Abstracts

For Māori and their ancestors, the results of living with, studying and talking about the stars were woven into science, language, culture, religious practice and environment. The movements of the celestial bodies were studied in great detail, and all tribal groups and regions throughout Aotearoa maintained their own unique beliefs and understandings of the universe. The extensive knowledge of the night sky was embedded into traditional Māori society, preserved in oral tradition, planting and harvesting practices, and incorporated into the building of ancestral houses. Every year, the rising and setting of important stars were celebrated, and all manner of cosmological events were worshipped. In this paper we will discuss the astronomical knowledge and science associated with Matariki (Pleiades) and discuss how the regeneration of the traditional practice associated with this celestial cluster is playing a significant role in the modern cultural landscape of Aotearoa.

Keywords: Indigenous Knowledge; Māori astronomy; Matariki (Pleiades); Systems of time; Maramataka

Māori astronomy

Māori astronomical knowledge was infused across the breadth and depth of Māori society, tradition, knowledge and language (Harris et al. 2013; Whaanga & Matamua 2016; Matamua 2017a, 2017b). Connecting observation, cultures, religion, mythology and astrological practices, this knowledge system was transmitted in oral traditions such as mōteatea (traditional song), whakataukī (proverbs), karakia (incantations) and kōrero tuku iho (oral tradition). Māori astronomy was also incorporated practically in areas such as the maramataka (the lunar calendar), through planting and harvesting practices and the engraving of carving pat-
tems and paintings that adorn ancestral houses (Harris et al. 2013). Māori astronomy was embedded and encoded into these carvings and integrated into the landscape through place names. Most famously, Māori astronomy is most well-known for its application to celestial navigation that helped the ancestors of the Māori to traverse the Pacific Ocean, one of the largest regions of the earth (Matamua et al. 2013; Tuaupiki 2017). Utilising the sky as a roadmap, detailed observations and astronomical knowledge supported the ‘ancestors of the Māori to undertake arguably the most remarkable voyage[s] in the history of humanity. ...’ (Harris et al. 2013; Matamua 2017b). Other elements of the star-knowledge of the central Pacific were adapted to become relevant to these islands and their climate. ... Over the next 800 years, Māori astronomy evolved with the people to become the situationally specific knowledge base that it is today (Whaanga & Matamua 2016, p. 60). With a change in location, in particular latitude, new stars became visible and thus new knowledge and understandings about those stars had to be developed.

The movements of the celestial bodies were studied in great detail, their appearance, position, colour and brightness were examined, and their heliacal rising and setting were celebrated. Māori astronomers (tōhunga kōkōrangi), developed an awareness of the different links between movements of celestial bodies and seasonal patterns in order to ensure food security, and all manner of cosmological phenomena were worshipped, studied and correlated to terrestrial events, and connections were drawn between them (e.g. seasonal changes, the timing of ocean tides, and the nature of comets, eclipses, meteors, and other transient celestial phenomena) (Harris et al. 2013; Matamua 2017b). This knowledge was regionally specific and while the stars gave a broad indication as to the season and event, more detailed understanding of the environment was deduced through the lunar calendar, such as the management and harvesting of species and the migration and spawning of animals around the cosmological cycle and seasonally timed rituals (Tāwhai 2013; Timoti et al. 2017).

During the 19th century and the early parts of the 20th century, the documentation of Māori traditions, life style, language and customs of the Māori was a preoccupation for many early European ethnographers, missionaries, and historians, with the likes of George Grey (1853, 1857), William Colenso (1868, 1878, 1879), S. Percy Smith (1898, 1913, 1915), John White (1887–1890), members of the Williams family (1906, 1844), James Cowan (1910, 1930), Edward Treagar (1904) and Elsdon Best (Holman 2008; Sissons 2010), leading the way.

