Textile production in Quartier Mu

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ÉTUDES CRÉTOISES 34

Fouilles exécutées à Malia

LE QUARTIER MU V

Vie quotidienne et techniques au Minoen Moyen II

par Jean-Claude POURSAT

avec des contributions de Tristan CARTER, Élise MORERO, Hara PROCOPIOU, Eva ANDERSSON STRAND, Joanne CUTLER, Marie-Louise NOSCH, Daniel HELMER, Abel PRIEUR, Emmanuelle VILA

ÉCOLE FRANÇAISE D'ATHÈNES

INTRODUCTION

Ce cinquième volume de la publication des fouilles du Quartier Mu[1] présente les séries d'objets non encore publiées dans les volumes précédents. Il s'agit à la fois d'outils (outils lithiques ou poids de tissage) découverts dans la couche de destruction finale des différents bâtiments de ce quartier (Minoen Moyen II), d'objets de terre cuite de la vie quotidienne (lampes, porte-brochettes, brûle-parfum), et de vestiges archéo-zoologiques. Ce volume permet ainsi d'examiner des aspects de la « vie de tous les jours », éclairage, nourriture, tissage, que F. Chapouthier avait le premier abordés (CHAPOUTHIER 1941) et de décrire des techniques artisanales différentes des activités spécialisées déjà étudiées dans *Mu* III.

État des recherches

En dehors de l'étude de Chapouthier, qui traite seulement de quelques-uns des objets énigmatiques qui seront présentés ici, la documentation recueillie dans les fouilles antérieures de Malia a été en partie rassemblée par Henri Van Effenterre dans sa synthèse intitulée *Le palais de Mallia et la cité minoenne* (VAN EFFENTERRE 1980). Cependant, faute de données suffisantes, et d'une manière générale de renseignements précis sur les contextes, les suggestions et les hypothèses de cet ouvrage n'ont pu conduire qu'à un tableau imprécis.

Au Quartier Mu, la fonction des différents secteurs et bâtiments est connue désormais au moins dans ses grandes lignes : des bâtiments à activité « administrative » (A et B), des annexes-entrepôts (D et E), des maisons d'artisans (Atelier de Sceaux, de Potier, de Fondeur, Atelier Sud, Bâtiment C), une maison ordinaire de fonction indéterminée (Bâtiment F). Rappelons que les différents bâtiments du Quartier Mu ont été détruits simultanément, à la fin de la période protopalatiale, dans une catastrophe accompagnée d'un violent incendie[2], et que les conditions de préservation du matériel archéologique y ont été exceptionnellement favorables. Le matériel, chronologiquement homogène, peut ainsi être replacé, le plus souvent, dans un contexte précis d'utilisation.

Les volumes précédents de la publication du Quartier Mu ont surtout présenté d'une part des séries de matériel caractéristiques de « l'élite » dirigeante de ce quartier (les documents inscrits en hiéroglyphique crétois ; les sceaux et empreintes de sceaux ; les objets de prestige comme le poignard en or ou des productions céramiques sophistiquées), d'autre part les témoignages de l'activité d'artisans, potier, graveur de sceaux, métallurgistes, dont l'essentiel de la production était destinée à cette élite.

Le volume consacré à la céramique (*Mu* IV) a constitué une introduction à certains aspects de la vie quotidienne. Il a permis de définir certaines fonctions (stockage, zones de préparation et de consommation des repas), à la fois dans les maisons ordinaires d'artisans et dans les grands bâtiments A et B ; il a permis aussi de constater certaines particularités maliotes dans les types de la vaisselle ordinaire. Mais bien des aspects de la vie de tous les jours et des activités domestiques restent à préciser. Quels étaient les outils des multiples occupations quotidiennes ? Comment les habitants de ce quartier s'éclairaient-ils, se chauffaient-ils, s'habillaient-ils ? Quelle était leur nourriture ? Comment vivait-on à Malia, et au Quartier Mu en particulier, vers la fin de l'époque protopalatiale ?

(1) Voir *Mu* I, *Mu* II, *Mu* III, *Mu* IV.

(2) Sur les circonstances de la destruction, voir *Mu* I, p. 20-21.

Le matériel étudié

Les objets présentés ici ont été trouvés dans la couche de destruction de la fin du MM II. Ils font partie de séries nombreuses, et sont dans quelques cas les plus anciens exemples connus d'ustensiles mieux attestés à l'époque néopalatiale. Les outils lithiques sont particulièrement abondants. Ces outils simples, qui peuvent convenir aussi bien pour des artisans spécialisés, sont présents dans tous les bâtiments du Quartier Mu ; ils constituent la plus grande partie de la « boîte à outils » indispensable aux activités quotidiennes. Les lames d'obsidienne peuvent servir à la fabrication des sceaux en stéatite, mais aussi au travail de la pierre comme aux soins corporels. Meules à moudre et molettes sont d'usage quotidien ; percuteurs, polissoirs, sont multi-fonctionnels. Les poids de tissage sont eux aussi présents dans chaque bâtiment ; si leur nombre (plusieurs centaines) implique une activité qui déborde probablement le cadre domestique, ils témoignent d'un savoir-faire partagé par les différentes familles du Quartier Mu.

Plusieurs catégories d'objets en terre cuite restent encore d'usage indéterminé. Si lampes et braseros étaient évidemment utilisés pour l'éclairage et le chauffage, la diversité de leurs types, comme l'inégalité de leur répartition à l'intérieur des bâtiments du Quartier Mu, indiquent que les conditions de leur utilisation restent à définir. Quant aux autres objets de fonction incertaine (« boîtes à feu », « porte-brochettes », « vases à trous »), désignés dans la littérature archéologique sous des noms divers qui montrent l'embarras à définir leur usage, leur présence en nombre relativement important, leur association à d'autres types d'objets, peuvent aider à préciser les circonstances de leur utilisation dans les activités du Quartier Mu.

Enfin, les études des vestiges archéozoologiques découverts au cours des différentes campagnes de fouille peuvent révéler non seulement une partie des habitudes alimentaires des occupants de ce quartier, mais aussi, plus largement, leur mode d'exploitation de l'environnement. En arrière-plan, c'est toute une partie de l'organisation maliote, pour l'acquisition des matières premières, la gestion du domaine agricole, la répartition des tâches de la communauté, qui peut apparaître grâce à l'étude de tous ces objets.

Remerciements

Je remercie très vivement tous les chercheurs qui ont bien voulu se consacrer à l'étude du matériel du Quartier Mu et apporter leur contribution à cet ouvrage, ainsi que C. Knappett qui a identifié les pâtes et techniques de fabrication de tous les objets en terre cuite ; le Centre for Textile Research dirigé par M.-L. Nosch, qui a permis la réalisation de l'étude sur la production textile ; l'Institute for Aegean Prehistory (Philadelphie et Pachyammos) qui a apporté son aide matérielle et scientifique. Ma gratitude va à ceux qui ont participé à la réalisation de cette publication : l'École française d'Athènes, ses photographes (É. Séraf, Ph. Collet), ses dessinateurs (I. Athanassiadi, N. Sigalas), son architecte M. Schmid ; B. Detournay, qui a tenu depuis 1969 le registre des pesons et de tous les « petits objets » qui font la plus grande part de cette publication ; ma femme, qui a assumé, comme pour le volume précédent, la préparation de l'illustration.

Jean-Claude Poursat
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CHAPITRE 5

TEXTILE PRODUCTION IN QUARTIER MU

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INTRODUCTION: FROM TOOLS TO TEXTILES

The most common archaeological evidence for weaving in the Aegean is the presence of loom weights, which indicate the use of the warp-weighted loom (**pl. 5.1 a**).

A wide variety of loom weight shapes have been recorded. In the past, this diversity has generally been explained in terms of cultural, geographical and chronological factors. In contrast, recent research has considered some aspects of shape as an expression of loom weight function. This new approach, which draws on experimental archaeology, has made it possible to render textile craft visible, even if the textiles themselves are not preserved (MÅRTENSSON, NOSCH et ANDERSSON STRAND 2009). It is this approach that has been adopted in the following analysis of the loom weights from Quartier Mu.

This chapter is divided into four parts. The first part gives an outline of general textile techniques and presents the methodology. The second part consists of an overview of the Quartier Mu loom weights, while the third part focuses on their contexts. The results of the analysis are discussed in the fourth and final part.

WEAVING AND WEAVING TECHNIQUES

A fabric is the result of weaving two thread systems, which cross each other at right angles. One of the systems, the warp, runs parallel to the side of the loom and is kept stretched during weaving. On a warp-weighted loom the vertically hanging warp threads are kept taut by the weight of the attached loom weights. The other system, the weft, runs alternately over and under the warp threads (**pl. 5.1 b**).

The warp-weighted loom can operate in a number of ways, depending on the type of weaving technique used. Tabby is considered to be the most common technique used in the Aegean during the Bronze Age. However, finds of Bronze Age textiles are extremely rare in the Mediterranean region generally, and this conclusion is based on only a handful of preserved textile fragments, which means that the existence of other weaving techniques therefore cannot be discounted (BARBER 1991; MOULHERAT et SPANTIDAKI 2012; ANDERSSON STRAND et NOSCH [à paraître]).

In a tabby weave the weft runs under one warp thread, over one warp thread, under one, over one, and so on. In order to weave a tabby on a warp-weighted loom, two rows of loom weights are generally used. In this case, the first warp thread would be fastened to a loom weight in the front layer, the next would be tied to a loom weight in the back layer, and so on, with a certain number of threads being attached to each individual loom weight (**pl. 5.1 a**). It is also possible to weave a tabby with the two layers of warp threads attached to just a single row of loom weights, although this alternative method appears to be less common and has to date received little attention.

(1) With the collaboration of R. Firth, J.-Cl. Poursat, and Fr. Rougemont.

Another technique is twill weaving (**pl. 5.1 c-d**). This entails the use of more than two layers of warp threads, in order to create different sheds, one behind the other. There are many variations of twill; for example, in a 2/2 twill the weft runs over two warp threads, under two warp threads, over two, under two, and so on. In this technique, there are four layers of warp threads (as opposed to the two layers/sheds needed for a tabby weave). The first four warp threads each lie in a different warp layer, and this pattern is repeated for every following set of four warp threads. The four layers are usually attached to four rows of loom weights (**pl. V.1 a-b**). It is also possible to use only two rows of weights, with the loom weights in each row having two layers of warp threads fastened to them. Experimental work has demonstrated that it is preferable to weave a 2/2 twill with four rows of loom weights (Batzer et Dokkedal 1992), but the alternative method of using just two rows of loom weights is attested in Icelandic ethnographic sources (Hoffmann 1964).

An alternative twill technique is 2/1 twill, in which the weft thread passes over two warp threads and under one, over two and under one, and so on (**pl. 5.1 d**). In this technique there are three layers, or sheds, of warp threads, with the first three warp threads each lying in a different layer. The different layers are attached to three (or, less commonly, two) rows of loom weights. Other weaving techniques with non-continuous patterns include brocade, tapestry and pile.

A fabric can be balanced with an equal number of weft and warp threads per square centimetre (cm), or the number of warp and weft threads may differ. The weave can be open, with a few threads per cm, or dense, with the threads packed closely together. Different types of yarn may also be used in the warp and in the weft respectively. The thread count refers to the number of warp and weft threads per square cm and is often used when describing an archaeological textile.

