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Cultural Evolution of Ritual Practice in Prehistoric Japan: The *Kitamakura* Hypothesis Is Examined

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Various disciplines, including evolutionary biology, anthropology, archaeology, and psychology, have studied the evolution of rituals. Archaeologists have typically argued that burial practices are one of the most prominent manifestations of ritual practices in the past and have explored various aspects of burial practices, including burial directions. One of the important hypotheses on the cultural evolution of burial practices in Japan is the *kitamakura* hypothesis, which claims that burial directions (including Kofuns and current burials) were intended to be oriented toward the north after the Kofun period under the influence of Confucianism or Buddhism. This hypothesis would be more plausible if burial directions were not oriented northward before the Kofun period. This research focused on the burial directions in the northern Kyūshū area of the Yayoi period, i.e., the directions of the *kamekan* jar burials. The results are almost consistent with the hypothesis, although one notable exception is found, and its possible interpretations and implications are discussed.

Keywords
Evolution of ritual; *kamekan* jar burials; Yayoi; archaeology; developmental system drift.

Introduction

The cultural evolution of rituals or ritual practices has been intensively and widely discussed in human evolutionary studies. Many evolutionary biologists, anthropologists, and archaeologists have argued that (especially costly) rituals such as trance dance, food sharing system, and bloodletting have strengthened social cohesion or solidarity and cooperation within the group and have functioned as commitments to the group (e.g., Bulbulia et al, 2013; Henrich, 2009; Munson et al., 2014; Rossano, 2015; Whitehouse, 2021; Whitehouse & Lanman, 2014). Psychologists have also explored the evolved cognitive mechanisms behind rituals and how rituals influence our cognitions and feelings related to group or social cohesion (e.g., Henrich, 2009; Lang et al.,2020; Liénard & Boyer, 2006; Singh et al., 2020). There has been a great deal of attention paid to the cultural evolution of rituals, as they are almost universal to humans (and perhaps were also found in *Homo neanderthalensis* [e.g., Nielsen et al., 2020]) and still play a key role in our daily lives in many ways.

Archaeologically, burial or mortuary practices have been regarded as good examples of ritual practice and one of the most popular topics (e.g., Binford, 1971; Chapman, 2009; Fogelin, 2007; Parker Pearson, 1999; Tarlow & Stutz, 2013; Ucko, 1969). Many relevant studies have examined various aspects of burial practices, such as the formation or configuration of burials and the richness of the grave goods within them. These studies have attempted to interpret such various aspects in terms of social and/or ritual contexts, including hierarchies and kinship of the deceased in Japan as well (e.g., Knopf et al., 2018; Mizoguchi, 2013, 2022; Nakao, 2023, 2024; Nakazono, 2004).

Burial directions have received considerable attention in this context. Japanese archaeologists have explored the social and ritual background of the burial directions, especially in the Jōmon (13,000 cal BC–800 cal BC) and Kofun periods (AD 250–600), and have proposed various hypotheses or interpretations of the directions (e.g., Hojo, 2017; Tsude, 2000; Yamada, 2008). One of the important hypotheses on the cultural evolution of burial practices in Japan is the *kitamakura* hypothesis (*kita* means the north and *makura* the orientation). The hypothesis consists of two claims: (1) the north-facing burial directions in modern Japan are influenced by the cultural and ritual traditions of Confucianism and Buddhism, which were introduced during the Kofun period; (2) The directions of some Kofuns are oriented to the north under the influence of the traditions, and this second claim has been examined with more thorough data (e.g., Hojo, 2017; Tsude, 1989, 2000).

In the present study, the second claim of the *kitamakura* hypothesis was examined by referring to data on burial directions before the Kofun period, i.e., burial directions in the Yayoi period (800 cal BC–AD 250). If burial directions before the Kofun period were not typically north, this hypothesis would be more plausible, although they do not directly support the hypothesis. If they were, then the cultural evolutionary origin of *kitamakura* practice in Japan might not be Confucianism or Buddhism, which is inconsistent with the hypothesis. In fact, some relevant research has argued that burial directions in the Jōmon period were relatively diverse and not necessarily north (e.g., Yamada, 2008). We focused on *kamekan* jar burials, which were common in the northern Kyūshū area from the late Early Yayoi period to the early Late Yayoi period. They are usually divided into five types: KI, KII, KIII,

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KIV, and KV, typically with subtypes from a to c, such as KIa, KIIb, and KIIIc. The typology depends mostly on the shapes of the rims and bodies (e.g., Hashiguchi, 2005; Nakagawa et al., 2021). The present study focused on and investigated the directions of the *kamekan* jar burials found mainly in the Fukuoka Prefecture, as the excavations in the northern Kyūshū area of the Yayoi period were more thorough than those in other areas, and the *kamekan* jar burial data could provide a good example of burials in the Yayoi period. In addition, archaeological research on burial directions in the Yayoi period has been more limited and less systematic than in the Jōmon or Kofun periods in Japanese archaeology. Thus, this study could contribute to both cultural evolutionary and archaeological research.