Regarded as one of the most important early ethnographers in Aotearoa, Elsdon Best (Te Pēhi) spent much of his time interviewing Māori elders, researching Māori tribal history and collecting mātauranga Māori (1922a, 1922b, 1922c, 1923, 1924, 1929, 1972). While in the Urewera, Te Pēhi formed a close working partnership with his key informants Tutakangahau of Maungapohatu, Paitini Wi Tapeka, Tamarau Waiari, Te Whenuanui of Tūhoe, and Hamiora Pio of Ngāti Awa, while maintaining his longstanding relationship and roles with the Polynesian Society and the National Museum. Te Pēhi produced a number of important works on various aspects of pre-European Māori life and tribal history, Māori religion and mythology, Māori forest knowledge, wānanga Māori, but his publication ‘The Astronomical Knowledge of the Māori Genuine and Empirical’, has been widely considered, for a long-time, as the leading work on Māori astronomy (Orchiston 2016b). In this publication he pronounced that ‘the available data concerning Māori sky-lore is now exhausted, and this account must be closed. The knowledge gained by us of this subject is meagre and unsatisfactory, but it is now too late to remedy the deficiency’ (Best 1922a, p. 64). This statement, however, was much too presumptuous, for unbeknown to Te Pēhi, the informants that he had interviewed had only shared with him a small portion of knowledge on Māori astronomy.

Over the past three decades, there has been a renaissance in the scientific study of Māori astronomy in a range of areas including reviews on Māori astronomy (Harris et al. 2013; Williams 2013; Tuaupiki 2017; Orchiston 2016b), lists on Polynesian and Māori star names (Johnson et al. 2015), accounts on the development of astronomy and emergence of astrophysics in Aotearoa (Hearnsaw & Orchiston 2017), histories of astronomy in New Zealand (Orchiston 2016a), critiques of Polynesian, aboriginal and Māori astronomical perspectives (Orchiston 1996, 2000), the use of astronomy as a cultural experience (Austin 2009), comparative cultural studies of astronomical knowledge (Selin 2000), a discussion on supernovas and meteors (Green & Orchiston 2004; Britton & Hamacher 2014), the application of portable planariums in the teaching of Māori astronomy (Harris 2017), horticultural and ethnopedological praxis (Roskrige 2011), waka navigation (Matamua et al. 2013; Tuaupiki 2017), the maramataka (Ropiha 2000; Roberts et al. 2006; Smith 2011; Tāwhai 2013; Clarke & Harris 2017), Matariki and Puanga (Matamua 2013; Williams 2013; Rerekura 2014; Matamua 2017a, 2017b), together with a number of popular publications and resources on Māori astronomy (Leather & Hall 2004; Hakaraia 2006, 2008).

The science and practice of Māori astronomy: Matariki

The renaissance in the scientific study of Māori astronomy has developed out of the burgeoning development of Māori-led cross-cultural celebrations and ceremonies of celestial events such as the heliacal rising and setting of Matariki (Hakaraia 2006, 2008; Hardy 2012; Matamua 2017a, 2017b). This star cluster, known as the Pleaidas elsewhere, has found new status within the cultural and societal landscape of Aotearoa (Hardy 2012). The revival of the Matariki celebration had a humble beginning, with small gatherings of people associated with Piπepe marae and Te Papa Tongarewa in Wellington in the 1990s (Hardy 2016). However, by the beginning of the 2000s, Matariki celebrations transformed into larger gatherings and events moving from a celebration of Māori culture to one associated with growth, development, and identity (Hardy 2012; Hardy 2016; Whaanga & Matamua 2016). Now, numerous Matariki events are held throughout Aotearoa in both the larger cities and smaller communities where ‘people are once again using the pre-dawn rising of this star cluster to foster unity and togetherness. Matariki has become part of school curriculum, is included within the structure of city councils and other organisations and is promoted on television, via radio and in print’ (Whaanga & Matamua 2016,}
Within Māori astronomy, many stars not only had an identity associated with them but also had a specific purpose or role intrinsically connected to the Māori world. Within Matariki, each of these stars represented either a food, a source or a weather occurrence, the dead or the promise of a prosperous year (similar to the notion of making a new year’s resolution or wishing upon a star). Pōhutukawa is a female, the eldest and she is associated with the dead who have passed since the last heliacal rising of Matariki. Tupūnuku is female and she is connected with food grown in the earth. Tupūrainga is male and he embodies the food that comes from the sky, including the fruit from trees and birds. Waiti is female and she holds the essence of food found in fresh water and Waitā is male and he holds the essence of the food in salt water. Waipunarangi is female and she is connected with rain and Ururangi is male and he is connected to the nature of winds for the year. Hiwai-ite-rangi is female and the youngest of this celestial family. She is associated with the promise of a prosperous year: Matariki is the mother and the conductor of the entire cluster (Matamua 2017b).

