EXARC JOURNAL
2020/4
16 Articles | Open Access

Reviewed Article:

Testing Mesoamerican Lunate Artifacts as Possible Crescent Loom Weights

Persistent Identifier: https://exarc.net/ark:/88735/10533

EXARC Journal Issue 2020/4 | **Publication Date:** 2020-11-25

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While the importance of textiles in Mesoamerica from the Classic period (AD 250-900) onward is well-recognized, scholars have conducted little exploration of earlier Mesoamerican textile production. This lack of scholarship may be attributed in great part to the scant preservation of perishable textiles and tools from ancient times. New sources of information have been recognized, however, in the re-examination of extant Pre-Columbian textiles that illustrate unusual manufacturing techniques and in the rich depictions of textiles that are preserved in

early sculpture. Further sources are found in the re-identification of a number of ancient jade objects as high-status versions of tools used for making textiles. Many of these textile tools are readily identifiable because closely comparable, preserved counterparts are found in later Mesoamerican cultures. Other early artifacts are much more difficult to identify, however, because they were involved in textile technologies used only during the Pre-Classic/Formative period (1500 BC-AD 250) and earlier; tools used for these extinct technologies would no longer be produced nor have comparable counterparts after the widespread Mesoamerican adoption of the backstrap loom at the beginning of the Classic period. One such possible tool used in early, experimental weaving technologies is a lunate jade artifact that compares closely with a crescent weight, a specialized type of loom weight found in ancient Central and Southern Europe. Replication studies serve as a pragmatic method for testing these lunate objects as warp-weighted loom weights, both by verifying their efficacy using methodologies developed to test the function of the European crescent weights, and also by exploring new possibilities for the practical applications of these types of weights.

> “This analysis further successfully demonstrates several new hypotheses. The lunate and crescent weights enable different methods for weaving that had not previously been explored in the research, as these loom weights are able to be used effectively to create different types of sheds for weaving both basic and more complex textile patterns.

Review of the Research

Research over the past century has demonstrated woven textiles played an important role in Mesoamerica from the Classic period (AD 250-900) through contemporary cultures. Archaeological evidence preserved in the arid caves of northern Mexico confirm, however, that textile production began in ancient times, with extant examples of loom-woven yucca, cotton, and cotton-blend cloth produced before 900 BC (Vaillant, 1930, p.38 and p.188; Vaillant, 1939, p.170; MacNeish *et al.*, 1967, pp.191-193 and pp.217-223; Johnson, 1971, pp.297-321; Wilkerson, 2001, p.325).

Important insights have been gained through the recent re-examination of preserved Pre-Columbian textiles. Analysis of one loom-woven cloth panel from the Laguna region has revealed a textile too large to have been produced on a backstrap loom, the iconic Mesoamerican weaving loom that was widely adopted by the Classic period. Replication studies have also confirmed that this textile was created by diagonally intertwining the warps, a technique that requires a type of warp manipulation not possible on a backstrap loom (Filloy Nadal, 2017, p.7 and pp.15-17, and p.36). The scholars in this study suggested that the intertwined-warp textiles were produced on fixed looms or horizontal ground looms, such as those still used today by the Tarahumara cultures of the American Southwest cultural region of North America; another well-known Pre-Columbian loom that allows for this type of creative warp manipulation is the warp-weighted loom, which commonly was used by cultures of the Pacific Northwest region of North America. These studies have revealed that Mesoamericans did not use the backstrap loom exclusively as once thought but experimented with elaborate weaving techniques on different types of looms.

Only recently have studies begun to explore the importance of textiles prior to the Classic period, and this is in part due to scant preservation in other regions of Mesoamerica. On the Gulf Coast of Mesoamerica, where the Olmec culture flourished during the early and middle eras of the Pre-Classic/Formative period (1500 BC-AD 250), the tropical environments and acidic soils have yielded little direct evidence of textiles. Only a few fragments of cordage and remnants of twill-patterned woven mats are extant (Rodríguez Martínez and Ortíz Ceballos, 1994, pp.23–27; Ortíz Ceballos *et al.,* 1997, pp.56–65), along with just two textile-impressed potsherds (Drucker, 1952, Plate 22e; Pohl *et al.,* 2019). The rich pictorial evidence of fibers and cloth in Olmec ceramic and stone sculpture nevertheless clearly attests to the making of elaborate fabric and clothing by these early cultures. Particularly abundant are depictions of garments composed of bands of finely woven cloth that may be wrapped, knotted, layered, or interlaced to form elaborate headdresses, necklaces and scarves, breast bands, crossed chest bands, arm bands, wide belts, narrow belts, belts made of multiple bands, wrapped loincloths with flaps, pubic apron flaps, and leg bands (Follensbee, 2000; 2006; 2008; 2009; 2014; 2017a; 2019b; *in press*). Recent research has also established that the Gulf Coast Olmec region was a favorable and productive area for growing and procuring high-quality cotton, fur, and feather fibers in pre-Hispanic times (Stark *et al*., 1998, pp.10–15, Stark, 2001, pp.336, Footnotes 6–8).[1] Little is known about loom-weaving methods or textiles experimentation before the Classic period (AD 250-900), but other archaeological remains provide some tantalizing clues.

As with textiles, the vast majority of Gulf Coast Olmec objects made of wood, bone, or shell are preserved only in the rarest of circumstances, and traditional textile tools and equipment —which are typically made of these materials--have not survived. However, the re-analysis of a number of enigmatic small stone objects found in Gulf Coast Olmec graves and in “heirloom caches” of Formative period jade objects found throughout Mesoamerica has revealed that the Olmec produced elite versions of tools and equipment made of highly coveted, non-perishable materials such as jade—a practice common among later Mesoamerican cultures (Follensbee, 2008, pp.87-88). While most of these Olmec jade objects were initially identified simply as “ornaments,” “objects of unknown use,” “miscellaneous objects,” and “implements for mysterious unknown purposes,” the excavators postulated that the more mysterious of these objects may have served as some sort of tool (Drucker, 1952, pp.168–171; Drucker, 1955, pp,63–65; Covarrubias, 1957, p.75; Drucker *et al*., 1959, pp.191–194; Coe and Diehl, 1980, pp.240–242). Re-analysis has revealed, in fact, that a number of these items are closely comparable to tools used in later Mesoamerican cultures for spinning and weaving; replication studies have subsequently demonstrated their effectiveness as spindle whorls, weaving awls and picks, battens and half-battens, and netting gauges (Follensbee, 2008; 2015; 2017b; 2018; 2019a).

In the quest to explore early Mesoamerican weaving loom experimentation and technology, other archaeologically recovered ancient objects are also worthy of reconsideration, such as the biconical, hand-molded ceramic objects found at the Middle Pre-Classic/Formative period Olmec sites of La Venta and Tres Zapotes. Each of these artifacts is impressed or engraved with a horizontal groove and a vertical groove that each encircles the object on an axis, clearly illustrating that these objects were meant to be tied and suspended by cordage (See Figure 1). Extant examples range in size from two to three centimeters wide and four to six centimeters tall, with a weight range of roughly 25 to 65 grams. Excavators offering an interpretation consistently suggested their possible function as loom weights for a warp-weighted loom (Weiant, 1943, p.118, Plate 65; Drucker, 1952, p.142, Plate 42; Drucker *et al*., 1959, p.245, Plate 61).[2]

Another object that may have served as a specialized form of loom weight is suggested by one of the enigmatic jade objects from a cache of Pre-Classic/Formative period jades found at the Gulf Coast site of Cerro de las Mesas (Drucker, 1955, p.64 and Plate 49l). This small object takes a solid lunate or crescent-shaped form with a conical hole drilled at each end; it is 7.7 centimeters long, 2.1 centimeters in maximum width, and 6 millimeters in maximum height, with an interpolated weight of under ten grams (See Figure 2). This artifact closely resembles a type of loom weight that is well-known in ancient Europe: the crescent loom weight.

