SA-HUYNH-KALANAY TRADITION OF SOUTHEAST ASIAN DECORATED POTTERY—CONFIRMED BY STATISTICAL ANALYSIS, BUT IF NOT, HOW NOT?

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ABSTRACT

W.G. Solheim II proposed the concept of a "Sa-Huynh-Kalanay pottery tradition" to cover Southeast Asian decorated-pottery repertoires older than AD 1000. This concept sprang from Solheim's perception of similarities between Sa-Huynh-culture sites in central Vietnam and Kalanay-complex sites of the central Philippines in their decorated pottery, similarities generically shared with the pottery from many other prehistoric sites across Mainland and especially Island Southeast Asia. To investigate these ideas, the author studied 141 repertoires (sites, site periods and site complexes) of Southeast Asian decorated pottery and assigned their described motifs to 84 different elements. I then joined similar repertoires into synthetic repertoires and, after the repertoires had all joined into a single super-synthetic repertoire, seriated the repertoires while splitting them in the reverse order in which they had joined. This exercise revealed several examples of adjacently seriated repertoires from sites, periods and complexes close to each other in space and time, which can be accepted as decorated-pottery cultures. Otherwise, repertoires that seriated or grouped together tended to be widely dispersed in time and space. Finally, no evidence emerged for the recognition of a Kalanay complex of the central Philippines.

INTRODUCTION

Early studies into decorated earthenware pottery in Southeast Asia (SEA) include the 1920s' description by French colonial archaeologists of Sa Huynh pottery from Central Vietnam, and the 1950s' description by W.G. Solheim II of pottery from Kalanay Cave in the central Philippines. Solheim (1964) recognized sufficient similarities between the decorated pottery from these two sites, and from previously described, Neolithic sites in Peninsular Malaysia (Gua Cha), Sarawak (Niah Caves West Mouth), and Sulawesi (Kamassi and Minanga Sipakko), to propose their incorporation into a "Sa-Huynh-Kalanay pottery tradition". With the subsequent proliferation in the publication of SEA sites with decorated pottery, Solheim expanded his rendition of the Sa-Huynh-Kalanay pottery tradition to include, for instance, the Tabon pottery complex of Palawan (Fox 1970), the Asin Cave pottery of Mindanao (Solheim *et al*. 1979), pottery from Timor-Leste sites (Glover 1986), and even pottery from sites in southern Vietnam, Cambodia, and Northeast Thailand such as Non Nok Tha and Ban Chiang (Solheim 2002). The main indication of which repertoires of decorated pottery in SEA would NOT qualify as belonging to the Sa-Huynh-Kalanay pottery tradition is that they date to after AD 1000, certainly in the Philippines (Solheim 2002: 185). This exclusion criterion can be tested by including repertoires in the analysis that postdate AD 1000, given Solheim's expectation that such repertoires should be distinct from Sa-Huynh-Kalanay repertoires.

The scope is better defined for the eponymous components of the Sa Huynh culture and the Kalanay pottery tradition (or complex). The pottery decorations and associated funerary items from Sa Huynh burial sites in Central and Southern Vietnam, dated to around the BC/AD transition, show a consistency that would allow most or all of them to be attributed to a single "culture" (Solheim 2002; Bellwood 2017; Nguyen 2017; Reinecke 2022). As for the Kalanay pottery tradition, Solheim (2002) provides reasonable detail on which repertoires should be included (all from the Philippines, as a minimal condition) or excluded from this tradition. For instance, the "Kalanay" pottery from Kalanay Cave is included, as is the pottery from Siquijor Site B23, Camotes Site C13, Leyte Site C14, Bohol Site C11, and "Unknown Site" (pp. 65–90), and from Pilanduk and Sa'gung Rockshelter in Palawan in the sense of being "obviously related" (p. 182). However, the "Bagupantao" pottery from Kalanay Cave represents a different tradition, as does the pottery from Calamianes Site C65, Asin Cave, and the Tabon complex, albeit all of them coming under the umbrella of the Sa-Huynh-Kalanay pottery tradition (pp. 57, 121–133, 205, 206).

Solheim's (2002) explanation for the widespread occurrence across SEA, as he perceived it, of the Sa-Huynh-Kalanay pottery tradition was long-distance interaction brokered through Southeast Asia's seafarers or "Nusantao". One predicted effect of this interaction would be for repertoires similar in their location to be more like each other than to repertoires farther afield, because interaction should be most intense over short distances and fade off with distance—as, for instance, with the Kalanay pottery tradition. A second predicted effect would be for repertoires of similar chronology to be more like each other than to repertoires of markedly different antiquity, because interaction is a staged, not an atemporal process. These are the results that Flavel (1997; summarized in Solheim 2006: 214–215) and Bulbeck (2006) obtained from their statistical analyses of Sa-Huynh-Kalanay pottery repertoires. Where Flavel (1997) and Bulbeck (2006) disagreed with each other is that Flavel proposed a mechanism of local agency in the choice of decorative motifs for why geographic integrity of Sa-Huynh-Kalanay pottery repertoires was not particularly strong, in anticipation of Balbaligo's (2015) later analysis of the ceramics from Palawan's Ille Cave which also highlighted variability in ceramic production as an expression of a group's social complexity and cultural identify. Bulbeck (2006), on the other hand, concluded that such local agency was not in evidence until approximately AD 1000.

Favereau and Bellina (2015) point out that the complexity of exogenous influences on decorated pottery at Isthmus of Kra sites in the Thai-Malay Peninsula may prevent simple comparisons from reflecting the breadth of cultural interactions. Nonetheless they identify particular styles of decorations at these sites as reflecting Sa-Huynh-Kalanay influences, and these are the particular motifs analyzed in this contribution as representative of the Isthmus of Kra. Similarly, the decorated pottery from the Central Vietnam site of Buu Chau, as utilized in this study, specifically excludes the designs that reflect Han Chinese influence (Glover *et al*. 1996).

Yamagata and Matsumura (2017) emphasize motif differences between Sa Huynh and Kalanay pottery, whereas the burial site of Hoa Diem, later chronologically than the Sa Huynh sites and located to the south of Sa Huynh, is deemed to show remarkable similarities with Kalanay pottery. Their paper does not challenge the concept of a wide-reaching Sa-Huynh-Kalanay tradition so much as identify a specific Kalanay-related immigration (supported by craniometric comparisons) from Island Southeast Asia (ISEA) to coastal Vietnam in the first century AD.

Flavel (1997) and Bulbeck (2006) focused on contrasting their results with proposals of local pottery cultures identified by a discrete set of decorative motifs exhibited by assemblages within a tightly defined area and time frame. An early example of a claimed culture is Bellwood's (1980, 1997) "Buidane culture", covering sites in the Talaud Islands dating to approximately the first millennium AD, albeit with uncanny

similarities to the pottery from the Unknown Site. However, in his most recent review of the type site of Leang Buidane, Bellwood (2017: 327–328) appears to have dispensed altogether with the notion of a Buidane culture. This latter publication also avoids commentary on the notion of a "Ban Kao" culture, which Bellwood (1997: 265) had identified with the expansion of Neolithic farmers from southern Thailand into Peninsular Malaysia at around 2000 BC. Vietnamese archaeologists have also proposed a considerable number of cultures (not just Sa Huynh) to cover the packaging of Vietnam's decorated pottery into geographically-chronologically defined groups (e.g., Ha Van Tan, 1984–5), while the Ban Chiang culture (White 1982) is a renowned example from Northeast Thailand.

Finally, it may be noted that Solheim's concept of a Sa-Huynh-Kalanay pottery tradition overlaps with Rispoli's (e.g., 2022) concept of an "Incised and Impressed" tradition of decorated earthenware pottery for Neolithic Mainland Southeast Asia (MSEA).

MATERIALS

A total of 141 repertories of decorated pottery from Southeast Asia (Figure 1) were selected for analysis. These include 140 of which the author had become aware up to and including September 2022, and, to address a referee's comments, the belated inclusion of Hoa Diem to see how the affinities of this repertoire fare compared with what would be expected based on the conclusions by Yamagata and Matsumura (2017). The numbers assigned to the repertoires in Figure 1 correspond to the numbers presented for the repertoires' grouping affinities in Tables 2 to 7. A minimum of six decorative elements was specified for inclusion of a repertoire, as this allowed for the inclusion of two repertoires from the Batanes Islands, northern Philippines, which may be important for the analysis in view of these islands' identification as a potential stepping zone in the migration of early Austronesian speakers southward from Taiwan into the Philippines (Bellwood 2017). Most of the repertoires relate to a single site but a minority cover a complex of related sites, when one or more of these sites is of interest to the analysis but does not have the minimum cutoff of six elements, and/or an element is specified for the complex of sites but not for any particular site within it.

After analysis, 18 groups of repertoires could be identified, while nine repertoires could not be authentically grouped. Data sources for the repertoires are presented in six tables in the Results section, where the implications for the groups (and the ungrouped repertoires) are presented.

Regrettably, any confidence in the available dating for the repertoires is often shaky. Solheim (2002) lacked radiometric determinations for any of the assemblages he described and, instead, largely relied on the absence versus the presence of imported, high-fired ceramics to assign assemblages respectively to the first and second millennium AD. Even with the sites excavated in the early days when radiometric dating had become available, but at a high cost, charcoal samples selected for dating were stratigraphically spread thinly, and there was insufficient awareness of the scope for potsherds' post-depositional vertical movement (e.g., Bellwood 1980; White 1982; Glover 1986). In cases like these, a wide chronological band provides the most appropriate level of accuracy, and at least provides greater security than when the archaeologist concerned simply labels an undated site "Neolithic" (e.g., Prasetyo (2008) for Lattibung; Hasanuddin (2018) for Buttu Batu). For Vietnam, radiometric dates for any sites have become available only recently, although in this case the rich assemblages of associated non-ceramic artifacts appear to have facilitated reliable dating (Reinecke 2022).

METHODS

The 84 decorative elements employed here (Table 1; Figure 2) were initiated by Clune (1996) in her analysis of surface collections of decorated pottery from the Makassar hinterland of South Sulawesi, Indonesia. Clune defined 34 elements but some of them were not represented in any of the repertories that she analyzed, and so are available for rebranding. Subsequently, Flavel (1997) added a further 17 elements to

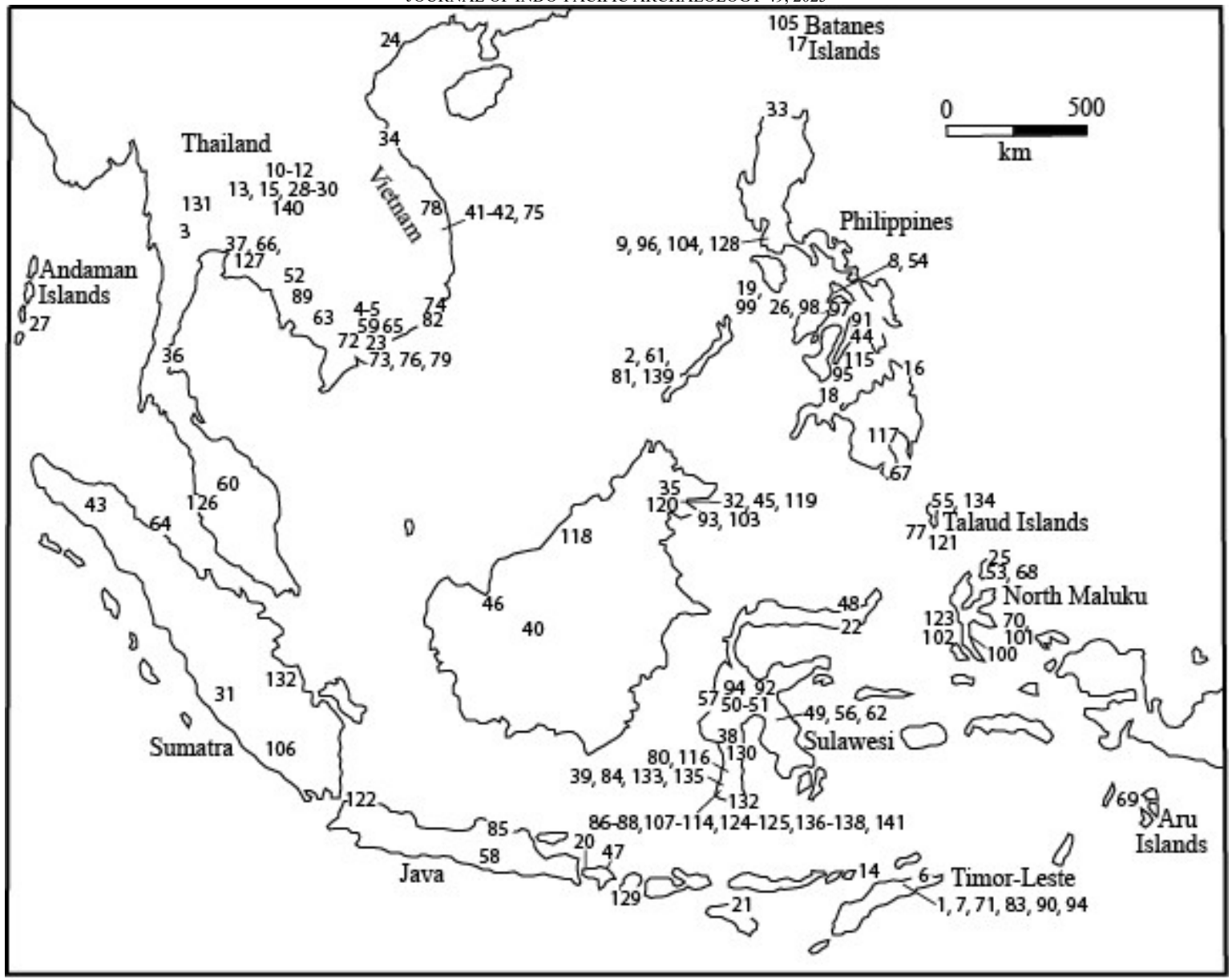

Figure 1. Location of the repertoires used in the analysis (Illustration by author)

Table 1. Decorative elements recognized in this study.

