ASTRONOMICAL ORIENTATIONS OF BORA CEREMONIAL GROUNDS

in southeast Australia

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Abstract

Ethnographic evidence indicates that bora (initiation) ceremonial sites in southeast Australia, which typically comprise a pair of circles connected by a pathway, are symbolically reflected in the Milky Way as the 'Sky Bora'. This evidence also indicates that the position of the Sky Bora signifies the time of year when initiation ceremonies are held. We use archaeological data to test the hypothesis that southeast Australian bora grounds have a preferred orientation to the position of the Milky Way in the night sky in August, when the plane of the galaxy from Crux to Sagittarius is roughly vertical in the evening sky to the south-southwest. We accomplish this by measuring the orientations of 68 bora grounds using a combination of data from the archaeological literature, and site cards in the New South Wales Aboriginal Heritage Information Management System database. We find that bora grounds have a preferred orientation to the south and southwest, consistent with the Sky Bora hypothesis. Monte Carlo statistics show that these preferences were not the result of chance alignments, but were deliberate.

Notice to Aboriginal and Torres Strait Islander Readers

This paper discusses bora ceremonies and contains the names of people who have passed away. The exact locations of these sites are concealed in order to protect them. The coordinates provided are within 10 km of the site and are used only to demonstrate the general distribution of the recorded bora grounds in southeast Australia.

Introduction

In traditional Aboriginal cultures across Australia, young males are taught the laws, customs and traditions of the community and undergo a transition ceremony from boyhood to manhood. This ceremony often includes a 'rite of passage' event in which the initiated males undergo some form of body modification (Jacob 1991), typically involving tooth evulsion in southeast Australia (e.g. Berndt 1974:27–30). This ceremony goes by many names, but in Queensland (Qld) and New South Wales (NSW) it has come to be known as 'bora', the name used by the Kamilaroi of north-central NSW (Ridley 1873:269). Bora ceremonies were one of the first Aboriginal cultural activities described by early colonists in the Sydney region (e.g. Collins 1798:468–480; Hunter 1793:499–500); however, because information about bora ceremonies is culturally sensitive, here we limit discussion of the ceremony per se.

There is a variety of evidence from the anthropological literature (e.g. Berndt 1974; Love 1988; Winterbotham 1957) that bora ceremonies are related to the Milky Way and that ceremonial grounds are oriented to the position of the Milky Way in the night sky at particular times of the year. In this paper, we begin by exploring connections between bora ceremonies and the Milky Way using ethnographic and ethnohistoric literature. We then use the archaeological record to determine if bora grounds are oriented to the position of the Milky Way at particular times of the year. Finally, we use Monte Carlo statistics to see if these orientations are deliberate or the result of chance.

Bora Ceremonial Grounds

The layout of bora grounds is similar across southeast Australia, with only minor differences between regions (Bowdler 2001:3; Mathews 1894:99). Several reports (e.g. Black 1944; Collins 1798:391; Fraser 1883; Howitt 1904; Mathews 1897a) describe the grounds as consisting of two rings of different sizes, connected by a pathway. In some places, bora sites may comprise three or more rings (Bowdler 2001; Steele 1984). The border of each ring is made of raised earth or stone, and the area within is cleared of debris and stamped until firm. The larger ring, which is considered public, has a typical diameter of 20–30 m. The smaller ring (generally 10–15 m diameter) is considered the sacred area, where body modification takes place, and is restricted to initiates and male Elders. The two rings are connected by a pathway that ranges from tens to a few hundred metres in length. In 2004, an Aboriginal man from Marulan, NSW, advised that parts of many such sites were destroyed immediately after the ceremony to conceal their location (Hardie 2004). Potentially this is the reason that some bora sites reported in the literature feature only a single circle, with the smaller, sacred circle possibly having been deliberately destroyed.