The results suggest that many *kamekan* jar burial axes were not oriented to the north–south axis, which is consistent with the *kitamakura* hypothesis. However, *kamekan* jar burials in the Sawara region tended to be aligned with the north–south axis. Possible interpretations and implications of the results will be discussed.

Methods

Data set

We obtained directional information on *kamekan* jar burials in the targeted regions from published excavation reports. We collected data from 88 sites, which included 2,838 *kamekan* jar burials. The present study focused on the *kamekan* jar burials from the Fukuoka Prefecture, i.e., the Sawara, Fukuoka, Mikuni, and Asakura regions (see Nakagawa et al., 2021, for the regional information), because the jar burials were most commonly used in these regions. Detailed information on the data is summarized in Supplementary Material S1. To examine burial practices at each site, we collected *kamekan* directional information from sites with more than 10 jar burials excavated (62 sites and areas). Because the Kuma-Nishioda (No. 22) and Yoshitake (No. 58) sites were relatively larger and contained more burials, they were divided into some independent areas (see Figure 1 and Table 1 for the detailed information).

Note that the directional information of the *kamekan* jar burial must be *axial* (e.g., Fisher, 1993; Mardia & Jupp, 1999). When human skeletal remains are found within burials, the direction of the dead can sometimes be inferred. However, relatively many skeletal remains have been found in the northern Kyūshū area (e.g., Nakagawa et al., 2017; Nakao et al., 2023), although many burials did not include skeletal remains. Even if skeletal remains are included, their original configurations are rarely preserved because the *kamekan* jar burials were sometimes tilted significantly. Furthermore, *kamekan* jar burials of some types (especially KIIa to KIIc types) were typically used in combination (see Figure 2). Therefore, it is often difficult to decide which jar the head was located in, and so their directions should be considered axial, i.e., θ_A and θ_B in Figure 2 are regarded as the same. To handle the axial data, we have to double all the *kamekan* directions because if $\theta_B = \theta_A + 180°$, then $2\theta_B = 2\,(\theta_A + 180°) = 2\theta_A + 360° = 2\theta_A$ (Fisher, 1993).

