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Abstract

Long-lasting indirect impacts on Indigenous peoples in the periphery of colonial control are poorly understood, especially in East Asia. Trade ornaments from Kiwulan (1350-1850 AD) in northeastern Taiwan show the indirect impacts of European colonial activities on local societies. The diversity of ornaments was greater during the period of European presence compared to previous periods, and their spatial distribution was more clustered. This hints at increasing social inequality resulting from colonial influence. Ornaments give insights into the increasing social inequality stimulated by the European colonial presence, and show the agency of Indigenous people to incorporate ornaments into their social system.

Keywords	Historical archaeology; European colonial period; 17th century; Trade ornaments; Exchange networks; spatial pattern; East Asia

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Dear Editor,

Thank you for forwarding to us your comments and the reviewers' comments. Sorry for our slow reply. We were pleased to see the positive feedback from the reviewers. We found all the comments most useful, and have diligently followed all their suggestions to improve our paper.

In our document of response to reviewers, we highlighted the actionable comments from you and the anonymous peer reviewers in red, and indicated our responses by these symbols >>>

Thanks again,

Li-Ying Wang

Response to Reviewers

In our detailed reply below, we highlighted the actionable comments from you and the anonymous peer reviewers in red, and indicated our responses by these symbols >>>

Reviewer 1

This manuscript contains several basic problems:

1. The authors base their work on their own interpretation of "assigning artifacts" to specific time periods of "pre-European" through "Chinese" contexts, yet those assignments are questionable and in disagreement with the original site reporting. The two authors here did not join in those original site investigations, and their re-interpretation of the site would require much more detail of the primary data management and justification in the methodology. Given a very short western colonization period in northern Taiwan, most attentive readers would not believe that a site deposit like in this instance can be divided so clearly into separate components of pre-European, European, and Chinese periods. The authors proposed their own interpretation of the site chronology, and considerably more evidence would be necessary in order to entertain this new interpretation. This problem is quite serious, because the chronology is fundamental for allowing the authors to interpret the chronological change of more diverse and spatially clustered ornaments through time. In order to resolve this key issue, the authors would need first to demonstrate the full amount of details of the site stratigraphic layers, material contents per layer, and positions of radiocarbon dates. The authors claim that they have performed this work already, but they did not share any of it in this manuscript, with enough clarity to compare with the original excavation reports that the authors admit to show different results.

>>>> We have uploaded a greatly expanded set of Supplementary Online Materials that includes detailed data of the site stratigraphic layers, the layers where the radiocarbon dates from, and materials per layer we used for chronology assigning accompanied. This includes a document to guide the reading of data and justify our methods.

2. Another problem is the “assigned artifacts” for the pre-European, European, and the Chinese periods. Before the Spanish and Dutch colonized Taiwan, the Chinese merchants and maritime pirates already had been active in East Asia, and they continued the trading activities in northern Taiwan during the Dutch and Spanish periods. Thus, the result of “social inequality” in northern Taiwan, if it had occurred, was not necessarily as simple as the authors suggest to be related with Western entities, and the “Chinese artifacts” in this manuscript may not have belonged to the” Chinese period” as defined by the authors. These issues have been noted by other scholars working in the region and by Taiwan-based archaeologists in particular.

>>>> We have noted the issue of time indicators. In the excavation background section, we have clarified that we focus on the context where those indicators prevailed to avoid misleading by a single, and individual diagnostic artifact. We also examine stratigraphic data to double check our interpretation. We added an acknowledgement that the chronological resolution may be diminished by this potential movement of Chinese artifacts. Nevertheless, we believe our chronological analysis shows a clear and reliable signal of a Chinese period following the European period.

3. Ornaments are the major objects in this study, yet the authors missed a few key points about ornaments in general. Contrary to what the authors suggest, a few obvious factors could account for the result of seeing more abundant and diverse ornamental objects at the site through time. For example, ornaments tend to endure over long time periods, and many were inherited through multiple generations, at time scales that

certainly could cause problems with the distinctions that the authors propose for pre-European, European, and Chinese Periods. If one generation was 20 years (or some would argue 25 or 35 years?), then how could the authors distinguish the time period, given that the Spanish period in Taiwan was about 16 years? Likewise, the Dutch/VOC period was about 38 years.

>>>> We have added some discussion of the issue of heirlooms in the personal ornaments section. We have explained that the amount in the archaeological records can reflect their frequency for each period, because we did not observe the accumulated increase over time. If heirloom behavior was significant at Kiwulan, we would see the highest amount of ornament in Chinese period, but we did not see this trend.

4. The authors propose that the degree of social status differential should be measurable through the diversity and spatial clustering of ornamental artifacts. This idea may be reasonable, but it would need to be introduced with reference to the established literature about reflections of social status in archaeological sites. The scholarly literature is full of relevant work in theory, methodology, and concrete examples in ethnography, archaeology, and ethnoarchaeology that the authors should already know.

>>>> We have updated the text to introduce the topic of social status that can be revealed by spatial clustering of artifacts with both classic references (Kintigh 1982; Orser 1988; Pearson 1993; Halstead 1993) and recent studies (Trubitt 2003; Wason 2004) to support our claims.

5. Furthermore, the population size likely increased through time, and accordingly more people would gain access to more ornaments. In this case, the number of residential houses and especially burial features at the site would reveal more clearly about what had happened, yet the authors have obfuscated this information or avoided it deliberately in the case of the burials.

>>>> We did consider the population issue by using local ceramics as an indicator for population dynamics. We have run a Poisson regression to model the relationship between ceramics and ornaments. We did not do the further research of population size directly based on burials and houses since the data is not available yet and it is beyond the scope of this paper.

Reviewer 2

In general it is proper for publication. However I could see some worth citing issues:

1) A similar or proportional way of adopting western modern products like in trade ornaments from Kiwulan (1400-1900 AD) in northeastern Taiwan, has been noted elsewhere.
The impacts of European colonial activities on local societies see:
Kaltham Al- Ghanim, Andrew Gardner and Sherine El-Menshawy (2017) The relation between spaces and cultural change: supermalls and cultural change in qatari society. SCIENTIFIC CULTURE, Vol. 3, No 2, pp. 21-32 DOI: 10.5281/zenodo.438184 (www.sci-cult.com)
Another issue imposed on traditional societies is the way they preserve conservation and preservation of historic monuments:
ZHENG Jie Jane (2015) the legal approach to historic preservation: a comparative study of historic preservation laws in new york and hong kong. SCIENTIFIC CULTURE, Vol. 1, No 3, pp. 61-68. DOI: 10.5281/zenodo.18452

>>>> We have cited Ghanim et al (2017) and Zheng (2015) in texts and added them to the reference list.

2) Concerning the jar shapes found at Kiwulan and their provenance it should be carried out a project on XRF analysis for characterization and provenance.

>>>> We agree and have mentioned that we will conduct XRF analysis for ornaments in future analysis. But currently it is beyond the scope of this paper.

3) Regarding pieces of locally made pipes and a few imported pipes were found at Kiwulan. Smoking is likely to have been introduced by Europeans…The authors should also consider the work in Turkey: 15th-8th c (Hasan Uçar (2019) ARCHAEOLOGICAL PROOF OF ENJOY AT TİRE KUTU HAN: CLAY PIPES, Mediterranean Archaeology and Archaeometry Vol. 19, No 2, pp. 119-134 DOI: 10.5281/zenodo.3340095 (www.maajournal.com).

>>>> We have cited Uçar (2019) in the excavation background section and added it to the reference list.

4) The ornaments in archaeological sites. A) in these ornaments assign a date, b) mention which archaeological sites? Not the Kiwulan one? Others?

>>>> We have clarified that ornaments were commonly found in Yilan at other sites during the same period. And we have noted that there are no direct dates on ornaments in Kiwulan or other sites. The dating on ornaments relies on the stratigraphic context where the ornament from which is dated by imported diagnostic ceramics and C14 dates on charcoals.

5) The dated ornaments and the C14 section (chronology) should be more explicit. How the dates in (which?) digs relate to which ornaments and define the pre and post European presence.

>>>> We prepared a much expanded set of Supplementary Online Materials that include extensive information and justification of the chronology we present. These data show the specific layers where the C14 samples are from and other time indicators including jars, pipes, stonewares, tiles, and bricks. The chronology of ornaments is determined by those layers, and our new SOM gives the full details of how we made these determinations for each unit.

Overall: Authors have introduced a model for understanding the dynamics of social inequality at Kiwulan, and have shown how remote indigenous groups were affected by major European colonial processes including Chinese influence as well.
The conclusion section should remain in the findings at this study and shorten considerably the intended future tests.

>>>> We have reorganized the conclusion with a stronger focus on the findings and shortened the intended future tests.

Reviewer 3

In this paper, the authors aim to compare the degrees of social inequity at Kiwulan, by estimating the numbers and spatial distributions of ornaments, in different time periods—before, during, and after the European encounters. They finally conclude that social inequity, displayed by the accumulation of ornaments (wealth) was especially prominent during the European colonial period. The competition to accumulate wealth among indigenous people was promoted by the presence of European colonists. Such aggrandizement of social

status also became a means to resist the intrusion of Europeans. The goal is clearly stated and the research strategy well designed.

