. In some instances, the actual painting or engraving of the rock walls was imbued with symbolic significance, and once accomplished the final product was of no significance. Conversely, rock paintings were sometimes made at the time of a significant event or activity to commemorate its occurrence or observation. Thirdly, some rock art was prepared in order for the site to be used in future for ceremonies associated with the motifs depicted there.

Solar eclipses, comets, meteor storms and supernovae were all spectacular apparitions, and there is good reason for believing that these sometimes were depicted in the rock paintings and engravings of pre-literate peoples (e.g. see Ronan 1996: 250–251, and 'Physical representations of celestial objects' in Warner 1996).

During the first five centuries of South Island settlement, rock art was a feature of Maori culture, particularly in the limestone regions of north and south Canterbury and northern Otago (see Trotter and McCulloch 1971: 28). Many of the motifs have been interpreted as humans, dogs and moas, and appear to depict moa-hunting expeditions, but there are a small number of paintings which do not seem to relate to the natural landscape and some of these may represent celestial objects.

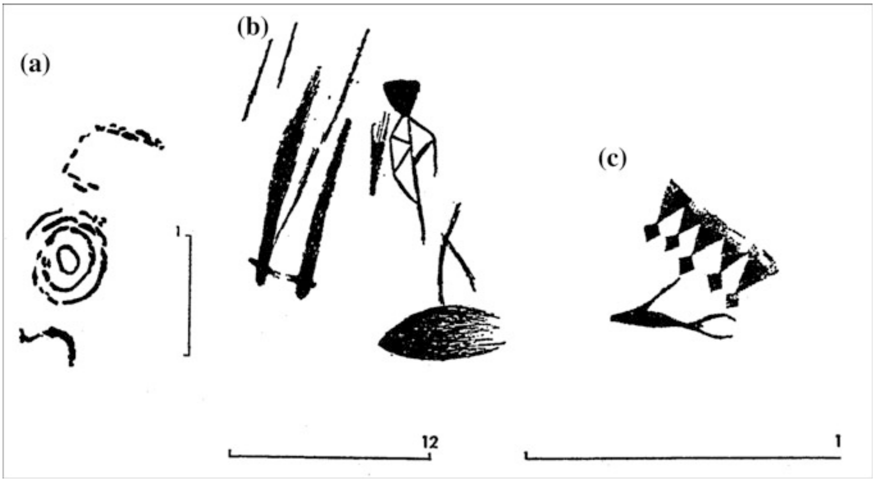

Fig. 2.32 Possible rock art depictions of celestial objects and events; scale in inches (after Ambrose 1970)

For example, Ambrose (1970) includes the concentric circles shown in Fig. 2.32a, which may possibly depict the Sun or a supernova. Similar concentric circles are found in other sites, but are rare (Trotter and McCulloch, 1971: 40). Of similar antiquity to the Fig. 2.32a painting are the six linear motifs on the left hand half of Fig. 2.32b, which may represent a meteor shower, the two most prominent objects being bolides. The sixth object in this group, on the right hand side also is reminiscent of a comet, and may portray a comet that was visible at the time of the meteor shower. Finally, Fig. 2.32c shows another composition from the same rock shelter, and the five aligned triangles with 'tails' may document the celestial movement of a conspicuous comet over a finite time interval. Obviously, all of these interpretations must remain speculative.

2.8 Maori Concepts of Time

The Maori developed their own calendar system, based in the main on the motion of the Earth round the Sun and on the movement of the Moon. In this way, they could identify seasons, months of the year, and days of the month. What they could not do, apparently, was count individual years: "The Maori had no tale of years as Europeans have …" (Best 1959: 11).

To the Maori, there were two main seasons of the year, summer (termed *Raumati*) and winter (*Takurua* or *Hotoke*), but autumn (*Ngahuru*) and spring (*Koanga* or *Mahuru*) also were recognised (Best 1959: 46). The first of the two words for winter is also a name for the star Sirius, while *Koanga* (spring) announces

Fig. 2.33 This painting by Gottfried Lindauer shows the preparation of the ground for the planting of the *kumara*, which occurred in *Koanga* or spring (https://en.wikipedia.org)

the 'digging season'—a time to plant the *kumara* and other crops (see Fig. 2.33). In contrast, *Ngahuru* (autumn) is the season for harvesting the crops; it was a time when food was plentiful, hence the terms *Ngahuru-kai-paenga* and *Ngahuru-kai-paeke*, where *kai* refers to 'food'.

Best (1959: 49) relates that

> Summer and winter were personified in two beings named Hine-raumati, the Summer Maid, and Hine-takurua, the Winter Maid. These damsels … were taken to wife by Te Ra, the sun. The Winter Maid dwells out on the ocean and controls the food supplies of that region … The Summer Maid dwells on land, her task being to foster the food products of the earth. Ra, the sun, spends half a year with each of his two wives.