Crescent loom weights were developed and used throughout central and southern Europe during the late 4th and early 3rd millennia BC, when warp-weighted looms were used widely throughout the region (Lassen, 2015, p.127; Costeira and Mataloto, 2018, p.59; Grömer, 2018, p.118; Ergün, 2020, p.5). These weights in actuality take a large variety of forms, varying in silhouette from a large, wide V or U shape, to a smaller, shallow curved crescent, to a short, wide lunate shape, semi-circular shape, or heart shape; the defining elements of these types of weights are a relatively flat silhouette, a wide body, and hole at the top of each end (See Figure 3). Likewise, these weights vary by material used, consisting of unfired clay, lightly fired terracotta, or fully fired terracotta (Grömer, 2018, pp.118-120; Ulanowska, 2018, p.165), and they vary greatly in size and weight, from an average weight under 100 grams and with small holes averaging three to five millimeters (Costeira and Mataloto, 2018, p.63) to over 500 grams with larger holes (Ulanowska, 2018, p.166). Studies indicate that the size and weight of the loom weights correspond to the type and size of fibers being woven, the number of threads strung through each hole of the weights, the different types of weighted looms, the type of fabric desired, and diverse weaving tradition use (Mårtensson, Nosch and Strand, 2009, pp.396-397; Costeira and Mataloto, 2018, p.59).

Although the Olmec lunate object from the Cerro de las Mesas cache is considerably smaller and lighter than extant European crescent loom weights, these differences easily may be explained by the same factors that explain the wide variation of size and weight among the European loom weights, which corresponds to the type and size of fibers being woven: The textile impressions on the Gulf Coast Olmec ceramic sherds both illustrate very fine, thin yarns of only 1.5 to 1.65 millimeters in diameter, and these yarns most likely were composed of lightweight cotton, feather, and/or fur fibers known to be used in Mesoamerican loom-woven fabrics during the Early Pre-Classic/Formative period (See Fig 4). Given the identification of multiple other jade objects in the Pre-Columbian caches as textile tools, and the strong similarities between the lunate artifact and European crescent loom weights, it is quite possible that the Pre-Classic/Formative period jade lunate artifact could likewise have represented a practical tool independently developed to create similar textiles and to address similar issues in warp-weighted loom weaving as were the European crescent weights.[3]

Multiple replication studies have illustrated that European crescent weights function very effectively as loom weights, particularly in band weaving. The crescent weights provide stable tension while helping to disperse stress on the warp threads, they balance well and shift smoothly with the movement of weaving, and these weights avoid the common problems prevalent with other shapes of weights by aligning in separated rows that remain in place and do not tangle easily. The crescent weights also offer the advantage of enabling flexibility in weaving techniques, allowing quick changes within a textile among tabby weaves, basket or panama weaves, and twill patterns (Lassen, 2015, pp.136-137; Grömer, 2018, pp.118-126; Ulanowska, 2018, p.170). Some studies also suggest that the crescent weights may have been used for warp-twined textiles, although this function has been less well-explored. In these latter studies, only one warp thread was tied into each of the crescent weight’s two holes, and the resulting separation of each pair of warp threads created a “natural shed” that facilitated the warp twining process (Grömer, 2018, pp.123-126). Some studies of weaving with the crescent weights also used warps strung so that the two holes in the weights separated the warp threads into a natural shed (Lassen, 2015, pp.129-136; Ulanowska, 2017, p.61; Grömer, 2018, pp.121-123). While one study took advantage of this one natural shed provided by the weights for tabby weaving, all of these studies used heddles, heddle bars, and/or battens to create the counter sheds; these studies did not explore the creation of potential counter sheds that might be provided using the natural separation of the warp threads by the two holes in the crescent weights.

The established functions and advantages of European crescent weights correlate very well with the types of textiles depicted in Gulf Coast Olmec sculptures, which illustrate a great deal of costume composed of relatively narrow bands of cloth (See Figure 5). In addition, one of the two Olmec extant textile-impressed potsherds illustrates what appears to be a weft-faced 2/2 tabby weave,[4] while the other appears to illustrate a tabby weave embellished with a single chevron composed of a 3/1 weft float twill weave; these are precisely the types of textile patterns and the method of easy shifting among patterns facilitated by crescent loom weights. Some Olmec sculpture does appear to depict more complex patterns, such as diamond twill, but these patterns appear later in the Olmec repertoire and on panels of cloth rather than on cloth bands.

One last factor to consider in this study is that the jade artifacts shown in previous studies to be Olmec textile tools are all elite versions of the traditional, everyday textile tools that usually were made of low-fired ceramic or of perishable materials such as shell, bone or wood. No ceramic artifacts similar to the lunate objects have been found, so were this lunate artifact an elite version or representation of a functional weaving tool, the typical version of this tool would have been made of perishable materials, which survive in Gulf Coast Olmec material culture only rarely, because of the tropical environment and acidic soils in this region. In past studies, extant examples of tools made of these materials from later Mesoamerican cultures have served to provide clear examples of closely comparable textile tools that confirm ancient elite jade tools identification. In the case of the lunate artifacts, however, such loom weights have not yet been clearly identified in the archaeological record of the Classic period or later cultures—and likely may not have existed, as these cultures would have replaced the vast majority of earlier, experimental types of looms and their associated paraphernalia with the much more efficient, flexible, and portable backstrap loom that was adopted by the beginning of this era. Given the likelihood that everyday versions of lunate loom weights would have been made in perishable materials, however, responsible testing of the lunate artifacts as loom weights should not begin with testing whether elite, presumably occasional-use jade versions of the artifacts were functional as weaving tools, but more logically would consider and explore what would have been everyday versions of these tools, likely made of lighter-weight, mundane weaving tool materials, to explore whether these objects would generally have been effective if used as early textile tools.

Experimental Archaeology Project

Based on the above background research, this experimental archaeology project has been proposed to use replication studies to test several hypotheses:

1. Even taking into consideration the relatively fine, lightweight fibers known to be in use by Mesoamericans in Pre-Classic/Formative period, would lunate artifacts composed of everyday materials still be of adequate mass to serve as warp-weighted loom weights?
2. Are the sizes and shapes of Mesoamerican lunate artifacts adequate to provide the same advantages (providing stable warp thread tension, good balance, smooth shifting during weaving, separation of the warp into rows and reduction of warp tangling) as the European crescent loom weights?
3. Would the lunate artifacts provide the same effectiveness as the European crescent loom weights in weaving of bands of cloth and of enabling flexibility of weaving techniques to quickly change back and forth among patterns of tabby and twill weaving, particularly in creating the patterns shown in Olmec potsherd textile impressions?
4. As weaving is binary, with the weft going over or under the warp, the two holes on the crescent and lunate weights suggest that these weights could be turned one way or the other, transposing the warp threads to the front or back of the loom and creating

different sheds without the use of a weaving pick, batten or heddle to lift the warp threads. Given the studies of European crescent loom weights where the warp was strung so that the crescent weights separated the warp threads into a natural shed, could further manipulation of such loom weights be used efficiently to create counter sheds of different types to reduce or eliminate the need for--or that were perhaps developed previous to the development of--heddles, heddle bars or battens?

To begin this analysis, replicas of the Mesoamerican lunate weights were produced for use as loom weights. These replicas mimic precisely the size and form of the two-holed lunate jade object recovered from the cache of Preclassic/Formative period jades found at Cerro de las Mesas (Drucker, 1955, p.64 and Plate 49l). As previous research has shown other objects in this cache, such as jade weaving picks and net gauges, to be elite versions of textile tools (Drucker, 1955; Follensbee, 2008; 2015; 2017b; 2018; 2019a), the original lunate jade artifact was possibly a high-status display version of a traditional textile tool. Similar to later Mesoamerican everyday textile tools, common versions of such objects were likely made of lighter-weight, perishable materials such as shell, wood, or bone. Thirteen replicas of the lunate artifacts were therefore made of air-dry clay, because this material allows for accurate replicas of the artifacts to be made quickly and efficiently in the proper size and form, and because the result closely mimics the interpolated weight (two to five grams) of common lightweight versions of these objects in shell, wood, or bone (See Figure 6). Thirteen weights were created so that cloth bands of 27 warp threads to 53 warp threads would be replicated, to accommodate single or double warp threads tied in each hole of the weights. In addition, five precise replicas of the biconical ceramic weights found at La Venta and Tres Zapotes were created in kiln-fired ceramic (See Figure 7) to replicate the size, weight, and surface of the original ceramic artifacts. These were used to provide tension for the final odd (the 27th or 53rd) thread of the warp, as odd-numbered warps facilitate even weaving, patterning, and selvage edges.