The authors suspect that the increasing number of ornaments was perhaps due to a growth of population during that time. They then examine both the diversity and the numbers of ornaments in each category for different periods. From this test, they can further indicate that the increase of diversity was because Kiwulan was involved in a larger trade network, which is an interesting finding (p.12). However, in comparison tests, such as chi-square, different ways of categorization may affect the comparison results. The authors need to justify their taxonomy. Why are different kinds of beads in the same level as different kinds of metal things, each of which is again divided into several sub-categories? Because of their shapes, outlooks, or raw materials? Whether each type of ornaments was attached the same social importance was mostly unknown, either. The authors also occasionally mention other kinds of ornaments, such as fish-shaped necklaces that were made of metal threads and also marked high social status (p.3). How these different kinds of ornaments related to or complimented each other can be further explored.

>>>> We have clarified that we used the well-established regional ornaments typology in this region for this study. The major type of ornament was classified based on their material and function, and the subtypes are classified based on the shapes. We focus on comparing the frequency of major types of ornaments relative to each other to ensure our sample size is adequate. We only briefly mentioned other kinds of ornament as a supplement since they are too few to robustly explore their relationships to each other.

Although the authors suggest that the presence of Europeans, making some types of ornaments more accessible, were responsible for the competitive accumulation and display of wealth among indigenous people, it is not clear that why the ownership of such wealth also became a way to resist the presence/intrusion of Europeans. It would be interesting to suggest more details about the role Europeans played in trading with local people. In other words, how the presence of Europeans might "simulate" the desire of ornaments needs more explication. By stating the European influence was "indirect", it might be useful to say something about the attitude of the Spanish and Dutch towards local people. Did they consider Kiwulan potential colony? It will also be interesting to compare Kiwulan with those under the direct control of Spanish and Dutch governance.

>>>> We have clarified in the discussion section how the European presence led to ornaments accumulation in the local society, which might be caused by the competition for trade goods and the image of European colonial power. We have mentioned that Kiwulan is included into the Dutch feudal system, but the colonial control is weak and flexible for which we define as an indirect influence. Regarding the attitude of Europeans toward Kiwulan, we have noted that we still need more evidence to discuss it. We agree that it will be interesting to compare Kiwulan with other local settlements in Taiwan under European governance, but we lack suitable sites for comparison currently.

The widespread of ornaments and their lack of pattern in the spatial distribution during European contact is intriguing (p.14). How this distribution might correspond to the distribution of social power is something worth thinking. It is valuable that the authors provide another view, the KDE hotspot, to suggest the distribution of social inequality in space. That can be useful to refer to certain social groups in their future research. Overall, this article to incorporate European contact and the assertion of social power by a small group of indigenous people is successful and convincing.

Some minor suggestions:
Fig.7-1 the x-axis of the topmost figure is better rendered as integral numbers to meet the unit of ornaments.
The English writing is easy to understand but some possible typos:
p.2, L22: "slightly" differences
p.3 L39: because of “to” a lack…

p.6 L18: bought-->brought
p.17 L25: resulted from; L30-33 better to rephrase

>>>> We have fixed the numbers on the figure. We have corrected all the typos and rephrased the sentences mentioned above.

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Ornaments as indicators of social changes in northeastern Taiwan before and after the European colonial period

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14 May, 2020

Long-lasting indirect impacts on Indigenous peoples in the periphery of colonial control are poorly understood, especially in East Asia. Trade ornaments from Kiwulan (1350-1850 AD) in northeastern Taiwan show the indirect impacts of European colonial activities on local societies. The diversity of ornaments was greater during the period of European presence compared to previous periods, and their spatial distribution was more clustered. This hints at increasing social inequality resulting from colonial influence. Ornaments give insights into the increasing social inequality stimulated by the European colonial presence, and show the agency of Indigenous people to incorporate ornaments into their social system.

keywords: Historical archaeology; European colonial period; 17th century; Trade ornaments; Exchange networks; spatial pattern; East Asia

Introduction

The direct impacts of European colonialism on Indigenous communities in East Asia were much less conspicuous than in island Southeast Asia and Oceania. Direct European colonial rule throughout East Asia was rare and limited, and the question of long-lasting indirect impacts on local Indigenous communities remains largely unanswered. Understanding the indirect effects of colonialism are important for detecting colonial impacts on Indigenous peoples in the periphery of colonial control (Acabado 2017; Trabert 2017). In many parts of the world, the introduction of foreign trade goods by colonial traders into local Indigenous societies caused substantial transformations of Indigenous economic, cultural, and socio-political systems (Dietler 2005; Dietler 1997; Junker 1993; Silliman 2005). Consumption patterns of foreign goods can give insights into negotiations between colonized and colonizer, and the resistance and accommodations of Indigenous people through their daily cultural practices (Dietler 2015; Given 2004; Mullins 2011; Scaramelli & Scaramelli 2005; Silliman 2001; Torrence & Clarke 2000; Voss 2005). Northeastern Taiwan is an ideal context to study peripheral colonial influence because although there was a prominent Spanish and Dutch colonial presence in parts of Taiwan, the northeastern region was isolated from intensive direct contact by the Xueshan Mountains.

This article describes personal ornaments excavated from the upper component of Kiwulan (1350 AD-1850 AD), the largest Iron Age settlement on the Yilan plain in northeastern Taiwan. Ornaments are found at many Iron Age sites in Yilan, but only Kiwulan shows clear stratigraphic contexts from pre-European period to modern time. The first recorded European presence in Yilan was a Spanish revenge attack on Indigenous villages in 1632

(Borao 2001: 163). In 1647 the Dutch attacked villages and forced them to accept colonial rule and pay an annual tribute (Andrade 2007). According to Dutch census reports in 1650, Kiwulan was the largest Indigenous settlement in the plain, with a population of 840 adults (Nakamura 1938: 12). Following defeat of Dutch by the Chinese general Koxinga in 1661-1662, the Dutch abandoned northern Taiwan. Direct contact with Han Chinese is indicated by Qing dynasty census reports mentioning Yilan villages in 1821 (Yao 1996).

One of the most commonly traded types of object in this region were ornaments such as glass and stone beads (Chen 2007; Li & Chiu 2014; National Musuem of Taiwan History 2005). Personal adornments in the archaeological record are useful as signal of an individual's status (Joyce 2005; Scaramelli & Scaramelli 2005). The consumption of stone beads in Southeast Asia during Iron Age is often associated with increasing social stratification or socio-political complexity (Bellina 2014; Carter 2016; Francis 2002; Theunissen *et al.* 2000; Kenoyer 2000). In this paper, we explore archaeological ornaments from Kiwulan spanning the pre-European contact period, the period of Spanish and Dutch presence, and the following period of Chinese presence. We address the question of whether indirect colonial influences on the Indigenous populations can be detected through the ornament assemblages.

Ornaments in complex exchange network during the late Iron Age and early historical period

The island of Taiwan lies at the junction of mainland China, Southeast Asia, and Northeast Asia in the Pacific Ocean. The prehistory of Taiwan island could be roughly divided into three major periods, Palaeolithic (c. 27,000 BP- 5000BP), Neolithic (c. 6500- 2000BP), and Iron age (c. 2000- 400BP) with slight regional differences in onset of each period and variations in style of artifacts and assemblages (Chen 2017; Liu 2011). It is generally accepted that Taiwan entered the historical period in the early 17th century due to the colonial activities of the Spanish and the Dutch who played an important role in keeping written records about Taiwan. The European colonial presence in Taiwan ended in 1662 when the Dutch were defeated by the kingdom of Tungning, founded by Koxinga from China. Later in 1683, Taiwan was incorporated into the Qing dynasty in China and a large wave of Han Chinese migrated to Taiwan during the late 18th century. Because of natural safe harbors, northeastern Taiwan was involved in a regional trade network through cross-culture interactions with Chinese merchants since the 14th century, and later the global trade network with the Europeans in the 17th century brought more trade goods circulated in Southeast Asia into Taiwan (Chen 2005; Liu & Wang 2017). Although located on the periphery of regional trade centers, Yilan was connected to trade networks via visits of other Indigenous groups, Chinese merchants, and Europeans, via sea.

