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IDENTIFYING SEASONAL STARS IN KAURNA ASTRONOMICAL TRADITIONS

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Abstract: Early ethnographers and missionaries recorded Aboriginal languages and oral traditions across Australia. Their general lack of astronomical training resulted in misidentifications, transcription errors and omissions in these records. In western Victoria and southeast South Australia many astronomical traditions were recorded but, curiously, some of the brightest stars in the sky were omitted. Scholars claimed these stars did not feature in Aboriginal traditions. This continues to be repeated in the literature, but current research shows that these stars may in fact feature in Aboriginal traditions and could be seasonal calendar markers. This paper uses established techniques to identify seasonal stars in the traditions of the Kaurna Aboriginal people of the Adelaide Plains, South Australia.

Keywords: Australian Aboriginal astronomy; cultural astronomy; ethnoastronomy; Indigenous knowledge

1 INTRODUCTION

In the astronomical traditions of Aboriginal Australians, the rising and setting of particular stars at dusk and dawn are used as calendrical markers, noting the changing of seasons, the availability of food sources and the breeding cycles of animals (Clarke, 2007; Hamacher, 2012; Johnson, 1998; Tindale, 1983). Some stars are described in Aboriginal traditions but their identities are unclear, in part because of misidentifications (e.g. Howitt, 1884a).

The Adelaide Plains of South Australia are the traditional lands of the Kaurna people (Figure 1).[1] Much of their culture was damaged by colonisation, particularly from 1836 onwards (Manning, 2002). Kaurna astronomical traditions are not well recorded, as the Kaurna "… carefully conceal them [astronomical traditions] from Euro-

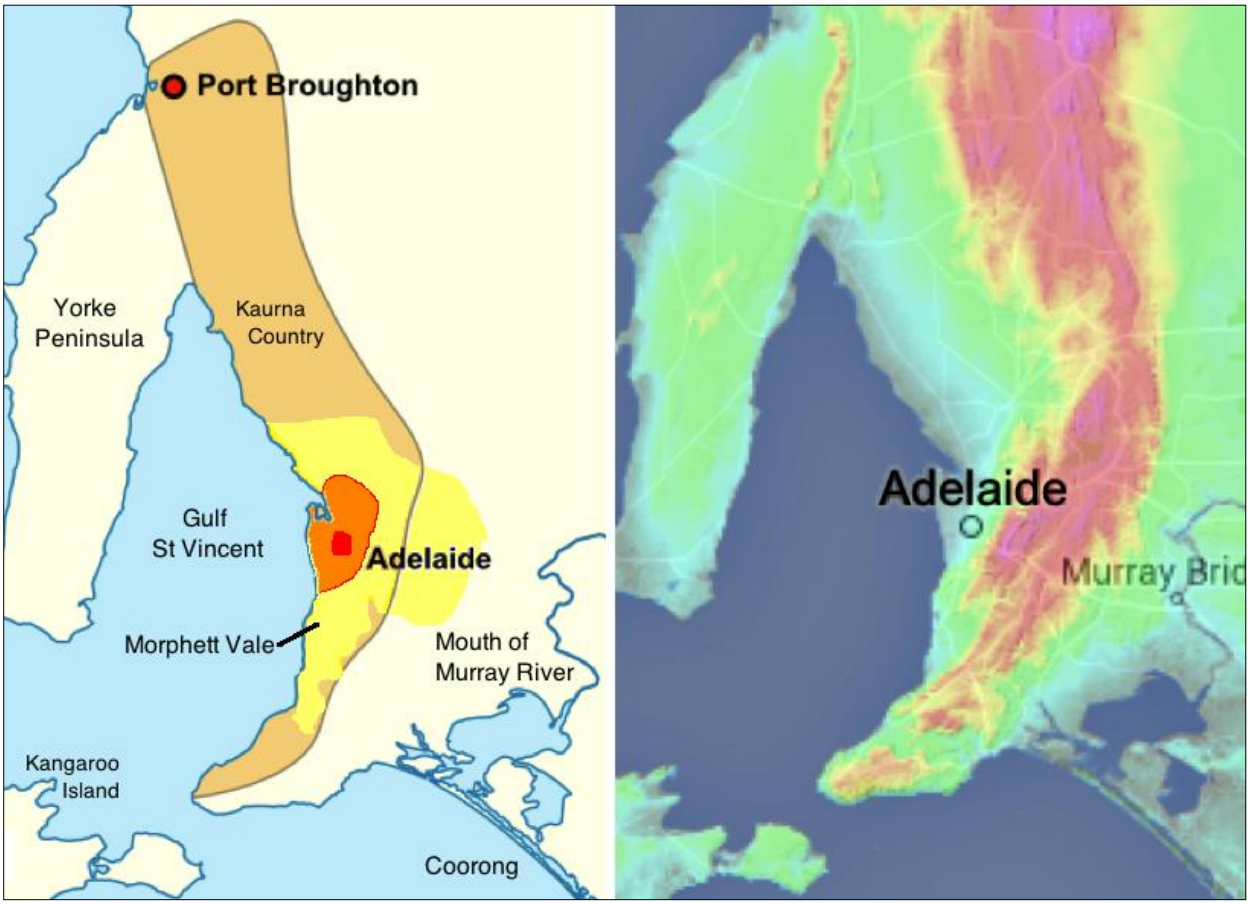

Figure 1, Left: The traditional lands of the Kaurna people, South Australia, stretching from Adelaide in the south to Port Broughton in the north (image: Wikipedia Commons license). Right: Topographic map showing the extent of the Adelaide Plains, following the Kaurna lands closely (green indicates low elevation areas while red/pink indicate higher elevation). (Image: topographic-map.com). The right image indicates the Mount Lofty Ranges (red/pink). Left image shows Adelaide Central Business District (red), Adelaide city (orange), and the greater metropolitan area (yellow), based on Google Maps.

peans, and even their own males are only at a certain age initiated into the knowledge of them." (Teichelmann, 1841).

What we do know about Kaurna language comes predominantly from the records of the German Lutheran missionaries Christian Gottlieb Teichelmann (1807–1888) and Clamor Wilhelm Schürmann (1815–1893), who came to Adelaide in October 1838. In 1840, they published a dictionary of 2,000 Kaurna words (Teichelmann and Schürmann, 1840). Much of the Kaurna language was provided by local Aboriginal men, including Mullawirraburka (*aka* King John) and Kadlitpinna (*aka* Captain Jack) (Amery, 2000).

Teichelmann continued working on the Kaurna language, compiling a manuscript of Kaurna vocabulary and grammatical notes (Teichelmann, 1857). Clarke (1990; 1997) published research on Kaurna astronomical traditions, but the identity of many of the stars remains a mystery.