Next, a simple warp-weighted loom needed to be constructed. General consensus dictates that the oldest warp-weighted looms were most likely composed of a live, horizontal tree branch from which warp threads could be suspended, while slightly later looms, like those of ancient Europe, were constructed very simply of two side bars that support a top cross bar, with a shed bar across the front that provides a rest for loom weights as well as extra stability; these latter early looms were typically leaned against a wall or tree. Because inclement weather would preclude the use of a live, natural tree branch still attached to the tree, a simple loom was constructed using the basic sidebars of two heavy, forked branches each cut off at an angle on the bottom so that the loom would securely rest against a wall at an approximately 60-degree angle. A thinner branch that fit neatly into the forked tops was selected to serve as the top loom bar, and these three pieces were tied together using 1.5-millimeter cotton yarn cordage. Another thin branch was tied horizontally across the middle of the front of the loom to provide a shed bar, that would also serve as a neutral rest for the weights and perhaps as a wrist-rest while weaving. Finally, a thin branch was suspended from each side of the top branch with cordage to create an adjustable floating back shed bar and to provide a secondary neutral rest for the weights (See Figure 8).

The fibers prepared for this analysis consisted of commercially produced 8/4 un-mercerized natural cotton yarn, which closely matched the 1.5-millimeter cotton yarn used to create the tabby-weave textile impressed in the La Venta ceramic potsherd. Because these experiments would also include twill weaves with at least a single chevron pattern, black-brown feline fur was also hand-spun into 1.5-millimeter and 2-millimeter yarns to provide the slightly larger, contrasting-color weft desirable for making the twill weaves clearly visible.

In the first experiment, 27 warp threads were tied to the top bar of the loom, and then one warp thread was tied per hole in the weights (two warp threads per lunate weight), with the first thread tied in the right hole and the second tied in the left hole, so that all of the lunate weights were lined up evenly across the warp, and the lunate weights were initially facing to the weaver's left. The final odd warp thread was tied to the lightest (25 grams) biconical weight, and this warp thread was made longer so that the weight could rest on the floor or drape over the front or back shed bar to stay in place (See Figure 9). Although the mass of the lunate reproductions is relatively light, the reproductions immediately illustrated that they worked well with the two cordage types in this experiment, providing ample weight to provide stable tension for the warp, but not too much weight that they strained or threatened to break the cordage used.

The first woven pattern was a simple tabby weave, also known as a plain weave or taffeta weave. As in the studies with the European crescent loom weights, the lunate weights provided good balance and smooth shifting during weaving, and kept the warp neatly separated into rows reducing the occurrence of warp tangling that often happens with other loom weight types. The tabby weave was simple to create using the lunate weights, without a need for a heddle bar or string heddle: the primary shed was created by the separation between the two holes of the lunate weight, with the odd-numbered warp threads directed toward the back of the loom and the even-numbered warp threads toward the front of the loom, and the resulting shed was wide and even, allowing for a smooth passing of the weft shuttle; the biconical weight on the final odd warp thread was placed across the back floating shed bar for an even weave. The counter shed was created by individually turning each lunate weight one half-turn counterclockwise, all of the crescents faced to the weaver's right; turning the lunate weights transposes the two warps, so the odd-numbered warp threads are now in the front of the loom and the even-numbered warp threads are now in the back of the loom. The biconical weight on the final warp thread was placed over the front shed bar of the loom, positioning the odd-numbered warp thread appropriately to facilitate even weaving, patterning, and selvage edges. (For the rest of this study, the biconical weight and warp thread were placed across the front shed bar or the back shed bar, as needed, to appropriately position this final odd-numbered warp thread.) The first weft could be packed, or pushed down, to create an even line across the loom, with a weaving batten, pick, or comb, and then the second weft could be passed through the counter shed. The lunate weights could then be each individually turned back one half-turn clockwise, the second weft packed, and the process repeated. Once initiated, the process is quick and simple, and much faster than by lifting each alternate warp thread with a pick or a batten for each pass of the weft, and this test produced an even tabby weave (See Figure 10).

Next, a weft-faced 2/2 tabby weave was created by placing each of the lunate weights in alternation in front of or behind one of the shed bars (See Figure 11), passing the weft through, and then reversing the positions of the weights for packing the weft and the next pass of the weft. When the weft was packed tightly, this procedure created a weft-faced textile closely comparable to the weave illustrated in the first Olmec potsherd impression (See Figure 12; see also Figure 4). This process is again much faster than lifting each alternating pair of warp threads with a pick or a batten for each pass of the weft.

The development of a 2/1 twill weave using just the sheds and counter sheds created by the lunate weights is more complicated. However, this pattern may still be achieved using only the sheds provided by lunate weights by focusing on the necessary configuration of the warp threads for each row of this pattern and either turning or placing the lunate weights over the shed bars as needed. By turning the lunate weights clockwise or counterclockwise, or by placing the weight in front of the front shed bar or behind the floating shed bar in the back, the warps could be arranged to create the correct shed, without the use of a heddle. While creating these sheds was initially slower than individually lifting the warp threads to create a 2/1 twill, the weaver was eventually able to get into a rhythm of creating the sheds as the weaving progressed. After some practice, moving the lunate weights to create the sheds proved to be a faster, more efficient process than lifting warp threads with a pick or batten for each row, and this process was used to produce an even 2/1 twill weave chevron pattern (See Figure 13).

Next, a 3/1 twill was attempted, and this was achieved by focusing on the necessary configuration of the warp threads and turning or placing the lunate weights and the biconical weight over the shed bars as appropriate. Developing this form of twill pattern turned out to be substantially more difficult for the weaver to create than the 2/1 twill using only the lunate weights and no weaving picks, battens, or heddles. The weaver was able to successfully produce a 3/1 chevron twill weave pattern using this method (See Figure 14). It is possible that a more experienced weaver could get into a rhythm of turning and moving the weights to create the more complex shed configurations quickly and easily.

Another important weave was depicted on the second Olmec textile-impressed potsherd, which illustrates a tabby weave with the embellishment of a single chevron composed of a

3/1 float weave. As with the previous tabby weave experiments, a tabby weave progresses very quickly using the lunate weights to create the sheds and counter sheds, and adding a 3/1 float to create the single chevron motif across the cloth is easily facilitated by simply turning the lunate weights or placing them over a shed bar as needed at the appropriate point in the pattern. The weaver successfully produced this pattern (See Figure 15), and using the weights to create the sheds turned out to be much quicker than using a pick or batten to lift the floating warps to create this motif; this method was also much more efficient than stringing the 24 heddles that would be necessary to create the wide chevron that completely spanned the 27 warp threads of this textile band.

Finally, in the spirit of experimentation, a diamond-and-dot twill weave pattern was added to the textile band. While it is possible that a much more skilled weaver would be able to plan out this design by creating a pattern for turning and lifting the lunate loom weights, the weaver in this study found this process to be beyond her skills. Instead, the weaver found an easier process by placing all of the lunate weights across the front shed bar, which provided stable tension for using a traditional brocade technique (See Figure 16). This technique involves following a sketched pattern for a complex design and lifting the warp threads individually with a pick or batten for each pass of the weft. The addition of this complex woven section to the band confirmed the findings of scholars studying the European crescent weights that weights of this type provide versatile, stable tension and balance when suspended as well as when placed over the front shed bar, and that these weights allow for great flexibility on a warp-weighted loom for changing back and forth among different weaving techniques within the same textile.

The success of the tabby weave and of the weft-faced 2/2 tabby weave inspired the weaver to conduct one last weaving experiment, which involved re-stringing the lunate weights so that each weight had two warp threads tied into each hole, but in the same configuration as used for the tabby weave. As anticipated, with the four warp threads per lunate weight, the weaver was able to successfully create a basket-weave (also known as a panama weave) pattern textile using the same technique as for the tabby weaves, and just as quickly and easily (See Figure 17).

One final note is that, during this analysis, the weaver confirmed a hypothesis suggested by a colleague that the lunate weights might also allow for more portability of textiles on the warp-weighted loom.[5] The tapered lunate form of the weights allows the excess warp threads to be wound smoothly around the middle of the weights and simply secured with an underhand loop, which prevents unrolling and tangling of the excess warp threads in transport and in storage.

Concluding Remarks

The results of these replication studies successfully establish the possibility that Gulf Coast Olmec lunate artifacts could have served effectively as loom weights that were comparable in form and function to European crescent weights for warp-weighted looms. Although the Mesoamerican lunate artifacts were much smaller and much lighter in weight, either in jade form or made in common materials such as shell, bone, or wood, their lightest mass is still adequate to have served effectively as loom weights for single or double warp threads, and they provide stable warp thread tension and good balance for weaving on a warp-weighted loom. In addition, the lunate shape allows for smooth shifting of the weights during weaving and for easy separation of the warp threads in rows that stay in place; these weights therefore greatly reduce the tangling that is a problem with other forms of warp-weighted loom weights. The lunate artifacts also proved effective for weaving bands of cloth and for enabling flexibility in easily changing weaving techniques and patterns within the same cloth, as has also been shown for the European crescent loom weights in previous studies. Perhaps most importantly for the purposes of this study, the lunate artifacts also proved fully effective in the weaving of fibers commonly used in ancient Mesoamerica spun in the sizes illustrated in preserved Gulf Coast Olmec textile impressions, in using the tabby and twill weaving techniques illustrated in these textile impressions, and in making woven bands like those illustrated in the clothing commonly depicted in Olmec sculpture.