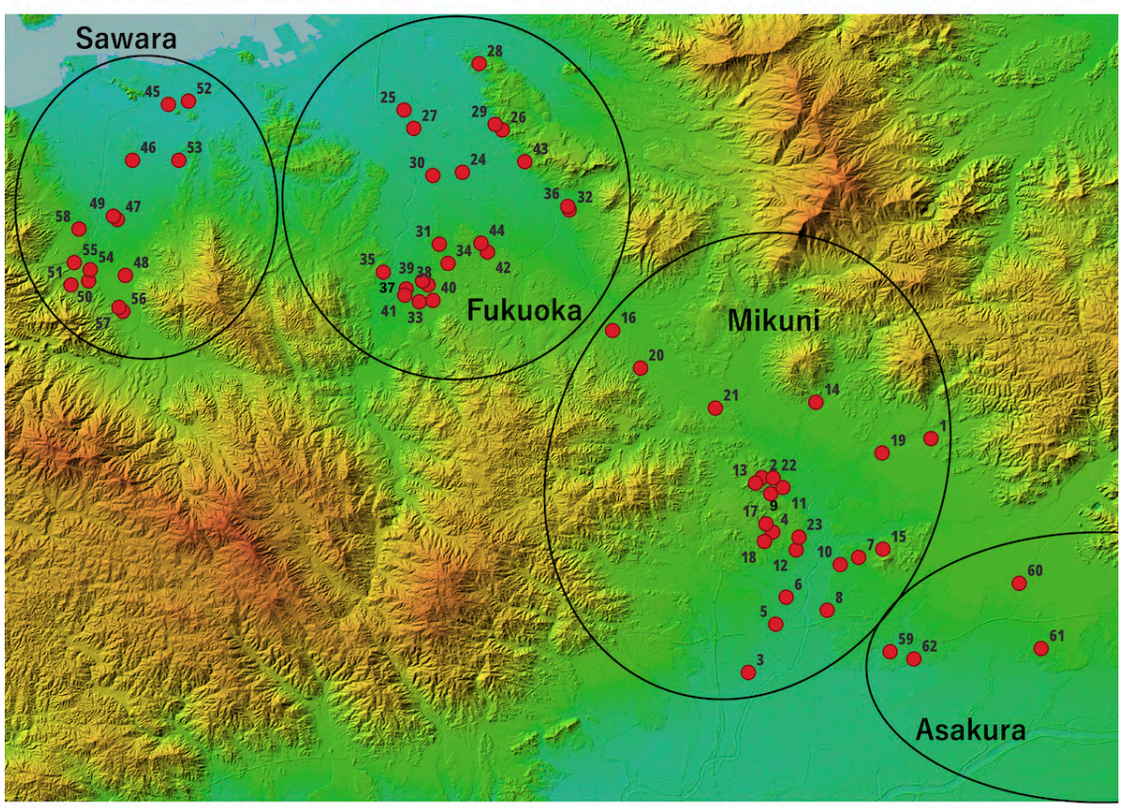

Figure 1. Site locations where the number of the *kamekan* jar burials is more than 10. The number of each site corresponds to the Table 1. The map is based on the color altitude map published by Geospatial Information Authority of Japan with information of the sea area from the Hydrographic and Oceanographic Department, Japan Coast Guard, and modified by HN using QGIS (3.20.3, QGIS Development Team, 2021).

Table 1. Summary of the *kamekan* directional information and the results of Rayleigh tests on the directions from each site.

Regions	Sites or areas	N	Mean	Rayleigh tests		
				p	$\bar{R}_0$	$^{**}p < .01$ $^{*}p < .05$
Mikuni	01. Kotonomiya	38	46.26	.5542	−0.0157	
	02. Ikenoue	11	−68.65	.9782	−0.4277	
	03. Terafukudo	17	−26.45	.0193	0.3529	*
	04. Mikuninohana	22	−22.795	.2488	0.1030	
	05. Oitai	40	−80.4	.8408	−0.1119	
	06. Ohoyokomakura	11	−1.264	.0099	0.4894	**
	07. Hikata	27	84.9	.9756	−0.2675	
	08. Inouekitauchihara	20	−72.55	.7770	−0.1214	
	09. Tsukohigashimiyabaru	10	78.75	.8816	−0.2672	
	10. Hikata Shimoyashiki	13	87.6	.8541	−0.2087	
	11. Tsukosoramae	19	2.6495	.0000	0.6174	**
	12. Yokokumakamiuchihata	13	50.45	.5376	−0.0188	
	13. Tsukomuta	46	−75.4	.9139	−0.1425	
	14. Yamae Area 3	10	69.3	.9991	−0.6638	
	15. Shiroyama	13	62.3	.9935	−0.4795	
	16. Kenzuka	14	42.36	.4169	0.0402	
	17. Hasakonomiya	27	12.85	.0004	0.4683	**
	18. Kitamuta	11	41.5	.4264	0.0402	
	19. Oki	48	76.55	.9958	−0.2672	
	20. Dojoyama	26	70.4	1.0000	−0.5338	
	21. Nagaoka	30	−25.88	.0010	0.3933	**
	22. Kuma-Nishioda Area 10	134	−34.3	.0513	0.0997	
	22. Kuma-Nishioda Area 2	325	−88.15	1.0000	−0.3816	
	22. Kuma-Nishioda Area 3	82	−86.85	.9360	−0.1189	
	22. Kuma-Nishioda Area 5	20	16.94	.0836	0.2191	
	22. Kuma-Nishioda Area 6	53	−66.9	.9935	−0.2403	
	22. Kuma-Nishioda Area 7	25	−56.55	.8875	−0.1723	
	22. Kuma-Nishioda Area 8	31	−8.4	.1744	0.1195	
	23. Yokogumakitsunezuka	133	39.925	.4347	0.0101	
Fukuoka	24. Morooka	22	−58.2	.6129	−0.0436	
	25. Hie	35	89.1	.9987	−0.3553	
	26. Kamitsukiguma	19	82.75	.9444	−0.2588	
	27. Naka	85	−70	.8884	−0.0935	
	28. Mushirodaaoki	27	23.53	.0816	0.1903	
	29. Shimotsukikuma Tenjinmori	35	−58.95	.8848	−0.1437	
	30. Ijiri B	10	17.89	.1517	0.2330	
	31. Yanagahara	19	50.3	.5489	−0.0202	
	32. Morizono	19	−53.6	.7895	−0.1315	
	33. Nakabarutonomoto	30	−79.75	.9960	−0.3390	
	34. Teradaike Kita	22	−45.23	.5148	−0.0056	
	35. Kannondo	43	39.94	.3059	0.0549	
	36. Naka-Terao	13	−72.1	.0000	−0.6958	
	37. Muneishi	22	−36.325	.2001	0.1276	
	38. Monden	25	89.1	.9997	−0.4695	
	39. Monden-tsujita	10	84.1	.9269	−0.3268	
	40. Haru	14	−2.399	.0022	0.5252	**
	41. Matsuki	29	−3.0595	.0000	0.7916	**
	42. Nishitairazuka	18	86.8	.9525	−0.2785	
	43. Kanenokuma	32	5.875	.0006	0.3974	**
	44. Hakugensha	17	49.755	.6761	−0.0792	