Element No.	Description	Visual reference*	No. repertoires
1.	Cogwheel rim	Bulbeck 1992: Photo 8-13	17
2.	Crosses	Bellina *et al*. 2012: Illustration 5 (#12 mouth)	29
3.	Herring bone	Beaumont *et al*. 2020 Supplementary File 3 OS 4-65	35
4.	Cross hatching	Bellwood 1989: Figure 9 (right lid knob)	66
5.	Vertical incisions	Mahirta 2000: Figure 5, left bottom (neck)	122
6.	Horizontal incisions	Beaumont *et al*. 2020 Supplementary File 4 OS 4-21	137
7.	Triangles	O'Connor *et al*. 2020: Figure 2.7 (b)	66
8.	Zigzag	Bellwood 1989: Figure 9 (left lowest shoulder)	92
9.	Circle	Azis *et al*. 2018: Figure 12.9, top sherd	82
10.	Comma	Beaumont *et al*. 2020 Supplementary File 4 OS 4-34	33
11.	Parallel stipples	Veth *et al*. 2005: Figure 6.13 WM-7-2	102
12.	Leaf	Soegondho 1985: Figure 2, design 25	22
13.	Vertical grooves	Beaumont *et al*. 2020 Supplementary File 4 OS 1-12	48
14.	Symmetrical semi-lunates	Prasetyo 2008: Figure 7.5 (central row, far-left sherd)	10
15.	Piecrust rim	Bellwood 1980: Figure 14 unnumbered left rim upper	56
16.	Serrated rim	Bellwood 2019: Figure 7.8, bottom right rim (Bawuwansi 6)	83
17.	Rectangular impressions	O'Connor *et al*. 2020: Figure 2.7 (a)	33
18.	Hat fretwork	Beaumont *et al*. 2020 Supplementary File 4 OS 5-24	3
19.	Cakra	Hung 2008: 175 (pointillé & punctate stamping)	10
20.	Horizontal raised ridge	Beaumont *et al*. 2020 Supplementary File 3 OS 2-23	76
21.	Slanting diagonals	Soegondho 1985: Figure 3, design 4	106
22.	Radiating lines	Glover *et al*. 1996: Figure 10, top left sherd	23
23.	Chatter marks	Veth *et al*. 2005: Figure 6.14 WM-17-2	88
24.	Keyhole	Sarjeant 2014: Figure 5.17, 09AS Trench 1 B5 Layer 2 Spit 3 sherd (top row of decoration)	12
25.	Waves	Mahirta 2000: Figure 6, central row, far left design	18
26.	Flower	Triwurjani 2018: Gambar 4 (29, left design)	6
27.	Polished band	Sarjeant 2014: Fig.5.16 (09AS Trench 1 A6 Layer 5 spit 6–7 vessel base)	36
28.	Interlocking semi-circles	Mahirta 2000: Figure 6, bottom row, design 2nd from right	16
29.	Appliqué	Beaumont *et al*. 2020 Supplementary File 4 OS 3-07	63
30.	Horizontal grooves	Soegondho 1985: Figure 3, design 3	61
31.	Dashed line	Bellwood 1980: Figure 4 right B1be vessel	23
32.	Half-moons	Bellwood *et al*. 2013 Fig. 6.7 (left lower-central rim)	16
33.	Eyelets in appliqué strap	Kress 1978: Figure 1 (e)	2
34.	Cord-marking	Sarjeant 2014: Fig.5.16 (09AS Trench 1 Layer 5 burial 2 vessel #1)	56
35.	Triangles with diagonal infill	Bellwood 1980: Figure 6 C3d vessel	44
36.	Square maze labyrinth	Bellwood 1980: Figure 14, left top (lid)	20
37.	Triangles with vertical infill	Soegondho 1985: Figure 2, design 21	7
38.	Wavy *Arca* shell impressions	Bellina *et al*. 2012: Illustration 6 (Khao Sam Kaeo 7 sherd, shoulder)	36
39.	Scalloping	Bellwood 1989: Figure 11 (surface lid sherds)	51
40.	Squares with infilled incised lines/punctate background	Flavel 1997: Figs 3.4, 3.6	8
41.	Punctate-filled curvilinear shapes	Bellwood 1980: Figure 18, Box-like vessel	27
42.	Locked semi-circles with punctate background	Flavel 1997: Fig. 3.4	1
43.	Punctate-filled triangle	Hasanuddin 2018: Figure 11.10, Combination Motif 7	37
44.	Infilled rectangular maze	Bellwood 1989: Figure 9 (pedestal, right-central sherd)	12

Table 1 (cont.). Decorative elements recognized in this study.

Element No.	Description	Visual reference*	No. repertoires
45.	Punctate piercing fields	O'Connor *et al*. 2020: Figure 2.7 (d)	73
46.	Interlocking Z's	Bellwood *et al*. 2013 Fig. 6.7 (top right rim)	4
47.	Fretwork of paired struts	Bellwood 1980: Figure 4, B1be vessels	2
48.	Square maze fretwork	Bellwood 1980: Figure 6 C1d vessel	33
49.	Carved paddle impressions	Bellwood 1980: Figure 5 B2f partial vessel	27
50.	Interlocking waves	Bellwood 1980: Figure 8 F1ad partial vessel	33
51.	Radiating X motif	Beaumont *et al*. 2020 Supplementary File 3 OS 1-21	13
52.	Incised diamonds	Sarjeant 2014: Figure 9.10 (bottom photo, top row, central sherd)	35
53.	Ellipse	Soegondho 1985: Figure 3, design 10	26
54.	Concentric semi-circles	Beaumont *et al*. 2020 Supplementary File 4 OS 4-69	43
55.	Tick variants	Soegondho 1985: Figure 2, design 34 (left)	18
56.	Feathered arrow	Beaumont *et al*. 2020 Supplementary File 4 OS 2-36	17
57.	Cross in a box	Bellwood 1980: Figure 5 B2d vessel	9
58.	Cord-marked/paddle-impressed net	Sarjeant 2014: Fig. 4.72 (Trench 2, Burial 2, Pot)	52
59.	Curvilinear comb	Soegondho 1985: Figure 2, design 33	29
60.	Looping/diverging scrolls	Veth *et al*. 2005: Figure 6.14 WM-16-13	21
61.	Chain of semi-circles	Mahirta 2000: Figure 6, bottom row, central design	39
62.	Star	Soegondho 1985: Figure 3, design 5	10
63.	Reflected waves	Mahirta 2000: Figure 6, bottom row, central-left design	6
64.	Bull figurine/appliqué	White 1972: Catalogue Nos. 47–50	4
65.	Pock marks	Beaumont *et al*. 2020 Supplementary File 4 OS 2-37	35
66.	Arches	White 1982: Catalogue No. 23	5
67.	Field of connected triangles	Ono *et al*. 2018a: Figure 15.4 (B)	37
68.	Banner of flags	Soegondho 1985: Figure 2, design 17	15
69.	Relief curvilinear	Bellina *et al*. 2012: Illustration 4 (Tham Tuay 7 neck sherd)	16
70.	Rectangular panels	Bellwood 1980: Figure 6 C1d partial vessel (shoulder)	36
71.	Chain of dots	Beaumont *et al*. 2020 Supplementary File 4 OS 5-29	45
72.	Irregular corrugations	Kress 1978: Fig. 10g	18
73.	Looping grooves/incisions	Beaumont *et al*. 2020 Supplementary File 3 OS 3-75	63
74.	Large circle	Bellwood 1980: Figure 7 C3d partial vessel	13
75.	Steep roulette zigzag	Sarjeant 2014: 273 (fine zigzag roulette Trench 1 layer 3 example)	10
76.	Miscellaneous polygons	Triwurjani 2018: Gambar 4 (24, right design)	18
77.	Fruit motif	Tjoa-Bonatz 2009: Fig. 9-12	7
78.	Anthropomorph	Ono *et al*. 2018a: Figure 7B/D	14
79.	Barbed wire	Bellwood 2019: Figure 7.7, top partial pot (Bawuwansi 3)	11
80.	Bird figurine	Kress 1978: Figure 2 (c–e)	9
81.	Miscellaneous mammal figurine	Bellwood 2019: Figure 7.8, lower central sherd (Bawuwansi 6)	6
82.	Turtle-shell impressions	Ono *et al*. 2018a: Figure 5	2
83.	Lizard figurine	Ono *et al*. 2018a: Figure 5	2
84.	Script	Main & Fox 1982: Fig. 8	5

*Open sources accessible through internet search preferred where available; for others, see Figure 2.

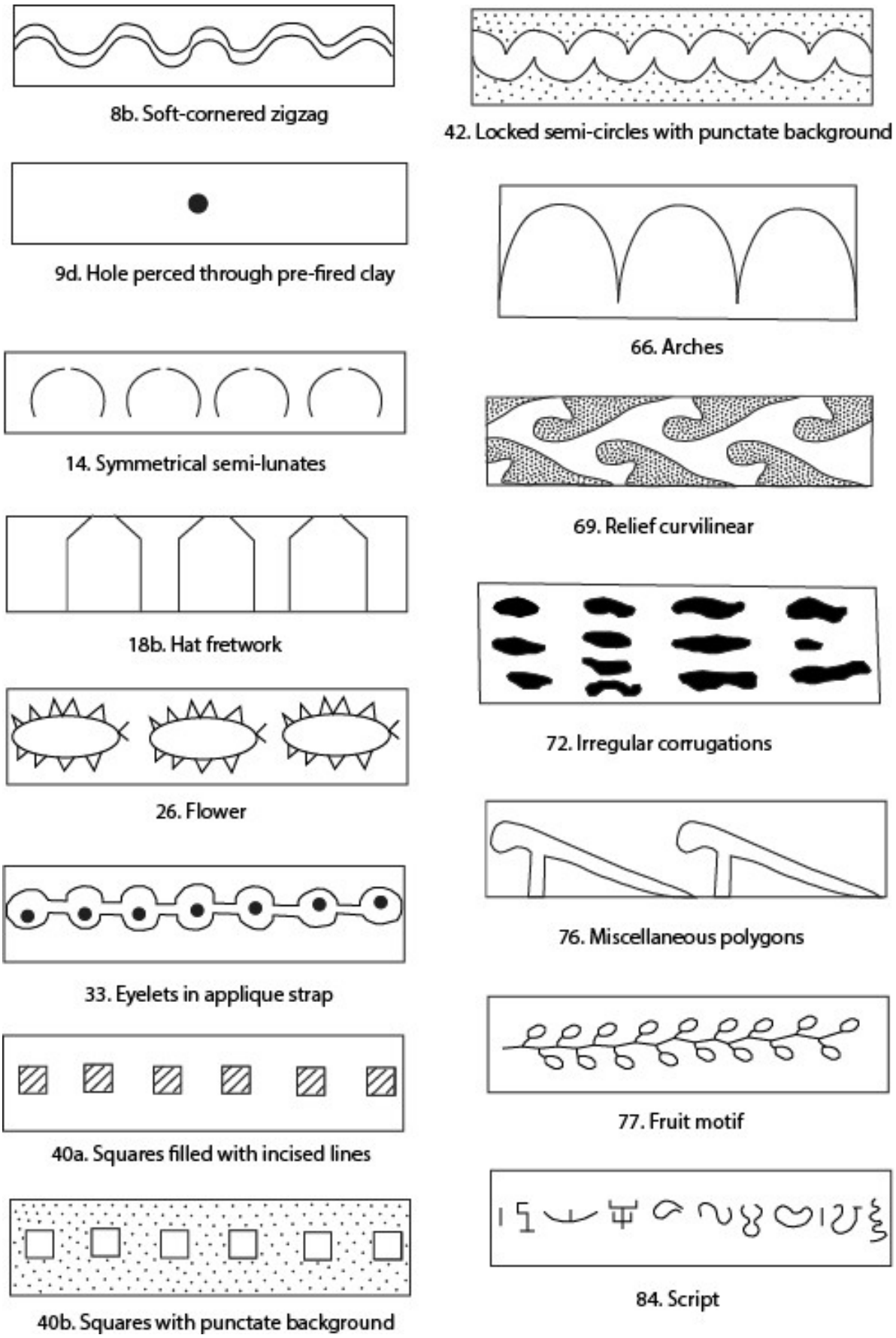

Figure 2. Motifs and variants not well-represented in Open sources (Illustration by author)

complete her coverage of repertoires in South Sulawesi that lie away from Makassar, notably elements defined by Solheim (1964) as emblematic of his posited "Sa Huynh-Kalanay" tradition. Finally, the author recognized 33 additional elements to cover Southeast Asian repertoires ranging geographically from the Andamans in the west, to North Vietnam and the Batanes Islands in the north, and to Java and the Aru Islands in the south (Figure 1).