The European presence in northern Taiwan started with the Spanish who founded Fort San Salvador at Heping Dao, Keelung in 1626, and Fort San Domingo in 1629 at Tamsui (Figure 1). They sent missionaries to local Indigenous settlements in this region (Blussé & Everts 2000: 343) and kept records about their observations of Indigenous communities. A Dominican priest in 1632 reported that the Taparri, an Indigenous tribe from northern

Taiwan, exchanged carnelian beads with other Indigenous groups. This form of exchange was widespread and even the Spanish soldiers used carnelian beads as bargaining chips for gambling (Li & Wu 2006: 132–49). The use of beads as prestige goods is further indicated by their role in bride price payments, and compensation to resolve disputes (Li & Wu 2006: 132–49). Other records mention that the women shamans in the tribe would use carnelian beads as magical items in ritual healing practices (Borao 2009: 122–51). Records of an Indigenous funeral describe the use of carnelian beads in ritual contexts, with more carnelian beads, pottery, and cloth placed into the graves of more influential people to indicate their family's higher status (Li & Wu 2006: 153). While a full critical analysis of these historical accounts remains to be produced, we take them to minimally indicate that carnelian beads were already treated as prestige goods in Yilan before the arrival of Europeans. In 1642, the Dutch Vereenigde Oostindische Compagnie (VOC) defeated the Spanish and took over their forts in northern Taiwan. They introduced a feudal system in an attempt to control the Indigenous communities by asking Indigenous leaders to attend an annual ceremony for demonstrating their loyalty and paying tribute (Andrade 2007, ch. 9; Kang 2016, ch. 4). The Dutch provided beads and other goods based on negotiations with Indigenous communities to secure alliances in the annual ceremony or during their travels (Kang 2016, ch. 6). We might predict that the activities of the Dutch feudal system to build and maintain alliances resulted in an increase in the amount and diversity of ornaments in northeastern Indigenous communities during this period.

Chinese historical records from 1829, 1837, and 1852 during the Qing dynasty (1616-1911) contain some notes on the purposes of ornaments from Yilan (Chen 1963: 228, 308; Ke 1993: 11, 126; Yao 1996: 77). According to those records, Indigenous people in Yilan wore ornaments in ceremonial contexts to display their wealth and status. Among those ornaments, fish-shaped necklaces made of metal threads had high value due to their delicacy and the exotic materials invested in production. These were usually possessed by wealthy people. Other people wore carnelian beads or glass beads on their head or neck to participate in ceremonies. In 1895, at the beginning of Japanese colonization, an academic field survey for plains Indigenous groups reported that fish-shaped metal necklaces were not used in Yilan at that time, but elderly people still used beads (Ino 1996: 227–32). Although these historical records are fragmentary and may contain some biases (Galloway 2006) that have not yet been studied in detail, we find consistency among multiple sources in their descriptions of how ornaments represent high status or specialized social roles in Indigenous communities in Yilan. Compared to the European period, there are fewer documentary mentions of beads in the Chinese period and the descriptions are limited to clothing, but these generally confirm the role of beads as status markers.

Ornaments found in northeastern Taiwan in the early historical period, including glass beads, stone beads, and metal ornaments, are considered to have been imported from other regions. This is because of a lack of archaeological evidence of beadmaking waste, metalworking, or accessible local raw materials. The chemical composition of glass beads from this region shows a high content of lead and, together with the winding/folding technique, these details suggest a Chinese beadmaking tradition (Cheng 2008; Gan *et al.* 2006; Wang 2018). Although there is a wide variety of metal ornaments such as bells, bracelets, rings, and pendants, the common components of metal ornaments are brass and

copper, with a small number made from lead and tin that indicates multiple origins that include Southeast Asia (Chen 2011). There is no direct evidence showing European delivery of beads, however, a large amount of the glass beads containing gold foil (hereafter, gold-foil beads) at Kiwulan might have been introduced by the Spanish through economic activities because similar beads were found at Luzon, northern Philippines, as part of the trading route of the Spanish between 16-19th century (Wang & Liu 2007). Both archaeological evidence and historical records indicate northeastern Taiwan was involved in regional networks with East Asia in the late Iron age. These included Chinese merchants trading metal items, clothes, and beads with local Indigenous people in Taiwan in exchange for local resources. The foreign-made large dark brown glazed stoneware jars frequently found in European shipwrecks were also commonly found from many sites in Taiwan, suggesting direct or indirect interactions. Despite the Chinese origin of some ornaments at Kiwulan, there is compelling evidence that a large amount of ornaments found at 17th century sites resulted from European colonial and economic activities in the region.

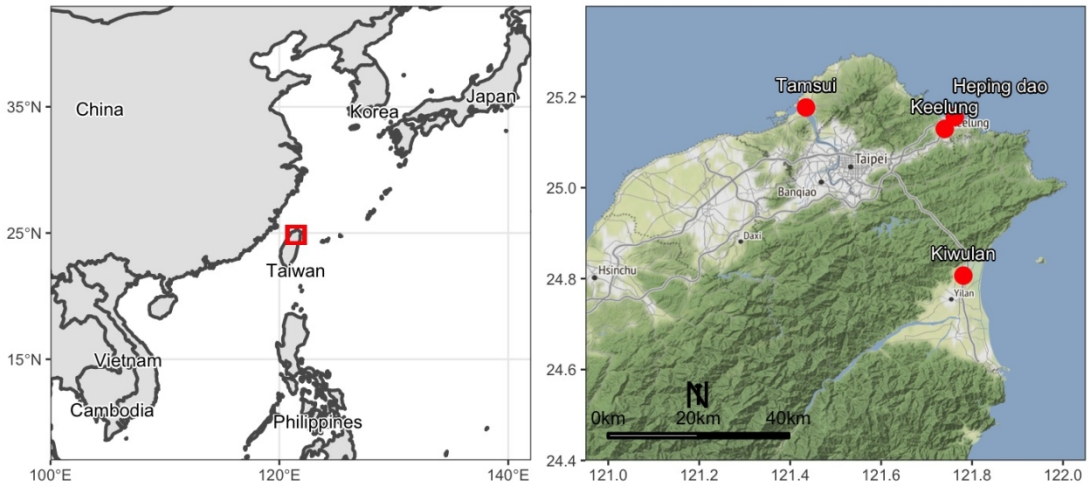

Figure 1: Map showing the location of Kiwulan, and other places in northern Taiwan named in the text. Map data from naturalearthdata.com

Excavations at Kiwulan in northeastern Taiwan

Archaeological ornaments from Kiwulan (Figure 1) come from a rescue archaeology project that was conducted between 2001-2004 in advance of a water diversion project and road bridge construction. The excavations used 2 mm and 1.5 mm mesh screens and covered eight open area sections in total of 262 squares (4 m by 4 m) reaching 3,814 m^2 (Chen 2007). The nearly 2 m thick archaeological deposits reveal a large amount of artifacts, burials, middens, post-holes, wooden pillars, and stone structures, all of which indicates it was a long-term settlement. Artifact locations were recorded to the 2 x 2 m sub-square they were recovered in; they lack individual point provenance. Based on the continuity of deposition and the frequency of artifacts, the center of the site is the open area consisting of the A and D sections, which is also the study area where our samples come from (Figure

2). In the AD area, post-holes were found aligned in a north-south direction in intervals with construction marks, which have been interpreted as the remains of stilt house structures. At the north margin of the dwelling place were burials that are mostly oriented in an east-west direction.

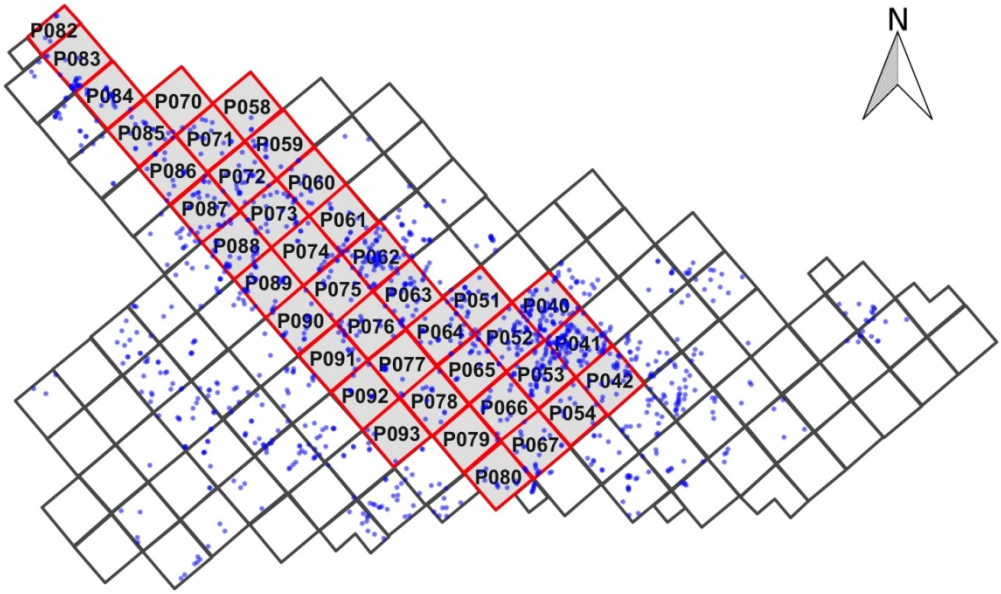

Figure 2: Map showing the largest section of excavation areas at Kiwulan, and the distribution of forty squares sampled in this paper presented in red with square ID numbers. Small dots represent the locations of post-holes. Each square is 4 x 4 m

The chronology of Kiwulan can be divided into two phases represented by a upper component (1350-1850 AD, 600-100 BP) and a lower component (650-1150 AD, 1200-800 BP) separated by a sterile deposit spanning c. 150 years (Chen 2007). The sterility may be related to dry weather, according to pollen analysis, leading to site abandonment (Lin 2015). These component divisions are based on the differences in color and texture of the deposit and the content of artifacts. Whether these two components represent a culture continuity from the same people is still under debate (Chiu 2004; Chen 2007). There are 32 radiocarbon ages spanning the two components, previously published by Chen (2007), and shown here in Figure 3 and Table 1. We focus on the upper component because only this component spans the periods of pre-European contact, European presence, and Chinese presence. In the upper component, all excavation squares in our sampling area show signs of continuous human occupation during each of the three phases. Previous work divided the upper component into six analytical units, spanning from the 14th century to the 19th century, according to the radiocarbon dates, excavation depth, consistency of contexts, and types of chronologically diagnostic ceramics such as blue and white porcelains (Hsieh

2009; Wang 2011). Based on these six units and copies of original excavation records, we have made some refinements of the original chronology to assign contexts into the pre-European, European, and the Chinese periods. The methods we used to devise the new chronology are described in the Supplementary Online Materials.