Bora grounds are distributed throughout most of NSW and southern Qld, and may extend into South Australia (Howitt 1904:501–508) and northern Qld (Roth 1909). Ceremonial rings, which may be bora grounds, have been found near Sunbury, Victoria (Vic.), although there are no ethnographic records attesting to their ceremonial use (Frankel 1982). Howitt (1904:512) cited a western boundary for bora running from the mouth of the Murray River to the Gulf of Carpentaria. Mathews (1897b:114) noted that the bora could be found across three-quarters of NSW and some distance into western Qld, with a boundary extending from Twofold Bay near Eden, NSW, in the south, to Moulamein, NSW, in the west, and Barringun, Qld, in the north. We recognise that the geographical area covered by this paper includes several distinct language groups, each of whom may have separate culture and traditions, and it may be misleading to aggregate the data from such a wide area. However,

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(a) the existence of similarly constructed bora rings implies some commonality in culture, and (b) aggregating orientations from a large geographic area will dilute any preferred orientations arising from a single Aboriginal group.

According to Love (1988), bora ceremonies were predominantly held in August each year, although other authors report a variety of dates, including March–May (Winterbotham 1957), April–June (Mathews 1894:99), May–July (Mathews 1894), August (Needham 1981:70), September–November (Winterbotham 1957) and October–December (Mathews 1894). This suggests that, in some cases, numerous variables influenced the date of the bora ceremony, including the availability of food and water, or having a sufficient number of boys to initiate (e.g. Mathews 1910). While these factors vary across the southeast, here we test an hypothesis advanced by Love (1988), who presented evidence associating the bora ceremony with the night sky and the orientation of the Milky Way, suggesting that most initiation ceremonies occur around August.

Anthropological Support for an Astronomical Connection

It is well established that the night sky plays a significant role in several Aboriginal cultures (e.g. Cairns and Harney 2004; Hamacher 2012; Johnson 1998; Norris and Hamacher 2009). In Aboriginal astronomical traditions, dark spaces within the Milky Way are as significant as bright objects. Two animals symbolically link bora ceremonies to these dark spaces. One was a spiritual serpent, commonly referred to as the 'Rainbow Serpent' across Australia, traced out by the curving dust lanes in the Milky Way. Needham (1981:69) explained that in the Hunter Valley (NSW), motifs of the spiritual serpent were represented in bora ceremonies, with information about the serpent being recounted during the ceremony itself. The other animal was an emu, which is also traced by dust lanes in the Milky Way (Norris and Norris 2009). Love (1988:129–138) argued that the emu was an important part of the bora ceremony, as did Berndt (1974:27–30), since male emus brood and hatch the emu chicks and rear the young (Love 1987). This is symbolic of the initiation of adolescent boys by their male elders.

Needham (1981) provided an illustration of the night sky and associated stars in local Aboriginal astronomical traditions. The illustration, which cites the 'All Father' as the star Altair, provides the positions of celestial objects in August, 'the month when Aboriginal initiation ceremonies were held' (Needham 1981:70). During the early part of the night in August, the Milky Way stretches across the sky from northeast to southwest. Many early colonial reports referred to an Aboriginal religion based on a deity variously described as Baiame, Bunjil or Mungan-ngaua (Henderson 1832:147; Howitt 1904:490–491; Ridley 1873:268). These names roughly translate to 'father' or 'father of all of us' (Howitt 1904:491). According to Fraser (1883:208) and Howitt (1884:458), Baiame gave his son, Daramulan, to the people and it is through Daramulan that Baiame sees all. Baiame is worshipped at the bora ceremony (Ridley 1873:269) and Daramulan is believed to come back to the earth by a pathway from the sky (Fraser 1883:212). Eliade (1996:41) reported that Baiame 'dwells in the sky, beside a great stream of water' (i.e. the Milky Way) and various reports (e.g. Berndt 1974; Hartland 1898; Howitt 1884) have claimed that the wife of Baiame (or in some cases Daramulan) is an emu. Reports of Baiame, Daramulan and Bunjil come from various cultures across southeast Australia, resulting in variations in these reports. However, they share some features, including a close connection between bora ceremonies and the Milky Way.

Testing the Hypothesis

To focus the discussion, we concentrate specifically on the hypothesis advanced by Love (1987, 1988), who argued that ancestral spirits in the heavens held bora ceremonies in the Milky Way, which we refer to as the 'Sky Bora'. Love based his work, in part, on Winterbotham (1957), who obtained information from a Jinibara man from southeast Qld named Gaiarbau. According to Winterbotham (1957:38), bora circles,

> … were always oriented towards points of the compass, the larger one to the north, and the smaller to the south ... They conformed in this rule to the position of two dark (black) spaces (circles)—the Coal Sacks in the heavens.