Table 1. (Continued)

Regions	Sites or areas	N	Mean	Rayleigh tests		
				p	$\bar{R}_0$	$^{**}p < .01$ $^{*}p < .05$
Sawara	45. Fujisaki	77	−5.585	.0462	0.1356	*
	46. Arita-Kotabe	39	20.98	.0118	0.2554	*
	47. Tamura	10	−46.07	.5329	−0.0188	
	48. Higashiirube	120	3.6025	.0000	0.6219	**
	49. Iikurakaraki	26	−17.51	.0001	0.5171	**
	50. Uraedani	29	18.65	.0152	0.2831	*
	51. Kuroto A	33	21.885	.0037	0.3267	**
	52. Nishijinmachi	12	−7.68	.0032	0.5440	**
	53. Harahigashi	19	2.721	.0001	0.5886	**
	54. Urae	17	2.5215	.0000	0.8985	**
	55. Shirota	18	20.88	.1421	0.1796	
	56. Matsukida	20	−1.8135	.0000	0.8784	**
	57. Kishida	42	0.937	.0000	0.8065	**
	58. Yoshitake (LM area)	46	34.785	.0979	0.1351	
	58. Yoshitake (MN area)	43	72.7	.9998	−0.3763	
	58. Yoshitake (Oishi area)	36	45.175	.5108	−0.0032	
	58. Yoshitake (Branch line No.2)	17	79.85	.9991	−0.5207	
	58. Yoshitake (IV area, 1st)	25	22.18	.0114	0.3201	*
	58. Yoshitake (Hiwatashi mound burial)	17	−19.115	.0023	0.4767	**
	58. Yoshitake (Nokata-Kanatake area)	43	66.95	.9249	−0.1554	
Asakura	59. Takaetsuji	35	46.965	.6413	−0.0435	
	60. Kamikawahara	19	−81.4	.9881	−0.3641	
	61. Kuriyama	62	87.05	.9973	−0.2488	
	62. Kocho Jinja	14	84.5	.9997	−0.6185	

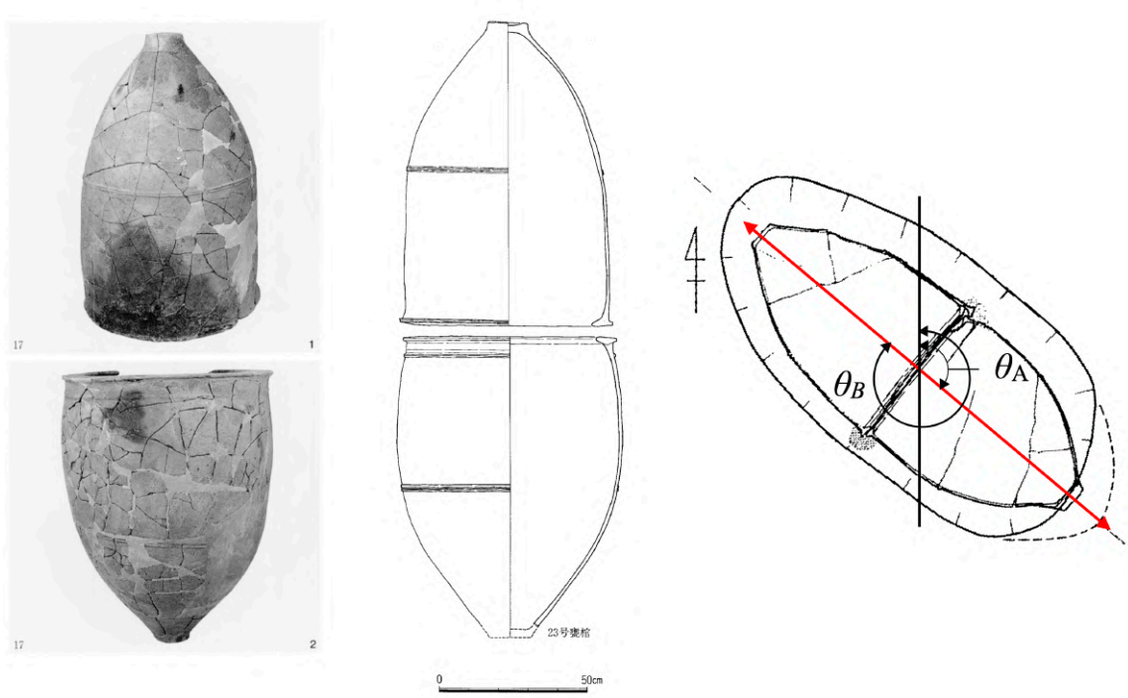

Figure 2. *Kamekan* jar burials from the Shimotsukiguma Tenjinmori site (KIIb type, No. 23) and the Morizono site (KIIb type, SJ07). *Kamekan* jar burials (especially KIIa to KIIc types, from the early Middle Yayoi period) were typically used in combination.