Various types of yarn can be used to produce different types of fabrics. The yarn can be spun from either plant or animal fibres and can be spun in a range of thicknesses, from very thin to very thick, depending on what type of fabric is required. The difference in thin and thick yarn can broadly be expressed in terms of the diameter of the thread. A thin yarn has a small thread diameter, while a thicker yarn has a larger thread diameter; in general, a yarn with a larger thread diameter contains more fibres than a yarn with a smaller diameter. Even a small difference in thread diameter, sometimes not even visible to the eye, will affect the final product, the fabric (**pl. 5.1 e-f**).

To summarise, it is possible to weave a wide variety of textiles on a loom. These can range from:

- textiles made using very thin threads, to textiles made using very thick threads;
- textiles that are open, with a relatively low number of threads per cm, to textiles where the threads are densely packed;
- textiles that are balanced, with an equal number of warp and weft threads per square cm, to textiles that are unbalanced, where the number of warp and weft threads are not the same. For example, a fabric may be weft faced (with a greater number of weft threads than warp threads), or alternatively, it may be warp faced (with a greater number of warp threads than weft threads);
- tabby textiles made on a loom generally set up using two rows of loom weights, to twills using between two and four rows of loom weights.

Before weaving

Several different processes are involved in the procurement and preparation of the thread to be used on the loom, before weaving can commence.

If the chosen fibre is flax, the flax has to be cultivated. When it is ripe, it is pulled up, rippled (to remove the seeds) and retted. To ret the flax, the stems can either be placed in water or spread on the ground. The moisture assists in the process of dissolving the pectin between the bundles of fibres in the bark and the stem. The next step is breaking, when a wooden club is used to break up the stem and the bark, which have to be separated from the fibres. After breaking, the flax has to be scutched with a broad wooden knife, which scrapes away the last remains of stem and bark. Finally, the fibres are hackled or combed.

If the choice is sheep wool, the wool has to be plucked or sheared and then sorted and washed. The wool fibres can either be teased in order to draw the fibres parallel with each other (which makes the spinning easier), or combed in order to separate the long hairs from the shorter under wool.

After the fibres have been prepared, they are twisted by hand into a short thread which is attached to the rod of a spindle. When spinning, the spindle can either hang freely – a so-called suspended spindle – or may be supported. The rod is rotated while the spinner simultaneously draws out the fibres, and it is the twisting of the fibres around their own axis that forms the thread. When spinning on a suspended spindle, a spindle whorl is often added to the spindle rod, but it is also possible to spin the thread on a rod alone. The raw material to be spun is frequently held on a distaff, so that the prepared fibres are not mixed up again. When a certain length of thread has been spun, it is wound up on the spindle and spinning then recommences. This process is repeated until the spindle rod has been filled with thread. The spun yarn is then wound onto a reel. After a couple of days, when the yarn is set, it is wound onto a stick or something similar, or is made into a ball of yarn; it is now ready to be used on the loom. The next stage is to prepare a starting border, warp the loom, fasten the loom weights to the warp threads, and attach the warp threads to the heddle rod(s) in order to create different sheds. Finally, one can start to weave.

In addition to the warp-weighted loom, other forms of loom were also used in the wider Mediterranean region during the Bronze Age: principally, the vertical two-beam loom and the horizontal ground loom. Since these loom types do not require loom weights, and since the looms themselves are rarely preserved, the additional use of alternative types of loom in the Aegean cannot be excluded. The advantage of the warp-weighted loom compared to the vertical two-beam loom is that it is possible to weave much longer fabrics (up to 12 metres, according to Icelandic sources; see GEIJER 1965).[2] It is also easier to weave denser twills on the warp-weighted loom than on either of the other two types of looms. This is because in a 2/2 twill woven on a warp-weighted loom there are four separate layers of warp threads that lie one behind the other, while on a vertical two-beam and a horizontal ground loom all the warp threads lie side by side in one layer. Finally, one can weave wider fabrics on a warp-weighted and a two-beam loom compared to the horizontal ground loom (BARBER 1991).

METHODOLOGY: THE FUNCTION OF A LOOM WEIGHT

In order to calculate a possible loom setup and the type of fabric that a particular loom weight may have been used to produce, it is first necessary to define the various possibilities and limitations. This has been achieved by combining the mathematics of weaving with weaving tests and weavers' experience, thereby making it possible to describe the range of textiles that can be produced using a particular loom weight (MÅRTENSSON, NOSCH et ANDERSSON STRAND 2009; FRANGIPANE *et al.* 2009; ANDERSSON STRAND et NOSCH [à paraître]).

Different types of yarn need different amounts of tension when they are used in the warp on a loom. On the warp-weighted loom, the tension is provided by the attached loom weights. It is partly the thickness of the thread that determines the appropriate warp tension, but the amount of tension required is also affected by how hard the thread is spun, the fibre quality, and the degree of fibre preparation. If too much tension is applied, the thread will break, whereas if the tension is not sufficient, the thread will not be held taut enough which will affect the weaving process, since it will be more difficult and time consuming to change the shed. In order to be strong enough to be able to support the tension provided by the loom weights, the warp yarn is generally hard spun; the weft yarn can be more loosely spun. The following thread measurements were obtained during experimental work (ANDERSSON *et al.* 2008; ANDERSSON STRAND et NOSCH [à paraître]):

- spinning with a 4 g spindle whorl yielded a very thin thread with an average thread diameter of ca. 0.29 mm. This thread required ca. 13 g warp tension per thread;
- spinning with an 8 g spindle whorl yielded a thin thread with an average thread diameter of ca. 0.37 mm. This thread required ca. 18 g warp tension per thread;
- spinning with an 18 g spindle whorl yielded a thread with an average thread diameter of ca. 0.46 mm. This thread required 25-30 g warp tension per thread;
- spinning with a 44 g spindle whorl yielded a thick thread with an average thread diameter of ca. 0.9 mm. This thread required 40-50 g warp tension per thread.[3]

Since different types of yarn need different tensions, this limits how many warp threads can be attached to an individual loom weight. If the yarn needs 20 g tension per warp thread, and the loom weight weighs 500 g, the weaver can attach 25 warp threads to the weight. If, however, the weaver uses yarn that requires 50 g tension, only 10 warp threads can be attached to the same loom weight. Experiments have demonstrated

(2) The length of the warp on a vertical two-beam loom is in general limited to the size of the loom, since the warp threads are stretched by being attached to the loom itself (GEIJER 1994).

(3) It should be noted that it is very rare that a yarn is evenly spun and even a machine spun yarn can vary in thickness; for example, 0.2-0.4 mm.

that attaching very few or very many warp threads to a single loom weight is not advantageous. During the setup of the loom the warp threads are wound up in groups, each group representing a loom weight. If, for example, one has groups of only five threads, it is necessary to wind up the warp threads several more times than if one had groups of, for example, 20 threads. Weavers generally consider that ≥10 warp threads and ≤ 30 warp threads on one loom weight is practical. More than 30 warp threads will create problems during the setup and weaving and will make it difficult to distribute the warp threads evenly, thereby having a negative effect on the final product. Attaching less than 10 threads per loom weight requires a larger number of loom weights and the setup will take longer. In calculating how suitable a given loom weight is for use with threads requiring different tensions, 10 has therefore been judged to be the lower limit for the number of threads that can be fastened to a single loom weight, and 30 has been set as the upper limit.

The weight of a loom weight therefore dictates how many threads of a given type can be fastened to it. Another key parameter, however, is the thickness of the loom weight. Weaving experiments have demonstrated that the width of the finished cloth is determined by both the width of the starting border and the total width of the loom weights in each row. If these widths differ, the width of the fabric will vary and/or the weaving process will become unnecessarily complicated (MÅRTENSSON, NOSCH et ANDERSSON STRAND 2009).

The thickness of the loom weights, in combination with the number of warp threads attached to an individual weight and the number of rows of loom weights used, also governs the thread count per cm of the finished textile:

$$\text{maximum number of warp threads per cm} = \frac{\text{the number of warp threads per loom weight} \times \text{the number of rows}}{\text{the thickness of the loom weight in cm}}$$

Thus, both the weight and the thickness of a loom weight govern the suitability of its use in the manufacture of different types of cloth. For example, heavy, thick loom weights would be optimal for the production of a coarse open fabric using thick yarn; in contrast, heavy, thin loom weights would be suited to the manufacture of a coarse dense fabric of thick yarn. On the other hand, if an open fabric of fine yarn were required, light, thick loom weights would be desirable. Finally, light, thin loom weights would be preferable when weaving a dense fabric using fine yarn, with many threads per cm (MÅRTENSSON, NOSCH et ANDERSSON STRAND 2009; ANDERSSON STRAND et NOSCH [à paraître]).

In analysing the suitability of a given loom weight for use with threads requiring different tensions, three threads per cm for both tabby and twill (2/1 and 2/2) has been suggested as the lowest practical number of warp threads per cm.

It is also important to consider the number of loom weights needed in a loom setup. Since no complete textiles are preserved, there is no information regarding the width of the fabrics, but it should be noted that the width of the cloth affects the number of loom weights needed for the setup, and that this number will furthermore vary depending on the thickness of the loom weights used. If the fabric was a metre wide, one would have needed 50-200 2 cm thick loom weights depending on the technique and the number of rows of loom weights. On the other hand, if the loom weights were 6 cm thick one would have needed only 17-68 loom weights. This factor may have influenced the choice of loom weights used in the production of particular types of textile. For optimal performance of the warp-weighted loom, the loom weights in a set should be similar.

AN OVERVIEW OF LOOM WEIGHTS AND WEAVING IN QUARTIER MU

WEIGHT TYPES

It is notable that a number of different loom weight types are present at the site (*supra*, chap. 4); the most common shapes are spherical, discoid and pyramidal truncated, but biconical, conical, cube, cylindrical, rectangular and torus types are also in evidence (**fig. 5.1**). Four unpierced spool-shaped loom weights, found on the surface, are likely to date to the Late Bronze Age Third Palace period. The majority of the loom weights are made of clay: 21 of the torus weights and one of the discoid weights are made of stone. A further 134 naturally pierced pebbles (132 from MM II contexts, the remaining two from unknown contexts) and a number of unpierced stone objects are also likely to have functioned as loom weights.

Loom weight type	MM IB	MM I-II	MM II	LM III	Unknown	Total
spherical			267		25	292
spherical lenticular			15		1	16
discoid rounded	1		102	1	21	125
discoid elliptical			4			4
pyramidal truncated	1		37		30	68
biconical			1			1
conical			1		1	2
conical truncated					1	1
cube			5		1	6
cylindrical short		1	15		2	18
cylindrical standard		1	23		3	27
rectangular, flat			6		4	10
rectangular, thick	1		5		5	11
torus			17		8	25
torus (small hole diam)			25		2	27
spool					4	4
other			4			4
Total	3	2	527	1	108	641

Fig. 5.1. — All loom weight types, by period.

Nearly all of the loom weights are manufactured from local clays. However, two of the MM II discoid loom weights are made from the same fabric as contemporary ceramic imports from the Mirabello region (Fabric E; see *Mu* IV for a description of this fabric). Two discoid weights of a non-local fabric have similarly been recorded at Mochlos (Soles *et al.* 2004, p. 28-29). Loom weights are unlikely to have been regarded as objects with any intrinsic value, but they would have been of considerable value to the craftsperson who used them; it is therefore probable that they moved around with their users, rather than travelling as imports (Barber 1991, Soles *et al.* 2004).