According to Love (1988:130–131), the Jinibara account identifies the Sky Bora with the Emu in the Sky (Gaiarbau et al. 1982:77; Winterbotham 1957:46). The 'Coal Sacks', or *Mimburi*, to which Winterbotham referred, are a dark absorption nebula bordering the western constellations Crux (Southern Cross), Centaurus and Musca that represent the head of the emu, with the star BZ Crucis representing the eye. The dust lanes that run through the stars Alpha and Beta Centauri represent the neck, while the Galactic bulge, near the intersection of Sagittarius, Scorpius and Ophiuchus, represents the body. This area is the centre of our Milky Way galaxy. The dust lanes along the Milky Way through Sagittarius trace out the legs (Figure 1). The celestial emu motif is found across Australia (e.g. Cairns and Harney 2004; Norris and Hamacher 2009:13; Stanbridge 1861:302; Wellard 1983:51).

According to Winterbotham, other Aboriginal groups also knew of the dark nebulae, including the Badjala people of Fraser Island and the adjacent mainland, who call them *Wurubilum*, and the Wakka Wakka people near Murgon, Qld. This concept extends beyond southeast Australia. For example, Smith (1913) explained that during an initiation ceremony in Western Australia (WA) the initiate is left tied to the ground until the Milky Way is visible. He is then asked if 'he can see the two dark spots' and when he is able to see them, he is released. While this account is not from the study area, it may be similar to the example that Gaiarbau described.

Gaiarbau said that bora ceremonies were not held until the celestial bora rings returned to their 'proper points of the compass' (Winterbotham 1957:38). In clear winter skies in the southeast, the Milky Way is visible about an hour after sunset. The orientation of the plane of the Milky Way, as seen from southeast Australia an hour after sunset, changes from near vertical in the south-southeast in March, to horizontal across the southern sky from east-southeast to west in June, and back to vertical (but inverted) in the southwest in September. The Galactic bulge and the Coalsack (celestial emu) are not visible in the sky together an hour after sunset until May. At this time, the emu is not vertical in the sky (perpendicular to the horizon), but stretches from south to east.

The only time that the Sky Bora is vertically aligned to the horizon and can be seen in the sky an hour after sunset is in August (or later in the night as the year progresses). The Galactic plane, which goes straight through the celestial emu, is vertical in August an hour or two after sunset (earlier in the evening later in the month) (Figure 2). At this time, the azimuth is approximately 213° (south-southwest).

If Love's hypothesis is correct, we expect the orientation of each bora site on an axis from the larger circle to the smaller circle to be oriented to roughly 213°, corresponding to the time ceremonies are held (August). This expectation agrees with Needham (1981:70), who claimed that bora ceremonies in the Hunter Valley were held in August when the Milky Way was vertical in the south-southwest.

Other researchers report that bora ceremonies in Qld and NSW were held at various times of the year, as noted above (Mathews 1894:99; Winterbotham 1957). Bora ceremonies may have been held at times of the year that had little or nothing to do with the position of the Milky Way in the sky, even if the ceremonies were symbolically linked to the Milky Way. For example, Mathews (1894:128) claimed that the direction of one bora ring to the other 'is entirely dependent on the conformation of the country within which the ceremony is being held'. If bora grounds were not oriented to any particular object or direction, we expect to find a roughly uniform distribution in their orientations. However, if at least some bora grounds were oriented to the position of the Sky Bora, then we expect to find a preference for south-southwest orientations when we look at the overall distribution of bora ground orientations.

Methods

To determine the orientations of bora ceremonial sites, we obtained data for 63 such sites from the following published literature: Mathews (1894, 1896a, 1896b, 1897a, 1907, 1917), Hopkins (1901), Towle (1942), Bartholomai and Breeden (1961), Anon. (1973), McBryde (1974), Steele (1984), Satterthwait and Heather (1987), and Bowdler (2001). We also assessed 1107 archaeological site cards related to stone arrangements and ceremonial grounds from the NSW Aboriginal Heritage Information Management System (AHIMS).