We do know that in Kaurna traditions, particular stars govern seasons. For example, autumn (*Parnatti*) is signaled by the morning appearance of the star *Parna*. This warns the Kaurna that the annual autumn rains will soon arrive and that they need to build large, waterproof huts (Teichelmann and Schürmann, 1840). Summer (*Woltatti*), the hot season, is governed by *Wolta*, the wild turkey 'constellation',[2] and Spring (*Willutti*) is under the influence of *Wilto*, the eagle star. Winter (*Kudlilla*), the rainy season, was not associated with any particular star in the record (Clarke, 1997; Teichelmann and Schürmann, 1840).

2 KAURNA ASTRONOMICAL TRADITIONS

Astronomical traditions of the Adelaide region were first recorded by Teichelmann and Schürmann as part of their linguistic study of the Kaurna language. Since then, a number of publications have explored the local language and astronomy (e.g. Black, 1920; Clarke, 1997; 2007; Gell, 1842; Hartland, 1898; Teichelmann and Schürmann, 1840; Tindale, 1937; 1974; 1983). However, surprisingly little detail about Kaurna astronomy was recorded. The records provide some details (Table 1), but most star names are given with no reference to their Western counterpart, and only fragmentary details are given about the stories of the stars themselves.

We know the Kaurna have rich astronomical knowledge. Gell (1842: 116–117) says that "… most of the stars have some legend attached to them …", and Teichelmann (1841: 9) wrote that:

> … the exaltation of almost every constellation they give the history of the attending circumstances, which the reasons of their present movements explain.

The sky was seen as a component of the land, a reflection, and

> … all the celestial bodies were formerly living upon Earth, partly as animals, partly as men, and that they left this lower region to exchange for the higher one. Therefore all the names they apply to the beings on Earth, they apply to the celestial bodies … (Teichelmann, 1841: 4).

But we also know that the Kaurna were very secretive about their astronomy, only providing fragments of information to the white colonists. For example, Schürmann's Aboriginal informants closely guarded their secrets, and when an Aboriginal man told Schürmann about his cosmology, he did so under the condition that Schürmann (1840) would not tell another Aboriginal person.

In Kaurna traditions (Gell, 1842; Teichelmann and Schürmann, 1840), *Tinniinyaranna* are the stars of Orion (most likely the Belt and scabbard, as with many Aboriginal cultures),[3] representing a group of boys who hunt kangaroo and emu on the celestial plain, while the *Mangkamangkaranna* (the Pleiades star cluster) represents a group of girls digging roots. The red star *Madletaltarni*, probably Betelgeuse (Alpha Orionis) or Aldebaran (Alpha Taurii), is the mother of the *Tinniinyaranna*, and *Parnakkoyerli* is the father, described as 'a seasonal star', possibly Rigel. Betelgeuse and Rigel flank the boys on either side (see Figure 2).

Linguistically, *Parnakkoyerli* could mean two things: 1) 'their father' (*yerli* = 'father' and 'their' refers to *Tinniinyaranna*), and 2) 'father of *Parna*'. In Teichelmann and Schürmann (1840), *Parnakkoyerli* is mentioned directly after *Tinniinyaranna*, which suggests that the Aboriginal informant pointed out the stars of *Tinniinyaranna*, then probably moved to Rigel and said it was 'their father'. In this case, *Parnakkoyerli* is a descriptiton rather than a proper name.

3 SEASONS ON THE ADELAIDE PLAINS

The fertile Adelaide Plains of South Australia (SA) are flanked by the Mount Lofty Ranges to the east and Gulf St Vincent to the west. The lower section of the Plains is taken up by the city of Adelaide. Rain is not evenly distributed throughout the year (Figure 3).[4] Long-term data show that February, the driest and hottest month of the year, only sees an average of 3.6 days and 15.8 mm of rain. June, the wettest month of the year, experiences 14.8 days and 80.6 mm of rain. The rainfall increases in autumn, and decreases in spring.

Ethnographic records indicate four distinct seasons in Kaurna traditions, similar to those of

Table 1: Celestial objects in the Kaurna sky (after Teichelmann and Schürmann, 1840 and Clarke, 1990; 1997).

Kaurna Name	Western Name	Description
Kakirra	Moon	Called *Piki* in eastern communities. The husband of *Tindo* (the Sun), first to ascend into the sky. Encouraged others to follow him to keep him company.
Kumomari	Constellation, *Unidentified*	
Kurkukurkurra	Orion	Same as *Tinniinyaranna*, the constellation Orion (probable reference to the Belt and scabbard stars).
Madletaltarni	Red Star, *Unidentified*	Mother of the *Tinniinyaranna*. Probably Betelgeuse.
Mankamankarranna	Pleiades	Girls who dig for roots.
Mattinyi	Constellation, *Unidentified*	
Monana	*Unidentified*	Man who threw spears into the sky.
Ngaiera	Sky	
Ngakallamurro	Magellanic Cloud (one of)	Ashes of parakeets (Adelaide Crimson Rosella?), from '*murro'* meaning 'ashes'. The birds are gathered there by another constellation, and then roasted. The constellation is not identified. Teichelmann (1841: 2) suggests both Magellanic Clouds are the lorikeets' ashes.
Njengari	*Unidentified*	A man who created the landscape, and then was transformed into a star.
Parna	Star, *Unidentified*	A star indicating autumn.
Parnakkoyerli	Star, *Unidentified*	Father of the *Tinniinyaranna*. This name translates as 'their father', probably Rigel.
Purle	Star, *Unidentified*	A generic term for a star?
Tindo	Sun	The wife of the Moon. She beats him to death every month but he comes back to life. This describes the lunar cycle.
Tinniinyaranna	Orion (Belt/Scabbard?)	A group of young boys who hunt kangaroos, emus and other game on the great celestial plain, probably represented by the Belt and maybe the scabbard of Orion.
Wayakka	Star or Constellation, *Unidentified*	
Willo	Star, *Unidentified*	One whose older brother (*Yunga*) has died.
Wilto	Star, *Unidentified*	Summer season, Eaglehawk (Wedge Tailed Eagle). Possibly the Southern Cross (Crux).
Wodliparri	Milky Way	A river (*parri*) with huts (*woldi*).
Wolta	Star? *Unidentified*	The wild turkey (Australian Bustard).
Womma	Space/Sky	The celestial plain, where the *Tinniinyaranna* hunted emu and kangaroo.
Yurakauwe	Absorption nebulae	Dark spots in the Milky Way, thought to be large ponds in the *Wodliparri*, and the residence of the aquatic monster *Yura. Yura* who punishes those who break sacred law.
Makko	Cloud	
Unnamed	Planets (generic)	The wives of the Sun-father?
Unnamed	Comets	Evil sisters of the Sun?
Unnamed	Meteors	Orphans.

other Aboriginal groups in southeastern Australia (Clarke, 1997; Stanbridge, 1861; Teichelmann and Schürmann, 1840). There is ongoing debate as to the reliability of this interpretation, as the traditions and language were recorded by German missionaries and contain their biases and interpretations. For example, Heyes (1999) suggests there were more than four seasons, but due to the backgrounds and research methods of Teichelmann and Schürmann, the Kaurna and European seasons were conflated. This may also be the case with other Aboriginal seasons recorded in southeast Australia that seem to correspond to the four European seasons.