It was possible to record both the weight and the thickness of 498 of the MM I-II loom weights (that is, loom weights recovered from MM IB, MM I-II and MM II contexts).[4] As demonstrated in **figure 5.2**, the majority of the weights weigh between 50 g and 400 g, with a thickness varying between 1.5 cm and 7.2 cm. Although the weight and thickness of the loom weights cover a wide range, there are clusters around certain weight/thickness combinations; for example, one concentration can be observed to relate to loom weights with a weight between 300 g and 380 g, combined with a thickness of 6.5 cm to 7.2 cm. Two other clusters are visible among the loom weights weighing between 75 g and 150 g: one representing loom weights with a thickness of 1.5 cm to 2.3 cm, and the other loom weights with a thickness of 4 cm to 5.2 cm.

The observable variation in weight and thickness also relates to the loom weight type (**fig. 5.3**). It can be seen that the spherical weights form one group, with the discoid weights (discoid rounded and discoid elliptical) and torus weights (torus and torus with small hole diameter) forming separate groups. The cylindrical (cylindrical short and cylindrical standard) and pyramidal truncated types form intermediate groups. The separation, particularly with regard to the spherical and discoid types, is largely a result of the geometry of

(4) In the measurement of thickness, it is assumed that the spherical and cylindrical loom weights would have hung with the hole lying horizontally (as indicated by string wear). It is further assumed that the discoid weights would have hung at right angles to the shed bar; if they had hung lying parallel to the shed bar, with the thickness therefore being equal to the maximum diameter, the loom weights would have moved out of alignment during shed changes and they would have produced a fabric that was extremely open.

Fig. 5.2. — All loom weights from MM I-II contexts: weight/thickness.

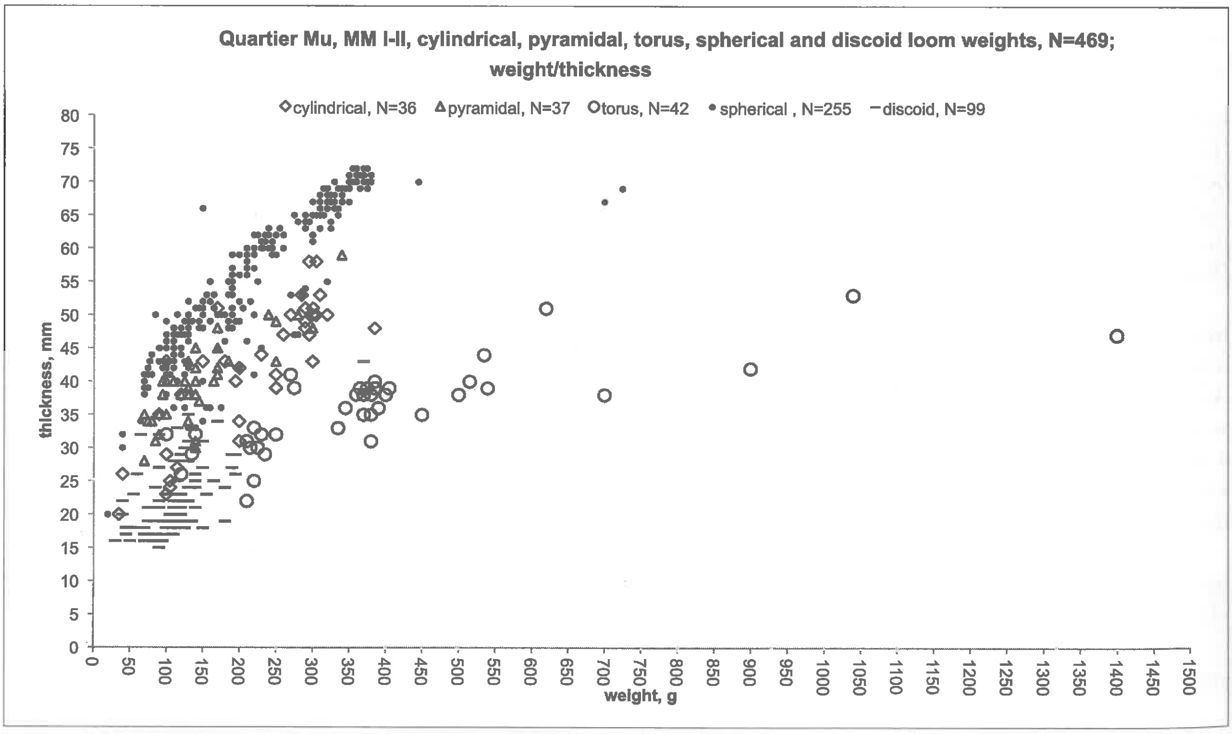


Fig. 5.3. — Main loom weight types: weight/thickness, MM I-II contexts. Cylindrical (cylindrical standard and cylindrical short); pyramidal (pyramidal truncated); torus (torus and torus with small hole diameter); spherical; discoid (discoid rounded and discoid elliptical). Please note that types with less than 20 weights are not included.

the loom weights; i.e. for a given material density and loom weight thickness, a spherical loom weight is less heavy than a discoid loom weight.

The weight and thickness of 129 of the pebbles recovered from Quartier Mu were also recorded. The majority of the pebbles have weights between 100 g and 250 g, with a thickness varying between 3 cm and 6 cm. When comparing the pebbles to the loom weights it is clear that the pebbles could also have functioned as loom weights. Furthermore, for the most part, the pebbles have properties that are intermediate between the spherical and discoid loom weights (**fig. 5.4**).

The weights of the loom weights naturally influence the range of textiles that can be manufactured. **Pl. V.1 c** shows that, based solely on their weight, some of the Quartier Mu loom weight types are more suitable than others for use with warp threads that require a particular tension. For example, the discoid loom weights are associated with the production of fine textiles made with threads that need warp tensions of 5-15 g. In contrast, the spherical loom weights could have been used to produce textiles made with a wider range of thread types.

Through an analysis of the warp thread count per cm that could have been obtained in different types of weave when using a loom weight of a given weight and thickness with thread requiring a particular tension, it has become clear that most of the main loom weight types could have been used for any of the weaving techniques considered: tabby with one or two rows of loom weights, 2/1 twill with three rows of loom weights and 2/2 twill with two or four rows of loom weights.

However, in this study it is assumed that weaving at Quartier Mu was well planned and that the preparation of weaving as well as the selection of equipment was done with knowledge and care. It is also assumed that the weavers were experienced and knew what decisions should be taken in order to facilitate an optimal production of textiles and to achieve a desired result. Therefore, we have chosen to compare the differences between two row tabby and a four row 2/2 twill since we consider these loom setups to be the setups that would have been deemed optimal by the weavers. Furthermore, since the discoid and the spherical weights constitute the two largest categories of loom weights from Quartier Mu, the analysis compares the differences between these two types. This analysis includes 237 spherical and 78 discoid loom weights (representing the loom weights found in secure MM I-II contexts within the excavated buildings).

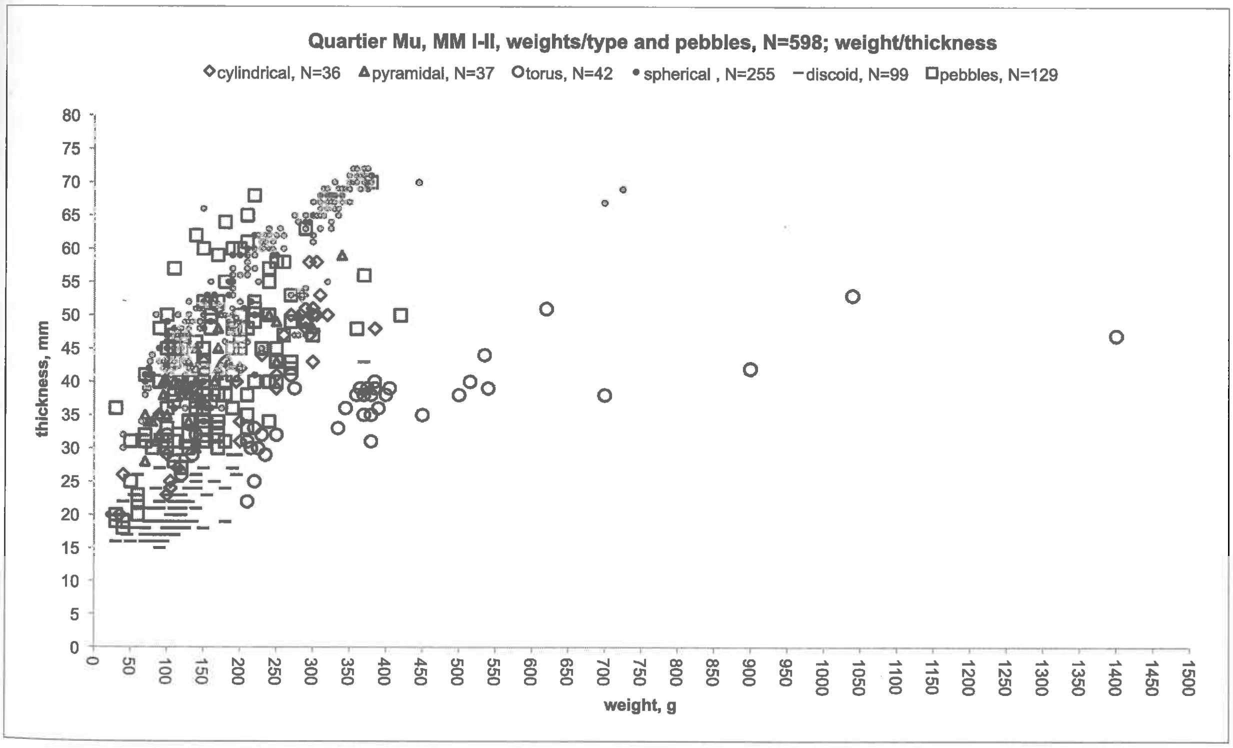


Fig. 5.4. — Main loom weight types and pebbles: weight/thickness, MM I-II contexts.

Pl. V.2-V.3 demonstrate that the discoid loom weights would have been suitable for producing dense fabrics while a tabby fabric produced using the spherical loom weights would be more open and/or weft faced. The discoid loom weights are better suited for use with thinner warp threads that need less tension, while the spherical loom weights are more suitable for use with thicker warp threads that need more tension. It would be possible to use the discoid loom weights with warp threads needing between 5 g and 35 g tension, but the distribution demonstrates the majority are best suited for use with very thin threads needing 5 g to 10 g tension, 87% and 72% respectively (**pl. V.2 a** and **V.3 a**). This suggests that the discoid loom weights would have been suitable for making a range of fabrics with very thin threads. The analysis also shows that the majority of the discoid loom weights could have been used for producing tabbies with 21-24 warp threads per cm, if using thread needing 5 g tension; if using thread requiring 10 g tension, the fabric would have 10-13 warp threads per cm (**pl. V.2 a**; NB all warp thread counts are approximate). If weavers in Quartier Mu instead wanted to produce a 2/2 twill, the majority of the discoid loom weights, used with thread needing 5 g or 10 g tension, would have produced a fabric with 42-47 or 22-24 warp threads per cm respectively (**pl. V.3 a**).

It would also be possible to use the spherical loom weights with threads needing a tension between 5 g and 35 g, but only 29% are suitable for thread needing 5 g tension, while the majority are best suited for use with thread needing 10 g to 20 g tension (61%, 74% and 61% respectively) (**pl. V.2 b** and **V.3 b**). However, it should be noted that a tabby weave using thread needing 5 g tension would be extremely open.

It should additionally be noted that the difference in thickness between the spherical and discoid loom weights has a direct effect on the corresponding loom setups, since for loom weights of the same weight, used with warp threads requiring the same tension, the number of loom weights in each row of loom weights would be substantially lower for spherical loom weights than for discoid loom weights.

