Spice and rice; pepper, cloves and everyday cereal foods at the ancient port of Mantai, Sri Lanka.

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Introduction

Sri Lanka's central position within the Indian Ocean allowed the island to become a highly important port-of-call for merchant ships from the early days of Indian Ocean trade (Francis 2013, Gupta 2005, Mathew 2016, Prickett-Fernando 2003, Ray 2003, de Silva 2005, Thapar 1992, Tomber 2008, Warmington 1928). The island formed a key link in a complex system of trade routes both within South Asia (particularly with India) and the rest of the Old World. Growth of the ports of Sri Lanka is associated with the development of long distance maritime trade during the Early Historic period, with goods from the East (both Mainland and Island Southeast Asia, as well as China) being bought and traded with those from the West (Europe, Africa and Southwest Asia). Trade was also extensive with the ports and markets that dotted the coasts of East and West India in this period, as evidenced by the material culture recovered from various Sri Lankan sites (see e.g. Coningham et al 2016, Prickett-Fernando 2003).

Mantai, situated on the north-western coast of Sri Lanka close to Mannar, was ideally situated to act as a coastal trade and transport 'hub' between the Arabian Sea, the Bay of Bengal and the east and west coasts of India, as well as a key gateway to the interior of Sri Lanka (figure 1). The shallow navigable channels near Mantai (the Palk Strait) allowed only small boats to sail around the north of Sri Lanka, therefore large vessels had to anchor at Mantai to offload their cargo for transport across the strait. Additionally, ships approaching from the west and wanting to sail around the south of the island would have had to anchor near Mannar and wait for southerly winds (Nicholas 1963; Shinde 1987). The site thus drew trade and served as the main seaport of the Anuradhapura kingdom for nearly two millennia (see Coningham and Gunawardhana 2013). Traces of an ancient river bed suggest that a channel of the Malvatu/Malwathu Oya (*Sinhala*, 'Aruvi Aru' in *Tamil*) may have run close to the site of Mantai and allowed for river traffic between the port and Anuradhapura from c.250 BC (cf. Nicholas 1963). By this time, Anuradhapura was the capital city of the Anuradhapura Kingdom, 500 BC-1017 AD (Deraniyagala 1990), with a centralised administration and control over many other regions of the island, but also developed in its own right as a successful, multi-cultural, trading centre (Coningham and Gunawardhana 2013, Seneviratne 2008 p.188). The riverine link between Mantai and Anuradhapura, as well as the site's ideal locale at a key geographical point of transshipment, meant that Mantai, through the course of its occupation, came to have a large, urban and multi-cultural population (Carswell 2013, Coningham et al 2017). The plant assemblage of Mantai therefore reflects the dietary needs of a large population and, potentially, the varied food preferences of its diverse populace, as well as holding potential evidence for the trade of exotic consumables. This paper also provides the opportunity to explore when rice agriculture and long-distance trade in plants and plant products began in the region, and to explore questions surrounding the extent to which the growth of Mantai and the wider Anuradhapura kingdom can be attributed to the growth of the entrepôt ports of Sri Lanka, including the international trade of foodstuffs, especially spices.

Unfortunately, little is known of the site of Mantai outside of South Asian archaeology, largely due to the abrupt end to the largest excavation of the site in 1984, at the beginning of the Sri Lankan civil war, and the subsequent delay in publication of the site report (Carswell et al.

2013), which included a brief report of the archaeobotanical remains recovered, but no quantitative data (Kajale 1990, 2013). This was compiled despite numerous setbacks, including the loss of stratigraphic data. Other smaller scale work was only briefly reported (Silva 1985) and other publications have addressed the site's extensive bead assemblage (e.g. Francis 2002). Despite the multiple seasons of exploration carried out there, only three radiocarbon dates have been published previously, covering c.200-300 AD (Carswell et al 2013 p512-513).

In this paper we present results from renewed excavations at Mantai, conducted in 2009-2010 as part of a joint effort by the Sri Lankan Department of Archaeology, European Research Council funded Sealinks Project and UCL Institute of Archaeology. It is difficult for any excavation to do justice to this complex site and so the 2009-2010 season aimed to conduct a detailed multi-disciplinary investigation into material recovered from one deep trench, including sieving for small finds, sampling throughout the sequence for macrobotanical remains and phytoliths, and obtaining a sequence of high-precision radiocarbon dates. A 3 by 3 metre trench situated towards the south of the mound, close to the site of previous excavations was excavated to a depth of 10 metres, down to apparent mid-Holocene contexts (figure 2). This paper presents a full sequence of new and secure radiocarbon dates coupled to a sequence of basic ceramic data, producing a chronology for developments and growth in Early Historic Indian Ocean trade. The archaeobotanical study provides insights into aspects of agriculture and plant foods, and recovers rare direct evidence for early trade in the valuable spice commodities upon which later empires would be founded.

Archaeobotanical methods

A total of 65 contexts were excavated at Mantai during the 2009-2010 field season, representing 11 stratigraphic periods (figure 3). Period 1 was identified during excavation as a sterile layer, therefore no samples were taken. 38 floatation samples of 10-20 litres each (677 litres in total) were taken from Periods 2-10, which represent pit fills and settlement deposits. Charred plant remains were retrieved via wash-over bucket floatation on a 0.25mm mesh to ensure the recovery of small weeds and rice spikelet bases. Samples were dried onsite, packed into zip lock bags and exported to UCL Institute of Archaeology for archaeobotanical analysis.