We filtered the sites through a rigorous selection process, discarding any bora ground that failed to meet any of the following criteria:

1. The site is clearly described as a bora ceremonial ground;
2. The site is in NSW or southeast Qld (Figure 3);
3. Measurements were made by an appropriately trained or qualified person (e.g. a surveyor or archaeologist);
4. The data are either first-hand, or second-hand from a trusted source;
5. There is unambiguous information on the direction from the large to the small circle; and,
6. a. Both rings and the pathway between them are identifiable, **or**
   b. Both rings and at least one opening are identifiable**, or**
   c. Only one ring is identifiable, but it has a clearly identifiable opening and there is unambiguous information as to whether it is the larger or the smaller ring.

Figure 1 The 'Emu in the Sky' visible over an emu engraving at Elvina Track in Kuringai Chase National Park north of Sydney, which may represent her celestial counterpart (image reproduced courtesy of Barnaby Norris).

Figure 2 The Sky Bora in the Milky Way oriented vertically in the south-southwest sky in mid-August an hour after sunset, as seen from Brisbane. The large circle represents the larger bora circle and the body of the emu (near zenith). The smaller circle represents the Coalsack and the head of the emu. Graphics are from the Stellarium astronomical software package.

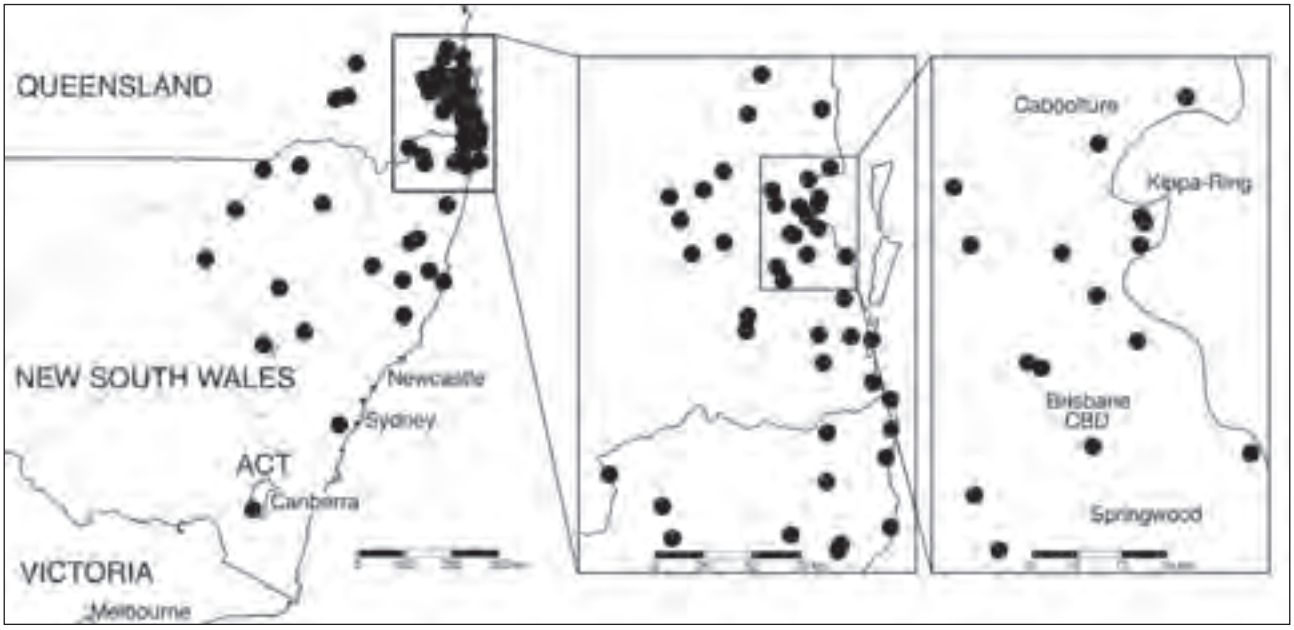

Figure 3 Locations of all bora grounds in Table 2, excluding the data from Satterthwait and Heather (1987). The coordinates given are adjusted to protect exact location and are within 10 km of the site, which is why some appear over the sea.