Spindle whorls and spinning

Among the MM II textile tools recorded as loom weights there are nine objects that, from their shape (two cylindrical, three spherical and four spherical lenticular), weight and dimensions, are likely to have functioned as spindle whorls. However, it is important to note that only one of these spindle whorls could have been used for producing the thinnest thread likely to have been used in Quartier Mu (corresponding to 5-15 g warp tensions). Very few spindle whorls dating to the First and Second Palace periods have been found on Crete, and when they are present they are only present in very small numbers. While it is possible that during these periods whorls were made out of a perishable material, such as wood, it is also possible that spinning and weaving were not being carried out in the same locations. It is clear that much of the warp yarn used in Quartier Mu was thin or very thin and it would have been necessary to have had access to raw material that was well prepared and of a good quality before spinning. Production of this thread would have been time consuming and would have demanded specialist knowledge.

Conclusion

In conclusion, the results strongly indicate that different types of loom weights were used for producing different types of fabrics; both tabbies and twills and also open, weft-faced and dense fabrics, in general with very thin or thin threads. In the following, we will compare and discuss the loom weights from individual buildings to investigate whether the weavers in Malia produced different types of fabrics in different locations.

LOOM WEIGHTS FROM INDIVIDUAL BUILDINGS

All of the buildings have produced loom weights (**fig. 5.5**). The small units around the eastern periphery of Quartier Mu (the Potter's workshop, the Seal workshop, the Founder's workshop, Building C, Building E, Building F and the South workshop) all contained small numbers of loom weights, while a slightly higher number were recovered from Building B and more substantial numbers were found in Buildings A and D. While some of the loom weights were found in groups, suggesting that they were *in situ* on the ground floor at the time of the destruction of the buildings, the majority were more widely dispersed, and are likely to have fallen from upper storeys. Few of the rooms on the ground floor, basement or semi-basement level had windows, and therefore would have received little light. In contrast, the upper storey rooms, where most of

Loom weight type	Seal workshop	Potter's workshop	Founder's workshop	South workshop	Building A	Building B	Building C	Building D	Building E	Building F	Total
spherical		13	2	2	75	18	11	126	8		255
spherical lenticular	1				3	4	1	1			10
discoid rounded		14	2	3	45	4	4	5	4		81
discoid elliptical					3						3
pyramidal truncated		3	1	1	14	4	7	2		1	33
biconical					1						1
conical		1									1
cube			1		2	1					4
cylindrical short		1	1		6	2		4			14
cylindrical standard					3	4	1	16			24
rectangular, flat					4		1				5
rectangular, thick			1		3					1	5
torus		1		2	4	3		4		1	15
torus (small hole diam)				2	2		17			1	22
other					2			2			4
Total	1	33	8	10	167	40	42	160	12	4	477

Fig. 5.5. — Loom weights from individual buildings, MM I-II contexts.

the living quarters and many of the work areas were located, were almost certainly provided with windows (*Mu* III, p. 79-80) and it is in these rooms that weaving is likely to have taken place, since it would have been possible to take advantage of the natural light. With the exception of five loom weights recovered from earlier deposits within Building A, all of the loom weights from the individual buildings date to MM II.

Building A

A total of 167 loom weights were found within Building A (sectors I-III; **fig. 5.6**). Of these, 162 were recovered from MM II contexts, while three (one discoid rounded, one thick rectangular and one pyramidal truncated) were from an MM IB fill in room III 9 and the remaining two (one cylindrical standard and one cylindrical short) were recovered from an MM I-II pit in room I 17. Building A is the largest complex in Quartier Mu, and contained a number of rooms with ceremonial functions, as well as storage areas and an archival deposit. Most of the loom weights appear to have fallen from an upper floor. Seven loom weights and 11 pierced pebbles recovered from Placette Est are also likely to have fallen from an upper storey of this building. Many of the rooms contained low numbers of loom weights. Significantly larger numbers of weights were found in rooms I 8, I 13, III 1 and III 11. In contrast to the majority of the loom weights from the building, the 30 weights from room I 8 were *in situ*, in what appears to have been a storage magazine. Three of the loom weights recovered from room I 11 were also found *in situ* in a small closet, along with a collection of 65 naturally pierced pebbles that are also likely to have been used on the loom. Two further pierced pebbles additionally come from this building (one from room I 21 and the other from room III 1). The recovery of three loom weights of different types (discoid rounded, thick rectangular and pyramidal truncated) from the MM IB fill in room III 9 indicates that a variety of loom weight shapes were already in use during the earlier period.

It was possible to record the weight and thickness of 143 of the loom weights from MM II contexts within Building A. The two clusters relating to loom weights with a weight of between 75 g and 150 g, visible in the overall MM I-II loom weight assemblage (**fig. 5.2**) are also visible among the loom weights from this building (**fig. 5.7**). Two of the spherical lenticular weights, weighing 20 g and 35 g respectively, would not have functioned well as loom weights, and are more likely to be spindle whorls.

Building A sectors I and II													
Loom weight type	I 2	I 3	I 8	I 11	I 13	I 14	I 15	I 17	I 20	I 21	I 23	II 1	II 3	Total
spherical	1		27		9	4	2		1	2				46
spherical lenticular													1	1
discoid rounded		1		2	4	1				1		2		11
pyramidal truncated		1		1	3									5
cube										1				1
cylindrical short								1			1			2
cylindrical standard			1					1						2
torus			2	1										3
other						1								1
Total	1	2	30	4	16	6	2	2	1	4	1	2	1	72

Building A sector III																	
Loom weight type	III 1	III 3	III 4	III 5	III 6	III 7	III 8	III 9	III 11	III 12	III 13	III 14	III 15	III 16	III 17	Placette Est	Total
spherical	11	2	4	1			3	2	5		1					1	30
spherical lenticular			1						1							3	5
discoid rounded	8	3	2				2	2	6	1	7	1		2		2	36
discoid elliptical			1						1						1		3
pyramidal truncated	1	1			1		2	1			1		1		1		9
biconical														1			1
cube		1															1
cylindrical short	3							1									4
cylindrical standard	1																1
rectangular, flat						1	1							2			4
rectangular, thick		1						1	1								3
torus	1															1	2
torus (small hole diam)							1		1								2
other												1					1
Total	25	8	8	1	1	1	9	7	15	1	9	2	1	5	2	7	102

Fig. 5.6 (i) & (ii). — Loom weights from Building A (sectors I-III), by room.

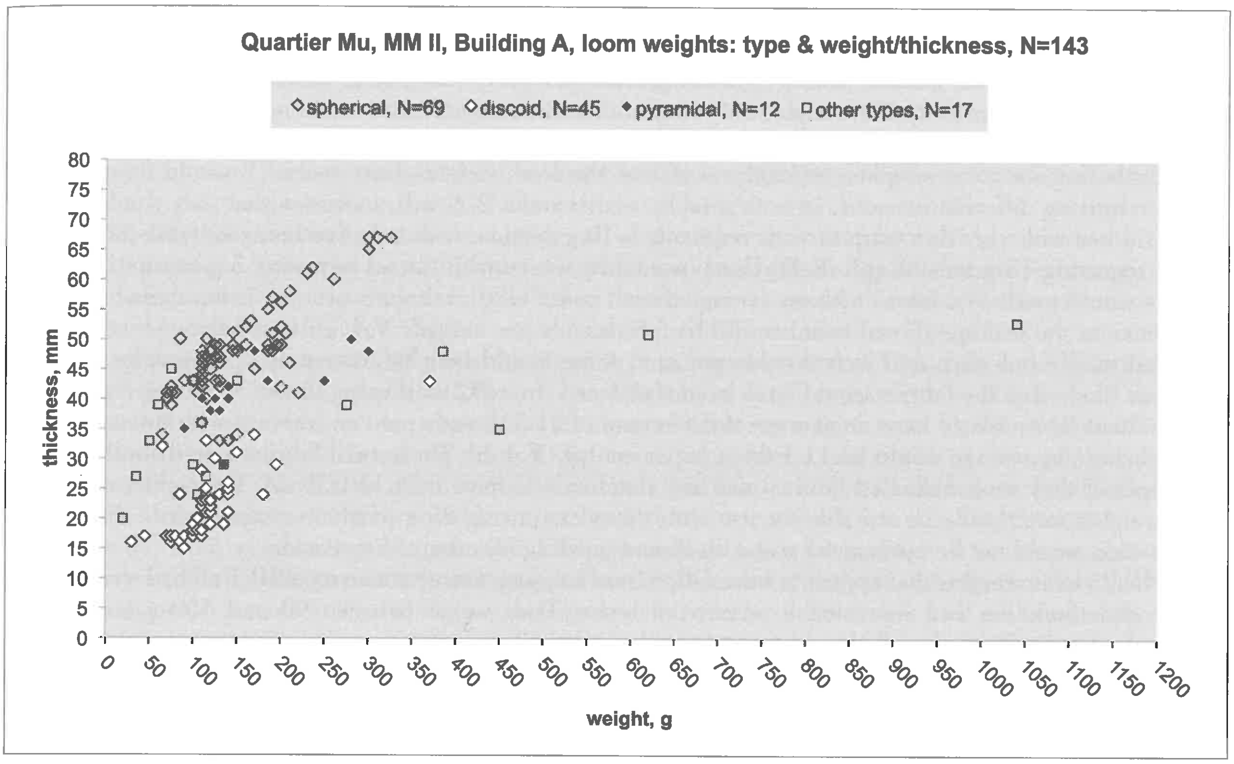


Fig. 5.7. — Building A, MM II, loom weights: type and weight/thickness.

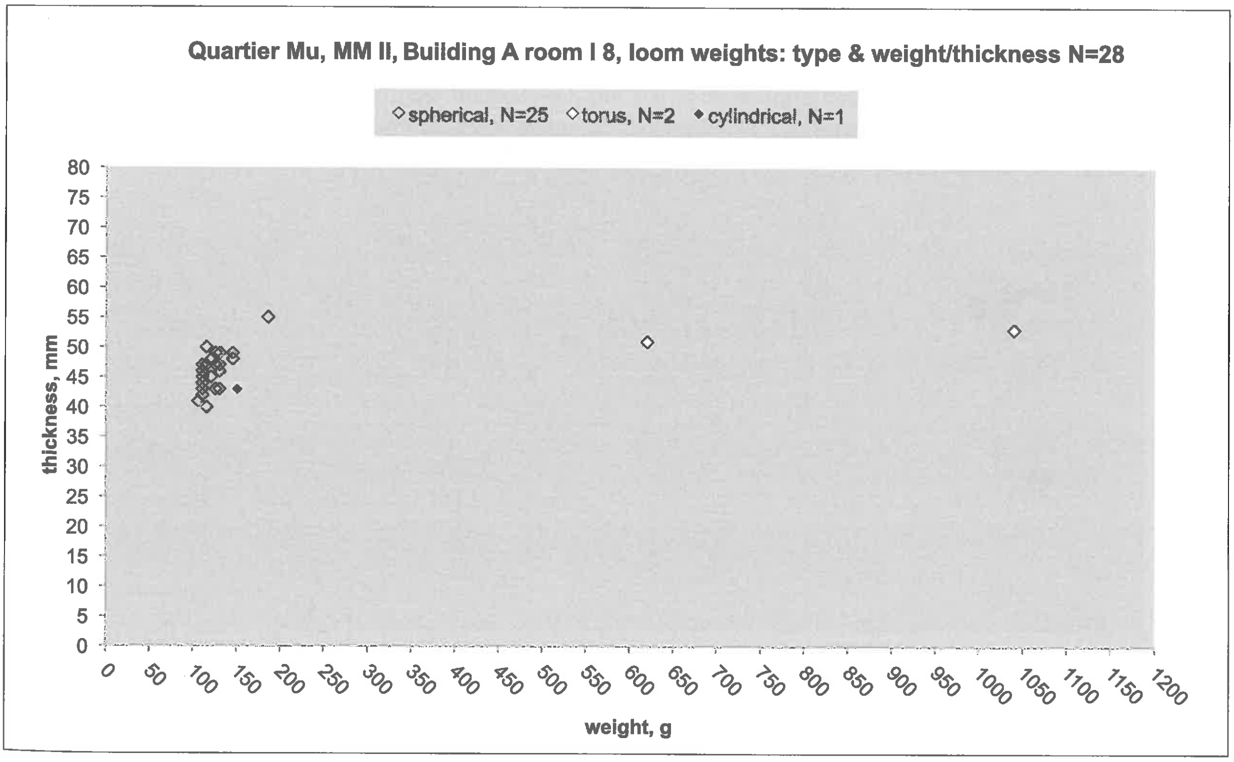


Fig. 5.8. — Building A, room I 8, MM II, loom weights: type and weight/thickness.