Data analysis

We performed the Rayleigh test on the axial information of the *kamekan* jar burials from the 62 sites and areas to investigate whether the burial axial data corresponded to the north–south axis. The Rayleigh test aims to detect directional bias; the null hypothesis is that the directional data have a uniform (generally von Mises) distribution (e.g., Fisher, 1993; Mardia & Jupp, 1999). As argued, because the directional data of this study should be axial, each direction is doubled. To test the *kitamakura* hypothesis, 0° is used as the specified mean direction in the alternative hypothesis of the Rayleigh test. If the *kitamakura* custom was introduced in the Kofun period, burial axes in the Yayoi period would not typically correspond to the north–south axis.

All statistical analyses were performed using R (version 4.2.1; R Core Team, 2020), with the circular package (version 0.5–0, Agostinelli & Lund, 2023) and Rstudio (2022.07.0+548, RStudio Team, 2020).

Results

The results of the Rayleigh test are summarized in Table 1. The *p*-value was calculated on the basis of the sample size and $\bar{R}_0$ (= $\bar{R}\cos(\theta - \mu_0)$, where $\bar{R}$ is the mean resultant length and μ_0 is the specified mean direction in the alternative hypothesis (i.e., 0° in the present study)) (Fisher, 1993). We found statistically significant results ($p < .05$) in 5 out of 29 sites (= 17.2%) in the Mikuni region, 3 out of 21 sites (= 14.3%) in the Fukuoka region, 13 out of 20 sites (= 65%) in the Sawara region, and 0 out of 4 sites (= 0%) in the Asakura region. These results suggest that the *kamekan* jar burials from many sites in the northern Kyūshū area of the Yayoi period were not aligned with the north–south axis, except in the Sawara region. The mean axial directions of each site are also described in Figure 3, which visually supports that the *kamekan* jar burial axes in the Mikuni, Fukuoka, and Asakura regions did not correspond to the north–south axis.

Discussion

The results in the Mikuni, Fukuoka, and Asakura regions are almost consistent with the *kitamakura* hypothesis. As expected, the *kamekan* jar burial directions from many sites in the three regions were not oriented toward the north–south axis. It should be noted, however, that many sites in the Sawara region oriented their burials to the north–south axis.

It might not be impossible to interpret that the sites of the Sawara region had already adopted a similar practice to the *kitamakura* custom from continental East Asia because the region is the closest to continental East Asia and the Yoshitake sites were the most prosperous in the earlier period (i.e., the Early Yayoi period) than other regions, including the Fukuoka region, which was the most well-off after the late Middle Yayoi period. However, this interpretation has some drawbacks. First, the *kamekan* jar burial directions from the Yoshitake sites do not always correspond to the north–south axis (see Table 1, especially the mean directions). Second, alternative interpretations are possible. Maikuma (2024) suggests that many burial directions were aligned with geographical conditions. Large parts of the Sawara region were formed by the