Overlapping with the growth in Matariki celebrations is the regeneration, by a small group of practitioners, in a number of traditional ceremonies that coincide with the heliacal rising of Matariki: ‘Te taki mōteatea’ (reciting of laments) and ‘Whāngai i te hautapu’ (to feed with a sacred offering). These ceremonies, led by Professor Range Matamua at Waikato University, are being analysed and reinvigorated by a group of young members known as Te Matapuenga, a group established by the language, tikanga and karakia expert, Professor Pou Temara. Since 2017, practitioners and followers of the ceremony ascend before dawn in the Tangaroa lunar phase of the month Pīpiri to view the heliacal rising of Matariki. Once ascended, the practitioners prepare food that corresponds to each of the domains of Matariki. The food is placed at an altar and ceremony is conducted with karakia and chants. During this ceremony a reading of the bounty of the year is conducted, the names of the dead of the year are recited and released (Te taki mōteatea), and the smoke from the food is offered to the cluster as sustenance (Whāngai i te hautapu). The regeneration of this practice associated with Matariki ceremony is in stark contrast to many of the celebrations that continue to be conducted nation-wide. The direction of this ceremony towards an honouring of Matariki via ceremony is a direction that many Māori are signalling favourably towards (Hardy & Whanga 2019).

**Matariki: Systems of time, the politics of time, and calendrical systems**

There are a number of beliefs, ideas and applications associated with Matariki. Matariki is many things for many people: it has a spiritual dimension, it has a community and cultural dimension, but what is often overlooked and misunderstood, more than any other element, is its association with time; in particular, its connection to Māori divisions of time. The Māori division of time follows a stellar lunar calendar, whereby predominantly heliacal risings of stars or sometimes settings are used as indicators of specific times of the year, with a lunar cycle playing another layer of time increment. These stars could indicate, for example, a month or season of the year. For Matariki, probably the most crucial...
element missing from its application in a modern context is its role in regulating our yearly cycle, especially because we no longer follow a traditional lunar calendar for our everyday activities.

Indigenous concepts of time, calendar systems, seasonality, rituals, and the rhythms of nature are intrinsically intertwined. Māori, similar to other Indigenous peoples, developed a complex time system integrating celestial, environmental and ecological occurrences to track time and seasonality. The movement of the sun, moon and stars, were used as clocks to regulate the timing of agricultural, fishing and hunting activities, and rituals. This division of time falls under the calendar system known as maramatanga (Roberts et al. 2006; Best 1922b; Ropihia 2000; Tawhai 2013). The maramatanga is a multilayered time system that utilises observations from the celestial such as the phases of the Moon and the sightings of certain stars, to ecological and environmental indicators such as the flowering of certain plants and occurrence of particular weather patterns (Clarke & Harris 2017).

The use and practice of the maramatanga has changed as part of the process of colonisation. The move to reform Indigenous time was part of a broader agenda to interrupt ‘the cycles of Indigenous and local seasons and calendars, and replacing them with the coloniser’s rituals and routines, along with a new calendar for counting the days, months and years .’ (Nanni 2012, p. 3). This colonial-settler agenda sought to alter time as one of the fundamental tenets of Indigenous culture. Calendar reform is closely aligned with geopolitical movements, the role of empire, ecclesiastical control and power (Nanni 2012). As the Gregorian calendar was introduced by Pope Gregory XIII in 1582 to replace the Julian calendar, the same calendrical system was used by European settlers and missionaries in Aotearoa as a colonial act to target the minds, culture and the timing mechanisms of Māori. Māori soon shifted away from following and celebrating traditional Māori months and started to apply and even infuse Māori time within the Gregorian cycle of 365¾-day calendar system including its months, the seven-day week, and the 24-hour clock. The observation of the movements of the celestial bodies and ecological indicators was replaced by colonial timekeepers such as clocks and watches and a calendar based on the movements of the sun (Roberts et al. 2006).

Accompanying the demise of the use of maramatanga and astronomical knowledge, was the devastating loss of land, language, and cultural practices led by successive polices of assimilation and integration, urbanisation, and restricted access to key resources (Walker 2004). These factors impacted profoundly on Māori cultural norms, collectivism, language, and the knowledge systems that were woven into the practice of Māori astronomy and the maramatanga (Whaanga & Matamua 2016). As a result, the celebration of Matariki had almost disappeared as a recognisable part of the cultural landscape of Aotearoa by the middle of last century. Driven by the impending threat to the future of Māori, a series of Māori-led campaigns, petitions, and claims were undertaken in the late 70s and 80s to revitalise the Māori language, its knowledge and cultural systems, focusing on issues such as the Treaty of Waitangi, Māori land rights, language and culture, and racism (Harris 2004; Walker 1984, 2004).