The degree of documentation of the 141 analyzed repertoires varies widely. In some cases, notably Thailand sites, every pottery vessel or sherd with decoration is illustrated/described, and in these cases the present author analyzed each vessel/sherd in terms of presenting single examples or combinations of the 84 recognized elements. In other cases, a repertoire is published in terms of the motifs that the authors recognize for that repertoire, and the present author assigned these motifs to the 84 recognized elements. Whichever path was required to be followed, I necessarily applied interpretation in assigning the myriad motif variants to 84 particular elements. I have prepared Excel workbooks with my element assignments for sharing with interested parties; see my "Southeast Asian decorated pottery repertoires" project at https://osf.io/xym4a/files.

The final result is that the 141 analyzed repertoires either have, or do not have, each of Numbers 1 to 84 of the recognized elements. In broad terms, similar repertoires should agree with each other in terms of these elements that they share, in the context of the number of elements that they might be expected to share, given that the number of elements recognized for potential sharing varies widely between 6 (e.g., Sunget, in the Batanes Islands) and 53 (Giong Ca Vo in southern Vietnam).

For the full details of my statistical calculations, summarized below, see my "Southeast Asian decorated pottery statistics" project at https://osf.io/xym4a/files

The "Simple Matching Coefficient" (SMC) is preferred over the Jaccard Coefficient (see Sneath and Sokal 1973), as shared element absences (as well as shared element presences) are considered important in capturing element-based similarities between repertoires.

A drawback with the SMC, at least for Operative Taxonomic Units (OTUs) where the majority of attributes are more often absent than present, is that shared absences may overwhelm shared presences. That is, generally speaking, the fewer the attributes in an OTU, the larger the resulting SMC when compared with another OTU. This can however be accommodated by calculating a calibrated SMC, which divides the obtained SMC with the greatest possible SMC. This will equate to 1 when all of the attributes in one of the compared OTUs are present in the other OTU. (A calibrated Jaccard Coefficient would be similar to a calibrated SMC, but reliably identical only in the case where there are no shared motif absences.)

Generally speaking, the greater the disparity between the compared OTUs in their number of attributes, the more likely that all of the attributes in the OTU with fewer attributes would also be present in the OTU with more attributes. This consideration was managed by applying the rules outlined below.

Rule 1. Analysis starts with assigning each combination of numbers of attributes (here, elements) to a "parcel". For instance, at the onset of the analysis, there are single repertoires with 53, 48, 44, 43, 42, 41, and 39 elements, and four repertoires with 38 elements. Accordingly, the parcels for the repertoires with between 53 and 39 elements all involve one comparison (1 X 1), the parcel for the repertoires with 53 and 38 elements involves four comparisons (1 X 4), and the parcels for the other repertoires with between respectively more than 38, and 38, elements also involve four comparisons (1 X 4).

Rule 2. Repertoires are compared with other repertoires having fewer or the same number of elements, by computing the calibrated SMC between them. For instance, Giong Ca Vo, with the highest number of elements (53), is compared with every other repertoire. Khok Phanom Di, with the second highest number of elements (48), is then compared with every repertoire other than Giong Ca Vo. And so on down the list till we reach the repertoires with 38 elements. These four repertoires are compared with each other

and with all repertoires with less than 38 elements, and so on.

All other things being equal, our theoretical expectation is that the highest calibrated SMCs will be found between Giong Ca Vo and the six repertoires with six elements, while the calibrated SMCs should trend downwards as we compare Giong Ca Vo with the repertoires with seven elements, then eight, and finally lowest for Giong Ca Vo when it is compared with Khok Phanom Di. Departures from this theoretical expectation identify instances of repertoires that are more than, less than, or as similar to each other as expected. These departures are identified by assigning the parcels to "packages", as described below, starting with Giong Ca Vo, and moving through the repertoires with progressively fewer elements.

Rule 3. To produce the first package, find the parcel with the highest average calibrated SMC (ASMC). Package it with all other parcels (if any) that involve a greater disparity in the number of attributes. To produce the second package, find and focus on the still unpackaged parcel with the highest ASMC. This second package also includes any parcels whose disparity (in the number of attributes) lies between the focus parcel and the parcels in the first package, and may also include additional parcels with a smaller disparity (in the number of attributes) if this is required to produce an ASMC which is less than the ASMC of the first package. And so on, until the parcels are exhausted.

For instance, taking the **repertoires with 38 elements**, their highest ASMC (0.9487) involves the parcel for compared repertoires with 6 elements, producing the first package. The second-highest ASMC (0.92767) involves the parcel for compared repertoires with 7 elements, producing the second package. However, the third-highest ASMC (0.9273) involves the parcel for compared repertoires with 9 elements, and so this third package combines these repertoires with the compared repertoires having 8 elements, producing an overall ASMC of 0.9221.

Moving on, the next highest ASMC (0.907) involves the parcel with 11 elements, and combining this with the parcel for 10 elements produces the fourth package with an overall ASMC of 0.9013. Then the next highest ASMC, and indeed the fifth package, involves the parcel for 12 elements (0.9009). Then come the sixth package headed by the parcel for 14 elements with its ASMC of 0.8806 (package's overall ASMC of 0.8786), the seventh package involving the parcel for 15 elements with its ASMC of 0.8672, the eighth package headed by the parcel for 18 elements with its ASMC of 0.8535 (package's overall ASMC of 0.8464), the ninth package headed by the parcel for 20 elements with its ASMC of 0.827 (package's overall ASMC of 0.822), the tenth package headed by the parcel for 23 elements with its ASMC of 0.826 (package's overall ASMC of 0.808), and the eleventh package headed by the parcel for 26 elements with its ASMC of 0.799 (package's overall ASMC of 0.751). A parcel involving the compared repertoires with 29 elements would produce the next-highest ASMC of 0.787, but a twelfth package combining just this parcel with the parcels for 28 and 27 elements would produce an overall ASMC of 0.756, higher than the ASMC for the eleventh package. The ASMC for the twelfth package is required to be lower, and so the parcel for repertoires with 31 elements is also included in this twelfth package (→ ASMC of 0.7505). The thirteenth package is headed by the parcel for 36 elements with its ASMC of 0.7256 (package's overall ASMC of 0.6877). Finally, the ASMC for the inter-comparisons of the four repertoires with 38 elements is 0.6468. In logical terms, packages are recognized when the ASMC in a package conforms to the overarching expectation of a lower ASMC with decreasing disparity between the repertoires in their number of elements.

Rule 4. Divide each calibrated SMC in a package by the package's ASMC. The resulting "similarity coefficient" will center on 1, with coefficients above 1 reflecting an above-expected level of similarity for the two repertoires being compared, and coefficients below 1 reflecting dissimilarity between the compared repertoires.

Rule 5. Recognize joins between repertoires if and only if both repertoires have a higher similarity coefficient between each other than either has in comparison with any other

repertoire. (This is the agglomerative clustering component of the analysis.)

For instance, in the first round of analysis, the Kamassi and Minanga Sipakko repertoires have their mutually highest coefficient of 1.233 with each other, and so are joined into a "Kalumpang" repertoire with 44 elements, dissolving the Kamassi and Minanga Sipakko repertoires from further individual analysis. The joining of these two geographically adjacent, West Sulawesi Neolithic sites is an expected outcome, but there are also unexpected joins into "synthetic" repertoires. For instance, Giong Ca Vo (Vietnam) and Leang Buidane (Talaud Islands, Sulawesi) join at a mutually highest coefficient of 1.183, dissolving these two sites into a "GCV-Buidane" repertoire with 55 elements. Overall, there are 22 joins in the first round of analysis, reducing the number of repertoires for analysis in the second round to 119 (141 minus 22).

With each round of analysis, additional synthetic repertoires are created through repertoire joins, until the 15th round, when there are four repertoires. Three are synthetic repertoires, and the fourth is Pao Pao cemetery, which has failed to join with any other repertoire. In this particular analysis, all four repertoires share a similarity coefficient of 1 with each other, which brings the joining process to an end (see Bulbeck 2020).

Seriation proceeds in the reverse order of joining, starting at the 14th round (where not all of the similarity coefficients equaled 1). There were six repertoires in this round, with two inter-repertoire joins, which places structure on the seriation in that joining repertoires have to seriate adjacently during the seriation exercise. Seriation is otherwise based on the compared repertoires' average similarity coefficients. One of the joining synthetic repertoires, actually the one with Kalanay Cave Bagupantao pottery (see Results), has the lowest average similarity coefficient with the other repertoires. Accordingly, it takes an extreme position (arbitrarily place it to the extreme Left). As it had joined with another synthetic repertoire (the one with the Kalumpang repertoires), this other synthetic repertoire takes the second-Left position. Compared to these two joining repertoires, Pao Pao cemetery has the lowest average similarity coefficient, and so takes the extreme Right position. The other three repertoires (two of which had joined) are then seriated to the Left or the Right based on the balance of their average similarity coefficients. Now that the six repertoires at the 14th round have been seriated, the analogous procedure can be applied to the nine repertoires that had joined at the 13th round. And so on, until reaching the first round of the joining analysis, when all 141 repertoires are seriated (see Bulbeck 2020).

After all of the 141 repertoires are seriated, they are grouped, based on statistically significant sequences of repertoires with above-expected similarities. The "null hypothesis" expectation is that any sequence of repertoires would have equal counts of inter-repertoire similarities respectively >1 and <1. Therefore, if application of the Chi-square test demonstrates a sequence of inter-repertoire similarities >1 that would allow rejection of the null hypothesis as improbable, we accept the alternative hypothesis of a grouping of inter-similar repertoires. The actual Chi-square test applied is a two-by-two test (actual versus "expected equal counts"), and the level of confidence for rejection of the null hypothesis is the conventional $p<0.05$ level (including the Bonferroni correction where the same data are exposed to sequential Chi-square tests), with one degree of freedom.

Application of the Chi-square test requires that at least 80% of the cells have an expected value >5, which means a barest minimum of six sequential repertoires (producing 15 inter-repertoire comparisons) or, if less than three of these comparisons are <1, a minimum of seven sequential repertoires (producing 21 inter-repertoire comparisons). Once a minimum sequence has been found, adjacent repertoires that have not yet been grouped can be added to the sequence as long as the Chi-square value increases (with the attendant implication of an increased Phi-square level of association). A "group base" is recognized for the minimum or expanded sequence that allows statistically significant rejection of the null hypothesis (including after allowing for the Bonferroni correction, where applicable). Note that this

"group base" may include adjacent repertoires that have already been grouped, as long as less than half of that group's repertoires are included. Where addition of an adjacent, ungrouped repertoire would result in a decreased Chi-square value, the grouping is closed, extending only to the final repertoire that had been associated with an increased Chi-square value.

Also note that a special case is made for sequences of five repertoires with ten inter-repertoire comparisons all >1, and which are isolates in the sense that all comparisons with adjacent repertoires reveal a dominant majority of these inter-repertoire comparisons <1. Ten inter-repertoire comparisons all >1 can allow rejection of the null hypothesis at $p<0.05$ using the Fisher exact probability test ($p\approx0.0163$). Finally, any repertoire that both terminates the previously recognized sequence to which it is adjacent, and cannot be grouped with any next sequence to be investigated, is deemed "ungrouped".

RESULTS

The repertoire groupings include some that result entirely from repertoire joins and some that result more from the seriation's adjacent placement to repertoires that had made dissimilar joins. In theory, if cultures/traditions of repertoires should be recognized based on their elements' similarities, these repertoires should be grouped either through the joining exercise or, failing that, through the seriation exercise. An example is the three Karama River sites of West Sulawesi which, although assigned to two separate groups, all seriate between positions 50 and 57.