The Maori year (with its four seasons) was made up of lunar months, but there were considerable variations throughout Aotearoa/New Zealand in the precise number of months recognised and in their names. Most tribes recognised twelve months in a Maori year, but Best (1959: 21–22) also cites 10 and 13 as rare alternatives. In regard to the naming of the months, Best (1959: 18–19) observes:

> … no common system of naming months existed. Several series of names were in use, even in the North Island. Each tribe recognised proper names for the months, but also, and apparently more commonly, employed a series of names consisting partially or entirely of ordinal numbers, as Te Tahi (The First), Te Rua (The Second), and so on. The remarkable point is that the proper names of the month did not agree. Two distinct series of such names were in use on the east coast of the North Island.

Table 2.11 Months of the Tuhoe Maori year (after Best 1959: 19)

Month	Name	Features
1	*Piripi*	All things on Earth come together owing to the cold; likewise man
2	*Hongonui*	Man is now extremely cold, and so kindles fires before which he basks
3	*Hereturi-koka*	The scorching effect of fire on the knees of man is seen
4	*Mahuru*	The Earth has now acquired warmth, as also have herbage and trees
5	Whiringa-nuku	The Earth has now become quite warm
6	Whiringa-rangi	It has now become summer, and the Sun has acquired strength
7	Hakihea	Birds are now sitting in their nests
8	Kohi-tatea	Fruits have now set, and man eats of the new food products of the season
9	Hui-tanguru	The root of Ruhi now rests upon the Earth
10	Poutu-te-rangi	The crops are now taken up
11	Paenga-whawha	All stakes are now stacked at the borders of the plantations
12	Haratua	Crops have now been stored in the store pits. The tasks of man are finished

This is yet another example of the way in which regional variations permeated Maori astronomical lore.

Regardless of the number of months used and their names, the Maori year was intimately associated with a succession of ecological situations and associated food-quest activities. This is illustrated below in reference to the Tuhoe tribe from the Ureweras (see Table 2.11). Because they lived in a mountainous somewhat inhospitable inland region of the North Island, there is greater emphasis than elsewhere on forest products (e.g. see Fig. 2.34) and of course there is no mention of maritime resources.

Identifying months by number rather than name was all very well so long as a clearly-defined start to the Maori year was universally adopted, but this was not the case:

> Now in some districts, as the east coast of the North Island, the Pleiades year was a permanent institution, but in others the heliacal rising of Puanga (Rigel in Orion) marked the commencement of the year. This was the case in the far North, in the South Island, and at the Chatham Isles. It is possible that the two systems were introduced by different bands of migrants, and possibly from different regions of the Pacific. (Best 1959: 6).

For some the year commenced in May and for others in June, depending upon whether Orion or the Pleiades controlled the Maori year. The actual starting date varied from year to year, and depended on the occurrence of the first new moon after the reappearance of the Pleiades or Rigel in the morning sky.

The month, in its turn, was composed of different named ‘nights of the Moon’ rather than ‘days of the month’. Most sources recognised 30 days per month, but others give 29 or 31, and one even lists 33.

Fig. 2.34 Pai Kanohi of the Ngāi Tūhoe tribe seated on the porch of his *whare* (house) at Ruatahuna in the early 1900s. Around him are *tahā huahua*, calabashes for pigeons preserved in their own fat. These were a vital part of the Maori diet, especially in inland forested areas, and sometimes were traded between tribes (*Courtesy* Alexander Turnbull Library, 1/2-019482-F)

Best (1959: 30) observes that the "Names of nights the moon differ to some extent in different districts, as also does the order in which the names occur." This is clearly illustrated by reference to Table 2.12, where the successive columns list the names supplied by Otaki, Tuhoe and Kahungunu informants (after Best 1959: 28–35).

In each instance, "The moon disappears on the Mutuwhenua night; it acquires form on the Whiro night and its radiance is seen." (Best 1959: 31). In other words, the first night of the Moon correlates with the initial appearance of the crescent Moon low in the western sky immediately after sunset.

One major problem with this calendar system was that the true lunar month was in fact less than 30 days (or nights), which sooner or later would have led to discrepancies between the stated night of the Moon and the required phase of the Moon. Best's Otaki informant explained how this dilemma was resolved:

> The fifteenth night is an Ohua, but in certain months it is the sixteenth night, and sometimes it is the seventeenth night – that is, ere the condition of full moon is obtained. If the moon does not become full until the seventeenth night, then the fifteenth, sixteenth and seventeenth nights are all termed Ohua, and then the last three nights of the moon, Orongonui, Maurea, and Mutu, are omitted, because a new moon has appeared. (cited in Best 1959: 29).

