The Use of Balances in Late Andean Prehistory (AD 1200–1650)

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Studies of balances (scales) in Europe, Asia and northern Africa have found that their use is not exclusively tied to state control or market exchange, but rather grew and evolved through interactions among bureaucrats in centralized states, merchants, artisans and local leaders. Research on balances from Andean South America can contribute to an understanding of the diverse roles and functions of balances, as they developed independently in a region where there were both exchange-based and non-market economies. This article includes data on Andean balances that reveal that they were used as early as the Late Intermediate Period (AD 1100–1400), and that there is variation in the characteristics and dimensions of the balances. Similar to other regions, balances in the Andes were likely used by different groups of specialists including merchants, bureaucrats and artisans. To understand how balances were used, they need to be understood alongside long-distance exchange practices, socio-political strategies, the organization of craft production and the possible use of currency.

Today, the acts of counting, weighing, and measuring are inherently linked to exchange, bureaucracy and even scientific research, but the act of quantifying goods and recording values is not something that humans have always done. Rather, it is a practice that evolved as part of complex social and political systems (Lugli 2019; Malafouris 2010). This is not to say that all humans do not inherently have the ability to quantify goods, but that for many thousands of years there were no tools that assisted in this process, nor registries that recorded these values. Once people began measuring, though, it became integral to many different political and social interactions. Quantification was necessary for keeping records and useful in mediating exchange between people from different cultural and ethnic groups. The act of weighing also came to be associated with symbolic meanings. In ancient Egypt, the heart of the dead is depicted as being weighed against the 'Feather of Ma'at—an abstract symbol of truth, justice, or virtue' to determine if an individual had lived a proper life (Pare 1999, 476).

Regardless of the rich implications of metrology, relatively little scholarly attention has been paid to the topic, particularly to the use of weights and scales. Most of this research has focused on Eurasia and northern Africa, where scales were used by bureaucrats, artisans and merchants to quantify tribute goods, measure raw materials for craft production and to mediate exchange (Michailidou 2001; 2008; Petruso 1984; 2019; Warburton 2019). In these regions, scales were used in interconnected systems that incorporated broad geographic areas and different specialists. Scales were also independently invented in South America—evidenced by the radiocarbon dates presented in this paper.

To understand the role of Andean balances within exchange and administration, this article presents analyses of balances from the Chincha Valley of Peru and museum collections that demonstrate (1) that there is variation in Andean balances linked to the types of goods measured and stylistic preferences, and (2) based on AMS radiocarbon dates and historic accounts they were used from the Late

Cambridge Archaeological Journal Page 1 of 20
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Intermediate Period (LIP, AD 1100–1400) to the present day.

Weights and balances in Eurasia and northern Africa

As weights and balances have not been studied extensively in the ancient Americas, studies in Eurasia and northern Africa provide a framework for understanding the diverse uses of balances and weights. I define balances as tools that measure an object's weight by suspending it from a central beam (Fig. 1). I define weights as items that are placed opposite the object to ascertain its weight. Weights have some sort of desired or acceptable mass, but they do not necessarily have to be standardized or correspond to a known numerical value.

Weights and balances were used in networks across Eurasia and northern Africa that were built on interactions between local leaders, state authorities and independent merchants. Within these interactions, scales and weights played an important role in assessing value and determining equivalency, which was useful for bureaucratic duties and exchange (Warburton 2019, 146). In many regions, weight and measurement were part of complex social and political systems that were tied to both centralized state authority and market trading (Ialongo 2018; Kilger 2019; Michailidou 2001; Pare 1999; Petruso 2019). In some cases, there were weights with similar masses and forms used across large areas (Ialongo & Rahmstorf 2019; 2022; Ialongo *et al.* 2021; Kroll 2012; Rahmstorf 2020), and in others different weights were used based on the types of goods being measured, or the cultural groups using them (Kershaw 2019; Michailidou 2008; Petruso 2019).

Weights

Studies of material artifacts associated with systems of weight and measurement often focus on weights, as they are made from durable materials that preserve in the archaeological record: though the known weights likely represent only a fraction of those that were used due to the fact that many lack clear markings (Rahmstorf 2007) or were common objects that served dual purposes, such as beads or beans (Kilger 2019, 256). The earliest use of weights is securely associated with the early third millennium BCE in Egypt and Mesopotamia. During the third millennium BCE, the use of weights expanded into Anatolia, the Aegean and the Indus Valley (Rahmstorf 2020). Questions still linger about the exact timeline of how the use of weights expanded across different regions, but it is clear that their presence coincides with dynamic changes in how administration and trade were carried out (Michailidou 2001; Pare 1999; Warburton 2019). Once weights began to be used, they were often central to how equivalency was determined, value assessed and quality verified.

Balances

In comparison to weights, balances have not been as widely studied or as thoroughly integrated into theoretical discussions of weight and measurement. They can, however, provide important information about how goods were weighed, the types of goods that were weighed, and the symbolic significance of practices of weight and measurement. In the Levant, the earliest artifact associated with measuring weight is a balance found at the site of Tell Fadous-Kfarabida in Lebanon, which is dated to the first half of the third millennium BCE (Genz 2011). In comparison, most weights for the region are dated to the middle of the third millennium. As Tell Fadous-Kfarabida was a secondary or tertiary site, and not a large commercial settlement, the use of weights was likely widespread during this period, even though there is sparse evidence.

Balances might not only be the earliest signs of systems of weight and measurement; they also contain information about what was measured. An experimental study of replicas of Bronze Age beams (9–22 cm long) concluded that they could have sustained up to 2.5 kg on each side, but that it is unlikely they were weighing goods of that weight (Hermann *et al.* 2020). An item weighting 2.5 kg, even if extremely dense, would have been too bulky to suspend easily from a beam with a length of 9–22 cm.

Balances also held symbolic value and are included in burials as symbols of the status and occupation of an individual (Pare 1999; Roscio *et al.* 2011), and they are depicted in art representing morality and truth (Kirsch 1965, 3). In South America, balances developed independently and can provide an interesting comparison for how systems of weight and measurement evolve. Balances have been recovered in archaeological contexts from the Andean region of South America, which refers to the area between northern Ecuador and northern Chile and Argentina. The region incorporates coastal climates, highland zones and high montane rainforests and was home to diverse economic practices in prehistory.

South America

Weights and balances have not been widely studied in the Andes, even though balances have been