Each sample was fully sorted and identified using an optical microscope at up to x35 magnification. The 0.25-0.5mm fraction was checked for previously unidentified species and *Oryza* sp. spikelet bases. Identifications were made using the reference collection at UCL Institute of Archaeology and published literature (e.g. Cappers et al 2009, Fuller and Harvey 2006, Fuller et al 2009). Length, height and width of whole, unpuffed rice and wheat grains were recorded.

Phytolith samples were taken from trench sections directly into zip lock bags. Approximately 100g of sediment was taken per sample and 0.8g of this was processed at the UCL Institute of Archaeology by heavy liquid flotation using sodium polytungstate (see Piperno 2006, Rosen 1995). The weight of sediment processed was recorded, as was the weight of phytoliths extracted and the weight of phytoliths mounted. Phytoliths were counted using a biological microscope at x400 magnification. A minimum of 300 single cell phytoliths and 100 multi-cell phytolith panels of 2+ individual phytoliths were counted per sample. Identifications were made using reference slides housed at UCL Institute of Archaeology as well as drawing on published literature (e.g. Ball et al. 2006, Pearsall online database, Piperno 2006).

Radiocarbon dates and ceramic sequence

24 samples, including 23 single seed samples from period 2 onwards, were submitted to the Oxford Radiocarbon Accelerator Unit (table S1). These were calibrated using OxCal 4.2. and modelled into an archaeological sequence using Bayesian methods to take into account stratigraphic position (table 1, figure 4). A shell from period 1, a pre-Iron Age layer excavated below the port site, was dated to 1691-1509 BC (table S.1). This lowest unit is associated with a few lithics but no ceramics. Subsequent to this is a hiatus, followed by three apparent phases of occupation: Phase 1, 200BC-600AD, (period 2-4) which correlates to Carswell et al's phase of "primary development of the mound" (2013 p.137). Phase 2, 600-850AD, (period 5-7). Period 6 represents a coral wall which sealed Periods 1 to 5. Unfortunately, it is unclear if Carswell et al's (2013) "The

developed settlement and defensive circuit" phase (which includes coral stone buildings) relates to this phase, due to a lack of stratigraphic data. Phase 3, 850-1400AD, (periods 8-11) which correlates to Carswell et al's "abandonment, decay and quarrying" phase (2013 p.139). Periods 8 to 11 were recognised as mixed and disturbed during the excavation.

The material culture recovered from Mantai contains a great range of ceramics and beads (figure 5). Mantai has long been identified as a major glass bead production centre of South Asia (cf. Francis 2013:349-363). Nearly 91% (1432 beads) of the assemblage recovered were of Sri Lankan manufacture. Imported beads make up 2.7% (43 beads) of the total bead assemblage (1580) and the regions of their possible provenance encompasses the Mediterranean, Afghanistan, Baluchistan, India and Southeast Asia (Bohingamuwa 2017:222-289).

The Total Ceramic Assemblage (TCA) recovered from our excavations conducted in 2009/2010 season comprises 11418 sherds, representing 123 different wares (table 2). 77.7% of the sherds are of Sri Lankan made and 20.9% are imported to the island from different overseas regions; the provenance of the rest remains undefined (Zhang and Bohingamuwa, in prep.). Sri Lankan origin assemblage occurs throughout the sequence, illustrating a continuous local ceramic industry (figure 6). The imported ceramic assemblage accounts for 2386 sherds and 101 different wares (table 2, figure 6). The provenance of these wares has been assigned to India, the Middle East (primarily from Iran, Iraq and Arabia), Southeast Asia, China and to overseas regions yet unknown (termed 'Imported.Unknown' wares, 6% of the TCA). Middle Eastern wares (7% of the TCA) are the largest ceramic group, even surpassing Indian wares (6%), which were expected to be the largest group. Chinese (2%) and Southeast Asian (0.5 %) wares were also anticipated to be more frequent than Middle Eastern wares. They are, however, only represented in smaller quantities (Bohingamuwa 2017:103-221).

Figure 6 illustrates the initial arrival of imported wares in period 2, c.200 BC, however this is only represented by a single find of Indian origin. During the next two periods there is a slight increase in the range and quantity of wares, with ceramics from China, Southeast Asia and the Middle East present in the sequence, however these make up only c.5% of the TCA. Period 5 (c. 650-800 AD) witnessed a significant increase in imported ceramics from all regions, rising to

21% of the TCA. The culmination of these developments is observed during period 7. This period includes 946 imported sherds, 36.7% of the TCA phase total. The upper ‘Disturbed’ periods contain the highest number of imported wares and sherds, particularly those from the Middle East and China, demonstrating the changing patterns of Indian Ocean trade post-900AD. Over 10.5% of the Middle Eastern and 2% of the Chinese sherds found in the ‘Disturbed’ periods are dated to between the 12th and 14th (possibly even in the 15th) centuries, indicating the continuation of Mantai as an international trading port well after the Chola attack in 993 AD.