The orientation of each site was measured from the centre of the largest circle to the centre of the smallest circle. If the second circle was missing, the orientation was taken from the centre of the circle to the middle of the opening. Measurements were either taken directly from the records given by the surveyor or measured from the survey with a protractor and ruler. We divided the azimuths into 16 bins (N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW), each with a width of 22.5° with N centred at 0°, NNE at 22.5°, and so on (Table 1).

Results and Analysis

Of the 1170 sites obtained from the literature and AHIMS site card search, only 68 met the specified selection criteria (Table 1, Figure 3). These can be divided into two groups:

1. Forty-six sites for which the orientation has been recorded individually for each site; and,
2. Twenty-two sites in Satterthwait and Heather (1987:Table 9) which provide the distribution of orientations without providing individual site orientations.

The 46 sites whose orientations are recorded individually are provided in Table 1 and are grouped into 22.5° bins, shown as a histogram in Figure 4a. The histogram reveals a clear preference for the S, SW and W orientations. Table 2 contains 34 orientations in ordinal (N, S, E, W, NW, NE, SE, SW) directions, but only 12 orientations in inter-ordinal (NNE, ENE, etc.) directions. The low number of inter-ordinal orientations suggests either that the sites tend to be oriented on ordinal points, or that some authors rounded to the nearest ordinal point.

To avoid a statistical bias in our results, we re-binned the data into the eight ordinal directions, dividing the counts of each inter-ordinal bin equally between the two neighbouring ordinal bins, resulting in eight 45° bins (Figure 4b). A preferred orientation to the south is evident (28% of the 46 data points), with lesser but significant preferences to the SW (17%) and W (15%) bins. The combined S, SW and W bins account for 61% of the total data points, while the remaining are evenly spread across the remaining bins. The highest peak of 12.5 orientations occurs in the S bin.

We compared this result with the 22 data points from Satterthwait and Heather (1987) (hereafter referred to as 'SH') by re-binning our data to four quadrants centred on the cardinal points (N, S, E, W), as shown in Figure 4c. This reveals a strong preference for the southern quadrant and a lesser, but significant, preference to the western quadrant, which, when combined, account for 74% of the 46 data points. The SH data (Figure 4d) is similar, with a significant preference for the southern quadrant (68% of the 22 data points), but with an even distribution among the remaining quadrants.

We then combined our 46 data points with the 22 SH data points, resulting in Figure 4e. A clear preference for the southern quadrant is evident, with 35 of the 68 orientations (51%) falling in the S bin. This result is consistent with the Love hypothesis.

To determine if this is a chance clumping of a random distribution of orientations, we conducted a Monte Carlo simulation, in which 68 orientations were distributed randomly in each of the bins shown in Figure 4e. We repeated this process 100 million times. In only 303 of the 100 million runs did the number in any one bin equal or exceed 35, from which we can conclude that the likelihood of the peak in Figure 4b occurring by chance is about $3x10^{-6}$ or 0.0003%. We therefore conclude that this distribution is clearly not the result of chance, and that the constructors of the bora rings intentionally aligned most of them to the southern quadrant.

Discussion and Conclusion

We have shown that the bora grounds studied have a preferred orientation to southerly directions and that these orientations are not the result of chance, but are deliberate. The reason for this is not known, but it is consistent with the Love hypothesis that southeast Australian bora ceremonial grounds have a