In addition, this analysis further successfully demonstrates several new hypotheses. The lunate and crescent weights enable different methods for weaving that had not previously been explored in the research, as these loom weights are able to be used effectively to create different types of sheds for weaving both basic and more complex textile patterns. Using the lunate and crescent weights to create such sheds is relatively simple and quick, and it greatly reduces the need to use a pick or batten to lift individual warp threads, as well as the need for complex groups of heddles. Finally, the shape of the lunate and crescent weights provides for securely storing excess warp threads, thereby enabling portability of the warp-weighted loom. Overall, these studies offer possible insights into early Mesoamerican experimentation with different types of looms, weaving tools, and the creation of loom-woven textiles during the Pre-Classic/Formative period.

1 Among other mammal fibers, fur fibers commonly procured in this region include rabbit fur and feline fur.

2 Another function commonly suggested for these objects is that they served as fishing net weights; however, only a few of these objects have been recovered, and fishing net weights are typically found in abundance at Mesoamerican sites. Other objects that could have possibly served as loom weights are the reworked ceramic potsherds found in abundance at Middle Formative period Olmec sites such as La Venta. These potsherds are ground into relatively consistent sizes with an average weight of 30 to 35 grams, and they were ground with notches on each side, presumably so that they could be tied and suspended by cordage. The excavators quite reasonably interpreted these objects to be fishing net weights, as they occur in abundance and they compare closely to ceramic sherd fishing net weights used exclusively as net weights in later Mesoamerican cultures (Drucker, 1952, p.142 and Plate 42). However, as these later cultures had widely adopted the backstrap loom by the Classic period, they would not likely be found to be employing these

objects as warp-weighted loom weights; this interpretation of these objects, therefore, does not preclude an earlier alternate use for these objects.

3 The independent development of highly similar tools and technologies in different regions of the world, without direct interaction among cultures, is a widely accepted phenomenon known as parallel evolution of cultural innovation. This phenomenon is common among textile tools such as spindles, whorls, awls, weaving combs, shuttles, and battens, which developed independently in very similar forms, as these types of tools represent simple, practical innovations that enable common techniques and that provide solutions to typical problems in weaving technology.

4 The excavator of this potsherd from the site of La Venta made a putty impression of this weave pattern and tentatively captioned this as "Sherd with textile impression, apparently of closely woven twined basketry (?)" (Drucker, 1952, Plate 22e), but as noted by Follensbee (2008) and Pohl et al. (2019), this impression could also be interpreted to illustrate tightly loom-woven, weft-faced 2/2 tabby weave cloth.

5 I gratefully acknowledge this observation by Edie (Mangun) Ballweg, a master weaver who also provided me with generous advice and responses to my questions about weaving during this project.

Keywords loom
weaving
textile
stone

Country Belize
Guatemala
Mexico

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Mesoamerican Research

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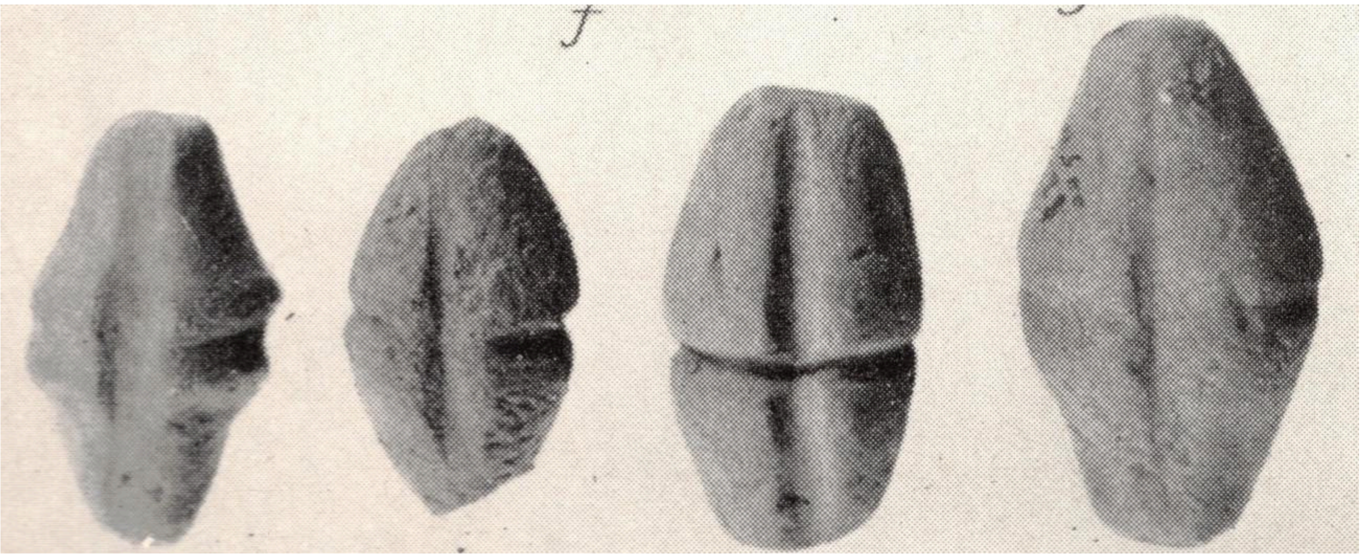

FIG 1A. BICONICAL, HAND-MOLDED CERAMIC OBJECTS FOUND AT THE MIDDLE PRE-CLASSIC/FORMATIVE PERIOD OLMEC SITES OF LA VENTA AND TRES ZAPOTES: 1A. FROM LA VENTA (DRUCKER 1952, 142, PLATE 42)

FIG 1B. BICONICAL, HAND-MOLDED CERAMIC OBJECTS FOUND AT THE MIDDLE PRE-CLASSIC/FORMATIVE PERIOD OLMEC SITES OF LA VENTA AND TRES ZAPOTES: 1B. FROM LA VENTA (DRUCKER ET AL. 1959, 245, PLATE 61); COURTESY OF THE SMITHSONIAN LIBRARIES: HTTPS://LIBRARY.SI.EDU/DIGITAL-LIBRARY/BOOK/BULLETIN1531952SMIT HTTPS://LIBRARY.SI.EDU/DIGITAL-LIBRARY/BOOK/BULLETIN1701959SMIT