Heyes (1999: 16) suggests that the missionaries melded multiple seasons into a single cycle to more closely match the four-season framework familiar to Europeans (Figure 4):

- *Woltatti* (hot season) or *Bokarra* (hot north winds that blow in summer)
- *Wadlworngatti* (time of building huts against fallen trees) or *Parnatti* (Autumn—when the *Parna* star appears)
- *Kudlilla* (winter—icy cold south west winds)
- *Wullutti* (spring—*Wilto*/*Willo* star appears).

Teichelmann and Schürmann attribute summer to *Woltatti*, autumn to *Parnatti*, winter to *Kudlilla*, and spring to *Willutti*.

The stars or constellations associated with *Parna* (autumn star), *Wolta* (wild turkey), and *Wilto* (eagle) are not identified in the literature by

Figure 2: Stars identified by name in Kaurna astronomical traditions (or inferred by Teichelmann and Schürmann). In Western terminology, Orion is to the right, the Pleiades to the left, and Aldebaran and the Hyades in between. The ecliptic is noted in red (image: Stellarium, altered by the author).

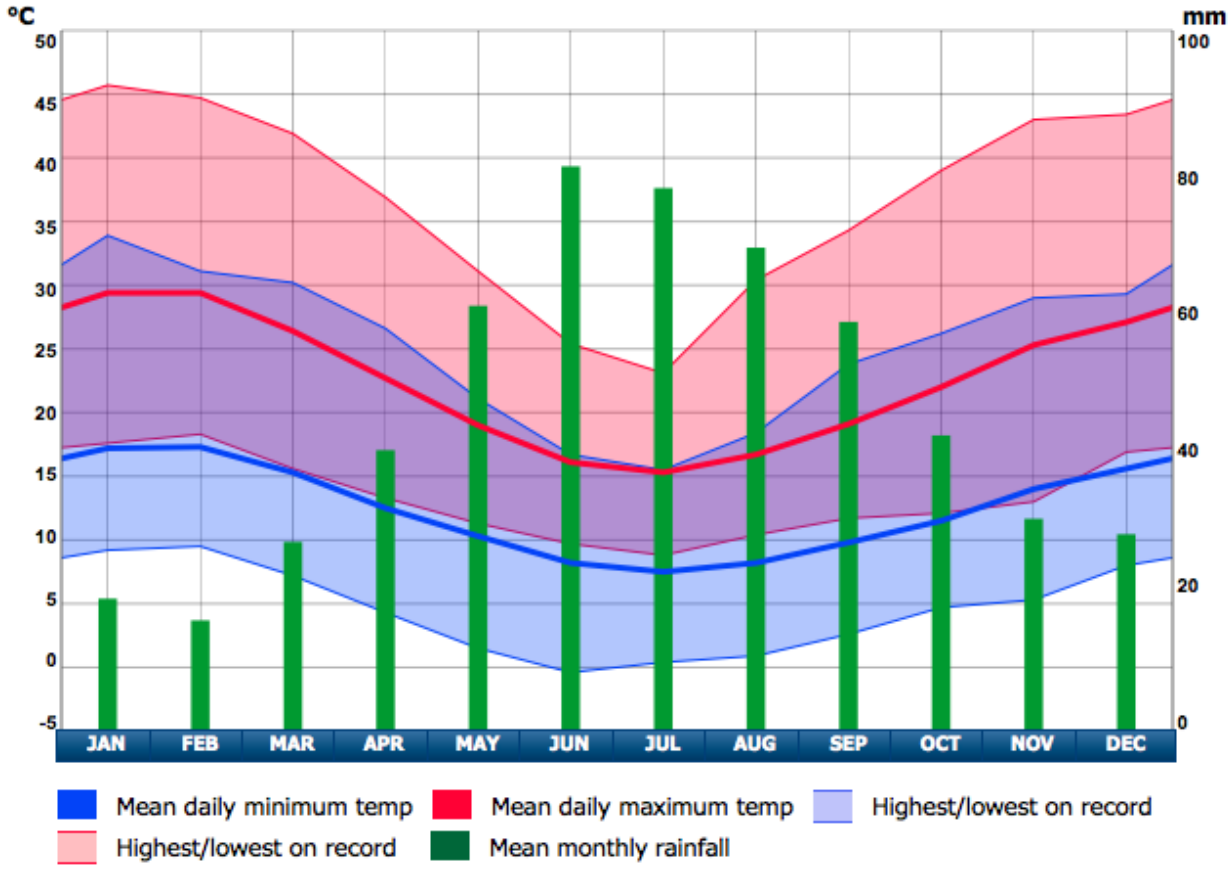

Figure 3: Long-term average seasonal data from Kent Town, Adelaide, recorded between 1977 and 2014, including information on temperature and rainfall. From Weatherzone and based upon data provided by the Bureau of Meteorology (www.weatherzone.com.au/climate/station.jsp?lt=site&lc=23090).

their Western counterparts. Clarke (1997) suggests that *Kudlilla* (winter) is associated with a star, but the original records do not state this.

We are given no information about the rising or setting of the other seasonal stars, so we apply the same criteria to them as we do to *Parna*: we assume they rise at dawn or dusk at the start of their associated seasons.

In this paper, we apply methods for identifying these stars by examining their heliacal and acronycal rise times and corresponding seasonal change, and by exploring their presence and/or associations in Kaurna astronomical traditions. The process of identifying previously-unnamed celestial objects in Indigenous astronomical traditions can be difficult, so developing and demonstrating rigorous methods for accomplishing this is useful for future work in cultural astronomy.