No.	Site Name	Location	Type	Orientation	Az (°)	Source
1	Kogan	–27.2, 150.5	1	W	270	Bartholomai and Breeden (1961)
2	Gurah	–29.4, 149.4	1	E	90	Hopkins (1901)
3	Gurah 2	–27.5, 153.3	2	S	180	Steele (1984)
4	Wellington	–32.3, 148.6	2	E	90	Mathews (1894)
5	Gundabloui	–29.1, 148.5	1	WSW	240	Mathews (1894)
6	Wilpinjong Creek	–32.2, 149.5	1	SW	215	Mathews (1894)
7	Eurie Eurie Run	–29.6, 148.1	1	SW	225	Mathews (1894)
8	Bulgeraga Creek	–30.6, 147.3	1	SSW	202	Mathews (1896a)
9	Camden	–34.3, 150.4	1	NE	45	Mathews (1896b)
10	Murrumbidgee River	–35.5, 148.5	1	S	185	Mathews (1897a)
11	Terry Hie Hie	–29.5, 150.9	1	W	270	Mathews (1917)
12	Wyrallah	–28.5, 153.2	3	SSW	202	McBryde (1974)
13	Brackenridge	–27.2, 153.1	3	SE	135	McBryde (1974)
14	Weir River	–27.4, 150.4	1	WNW	298	Mathews (1907)
15	Casino	–28.5, 153.2	3	N	0	RRHS (1973)
16	Tucki Tucki	–28.6, 153.2	1	SW	225	RRHS (1973), AHIMS 04-4-0024
17	Lennox Head	–28.5, 153.4	3	NNW	315	RRHS (1973)
18	Burleigh	–28.5, 153.3	1	SSW	202	Steele (1984)
19	Nudgee	–27.2, 153.5	1	W	270	Steele (1984)
20	Hilliards Creek	–27.3, 153.2	2	E	90	Steele (1984)
21	Tamborine	–27.5, 153.7	1	S	180	Steele (1984)
22	Kippa Ring	–27.1, 153.5	1	SSW	202	Steele (1984)
23	Sandy Creek	–26.5, 152.4	1	S	180	Steele (1984)
24	Wooyung	–28.3, 153.3	1	N	0	Bowdler (2001)
25	Kangaroo Flat	–31.1, 152.1	3	SW	225	Bowdler (2001), AHIMS 03-5-001
26	South Tweed Heads	–28.1, 153.3	3	W	270	Bowdler (2001), AHIMS 04-2-009
27	Bogangar	–28.2, 153.3	2	SW	225	AHIMS 04-2-0133
28	South Grafton	–29.4, 152.6	3	SSE	157	AHIMS 12-6-0115
29	Woolbrook	–30.6, 151.2	1	NW	315	AHIMS 20-6-0022
30	Diamond Flat/Petroi	–31.0, 152.4	1	S	180	AHIMS 21-5-007
31	Ruby Creek	–28.4, 152.1	1	S	180	Towle (1942), AHIMS 03-5-0006
32	Wheatley Creek	–28.5, 152.2	3	WNW	307	AHIMS 03-5-0011
33	Yellow Creek	–28.5, 152.2	1	W	270	AHIMS 03-6-0028
34	Nimbin Brookside	–28.4, 153.1	3	W	270	AHIMS 04-4-0037
35	Dyamberin Station	–30.2, 152.2	3	NNE	22	AHIMS 21-2-0006
36	Yooroonah	–30.3, 152.1	3	NE	45	AHIMS 21-5-0012
37	Timor Dam	–31.3, 149.2	2	W	270	AHIMS 28-2-0002
38	Richardsons Crossing	–31.1, 152.6	3	N	0	AHIMS 30-3-0001
39	Bundook	–31.5, 152.8	2	S	180	AHIMS 30-5-0011
40	Tyalgum	–28.2, 153.1	1	SW	225	Steele (1984)
41	Alberton	–27.4, 153.2	1	S	180	Steele (1984)
42	Amity Point	–27.5, 153.3	1	E	90	Steele (1984)
43	Glenore Grove	–27.3, 152.2	3	SSE	157	Steele (1984)
44	Milbong	–27.5, 152.4	1	S	180	Steele (1984)
45	Cedar Creek	–27.9, 153.2	1	SSE	158	Steele (1984)
46	Kunopia	–29.4, 149.4	1	SW	240	Mathews (1896a)
47	Somerset Dam		1			Satterthwait and Heather (1987)
48	Samsonvale		1			Satterthwait and Heather (1987)
49	Samford		1			Satterthwait and Heather (1987)
50	Canungra		1			Satterthwait and Heather (1987)
51	Kippa Creek		1			Satterthwait and Heather (1987)
52	Mt Esk Pocket		1			Satterthwait and Heather (1987)

Table 1 The bora grounds after filtering the original data through the selection criteria, grouped alphabetically by reference author, followed by the SH data. The coordinates given are approximate and do not reveal the exact location of the site. Data includes the site number, name and location. Also included is the site layout type: Type 1 consists of two circles and a pathway; Type 2 consists of two circles and one opening; and Type 3 consists of one circle and an opening. All orientations are given in terms of cardinal, ordinal or inter-ordinal points measured from the large ring to the small ring, with the specific azimuth given where applicable. Satterthwait and Heather (1987) do not give coordinates or azimuths—only orientations in four quadrants (N, S, E and W).