As part of the cultural renaissance of reinvigorating the use of maramatanga and Māori astronomical knowledge with star and lunar indicators, the recovery has had many challenges. In particular, in order to decolonise the calendar system and return to a traditional calendar system we have had to step away from the need to resolve and merge the Gregorian calendar with the maramatanga. This has been due to how the Gregorian calendar has evolved away from its traditional origins. The evolution of this calendar has involved adding and subtracting days to the original true lunar months, giving 28–31 days in the Gregorian months, which could then be added to give a solar year of 365 days. In addition, the leap year is used to readjust the calendar to fit the solar year approximately every 4 years. Also, what is not commonly known is that additional seconds are added where needed to keep Coordinated Universal Time (UTC) in alignment with the actual length of time it takes the Earth to rotate (Frankston 2017). With such a number of adjustments, the reconciling of the Gregorian calendar with the maramatanga is somewhat futile and what is needed is to understand the maramatanga as its own independent system.

The stellar component of the maramatanga, which includes Matariki, is a regulator for the Māori year and it was a cyclic indicator that determined when the Māori year commenced. Māori also traditionally followed a lunar component of the calendar, which is 354 days long and is based upon the cycles of the moon phases (synodic months). Thus, there is an 11-day difference between the Māori lunar calendar and the 365 day year; 12 months western solar calendar that we currently follow. Over a two-year cycle this difference becomes 22 days, over three-years it results in 33-days and therefore there becomes a full month variation between a lunar and solar calendar.

Māori understood the subtleties and importance of this relationship and they practised a system to ensure that they harmonised with the cycle of the year and the seasons. This was done every three years, when they would insert an extra month into their calendar system. This month was known as Ruhanui or the listless or lazy month. The use of what is known as an intercalary month was a common practice world-wide. Early uses of an additional month can be found in calendars of the Greeks (Van der Waerden 1960), Hebrews (Segal 1957), and Chinese (Aslaksen 2010; Martzloff 2016) amongst many others. These calendars place the insertion of a 13th month at various stages during their calendars with varying degrees of accuracy. For Māori, however, the intercalary month was more approximate and precision was less of a concern with a focus more on what works. Other systems around the world have adopted the metonic scale that places 7 extra months over a 19-year time scale.

For Māori, the indicator of when to place the intercalary month was related to the appearance of the constellation Pipiri, which are two stars in the constellation of Aries known as Sheratan and Hamal. These two stars for Māori are called Pipiri and Ruhanui. For many Māori constellations the name of one particular star in the group will also be the name of the entire constellation. Hence Pipiri is the name of the constellation and also the name of a particular star (Sheratan) in the constellation. These two stars are referred
to as twins, as they appear in close proximity to each other and rise very near each other in the night sky. In the Māori calendar system, the months also often carried the names of stars. For example Pipiri rises in the eastern-sky in late May. When the first star in the constellation of Pipiri rose, it was taken as a sign that the winter month was upon us and the year was about to start, it also indicated that the following month after the sighting would be Pipiri, which is named after the constellation. As the *maramataka* is a solar-luni calendar, many events would also coincide with a particular moon phase. In the case of the new year, as soon as Matariki was seen in the sky during the month of Pipiri our ancestors would wait until its sighting coincided with a particular lunar phase of Tangaroa (the last quarter). Thus, the Māori new-year begins when Matariki is seen in the sky on the last quarter of the first month of the year, called Pipiri.

When following both a lunar and stellar cycle, as described earlier, 12 lunar months will add up to only 354 days and will leave a remainder of 11 days till the solar year is completed. The implication of this is that the lunar phase Tangaroa will be occurring 11 days earlier than the previous year. When observing the night sky, the 11-day shift between lunary and stellar cycles across the year will thus mean that each year Matariki would appear lower and lower in the sky on the horizon at the time of Tangaroa (last quarter phase) as the years progress (see Figure 1).