Of the 30 loom weights found *in situ* in room I 8, 28 had a recordable weight and thickness (25 spherical, one cylindrical standard and two torus; **fig. 5.8**). Except for the heavier torus weights (weighing 620 g and 1040 g respectively), all of these loom weights weigh between 105 g and 185 g, with a thickness ranging from 4 cm to 5.5 cm. The majority (23) weigh 110-145 g, with a thickness of between 4 cm and 5 cm: thus forming part of one of the two weight/thickness clusters visible among the loom weights from the building as a whole.

Excluding the torus weights, an analysis of how the loom weights from room I 8 would function with thread requiring different tensions, in both a tabby weave and a 2/2 twill, indicates that they would be best suited for use with very thin warp threads requiring 5-10 g tension, with only five being suitable for use with thread requiring 15 g tension (**pl. V.4**). Used in a tabby weave with thread requiring 5 g tension, the loom weights would produce a fabric with an average thread count of 10.8 threads per cm; using thread requiring 10 g tension, the average thread count would be 5.5 threads per cm (**pl. V.4 a**). In a balanced weave, with an equal number of warp and weft threads per cm^2, these would both be extremely open textiles and it is therefore likely that the fabrics would have been weft faced. In a 2/2 twill using thread requiring 5 g tension, the resultant fabric would have an average thread count of 21.5 threads per cm, whereas with thread needing 10 g tension the average would be 11.1 threads per cm (**pl. V.4 b**). These twill fabrics would similarly have been open if they were balanced fabrics, and are also likely to have been weft faced. The lighter of the two torus weights would only be suitable for use with thread requiring 25 g tension or more, while the heavier torus weight would not be optimal for use with thread needing less than 35 g tension.

The 25 loom weights that appear to have fallen from an upper storey above room III 1 all had a recordable weight and thickness and represent a mixture of types. They weigh between 90 and 450 g and have a thickness of 1.7-6.2 cm (**fig. 5.9**).

The eight discoid weights among them would only be suitable for use with very thin thread requiring 5-10 g tension (**pl. V.5**). In a tabby weave using thread requiring 5 g tension, the finished textile would have an average of 21.3 threads per cm; with thread needing 10 g tension the average thread count would be

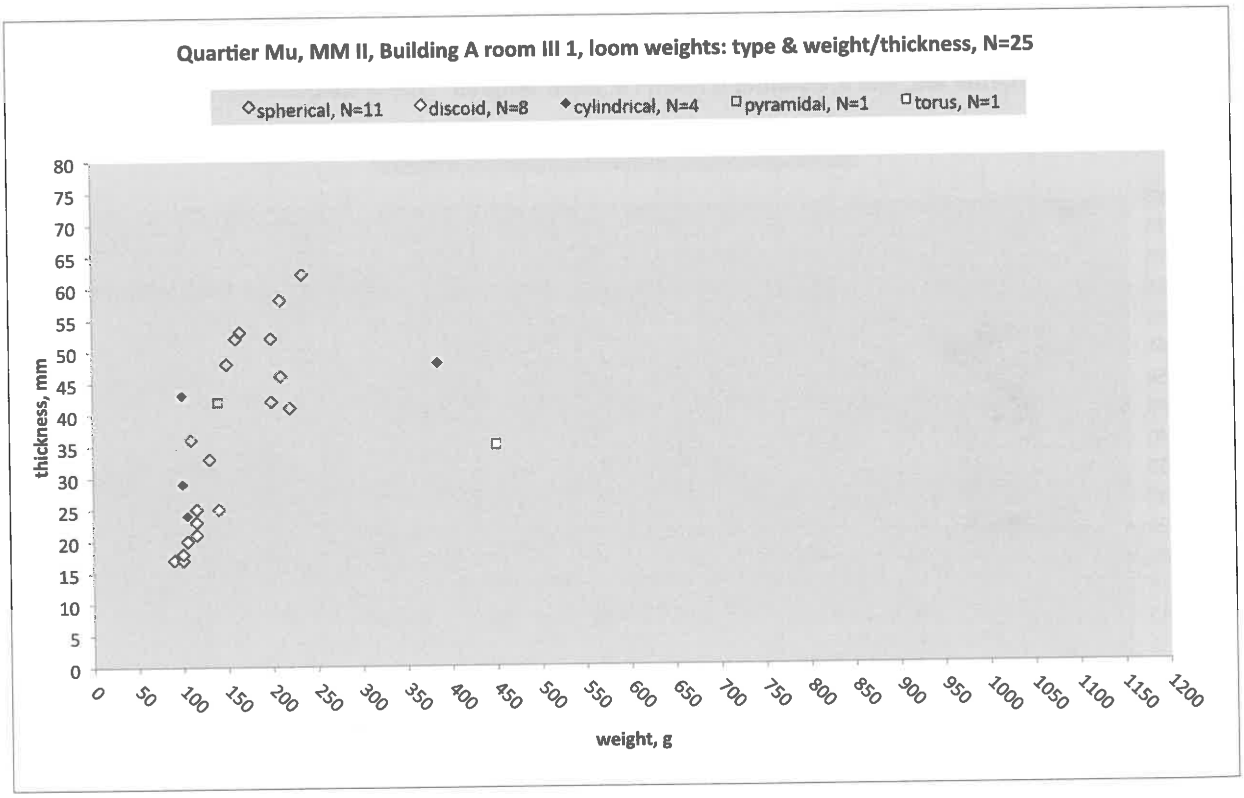


Fig. 5.9. — Building A, room III I, MM II, loom weights: type and weight/thickness.

10.9 threads per cm (**pl. V.5 a**). Used in a 2/2 twill with thread requiring only 5 g tension, the fabric produced would have an average of 42.6 threads per cm; with thread needing 10 g tension the average thread count would be 21.9 threads per cm (**pl. V.5 b**). The discoid loom weights from room III 1 could thus be used with very thin thread to produce both tabby and twill fabrics with a relatively high thread count.

In a tabby weave, none of the remaining loom weights from room III 1 (11 spherical, four cylindrical, one pyramidal truncated and one torus) would be suitable for use with thread requiring a tension of more than 40 g, and only the torus weight and one of the cylindrical weights would be suitable for use with thread requiring 25-40 g tension. Setting these two aside, all of the other loom weights could be used with thread requiring 10 g tension, to produce a cloth with a thread count ranging from 5 to 11 threads per cm; giving an average thread count of 7.5 threads per cm (**pl. V.6 a**). In a balanced weave, this would be an extremely open textile, however. Fewer of the loom weights would function with thread needing 5 g or 15-20 g tension, and the fabric produced would be similarly open, with an average thread count of 13.6, 5.1, and 4.5 threads per cm respectively. Tabby textiles made with these loom weights are therefore likely to have been weft faced.

Again setting aside the two heavier weights, if the same 15 loom weights were used to make a 2/2 twill, all of them could be used with thread requiring 10 g tension, to produce a fabric with an average thread count of 14.8 threads per cm (**pl. V.6 b**). This would be an open twill fabric, and is likely to have been weft faced. Fewer of the loom weights would be suitable for use with thread requiring 5 g or 15-20 g tension.

Since the loom weights found in room III 1 appear to have fallen from above, it is not possible to say whether they were originally part of the same group. However, the above analysis suggests that they fall into at least three distinct categories. Two of the weights are heavier, and would not work well with any of the other weights in either a tabby weave, or a 2/2 twill. The discoid weights would only be suitable for use with thread requiring 5-10 g tension, but could be used to produce either a tabby or a 2/2 twill. The remaining weights could be used with a wider range of thread tensions (5-20 g), although they seem best suited for use with thread needing 10 g tension. However, in both tabby and twill weaves, these loom weights would produce extremely open fabrics, and they would therefore be best suited for use in the manufacture of weft faced textiles.

Building B

The majority of the 40 loom weights from Building B (sectors IV and V) similarly appear to have fallen from an upper storey (**fig. 5.10**). A group of nine loom weights recovered from room IV 5 were *in situ*, however. These weights were found, along with 25 pierced pebbles, lying close together forming the shape of a square, suggesting that they may originally have been stored in a box or chest. This room has been interpreted as a storage area (one in a row of storage magazines), but the loom weights and pebbles were its only contents; it is possible that finished textiles or raw fibre materials may also have been stored here, but if so, these have not survived. In this respect, it is interesting to note that a Cretan Hieroglyphic tablet (HM 1676) with a

Loom weight type	IV 1	IV 3	IV 4	IV 5	IV 7	IV 8	IV 14	IV 16	V 1	V 1/5	V 5	V 6	Total
spherical			8	5			1		1		3		18
spherical lenticular			2					1			1		4
discoid rounded			1	2		1							4
pyramidal truncated		1								2	1		4
cube											1		1
cylindrical short				2									2
cylindrical standard	1	1	2										4
torus					1							2	3
Total	1	2	13	9	1	1	1	1	1	2	6	2	40

Fig. 5.10. — Loom weights from Building B (sectors IV & V), by room.

suspension hole pierced through it was found in the doorway of room IV 5, possibly having fallen from an upper floor (Poursat 1990, p. 27; Godart et Olivier 1978, p. 70). The text on one side of the tablet includes two occurrences of the Hieroglyphic sign P41, which takes the same form as the Linear B TELA textile ideogram. It also contains a sign that has been interpreted as the equivalent of the Linear B wool unit, LANA (Younger 2005). Younger (*ibid.*) has suggested that the entry should be read as 'TA <-PE>+CLOTH LANA = 3 double minas CLOTH', thus possibly recording the assessment of the amount of TA<-PE> cloth made from one unit of wool, with TA<-PE> perhaps representing the Minoan predecessor of the Mycenaean *te-pa* variety of cloth. Whether or not this interpretation is accepted, the presence of the Hieroglyphic sign P41 does suggest the possibility that the tablet may be associated with the recording of textiles.

It was possible to record the weight and thickness of 37 of the loom weights from Building B (**fig. 5.11**). Four of these, weighing between 35 g and 40 g, are more likely to be spindle whorls (one spherical rounded, two spherical lenticular and one cylindrical standard). The remaining loom weights weigh between 55 g and 240 g, with a thickness varying between 1.8 cm and 6.6 cm. Some of the loom weights from Building B fall within one of the clusters visible in the Building A loom weight assemblage (relating to loom weights with a weight of 75-150 g and a thickness of 4-5.2 cm), and would have been suitable for making the same range of fabrics. The general weight range of loom weights in Building B is more limited than that of the loom weights recovered from Building A, however.