The archaeological indicators of the start of the European influence at Kiwulan are the appearance of light grey glazed jars, known as "An-ping" jars in China and Taiwan, and large dark brown glazed stoneware jars that were introduced to Taiwan during the early 17th century. Large dark brown glazed stoneware jars may have been made in Southeast Asia, but are frequently found in European shipwrecks from this period as vessels for transporting water, wine or other liquids on long voyages. The earliest evidence of light gray glazed jars in this region has been found among the cargo of the Spanish shipwreck *San Diego*, which sunk in 1600 AD (Dizon 2016; Hsieh 1995). Southeast China is assumed to be the origin of the light gray glazed jars, however these are commonly found at sites in Taiwan that were associated with European activities, such as the Zeelandia fort site in Tainan (Wang & Liu 2007). The jar shapes found at Kiwulan are typical of those found elsewhere in VOC sites occupied during the 17th century (Berrocal *et al.* 2018: 917; Cort 2017: 282; Grave & McNiven 2013; Ketel 2011; Klose & Schrire 2018: 131). We cannot be sure of the exact process that brought them to Kiwulan: they might have been directly imported by Europeans, by Chinese merchants, or by Indigenous groups via regional networks in north Taiwan. In any case, the high volume of ceramics transported by Europeans, and their high mobility in the shipping trade played an important role in introducing foreign jars to Taiwan.

Those jars were widely distributed across the site and can serve as indicators, together with the radiocarbon dates, to identify the excavation units associated with the pre-European period and the start of European influence at Kiwulan. In addition to stoneware jars as indicators of European presence, around 300 pieces of locally made clay pipes and a few imported pipes were found at Kiwulan. Smoking is likely to have been introduced by Europeans. This custom was widely adopted in many European countries in the 16th century and spread to other regions through interactions (Uçar 2019). We found that the presence of pipe bowls in the archaeological record here is consistent with distributions of glazed jar fragments, which are far more numerous and widespread across the site (n = 1685). It should be noted that these temporal indicators might have been introduced before direct European contact by Chinese traders, and this could result in some uncertainty in identifying the start of European phase. However, the archaeological evidence shows that the layers with abundant trade ceramics match the 17th century according to the excavation report and previous studies (Hsieh 2009; Wang 2011). Thus, we focus on identifying the contexts with high frequencies of those ceramics as indicators the early 17th century.

The archaeological signature of the Chinese period at Kiwulan is the large amount and diversity of Chinese porcelains in many styles and forms such as bowls, plates, and cups. Other indicators include opium pipe-bowls and distinctive architectural bricks and tiles used by Chinese (Hsieh 2009). Chinese migrations to Yilan were also recorded in official Chinese records written in the early 19th century recording the first immigrants in 1768 (Chen 1963; Ke 1993). The details about the distribution of the temporal indicators,

accompanied with stratigraphy data, radiocarbon dates, and archaeological contexts for each sampled excavation unit are provided in Supplementary Online Materials.

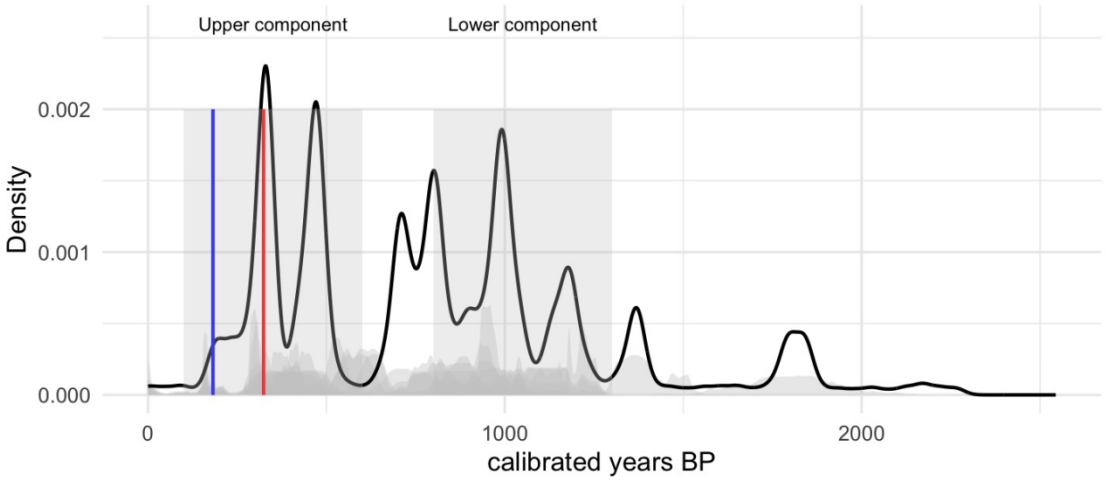

Figure 3: Summed probability distributions for dates from Kiwulan. The dark line represents the summed probabilities of all radiocarbon ages, and the grey lines in the background are the probabilities of individual ages. Grey rectangles indicate the approximate chronology of the major archaeological components of the deposit. For the upper component, the red line indicates the start of European presence, while the blue line is the Chinese presence. Ages calibrated with the Bchron package (Parnell et al. 2008)

Lab code	Pit-Layer	Depth (cm)	Uncalibrated Age BP	Calibrated Age BP (95% credible interval)	Context
NTU-3803	P052-L7	0 to -10	<200		artefact-bearing deposit
NTU-3925	P051-L17	-36 to -56	<200		sterile deposit
NTU-3943	P051-L19	-70 to -90	<200		sterile deposit
NTU-4283	P063-L12	-30 to -70	<200		midden H044
NTU-4293	P089-L11	-50 to -70	<200		artefact-bearing deposit
NTU-4305	P089-L7	-20 to -30	<200		artefact-bearing deposit
NTU-4322	P051-L11	0 to -40	<200		midden H026
NTU-4323	P070-L3	20 to -57	<200		burial M095
NTU-3993	P041-L7	-25 to -45	250±40	5-431	artefact-bearing deposit
NTU-4419	P162-L3	-10 to -110	280±70	14-484	midden H172
NTU-4311	P052-L16	-110 to -130	310±100	18-512	artefact-bearing deposit
NTU-4320	P168-L1	6 to -51	340±100	30-529	midden H193

NTU-4016	P028-L9	-44 to -80	270±40	152-454	burial M020
NTU-4310	P018-L2	-28 to -70	360±100	87-545	burial M039
NTU-3791	P049-L11	-20 to -30	340±30	315-482	artefact-bearing deposit
NTU-4292	P052-L6	4 to -56	510±75	344-648	burial M009
NTU-4304	P066-L11	-40 to -60	600±75	516-674	artefact-bearing deposit
NTU-4423	P144-L5	-10 to -30	610±90	499-705	artefact-bearing deposit
NTU-4315	P248-L5	-100 to -120	800±120	563-948	artefact-bearing deposit
NTU-3926	P041-L9	-70 to -90	900±50	716-917	sterile deposit
NTU-4421	P162-L11	-160 to -180	920±70	707-952	artefact-bearing deposit
NTU-4319	P154-L3	10 to -10	920±105	686-1046	artefact-bearing deposit
NTU-4430	P238-L10	-130 to -150	1020±60	797-1058	sterile deposit
NTU-4422	P237-L4	-70 to -90	1030±80	768-1154	artefact-bearing deposit
NTU-3788	P028-L15	-130 to -150	1050±40	904-1049	artefact-bearing deposit
NTU-4428	P154-L13	-170 to -180	1080±90	800-1227	artefact-bearing deposit
NTU-4427	P246-L8	-160 to -180	1170±70	957-1257	artefact-bearing deposit
NTU-4316	P019-L5	-100 to -120	1190±70	967-1264	burial M066
NTU-3792	P041-L13	-150 to -170	1240±30	1079-1262	artefact-bearing deposit
NTU-4434	P144-L11	-130 to -150	1480±70	1291-1524	artefact-bearing deposit
NTU-4321	P154-L14	-180 to -190	1870±110	1562-2084	artefact-bearing deposit

Table 1: Radiocarbon ages from charcoal samples excavated from Kiwulan (Chen 2007), calibrated using IntCal13 Atmospheric curve. All depth is recorded in centimeters above mean sea level. The codes in the context column refer to the excavator's feature labels, cf. Chen 2007

The personal ornaments

Ornaments (Figure 4) were found in a variety of archaeological contexts including post-holes area, burials, and middens. For the ornament categories, we follow the well-established topology based on raw materials and shapes for the region of northeastern Taiwan (Chen 2007; National Musuem of Taiwan History 2005). This study focuses on 406 ornaments from 40 sampling squares located at the main habitation areas of Kiwulan, indicated by aligned post-holes with *in-situ* posts (Figure 2). Occupation floors were not identified during excavation. We choose these units because they were stratigraphically intact and undisturbed by modern construction activity, compared to excavation squares on the periphery of the site. There are 35 burials in the sampling area, one third of the total number of burials at Kiwulan. Ornaments are commonly used as grave goods in burials, with the total number of ornaments in burials including 3,173. There are also 27 ornaments found in midden contexts. The obvious difference in number in burials and midden contexts indicates the property of ornaments as prestige goods. The high number in burials is due to the presence of bead strands or patterned bands of beads, which

sometimes contain thousands of beads in an individual burial (Chen 2007). The highly uneven distribution of beads between burials was interpreted as the evidence for hierarchy by Cheng (2008). However, Hsieh (2012) suggests a relatively egalitarian society from the comparative analysis of frequency and proportion of burial goods.