The published records of Kaurna astronomical

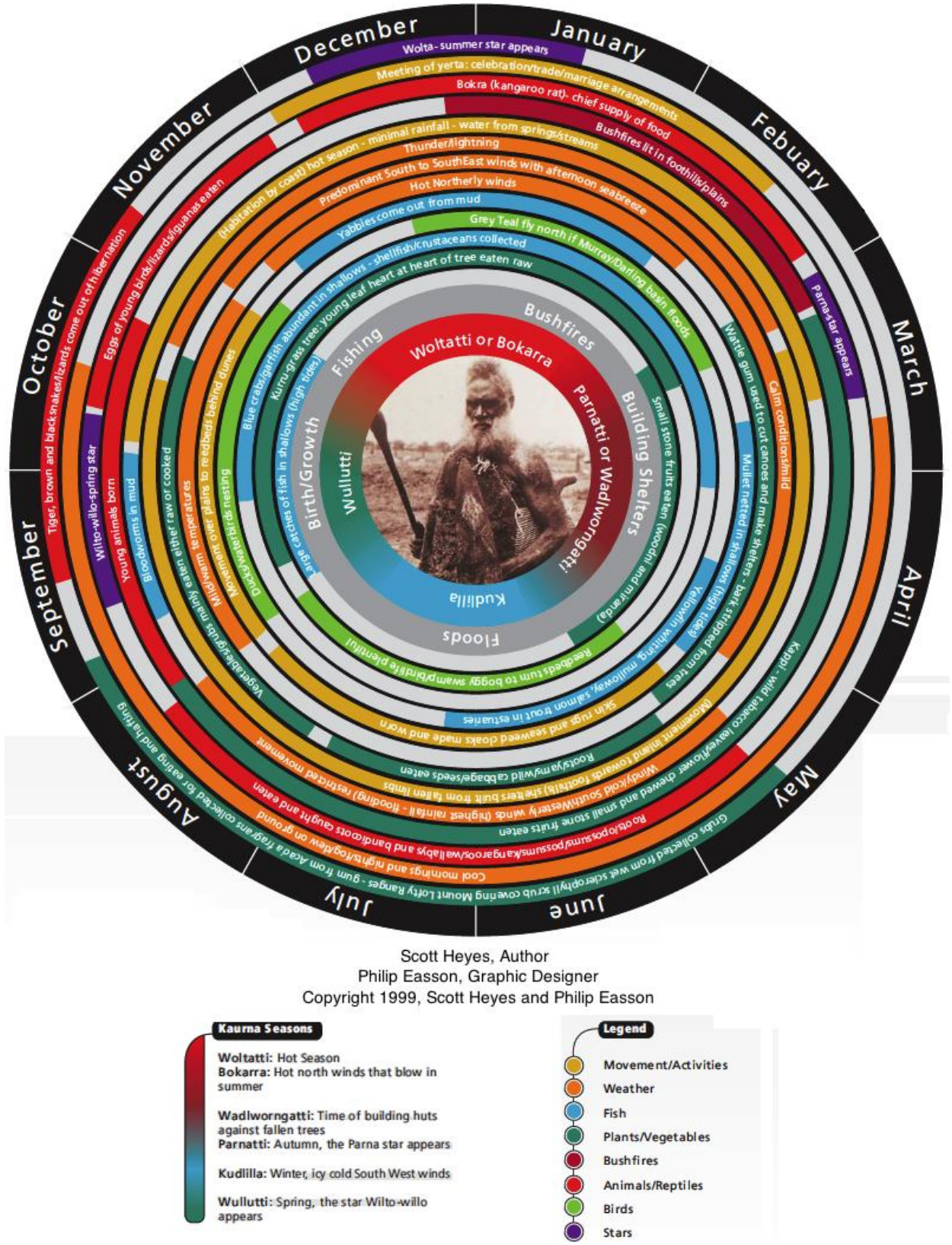

Figure 4: A seasonal Kaurna calendar, based on the Honours research of Scott Heyes (1999). Seasonal stars and the times of their appearance are noted in purple (image: Scott Heyes and Philip Easson).

traditions are incomplete and may contain errors. Only *Parna* is clearly denoted as appearing to signal coming winter rains. Neither *Wolta* nor *Wilto* is said to rise at dawn or dusk to signal seasonal change, and *Kudlilla* is never specifically associated with a star.

No further information is given so it is assumed, for the purposes of this study, that they rise heliacally. By extrapolating the relationship between *Parna* and seasonal change, we apply criteria to search for candidate stars for *Wolta*, *Wilto* and *Kudlilla*, as an associated star may

exist but simply not have been recorded.

4 METHODOLOGY

For this study, two important factors are necessary to determine the identity of Kaurna seasonal stars:

1) The heliacal and acronycal rise times and locations of stars, and;
2) The time of seasonal change on the Adelaide Plains.

The former can be calculated very precisely (to the day), while the latter cannot (it ranges from weeks to months). Therefore, a suitable methodology must be developed to identify the best candidates for Kaurna calendar stars.

4.1 Calculating Heliacal/Acronycal Rising

When a star first appears on the eastern horizon just before sunrise (before its light is drowned out by the Sun), it is referred to as *heliacal rising*. For millennia, cultures across the globe, including those in Australia (Johnson, 1998), have used the heliacal rising of particular stars for hunting and gathering, agriculture and as seasonal markers (see Aveni, 2003; Kelley and Milone, 2011). *Acronycal rising* (meaning opposite the Sun) is when a star rises in the east at sunset. This is also significant for denoting calendar changes in Aboriginal astronomical traditions (e.g. see Hamacher, 2012).

Table 2: First magnitude stars, their Bayer designations and their apparent magnitudes (V_{mag}). The V_{mag} for each star is its average apparent magnitude in the absence of an atmosphere (not its apparent magnitude when at an altitude of 5°), taken from the SIMBAD catalogue (simbad.u-strasbg.fr/simbad/).

Name	Bayer Designation	V_{mag}
Sirius	Alpha Canis Majoris	−1.46
Canopus	Alpha Carinae	−0.72
Rigil Kent	Alpha Centauri	−0.29
Arcturus	Alpha Boötis	−0.04
Vega	Alpha Lyrae	0.03
Capella	Alpha Auriga	0.08
Rigel	Beta Orionis	0.12
Procyon	Alpha Canis Minoris	0.34
Achernar	Alpha Eridani	0.46
Betelgeuse	Alpha Orionis	0.45
Hadar	Beta Centauri	0.61
Altair	Alpha Aquilae	0.77
Acrux	Alpha Crucis	0.77
Aldebaran	Alpha Taurii	0.85
Spica	Alpha Virginis	0.98
Antares	Alpha Scorpii	1.06
Pollux	Beta Geminorum	1.14
Fomalhaut	Alpha Piscis Austrini	1.16
Mimosa	Beta Crucis	1.25
Deneb	Alpha Cygni	1.25
Regulus	Alpha Leonis	1.36

The heliacal or acronycal rising of a star is dependent on a number of factors, including the azimuth and altitude of a star, the altitude and azimuth of the Sun relative to the star's position in the sky, the location and elevation of the observer, atmospheric conditions and the star's brightness and colour.