At the left pole of the seriation sits a grouping of three sets of repertoires very distant from each other in time and space (Table 2; Figure 3). One set comprises southern MSEA repertoires dated to around 2000 BC, the second set comprises Philippine repertoires dated to the millennia AD, and the third set comprises Timor-Leste repertoires, two broadly dated and one dated to the late second millennium AD. This grouping includes the Bagupantao pottery from Kalanay Cave, which shows a similarity coefficient >1 with every other repertoire in the grouping.

Next comes the Ban Na Di (BND)-like grouping composed mainly of Northeast Thailand repertoires whose dating centers on the first millennium BC. However, the grouping also includes three scattered ISEA repertoires: Sunget, in the Batanes Islands, of similar antiquity to the Thailand repertoires; Surigao C5, in Mindanao, dated much later to the second millennium AD; and, with an antiquity spanning the last-two mentioned repertoires, Makpan in Nusatenggara (Table 2; Figure 4).

The ungrouped repertoires (Table 3) are those that cannot satisfy the criteria for being grouped. A common feature of these repertoires is their being joined only in the last rounds of the joining exercise, reflecting no particular similarity to any other analyzed repertoire. Sometimes, however, the seriated position of the ungrouped repertoires can be informative. For instance, three of the six ungrouped repertoires between positions 125 and 141, in the seriation, lie in the southwest corner (Makassar) of South Sulawesi, and seriate close to the other repertoires from here (Figure 1).

The Mansiri-like repertoires (Table 4; Figure 5) are predominantly located in the Philippines and central to eastern Indonesia, but also include two Vietnam repertoires. Dating varies widely between the first millennium BC and the second millennium AD.

The Jambi-megalithic-like repertoires (Table 4; Figure 6) are dispersed widely across SEA, from the Andamans and Sumatra in the west to Sulawesi and the Philippines in the east, and to northern Vietnam and Northeast Thailand in the north. The continental MSEA repertoires all date between 2500 and ~1000 BC, an age range partially overlapping with Nagsabaran in the northern Philippines, but a millennium or more older than any other repertoire in the grouping.

The Kalimantan-like repertoires (Table 4; Figure 7) occupy the central belt of SEA, from South Sulawesi in the south to Central Vietnam in the north. The Central Vietnam repertoires are Sa-Huynh culture repertoires and, indeed, notably similar to the Sa Huynh repertoire (No. 75), but in this particular analysis they join to the Kalimantan highlands repertoire and also fail to seriate close to the Sa Huynh repertoire. The Nong Nor Neolithic repertoire is considerably

Table 2. Bagupantao-like (1–9) and BND-like (10–17) repertoires.

Repertoire No.	Site/ Complex	Antiquity	Reference for location/antiquity	No. elements	References for elements
1.	Fatu Aki Anik Knua (FAAK)	AD 200–1650	Beaumont *et al*. 2020	31	Beaumont *et al*. 2020
2.	Sa'gung rockshelter	~AD 1000	Kress 1978	17	Kress 1978
3.	Ban Kao	2000–1500 BC	Higham 2022b	19	Sørenson & Hatting 1967
4.	An Son	2200–1500 BC	Piper *et al*. 2022	38	Diem *et al*. 1997; Sarjeant 2014
5.	Loc Giang	~2000 BC	Piper *et al*. 2022	18	Diem *et al*. 1997
6.	Macapainara	AD 1600–1950	O'Connor *et al*. 2020	28	O'Connor *et al*. 2020; author, laboratory notes
7.	Uai Bobo 1	1500–1 BC	Glover 1986	13	Glover 1986
8.	Kalanay Cave (Bagupantao pottery)	1st millennium AD	Solheim 2002	19	Solheim 2002
9.	Pulong Bakaw Complex	15th–16th centuries AD	Main & Fox 1982	18	Main & Fox 1982
10.	Ban Chiang culture	2nd–1st millennia BC	Higham 2022b, c	38	White 1982; White *et al*.1991
11.	Ban Na Di	1500 BC–AD 200	Vincent 1988	39	Vincent 1988
12.	Ban Muang Phruk	1500 BC–AD 200	Vincent 1988	17	Vincent 1988
13.	Noen-U-Loke	500 BC–AD 500	Higham & Higham 2022	16	Higham *et al*. 2007
14.	Makpan	~1300 BC–AD 1500	Beaumont *et al*. 2022	14	Beaumont *et al*. 2022
15.	Ban Non Wat Iron Age	BC/AD transition	Higham & Wiriyaromp 2013	13	Higham & Wiriyaromp 2013
16.	Surigao Site C5	2nd millennium AD	Solheim 2002	12	Solheim 2002
17.	Sunget	1200–800 BC	Bellwood *et al*. 2013	6	Bellwood *et al*. 2013

Table 3. Ungrouped repertoires.

Reper-toire No.	Site/ Complex	Antiquity	Reference for location/antiquity	No. elements	References for elements
18.	Zamboanga Site B4	2nd millennium AD	Solheim 2002	12	Solheim 2002
56.	Gua Lampetia	~AD 1000	Bulbeck *et al*. 2016	14	Bulbeck *et al*. 2016; author, laboratory notes
83.	Uai Bobo 2	1500–0 BC	Glover 1986	8	Glover 1986
125.	Sompu	14th–17th centuries AD	Bulbeck 1996–7	8	Tjandrasasmita 1970
132.	Jambi Sungai Hangat	2nd millennium AD	Tjoa-Bonatz 2009	11	Tjoa-Bonatz 2009
138.	Garassik	14th–17th centuries AD	Bulbeck 1992	16	Clune 1996
139.	Pilanduk	2nd–1st millennia BC	Kress 1978	12	Kress 1978
140.	Non Ban Jak	4th–8th centuries AD	Higham & Kijngam 2020	28	Higham & Kijngam 2020
141.	Pao Pao cemetery	14th–18th c's AD	Bulbeck 1992	8	Clune 1996

Figure 3. Location of the Bagupantao-like repertoires (Illustration by author)

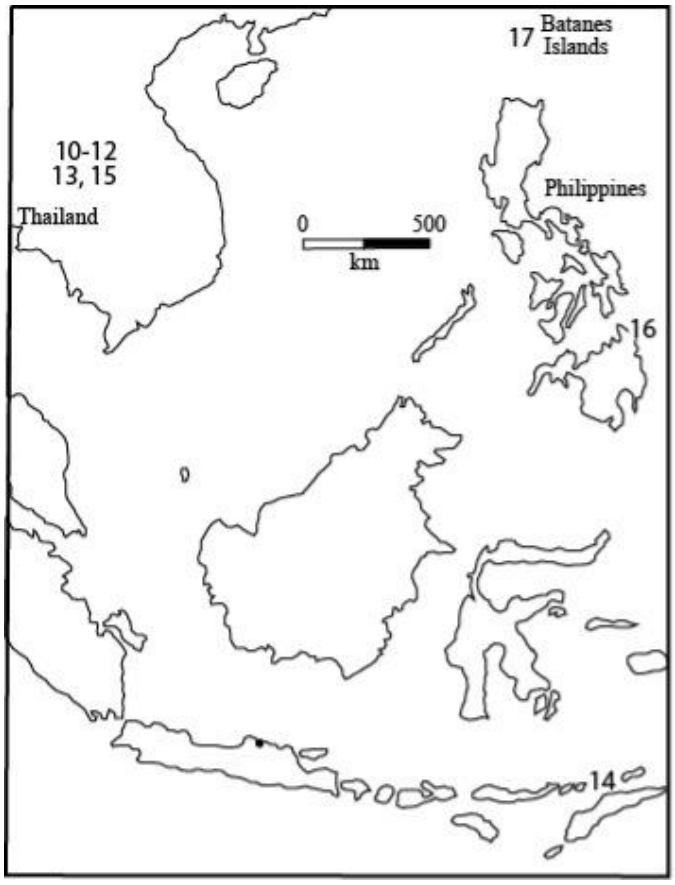

Figure 4. Location of the BND-like repertoires (Illustration by author)

Table 4. Mansiri-like (19–26), Jambi-megalithic-like (26–38), Kalimantan-like (35–42), and Sembiran-like (41–48) repertoires.

Reper-toire No.	Site/ Complex	Antiquity	References for location/antiquity	No. elements	References for elements
19.	Calamianes Site C64	AD 1500–1950	Solheim 2002	18	Solheim 2002
20.	Gilimanuk	BC/AD transition	Bellwood 2017	34	Soegondho 1985, 1995
21.	Melolo	BC/AD transition	Soegondho 1995; Bellwood 2017	18	Van Heekeren 1972; Soegondho 1995
22.	Mansiri	1000–500 BC	Azis *et al*. 2018	12	Azis *et al*. 2018
23.	Go Cao Su	Late centuries BC	Diem *et al*. 1997	20	Diem *et al*. 1997
24.	Hao Xa	Late centuries BC	Diem *et al*. 1997	9	Diem *et al*. 1997
25.	Aru Manara	BC/AD transition	Ono *et al*. 2017	17	Ono *et al*. 2017, 2018a
26.	Lapuz Lapuz	2nd millennium AD	Coutts 1983	12	Coutts 1983
27.	Chauldari, Andamans	1st millennium AD	Cooper 2002	12	Cooper 2002
28.	Ban Non Wat Bronze Age	11th–9th centuries BC	Higham 2022c	38	Higham & Wiriyaromp 2012
29.	Ban Lum Khao	13th–8th centuries BC	Higham 2022b, c	17	Higham 2004; O'Reilly 2004
30.	Ban Non Wat Neolithic	17th–13th centuries BC	Higham 2022b	34	Higham & Wiriyaromp 2011
31.	Jambi highland megalithic sites	12th–18th centuries AD	Tjoa-Bonatz 2009	20	Tjoa-Bonatz 2009
32.	Pusu Samang Tas	AD 500–1500	Bellwood 1988	17	Bellwood 1988
33.	Nagsabaran	1500–1 BC	Bellwood 2017	18	Hung 2008
34.	Bau Tro culture	2500–2200 BC	Piper *et al*. 2022	20	Thi 1997
35.	Pusu Lumut	AD 500–1500	Bellwood 1988	20	Bellwood 1988
36.	Isthmus of Kra	BC/AD transition	Bellina *et al*. 2021	44	Bellina 2013; Bellina *et al*. 2012, 2021
37.	Nong Nor Neolithic	2500–2200 BC	Higham 2022a	17	O'Reilly 1998
38.	Buttu Batu	"Neolithic"	Hasanuddin 2018	18	Hasanuddin 2018
39.	Ulu Leang 2	1st millennium AD	Bulbeck 2004	34	Andrews & Glover 1986; Flavel 1997
40.	Kalimantan highland sites	~1000 years ago	Kusmartono *et al*. 2017	17	Chazine 2003; Kusmartono *et al*. 2017
41.	Thanh Duc	Late centuries BC	Reinecke 2022	13	Reinecke 1993
42.	Phu Khuong	Late centuries BC	Reinecke 2022	14	Reinecke 1993
43.	Loyang Mendali	Early centuries AD	Setiawan 2018	11	Setiawan 2009
44.	Camotes Site C13	~1000 years ago	Solheim 2002	10	Solheim 2002
45.	Agop Atas Atas Period	200 BC–AD 500	Bellwood 1988	36	Bellwood 1988
46.	Gua Sireh	1500 BC–AD 650	Bellwood 2017	26	Solheim *et a*l. 1959; Datan & Bellwood 1991
47.	Sembiran Early Period	BC/AD transition	Bellwood 2017	34	Ardika 1991
48.	Guaan	BC/AD transition	Simanjuntak & Siswanto 2008	15	Simanjuntak & Siswanto 2008

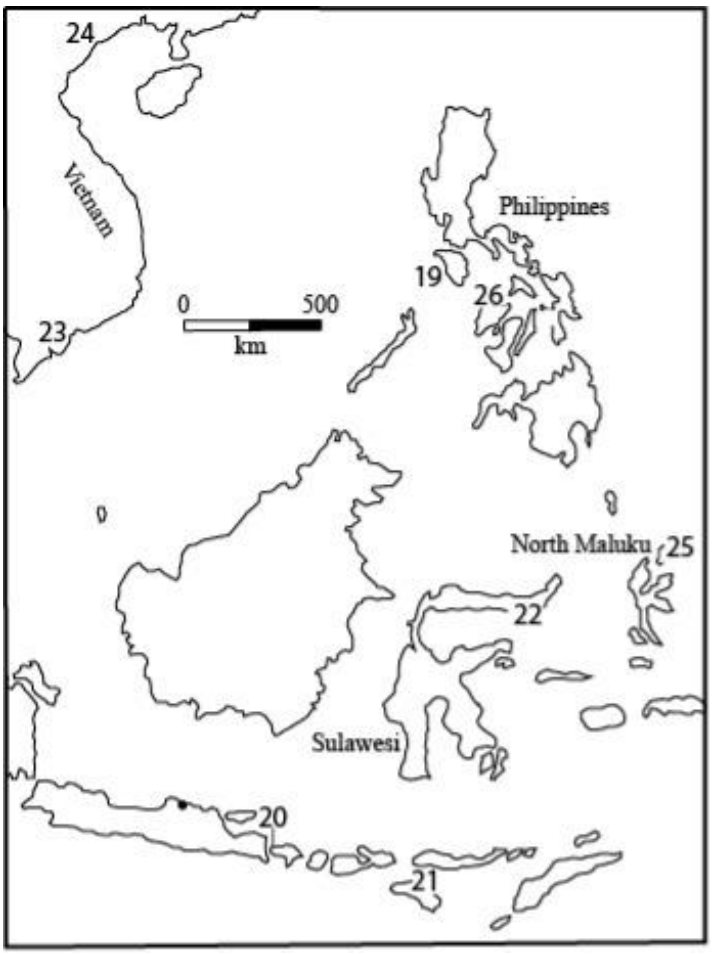

Figure 5. Location of the Mansiri-like repertoires (Illustration by author)