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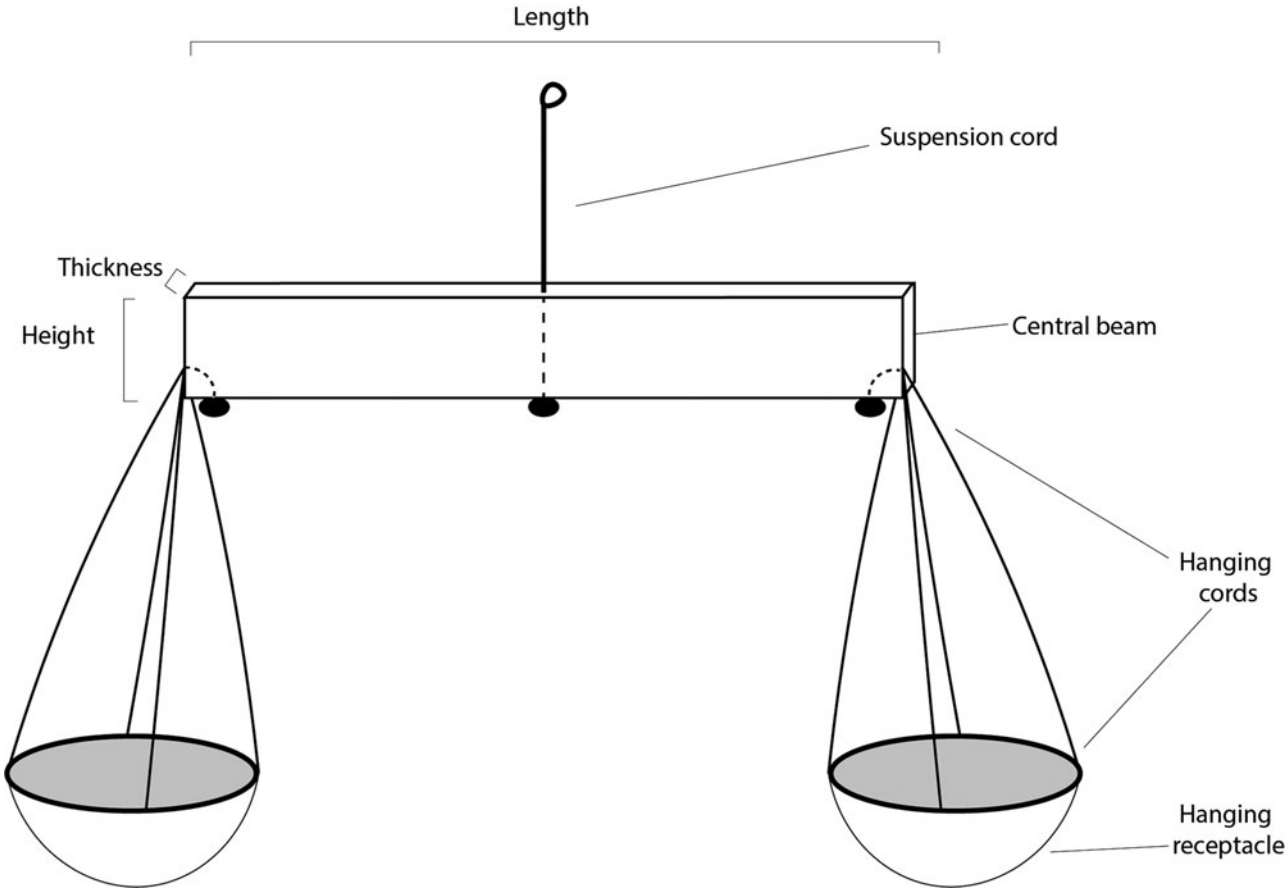

Figure 1. *Model of an equal-arm balance showing the different parts and dimensions that were measured.*

found throughout the coast (Fig. 2). My current database of balances[1] contains 311 artifacts from museums, pictured in publications and recovered by archaeological projects. While balances are by no means ubiquitous, their prevalence in coastal contexts necessitates that archaeologists seriously consider their role in administrative practices and diverse economic interactions.

In the central and southern Andean highlands, researchers have reported that groups participated in a nonmarket economic system that relied on the institutions of kinship and reciprocity, and upon the redistribution of staple products and luxury goods (Covey 2015; D'Altroy & Earle 1985; Murra 1980; Stanish 1997). In the northern part of the Andean region in Ecuador, groups relied on a trading economy (Hartmann 1971; Salomon 1978; 1987) and research from throughout the Andean region has shown that merchants and markets existed (Hirth & Pillsbury 2013; Mayer 2002; Shimada 1985; Stanish & Coben 2013; Topic 2013). Exactly how widespread these activities were remains to be determined, but the region was home to a wide range of economic practices.

Weights

Weights have not been widely documented in the Andean region. This is similar to Eurasia and northern Africa, and is likely due to similar factors, such as weights being mislabelled, unidentified, and hard to interpret. Weights could have varied throughout the region and been commonplace items such as stones, beans, or ceramic artifacts that might not get labelled as weights by archaeological projects.

Recovered objects interpreted as weights are typically smoothed stones found in pouches. In one of the few studies that has been conducted on potential weights, it was concluded that there was no standard unit of measurement, but rather that the scalar relationship between the weights was important (Nordenskiöld 1921; 1930; Sprager 1994). Nordenskiöld (1930) hypothesizes that the weights scaled up at a ratio of 1, 3, 5, 18 and 25. Due to the

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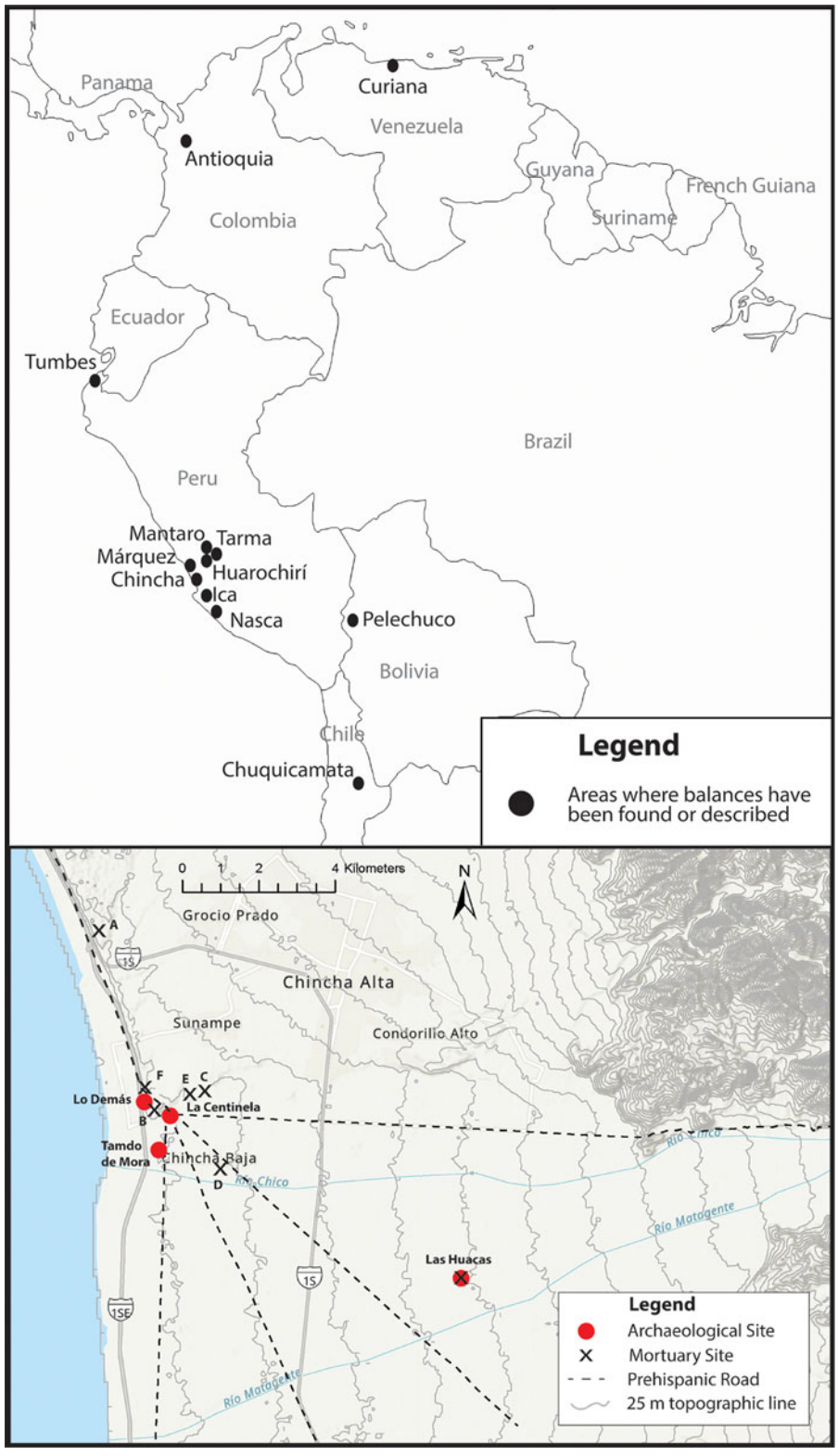

Figure 2. *(Above) Northern South America, noting locations where balances have been discussed or found; (below) the Chincha Valley, showing the locations of Las Huacas and the burials around La Centinela where the Uhle Collection balances were recovered.*

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small sample size of this study (only two sets of seven and nine weights), there is still much to learn about weights in the region, and renewed interest in exploring what could have been used as weights will expand the sample size.