No.	Site Name	Location	Type	Orientation	Az (°)	Source
53	Camira		1			Satterthwait and Heather (1987)
54	Purga Creek		1			Satterthwait and Heather (1987)
55	Oakey Creek		1			Satterthwait and Heather (1987)
56	Waraba Creek		1			Satterthwait and Heather (1987)
57	Buaraba		1			Satterthwait and Heather (1987)
58	Dayboro West		1			Satterthwait and Heather (1987)
59	Walli Creek		1			Satterthwait and Heather (1987)
60	Upper Coomera River		1			Satterthwait and Heather (1987)
61	Moggill		1			Satterthwait and Heather (1987)
62	Toorbul Creek		1			Satterthwait and Heather (1987)
63	Keperra		1			Satterthwait and Heather (1987)
64	Petrie		1			Satterthwait and Heather (1987)
65	Lowood		1			Satterthwait and Heather (1987)
66	Kipper Creek		1			Satterthwait and Heather (1987)
67	Woolloongabba		1			Satterthwait and Heather (1987)
68	Jerribribillum		1			Satterthwait and Heather (1987)

Table 1 cont. The bora grounds after filtering the original data through the selection criteria, grouped alphabetically by reference author, followed by the SH data. The coordinates given are approximate and do not reveal the exact location of the site. Data includes the site number, name and location. Also included is the site layout type: Type 1 consists of two circles and a pathway; Type 2 consists of two circles and one opening; and Type 3 consists of one circle and an opening. All orientations are given in terms of cardinal, ordinal or inter-ordinal points measured from the large ring to the small ring, with the specific azimuth given where applicable. Satterthwait and Heather (1987) do not give coordinates or azimuths—only orientations in four quadrants (N, S, E and W).

Orientation	Minimum Azimuth	Central Azimuth	Maximum Azimuth	Orientation	Minimum Azimuth	Central Azimuth	Maximum Azimuth
N	348.76	0	11.25	N	337.5	0	22.5
NNE	11.26	22.5	33.75	NE	22.6	45	67.5
NE	33.76	45	56.25	E	67.6	90	112.5
ENE	56.26	67.5	78.75	SE	112.6	135	157.5
E	78.76	90	101.25	S	157.6	180	202.5
ESE	101.26	112.5	123.75	SW	202.6	225	247.5
SE	123.76	135	146.25	W	247.6	270	292.5
SSE	146.26	157.5	168.75	NW	292.6	315	337.5
S	168.76	180	191.25				
SSW	191.26	202.5	213.75				
SW	213.76	225	236.25	N	316	0	45
WSW	236.26	247.5	258.75	E	46	90	135
W	258.76	270	281.25	S	136	180	225
WNW	281.26	292.5	303.75	W	226	270	315
NW	303.76	315	326.25				
NNW	326.26	337.5	348.75				

Table 2 Azimuths of the inter-ordinal (left), ordinal (right top) and cardinal (right bottom) orientations (in degrees) used to bin the data in Figure 4. Each bin in the left-hand column has a width of 22.5° (±11.25°) centred on the central azimuth.

preferred orientation to the celestial emu in the Milky Way in the south-southwest skies. The celestial emu is in this position in the evening sky during the month of August, the time during which Winterbotham (1957) and Needham (1981) claimed that bora ceremonies were held. Hamacher et al. (2012) showed that linear stone arrangements in NSW also have a preferred orientation to the cardinal points, especially north-south orientations. Since many stone arrangements are ceremonial sites, this lends support to the claim that orientation is an important factor utilised by Aboriginal people when laying out ceremonial sites.

Although our analysis supports the Love hypothesis, it is not definitive evidence that bora grounds are oriented to the Sky Bora. Some researchers, including Winterbotham (1957) and Mathews (1894), stated that many bora ceremonies across NSW and Qld were held at various times throughout the year, which do not correspond to any particular orientation of the Milky Way. However, there is strong ethnographic evidence that the Milky Way is associated with the bora ceremony and we consider it likely that at least some ceremonies were timed, and bora sites oriented, such that the vertical Milky Way was visible above the path connecting the two circles. Additional research is necessary to understand these links; we are currently engaged in further research projects to explore this.