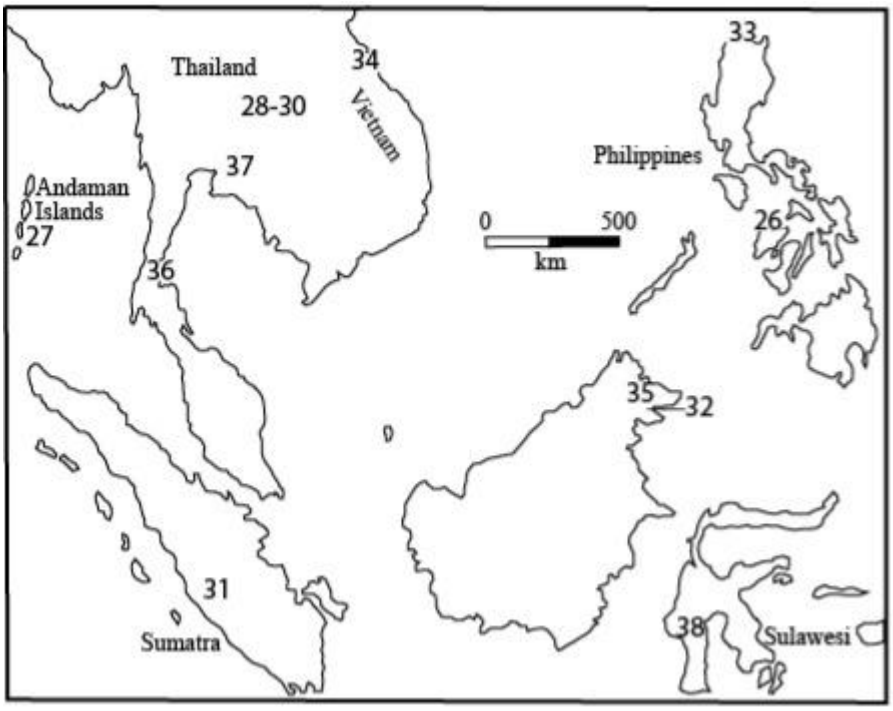

Figure 6. Location of the Jambi-megalithic-like repertoires (Illustration by author)

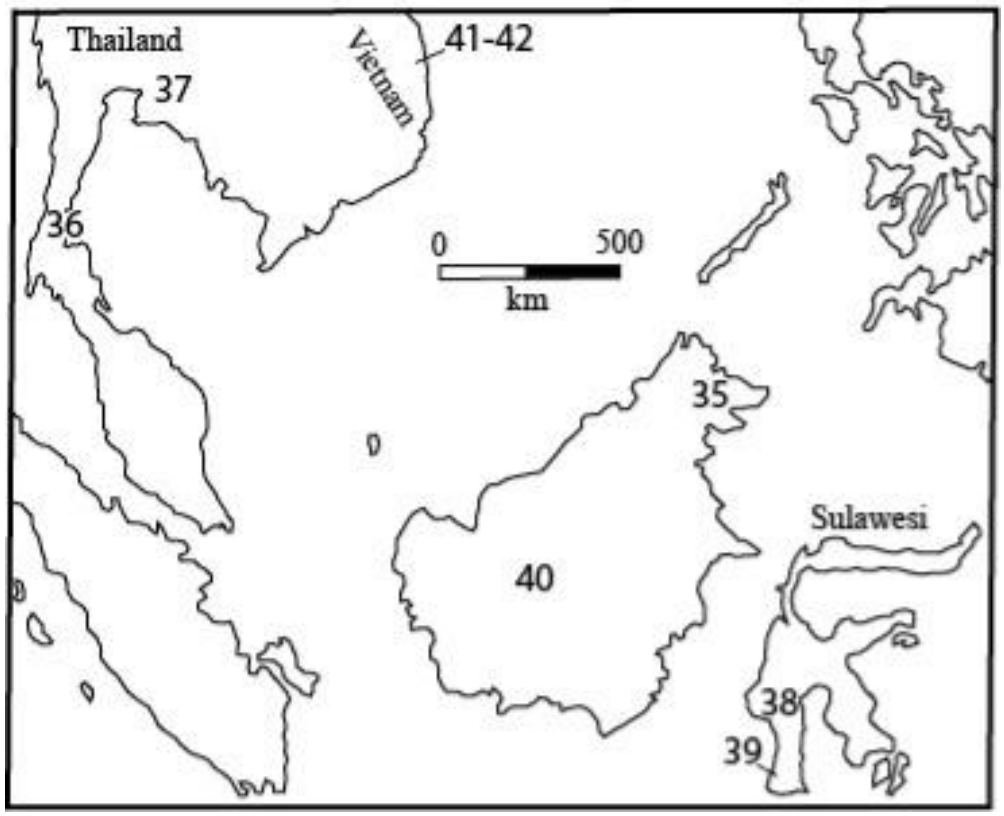

Figure 7. Location of the Kalimantan-like repertoires (Illustration by author)

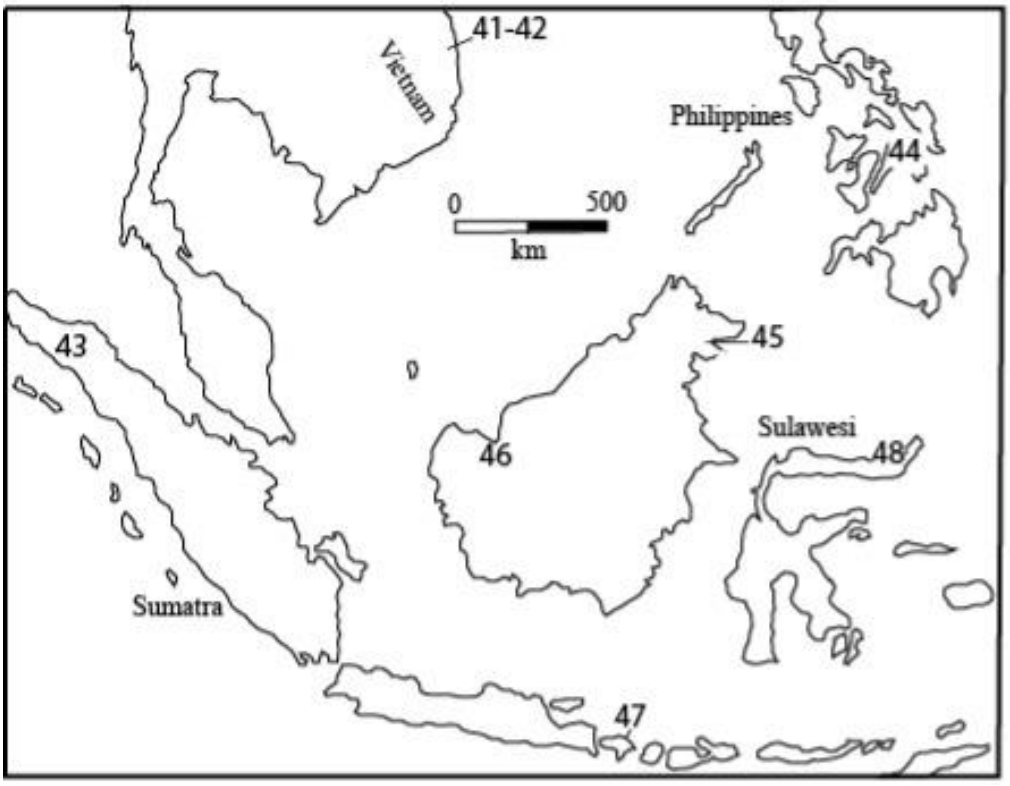

Figure 8. Location of the Sembiran-like repertoires (Illustration by author)

earlier than the other datable repertoires in this group which all date between the late centuries BC and the first millennium AD. The repertoire of "Sa-Huynh-Kalanay" motifs from Isthmus of Kra sites is grouped with similar counts of MSEA repertoires to the north and ISEA repertoires to the east.

The Sembiran-like repertoires (Table 4; Figure 8) are widely distributed across SEA, from Central Vietnam in the north to northwestern Sumatra in the west, to Bali in the south and to North Sulawesi and the central Philippines in the east. The dating for most of the repertoires centers on the BC/AD transition, but the Camotes C13 repertoire in the Philippines is estimated to date to only ~1000 years ago.

Next come the Minanga-Sipakko-like repertoires (Table 5; Figure 9), which include the Kalanay pottery from Kalanay Cave and so are critical to testing Solheim's (1964, 2002) postulation of a Kalanay complex in the central Philippines. Now, Solheim's postulation appears to be disproved, because Kalanay Cave is the only Philippine site in this group, which is dominated by Neolithic to Metal Age repertoires in eastern Indonesia, notably Sulawesi. This grouping also includes the poorly dated repertoire from Laang Spean in Cambodia as a geographical outlier.

The Gua-Cha-like repertoires (Table 5; Figure 10) form a ring around Borneo, from Peninsular Malaysia in the west to Java in the south, and Sulawesi in the east to South Vietnam in the north. Of the repertoires that are dated, all date to AD 500 and earlier, extending back to the second millennium BC.

The Bawuwansi-like repertoires (Table 5; Figure 11) fall into two sections: a western section extending from North Sumatra northwards to southern MSEA; and an eastern section extending via eastern Indonesia from the southernmost Philippines southwards to Timor-Leste. Dating varies widely with pre-AD repertoires in both sections, but also repertoires securely dated to the second millennium AD in both sections (Kota Cina in North Sumatra, and the Wangil midden in the Aru Islands).

The GCV (Giong Ca Vo)-like grouping is dominated by Central and South Vietnam repertoires, including Hoa Diem. However, it also includes three eastern ISEA repertoires from Palawan, the Talaud Islands and South Sulawesi. To its south lie the Plawangan-like repertoires which include this Java repertoire and otherwise South Sulawesi repertoires, including the Left-most Makassar repertoires in the seriation (Nos. 86–88). Chronologically, the Vietnam members of the GCV-like grouping have a dating centered on the BC/AD transition, whereas the eastern ISEA members are dated to the first millennium AD. The Plawangan-like repertoires are not well dated except for the three Makassar repertoires, which are well dated to the mid-second millennium AD based on the associated trade ceramics (Figure 12; Table 6).

The Lie-Siri-like repertoires include Samrong Sen in Cambodia, but otherwise repertoires located in eastern ISEA, notably the central Philippines but also Sabah in Borneo, Sulawesi, North Maluku and Timor-Leste. Samrong Sen, Late Bukit Tengkorak in Sabah, and Lie Siri in Timor-Leste all date to the first–second millennia BC, whereas the other repertoires are dated to the first–second millennia AD (Table 6; Figure 13).

The Uattamdi-like grouping (Table 6; Figure 14) groups numerous repertoires from the central Philippines with a few repertoires from North Maluku. The dating for these repertoires extends across the first and second millennia AD, but no earlier.

The location of the Santa-Ana-like repertoires (Figure 14; Table 7) extends widely, from the Batanes Islands in the north to South Sumatra and South Sulawesi in the south. The dating for Anaro (Batanes Islands) and Gua Harimau (South Sumatra) reaches back to 1000 BC, which is the central dating for the Early Bukit Tengkorak repertoire in Sabah. On the other hand, Santa Ana (southern Luzon) and the Makassar repertoires date entirely to the second millennium AD.

The Bayoa 1-like repertoires (Figure 15; Table 7) group together nearly half of the Makassar repertoires, dating to the mid-second millennium AD, with repertoires further north in South Sulawesi and the southern Philippines. As these latter repertoires are dated to around the

Table 5. Minanga-Sipakko-like (49–55), Gua-Cha-like (57–62), and Bawuwansi-like (63–71) repertoires.