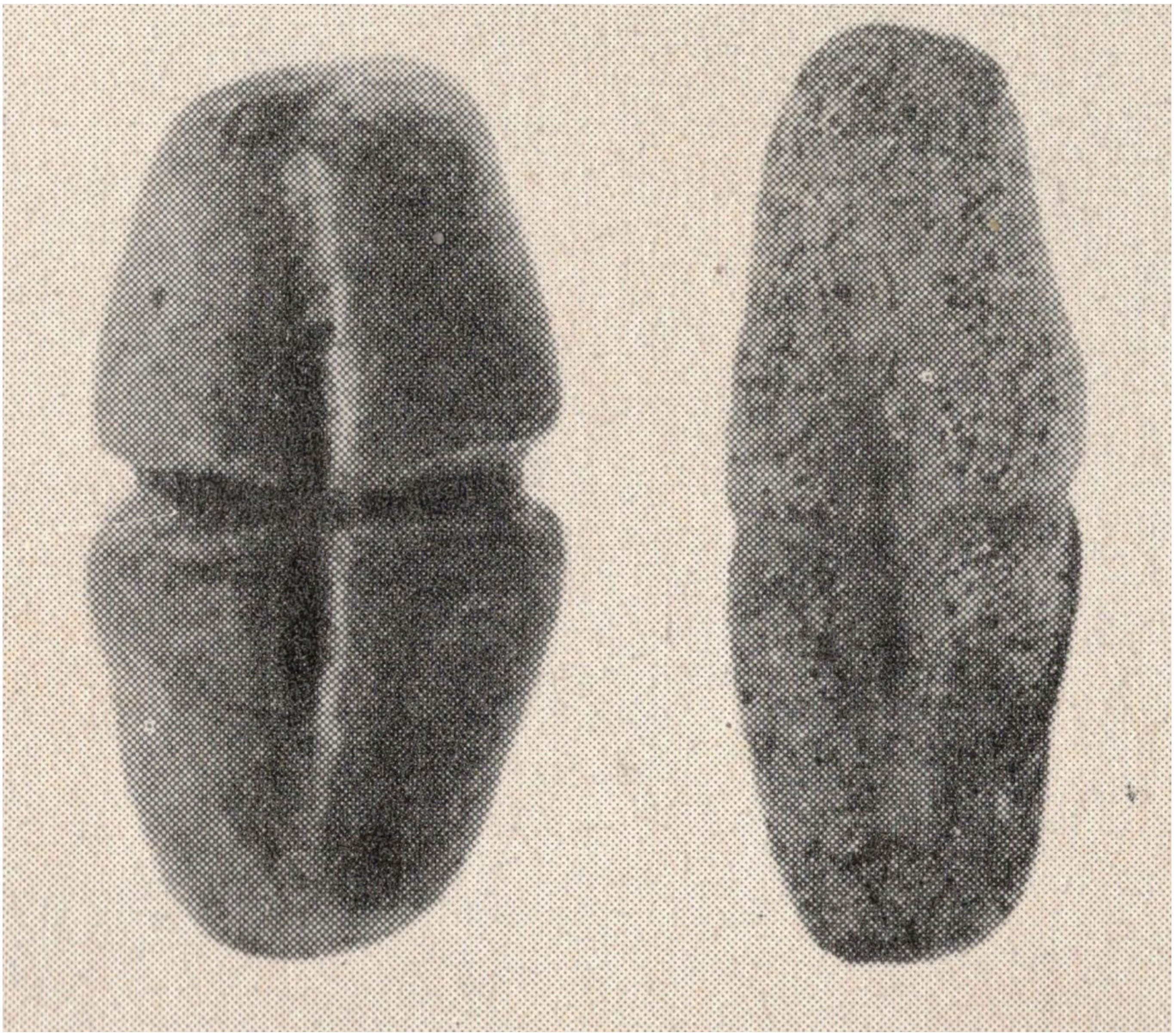

FIG 1C. BICONICAL, HAND-MOLDED CERAMIC OBJECTS FOUND AT THE MIDDLE PRE-CLASSIC/FORMATIVE PERIOD OLMEC SITES OF LA VENTA AND TRES ZAPOTES: 1C FROM TRES ZAPOTES (WEIANT 1943, 118, PLATE 65). COURTESY OF THE SMITHSONIAN LIBRARIES: HTTPS://LIBRARY.SI.EDU/DIGITAL-LIBRARY/BOOK/BULLETIN1391943SMIT

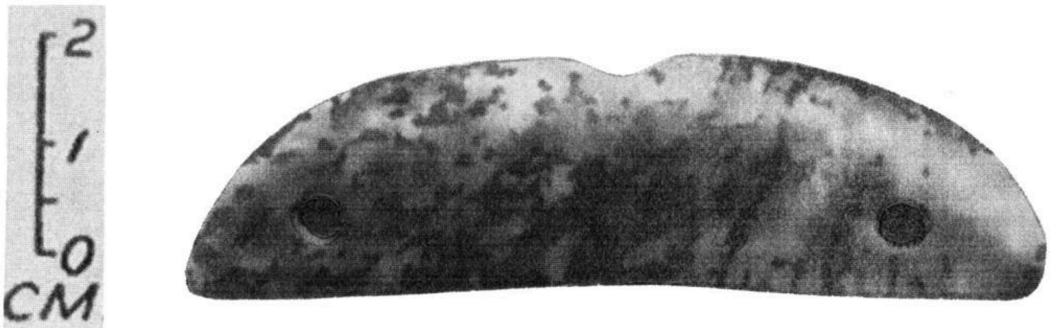

FIG 2A. LUNATE JADE ARTIFACT FROM A CACHE OF PRE-CLASSIC/FORMATIVE PERIOD JADES FOUND AT THE GULF COAST SITE OF CERRO DE LAS MESAS: 2A. FRONT (DRUCKER 1955, 64 AND PLATE 49, WITH OUTLINES TO CLARIFY EDGES, BY THE AUTHOR). COURTESY OF THE SMITHSONIAN LIBRARIES: HTTPS://LIBRARY.SI.EDU/DIGITAL-LIBRARY/BOOK/BULLETIN1571955SMIT

FIG 2B. LUNATE JADE ARTIFACT FROM A CACHE OF PRE-CLASSIC/FORMATIVE PERIOD JADES FOUND AT THE GULF COAST SITE OF CERRO DE LAS MESAS: 2B. BACK (DRUCKER 1955, 64 AND PLATE 49, WITH OUTLINES TO CLARIFY EDGES, BY THE AUTHOR). COURTESY OF THE SMITHSONIAN LIBRARIES: HTTPS://LIBRARY.SI.EDU/DIGITAL-LIBRARY/BOOK/BULLETIN1571955SMIT

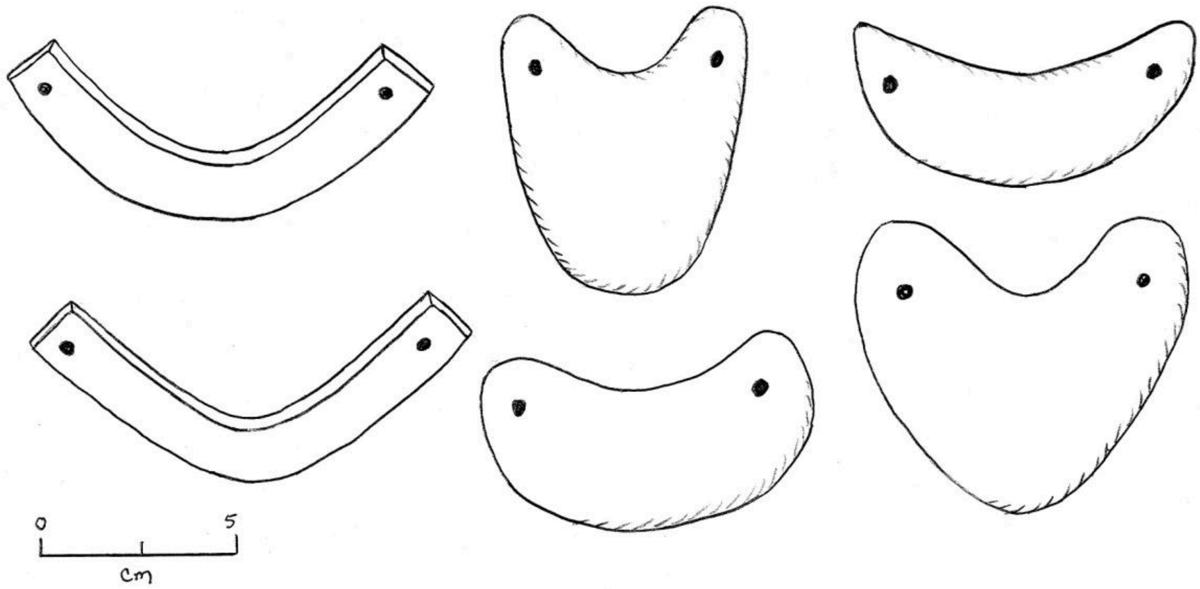

FIG 3. CRESCENT LOOM WEIGHTS FROM CENTRAL AND SOUTHERN EUROPE, LATE 4TH AND EARLY 3RD MILLENNIA BC (DRAWINGS BY THE AUTHOR AFTER COSTEIRA AND MATALOTO 2018, 62-64; ERGÜN 2020, 9; MÅRTENSSON, NOSCH AND STRAND 2009, 375; GRÖMER 2018, 125; SARI 2018, 217).