4.1.1 Star Brightness

First magnitude stars are the 22 brightest stars in the sky, ranging from the brightest, Sirius (Alpha Canis Majoris, V_{mag} = −1.46), to the dimmest, Regulus (Alpha Leo, V_{mag} = 1.35, see Table 2). Many single stars used for calendrical purposes in Aboriginal astronomical traditions are first magnitude (Clarke, 2007; Hamacher and Norris, 2011; Johnson, 1998).[5] Named celestial objects that are dimmer than this magnitude limit tend to be star clusters (e.g. the Pleiades), the Milky Way (including the dark spaces within it), close pairs of stars (e.g. Shaula and Lesath in Scorpius) or stars that form an asterism (e.g. Crux, and the Belt and scabbard of Orion). Therefore, we assume Kaurna seasonal stars are all first magnitude.

4.1.2 Stellar and Solar Position

The minimum altitude of a star when it is first visible to the naked eye depends on the brightness of the star, the colour of the star, the elevation of the observer, the atmospheric conditions between the star and the observer and the presence and phase of the Moon. Under good seeing conditions, a human observer with very good visual acuity can detect stars as faint as magnitude 8 (Kelley and Milone, 2011; Schaefer, 2000).

Assuming the observer is at sea-level, looking towards an unobstructed horizon in very good seeing conditions, a first magnitude star needs to have a minimum altitude of 5° to be visible (ibid.). Otherwise, extinction of the star's light is too great. The Sun needs to have a maximum altitude of −10° for a first magnitude star to be visible when it rises (Aveni, 2001). If the Sun's altitude is greater than this limit, its light will drown out the light of the star.

Heliacal and acronycal rising only applies to objects with an azimuth between 0° (due north) and 180° (due south). The appearance of stars nearer to the Sun will be more greatly reduced by the Sun's light than stars with an azimuth further from the Sun, such as those rising acronycally.

Stars that are circumpolar as seen from Adelaide ($\delta \leq -54.5°$) are always visible above the horizon and therefore do not 'rise'.

4.2 Selection Criteria

Seasonal change occurs on a timescale of weeks to months. Therefore, minor factors affecting the calculation of heliacal and acronycal rise times by a few days can be ignored for this study. The interested reader is referred to Purrington

(1988) and Schaefer (2000) for detailed analyses of heliacal rising calculations.

Using the major factors for calculating heliacal and acronycal rise times, calendar stars must meet the following four criteria:

1. The star must be first magnitude.
2. The star must not be circumpolar as seen from Adelaide ($\delta \leq -54.5°$)
3. The star must have an azimuth between 0° and 180° at the time of heliacal or acronycal rising.
4. The star must have a minimum altitude of 5° when the Sun has a maximum altitude of −10°.

Because early ethnographers sometimes conflated 'star', 'planet' and 'constellation', we are unsure if some seasonal stars are in fact a star or an asterism/constellation. We consider the latter case, provided that at least one star in the asterism is first magnitude. It should be noted that connect-the-dots constellations in Aboriginal astronomical traditions are rare. Clarke (2014) suggests that Aboriginal observers focused on individual elements, such as stars, rather than drawing lines between them to make shapes.

4.3 Estimating Seasonal Markers

The Kaurna traditions do not claim that seasonal change occurs exactly when the star is first visible. In the case of *Parna*, it serves as a warning of the coming wet season, allowing the people a 'grace period' during which they need to prepare.

The association between stars and seasons is less clear with *Wolta* and *Wilto*, and nonexistent for *Kudlilla*. We use the description given in Kaurna traditions (if any) and combine that with temperature and rainfall data from the region to approximate the time of year we expect to see the calendar star rise.

When estimating the time of month we search for heliacally- and acronycally-rising seasonal stars, and the following definitions are used:

- Early = 1st to 10th of the month
- Mid = 11th to 20th of the month.
- Late = 21st to 30th/31st of the month.

4.4 Comparative Studies

Another line of evidence for identifying celestial objects in Kaurna traditions is to compare the roles of these stars and their terrestrial counterparts in nearby Aboriginal astronomical traditions. Although Aboriginal languages and cultures are distinct, many have similar linguistic themes and related astronomical associations, particularly in southeastern Australia (Clarke, 2007; Fredrick, 2008; Hamacher, 2012; Johnson, 1998; Tindale, 1983).[6]

5 KAURNA SEASONAL STARS

5.1 *Parna*: The Autumn Star

In the Kaurna language recorded by Teichelmann and Schürmann (1840: 37), *Parna* has three different meanings. It can signify (1) the personal pronoun 'they'; (2) one of the two men

Figure 5: Aboriginal huts, or 'wurlies', constructed by the Kaurna as shelter during the rainy winter season (image: Alexander Schramm, South Australian Museum).

placed at either side of a line the people form when about to perform a circumcision as part of a male ceremony (the other man, *Tappo*, is a fly); or (3) the 'autumn star', which is derived from *Parnatti*, meaning "… autumn, when the star Parna is seen."

Autumn on the Adelaide Plain is denoted by increased rainfall, which peaks during the winter months. Building waterproof homes (colloquially called 'wurlies', Figure 5) was essential for the Kaurna to survive the cold, wet winter months (Taplin, 1879). This is due, in part, to water run-off from the Mount Lofty Ranges to the east, flooding the relatively flat plains that drain into Gulf St Vincent to the west (Figure 1).

The most significant rise in rainfall in terms of the percentage difference between any particular month and the previous month occurs in March (Table 3). Rain increases by an average of 20 mm each month until it peaks in June. The

Table 3: The mean and median rainfall (in millimeters) in the Adelaide Plain, taken from the data in Figure 3. The percentage change in rainfall from the previous month to the current month is given in columns 2 and 4.

Month	Mean Rainfall	% Change	Median Rainfall	% Change
January	18.9	−32.7*	20.1	−15.5
February	15.8	−16.4	06.8	−66.2
March	27.0	70.9	19.0	179.4
April	40.1	48.5	33.6	76.8
May	60.7	51.4	56.8	69.0
June	80.6	32.8	76.8	35.2
July	77.5	−03.8	68.8	−10.4
August	69.0	−11.0	69.2	00.6
September	58.4	−15.4	58.0	−16.2
October	42.2	−27.7	37.0	−36.2
November	30.3	−28.2	30.3	−18.1
December	28.1	−07.3	23.8	−21.5

* Note that a negative value indicates a decrease in rainfall.

records indicate that the appearance of the star *Parna* provides enough time for the Kaurna to build their huts before the heavy rains arrive. This suggests that *Parna* appears at the start of March, in agreement with Heyes (1999).