Plant foods and cultivation at Mantai

A total of 3235 cereal grains and grain fragments could be identified from the 2009-2010 excavation assemblage, 1830 (57%) of which have been identified as rice (*Oryza* sp.) and 84 (2.5%) as wheat (*Triticum* spp.) (table S2) (Kingwell-Banham 2015). Period 2 provides some evidence for crops within the macro-remains, although no crops were identified in the phytoliths (figure 7), which like the ceramics, suggests initial low level use and occupation of the site during this period. Archaeobotanical finds, ceramics and small finds all increase in volume by period 3, as the site entered into its main period of occupation c.100-350 AD. By this period the archaeobotanical evidence from Mantai demonstrates the presence of two different food cultures: 1) rice, South Asian pulses and millets reflecting South Asian cuisine and 2) wheat and Southwest Asian pulses reflecting “Western” cuisine (see van der Veen 2011 p7). This supports the suggestion that Roman traders were settled at Mantai by c.200 AD (see discussions in Carswell et al 2013, Coningham et al 2017).

Trade for food staples as well as exotic goods occurred at port markets, and it is likely that rice produced in the interior of Sri Lanka was transported in the husk for trade at coastal ports. This accounts for the lack of culm nodes, arable weed seeds and cf. *Oryza* leaf/culm multi-panelled cells within the Mantai assemblage. Today, most rice fields are located over 3km away from the site, however some areas around 1km away are under cultivation, on nearby deposits of vertisols and alluvium. Small reservoirs have been located in the areas surrounding Mantai, attributed to King Vasabha (AD 67-111), indicating the existence of small scale water management in the area by the 1st century AD (Bohingamuwa 2017: 83-84). However the scale of agricultural use is not clear. Therefore the population of Mantai likely consumed grain from a larger area, including the farm lands from further within the interior of Sri Lanka and those surrounding Giant's Tank. Giant's Tank, 12 km inland from Mantai, is claimed to have been built by King Dhatusena c.460 AD (Carswell 2013 p24, Geiger 1912 ch.35), falling towards the end of the first phase of occupation and coinciding with the increase in trade visible in the ceramic and archaeobotanical assemblages. Additionally, the possibility that Mantai imported rice from the ancient ports of coastal India (areas with high rainfed rice yields) should not be ignored. Excavations of Early Historic port sites along the Odisha and Andhra Pradesh coasts reveals a very similar material culture to that of Sri Lankan sites, including Mantai (see for e.g. Mohanty and Smith 2008, Tripathi et al 2016, Tripathi and Vora 2005), suggesting regular trade. Buying grain from these regions was likely relatively easy, and is documented from the medieval period onwards (see e.g. Dasgupta 1982).

The length/width ratios of rice from Mantai suggest that *Oryza sativa japonica* was consumed throughout the course of the site (figure 8). The profile in figure 8 is similar to that of Early Historic Ter (Maharashtra) and Balathal (Rajasthan), which have both been shown to have consumed a majority *japonica* crop alongside a smaller quantity of *indica* (Castillo et al 2016). Put together, this data suggests that *japonica* was common across South Asia by c.200 BC.

Banana (*Musa* sp.) is conspicuous by its absence. In India, banana cultivation in the Gangetic Plains dates back to the 4th or 5th century BC, while Old Tamil sources and historical linguistics suggest establishment in Tamil Nadu by the early centuries AD (Fuller and Madella 2009). Banana-type phytoliths are produced in the leaves and are thought to be incorporated into archaeological assemblages through the use of leaves in cooking or as building materials. Therefore it may be that banana leaves were not used in this way to any great extent at Mantai. The high numbers of echinate spheroids (produced by Arecaceae) within the assemblage indicates that the inhabitants primarily used palm leaves as building materials (figure 9). It is also likely that palm fibres were used to create ropes used at the ports and along shipping canals, or in boat construction (see Vosmer 2003). These trees were obviously highly important economically and would have been cultivated in local orchards for use in building, as well as food and drink (coconut and toddy palms).

Mantai and the Indian Ocean: Evidence for trade links across the Old World

A number of the plant remains recovered likely reflect imports and point to Mantai's key role as a centre of Indian Ocean trade. Wheat, for example, is present in small but notable quantities, and the absence of wheat chaff or phytoliths (only one wheat rachis was recovered) indicates that the crop was brought onto the site as a clean grain import. Again, likely sources of this import include West Asia and the Mediterranean, but also India and Pakistan.

Grape, revered from period 5 (c.650-800 AD), cannot be grown in tropical Sri Lanka and must also have been imported (figure 10). Grape is present at Harappan sites, having been recovered from the late 3rd millennium BC (Saraswat and Pokharia 2001-2002), and while it is reasonable that grapes were among the fruit crops of the Indus region (Fuller and Madella 2001), they are unlikely to have fared well in the wetter, tropical conditions around Mantai. Although edible fresh or dried, for reasons of preservation it is likely that grapes came to Sri Lanka as a dried luxury product, probably from West Asia, where grape cultivation was common.

While early long-distance trade in spices is indicated in historical sources such as the *Periplus of the Erythraean Sea* (Casson 1989, Morrison and Lycett 2013, Warmington 2014), direct identifications of spice remains in ancient archaeobotanical assemblages are relatively rare (though see van der Veen 2011). The archaeobotanical assemblage from Mantai has produced evidence for several high value spice products, supporting the existence of a spice trade network that extended between Sri Lanka, India, Indonesia and the Mediterranean region (figure 10). The existence of an active trade in black pepper (*Piper nigrum*) between Southern India and the Roman Empire is well documented historically (Thapar 1992, Warmington 2014) but archaeobotanical remains from the subcontinent are rare. The recovery of black pepper demonstrates that a market for exotic spices was in place at Mantai by the middle of the first millennium AD. Native to the forests of the Western Ghats, black pepper was most likely initially shipped from ports in Southwest India and later grown in the wet zone of Sri Lanka. Harvesting wild black pepper before 500 AD has tentatively been associated with mobile groups of shifting cultivators or hunter-gatherers engaging in the producer end of the spice trade (Kingwell-Banham and Fuller 2012, Morrison and Lycett 2013). These finds therefore represent the economic activities of multiple, and very different, social groups engaging to different degrees in early international trade.