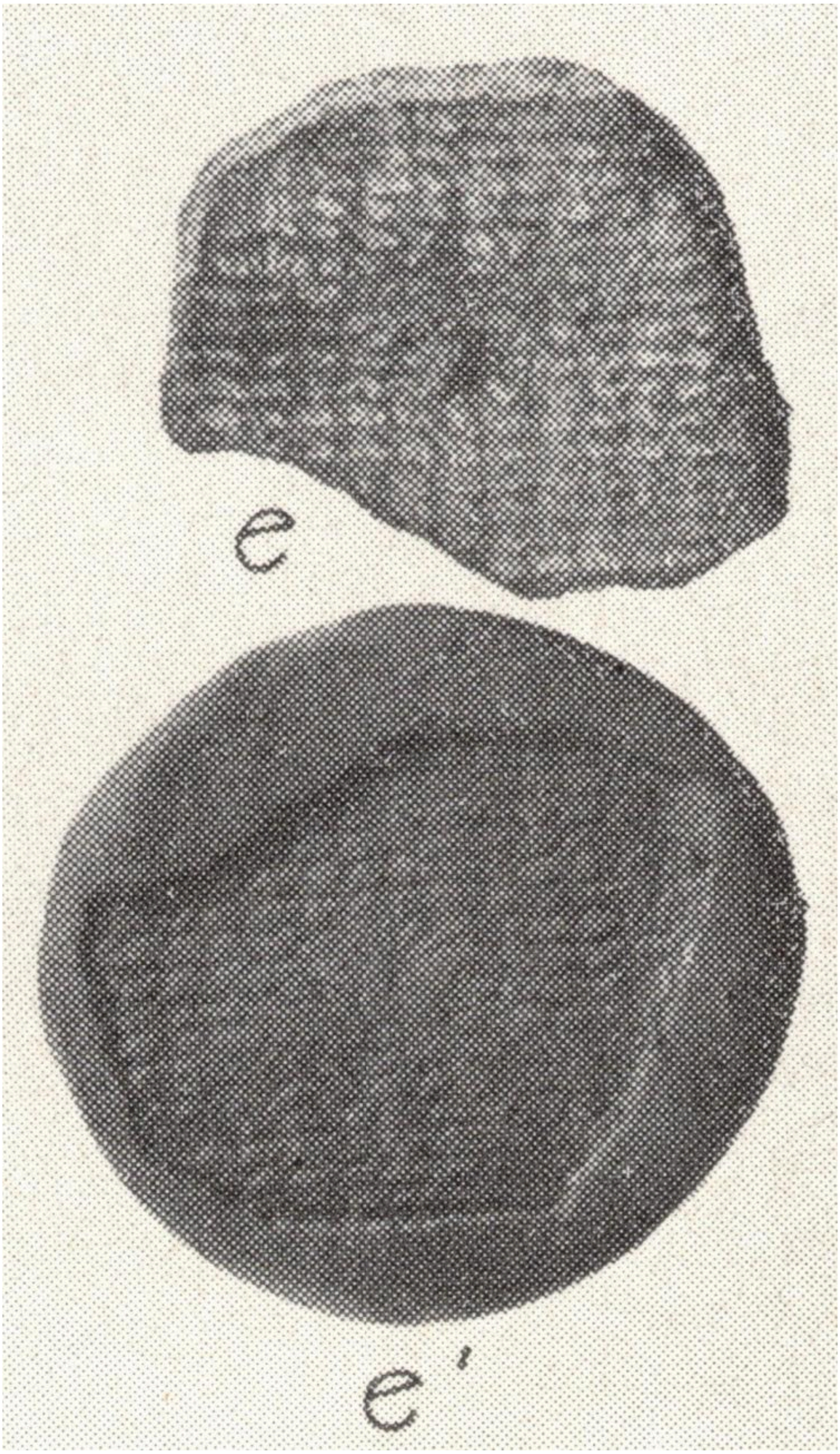

FIG 4. TEXTILE IMPRESSION ON A MIDDLE PRE-CLASSIC POTSHERD FROM THE SITE OF LA VENTA, AND ITS PUTTY IMPRESSION (DRUCKER 1952, PLATE 22E). COURTESY OF THE SMITHSONIAN LIBRARIES: HTTPS://LIBRARY.SI.EDU/DIGITAL-LIBRARY/BOOK/BULLETIN1531952SMIT

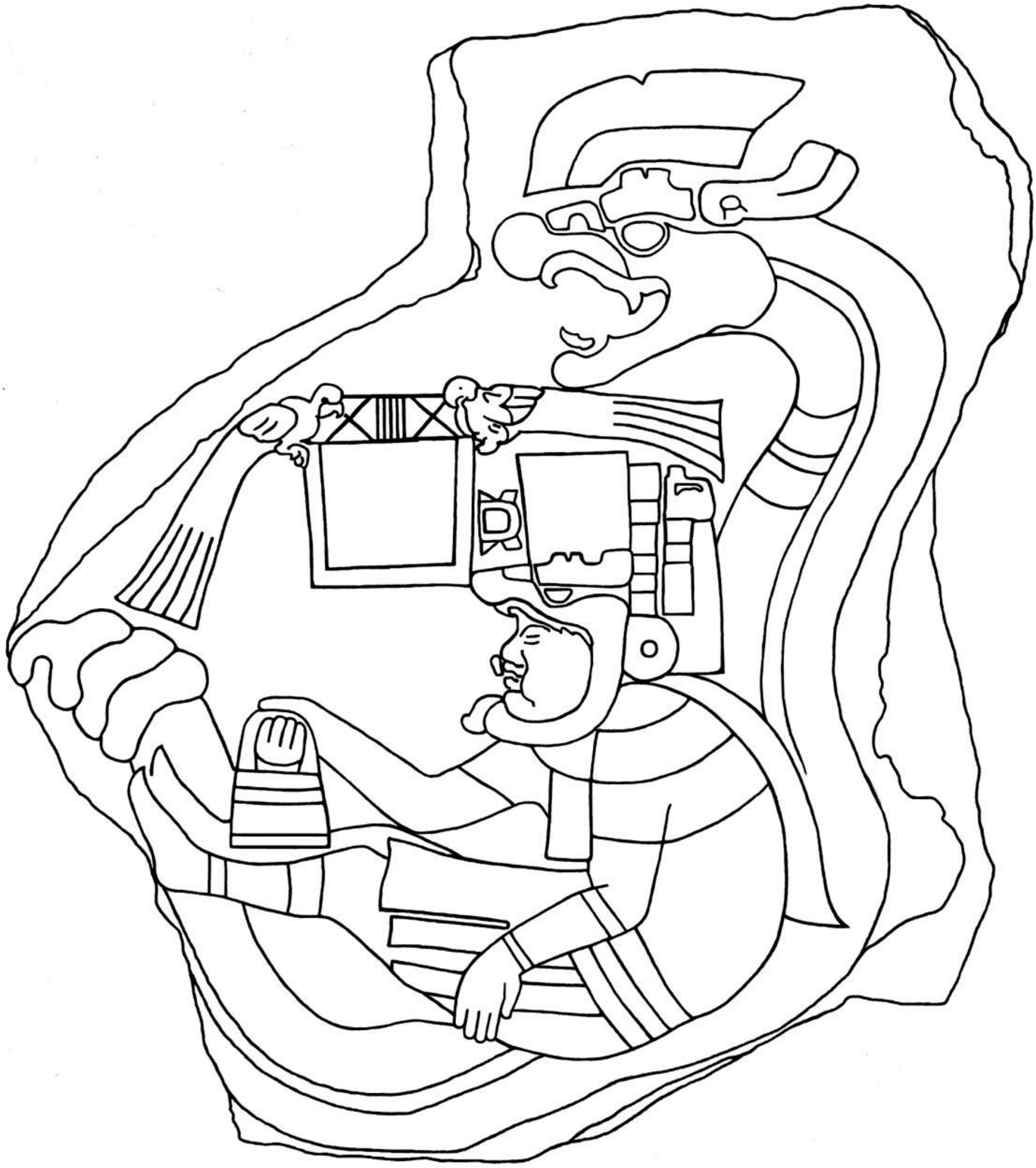

FIG 5. LA VENTA MONUMENT 19, WHICH DEPICTS AN AMBIGUOUSLY GENDERED FIGURE ENCIRCLED BY A SERPENT. THE FIGURE WEARS ARM BANDS, LEG BANDS, A CAPE COMPOSED OF LAYERED BANDS AND A BELT COMPOSED OF LAYERED BANDS. DRAWING BY BILLIE J. A. FOLLENSBEE