Balances

In comparison to weights, there is more information on balances. Descriptions in the historic record recount how balances were used to weigh small amounts of coca, cotton and metal (Saville 1925). The use of balances to measure cotton is evidenced by the recovery of balances in two weaving baskets in museums (Dransart 2020; Young & Kaplan 2023), and a balance found in a wool bag with yarn balls associated with a burial at Cerro Azul (Marcus 2024, 238–40). The presence of balances in weaving baskets from museum collections might be due to collectors tampering with the artifacts, but the *in situ* balance from Cerro Azul corroborates the association between balances and weaving. Dransart (2020, 87) hypothesizes that balances might have been used by an administrator 'to weigh yarn produced by the spinners' they administered. This could have been to discern between cotton and much heavier wool yarn. Analyses of a sample of textiles from the site of Las Huacas in the Chincha Valley found that wool yarn was only used 'as an accent and not part of the main body' (Dalton *et al.* 2022b, 244). The restricted use of wool in Chincha and the association between balances and weaving tools could signify that wool was a controlled good in weaving on the Andean coast, similar to the Aegean (Michailidou 2008, 179–224).

Young and Kaplan (2023, 12) also note that balances could have been used to measure cinnabar, as a balance from Marquéz (central coast of Peru) has pans with 'a thick crust of dry red pigment'. Unlike in Egypt and Rome, in South America there are not many depictions of scales to provide hints about how they were used. There is a Chimú-Inca blackware double-spouted vessel that has an individual holding a balance seated on top of one spout, but it is unclear what the balance depicted on the vessel was used for (Rostworowski 1960, Lamina 3).

Descriptions in the historic record associate balances with merchants and metals. The Spanish Capitan Bartolomé Ruiz described scales '*hechura de romana*' [of Roman workmanship] near Tumbes (Fig. 2) on a merchant boat that carried goods such as *chaquira* (red and white shell beads), gold, silver, blackware vessels and cloth (Oviedo y Valdés [1535] 1852–55, 421–2. Typically, Roman scales are interpreted as unequal-arm balances (Espinoza 1987, 120–24), but there are also Roman scales in collections that are equal-arm balances (Supplementary Table 1). It is possible, then, that the use of this term in the Spanish chronicles does not necessarily refer to an unequal-arm balance. The differences between equal and unequal-arm balances will be expanded upon below.

Early historical records (prior to 1570) also mention balances in Ecuador associated with the Pasao and Coaque (Estete [1534] 1924), in the town of Curiana in Venezuela, and used by the Pacabuyes who lived near the Xiriri river (López de Gómara [1552] 1941). The Pacabuyes were described as being talented metal workers and having two types of balances, one that was made from bone and looked like ivory, and another that was a black rod that looked like ebony (Oviedo y Valdés [1535] 1852–55, 274). These balances were small and probably only weighed up to eight ounces (Rostworowski 1960, 23–4).

These descriptions in the ethnohistorical record recount how balances were used and where they were found after the arrival of the Spanish, but it is not known how their use relates to the Prehispanic role of balances. Previous studies of balances assert that they were short, generally less than 15 cm in length (Sprager 1994, 33), and that they were sensitive and sophisticated (Lothrop *et al.* 1957:277). Broadly, tools for measuring weight in the Andean region can be broken into two categories: one is an unequal-arm balance known as a *wipi* (also spelled *huipe*, *wipe*) in Quechua (Dalton & Bennison 2023) and the other is an equal-arm balance known as an *aycana* in Quechua (Rostworowski 1960, 26).

Unequal-arm balances

Unequal-arm balances (Fig. 3) can be used to measure an exact amount that is determined by: (1) the amount of weight on the weighted side, (2) the location of the fulcrum (where the artifact is suspended from), and (3) where the object being measured is placed. Through moving the fulcrum, the scale can achieve balance, and similarly moving the object being weighed along the shaft can also achieve balance; these placements can then be associated with certain desired weights. Scales of this type have been documented ethnographically and historically in the central highlands in places such as Mantaro, Casta and Tarma, and the Ecuadorian coast in Manabí (Espinoza Soriano 1987, 120–24). In Casta, from at least the twentieth century to the present day, the community uses a *wipi* to measure contributions of coca to the annual canal-cleaning ceremony (Tello & Miranda 1923). During the 2022 ceremony,

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Figure 3. *Unequal-arm balances from the highland Bolivian village of Pelechuco, collected by Adolph Bandelier (AMNH, B/6675A, B/6675B, B/6675C). (Courtesy of the Division of Anthropology, American Museum of Natural History.)*

the scale was not used to calculate precise weights, but rather to show the relative weight between the amount of coca that different functionaries brought, where some were expected to bring more and others less (Bennison 2023; Dalton & Bennison 2023). Unequal-arm balances are used in modern communities and described in historic records, but they have not been found in prehistoric contexts. To date, the only balances that are known to have been used prior to the Spanish are equal-arm balances.

Equal-arm balances

In their complete form, equal-arm balances are composed of a central beam that is typically a flat rectangle (6–20 cm) made of bone or wood (Fig. 4), but there are also artifacts made of metal and stone. A suspension cord is attached to the centre of the beam through a vertical hole running from top to bottom. Typically, the suspension cord is looped around or held in place by a knot. On either end of the central beam are hanging cords that are attached through a 90 degree hole with a knot at the end (Fig. 1). The hanging cords are then attached to a hanging receptacle that can be made from nets, metal discs, gourd vessels, baskets and textiles. Based on the dimensions of these different receptacles, they were likely used to weigh different types of goods. For example, metal discs might have been used for metal and nets might have been used for cotton.

There are some equal-arm balances that differ from this typical construction. Some specimens have a rod-shaped rather than flat rectangular central beam. On other artifacts, the hanging and/or suspension cords were attached through a simple hole that has been drilled front to back rather than at a 90 degree angle or from top to bottom. Apart from these more subtle differences in the construction of balances, there is also a hollow type, where the central beam is not a flat rectangle, but rather a semi-cylindrical tube with a hollow interior where a hanging cord would have passed through and extended out of either end (Fig. 5). This type is interpreted as a balance based on similar artifacts in collections having weights or hanging cords.[2]

For most artifacts of the hollow type, the suspension cord would have been attached through two holes that ran front to back on the top of the beam. One artifact of this type was found with the suspension cord still attached, and the cord was circular and looped around. Five artifacts of this hollow type were included in this study. They were all made of wood, but there are similar artifacts in publications that are made of metal (Schmidt 1929, 544). The hollow type is found both decorated and undecorated, and when decorated, isosceles triangles have been carved into the edge of the shaft (Fig 5B).