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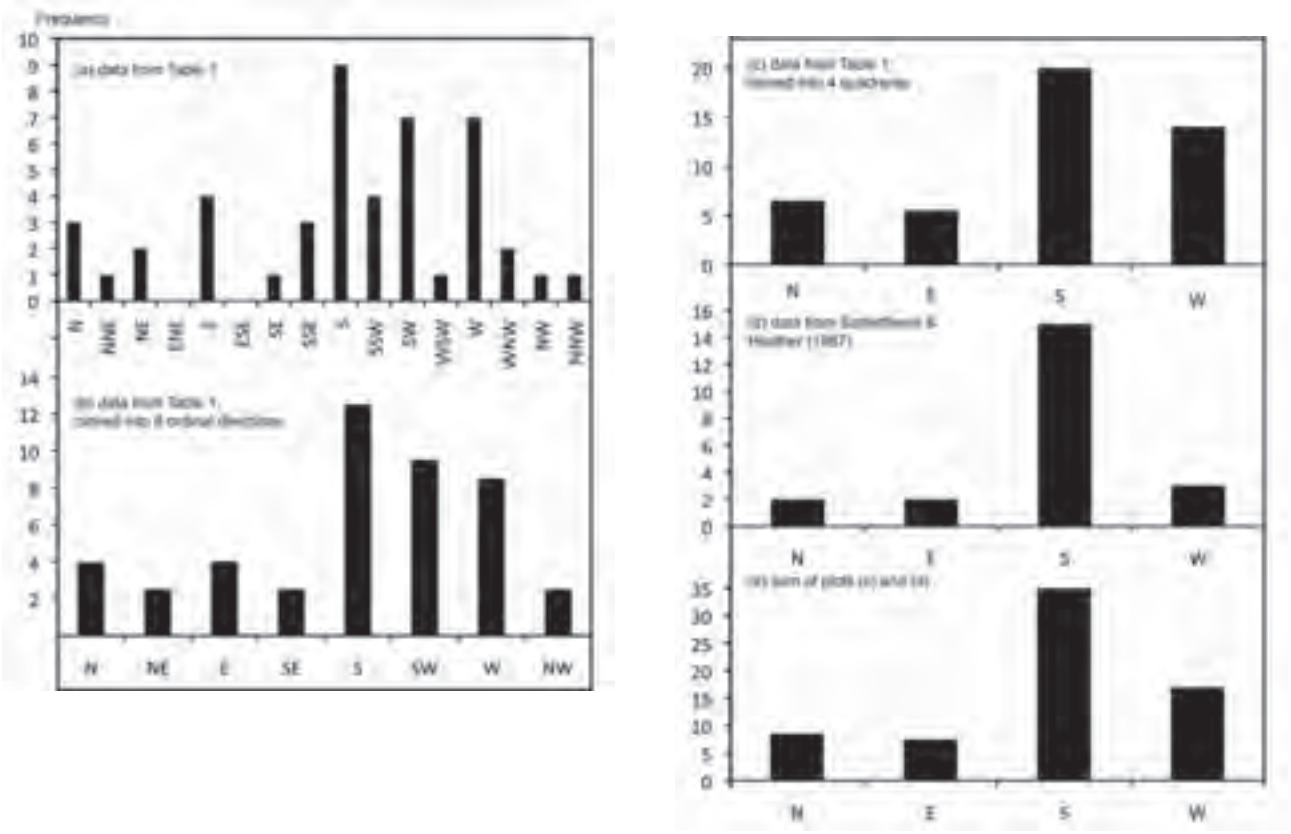

Figure 4 Orientations of bora sites using data from Table 1. Data in (a) are given in 22.5° bins, (b) are given in 45° bins, and (c) through (e) are given in 90° bins.

Environment and Heritage. This research made use of the TROVE and JSTOR databases, Google Maps and the Stellarium astronomical software package. DH conducted his component of this research while a PhD student at Macquarie University, and finished the analysis and writing as a staff member at the University of NSW.

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