One clove (*Syzygiun aromaticum*) was recovered from period 10, c.900-1100 AD. Archaeological finds of clove are both sporadic and exceptionally rare. They are native to the Maluku Islands in Indonesia, around 7,000 km away from Mantai by sea. Archaeologically, the earliest evidence for possible cloves dates back to 1721 BC in Syria (Turner 2004), however the spice is known to have been traded between India and Rome through the writings of Pliny the Elder (Pliny and Rackham 1938). The earliest mention of cloves in South Asian texts comes from the Ramayana, c. first century BC (Mahdi 1994, see also Zumbroich 2012). It is unlikely that merchants sailed from Sri Lanka directly to Indonesia, and instead cloves may have been traded across the Bay of Bengal from Southeast Asian ports. Archaeobotanical analysis by Castillo (2011) evidences early culinary and trade connections between South and Southeast Asia c.50 BC-125 AD, but neither clove remains or black pepper have yet been recovered from early historic Southeast Asia.

Conclusion

Archaeobotanical evidence from Mantai has yielded a rich array of species, providing insights into local food choices and economic connections with the wider world, and highlighting the interplay of several different cultures via economic exchange. The site of Mantai appears to have been a cosmopolitan locale, where different culinary traditions and foods were exchanged, and where the trade in consumer goods occurred alongside trade in organic products that has, until recently, been less effectively documented by archaeology due to a paucity of archaeobotanical studies. While there are limits to the conclusions that can be drawn from the present study, focused on an assemblage emerging from a single trench, the findings here are in agreement with previous work (Kajale 1990, Carswell et al 2013) and has begun to fill in gaps in the archaeobotanical and stratigraphic data. Rice appears to have provided the foundation for the development of a settlement at Mantai c.200BC, offering a staple to local populations over hundreds of years, with limited evidence for the cultivation of millets. However, it is only with the development of trade, including in beads, ceramics and spices, that Mantai entered into its main phase of occupation c.650 AD and continued to flourish into the 2nd millennium AD.

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Figure 1: Map of Early Historic Sri Lanka showing key ports and cities. Mantai, Uraturai, Jambukolapattana and Godavaya were important ports of the Anuradhapura Kingdom. Ports on the east and south coasts became increasingly important post 1000AD, after the establishment of Polonnaruwa as a capital city.

Figure 2: Plan of Mantai and surrounding area, showing the location of the 2009-2010 trench.

Figure 3: Work in progress at Mantai 2010, excavation and (right) bucket floatation at the tank.

Figure 4: Bayesian model of radiocarbon dates from Mantai.

Figure 5: A selection of small finds from Mantai. A) Rouletted ware, origin: India (late 1st-early 3rd century AD) b) Rouletted ware with chattering marks, origin: India (late 1st-early 3rd century AD) c) Dusun ware, origin: China/Guangzhou/Guangdong (7th–10th century AD) d) Changsha ware, origin: China/Hunan (9th century AD) e) bangle fragments, f) Indo-Pacific, and some organic, beads (200 BC-10/11th century AD) g) perforated shell "pendants".

Figure 6: Origin-wise distribution of ceramic assemblage from Mantai. Top: Sri Lankan ware. Bottom: imported wares. Note the increasing assemblage size and diversification in composition from period 3. Periods 8-11 are disturbed. (After Bohingamuwa 2017, figure 3.11)

Figure 7: Top: ubiquity of key crops from Mantai by period. "Exotic goods" includes black pepper, 1 clove and 1 grape seed. Bottom: relative frequency of the main phytolith morphotypes present, periods in brackets. "Other morphotypes" includes *Oryza*-type leaf/culm multi cell panels, only identified in samples 37, 44 and 45. (After Kingwell-Banham 2015, figures 69, 95)

Figure 8: Length/width (mm) of 173 rice grains recovered during archaeobotanical analysis compared to *Oryza sativa japonica* and *Oryza sativa indica* length/width data from Castillo et al (2016). A) “Indica-type” rice grain B) “Japonica-type” rice grain.

Figure 9: Clove (a) transverse view (b) distal end (note the four petals), black pepper (c) and grape seed (d) lateral view (e) ventral view, recovered from Mantai.

C14 phases	**Archaeological periods**	**Broad cultural period**	**Carswell et al’s (2013) sequence**
Single date, 1691-1509 cal BC	1	Pre-Iron Age	“Mesolithic”
200 BC-600 AD	2	Early Historic	The primary development of the mound, c.200-600 AD
	3	Early Historic	
	4	Middle Hostoric	
600-850 AD	5	Middle Historic	
	6	Middle Historic	
	7	Middle Historic	
850-1400 AD	8	Disturbed and mixed deposits	Abandonments, quarrying and decay, pre-1815 AD
	9	Disturbed and mixed deposits	
	10	Disturbed and mixed deposits	
	11	Disturbed and mixed deposits	

Table 1: Stratigraphic sequence of Mantai.