Based on the current state of research on late Andean prehistory, balances were used most

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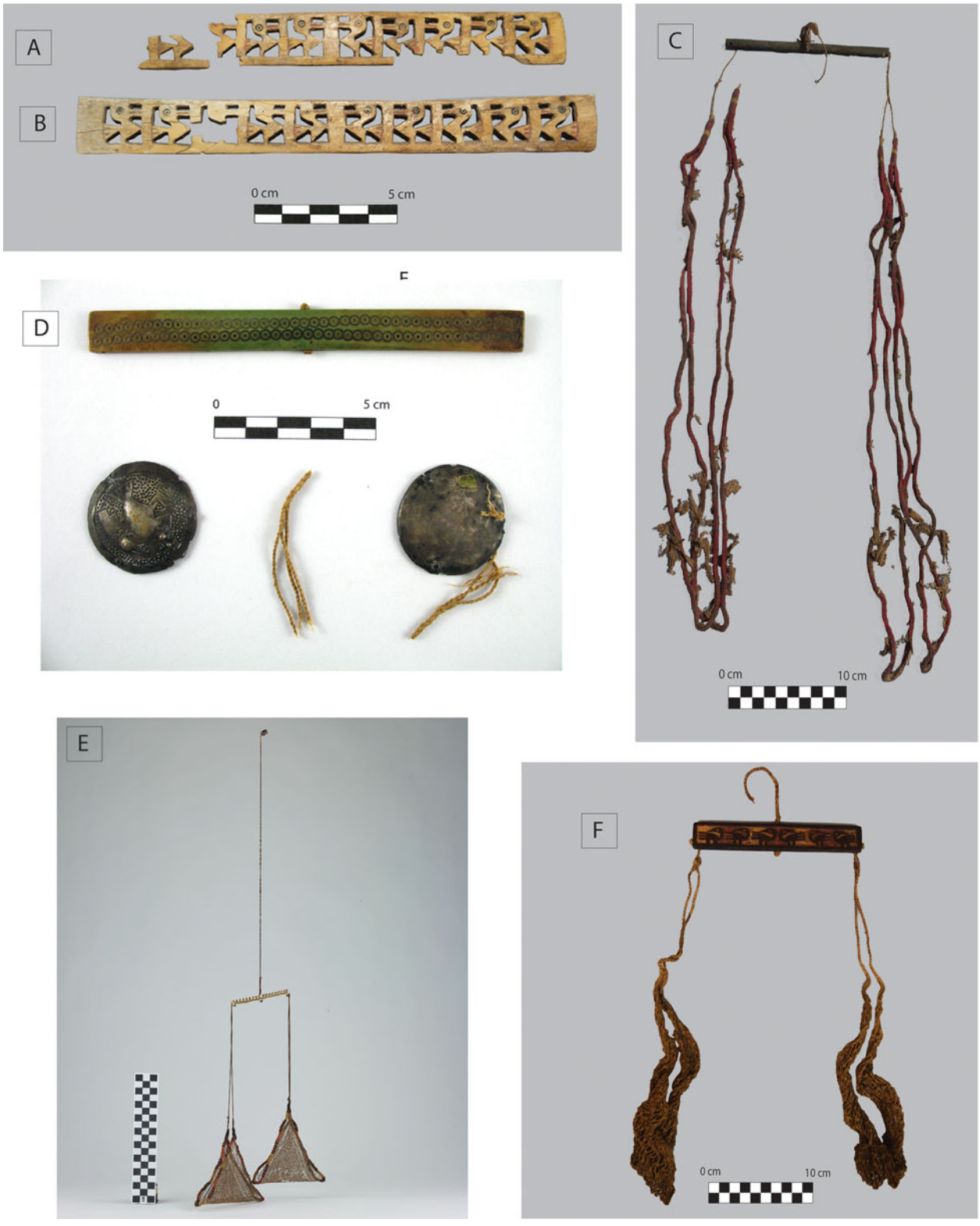

Figure 4. *Equal-arm balances. (A/B) two nearly identical bone beams with incised bird designs (LH 3972, LH 4683/4826); (C) a mostly complete bone beam from Las Huacas (LH 4822); (D) a bone beam decorated with incised concentric circles and associated with metal pans (PAHMA 4-3622, photograph by Di Hu with permission from the Phoebe A. Hearst Museum of Anthropology); (E) a complete balance with nets (AMNH 41.2/8987) (Courtesy of the Division of Anthropology, American Museum of Natural History); (F) a complete wood balance with red and yellow pigment (BM 86.224.104) (photograph by author reproduced with permission from the Brooklyn Museum).*

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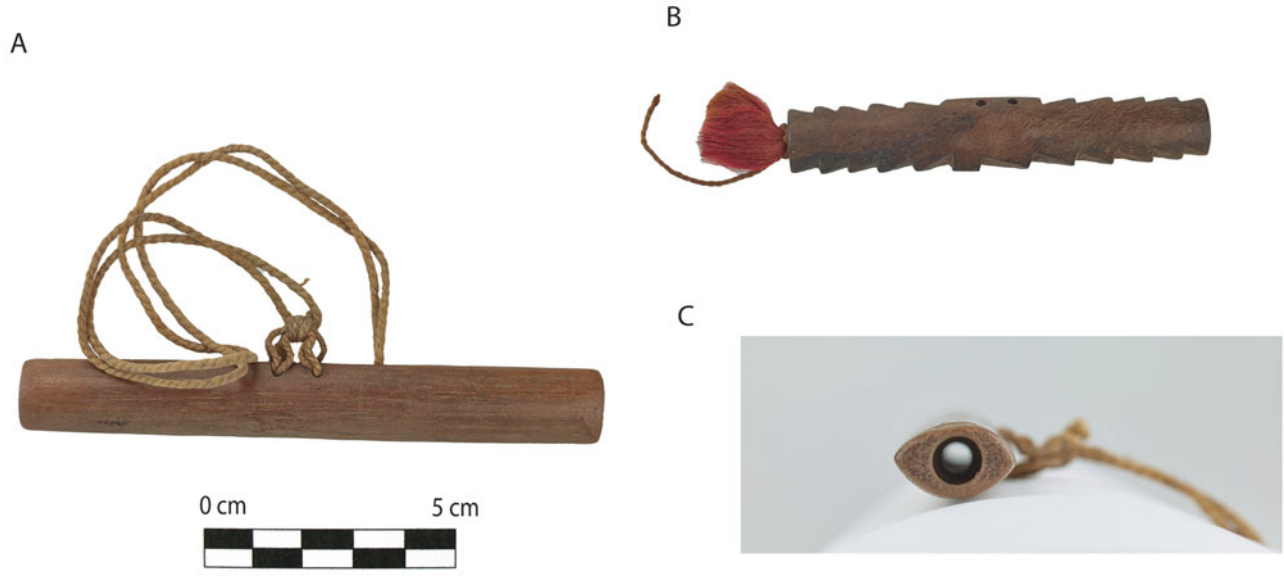

Figure 5. *Examples of hollow beams. (A) Undecorated wooden beam with suspension cord (AMNH B/8071); (B) hollow wooden beam (AMNH B/8065) with carved triangles and fragments of a hanging cord and animal hair (likely camelid) dyed red; (C) detail of the hollow interior (AMNH B/8071). (Courtesy of the Division of Anthropology, American Museum of Natural History.)*

prevalently in Chincha and the surrounding regions, such as Ica and Cañete (Kroeber & Strong 1924; Marcus 2024). Currently, there are no published cases of balances found in excavations from the north coast or Andean highlands. However, many artifacts in museum are labelled as Chimú or Chimú-Inca or attributed to the north coast of Peru.