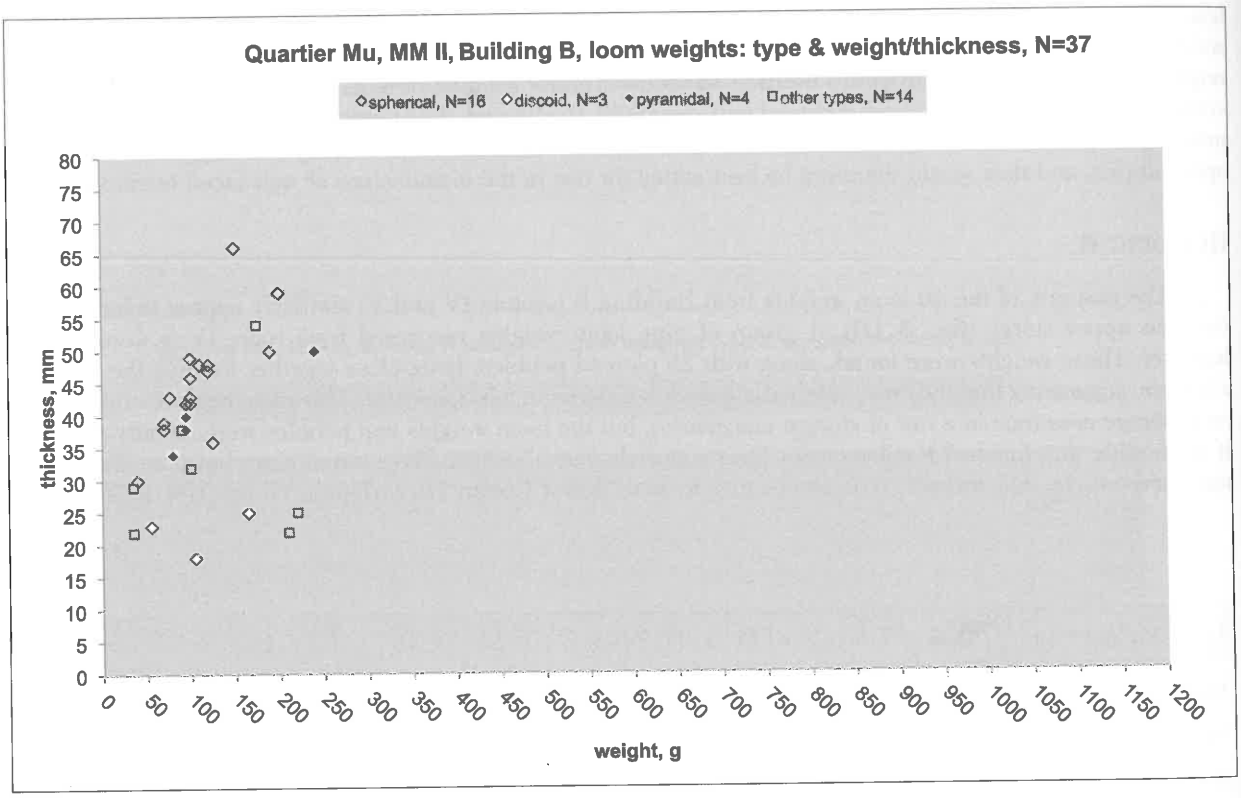


Fig. 5.11. — Building B, MM II, loom weights: type and weight/thickness.

Building D

The 160 loom weights recovered from Building D (sector VII) were all found *in situ*, in rooms VII 3 and VII 4 (**fig. 5.12**). Twenty-eight pierced pebbles were additionally found with the loom weights in room VII 3. The building appears to have been a storage structure.

The weight and thickness of 153 of the 160 loom weights from Building D could be recorded. The large cluster of loom weights visible in **figure 5.13** (with a weight of 300-380 g and a thickness of 6.5-7.2 cm) corresponds closely to the third cluster of weights present in the overall MM I-II loom weight assemblage.

Loom weight type	Room VII 3	Room VII 4	Total
spherical	94	32	126
spherical lenticular	1		1
discoid rounded	4	1	5
pyramidal truncated	2		2
cylindrical short	4		4
cylindrical standard	9	7	16
torus	4		4
other	1	1	2
Total	119	41	160

Fig. 5.12. — Loom weights from Building D (sector VII), by room.

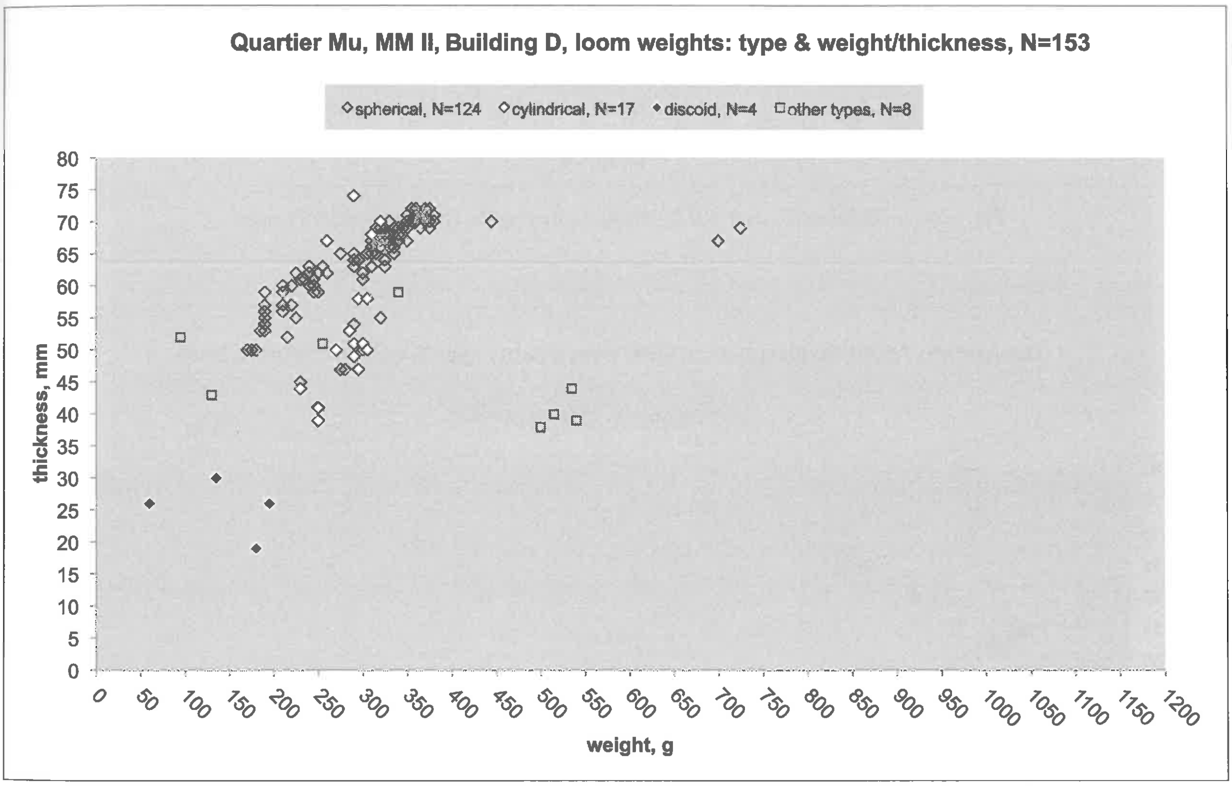


Fig. 5.13. — Building D, MM II, loom weights: type and weight/thickness.

It was possible to record the weight and thickness of 118 of the 119 loom weights from room VII 3 (**fig. 5.14**). Of these, only four would function with warp threads needing 5 g tension and the resulting fabric would have an average thread count of 10.8 threads per cm (**pl. V.7 a**). The majority of the loom weights would be best suited for use with thread requiring 15-25 g tension, but a number could also be used with thread needing 10 g tension and 30-35 g tension. Very few (six or less) would function with thread requiring 40-50 g tension. In a tabby weave, the weights that could be used with thread requiring 15-25 g tension would produce a fabric with an average thread count of between 6.6 threads per cm (15 g tension) and

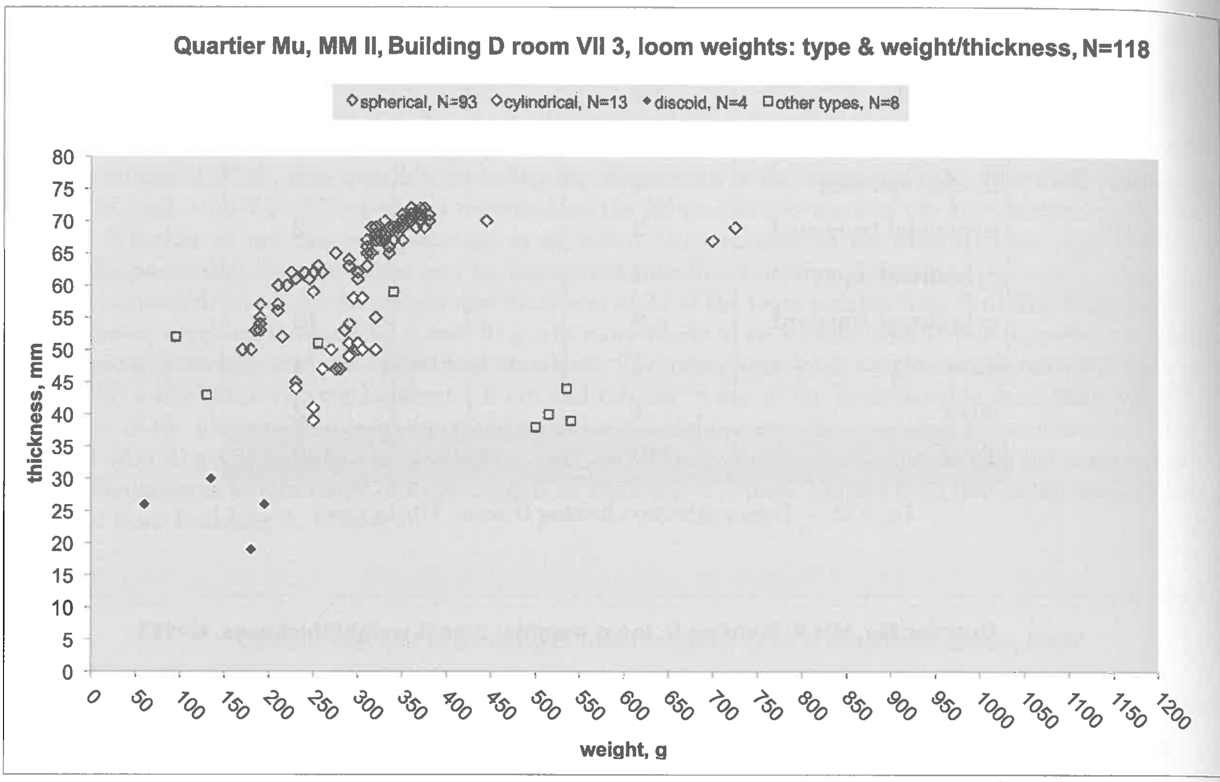


Fig. 5.14. — Building D, room VII 3, MM II, loom weights: type and weight/thickness.