Teichelmann and Schürmann (1840: 50) say people begin building huts during *Wadla-worngatti*, "… the beginning of April (autumn season)." Heyes suggests that the confusion may be due to Teichelmann and Schürmann conflating *Parnatti* and *Wadlaworngatti* into a single 'autumn' season that stretched from late February to early June. Teichelmann and Schürmann do not clarify the time of day the star *Parna* is seen; only that it signals the start of autumn.

In the nearby Yaraldi dialect of the Ngarrindjeri language, the term for autumn is *marangal-kadi*, which means "… autumn, time of the crow …" (raven)—from February to April—and *parnar* means 'rain'. The raven is a prominent figure in Ngarrindjeri Dreamings (Berndt et al., 1993). In Ngarrindjeri culture, the 'autumn stars' are low in the southeastern sky because the crow-spirit entered the Skyworld to the southeast of the Lower Murray, towards Mount Gambier in the far southeast corner of South Australia (Clarke, 1997).

Although the Ngarrindjeri language is very different from the Kaurna language, there are cultural relationships between the groups. It is unknown if this plays a significant part in the identity of *Parna*, but the link is plausible.

Given the information above, we search for stars that meet the criteria in both early March and early April. Ngarrindjeri traditions indicate that *Parna* may have a southeasterly azimuth (between 90° and 180°). Heyes (1999) identifies early-March as the time *Parna* appears in the sky.

5.1.1 Place Names Indicating *Parna*

Place names incorporate *Parna* and its stellar significance. *Parnangga*, a hilltop campsite at Morphett Vale, in the southern suburbs of Adelaide, allegedly means "… place of the autumn star." The suffix *–ngga* is locative (Amery, 2002: 167). *Parnangga* may refer to the appearance of *Parna* and/or "… place of the procession leader." (Schultz, 2013a). The latter probably relates to male circumcision, a common component of manhood rites and male initiation. In the nearby Nukunu culture, *partnapa* was the "… first stage of initiation; young initiate who has gone through this." (Hercus, 1992: 26).

Amery (2002) suggests that *Parnangga* may be a 'stepping-off' place (typically mountains or hills) where an ancestor ascended into the sky. The campsite is believed to be near the primary school at Morphett Vale East, although this is uncertain (Schultz, 2013a). Considering the topography of the area, such as the elevation of *Parnangga* and the maximum elevation of the nearby Lofty Ranges, a star with a minimum altitude of 5° will be visible above the Ranges as seen from *Parnangga*. Tindale (c.1931) relates *Parna* to *Parnangga*, which he claims means "… autumn rains …" or "… place of autumn rains." This is probably based on the mistaken equivalence of the Ngarrindjeri word *Parnar* (rain) for the Kaurna words for rain (*kuntoro* and *manya*; Teichelmann and Schürmann, 1840). The Ngarrindjeri are south of Adelaide, along the Coorong, and speak a very different language to the Kaurna.

According to Tindale (c.1931), a stream near Second Valley on the Fleurieu Peninsula south of Adelaide named *Parananacooka* translates to "… excreta and urine of the Autumn Star women, so called because of the intense brackishness of the river at the end of summer." Schultz (2013b) and Clarke (1997) both claim Tindale's derivation is speculative. The interest-

ed reader is directed to Schultz (2013a; 2013b) for a detailed etymology of the place names *Parnangga* and *Parananacooka*.

5.2 *Kudlilla*: The Winter Star?

Kudlilla is "… winter … the rainy season …" (Teichelmann and Schürmann, 1840: 12). It is not associated with a star in the recorded literature. For this study, we propose it *could* be, and we predict it will rise at the beginning of winter. The mean monthly rainfall is highest from June to August, which corresponds to the three coldest months of the year (in terms of mean daily temperature).

For this reason, we search for stars that meet the criteria in late May or early June.

5.3 *Wilto*: The Spring Star

Teichelmann and Schürmann (1840) record *Wilto* as a species of eagle (most likely the wedge-tailed eagle, *Aquila audax*).

As with *Wolta*, little information is provided in the literature about the appearance of either the star or its relationship to the season (or the eagle). In the Turra (Narangga) traditions of Yorke Peninsula (bordering Kaurna country to the west), *Wiltu* is the eaglehawk (wedge-tailed eagle) (Fison and Howitt, 1880; Tindale, 1936).

Teichelmann and Schürmann (1840) refer to *Wilto* as a star or constellation. Teichelmann (1857: 41) clarifies that Wilto is an eagle and a "… constellation governing the spring." Clarke (1990) suggests that *Wilto* refers to the brightest stars in the Southern Cross (Crux), as it shares linguistic similarities with Ngadjuri traditions in north-central South Australia where the eagle, *Wildu*, is associated with Crux (regarded as the footprint of the eagle). Crux is also related to the wedge-tailed eagle in other Aboriginal traditions, such as the Adnyamathanha of South Australia (Hamacher et al., 2015; Johnson, 1998). Crux is at its highest altitude (crossing the meridian) at dawn in mid-January and its lowest altitude at dawn in early July. Crux is circumpolar as seen from Kaurna country (the minimum altitude of Gamma Crucis in 1840 as seen from Adelaide was ~1.5°), and was thus rejected from the criteria.

Across Aboriginal Australia, stars are connected to birds or animals because the rising and setting times of stars at dusk and dawn respectively correlate with some aspect of that bird's or that animal's behaviour. This might include migration patterns, nest building, breeding, whelping and brooding. Therefore, we examine eagle behaviour to see if any aspects correspond to the heliacal rising of first magnitude stars. This is conjecture, but may provide some insight as to why the star is associated with a particular bird. The study of the stars' rising and setting times and their avian counterparts in Indigenous traditions is the focus of ongoing research by Leaman et al. (n.d.).

The breeding cycle of the wedge-tailed eagle begins in March and April and runs to September, but the majority of eagles lay their eggs in July (Olsen, 1995; 2005). Mid-July is the middle of winter, thus making it a poor 'spring star'. Eagles incubate their eggs for 45 days and brood the chicks for an additional 30 days.

Therefore, most young eagles are leaving their nests in mid-September (between 11 and 20 September), which is also the end of the greater breeding season and the middle of spring. Heyes (1999) cites the appearance of the *Wilto* star in early to mid-September, although he does not associate this with the bird's behaviour.

Given this information, we search for a star that meets the criteria in mid-September, keeping in mind that linguistic evidence supports Crux as *Wilto*.