Chincha

The Chincha Valley is located along Peru's Pacific coastline 200 km south of the modern-day city of Lima, right in the transition between the central and south coast (Fig. 2). Around AD 1400, the Chincha were incorporated into the Inca Empire (Dalton 2020), which ran from Ecuador in the north to central Chile in the south. Studies of Inca economic practices have found that in some regions the Inca relied on a non-market economy (Murra 1980; Stanish 1997), but in other regions under Inca control there is evidence for diverse economic practices, and the presence of markets and merchants (D'Altroy & Earle 1985, 195; Gallardo 2013; Mayer 2002; Pease 1992; Rámirez 1995; Rostworowski 1970; Salomon 1987). Chronicles also describe the use of weights, where in coastal communities the Inca gave weights to the local *curacas* [leaders] that corresponded to the amount of gold and silver that they owed in tribute (Santillán [1563] 1879, 42, 45).

In the ethnohistorical record, the Chincha are described as a group that was economically specialized, where fishers, farmers, and merchants lived in distinct settlements (Rostworowski 1970). During the Late Horizon (AD 1400–1532), the Inca constructed a palace at the coastal capital of La Centinela and developed roads that ran along the coast and up to Cusco (Castro & Ortega Morejón [1558] 1938; Morris & Santillana 2007; Rostworowski 1999, 112–16). Within the empire, the Chincha oversaw trade to Ecuador for gems and *Spondylus* shell (Barraza Lescano 2017; Rostworowski 1970). *Spondylus* is a bright red/orange spiny oyster shell that was transformed into beads and figurines. *Spondylus* beads took various forms such as birds, trapezoids and small discs sometimes referred to as *chaquira*. Scholars offer conflicting accounts of exactly what *chaquira* was; some refer to it as bits of gold (Patterson 1987; Rostworowski 1970, 163–73), while others describe it as a type of bead wealth, where beads were made from shell and bone (Salomon 1987). This latter use is the most common and is what is meant by the term in this manuscript. One example of *chaquira* in the Chincha Valley is long strands of beads that were recovered from a high-status grave near the site of La Centinela (Sandweiss & Reid 2016, 316)

While the Chincha are commonly described as merchants, the exact role of the Chincha in exchange

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during the LIP and the Late Horizon remains to be determined. Recent research hypothesizes that Chincha involvement in long-distance exchange was amplified under the Inca, and that in the LIP they were not in control of trade to Ecuador, as it was likely dominated by the powerful Chimú Empire on the north coast (Morris & Santillana 2007, 136–7; Sandweiss & Reid 2016). Similarly, there are debates around whether exchange routes between Ecuador and the Central Andes were by land or by sea (Barraza 2017; Hocquenghem 1993; Sandweiss & Reid 2016).

Regardless of the exact nature of Chincha involvement in long-distance trade, there was an increase in long-distance trade goods on the south and central coasts during the Inca Period. In this region, the number of highly polished blackware vessels (similar to those made by the north coast Lambayeque and Chimú cultures) and *Spondylus* shell artifacts increases during the Late Horizon (Carter 2011; Kroeber & Strong 1924; Sandweiss & Reid 2016). This trend on the south and central coasts is not reflective of the entire empire, as in many other regions the use of *Spondylus* decreases under the Inca (Carter 2011, 78).

In addition to an increase in long-distance trade goods, the historical documents also reference other aspects of exchange-based economies in Chincha, such as forms of metal currency and fixed exchange rates. The Chincha were said to buy and sell objects amongst themselves using copper, and that there was a fixed exchange rate between gold and silver (Rostworowski 1970, 171). However, these statements from the ethnohistoric record about the value and role of metal are yet to be substantiated by archaeological research. Currently, the only potential evidence of metal currency in Chincha are a few copper pieces found in a cloth bag at the site of Lo Demás (Sandweiss 1992, 71–2; Sandweiss & Reid 2016). While these bits of copper are intriguing, their function as a currency is uncertain. Outside Chincha, in northern Peru and Ecuador there are items that served as mediums of exchange and potential forms of currency, such as *naipes* (Shimada & Merkel 2021), axe-monies (Montalvo-Puente *et al.* 2023) and *chaquira* (Salomon 1987).

Along with descriptions of currency in the historic record and the presence of long-distance trade goods, balances are also found in the Chincha Valley and could be associated with merchants and markets. Balances have been found throughout the valley (a total of 50 referenced in publications), including one at Tambo de Mora (Barraza Lescano 2017, 430), one at an upper valley cemetery (Bongers 2019, 195), 33 in burials near La Centinela (Hu 2013; Uhle 1924), and fragments from 15 separate balances at Las Huacas (Dalton 2020, 303–7). The artifacts from Las Huacas and the Uhle collection were included in analyses presented in this paper.

Collections and methods

The balances included in this study come from sites in the Chincha Valley and museum collections. The Chincha Valley artifacts were recovered by excavations at the site of Las Huacas by the 'Proyecto de Investigación Arqueológica Las Huacas' (Dalton 2020, 285–94) and excavations in and near the site of La Centinela by Max Uhle in the 1920s that are housed at the Phoebe A. Hearst Museum of Anthropology (PAHMA) at UC Berkeley (Hu 2013; Kroeber & Strong 1924). The other artifacts are from the American Museum of Natural History (AMNH) and the Brooklyn Museum (BM) and do not have detailed provenience information. Even though they lack provenience information, these objects provide important insights on variation in balances and help to contextualize the Chincha data. Of the artifacts included in this study, some include hanging receptacles and cords, but the majority only include the central beam and some cord remnants. These specimens are identified as balances based on their similarity to central beams from known complete balances.

Uhle Collection

During his work in Chincha, Max Uhle collected artifacts from six different grave sites located in and around the site of La Centinela (Fig. 2). La Centinela was the capital of the Chincha polity, and the central administrative and elite core covers 12 ha that overlook the ocean. Many of the burial sites Uhle excavated are on the bluffs just to the north of the urban core, but one was located in an earlier construction known as Huaca Alvarado just to the southeast (D), and another was located 5 km to the north (A) (Kroeber & Strong 1924). All these graves are located within a few kilometres of the ocean and near the Inca coastal road.

Uhle's excavations recovered 33 equal-arm balances (Hu 2013) that are associated with both the LIP and Late Horizon, based on the other types of artifacts included in the burials (Kroeber & Strong 1924). However, these burials were never dated using absolute dating techniques, so these temporal classifications should be used with caution. Due to an overlap in material culture, it is possible that some of the balances also date to the colonial period (AD 1532–1821). The burials were mostly communal

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tombs and there is no evidence linking a balance to a specific individual. Data from 29 artifacts are included in this study, due to some artifacts being incomplete or missing. For the majority of the artifacts only the central beam is preserved but some specimens have suspension cords, hanging cords and hanging receptacles (both nets and metal pans). Central beams are made from wood and bone, and both decorated and undercoated. The only type of incised design recorded in the collection is concentric circles.

Kroeber and Strong (1924) stated that, while overall tombs with Inca artifacts were the richest, they contained fewer balances than tombs with more Chincha material culture. This highlights the possibility that scales may have been tied to local practices and individuals 'who did not rank highly in the Inca prestige system' (Menzel 1966, 124). Along with the balances, the burials also included 49 lithic artifacts that are predominantly smoothed stones. Studies of whether these smoothed stones are weights are inconclusive, as one study concluded that they are weights (Brooks 1986) and another concluded that they are ritual objects (Hu 2013). Renewed interest in these artifacts will help to clarify their use.