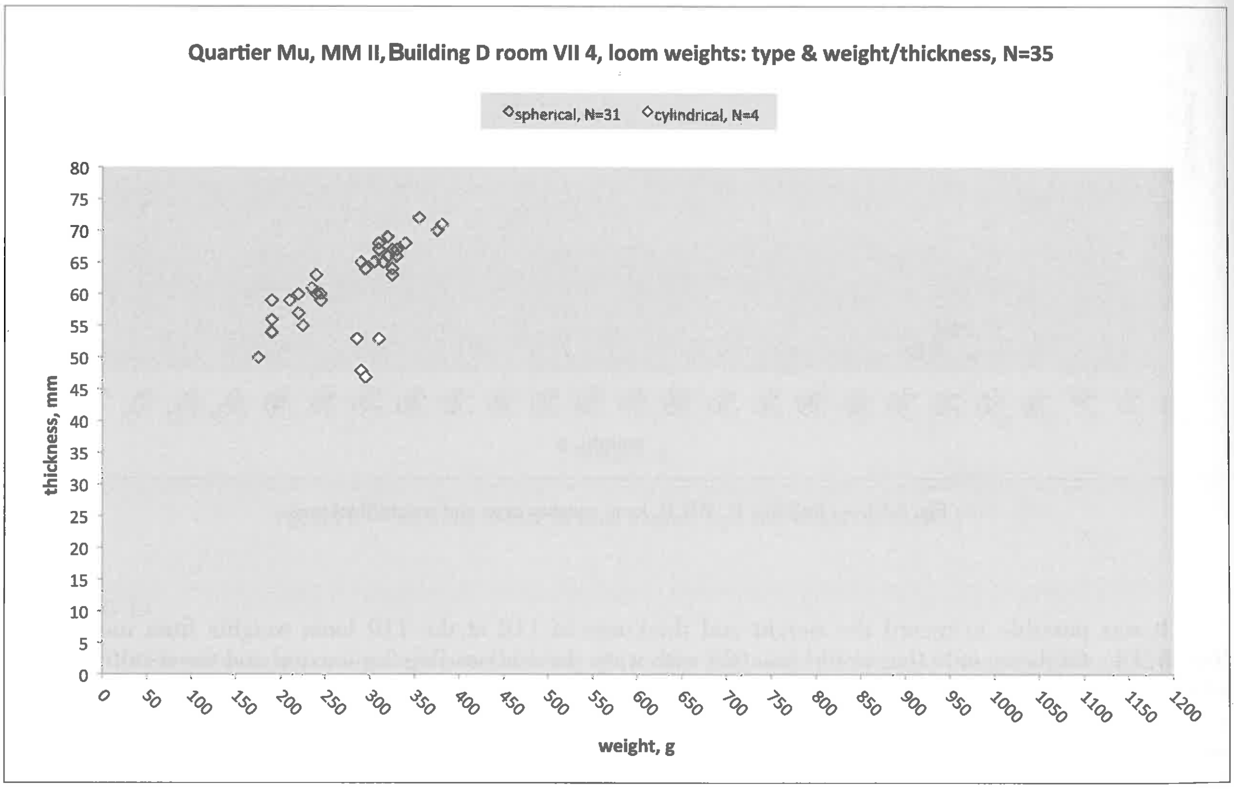


Fig. 5.15. — Building D, room VII 4, MM II, loom weights: type and weight/thickness.

Loom weight type	VIII 1	VIII 2	VIII 3	VIII 4	VIII 5	Total
spherical	3		1	1	8	13
discoid rounded	3	8	2	1		14
pyramidal truncated	1	1			1	3
conical					1	1
cylindrical short					1	1
torus			1			1
Total	7	9	4	2	11	33

Fig. 5.16. — Loom weights from the Potter's workshop (sector VIII), by room.

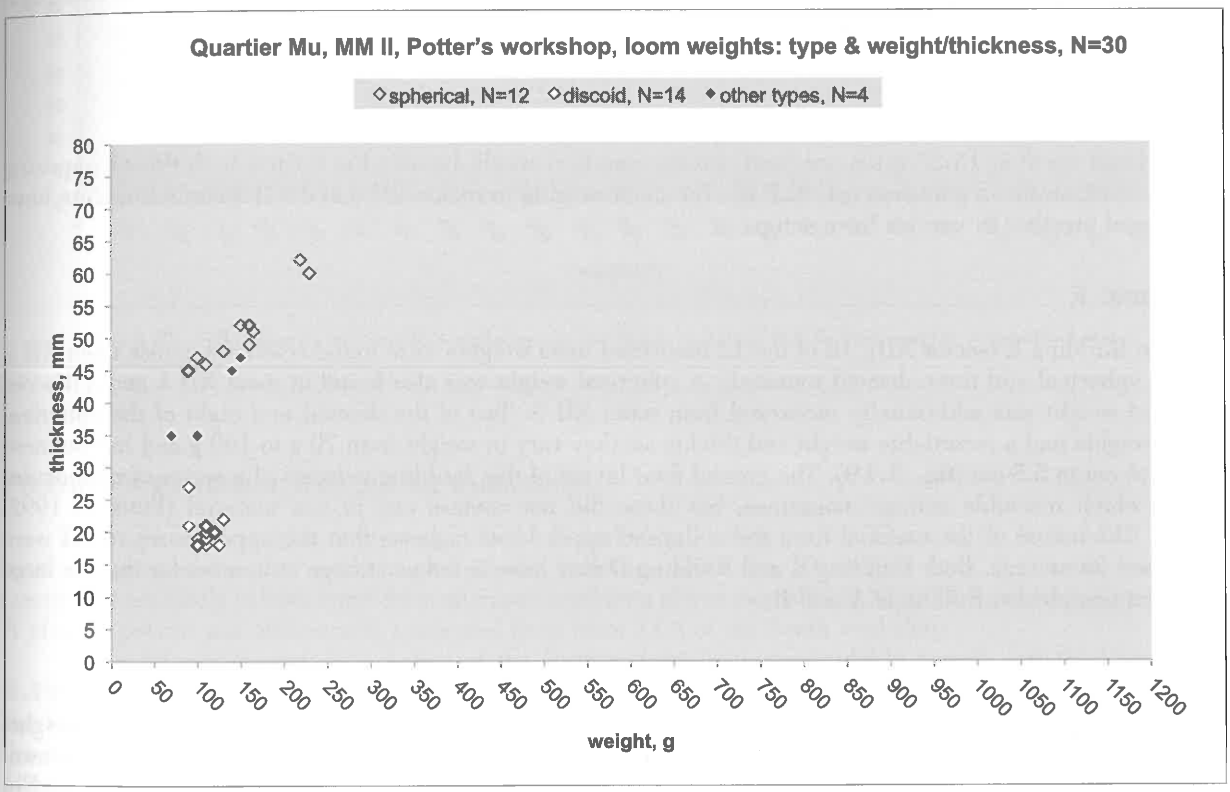


Fig. 5.17. — The Potter's workshop, MM II, loom weights: type and weight/thickness (excluding stone torus weight weighing 1400 g).

4.2 threads per cm (25 g tension). Those that could be used with warp threads requiring 10 g or 30-35 g tension would produce a textile with an average thread count of 9.2 and 3.4 threads per cm respectively. These would be open textiles, and are likely to have been weft faced. In a 2/2 twill, the average thread counts for the various weight tensions would be approximately double those in a tabby. The pierced pebbles recovered from room VII 3 (with the exception of one pebble weighing 1170 g) have a weight of between 100 g and 380 g and a thickness of 2.7-7.0 cm. They would therefore be suitable for use in various loom setups with the other loom weights found in the room.

Of the 41 loom weights from room VII 4, 35 had a recordable weight and thickness (**fig. 5.15**). These weights would have been suitable for manufacturing a very similar range of fabrics to those that could have been produced using the loom weights from room VII 3, with closely corresponding thread counts: none of the weights would have functioned with thread requiring 5 g tension, while the majority could have been used

Loom weight type	X 3	X 4	X 5	Total	XI 2	XI 3	XI 4	XI 5	Total
spherical	1		1	2			2	1	3
discoid rounded		2		2		2	1		3
pyramidal truncated			1	1			1		1
cube		1		1					
cylindrical short	1			1					
rectangular, thick			1	1					
torus						1	1		2
torus (small hole diam)					1				1
Total	2	3	3	8	1	3	5	1	10

Fig. 5.18. — Loom weights from the Founder's workshop (sector X) and the South workshop (sector XI), by room.

with thread needing 15-25 g tension, and smaller numbers would be suitable for use with thread requiring 10 g tension or 30-35 g tension (**pl. V.7 b**). The loom weights in rooms VII 3 and VII 4 could therefore have been used together in various loom setups.

Building E

In Building E (sector XII), 10 of the 12 recovered loom weights were found scattered across room XII 2 (seven spherical and three discoid rounded). A spherical weight was also found in room XII 1 and a discoid rounded weight was additionally recovered from room XII 5. Two of the discoid and eight of the spherical loom weights had a recordable weight and thickness: they vary in weight from 70 g to 160 g and in thickness from 1.6 cm to 5.5 cm (**fig. 5.19**). The ground floor layout of this building consists of a series of rectangular rooms which resemble storage magazines, but these did not contain any *in situ* material (Poursat 1992, p. 48). The nature of the material from the collapsed upper level suggests that the upper storey rooms were also used for storage. Both Building E and Building D may have acted as storage structures for the two large adjacent complexes, Buildings A and B.

Seal workshop

The Seal workshop was partly excavated by A. Dessenne in 1956 (*Mu* III, p. 7). A few loom weights were recorded among the finds from this excavation, but the exact contexts for these weights are not known. Only one loom weight was recovered from the Workshop building itself when the area was re-examined in 1977 (**fig. 5.5**); a further three (one pyramidal truncated and two discoid rounded) were found in First Palace contexts in the general area of the workshop.

Potter's workshop

The loom weights from the Potter's workshop, the Founder's workshop and the South workshop all appear to have fallen from rooms above. In the Potter's workshop (sector VIII), the 33 loom weights were found scattered over the ground floor area (**fig. 5.16**).

It was possible to record both the weight and the thickness of 31 of these 33 loom weights. With the exception of one stone torus with a weight of 1400 g, the loom weights from this building weigh between 70 g and 230 g, with a thickness varying between 1.8 cm and 6.2 cm (**fig. 5.17**). Excluding the stone torus weight, the loom weights of all types would function best with very thin thread requiring 5-10 g tension. The thinner, discoid loom weights would produce a denser fabric, with more warp threads per cm than the thicker, spherical weights, however.