We focus on ornaments from the habitation contexts (Figure 5, Table 2) because these give us the greatest spatial and temporal representation across the three time periods, and so are most informative of social inequality as indicated by uneven distributions of ornaments. The burials are excluded because most burials from the sampling area date to the European period (n = 21), limiting the usefulness of comparisons between the periods. A possible limitation to our chronological resolution is that ornaments could be heirlooms inherited over multiple generations and well-preserved for a long time. This is difficult to rule out completely, but we consider that because there is no continuous increase in ornament frequency over time, we conclude that accumulation and discard of ornaments is not constant. Thus, we assume that changes in the abundance of ornaments reflect relatively continuous discard behaviours rather than accumulations due to collecting of heirlooms.

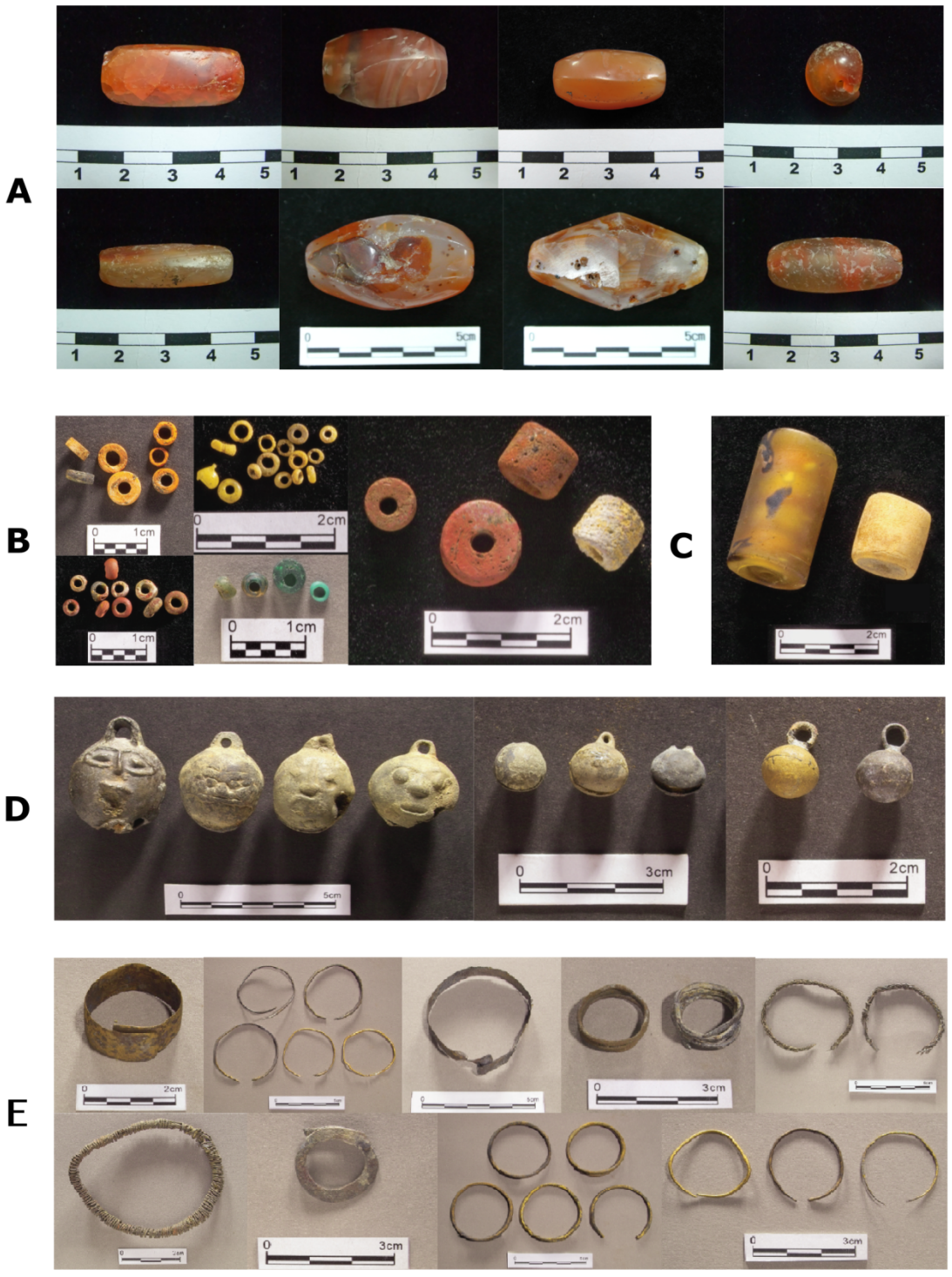

Figure 4: Subtypes of ornament in each major class. A: carnelian beads, B: glass beads, C: gold-foil beads, D: bells, E: metal rings. Photographs are presented in the same order as those subtypes in the table but from left to right instead. The photographs of B, C, D, E classes are from the original excavation report (Chen 2007)

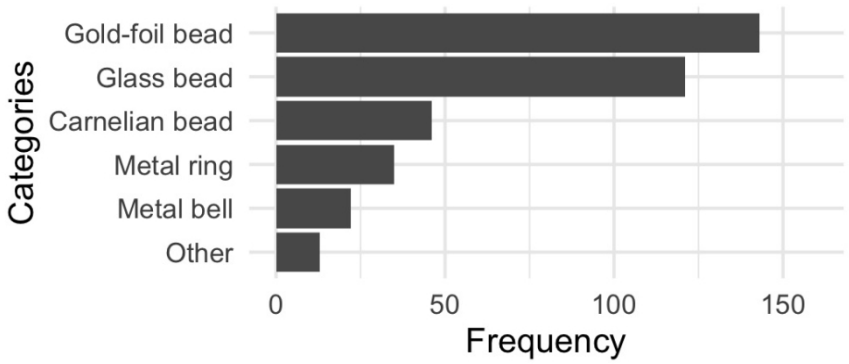

Figure 5: Frequency of the major class of ornaments at Kiwulan. Frequency represents artifact counts

Categories	Type	Before European Contact	European Presence	Chinese Presence
Carnelian bead	hexagonal	6	17	5
Carnelian bead	waxy oval	0	4	0
Carnelian bead	small oval	3	3	0
Carnelian bead	globular	0	1	0
Carnelian bead	pentagonal	0	1	0
Carnelian bead	big oval	0	0	1
Carnelian bead	long bicone	0	0	1
Carnelian bead	octagonal	0	0	1
Glass bead	small (0.5-1 cm)	60	37	1
Glass bead	medium (1-2 cm)	8	15	0
Gold-foil bead	NA	48	93	2
Metal bell	large	3	8	3
Metal bell	plain small	0	4	1
Metal bell	thin small	0	1	1
Metal ring	wide small	1	9	1
Metal ring	thin large	4	5	2
Metal ring	wide large	0	5	0
Metal ring	overlapped	0	2	0
Metal ring	braid	0	1	0
Metal ring	entwined	1	1	0
Metal ring	flat	0	1	0
Metal ring	large thick string	0	1	0
Metal ring	small thin string	0	1	0

Table 2: Frequencies of ornaments by subtype at Kiwulan. Frequency represents artifact counts

Reproducibility and open source materials

To enable re-use of materials and improve reproducibility and transparency (Marwick 2017), the entire R code (R Core Team 2019) used for all the analysis and visualizations contained in this paper is included in the Supplementary Online Materials at http://doi.org/10.17605/OSF.IO/R8YGA. Also in this version-controlled compendium (Marwick *et al.* 2018) are the raw data for all the visualizations and tests reported here. All of the figures, tables, and statistical test results presented here can be independently reproduced with the code and data in this repository. The code is released under the MIT license, the data as CC-0, and figures as CC-BY, to enable maximum re-use.