Table 2.12 Maori names for nights of the Moon from different regions of the North Island

Night	Region		
	Otaki	Ureweras	Wairarapa
1	*Whiro*	*Whiro*	*Whiro*
2	*Tirea*	*Tirea*	*Tirea*
3	*Ohoata*	*Hoata*	*Hoata*
4	*Oue*	*Oue*	*Ouenuku*
5	*Okoro*	*Okoro*	*Okoro*
6	*Tamatea*	*Tamatea-tutahi*	*Tamatea-ngana*
7	*Tamatea-ngana*	*Tamatea-ngana*	*Tamatea-kai-ariki*
8	*Tamatea-aio*	*Tamatea-aio*	*Huna*
9	*Tamatea-whakapau*	*Tamatea-kai-ariki-whakapa*	*Ari-roa*
10	*Huna*	*Ari-matanui*	*Maure*
11	*Ari*	*Huna*	*Mawharu*
12	*Hotu*	*Mawharu*	*Ohua*
13	*Mawharu*	*Maure*	*Hotu*
14	*Atau*	*Ohua*	*Atua*
15	*Ohau*	*Atua*	*Turu*
16	*Turu*	*Hotu*	*Rakau-nui*
17	*Rakau-nui*	*Turu*	*Rakau-matohi*
18	*Rakau-matohi*	*Rakau-nui*	*Takirau*
19	*Takirau*	*Rakau-matohi*	*Oike*
20	*Oike*	*Takirau*	*Korekore-te-whiwhia*
21	*Korekore*	*Oika*	*Korekore-te-rawea*
22	*Korekore-turua*	*Korekore-whakatehe*	*Korekore-hahani*
23	*Korekore whakapiri ki nga Tangaro*	*Korekore-piri-ki-te-Tangaroa*	*Tangaroa-amua*
24	*Tangaroa-a-mua*	*Tangaroa-a-mua*	*Tangaroa-aroto*
25	*Tangaroa-o-roto*	*Tangaroa-a-roto*	*Tangaroa-kiokio*
26	*Tangaroa-kiokio*	*Tangaroa-kiokio*	*Otane*
27	*Otane*	*Otane*	*Orongonui*
28	*Orongonui*	*Orongonui*	*Mauri*
29	*Maurea*	*Mauri*	*Omutu*
30	*Mutu*	*Mutuwhenua*	*Mutuwhenua*

This flexibility not only allowed corrections to be made to accommodate the changing phase of the Moon, but it also goes some way towards explaining why identical names in Table 2.12 sometimes denote very different nights of the Moon.

This flexibility aside, the Maori were able to use their calendar system to pinpoint particular dates during the year with great precision, by simply specifying the month in question and the relevant night of the Moon.

2.9 Concluding Remarks

The foregoing account indicates that Maori astronomy was intricately inter-woven with mythology, ritual and religion, and that various celestial bodies were attributed human qualities—good and bad. The Sun, the Moon and certain stars (and groupings of stars) played an on-going role in everyday life on Earth, and their surveillance and study was therefore a matter of considerable importance.

It is equally apparent when comparing the various objects and events that we know were visible in the Aotearoa/New Zealand night sky between AD 1200 and 1768 with what is actually recorded in Best's accounts that either

1. the Maori astronomer was basically disinterested in much of what was happening in his night sky, or
2. the account provided by Best is superficial and in no way reflects the actual interests, skills and knowledge-base of the pre-European Maori astronomer.

I believe the second alternative best represents the true situation and that Best's work simply presents the tip of the Maori 'astronomical iceberg'.

Given the passage of time and the degree of acculturation that has occurred in Aotearoa/New Zealand, I initially wondered (Orchiston 2000) whether there was still a chance of capturing details of pre-contact Maori astronomy and reconstructing the morphology of that all-elusive 'astronomical iceberg', with its regional variations and ramifications. Back in 1922 Best noted that: "The knowledge … of this subject is meagre and unsatisfactory, but it is now too late to remedy the deficiency." But maybe he was overly pessimistic. Currently there is a resurgence of interest in all aspects of Maori astronomy, and the initiatives of groups like SMART (see Harris et al. 2013)[1] are already leading to a greater understanding of the various regional astronomical systems that existed in Aotearoa/New Zealand at the time of initial European contact. Harris et al. (2013: 334) note that

> As our communities engage in dialogue, the celestial knowledge of the past continues to emerge, enabling researchers to record details that were hidden from the early ethnographers, thus countering Best's claim that all sources of information on Māori astronomy have been exhausted.

The challenge now surely is to delineate the ways in these pre-contact regional astronomical systems developed from the initial proto-Polynesian astronomical beliefs and practices introduced by the first Maori settlers, and the ways in which the Maori astronomical knowledge base has evolved and adapted since European settlement. We therefore must document contemporary Maori astronomical knowledge, note any evidence of regional variations, and see if we can establish which components are drawn directly from Best's accounts and which definitely

[1]SMART is the acronym for the Society of Maori Astronomy Research and Traditions, which was formed in the late 2000s. This group has "… dedicated itself to the preservation and revitalization of Māori astronomical knowledge … [and] consists of Maori knowledge experts, educators, navigators and scientists." (Harris et al. 2013: 326).

derive from the post-contact period and reflect European religious and scientific views. We must also quantify the various ways in which this contemporary astronomical knowledge-base is utilised in everyday life. This is our challenge.

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