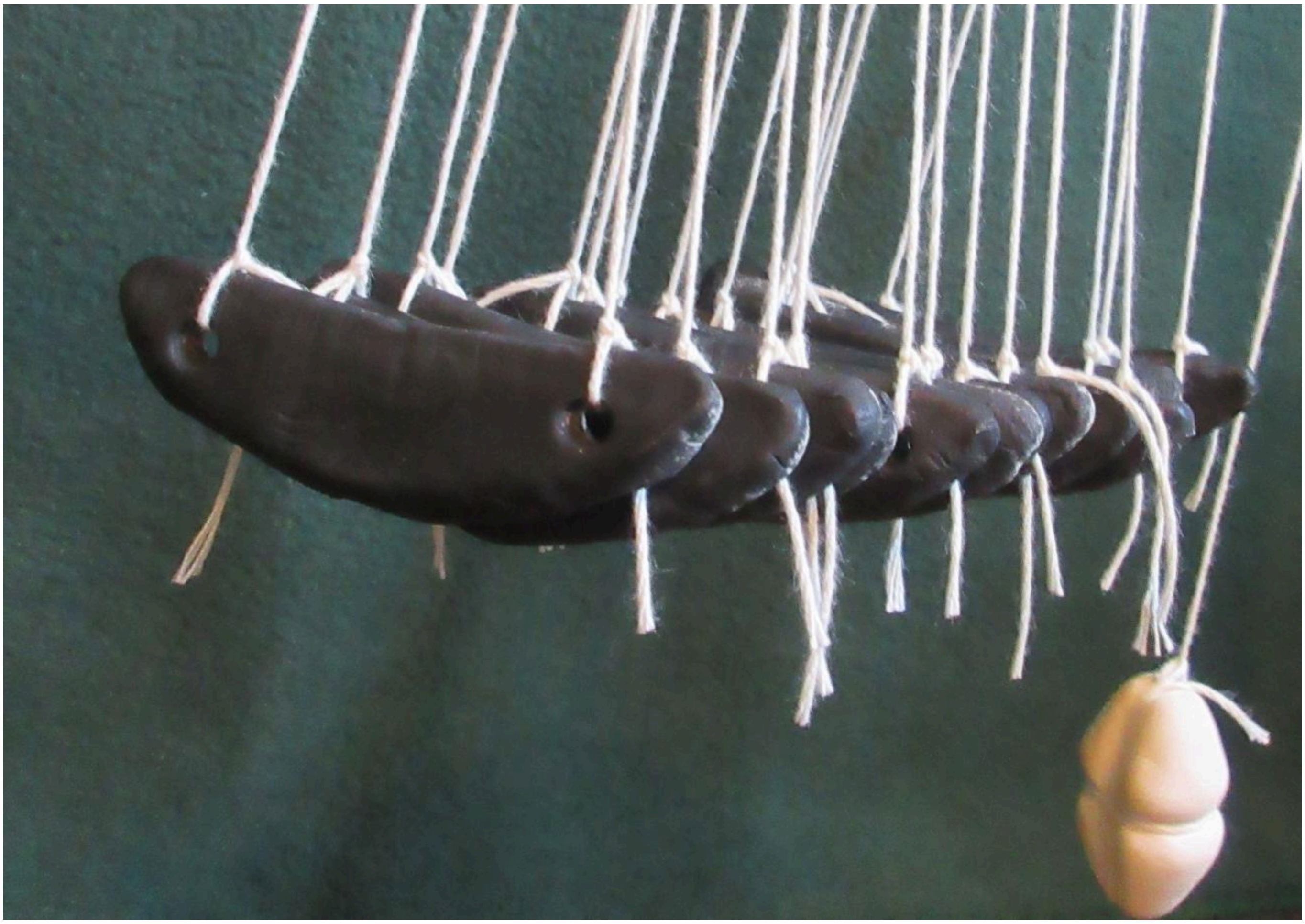

FIG 6. THE THIRTEEN REPLICAS OF THE LUNATE ARTIFACTS USED IN THIS EXPERIMENT. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 7. REPLICAS OF BICONICAL CERAMIC WEIGHTS. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 8. THE WARP-WEIGHTED LOOM CONSTRUCTED FOR THIS EXPERIMENT. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 9. THE WARP-WEIGHTED LOOM, STRUNG WITH COTTON YARN AND WEIGHTED WITH THE 13 LUNATE ARTIFACT REPLICAS AND ONE BICONICAL WEIGHT REPLICA. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 10. THE TABBY WEAVE PRODUCED IN THIS EXPERIMENT. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 11. PLACEMENT OF THE LUNATE WEIGHTS FOR CREATING A ROW OF WEFT-FACED 2/2 TABBY WEAVE. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 12. THE WEFT-FACED 2/2 TABBY WEAVE PRODUCED IN THIS EXPERIMENT. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 13. THE 2/1 TWILL WEAVE PRODUCED IN THIS EXPERIMENT. PHOTO BY BILLIE J. A. FOLLENSBEE