As heliacal risings of stars occur early in the morning before the sun rises, the closer the star is to sun below the horizon, the more difficult it is to see. Given that Matariki is a 3rd magnitude star, in order to view its heliacal rise with the naked eye, the cluster will need to be at least 5 degrees above the horizon while the sun is at least 16 degrees below (Matamua 2017a). As Matariki is supposed to occur during the month of Pipiri in Tangaroa, eventually the 11-day slippage will be so far out that Matariki will not be visible at that time. When Matariki was not visible during the Tangaroa phase of the month of Pipiri, Pipiri would become a double month. This is when the intercalary month known as Ruhanui would be applied and Māori would follow the second star in Pipiri to determine when our new year would commence. Figure 1 shows the position of Matariki in the early predawn sky in the month of Pipiri on the first phase of Tangaroa for the years 2018 (Fig 1a), 2019 (Fig 1b), 2020 (Fig 1c) and 2021 (Fig 1d). In order to ensure visibility, the times chosen were for when the sun is at least 16 degrees below the horizon. For 2018, 2019, and 2021 Matariki is clearly seen above 5 degrees; however, for 2020, Matariki is below the 5 degree limit and thus is not visible. Therefore in 2020 an intercalary month needs to be inserted following Pipiri and is called Ruhanui. Thus, when Matariki is not visible because of the ongoing 11-day slippage every year, an additional month is added in the first month of the Māori new year and the whole cycle resets itself.

![Figure 1a–1d: Star maps where Matariki is present in the pre-dawn sky in the moon phase Tangaroa-a-mua in the month of Pipiri for 2018–2021 (after Matamua 2017a). The sun is located at approximately 16 degrees below the horizon in each map.](image-url)
With many people wanting to engage in Matariki celebration, much of the understanding around this concept has become muddled and confused in the public domain. As many try to fit the timing of Matariki within the Gregorian system, these two completely different time-keeping systems clash and there remains much confusion about when Matariki is visible and when it should be celebrated. Without the understanding of such intricacies of the intercalary month information regarding the timing of Matariki becomes incorrect. Attempting to reconstitute and reconfigure our sighting of Matariki with a Gregorian calendar is fundamentally flawed and continues to cause confusion when trying to understand the internal workings of a Māori system of time.

Conclusion

This paper has highlighted a small portion of the extensive scientific and astronomical knowledge base that our ancestors infused across all facets of Māori society. Over the past three decades, there has been a renaissance in the scientific study of Māori astronomy, with the celestial cluster of Matariki playing a significant role in the regeneration of Māori astronomy, science and traditional practice in Aotearoa. A key area that has enabled the growth of this knowledge has been government funding that has supported the myriad of projects and initiatives driven by Māoriastronomy practitioners and organisations. In the past 15 years there has been a shift to engage with policies such as Vision Mātauranga (VM) and Mātauranga Māori more effectively including Māori aspirations into these spaces, with its aim to grow and flourish with a Gregorian calendar that is occurring is unprecedented. Over the past 20 years researchers and practitioners have been actively sharing and growing the navigation, Māori astronomy and maramatanga space by engaging the public in over 1000 talks, roadshows to over 8000 people, outreach to over 10,000 Māori and Pacific rangatahi and museum exhibitions that attracted more than 315,000 visitors.

Nevertheless, as this renaissance and revitalisation continues, tohunga kōkōrangi, navigators, Māori researchers, practitioners, and Māori communities face a number of challenges to decolonise and reconcile many facets of this knowledge base. The challenge for these groups lies in bringing together the collective knowledge, experiences, and voices to ensure its authenticity and legitimacy for future generations of aspiring Māori astronomers.

References


Best, E. 1922a. The astronomical knowledge of the Māori, genuine and empirical: Including data concerning their systems of astrology, astrology, and natural astrology, with notes on certain other natural phenomena. Govt Print., Wellington.


Best, E. 1924. The Māori. Board of Māori Ethnological Research for the Author and on behalf of the Polynesian Society, Wellington.


Best, E. 1972. Tuhoe, the children of the mist: a sketch of the origin, history, myths and beliefs of the Tuhoe tribe of the Māori of New Zealand, with some account of other early tribes of the Bay of Plenty district. Published for the Polynesian Society by A.H. & A.W. Reed, Wellington.


Cowen, J. 1930. The Maori, yesterday and today, Whitcombe & Tombs, Christchurch, New Zealand.