5.4 *Wolta*: The Summer Star

Wolta, the 'wild turkey' star, is associated with 'summer' (*Worltatti*). Little information is provided about the appearance of *Wolta* or its relationship to summer. Summer is the hottest and driest season of the year, with the highest temperatures occurring in January and February, and with nearly equal mean temperatures in December and March.

The terms 'brush turkey', 'plains turkey' and 'wild turkey' are commonly used by Aboriginal people to describe the Australian bustard (*Ardeotis australis*), which is found across the Adelaide Plains. *Walta*/*Waltja* is also the name of the bustard in the nearby Narranga language of southern Yorke Peninsula (Tindale, 1936). In the Nukunu language, *Waalha* refers to the 'plains turkey' (Hercus, 1992)

The relationship between the star and the bird is unknown, but probably relates to some aspect of the bird's behaviour, such as the breeding cycle or seasonal migrations. The Australian bustard breeds once a year. In South Australia, egg-laying occurs from July to November (Boehm, 1947), but primarily from September/October through to November/December, and the eggs incubate for 23–24 days (Beruldsen, 2003). The bustard is diurnal, being active in the early morning and late evenings.

Detailed study of bustard behaviour in Victoria (Ziembicki, 2009) shows that the bustard returns to its breeding ground in spring and summer when more food is available (following the wet winter rains). Anecdotal observations suggest that numbers peak during the summer in Victoria, implying possible movements southwards from inland regions at this time (ibid.). No

similar, in-depth studies have been conducted on the Adelaide Plains, so any comparison with bustard behaviour in Victoria is conjectural.

This poses a challenge to clearly identify the time of year this star might rise heliacally or acronycally. For this study, we search for stars that rise in early to mid-December, coinciding with the end of the bustard breeding season and the start of the hot, dry summer. In agreement, Heyes (1999) cites early to mid-December as the time when *Wolta* appears.

6 RESULTS

All first magnitude stars that rise heliacally and acronycally during the year as seen from Adelaide are given in Table 4. Stars that meet the criteria for each seasonal star for both heliacal and acronycal rising are given. Those in green are the best candidates, and those in red are within two days of the time period explored for each candidate (i.e. early, mid, late month).

Table 4: Stars visible from Adelaide that meet the criteria for dates in 1840 (when Teichelmann and Schürmann published their work on the Adelaide Aboriginal language). The dates given are the first day the criteria are met (using Stellarium). The azimuth (Az in degrees) is rounded up to the nearest degree. Stars in green meet the criteria. Candidate stars (CS) in red 'marginally' meet the criteria, meaning they are within two days of the estimated start or end period.

Star	Az (°)	Heliacal Rise		Acronycal Rise	
		Date	CS	Date	CS
Arcturus	61	17 Dec	*Wolta*	18 May	*Kudlilla*
Altair	76	16 Feb		29 Jul	
Vega	35	27 Feb	*Parna*	11 Aug	
Fomahlaut	124	1 Mar	*Parna*	14 Aug	
Deneb	23	4 Apr	*Parna*	18 Sep	*Wilto*
Canopus	156	10 May		22 Oct	
Rigel	97	5 Jun	*Kudlilla*	15 Nov	
Aldebaran	66	12 Jun	*Kudlilla*	21 Nov	
Sirius	106	21 Jun		28 Nov	*Wolta*
Betelgeuse	77	24 Jun		2 Dec	*Wolta*
Procyon	79	21 Jul		22 Dec	
Capella	20	7 Aug		4 Jan	
Pollux	50	17 Aug		11 Jan	
Regulus	71	18 Sep	*Wilto*	8 Feb	
Spica	99	8 Nov		30 Mar	*Parna*
Antares	119	16 Dec	*Wolta*	17 May	

6.1 *Parna*

Three stars are possible contenders for *Parna*: Fomalhaut and Deneb, depending on whether it coincides with early March or early-April (Heyes, 1999 suggests the former—see Figure 4), and Vega, as it is within two days of early March.

The stars Fomalhaut and Vega appear in the sky at close to the same time, with Vega appearing in the northeast and Fomalhaut in the southeast. Deneb appears in early-April in the far northeastern sky. Because of the declination of Fomalhaut (−29.61°), from the latitude of Adelaide it also heliacally sets on the same days it heliacally rises. This means Fomalhaut has an altitude of 5° when the Sun has an altitude of −10° at both dusk and dawn around the first of March. This is not the case with either Vega or Deneb.

In the nearby Mallee region of southeast South Australia and western Victoria, Vega is associated with the malleefowl (*Leipoa ocellata*), a ground dwelling megapode (mound-building bird) in Wergaia traditions (Stanbridge, 1861). The acronycal rising of Vega coincides with the time of year the birds are building their nesting mounds. The star's heliacal setting coincides with the time when Aboriginal people collected the eggs.

Fomalhaut meets the description of an autumn star in Yaraldi (Ngarrindjeri) traditions, as it appears in the southeastern sky (both Deneb and Vega are northerly stars with an Az <35°). Fomalhaut also rises and sets heliacally on the same days, unlike any of the other calendar stars listed in Table 4. It is unknown if this is significant.

With this information, Fomalhaut is the most plausible candidate for *Parna*. Tindale (1934) originally identified *Parna* as the Pleiades, but the heliacal rising of that cluster occurs in June, and the Pleiades are also already identified in Kaurna astronomical traditions as the *Manka-mankarranna*.

6.2 *Kudlilla*

In terms of heliacal rising, only one candidate star meets the criteria for *Kudlilla* and this is Rigel, although Aldebaran is near the boundary of the upper-limit of the time period for *Kudlilla*. In terms of its acronycal rising, Arcturus marginally qualifies. When comparing candidate stars with those identified in Kaurna traditions, we see that Rigel is already associated with *Parnakkoyerli*. Heyes does not include *Kudlilla* as a seasonal star in his analysis of the Kaurna calendar—see Figure 4.

Both *Kudlilla* and *Parna* have marginal associations with Arcturus and Spica.

6.3 *Wilto*

Regulus meets the heliacal rising criterion and Deneb meets the acronycal rising criterion. For reasons described in Section 4.3, *Wilto* is probably the Southern Cross (which includes two

first magnitude stars), but this constellation is circumpolar when viewed from the Adelaide Plains and thus is rejected in this analysis.

6.4 *Wolta*

Two stars meet the criterion for heliacal rising in mid-December: Antares and Arcturus. Betelgeuse meets the criterion for acronycal rising, and Sirius marginally does. It should be noted that Arcturus, Antares and Betelgeuse are all visibly red stars, and this may somehow relate to the hot, dry season as red stars commonly relate to fire.