Las Huacas

Las Huacas is an approximately 100 ha site located in the centre of the Chincha Valley. It was an agricultural centre that is composed of 20–25 dispersed mounds and complexes and is located 9 km from the ocean. Excavations have focused on Complex N1, a nearly 2 ha compound that was transformed throughout the Late Horizon (Dalton 2020, 319–20). Within Complex N1, balances were recovered in burials or mixed contexts likely associated with burials in Room A2. The artifacts include 23 fragments that derived from at least 15 separate balances.[3] Dimensions were able to be measured or estimated for 11 artifacts. Based on AMS dates and associated artifacts, these balances date to the Late Horizon and early colonial period. Due to an overlap in material culture and a plateau on the calibration curve, it is not possible at this point to differentiate.

The burials at Las Huacas associated with balances include subterranean communal tombs, a large ossuary and temporary resting places that were part of a multi-stage burial programme (Dalton *et al.* 2022a, b). It is not possible to associate balances with a specific individual. The artifacts from Las Huacas are all made from bone and contain multiple different types of incised designs, including birds, stair-step motifs, concentric circles and human figures. Many of the beams from Las Huacas also had red and black pigment. At this time, it is not possible to speciate the animal bone used due to its heavy modification, but the beams are likely made of the long bone of a medium-sized mammal, such as the numerous camelids from the site (Dalton 2020, 261–2). One nearly complete specimen (Fig. 4C)[4] has a central beam that differs from the others; it was rod shaped and decorated through charring. When this artifact was recovered, the hanging cords were wrapped around the central beam and then wrapped by a cord with a single small *Spondylus* disc bead.

At Las Huacas, excavations did not recover any items that were clearly weights, but there was one smoothed stone recovered (Fig. 6). There are also other artifacts with unknown uses that were recovered through excavations, including ceramic discs and ceramic/wood objects that Sandweiss (1992, 90–92) refers to as 'half-bobbin objects'. Half-bobbin objects were also found at other sites such as Lo Demás (Chincha Valley) made from ceramics, Quebrada La Vaca (near Chala) made from bone, and Cerro Azul (Cañete) made from wood. The exact function of these objects is unknown, and it is possible that they could have served as weights for balances or fishing nets. Their presence across a variety of sites in distinct ecological zones along the coast merits further study.

Unknown proveniences

This article also includes data on equal (n = 41) and un-equal arm balances (n = 3) in museum collections that largely lack provenience information. For the equal-arm balances, if there is information on provenience it refers to non-specific coastal regions such as the central or south coast, with one coming from the Hacienda Huando in Chancay, Peru. The unequal-arm balances are part of an ethnographic collection from the late 1800s from the Bolivian town of Pelechuco, collected by Adolph Bandelier (Fig. 3).

The data on the Uhle specimens were collected by Hu (2013). I collected the data on the Las Huacas, AMNH and BM balances. To contextualize the Andean data, I also analysed one balance from Mexico at BM and balances at the Kelsey Museum of Archaeology (KMA) at the University of Michigan from the sites of Karanis and Rome, and European scales without provenience information (Supplementary Table 1).

Methods

In measuring height and thickness, a representative point was used. While the balances from museums

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Figure 6. *Artifacts at the site of Las Huacas that might have served as weights. (Left) A polished stone; (centre) ceramic discs; (right) half-bobbin ceramic beads.*

were mostly complete, many of the central beams from Las Huacas were not. In these cases, the length was calculated by doubling the distance from the end to the central point where the suspension cord would have been attached. To evaluate how the use of balances might have changed through time, nine balances from BM and AMNH were sampled for AMS radiocarbon dating (Supplementary Table 2). There are also associated dates from the burial features at the site of Las Huacas where some of the balance fragments were found. The balances that were dated varied in size and material. Samples were taken from cords and a tassel attached to the beams, except for artifact AMNH 41.0/9003A from Chuquicamata, Chile. For this artifact, the cords attached to the beam were not long enough to be sampled and the sample was taken from a string with stone beads associated with the balance (AMNH 41.0/9003B). This artifact also differed from the others, as it had multiple attachment points for the hanging and suspension cords.

Results

Dimensions and characteristics of balances

Within the equal-arm balances, there are differences in the characteristics and dimensions of the central beam. The length of Andean beams varies between 5.9 and 19.9 cm and the distribution of lengths is likely multi-modal. This includes a group of small beams with lengths of approximately 5.9–9 cm, medium beams (9.1–14.5 cm) and long beams (14.6–20.0 cm) (Fig. 7A). Based on their lengths and thickness, the Andean scales were not used for staple products. Scales from Karanis that were used to weigh bulk goods (such as grains or agricultural products) are significantly longer (many over 30 cm) and thicker (15–44 mm) and have heavy signs of use (Supplementary Table 1).

There is also variation in the dimensions of the central beams. The majority of balances are long flat rectangles, but there are some that have a more square shape. In looking at the height to length ratio, these specimens are clear outliers (Fig. 7B), with a ratio greater than 0.22. The more square shape creates a larger surface area for decoration, but would likely have made the balances less sensitive and possibly non-functional, as they are top heavy (particularly the clear outliers BM 86.224.119 and BM 41.1275.126: Fig. 8C, 8D). For comparison, balances not from the Andean region (Mexico, Karanis, Rome and Europe) are at the lower end of height to length ratio and known balances from other regions are not square shaped but rather a flat rectangle or rod shaped (Hermann *et al*. 2020; Pare 2013, fig. 29.6).

Context

In comparing the central beams from Las Huacas to those from the Uhle collection, there is evidence for differences in balances based on their provenience. There is a significant difference in the lengths of beams from Las Huacas and the Uhle collection ($p = 0.001$).[5] In comparing each of these sites individually to all the other Andean equal-arm balance beams, both Las Huacas ($p = 0.005$) and the Uhle collection ($p = 0.031$) differed significantly from the rest of the sample, with the Las Huacas beams being much longer and the Uhle beams being shorter and less variable. When comparing all the Chincha balances to the Andean balances with unknown proveniences, there was not a significant difference in the distribution of lengths ($p = 0.595$). This shows that the Chincha beams as a group are not clearly distinct

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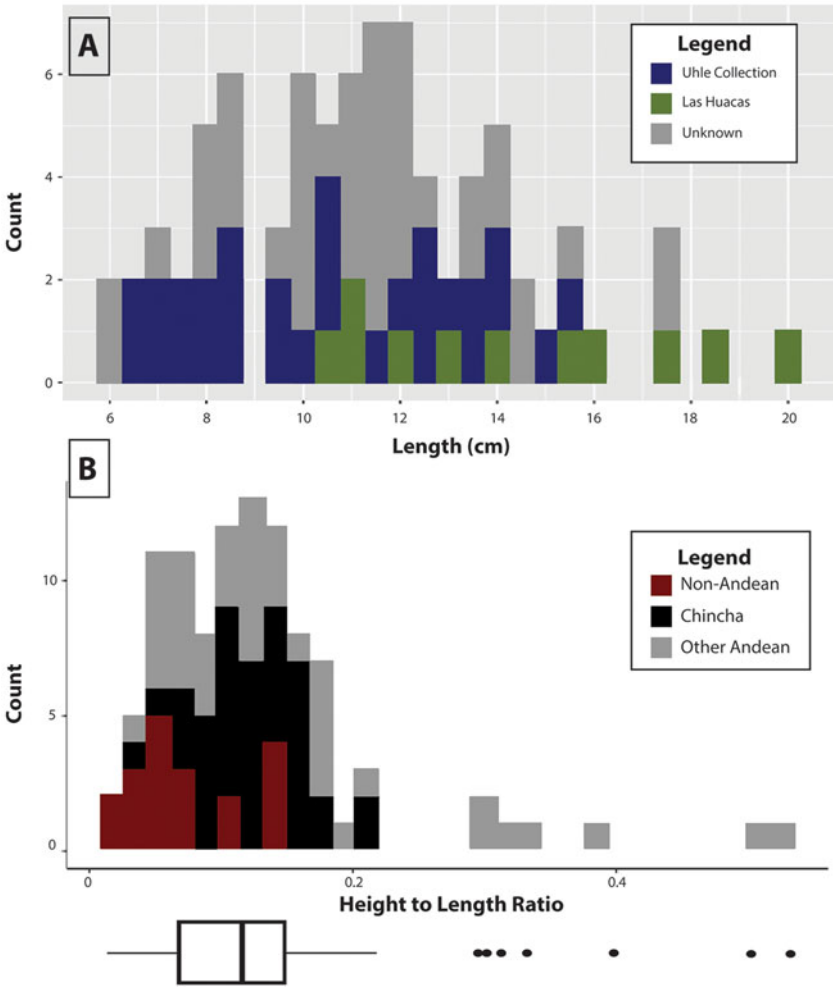