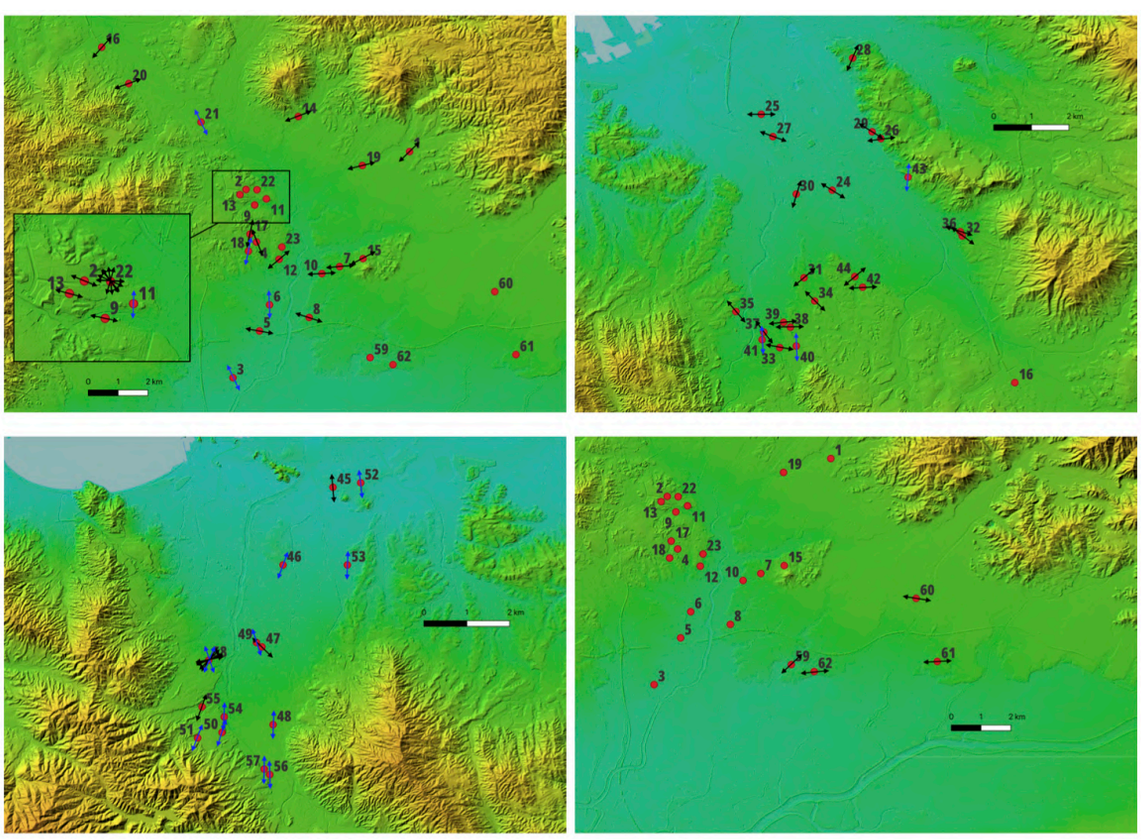

Figure 3. Mean directions of each site are described. Blue axes mean statistically significant results in the Rayleigh test are found at the sites. The number of each site corresponds to the Table 1.

Muromi River, which runs from the south to the northern Genkai Sea. It is also suggested that the geography around the Yoshitake sites was formed by the Hinata River, which flows from the southwest to the northeast (Fukuoka City Board of Education, 1988). It is possible that such geographical conditions influenced the *kamekan* jar burial directions in the Sawara region.

If the *kamekan* jar burial directions correspond to the geographical conditions and many sites from the Sawara region oriented their burials to the north–south axis, and this was not due to the *kitamakura* custom, it is possible that the modern burial *kitamakura* practice mixed different ritual practices in its cultural evolutionary process. In other words, more diverse and less systematic ritual practices in the Yayoi period may have been strengthened and/or integrated in some areas via the transmission of Confucianism or Buddhism from continental East Asia after the Kofun period.

We could also say that the burial practice itself orienting the burials to the north in the Sawara region did not change, although the background ritual beliefs were different in the different periods. Similar types of evolutionary processes or changes are sometimes observed in biological evolution. Homologous characters in different species sometimes evolve with background developmental systems changing, although the characters themselves are stable (a phenomenon called 'developmental system drift [Haag & True, 2018; True & Haag, 2001]). The burial practice, depending on the geographical conditions in some regions, might have evolved with a background system (i.e., a kind of developmental 'cultural' system) drifting such as the introduction of the *kitamakura* belief.

Some limitations of this study should be mentioned. As argued, the *kamekan* jar burials could be a good example of burial practices in the Yayoi period, but more thorough research on larger regions or areas, including the Kinki, Sanin, and other areas, is needed. If we include the data from other regions and they show that many burial directions are north facing, it is possible that the *kitamakura* custom emerged in and was diffused from the targeted regions. It should be noted that because burials found in these areas were typically placed on a square mound surrounded by a moat, we should carefully compare them with *kamekan* jar burials.

If the *kitamakura* custom was accompanied by the introduction of Confucianism or Buddhism in the Kofun period and influenced the directions of some Kofuns, the degree to which burial directions were oriented to the north after the Kofun period could be a proxy for the cultural impacts or evolutionary functions of the religion on group cohesion. In fact, the introduction of systematic religions such as Buddhism and their impact on human society and behavior is evolutionarily critical, as recent evolutionary research has enthusiastically focused on how the cultural evolution of 'moralizing gods' affected the evolution of human cooperation and societies (e.g., Lang et al., 2019). In exploring the degree of impact, variations in burial directions before the Kofun period would provide a standard for comparison.

Conclusion

The present study investigated the axial directions of *kamekan* jar burials in the northern Kyūshū area of the Yayoi period to test the *kitamakura* hypothesis on the cultural evolution of burial practices in Japan. The results suggest that the burial axes in many regions of the study area were not aligned with the north–south axis, which is almost consistent with the hypothesis. One notable exception is found in the Sawara region, which is similar to developmental system drift in some ways.