Results

Changes in the frequencies of ornament types over time

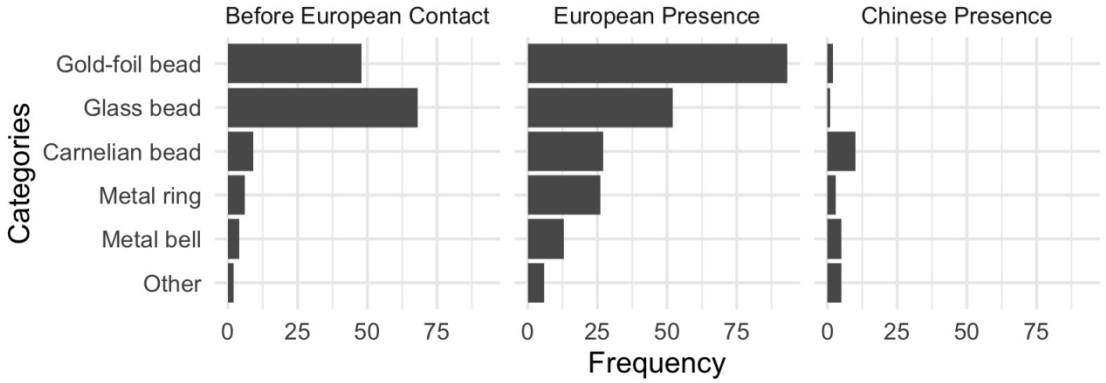

Figure 6: Frequency of the major ornament types across different time periods.

Figure 6 shows the comparison of frequencies of the major classes of ornaments for different time periods at Kiwulan. The difference in frequencies between the three time periods reflect significant differences in the use of ornaments (chi-square = 71.82, df = 8, p-value = 2.14×10^{-12}). Most ornament types were present before European contact. Ornament frequencies reached a peak during the European period and then dropped during the Chinese period, especially gold-foil beads. This trend can be also seen on other ornaments including carnelian beads, metal rings, and bells. However, glass beads show a different pattern that indicates a higher frequency in the pre-European contact, and then a decrease in the European period and a further decrease in the Chinese period. To model the number of ornaments as a function of the mass of ceramics in each period, we used a Poisson GLM with a log link function. The model reveals that ceramic abundance strongly predicts the number of ornaments ($\beta = 1.94 \times 10^{-5}$, $p = 4.225 \times 10^{-29}$). If ceramic abundance is a suitable proxy for population at Kiwulan due to its basic role as cooking vessels, then ornament quantities per period may be influenced by the number of people living at the site.

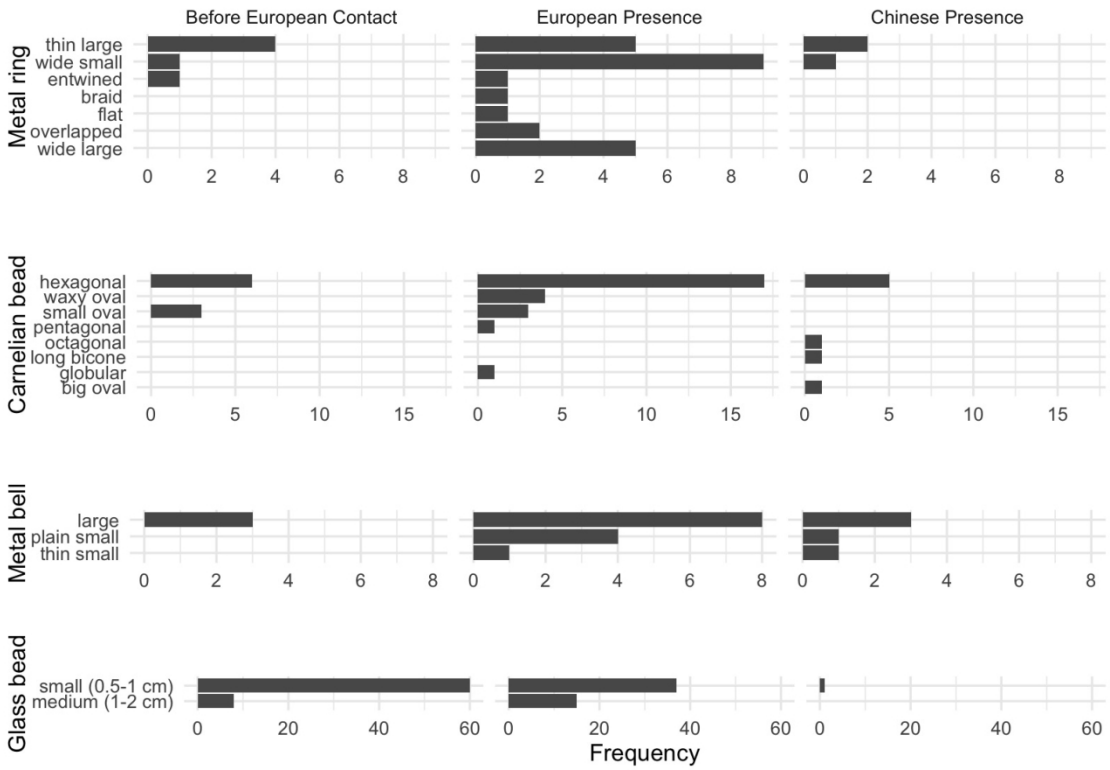

Figure 7: Frequency of ornament subtypes showing the changes in frequency across time periods for metal rings, carnelian beads, bells, and glass beads.

Figure 7 shows the distribution of frequencies for subtypes in each major class. Spearman's correlation test shows that there is no significant relationship between diversity of subtypes and sample size (S = 173.16, rho = 0.39, p = 0.20438). This indicates that the increases in diversity can be explained by the effects of culture interaction instead of the effects of sample size. Carnelian beads and metal rings have greater quantity and variety of shapes compared to copper bells and glass beads during the European period. The greater varieties for carnelian beads and metal rings might indicate multiple origins due to participation in large scale trade networks stimulated by the European presence. In contrast, copper bells have less variety, typically >2 cm long with a wide variety of human faces as a motif. Although glass beads have less variety in size, presenting as small (0.5-1 cm) or medium (1-2 cm), they have a wide variety of colors or patterns mostly made by a winding technique and with high lead content indicating possibly from China (Cheng 2008). Although we are not certain of the specific origin of these beads, research suggest that these glass beads and metal ornaments have similar production techniques and composition to those found in China (Chen 2011; Wang 2018). There seem to be no obvious changes in the sources of glass beads or metal ornaments at different periods in the upper component of Kiwulan (1350-1850 AD). However, the glass beads found from the lower component (650-1150 AD) are mostly Indo-Pacific beads, widespread in Southeast Asian sites from 300 BC until the early 2nd millennium (Francis 2002; Wang 2018).

Changes in patterns of the spatial distribution of ornament types

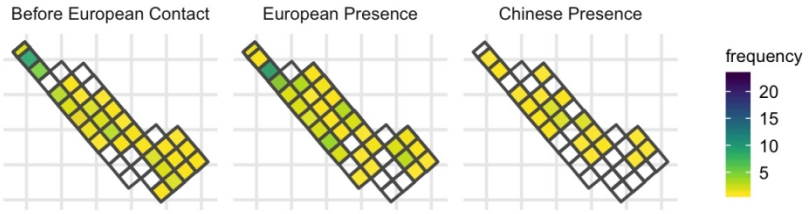

Figure 8: Spatial densities of all class of ornament by time periods.

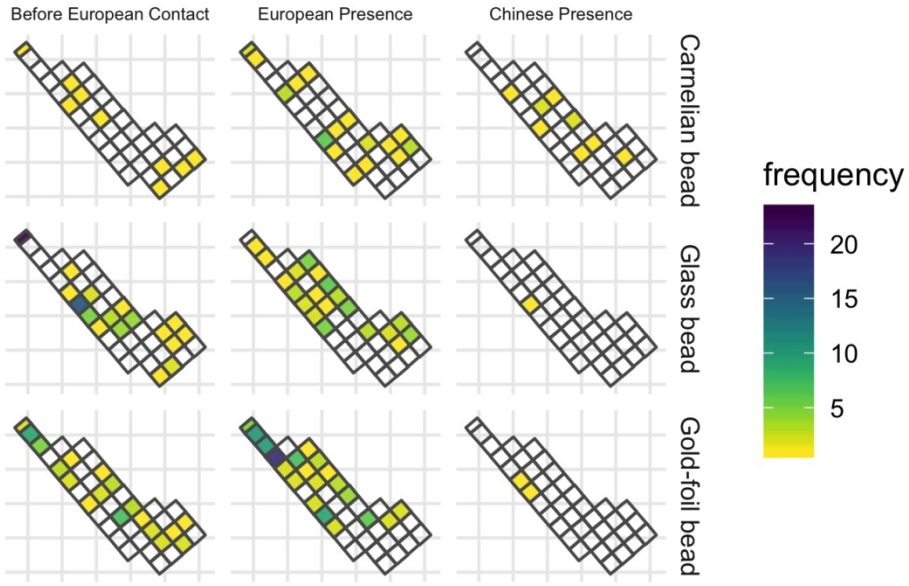

Figure 9: Spatial densities for ornament class by time periods, only those types with more than 5 pieces are shown here.