Reper-toire No.	Site/ Complex	Antiquity	Reference for location/antiquity	No. elements	References for elements
49.	Gua Mo'o hono	1st–2nd millennia AD	O'Connor *et al*. 2018	15	O'Connor *et al*. 2018; author, laboratory notes
50.	Kamassi	~1000 BC	Bellwood 2017	38	Van Heekeren 1972; Flavel 1997; Bulbeck & Nasruddin 2002; Prasetyo 2008
51.	Minanga Sipakko	~1000 BC	Bellwood 2017	33	Flavel 1997; Bulbeck & Nasruddin 2002; Prasetyo 2008
52.	Laang Spean	2000 BC–AD 900	Higham 1989	8	Higham 1989
53.	Tanjong Pinang	BC/AD transition	Bellwood 2019	17	Bellwood 2019
54.	Kalanay Cave (Kalanay pottery)	1st millennium AD	Solheim 2002	31	Solheim 2002
55.	Leang Balangingi	~1000 years ago	Bellwood 1980	17	Bellwood 1980
57.	Lattibung	"Neolithic"	Prasetyo 2008	20	Prasetyo 2008
58.	Gunung Wingko	Undated	Nitihaminoto 1984	21	Nitihaminoto 1984
59.	Binh Da	2nd millenn-ium BC	Diem *et al*. 1997	12	Diem *et al*. 1997
60.	Gua Cha	~1000 BC	Bulbeck 2011	13	Sieveking 1954
61.	Tabon complex	1000 BC–AD 500	Fox 1970	43	Fox 1970
62.	Gua Talimbue	AD 250–400	Bulbeck *et al*. 2016	22	Bulbeck *et al*. 2016; author, laboratory notes
63.	Rach Rung	2000–1500 BC	Diem *et al*. 1997	13	Diem *et al*. 1997
64.	Kota Cina	12th–14th centuries AD	Wibisono 1982	34	Wibisono 1982
65.	Ben Do phase	~1000 BC	Thang *et al*. 1998	26	Thang *et al*. 1998
66.	Nong Nor Bronze Age	~1000 BC	Higham 2022a	15	Debrucency 1988
67.	Asin Cave	1st millennium BC	Solheim *et al*. 1979	23	Solheim *et al*. 1979
68.	Sabatai Tua	1st–2nd millennia AD	Bellwood 2019	16	Bellwood 2019
69.	Wangil midden	AD 1150-1650	Veth *et al*. 2005	22	Veth *et al*. 2005
70.	Bawuwansi	10 BC–AD 630	Bellwood 2019	24	Bellwood 2019
71.	Bui Ceri Uato	1500–0 BC	Glover 1986	13	Glover 1986

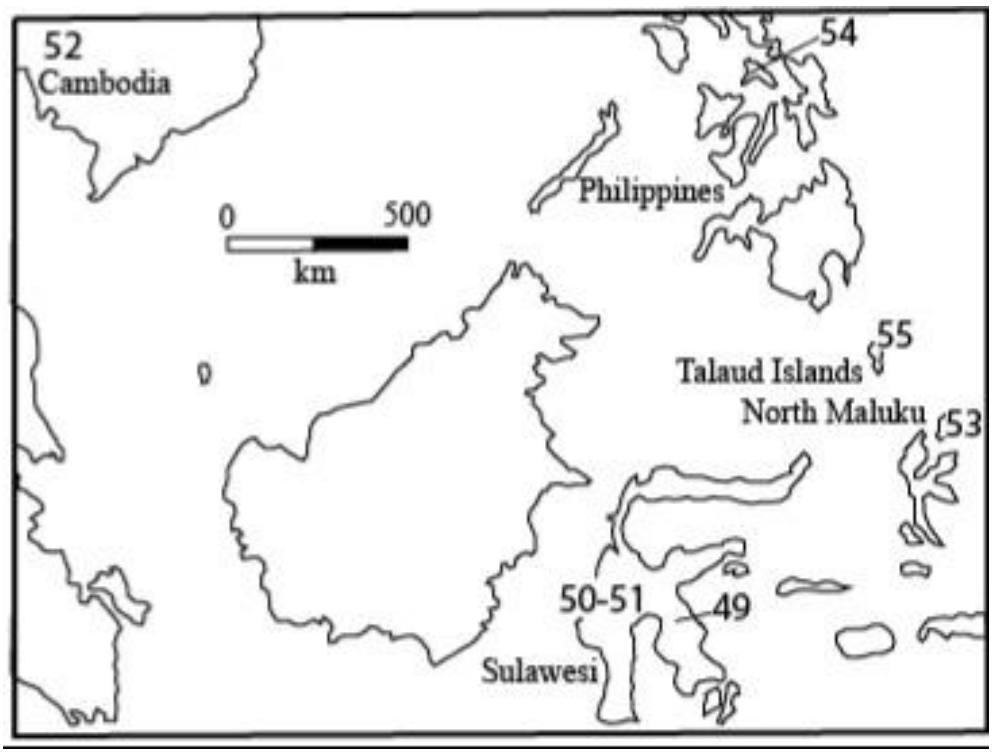

Figure 9. Location of the Minanga-Sipakko-like repertoires (Illustration by author)

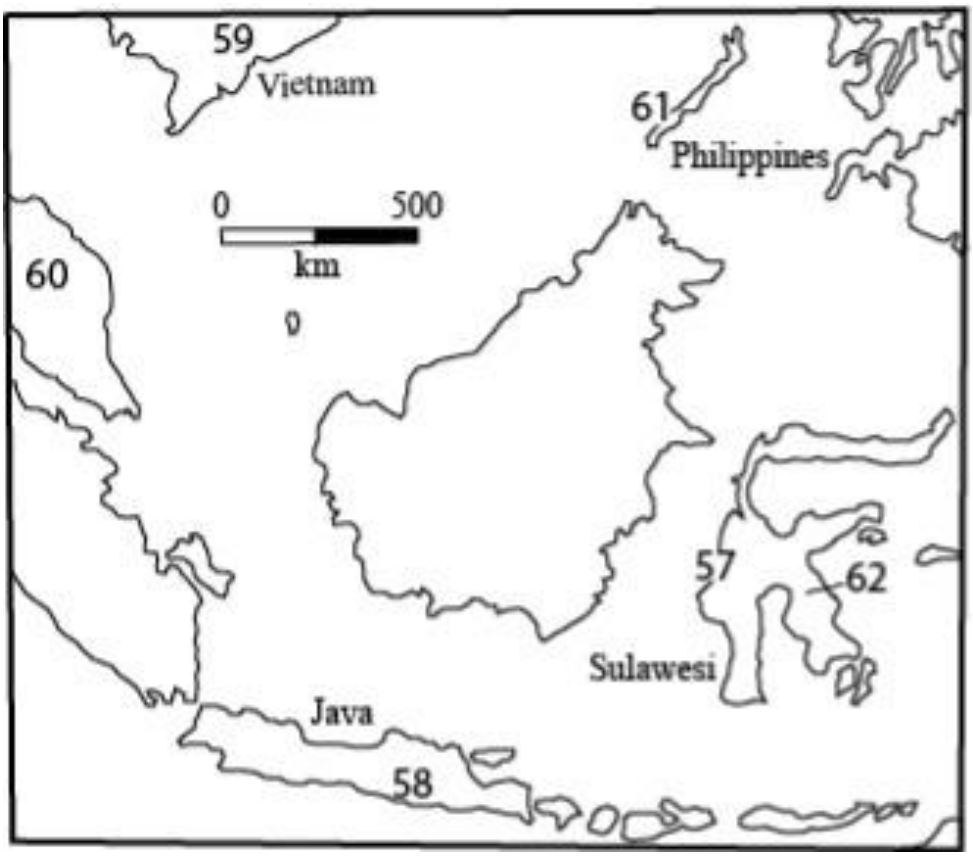

Figure 10. Location of the Gua-Cha-like repertoires (Illustration by author)

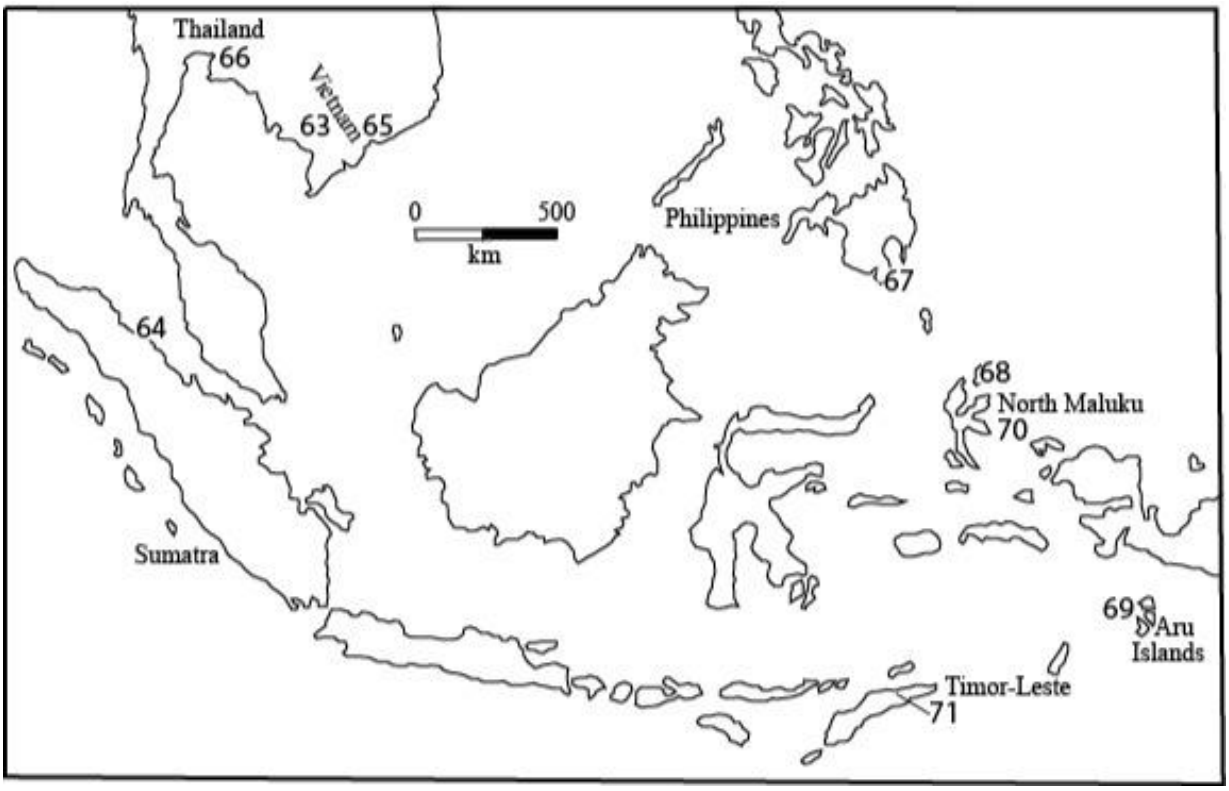

Figure 11. Location of the Bawuwansi-like repertoires (Illustration by author)

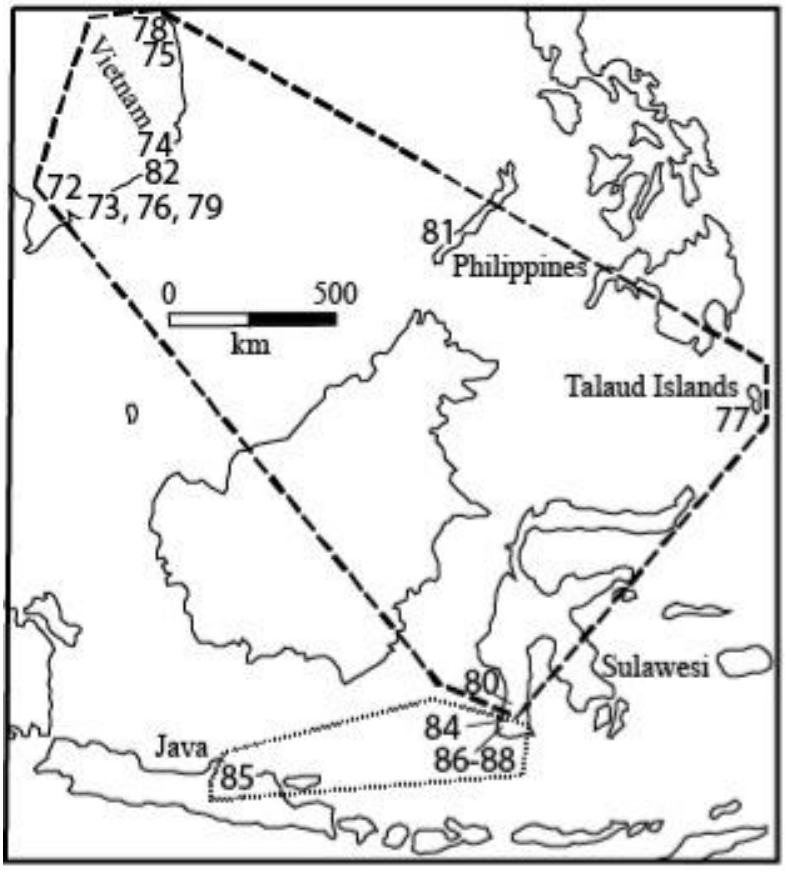

Figure 12. Location of the GCV-like (dashed line) and Plawangan-like (dotted line) repertoires (Illustration by author)

Table 6. GCV-like (72–82), Plawangan-like (84–88), Lie-Siri-like (89–100), and Uattamdi-like (96–102) repertoires.