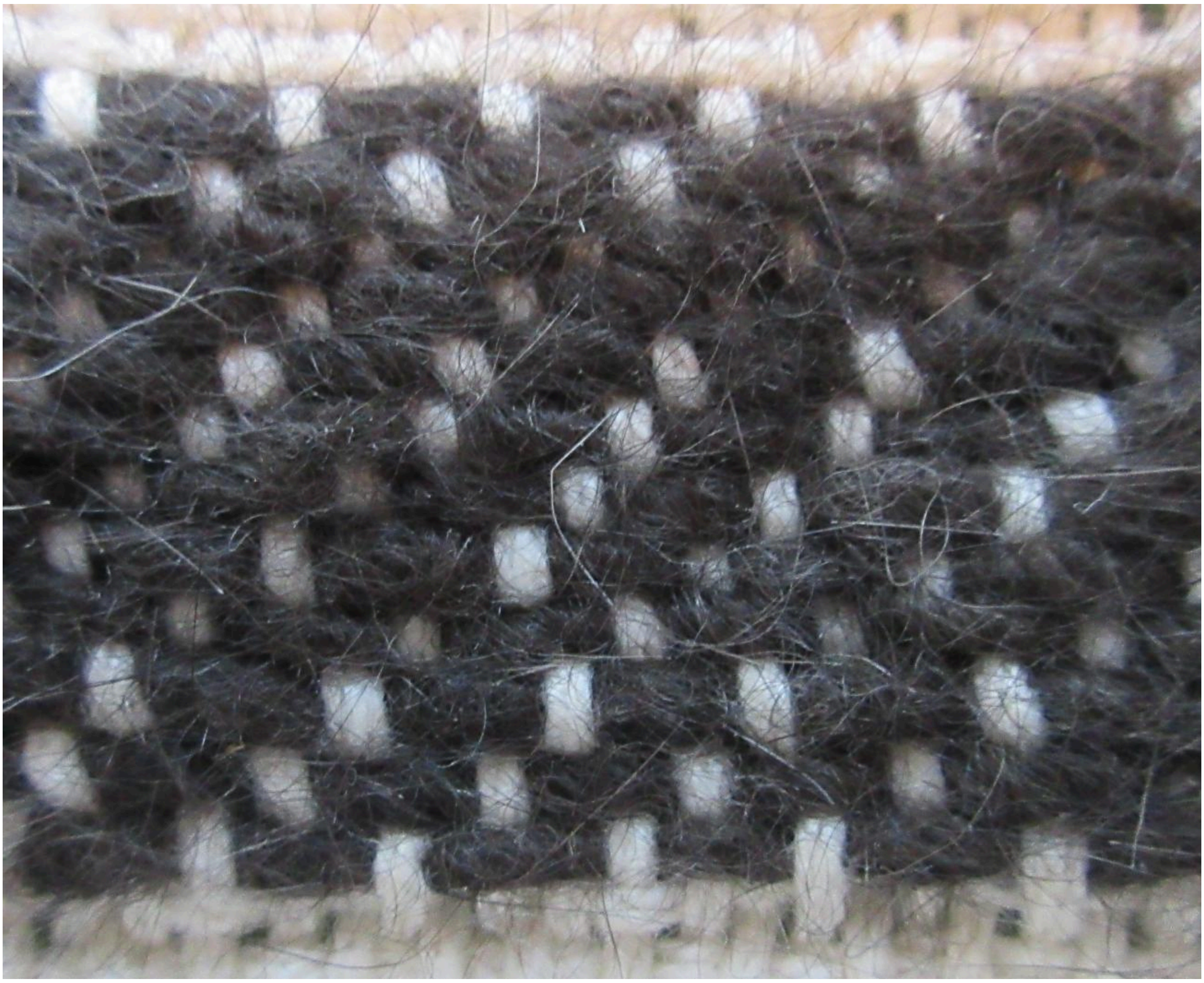

FIG 14. THE 3/1 TWILL WEAVE PRODUCED IN THIS EXPERIMENT. PHOTO BY BILLIE J. A. FOLLENSBEE

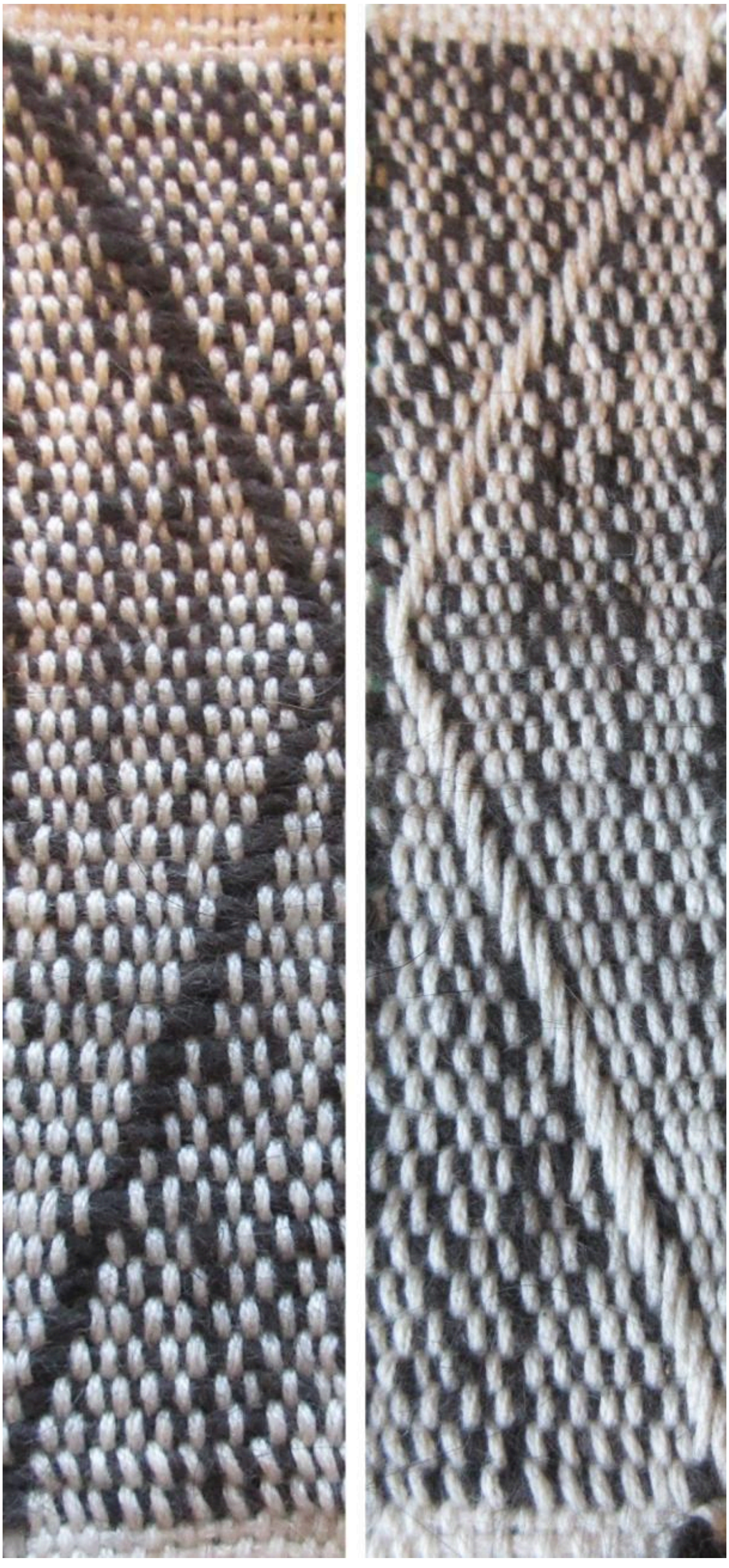

FIG 15. THE TABBY WEAVE EMBELLISHED WITH A SINGLE CHEVRON COMPOSED OF A 3/1 WEFT FLOAT TWILL WEAVE, WHICH WAS PRODUCED IN THIS EXPERIMENT: FIG 15A. FRONT, WEFT-FACED CHEVRON; FIG 15B. BACK, WARP-FACED CHEVRON. PHOTO BY BILLIE J. A. FOLLENSBEE

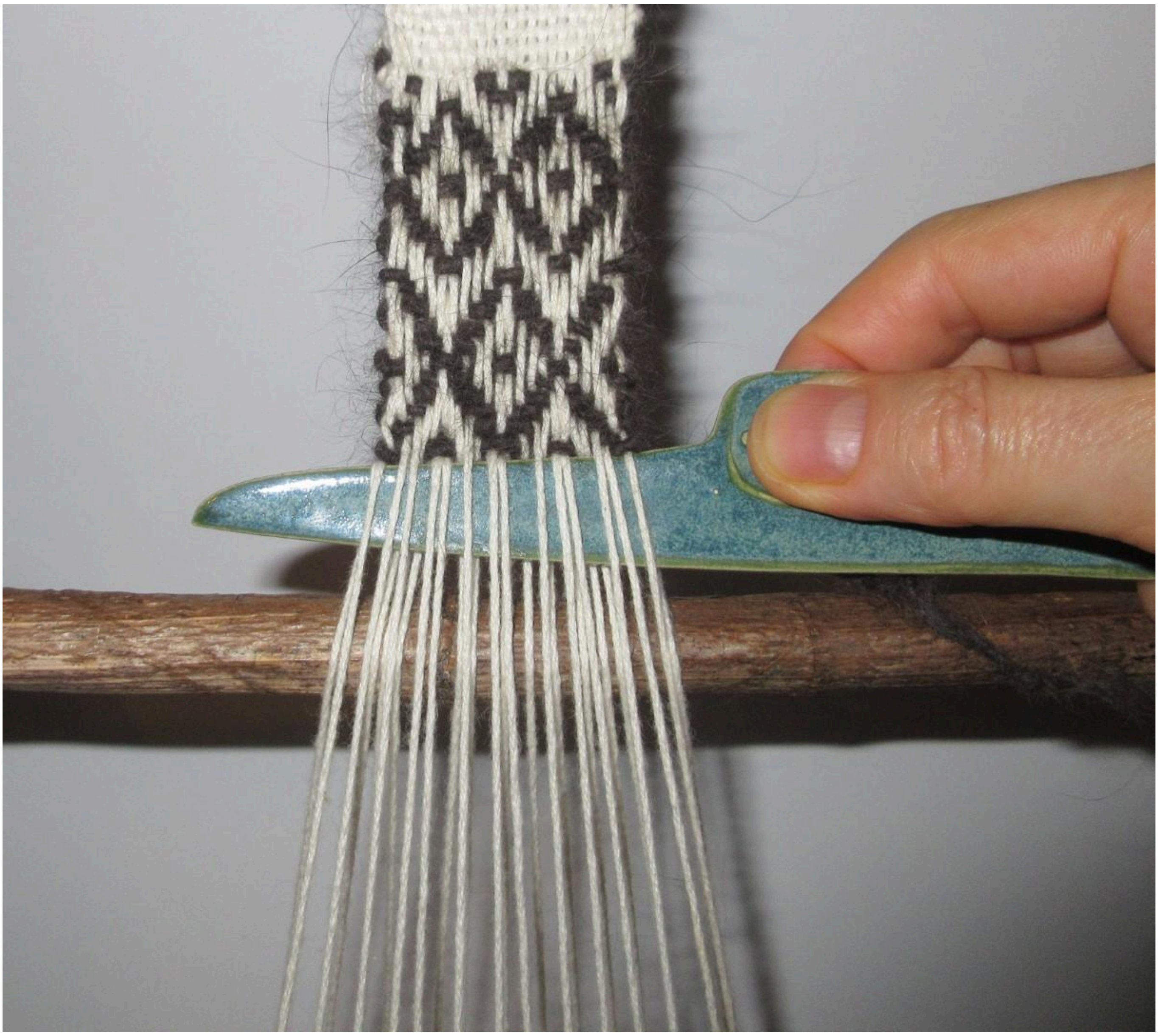

FIG 16. THE DIAMOND-AND-DOT TWILL WEAVE PRODUCED IN THIS EXPERIMENT. THE DIAMOND-AND-DOT TWILL WEAVE PRODUCED IN THIS EXPERIMENT

FIG 17. THE BASKET WEAVE PRODUCED IN THIS EXPERIMENT. PHOTO BY BILLIE J. A. FOLLENSBEE