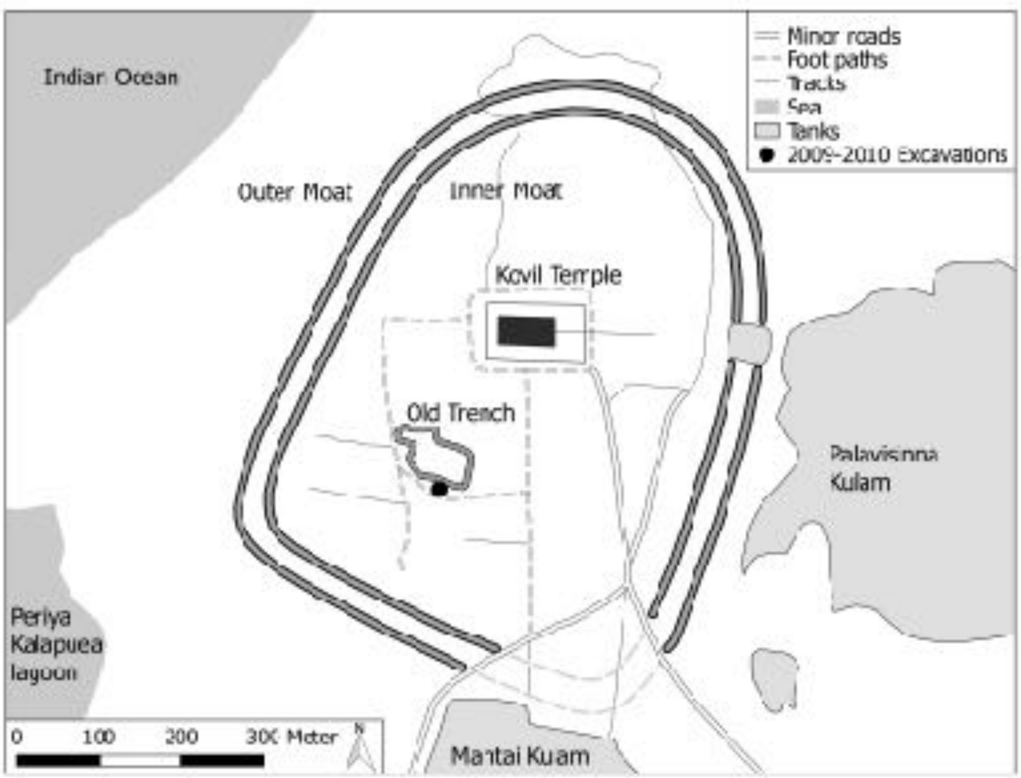
Origin	**Period 2**	**Period 3**	**Period 4**	**Period 5**	**Period 6**	**Period 7**	**Periods 8-11**	**Total**
Sri Lanka	*63 (96.92%)*	*1287 (94.49%)*	*2218 (94.38%)*	*527 (77.39%)*	*79 (76.70%)*	*1589 (61.35%)*	*3108 (72.86%)*	*8871 (77.69%)*
China		2 (0.15%)	1 (0.04%)	10 (1.47%)	5 (4.85%)	88 (3.40%)	84 (1.97%)	190 (1.66%)
India	1 (1.54%)	19 (1.39%)	16 (0.68%)	43 (6.31%)	8 (7.77%)	312 (12.05%)	279 (6.54%)	678 (5.94%)
'Imp.Unk'	1 (1.54%)	34 (2.49%)	85 (3.62%)	52 (7.64%)	3 (2.91%)	212 (8.19%)	257 (6.02%)	644 (5.64%)
ME		6 (0.44%)	11 (0.47%)	36 (5.29%)	4 (3.88%)	315 (12.16%)	448 (10.50%)	820 (7.18%)
SEA		2 (0.15%)	6 (0.26%)	4 (0.59%)	1 (0.97%)	19 (0.73%)	22 (0.52%)	54 (0.47%)
TCA	**65**	**1363**	**2350**	**681**	**103**	**2590**	**4266**	11418
Total Imported wares (% TCA)	2 (3.08%)	63 (4.62%)	119 (5.06%)	145 (21.29%)	21 (20.39%)	946 (36.53%)	1090 (25.55%)	2386 (20.90%)