Figure 7. *(A) Graph showing the distribution of lengths of Andean balances, highlighting those from the Uhle collection around La Centinela (blue) and Las Huacas (green). (B) Histogram and boxplot of the height to length ratio of Chincha (black), other Andean (grey) and non-Andean (red) balances.*

from other Andean balances based on their length, but that there are significant differences between the Uhle and Las Huacas collections.

The Uhle and Las Huacas balances do not only differ based on length, but there are also differences in the types of decorations. The only type of incised design recorded at La Centinela was concentric circles, while Las Huacas included a variety of designs. In running a fisher's exact test, balances decorated with concentric circles are significantly more common in the Uhle Collection when compared to all other Andean beams ($p = 0.002$). Balances primarily decorated with concentric circles are also typically shorter; none are longer than 13.8 cm. In comparing the distribution of lengths between balances decorated with concentric circles and those not, there is a significant difference in their length ($p = 0.007$). There is not a significant difference in the length of beams that are decorated *versus* undecorated beams ($p = 0.891$).

While there are differences between balances in different parts of the Chincha Valley, all Chincha beams have hanging cords that were attached through 90 degree holes and suspension cords that were attached through a hole that ran from top to bottom. None of the beams from Chincha are of the hollow type either. The use of similar attachment techniques throughout the Chincha region could be related to communities of practices, where people learned to make balances in the same way (Wenger 1991), even if they were used to weigh different items. Similarly, none of the Chincha balances vary substantially from the typical height to length ratio (i.e. the ratio is less than 0.22) and were all likely functional (Fig. 7B).

Time period

AMS dates of balances and associated plant material from Las Huacas were grouped into a Phase using OxCal (Bronk Ramsey 2009; 2021). Not included in this phase were AMNH 41.0/9003A (which had multiple cord attachment points), AMNH B/8065 (a hollow beam) and BM 36.417 (which differed from most

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Figure 8. *Equal-arm balances that were highly decorated and have a height to length ratio over 0.22. (A) A wood beam that depicts two pairs of seated figures facing each other (AMNH B/8068); (B) a wood beam that could be depicting two pairs of seated figures in an abstract form (AMNH B/8067); (C) a wood beam that features a central figure, zoomorphic and geometric motifs, and red and yellow pigments (BM 41.1275.126); (D) a metal beam that features two pairs of seated individuals (BM 86.224.119). (Photographs of AMNH artifacts courtesy of the Division of Anthropology, American Museum of Natural History. BM artifacts reproduced with permission from the Brooklyn Museum.)*

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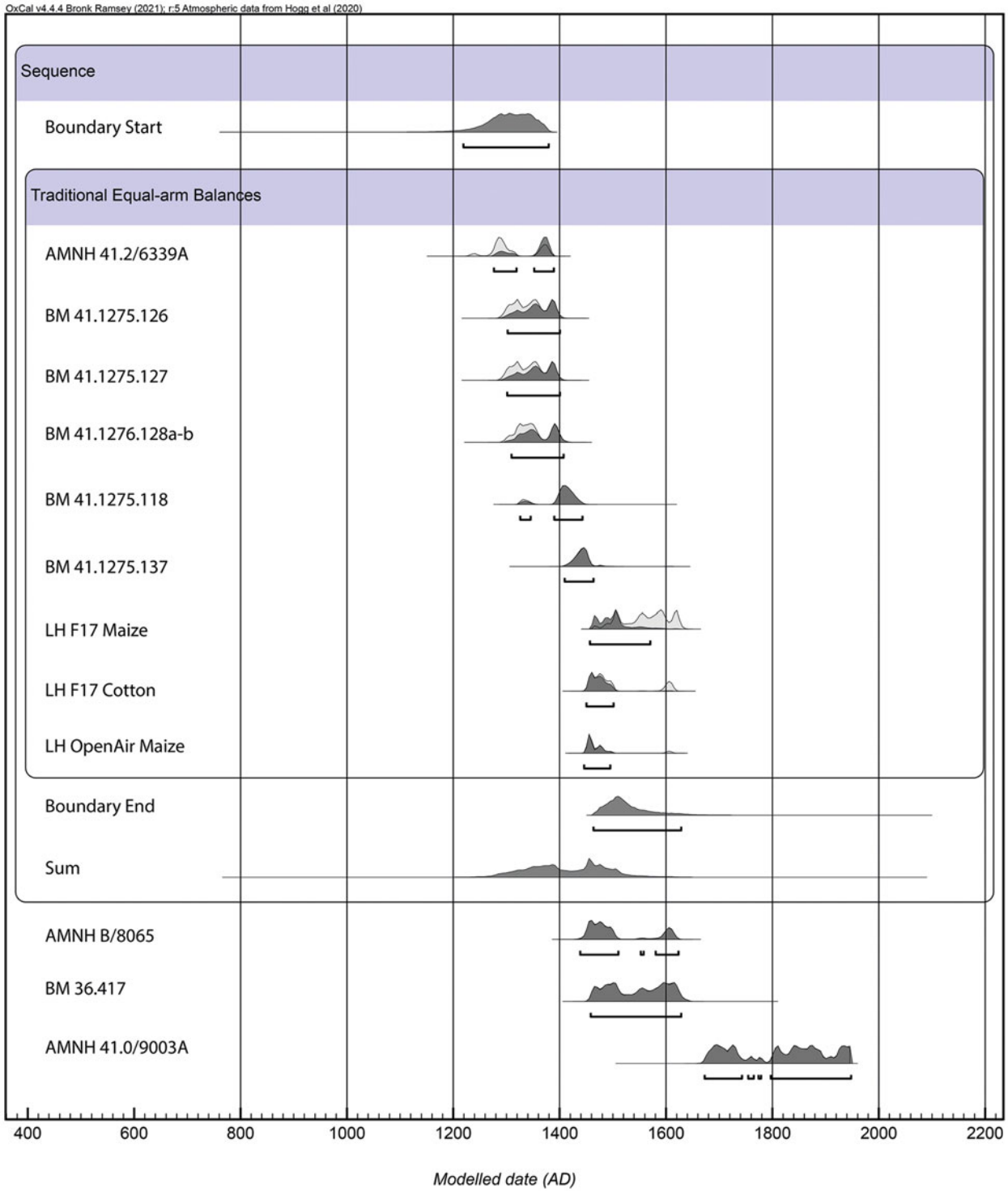

Figure 9. *Modelled AMS dates (Supplementary Table 2) where the balances have been grouped into a phase, excluding AMNH B/8065, BM 36.417 and AMNH 41.0/9003A (Bronk Ramsey 2009; 2021; Hogg* et al. *2020).*

beams where the hanging cords attached to the top and bottom of the beam). These artifacts were excluded because they differ substantially from the typical equal-arm balance (Fig. 1). Furthermore, the date for 41.0/9003A came from a string of beads associated with the balance and produced a potentially modern date. The use of balances has an estimated start date of AD 1219–1379 (Fig. 9), during the LIP.