Reper-toire No.	Site/ Complex	Antiquity	Reference for location/antiquity	No. elements	References for elements
72.	Phu Hoa phase	Late centuries BC	Reinecke 2022	28	Thang *et al*. 1998
73.	Giong Phet	Late centuries BC	Reinecke 2022	27	Thang *et al*. 1998
74.	Xom Con	BC/AD transition	Reinecke 2022	20	Diem *et al*. 1997
75.	Sa Huynh	Late centuries BC	Reinecke 2022	18	Solheim 1959
76.	Giong Ca Vo	Late centuries BC	Reinecke 2022	53	Thang *et al*. 1998
77.	Leang Buidane	~1000 years ago	Bellwood 2017	34	Bellwood 1980
78.	Buu Chau	BC/AD transition	Glover *et al*. 1996	20	Glover *et al*. 1996; Yamagata 1997: Figure 2
79.	Giong Am	Early centuries AD	Thang *et al*. 1998	11	Thang *et al*. 1998
80.	Gua Mangana	1st millennium AD	Flavel 1997	13	Flavel 1997
81.	Sasak	AD 600–400	Fox 1970	10	Fox 1970
82.	Hoa Diem	2nd–3rd centuries AD	Yamagata & Matsumura 2017	10	Yamagata & Matsumura 2017
84.	Leang Karassak	1000 BC–AD 1600	Bulbeck 2004	11	Clune 1996; Flavel 1997
85.	Plawangan	BC/AD transition	Bellwood 2017	21	Prasetyo 1995; Soegondho 1995
86.	Kale Gowa	14th–18th c's AD	Bulbeck 1992	8	Clune 1996
87.	Campagaya Lama	15th–16th centuries AD	Bulbeck 1992	6	Clune 1996
88.	Benteng Sanrabone	16th–18th centuries AD	Bulbeck 1992,1996–7	6	Clune 1996
89.	Samrong Sen	~1800–1200 BC	Rispoli 2022	29	Bellwood 1978; Sarjeant 2014
90.	Lie Siri	1500–1000 BC	Bellwood 2017	17	Glover 1986
91.	Leyte Site C14	1st millennium AD	Solheim 2002	15	Solheim 2002
92.	Gua Topogaro	Early centuries AD	Ono *et al*. 2019	33	Ono *et al*. 2019; Qalam *et al*. 2020
93.	Late Bukit Tengkorak	1st millennium BC	Bellwood 2017	22	Bellwood 1989
94.	Lake Matano	~AD 600–1500	Adhiyatama *et al*. 2023	41	Adhiyatama *et al*. 2017, 2021; Triwurjani 2018; Triwurjani & Adhiyatama 2019
95.	Siquijor Site B23	~AD 1000	Solheim 2002	13	Solheim 2002
96.	Kay Tomas Complex	14th–16th centuries AD	Main & Fox 1982	27	Main & Fox 1982
97.	Unknown Site	1st–2nd millennia AD	Solheim 2002	25	Solheim 2002
98.	Pilar	2nd millennium AD	Coutts 1983	20	Coutts 1983
99.	Calamianes Site C65	1st millennium AD	Solheim 2002	22	Solheim 2002
100.	Gua Siti Nasifah	~AD 350	Bellwood 2019	10	Bellwood 2019
101.	Um Kapat Papo	~AD 350	Bellwood 2019	7	Bellwood 2019
102.	Uattamdi 1	AD 1–500	Bellwood 2019	17	Bellwood 2019

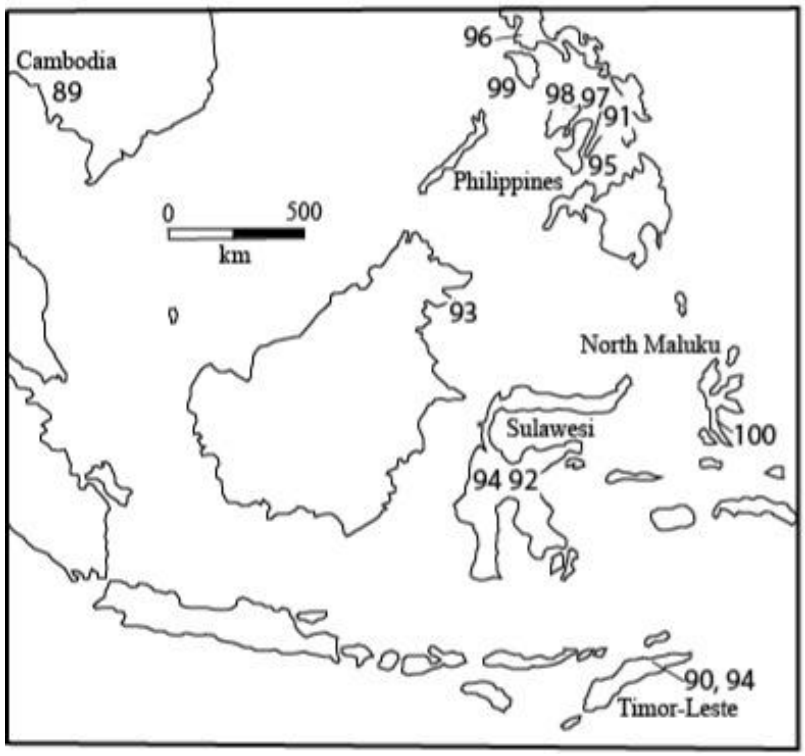

Figure 13. Location of the Lie-Siri-like repertoires (Illustration by author)

Figure 14. Location of the Uattamdi-like (dashed line) and Santa-Ana-like (dotted line) repertoires (Illustration by author)

Table 7. Santa-Ana-like (103–110), Bayoa 1-like (107–117), Bayoa 3-like (118–124) repertoires, KPD-like (126–131), and Batu-Ejaya-like (133–137) repertoires.

Reper-toire No.	Site/ Complex	Antiquity	Reference for location/antiquity	No. elements	References for elements
103.	Early Bukit Tengkorak	1200–800 BC	Bellwood 2017	10	Bellwood 1989
104.	Santa Ana Complex	12th–14th centuries AD	Main & Fox 1982	14	Main & Fox 1982
105.	Anaro	1000 BC–AD 600	Bellwood *et al*. 2013	19	Bellwood *et al*. 2013
106.	Gua Harimau	1000 BC–AD 1000	Oktaviana *et al*. 2016	17	Ansyori 2016
107.	Bonto Ramba-Likuloe	~AD 1000–1600	Bulbeck 1996–7	7	Clune 1996
108.	Moncongloe Lappara	15th–19th centuries AD	Bulbeck 1992	8	Clune 1996; Rowley 1997
109.	Pakka Mukang	15th–17th c's AD	Bulbeck 1992	6	Clune 1996
110.	Biring Balang	15th–18th c's AD	Bulbeck 1992	6	Clune 1996
111.	Mandallek Toa	14th–16th c's AD	Bulbeck 1992	8	Clune 1996
112.	Bayoa 1	14th–17th c's AD	Bulbeck 1992	12	Clune 1996; author, laboratory notes
113.	Balang Sari	13th–17th c's AD	Bulbeck 1992	7	Clune 1996
114.	Kanjilo	14th–17th centuries AD	Bulbeck 1992	6	Bulbeck 1992; Clune 1996
115.	Bohol Site C11	~1000 years ago	Solheim 2002	16	Solheim 2002
116.	Mallawa (Bulu Bakung)	BC/AD transition	Bulbeck 2004	16	Najemain 1998; Mahmud 2008
117.	Davao Site C76	1st millennium AD	Solheim 2002	19	Solheim 2002
118.	Niah Neolithic	1500–200 BC	Bellwood 2017	35	Solheim *et al*. 1959; Harrisson 1971
119.	Agop Atas Idahan Period	AD 1550–1950	Bellwood 1988	17	Bellwood 1988
120.	Hagop Bilo	1st millennium AD	Bellwood 1988	20	Bellwood 1988
121.	Leang Buida	2nd millennium AD	Ono *et al*. 2018b	14	Bellwood 1980; Ono *et al*. 2018b
122.	Buni culture	BC/AD transition	Bellwood 2017	34	Nitihaminoto 1984; Soegondho 1995; Bulbeck 2006
123.	Ancient Mare	13th–18th c's AD	Mahirta 2000	19	Mahirta 2000
124.	Bayoa 3	13th–17th c's AD	Bulbeck 1992	9	Clune 1996
126.	Kuala Selinsing	1st millennium AD	Bulbeck 2011	36	Hassan 1999
127.	Khok Phanom Di	2000–1500 BC	Higham 2022a	48	Vincent 2004
128.	Kay Tomas Intrusive	10th–16th centuries AD	Main & Fox 1982	18	Main & Fox 1982
129.	Gunung Piring	~AD 1000	Nitihaminoto *et al*. 1978	17	Nitihaminoto *et al*. 1978; Nitihaminoto 1984
130.	Allangkanang-nge ri Latanete	13th–17th centuries AD	Hakim *et al*. 2018	14	Bulbeck & Caldwell 2008; Hakim *et al*. 2018
131.	Khok Charoen	~1000 BC	Bulbeck 2011; Higham 2022b	42	Loofs-Wissowa 2019
133.	Leang Pettekere	500 BC–AD 1000	Bulbeck 1996–7	10	Flavel 1997
134.	Leang Tuwo Mane'e	1500 BC–AD 1000	Bellwood 1980, 2017	11	Bellwood 1980
135.	Leang Paja	BC/AD transition	Bulbeck 2004	25	Flavel 1997
136.	Batu Ejaya	~AD 1000	Bulbeck 2004	28	Flavel 1997
137.	Somba Opu	16th–17th centuries AD	Bulbeck 1992	15	Nurhadi *et al*. 1980; Tim Penyusun 1992; Clune 1996

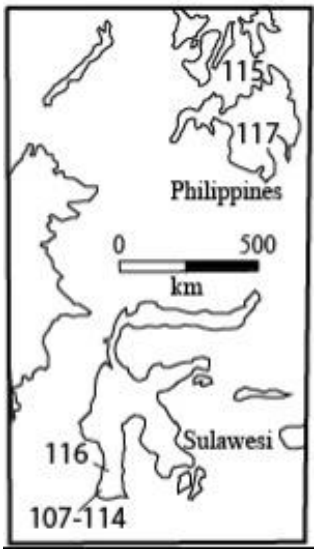

Figure 15. Location of the Bayoa 1-like repertoires (Illustration by author)

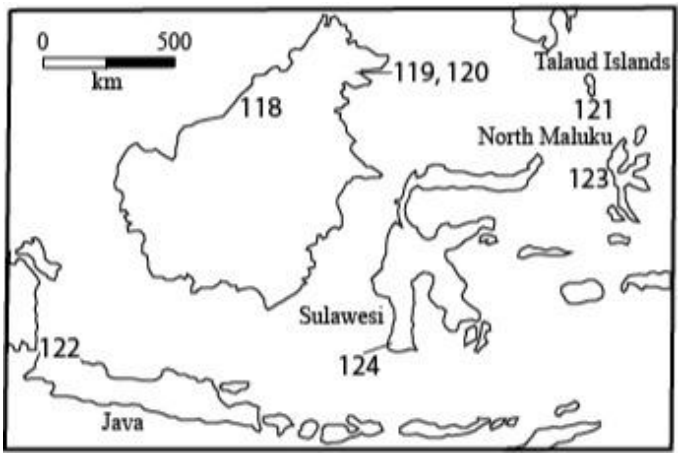

Figure 16. Location of the Bayoa 3-like repertoires (Illustration by author)