Figure 8 presents the spatial distribution of all ornaments from the research area for each time period. For deposits predating the European arrival, a greater amount of ornaments were found at the northern and middle parts of the research area. In European period deposits, ornaments were more widespread, with some clusters on the northern part. In units dating to the Chinese period the distribution is more even without clear clusters. Figure 9 presents the distribution for the major ornament classes individually, some clusters across the area can be observed during the European period, such as gold-foil beads and carnelian beads. However, there seems to be no consistent pattern across those different ornaments. Each class shows its own pattern where the squares with higher numbers of ornaments distributed separately and independently. For example, a cluster of gold-foil beads was found at the northern part, while a cluster of carnelian beads was found in the middle part. In contrast, there are multiple clusters of metal rings that are distributed separately across the research area. Copper bells were usually found

individually and appear randomly distributed across the area. In the Chinese period, both the amount and density of different classes of ornaments decreased.

Point pattern analysis of ornament distribution

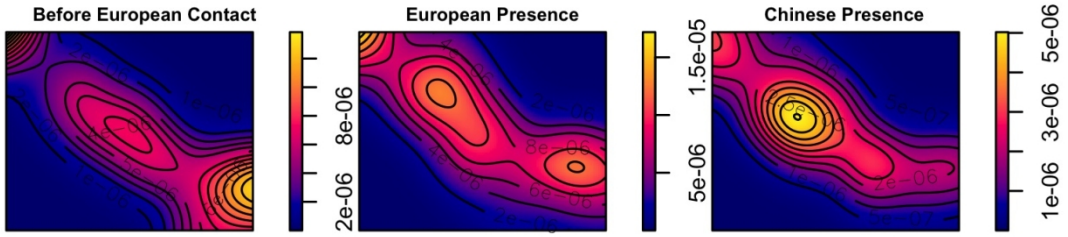

Figure 10: Kernel density map for ornaments by periods, using a bandwidth based on Silverman (1986)'s rule of thumb

The distribution and density of prestige goods across the residential area can provide information on social structure based on the assumption that distribution patterns observed from spatial data can reveal cultural processes (Kintigh & Ammerman 1982). The differential accumulation of artifacts, especially high value goods, in many archaeological contexts can reflect social differentiation or hierarchy in a society (Halstead 1993; Orser 1988; Pearson 1993; Trubitt 2003; Wason 2004). We used point pattern analysis to assess whether the distribution of artifacts represents hotspots produced by non-random processes (Bevan & Lake 2016; Ducke 2015), such as concentrations of ornaments in specific households that might result from social inequality stimulated by a colonial presence. To prepare the ornament location data for point pattern analysis, we assigned each ornament to a random coordinate pair in the square it was recovered from because artifacts from Kiwulan lack exact piece-provenance data. The next step was to divide the ornaments into three time periods. Finally we computed the density maps for each time period for comparison. Density values of artifacts per square meter were calculated for each cell. Here we use kernel density estimation (KDE) for visualization and identification of spatial clusters (Baxter *et al.* 1997), in this case the core areas of ornaments and surrounding neighborhoods. KDE is a method of spatial analysis that computes the probability of the density of ornaments across space by creating a continuous, smooth density surface across space (Bonnier *et al.* 2019; Cortegoso *et al.* 2016).

Figure 10 shows that there is one major core area during the pre-European period, multiple core areas during the European period, and a single core during the Chinese period. There are three consistent sub-regions with a core area that shifts over time. The distribution might indicate an increase and decrease in the number of social groups who possessed ornaments. The multiple groups during the European period might reflect unequal consumption of ornaments across the site, relative to other periods, or random patterns resulting from a bigger sample size. In addition, the generation of core areas might be biased due to small sample sizes, for example, a few ornaments found at one single square during the Chinese period could create an obvious hotspot. Whether the observed

clustering is random or non-random is crucial for making reliable interpretations of intentional human activities at Kiwulan.

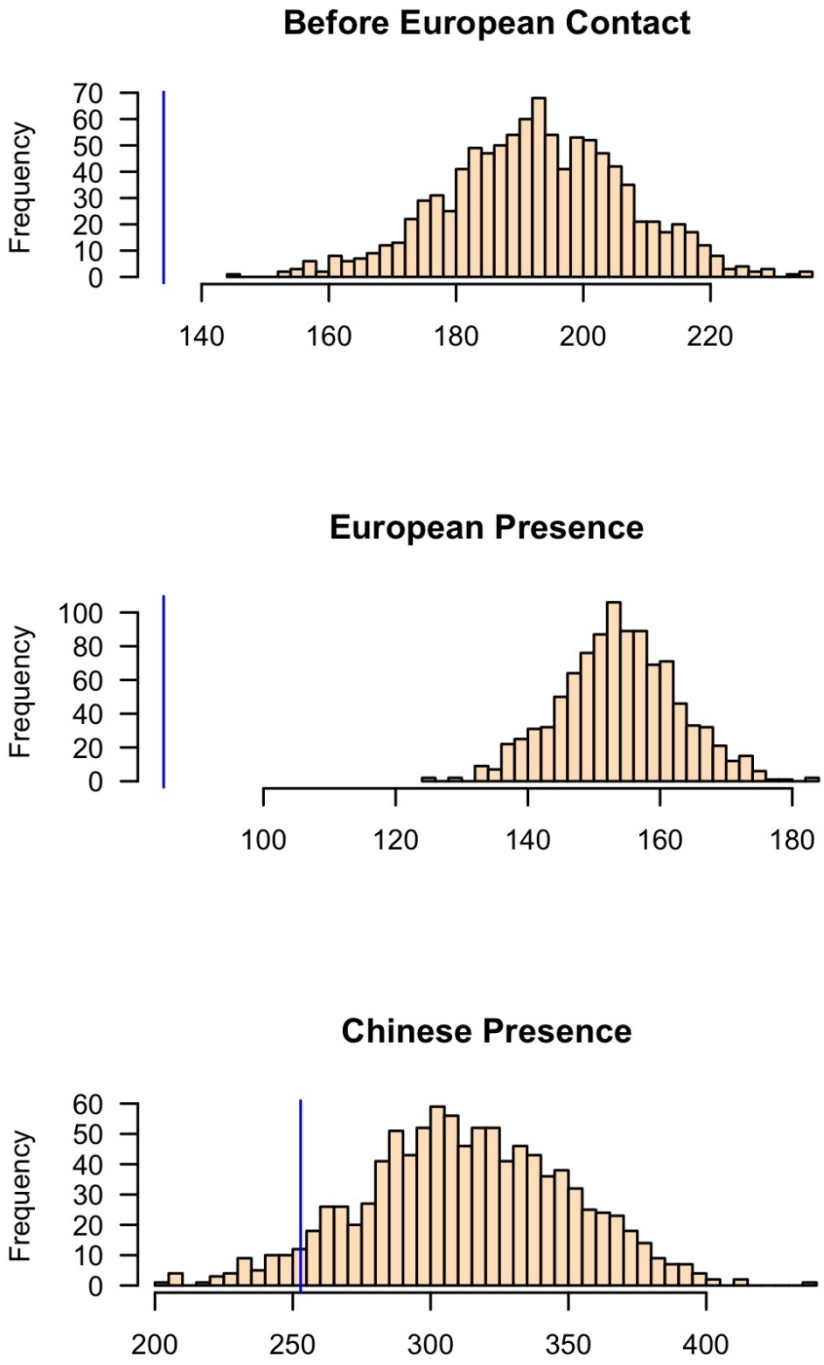

Figure 11: Histograms of simulated ANN values from 1000 simulations for three time periods. X-axis values represent ANN expected values under a completely random process resulting from a simulated pattern. Each sample distribution presents the null hypothesis with the blue line indicating the observed ANN value

To test for randomness in spatial locations, we used a Monte Carlo method to simulate average nearest-neighbour distances (ANN). Figure 11 shows the observed ANN distances with the distributions of the ANN distances calculated on 1000 simulations of random ornament locations. The results show that 100% of the simulated values are much greater than our observed ANN value during the European period, which means the ornaments have non-randomly clustered distributions. A similar, but less extreme, result is also observed during the pre-European period. The observed distribution of ornaments is more similar to the random distributions during the Chinese period, with about one third of the simulated values are greater than our observed ANN value. The Chinese period has fewer artifacts in any category, likely reflecting a smaller population at Kiwulan at this time, making spatial patterns and hotspots difficult to discern with confidence. Our Monte Carlo testing reveals that clustering of ornaments during the European period is highly non-random, potentially indicating different degrees of access to foreign ornaments or a concentration of power to control the distribution of ornaments at Kiwulan during this period.

Discussion

An indirect colonial influence may be indicated at Kiwulan by the greater diversity of ornament types and materials during the European period. Yilan was involved in complex trading networks both on a regional scale with other Indigenous groups and Chinese merchants, and at a global scale with Europeans, including the Dutch and the Spanish. Those trade ornaments have multiple origins, including Southeast Asia and China, and were first introduced into northeastern Taiwan by Chinese merchants before 17th century. Later, trade activities became more frequent and intense in the 17th century due to European activities. The greater diversity and quantity of ornaments likely resulted from participation in large scale exchange networks that stimulated the circulation of different ornament classes. The frequency of overall ornaments and each subtype declines significantly after European influence fades during the Chinese period in the early 19th century. This may be due to a smaller scale of trading networks, the overall decline of Indigenous populations in Yilan, or the adoption of Han Chinese practices. The decline of the population at Kiwulan may be related to the movement of many Indigenous people southwards to Hualien due to the increasing numbers of Han Chinese immigrants who took over their lands at the end of the 18th century (Chen 2007). Houses and burials may also be a useful source of evidence to understand population size but a proper treatment of those is beyond the scope of the paper.