7 DISCUSSION AND CONCLUDING REMARKS

The identification of only one seasonal Kaurna star is supported by this study with multiple lines of evidence: *Parna*. *Parna* is identified as Fomalhaut, which meets the criteria and is at such a declination that it heliacally rises *and* sets at the same time of year—the start of the autumn season.

Additional circumstantial evidence is found by examining Ngarrindjeri traditions to the south, where the autumn stars *Maranganil**Marangalkadi* (Western counterpart unidentified) are visible in the southeastern sky towards Mount Gambier. Autumn is the time of the crow (Australian Raven) and lasts from February to April (Berndt et al., 1993). Records of both the Kaurna and Ngarrindjeri indicate that they have four main seasons, each denoted by a star or group of stars (ibid.). This suggests that if these two groups possess some similarities in their astronomical traditions, *Parna* may also appear in the southeastern sky.

It should be emphasized that the Kaurna and Ngarrindjeri languages are very different, so traditions from both groups cannot be easily conflated. Therefore, without further supporting evidence, any connection is speculative. A more detailed study of Ngarrindjeri astronomical traditions will be the focus of future work.

Fomalhaut is found in the astronomical traditions of other Aboriginal cultures of Australia, though rarely (Clarke, 2007; Hamacher and Frew, 2010; Johnson, 1998):

- In Wotjobaluk (Wergaia) and Mara (Gunditjmara) traditions of western Victoria, Fomalhaut is the moiety eaglehawk (wedge-tailed eagle) ancestor (Massola, 1968), despite not being included in the detailed Boorong (Wergaia) study by Stanbridge (1861).
- In Wurundjeri traditions of central Victoria, Fomalhaut is *Bunjil*, the primary sky-hero and 'all father' (Dawson, 1881; Hartland, 1898; Howitt, 1884a; 1884b; Howitt, 1904), although *Bunjil* also relates to the star Altair (ibid.).
- In Bundjalung traditions of northern coastal NSW, Fomalhaut is *Bunnungar*, the 'frill-necked lizard' (Patston, 1997), a probable reference to the Eastern bearded dragon (*Pogona barbata*).
- Similarly, in Euahlayi traditions of north-central NSW, Fomalhaut is *Gani*, a 'small iguana' (Brough-Smyth, 1878; Ridley, 1875). This is probably a reference to a small species of goanna.
- In Wardaman traditions of the north-central Northern Territory, Fomalhaut is *Menggen*, the white cockatoo, whose feathers were used for ceremonial decoration (Cairns and Harney, 2003). *Menggen* watches over ceremonies and is part of a complex songline. Senior Wardaman custodian, Bill Yidumduma Harney, is from the *Menngen* (White Cockatoo) community.
- In the Torres Strait, Fomalhaut was called *Panauna graz* (Rivers, 1912), but no further details about its meaning are provided.[7]

In the records of Aboriginal astronomical traditions across Australia, some first magnitude stars are conspicuously absent. For example, the first magnitude stars omitted by Stanbridge (1861) in his study of Boorong (Wergaia) traditions of western Victoria are Procyon, Betelgeuse, Spica, Fomalhaut, Deneb and Regulus. Curiously, these are all potential seasonal stars described in this paper (see Table 4).

The Reverend Peter MacPherson (1881) provides a possible explanation for the omission of some of these first magnitude stars: Fomalhaut, Spica and Regulus (as well as Procyon) are 'isolated' stars that do not fit into any 'mechanical' grouping, an apparently common occurrence in the Aboriginal astronomical traditions of nearby western Victoria.

In this grouping process, MacPherson proposes that characters represented by stars of a particular family are either:

(1) grouped based upon their arrangement in the sky, specifically grouping three stars (or clusters) in a linear pattern;
(2) grouped into four linear arrangements that are roughly parallel to each other; or
(3) arranged roughly parallel to the horizon as they rise in the evening sky in their respective seasons at the latitude of the region (36° S) (after Hamacher and Frew, 2010).

Perhaps another reason these stars do not feature in Aboriginal traditions is that certain stars are considered secret and sacred. For example, an Aboriginal man was once pressed as to why Procyon was unnamed in his people's astronomical traditions, and he "… merely shook his head in a negative sort of way." (EKV, 1884).

Considering the diversity of Aboriginal cultures (over 350 distinct languages) and the length of time people have been in Australia (>50,000 years), relatively little research has been conducted on Aboriginal astronomical traditions, and much of that was recorded by amateur (and professional) ethnographers with limited astronomical training. It is possible that the omission of these stars reflects the incompleteness of recorded Aboriginal astronomical traditions. Hopefully, further research will shed light on this issue.

Using a combination of linguistic analysis, heliacal and acronycal rise-time calculations, seasonal weather data, and comparative studies of Aboriginal astronomical traditions, we attempted to identify Kaurna seasonal stars.

Only one star is supported by more than one line of evidence, and this is Fomalhaut, the autumn-star *Parna*. This star is uncommon in recorded Aboriginal astronomical traditions, which poses important considerations for future research.

8 NOTES

1. The term Kaurna was not used at the time of European colonisation to refer to the Aboriginal people of the Adelaide Plains. It was later popularized by Norman Tindale in the 1920s, resulting in its adaptation by Adelaide Plains traditional owners and its common usage today (see Amery, 2000; Clarke, 1997). A comprehensive database of information on the Kaurna language can be found at: www.mobilelanguageteam.com.au/languages/kaurna
2. Sometimes ethnographers conflate the terms 'star' and 'constellation', such as *Wayakka,* which is a Kaurna word for an unidentified star or constellation (Teichelmann and Schürmann, 1840).
3. In Aboriginal astronomical traditions across Australia, the stars of Orion's Belt and scabbard commonly represent a group of boys or men and the Pleiades commonly represent a group of girls or women (see Clarke, 2007; Fuller, et al., 2014; Hamacher, 2012; Johnson, 1998; Leaman and Hamacher, 2014; Tindale, 1983). A detailed study of the Pleiades and Seven Sisters Dreamings in Aboriginal traditions is the focus of doctoral candidate Melissa Razuki at RMIT in Melbourne.
4. Weather data (1977–2014) for Adelaide are taken from: www.weatherzone.com.au/climate/station.jsp?lt=site&lc=23090
5. There are exceptions to this, as one would expect. But this tends to be the case overall.
6. Kaurna astronomical traditions are not well known to non-initiated Kaurna men, and only a small portion of these traditions have been recorded (Curnow, 2006).
7. *Panauna* was not defined or otherwise mentioned in any Torres Strait Islander records, but *graz* is a fishtrap or weir built of stones on a reef (Ray, 1907). This term was recorded on Mabuiag Island, suggesting it is from the Kalaw Lagaw Ya language.

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