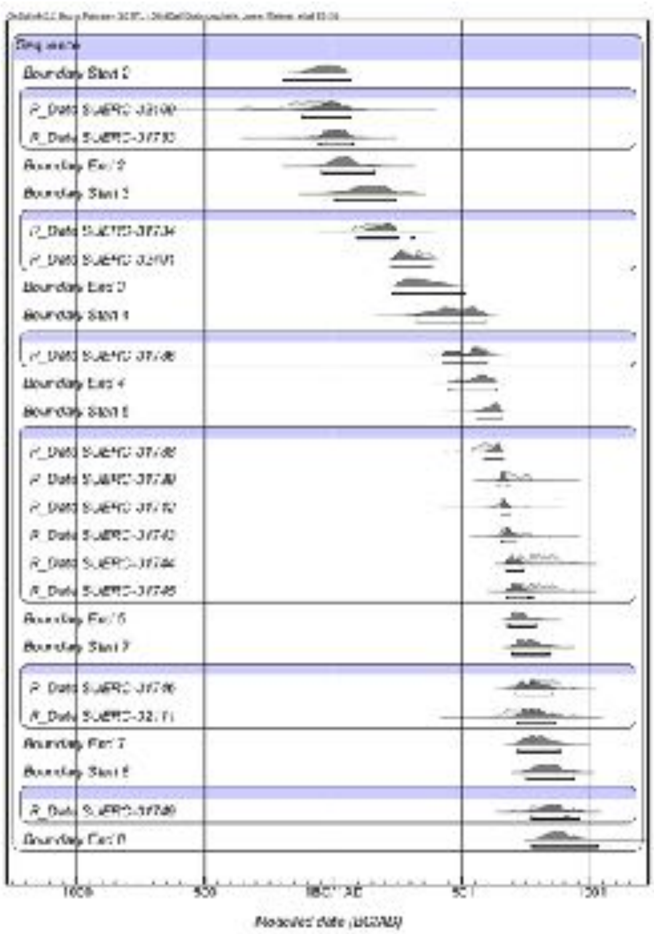
Table 2: Geographic origin of ceramic wares across periods at Mantai (% from the TCA period total). (Modified after Bohingamuwa 2017: C3.9.11)

Species	**Description/common name**	**Total count**	**Ubiquity (38 samples)**
Cereal indet		965	76.3
cf. *Oryza* spp.	cf. Rice fragment	275	28.9
Oryza spp.	Rice grain/fragment with embryo	1830	94.7
cf. *Triticum* spp.	cf. Wheat fragment	81	47.4
Triticum spp.	Wheat grain/fragment with embryo	27	39.5
Triticum cf. *aestivum.durum*	cf. Naked wheat grain/fragment	12	18.4
Triticum aestivum/durum	Naked wheat grain	45	34.2
*Oryza sp*p. spikelet bases	Rice spikelet bases	2573	55.3
Triticum spp. rachis	Wheat rachis	1	2.6
Legume indet		26	28.9
cf. *Vigna* spp.	cf. *Vigna* bean fragment	8	7.9
Vigna spp.	*Vigna* bean/fragment	15	21.1
Vigna cf. *radiata*	cf. Mung bean/fragment	1	2.6
Vigna cf. *urad*	cf. Urd bean/fragment	1	2.6
Vigna aconitifolia	Moth bean/fragment	3	2.6
Lens culinaris	Lentil bean/fragment	6	7.9
Small millet indet.		14	13.2
Setaria spp.	Setaria grain/fragment	4	5.3
Setaria verticillata	Brisley foxtail grain	1	2.6
cf. *Setaria/Bracharia*	cf. *Setaria/Brachiaria* grain/fragment	2	5.3
Setaria/Brachiaria	*Setaria/Brachiaria* grain/fragment	3	5.3
Piper cf. *nigrum*	cf. Black pepper	9	13.2
Piper nigrum	Black pepper	8	13.2
Syzygiun aromaticum	Clove	1	2.6
Vitis vinifera	Grape seed	1	2.6
cf. Fruit peel		2	2.6
Canarium sp.	Canarium nut shell	4	10.5
cf. *Canarium*	cf. Canarium nut shell	1	2.6
Nut shell indet.		19	39.5
Wild/weedy seeds		160	44.7

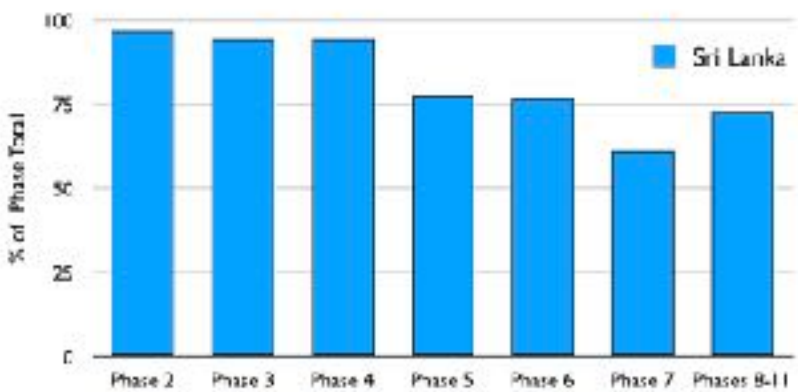
Table 3: Total counts and ubiquities of the macrobotanical remains of crops and wild/weedy seeds recovered from Mantai.


Jambukolapattana
Mannar
Manta
Gokanna
Anuradhapura
Polonnaruwa
Galle
Godavaya
0 25 50 75 100 km

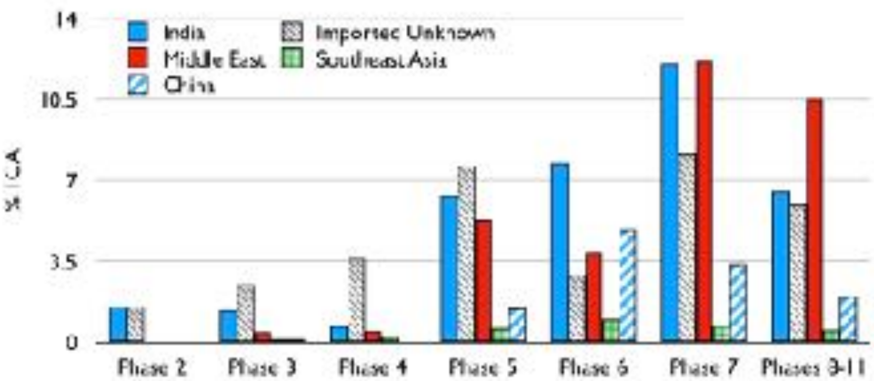

Minor roads
Foot paths
Tracks
Sea
Tanks
2009-2010 Excavations
Indian Ocean
Outer Moat
Inner Moat
Kovil Temple
Old Trench
Kulam
Periya
Kalapuea
lagoon
0 100 200 300 Meter
N