Archaeological contexts show that ornaments are especially abundant in burial contexts serving as grave goods (Chen 2007). This supports the interpretation of ornaments as valuable objects functioning as status indicators. Spatial patterns of ornaments in dwelling contexts show that their distribution was clustered during the pre-European and European periods. These clusters are non-random, and are most highly concentrated during the European period. This may indicate that a degree of social inequality based on the uneven distribution of ornaments was already present before European contact, and then it was reinforced and amplified during the European period. A further indicator of increased

social inequality is a burial dated to the 17th century that included 60 gold-foil beads, well above the average of 2-3 pieces in the pre-European period (Chen 2007; Cheng 2008).

How might these results fit into a bigger picture of social change at periphery of colonial systems? We may get some insight into the general pathways that led to social inequality in northeastern Taiwan by considering how people have achieved and maintained power in a wide variety of societies (Ames 2010; Bowles *et al.* 2010; Drennan *et al.* 2010; Feinman 2000). The corporate/network model proposed expands traditional hierarchical complexity to provide a comparative basis for distinct strategies for power (Feinman 2000). In the network mode, inequality develops when individuals accumulate wealth through their individual networks and people use their wealth to attract factions, control resources, and monopolize trade networks. In contrast, the corporate mode stresses shared power across different groups and sectors, integrative ceremonies and rituals, and large cooperative labour tasks (Feinman 2000; Siegel 1999).

The Kiwulan ornament data may be interpreted as indicating that Yilan social organization moved from a corporate mode, before the European arrival, to a network mode during European presence. The changes from a less concentrated to a more concentrated distribution of ornaments before and after the presence of Europeans appears consistent with the shift from shared power and wealth to accumulated wealth and monopolization. One possible explanation for the shift could be the long-distance trade network introduced by Europeans. The rarity and the image of colonial power of foreign trade goods resulted in the emergence of competition among ambitious individuals for prestige, wealth, or power through collecting them (Boone 1992; Brumfiel 1994; Clark & Blake 1994). Because of the weak direct control from the European colonizers in northeastern Taiwan, local leaders may have had the flexibility to manipulate European colonial images, expand personal power, and monopolize the high-value trade goods (Kang 2012).

That said, the evidence from Kiwulan may be consistent with a variety of scenarios of indigenous-colonial relations. The increasing number and concentrated spatial patterns of ornaments may also indicate a practice of cultural resistance against the European intrusion. Resistance to European economic and political demands may be inferred if ornaments were used as a display of social identity and to emphasize the local customs that had existed before European contact (cf. Rubertone 2000). Resistance could be presented in many forms, but we have no specific evidence from Kiwulan to prefer resistance as the primary mechanism behind the distribution of ornaments over colonial influence. Another scenario is that ornaments were treated as heirlooms, such as carnelian beads and gold-foil beads, that passed from one generation to the next, accumulating at Kiwulan over time. This process would result in a natural increase in ornaments over time, unrelated to colonial influences. As noted above, this pattern is not a good fit for the ornament distribution at Kiwulan, and adds little value in explaining the shifts in spatial patterns.

Conclusion

Examination of the archaeological record at the peripheries of colonial activity shows how remote Indigenous groups were affected by major European colonial processes (Trabert

2017), and similar impacts can be also seen in modern societies today when adopting western products (Al-Ghanim *et al.* 2017; Jane 2015). Kiwulan in northeastern Taiwan is an exceptional case study as an East Asian location that was relatively isolated and peripheral, and yet connected by regional and global trade networks. Kiwulan provides valuable insights into the discussion of indirect colonial influence on local societies living beyond the reach of direct European colonial occupation. The frequency and spatial distribution of personal ornaments at Kiwulan present three distinct patterns during different dominant culture interaction periods. The greater amount and diversity of ornament types during the European period reflects an increasing use in ornaments in a colonial context. Before European contact, ornaments were traded into local Indigenous societies via the regional exchange network with Chinese merchants, and viewed as prestige goods in the local Indigenous culture. After the arrival of the Europeans, the exotic and powerful image carried by those ornaments may have intensified, further signaling wealth and privileged trading connections among the inhabitants of Kiwulan. This may have stimulated more competition between aggrandizing individuals for prestige and wealth accumulation at Kiwulan, which might have resulted in an increase in social inequality. This might also indicate an act of intentional resistance to the intrusion of the Europeans by using more ornaments that are symbolic of cultural tradition, but additional evidence is required to confirm this.

By focusing on the distribution patterns in a settlement site, the Kiwulan ornaments suggest that foreign ornaments can be a proxy to detect indirect colonial influence on local Indigenous populations. Ornaments give insights into the amplification of social inequality stimulated by European colonization. It also shows the agency of Indigenous people to incorporate ornaments into their social system and use them in their daily lives to display or intensify status differences. We are still far from understanding the full variety of colonial impacts on peripheral Indigenous communities. We have introduced here the corporate/network model for understanding the dynamics of social inequality at Kiwulan, and further provenance analysis of imported ceramics and ornaments such as X-ray fluorescence analysis would provide more information to construct a clear picture of complex trade networks during this periods.

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Word count: 5603

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Dear Editors:

We confirm that there are no conflicts of interest associated with this manuscript.

Sincerely,

Li-Ying Wang

Notes on constructing a chronology for ornaments recovered from archaeological excavations at Kiwulan, Taiwan.

This document provides guidance for reading spreadsheets included in the Supplementary Online Materials for our paper "Ornaments as indicators of social changes in northeastern Taiwan before and after the European colonial period". The purpose is to provide details to justify our methods used for assigning ornaments into one of three phases: pre-European period, post-European, and Chinese period. We have included four spreadsheets that provide detailed information about the stratigraphic data, soil color, layer depth, diagnostic artifacts, radiocarbon dates, descriptive observations for artifacts in general, judgements for assigning, and the final decision for the chronology of each excavation unit. The information assembled here was collected from the original field notes and excavation report.

KWL_excavation_depth.xlsx provides the depth in centimeters for each layer. L1 means first layer and so forth. The depth was recorded based on the sea level. Some units are recorded based on sections A, B, C, D, these are 2x2 m subunits in each 4x4 m unit.

KWL_soil_color.xls provides.xlsx provides the soil color we identified from original field notes for each layer. L1 means first layer and so forth. The color was recorded according to Mansell color chart. Some units are recorded based on sections A, B, C, D, these are 2x2 m subunits in each 4x4 m unit.

KWL_layer_assign_details.xlsx provides detailed information of the archaeological contents of each unit that we used for assigning chronology. L1 means first layer and so forth. We listed the diagnostic items, including pipes, jars (An-ping jars), stonewares for the European period, and tiles, bricks for Chinese periods for the enclosing layer. The European period indicators are indicated with number after * to indicate their frequency.

The column, “radiocarbon dates (tree rings)”, includes the layers where charcoals were collected for radiocarbon dating. The original radiocarbon dates were corrected by the original excavators using tree rings data, these are represented in the parenthesis. Some charcoals were collected from features: H represents middens and M represents burials.

The column, “stratigraphic analysis based on field note”, describes the changes in color and distribution of potsherds. Those two variables are highly correlated to the depth between 20 cm to -20 cm that is around 17th century.

The column, “assessment (1: excellent, 2: good, 3: fair)”, is our assessment for the overall reliability of our chronological determination of the unit.

The column, “observations on artifacts & features based on field notes”, presents our judgment of possible post-depositional issues based on the description in the original field notes.

The column, “previous studies indicating 17th layer” and “previous studies indicating 19th layer” are based on the chronology used by previous studies on Kiwulan site, Hsieh 2009 and Wang 2011.

The column, “assigning the layer indicating the start of European phase” is our judgment for the European period. First, we determined the layer based on the presence or the higher frequency of time indicators. Second, we examined whether there are radiocarbon dates from the layer. Third, we examined the color changes and the distribution of potsherds. Fourth, we checked if there are any post-depositional issues. Fifth, we compared the stratigraphic context between adjacent units. Sixth, we refer to previous studies.

The column, “assigning the layer indicating the start of Chinese phase” is our judgment for the Chinese period. First, we determined the layer based on the presence of time indicators. Second, we examined whether there are radiocarbon dates from the layer. Third, we examine the soil color. Fourth, we checked if there are any post-depositional issues. Fifth, we compared the stratigraphic context between adjacent units. Sixth, we refer to previous studies.

The columns, “The start of European phase (17th)” and “The start of Chinese phase (19th)”, are our final decision for the layer that represents start of each contact period.

KWL_reassigned_chronology.xlsx provides our final assignment of three phases. L1 means first layer and so forth. Some units are recorded based on sections A, B, C, D, these are 2x2 m subunits in each 4x4 m unit.