Acknowledgments

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Author contribution

Both authors designed the research and wrote the original draft. MM gathered the data. Both authors edited and approved the final manuscript.

Ethical statement

This study did not use any living materials.

Supplementary material

Electric Supplementary Material S1 is available online.

References

Agostinelli, C. & Lund, U. (2023). *R package 'circular': Circular Statistics (version 0.5-0)*. https://CRAN.R-project.org/package=circular

Binford, L. R. (1971). Mortuary practices: Their study and their potential. *Memoirs of the Society for American Archaeology*, *25*, 6–29. https://doi.org/10.1017/S0081130000002525

Bulbulia, J., Geertz, A. W., Atkinson, Q. D., Cohen, E., Evans, N., François, P., Gintis, H., Gray, R. D., Henrich, J., Jordan, F. M., Norenzayan, A., Richerson, P. J., Slingerland, E., Turchin, P., Whitehouse, H., Widlok, T., & Wilson, D. S. (2013). The cultural evolution of religion. In P. J. Richerson & M. H., Christiansen (Eds.), *Cultural evolution: Society, technology, language, and religion* (pp. 381−404). Cambridge University Press. https://doi.org/10.7551/mitpress/9780262019750.003.0020

Chapman, R. (2009). *The archaeology of death*. Cambridge University Press.

Fisher, N. I. (1993). *Statistical analysis of circular data*. Cambridge University Press. https://doi.org/10.1017/CBO9780511564345

Fogelin, L. (2007). The archaeology of religious ritual. *Annual Review of Anthropology*, *36*, 55–71. https://doi.org/10.1146/annurev.anthro.36.081406.094425

Fukuoka City Board of Education. (1988). *Yoshitake iseki gun* [Yoshitake sites]. Fukuoka City.

Haag, E. S. & True, J. R. (2018). Developmental system drift. In L. Nuño, G. B. de la Rosa, and G. Müller (Eds.), *Evolutionary developmental biology: A reference guide* (pp. 99–110). Springer.

Hashiguchi, T. (2005). *Kamekan to Yayoi jidai nendai ron* [*Research on kamekan jar burials and absolute dates of the Yayoi period*]. Yuzankaku.

Henrich, J. (2009). The evolution of costly displays, cooperation and religion: Credibility enhancing displays and their implications for cultural evolution. *Evolution and Human Behavior*, *30*(4), 244–260. https://doi.org/10.1016/j.evolhumbehav.2009.03.005

Hojo, Y. (2017). *Kofun no hōi to taiyō* [Directions of kofuns and the sun]. Doseisha.

Knopf, T., Steinhaus, W., & Fukunaga, S. (Eds.). (2018). *Burial mounds in Europe and Japan: Comparative and contextual perspectives*. Archaeopress. https://doi.org/10.2307/j.ctv1228gf7

Lang, M., Krátký, J., & Xygalatas, D. (2020). The role of ritual behaviour in anxiety reduction: An investigation of Marathi religious practices in Mauritius. *Philosophical Transactions of the Royal Society B*, *375*, Article 20190431. https://doi.org/10.1098/rstb.2019.0431

Lang, M., Purzycki, B. G., Apicella, C. L., Atkinson, Q. D., Bolyanatz, A., Cohen, E., Handley, C., Klocová, E. K., Lesorogol, C., Mathew, S., McNamara, R. A., Moya, C., Placek, C. D., Soler, M., Vardy, T., Weigel, J. L., Willard, A. K., Xygalatas, D., Norenzayan, A., & Henrich, J. (2019). Moralizing gods, impartiality and religious parochialism across 15 societies. *Proceedings of the Royal Society B*, *286*, Article 2019202. https://doi.org/10.1098/rspb.2019.0202

Liénard, P. & Boyer, P. (2006). Whence collective rituals? A cultural selection model of ritualized behavior. *American Anthropologists*, *108*(4), 814−827. https://doi.org/10.1525/aa.2006.108.4.814

Maikuna, M. (2024). Kamekanbo no hōko no kisokusei nitsuite [Directions of the kamekan jar burials] [Unpublished master's thesis]. Nanzan University.

Mardia, K. V. & Jupp, P. E. (1999). *Directional statistics*. Wiley. https://doi.org/10.1002/9780470316979

Mizoguchi, K. (2013). The archaeology of Japan: From the earliest rice farming villages to the rise of the state. Cambridge University Press. https://doi.org/10.1017/CBO9781139034265

Mizoguchi, K. (2022). *Shakai kōkogaku kōgi: Komyunikēshon o bunseki saishō tan'i to suru kōkogaku no saihen* [Lectures on social archaeology: Reorganizing archaeology bases on a minimal unit of communication]. Doseisha.