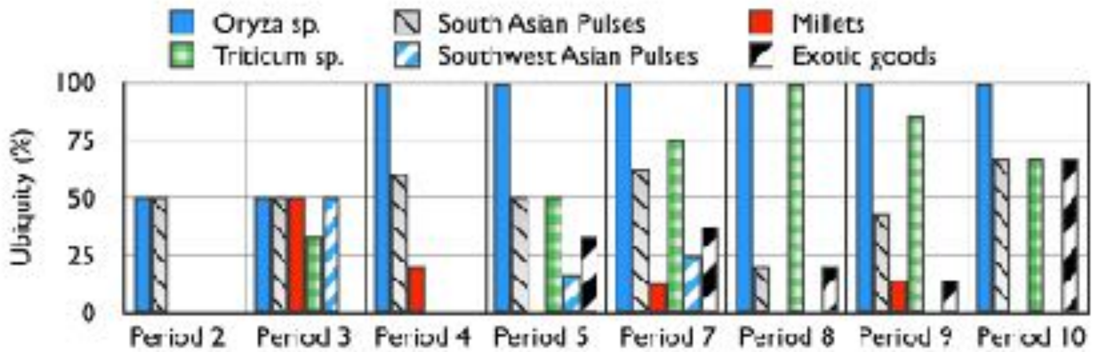
A
B
C
5cm
D
4cm
E
1cm
F
1cm
G
1 cm

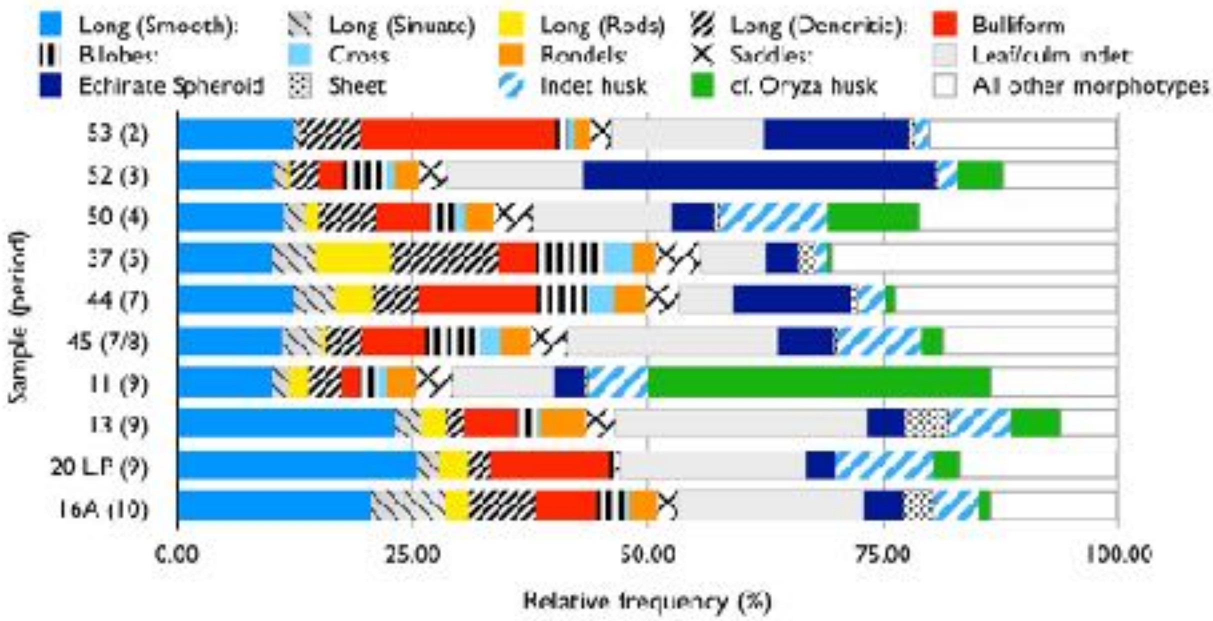


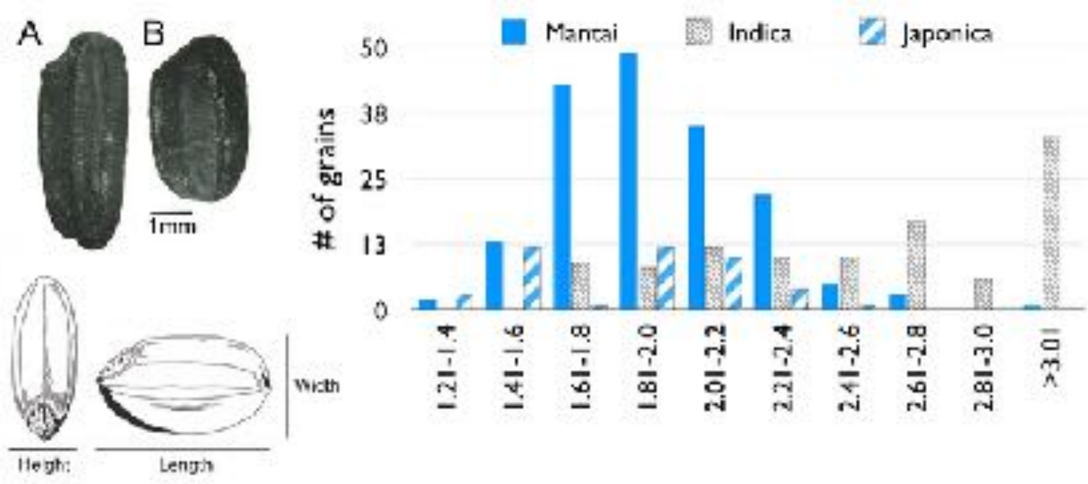
Sri Lanka
% of Phase Total
100
75
50
25
0
Phase 2
Phase 3
Phase 4
Phase 5
Phase 6
Phase 7
Phases 8-11

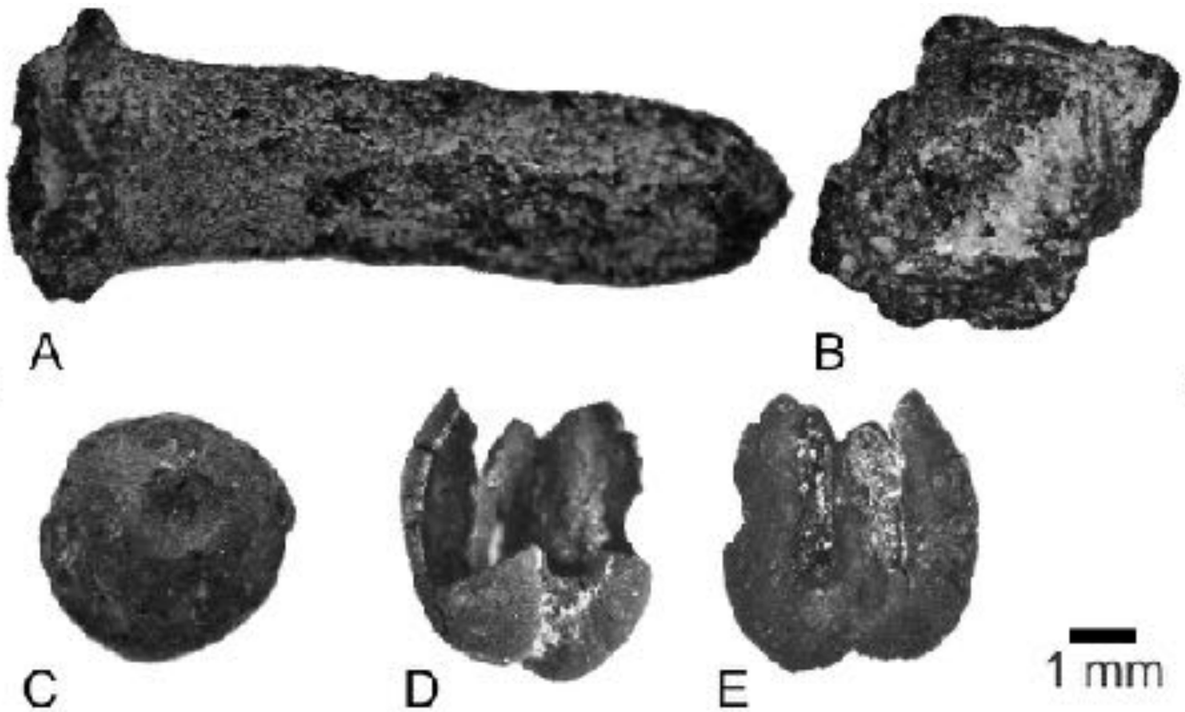


India
Middle East
China
Imported Unknown
Southeast Asia
14
10.5
7
3.5
0
Phase 2
Phase 3
Phase 4
Phase 5
Phase 6
Phase 7
Phases 8-11


Oryza sp.
Triticum sp.
South Asian Pulses
Southwest Asian Pulses
Millets
Exotic goods
Ubiquity (%)
100
75
50
25
0
Period 2
Period 3
Period 4
Period 5
Period 7
Period 8
Period 9
Period 10


Long (Smooth):
Long (Sinuate)
Long (Rods)
Long (Dendritic):
Bulliform
Bilobes:
Cross
Rondels:
Saddles:
Leaf/culm indet
Echinate Spheroid
Sheet
Indet husk
cf. Oryza husk
All other morphotypes
Sample (period)
53 (2)
52 (3)
50 (4)
37 (5)
44 (7)
45 (7/8)
11 (9)
13 (9)
20 LP (9)
16A (10)
0.00
25.00
50.00
75.00
100.00
Relative frequency (%)


A
B
1mm
Height
Length
Width
Mantai
Indica
Japonica
# of grains
50
38
25
13
0
1.21-1.4
1.41-1.6
1.61-1.8
1.81-2.0
2.01-2.2
2.21-2.4
2.41-2.6
2.61-2.8
2.81-3.0
>3.01


A
B
C
D
E
1 mm