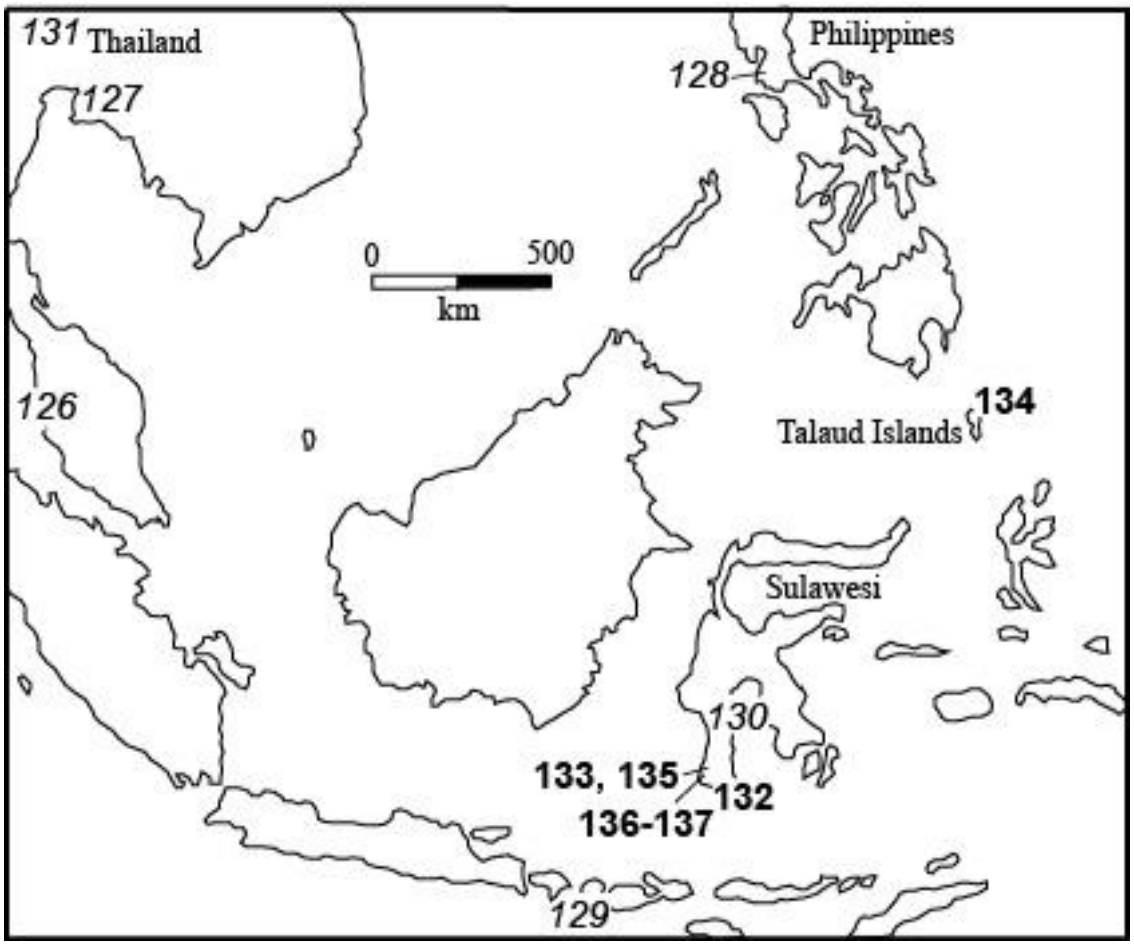

Figure 17. Location of the KPD-like (italicized), and Batu-Ejaya-like (bold face) repertoires (Illustration by author)

first millennium AD, they are a potential ancestral source for the Makassar repertoires.

The Bayoa 3-like repertoires (Figure 16; Table 7) are more wide-ranging, extending from Java in the west to northern Borneo in the north, and to North Maluku in the east. Chronologically, the Niah Cave and, to a lesser extent, the Buni culture repertoires are notably earlier than the other repertoires, which are predominantly dated to the second millennium AD.

The KPD (Khok Phanom Di)-like grouping extends from southern continental Thailand in the north to Lombok in the south, and from Peninsular Malaysia in the west to Luzon and South Sulawesi in the east. The Thailand representative are millennia older than the other repertoires, whose dating embraces the first and second millennia AD (Table 7; Figure 17).

The Batu-Ejaya-like grouping essentially consists of South Sulawesi repertoires located to the south of South Sulawesi's single KPD-like repertoire. However, it also includes Leang Tuwo Mane'e in the Talaud Islands as a geographical outlier. Dating for the Batu-Ejaya-like repertoires centers on the first millennium AD, with the second millennium AD repertoire of Somba Opu incorporated as a more recent representative (Table 7; Figure 17).

DISCUSSION

Remarkably, all of the groupings that **include** Makassar repertoires (Repertoire Nos. 86 to 141 in Figure 1) otherwise include only ISEA repertoires. Equivalently remarkably, with the single exception of the Uattamdi-like repertoires, all of the groupings that **exclude** Makassar repertoires are joint groupings of MSEA and ISEA repertoires. The implications of this dichotomy are discussed below.

The Makassar repertoires strongly feature in the right-hand third of the seriation, even though they constitute, at best, an interrupted sequence. They certainly fall far to the right of any Sa-Huynh- or Kalanay-related repertoires. Clune (1996) appears to have been fully justified in disregarding any potential Sa-Huynh-Kalanay affinities in her analysis of Makassar decorated pottery. The Makassar repertoires can certainly be assessed as not belonging to any Sa-Huynh-Kalanay tradition, and arguably constitute an identifiable culture of decorated earthenware pottery.

Several other examples of decorated-pottery cultures (repertoire sequences unified in time and space) emerge from the results. One such sequence involves the Sa-Huynh-culture sites of Iron Age South and Central Vietnam (Nos. 72–76, 78–79), albeit missing out on Phu Khuong and Thanh Duc (Nos. 41–42) in this particular analysis, but on the other hand in apparent close association with Hoa Diem (No. 82). Two further examples are the Neolithic sites of the Karama River in West Sulawesi (repertoire Nos. 50–51, 57), and the Uattamdi-like repertoires of the first and second millennia AD of the central Philippines and North Maluku (Figure 14). The Northeast Thailand repertoires fall into two groupings, one of Neolithic to Bronze Age chronology (Nos. 28–30), and a second, predominantly later grouping of repertoires, all of which have at least some Iron Age associations (Nos. 10–13, 15).

As noted above, apart from the exceptions mentioned previously, all of the groupings combine MSEA and ISEA repertoires. Could these provide justification for the posited Nusantao-mediated, Sa-Huynh-Kalanay tradition? The details of the groupings suggest not. In several cases (Bagupantao-like, Jambi-megalithic-like, Kalimantan-like, GCV-like, and KPD-like groupings), the MSEA repertoires are much older than the ISEA repertoires. In other cases (BND-like, Mansiri-like, Minanga-Sipakko-like, Gua-Cha-like, Bawuwansi-like, and Lie-Siri-like groupings), the chronological range for both the MSEA and ISEA repertoires is too long to attribute the similarities in the pottery decorations to contact between contemporaneous communities. The Sembiran-like grouping is the only combination of MSEA and ISEA repertoires that have a reasonably tight chronology, centered on the BC/AD transition, but this may be coincidence. It is conceivable that improved chronological control over the repertoires (see Materials) may have enhanced chronological comparability, but specific cases where this would affiliate statistically similar repertoires

Table 8. Main elements affecting the Results.

	Element																									
Grouping	**23**	**4**	**73**	**29**	**34**	**9**	**45**	**65**	**16**	**20**	**13**	**8**	**7**	**54**	**10**	**35**	**52**	**43**	**15**	**14**	**39**	**71**	**3**	**22**	**1**	**25**	**32**
Bagupantao-like	++	+	++	++	+	+	+	+–	+	+	+	++	+	–	–	–	–	–	–	–	—	+–	–	—	—	—	—
BND-like	+–	+	+–	+–	+–	+	+–	+–	+–	+–	+–	–	–	+–	–	—	—	—	–	—	+–	—	—	—	—	—	—
Mansiri-like	+	—	—	–	–	+–	++	—	–	+–	—	+	+	–	+–	–	–	—	—	—	–	+	—	—	—	—	–
Jambi-megalithic-like	+	++	++	–	+	+–	+	–	+	+	–	++	–	–	—	–	—	–	+–	—	–	–	—	—	—	—	—
Kalimantan-like	++	++	–	–	++	+–	+	–	+–	+	—	+	–	+–	–	+	+–	+	+	—	+–	—	—	—	—	—	—
Sembiran-like	++	+	–	+	+	+	+–	—	+–	+–	–	+–	+–	–	—	+–	+–	–	–	—	–	—	–	—	—	—	—
Minanga-Si-pakko-like	++	–	+–	—	—	–	–	—	+–	–	–	+	++	++	+–	+–	+–	+–	+	+–	+–	+	—	—	—	—	—
Gua-Cha-like	+–	++	+	—	+	++	++	—	—	+	—	+	+–	—	+–	—	—	+–	—	—	—	—	+–	—	—	—	—
Bawuwansi-like	+	–	+–	++	+–	+–	–	+	++	+	—	+–	—	+	+	+–	–	—	–	—	+	—	–	–	—	–	–
GCV-like	++	+–	+–	–	+	—	+	–	+–	+	—	++	+–	–	—	+–	–	–	–	—	–	—	+–	+–	—	–	—
Plawangan-like	—	+	—	—	—	+–	—	—	+–	+–	++	—	–	–	–	—	—	–	+–	—	+–	—	–	–	+–	—	—
Lie-Siri-like	++	—	+–	+–	—	++	++	–	+	+–	–	++	+	+–	—	+–	–	+–	+–	—	+–	+	–	—	—	—	—
Uattamdi-like	+	—	+–	–	—	+–	+–	—	++	+–	+–	+–	+–	–	—	+–	—	+–	+	—	+–	+	—	—	—	+–	—
Santa-Ana-like	—	–	–	+–	—	+	—	—	—	+–	–	+–	–	—	—	—	—	—	—	—	—	+–	–	—	+–	—	–
Bayoa 1-like	—	—	—	–	—	++	–	—	+–	—	+	+–	–	—	—	—	—	—	–	—	—	—	+–	—	+	—	—
Bayoa 3-like	+–	+–	–	—	–	+–	—	–	++	–	+–	++	+	+–	—	+–	+–	—	++	—	+–	—	–	—	–	–	+–
KPD-like	–	+	++	++	+–	–	++	+–	+–	++	+	+	++	–	+	+	+	–	–	—	++	++	+–	+–	—	—	+–
Batu-Ejaya-like	+–	+–	—	+–	—	+–	+–	—	++	+	–	++	–	–	—	—	—	+	—	+–	+	—	—	+–	–	+–	—

Proportion of repertoires in a grouping with the element in the column heading: — stands for 0–19% of repertoires; – stands for 20–39% of repertoires; –+ stands for 40–60% of repertoires; + stands for 61–80% of repertoires; ++ stands for 81–100% of repertoires.

For description of the elements, see Table 1.

that do not already represent the same culture are hard to identify.

Table 8 explores the role of key elements in characterizing the identified groupings and the seriated order of these groupings. Very common elements, recorded for more than 100 repertoires, are left out of consideration, because they will be present for a high proportion of the repertoires in all of the groupings. On the other side of the coin, very rare elements are also excluded from consideration because of their low representation amongst the repertoires in any of the groupings. When we review the 27 considered elements whose representation by grouping appears to have the greatest effect on the seriated order and/or distinctiveness of a grouping, we find that fully 19 of them of them are elements originally defined by Clune (1996) in her analysis of Makassar pottery. These are all simple elements (such as chatter marks and cross-hatching) that may be expected to re-emerge in unrelated craft centers for decorated pottery. The single exception here is the cogwheel rim (element no. 1) which is diagnostic of Makassar repertoires, apart from the surely coincidental appearance of similar rims on small votive vessels of the first millennium AD at Non Ban Jak in Thailand. Only four of the elements defined by Flavel (1997), with a Sa-Huynh-Kalanay orientation, merit inclusion in Table 8, and so their effect on the Results is slight. A similarly mild influence is apparent from the four supplementary elements (concentric semi-circles, pock marks, chains of dots, and looping grooves/incisions), as defined by the author, that merit inclusion in Table 8.

Finally, it is worth noting that the six repertoires nominated by Solheim (2002), as representative of his Kalanay pottery tradition, slot into four different groupings: Sembiran-like (Camotes Site C13); Minanga-Sipakko-like (Kalanay pottery from Kalanay Cave); Lie-Siri-like (Leyte Site C14, Siquijor Site B23, and Unknown Site); and Bayoa 1-like (Bohol Site C11). The grouping of Kalanay Cave Kalanay pottery with West Sulawesi Neolithic repertoires may be interesting but not necessarily diagnostic, in view of the general sense of chaos in the groupings that reach out for affinities beyond the identifiable cultures of decorated pottery.

CONCLUSIONS

The notion of a Sa Huynh-Kalanay pottery tradition has been defined so widely (Solheim 2002) that it would admit almost any aggregation of Southeast Asian earthenware pottery decorative repertoires. One aggregation that it would not admit is the aggregation of second millennium AD Philippine repertoires with earlier Philippine repertoires, but contrary to expectations, there are several such aggregations (Bagupantao-like, Lie-Siri-like, and Uattamdi-like groupings). Also, Solheim's concept of a "Nusantao" trading network to explain similarities across geographically dispersed repertoires of decorated pottery does not fare well, because contemporaneity of these repertoires is rarely in evidence. Instead, where contemporary repertoires show signs of decorative unity, they also reflect geographical unity, and can be assigned to cultures of decorated pottery. Otherwise, the bulk of the motifs used for decorating pottery in Southeast Asia appear to lack the necessary level of diagnostic assignment that would allow exchange networks to be inferred from similarities in decorative elements.

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