Munson, J., Amati, V., Collard, M. & Macri, M. J. (2014). Classic Maya bloodletting and the cultural evolution of religious rituals: Quantifying patterns of variation in Hieroglyphic texts. *PLoS ONE*, Article e107982. https://doi.org/10.1371/journal.pone.0107982

Nakagawa, T., Nakao, H., Tamura, K., Arimatsu, Y., Matsumoto, N., & Matsugi, T. (2017). Violence and warfare in the prehistoric Japan. *Letters on Evolutionary and Behavioral Science*, *8*(1), 8–11. https://doi.org/10.5178/lebs.2017.55

Nakagawa, T., Tamura, K., Yamaguchi, Y., Matsumoto, N., Matsugi, T., & Nakao, H. (2021). Population pressure and prehistoric violence in the Yayoi period of Japan. *Journal of Archaeological Science*, *132*, Article 105420. https://doi.org/10.1016/j.jas.2021.105420

Nakao, H. (2023). Cultural identity and intergroup conflicts: Testing parochial altruism model through archaeological data. *Annals of the Japan Association for Philosophy of Science*, *32*, 75–87. https://doi.org/10.4288/jafpos.32.0_75

Nakao, H. (2024). Yayoi jidai chūki hokubu Kyūshu ogata kamekan no daen hurie kaiseki: Kamekan keijō no jikūkan hendō ni tsuite [An elliptic fourier analysis of Kamekan jar burials from the northern Kyūshū area in the Middle Yayoi period: Spatiotemporal variations of Kamekan shapes] [Unpublished manuscript].

Nakao, H., Nakagawa, T., Kaneda, A., Noshita, K., & Tamura, K. (2023). Demic diffusion of the Yayoi people in the Japanese archipelago. *Letters on Evolutionary and Behavioral Science*, *14*(2), 58–64. https://doi.org/10.5178/lebs.2023.111

Nakazono, S. (2004). *Kyūshū Yayoi bunka no tokushitsu* [The nature of the Yayoi culture in the Kyushu]. Kyushu University Press.

Nielsen, M., Langley, M. C., Shipton, C., & Kapitány, R. (2020). *Homo neanderthalensis* and the evolutionary origins of ritual in *Homo sapiens*. *Philosophical Transactions of the Royal Society B*, *375*, Article 20190424. https://doi.org/10.1098/rstb.2019.0424

Parker Pearson, M. (1999). *The archaeology of death and burial*. Sutton Publishing Ltd.

R Core Team. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

QGIS Development Team (2021). *QGIS geographic information system*. Open Source Geospatial Foundation Project. https://qgis.org/en/site/

Rossano, M. (2015). The evolutionary emergence of costly rituals. *PaleoAnthropology, 2015*, 78–100.

RStudio Team. (2020). *RStudio: Integrated development for R*. RStudio, PBC, Boston, MA. https://www.rstudio.com/

Singh, P., Tewari, S., Kesberg, R., Kari, J. A., Bulbulia, J., & Fischer, R. (2020). Time investments in rituals are associated with social bonding, affect and subjective health: A longitudinal study of Diwali in two Indian communities. *Philosophical Transactions of the Royal Society B*, *375*, Article 20190430. https://doi.org/10.1098/rstb.2019.0430

Tarlow, S. & Stutz, L. N. (Eds.). (2013). *The oxford handbook of the archaeology of death and burial*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199569069.001.0001

True, J. R. & Haag, E. S. (2001). Developmental system drift and flexibility in evolutionary trajectories. *Evolution and Development*, *3*(2), 109–119. https://doi.org/10.1046/j.1525-142x.2001.003002109.x

Tsude, H. (1989). Zenpō kōen fun no tanjō [The birth of the keyhole-shaped mounds]. In T. Shiraishi (Ed.), *Kofun: Kodai o kangaeru* (pp. 1–35). Yoshikawa Kobunkan.

Tsude, H. (2000). *Ōryō no kōkogaku* [Archaeology of imperial monuments]. Iwanami Shoten.

Ucko, P. J. (1969). Ethnography and archaeological interpretation of funerary remains. *World Archaeology*, *1*(2), 262–280. https://doi.org/10.1080/00438243.1969.9979444

Whitehouse, H. (2021). *The ritual animal: Imitation and cohesion in the evolution of social complexity*. Oxford University Press. https://doi.org/10.1093/oso/9780199646364.001.0001

Whitehouse, H. & Lanman, J. A. (2014). The ties that bind us: Ritual, fusion, and identification. *Current Anthropology*, *55*(6), 674−695. https://doi.org/10.1086/678698

Yamada, Y. (2008). *Jinkotsu shutsudo rei ni miru Jōmon no bosei to shakai* [Burial practices and society in

the Jōmon period via burials with human skeletal remains]. Doseisha.