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Discussion

The analyses and descriptions of balances outlined in this article highlight variation in Andean balances that is related to how they were used. While Andean balances were used to weigh a variety of goods, based on their lengths, they were all used to weigh relatively small amounts of important resources. Andean balances were likely used by merchants, artisans, bureaucrats and *curacas*.

Balances would have been useful in measuring precious resources for craft production. As described above, balances have been found in bags and baskets with weaving items and might have been used to regulate yarn, as wool is much heavier than cotton and was used less frequently on the coast. In craft production, balances could also have been used to create specific alloys for metal artifacts, such as in creating the copper-tin bronze alloy that was used in many Inca prestige items (Lechtman 1976). These different uses of balances in making craft goods could be reflected in the types of hanging receptacles (i.e. nets *versus* metal discs).

The iconography on some of the beams offers insights on their uses (Fig. 8). A metal beam (BM 86.224.119) and a wooden beam (AMNH B/8068) feature two pairs of seated individuals facing each other and touching hands, and AMNH B/8067 could be a more abstract depiction of this same scene. These individuals might be administrators, similar to seated figures found on bars used to hang the Andean knot record, *khipus* (Schmidt 1929, 547). The connection of the hands could also signify some sort of trade or exchange. Another tall wooden beam (BM 41.1275.126) features a central figure holding two staffs with two birds perched on the hands. Around this central figure are lizards, birds and triangles. These highly decorated balances all fall into the square shaped category, where they were likely not highly sensitive and might only have been made to be buried with an individual or used in public rituals. This is similar to the three non-functional gold balances found in a burial at Mycenae (Karo 1930).

As developed in the introduction, in Eurasia and northern Africa balances are associated both with state bureaucracies and exchange between people of different ethnic groups, and it is likely that this would be the case in the Andes as well. To understand these different uses better, balances need to be put into their context of use and studied alongside other artifacts such as accounting tools, mediums of exchange, administrative infrastructure and trade items. The prevalence of balances in Chincha, a group that is described in the historic record as having 6000 merchants (Rostworowski 1970), likely demonstrates that they were used by merchants conducting trade at the edge of the empire in Ecuador. This is further supported by the fact that balances are described in Colombia and Venezuela in the colonial records. While the Chincha themselves were not necessarily engaging in trade in these regions, their connections with Ecuador put them into the same interconnected system.

Merchants during the Inca period might have been vassals of the Inca state (Ramírez-Horton 1982) or independent traders (Rostworowski 1970), but either way, they engaged with groups who relied on exchange-based economies that operated outside Inca state redistribution. In these regions there are artifacts that functioned as mediums of exchange (*naipes*, axe-monies, *chaquira*), which has raised the possibility of the use of currency in Prehispanic South America (Hosler *et al.* 1990; Montalvo-Puente *et al.* 2023; Shimada & Merkel 2021). While current research has not concluded these artifacts were a type of currency, further research can provide insights on how and where they were used, and their association with balances. Some balances in museum collections have beads along the suspension cord,[6] which could signify a connection between *chaquira* and balances.

Alongside the use of balances by merchants, balances could also have been used by bureaucrats and *curacas* to measure tribute. Indeed, Santillán ([1563] 1879) describes how the Inca would give *curacas* weights that would correspond to the amount of gold and silver they were expected to pay in tribute. In these instances, balances might have been used alongside Andean accounting tools, such as *yupanas* (an Andean abacus) and *khipus* (Barraza Lescano *et al.* 2022). *Curacas* might have also used them in community events, where goods were weighed in front of the public to certify that people's obligations had been met, as occurs in modern-day Casta (Bennison 2023; Dalton & Bennison 2023).

The different uses of balances outlined above might have relied on standardized weights and measurements, but not necessarily. As Nordenskiöld's (1930) early research on weights highlights, they could have been used for scalar measurements, or there might have been regional variation as seen in Europe before the introduction of the metric system at the end of the eighteenth century (Kirsch 1965; Lugli 2019). The use of weight and measurement is separate from the standardization of practices of weight and measurement, which can be an important political tool.

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Studies of Andean metrology highlight that measurements were not standardized and were linked to how people used the goods or interreacted with the landscape (Rostworowski 1960; 1981). However, it is possible that there was some level of standardization in particular contexts, as balances decorated with concentric circles have less variable lengths and are numerous in particular contexts in Chincha. These graves in Chincha are close to the ocean and sites where fishermen or merchants might have lived. These sites are also closer to known Inca coastal routes and adjacent to La Centinela, where the Inca constructed a palace (Morris & Santillana 2007). The differences in the collections of balances from Las Huacas and the Uhle collection could be tied to Inca presence, economic specialization, or due to temporal variation. Future research should explore how balances changed through time and compare collections from contemporaneous sites.

Conclusions

Variation in Andean balances described in this article includes: (1) the mechanical process of how they measured weight (unequal *versus* equal-arm balances), (2) the types of hanging receptacles, (3) the dimensions and characteristics of the central beams, and (4) how the different parts were attached. This variation highlights that balances did not have a singular use and that their structure and function changed across sites and regions. To understand the use of balances, researchers need to evaluate the types of artifacts and infrastructure that these tools were associated with (weights, currencies, accounting tools and production facilities). Furthermore, the dates and historic accounts shared in this article demonstrate that they were used in the LIP, Late Horizon and colonial period, which are all associated with vastly different social and economic organizations. More radiocarbon dates of artifacts will shed light on how the use of balances varied across these time periods.

Characterizing the use of balances in South America will expand the current understanding of the roles of weight and measurement in exchange and administration. In Eurasia and northern Africa, groups were connected through complex trade networks. In these regions, innovations by one group could be integrated and transformed by groups in another area. Analysing the independent invention of weighing devices in South America will add to interpretations of the diverse impacts and uses of weight and measurement in economic and social relationships, particularly since the Andes were home to diverse economic practices.

Notes

1. This database was originally sent to me by Dr Deborah Spivak and contained 190 balances from different museum collections. I have attempted to make sure balances that are in collections databases and publications have not been double counted.
2. Balances at Harvard's Peabody Museum, objects 46-77-30/9741 and 46-77-30/6558.
3. Total number of balances was estimated based on distinct contexts and design elements. Fragments that were found in the same context with similar designs were counted as likely belonging to the same balance if their percentage of completeness was less than 50.
4. Referred to as Balanza V in Dalton (2020); Dalton *et al.* (2022b).
5. To account for the positive skew of the data, the square root of the length was used when running a t-test for all distributions.
6. From this study: AMNH 41.2/6339A. From collections: Art Institute of Chicago, object 1955.2579g; Harvard's Peabody Museum, objects 39-83-30/1859 and 36-120-30/1400; Museo de América, object 13027; Lowe Art Museum, object 99.0019.05

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Supplementary material

Supplementary Tables may be found at <https://doi.org/10.1017/S0959774324000076>

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