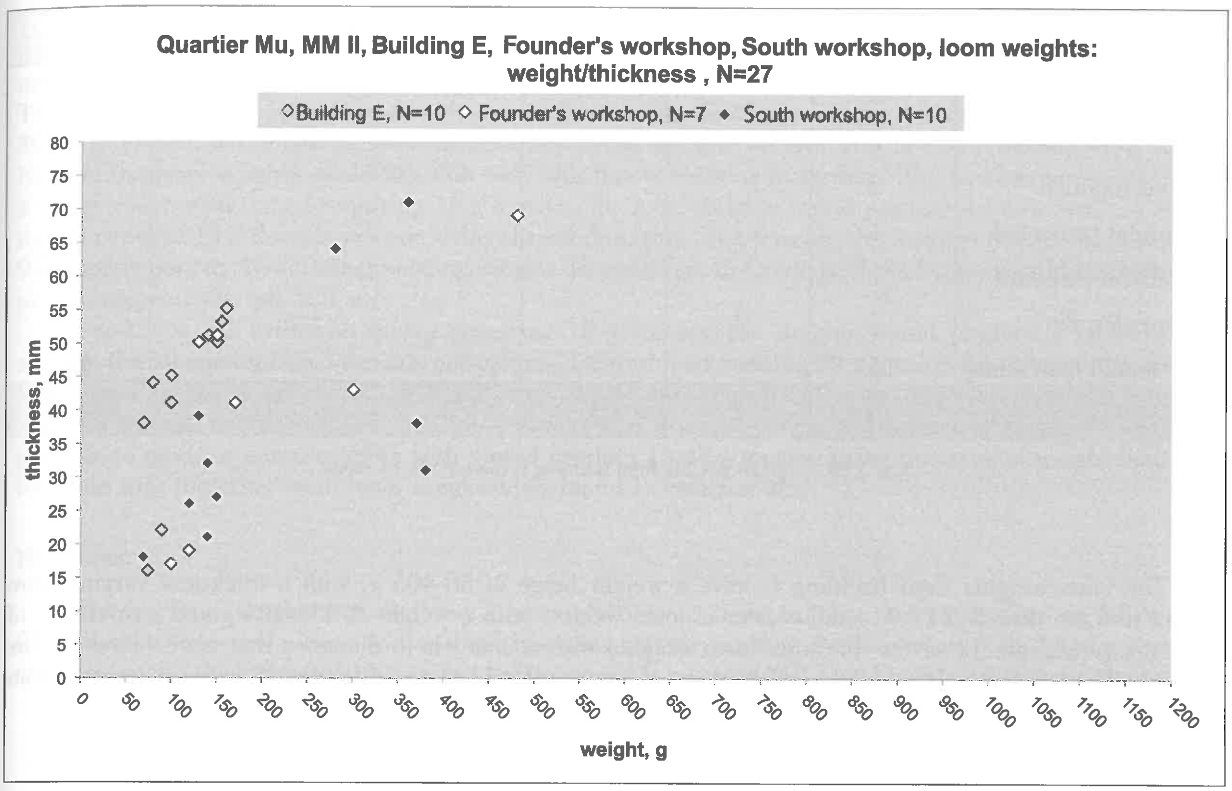


Fig. 5.19. — Building E, the Founder's workshop and the South workshop, MM II, loom weights: weight/thickness.

Founder's workshop and South workshop

The eight loom weights recovered from the Founder's workshop (sector X) appear to have fallen from a room or rooms above the southern part of the building, while the 10 weights from the South workshop (sector XI) are likely to have come from an upper level area above rooms XI 2, XI 3, XI 4 and XI 5 (**fig. 5.18**). A pierced pebble was additionally recovered from room XI 4 of the South workshop.

In the Founder's workshop, seven of the loom weights had a recordable weight and thickness (**fig. 5.19**). The majority of the weights weigh between 100 g and 170 g, with a thickness of 1.7-5.1 cm; two of the weights are heavier, however (300 g and 480 g, with a thickness of 4.3 cm and 6.9 cm respectively). In the South workshop, six of the 10 loom weights weigh between 70 g and 150 g, with a thickness of between 1.8 cm and 3.9 cm; the remaining weights weigh 280-380 g, with a thickness of between 3.1 cm and 7.1 cm (**fig. 5.19**). The majority of the weights from both buildings would be most suitable for use with thread requiring 5-10 g thread tension, but the heavier weights would work best with thread needing a higher tension of 15-25 g.

Building C

In Building C (sector VI), the loom weights were again found dispersed over the ground floor area, with the majority being recovered from rooms VI 1, VI 2 and VI 3 (**fig. 5.20**). A further 11 loom weights were found in the Courtyard.[5]

(5) A group of *ca.* 30 loom weights was additionally recovered from the southern half of room VI 7, during an earlier excavation (1948) by Dessenne; unlike the other loom weights from the building, these appear to have been *in situ* (these loom weights are not included in the current analysis). This room was empty apart from the group of weights, and appears to have been used as a storage magazine. Like room IV 5 in Building B, it is possible that this room and the apparently empty storage magazines on the ground floor of Building E were used to store textiles or raw fibre materials.

Loom weight type	VI 1,2,3	VI 5	VI 6,7,10	VI 9	VI 4 (courtyard)	Total
spherical	5			3	3	11
spherical lenticular	1					1
discoid rounded	2				2	4
pyramidal truncated	1	1	1		4	7
cylindrical standard	1					1
rectangular, flat		1				1
torus (small hole diam)	15				2	17
Total	25	2	1	3	11	42

Fig. 5.20. — Loom weights from Building C (sector VI), by room.

The loom weights from Building C have a weight range of 50-405 g, with a thickness varying from 1.6 cm to 6 cm (**fig. 5.21**). A small cluster of loom weights with a weight of 335-405 g and a thickness of 3.3-4 cm represents 13 of the 17 torus loom weights with a small hole diameter that were found in this building. The majority of the weights of this type come from Building C, with only 27 being recovered from MM I-II contexts from the site as a whole (25 from MM II deposits and two from unknown contexts).

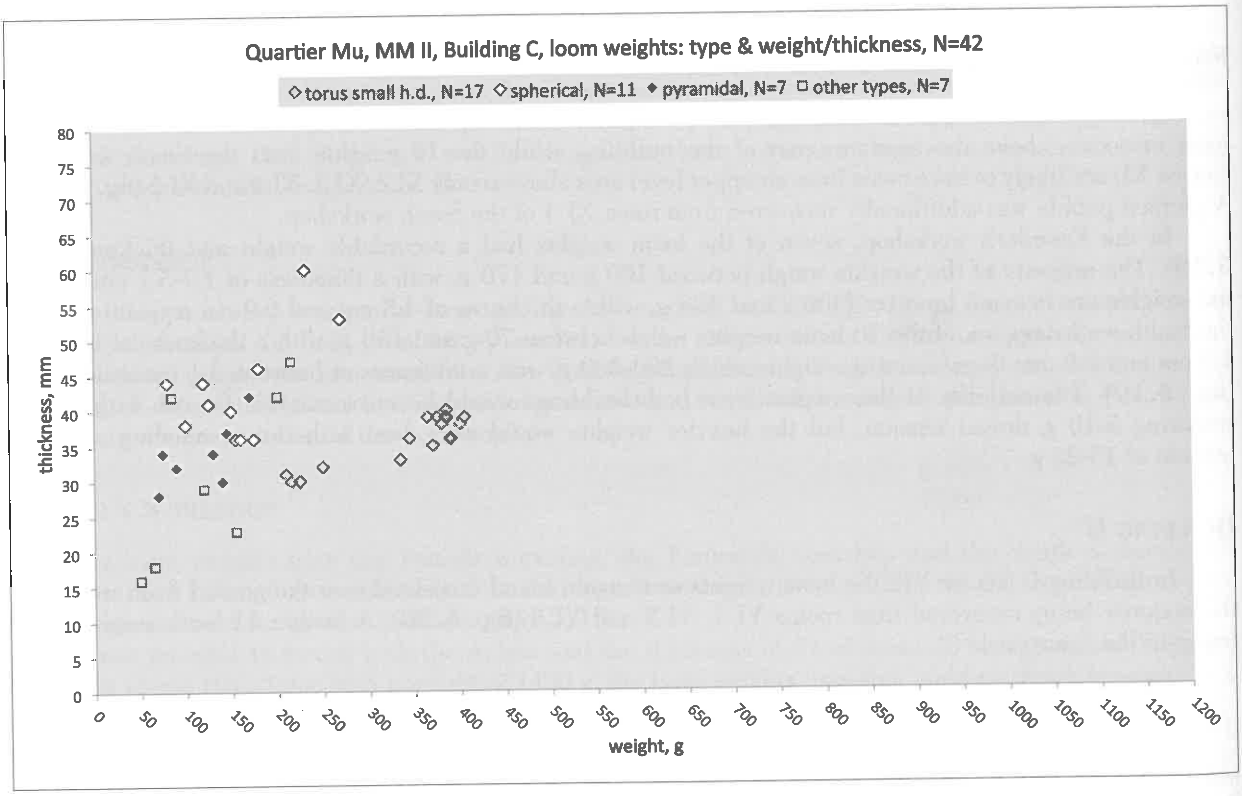


Fig. 5.21. — Building C, MM II, loom weights: type and weight/thickness.

None of the 17 torus loom weights with a small hole diameter recovered from Building C would be suitable for use with thread needing 5 g tension and only four of them would be suitable for use with thread needing 10 g tension (**pl. V.8**). All of the loom weights would function with thread requiring 15-20 g tension. The 13 weights represented by the cluster visible in **fig. 5.21** could also be used with thread needing 30-35 g tension, with eight of these additionally being suitable for use with thread requiring 40 g tension. None of the loom weights would function well with thread needing more than 40 g tension, however. Used in a tabby weave with thread requiring 15 g tension, the loom weights would produce a fabric with an average thread count of 12.5 threads per cm; using thread requiring 20 g tension, the average thread count would be 9.5 threads per cm. With thread needing 30 g or 35 g tension, the average thread count would be 6.9 and 5.9 per cm respectively (**pl. V.8 a**).

Used in a 2/2 twill with thread requiring 15 g tension, the weights would produce a fabric with an average thread count of 25.5 threads per cm; used with thread needing 20 g tension the average thread count would be 19 threads per cm (**pl. V.8 b**). Using thread that requires 30 g or 35 g tension would produce a 2/2 twill with an average thread count of 13.5 and 11.7 threads per cm respectively. Therefore, it would be possible to produce a denser cloth with thread needing 15-40 g tension using this type of weight than could be made with the other main loom weight types found in Quartier Mu.

Building F

The four loom weights from Building F (sector XIII) were dispersed over three rooms, having fallen from a floor above; a torus and a torus with a small hole diameter weight were found in room XIII 2 and a pyramidal truncated and a thick rectangular weight were recovered from room XIII 1 and room XIII 3 respectively.

FROM CALCULATIONS TO TEXTILES

The inhabitants of Malia would have needed many different types of textiles, for example, fabrics for furnishing and possibly also wall hangings and sailcloth. Furthermore, people needed clothes for winter and summer; costumes that protected them from the heat, but also from the rain and cold weather. The iconography of the preserved Aegean Bronze Age frescoes demonstrates that costumes could be extremely elaborate and colourful. Unfortunately, nothing is known about how people dressed in everyday life, but the results from the analysis of the Quartier Mu loom weights confirm that people are likely to have worn costumes made of fabrics of different types and qualities.

From loom weights to fabrics

The analysis of the loom weights suggests that the different types of loom weights are likely to have been used for the production of different types of fabric. Furthermore, the results demonstrate that the majority of fabrics in general were produced with thin warp threads needing 25 g tension or less. These types of thread would not be practical for the manufacture of coarser textiles such as sails and sacks.

It could be suggested that spherical loom weights were specifically intended for open weaves. However, although there would have been some requirement for open weaves to produce certain high quality textiles such as veils, the large number of spherical weights would suggest that their use extended beyond this. In general, the textiles woven with spherical loom weights are likely to have been weft faced; in which case, a high thread count in the weft would have compensated for the limited thread count in the warp, thus enabling the production of a denser material. The results clearly demonstrate that the discoid loom weights were used for producing denser textiles.

The analysis of the pebbles confirms that these could also have been used as loom weights. Furthermore, they could have been used on the loom within the same setup as clay loom weights.

Via tools and contexts to production and textiles

The extremely good archaeological contexts in Quartier Mu have provided a unique insight into Middle Bronze Age textile production at the site. Although very few remains of actual textiles have been recovered (see Addenda, p. 118), the analysis of the loom weights has made it possible to suggest what types of fabric may have been produced in the different buildings.

The majority of the loom weights were found scattered over the ground floors of the various buildings. It is preferable to have good lighting when weaving, particularly when weaving fabrics with a large number of threads and/or very thin yarn. Therefore, it is not surprising that many of the loom weights appear to have fallen from the upper storeys of the buildings. In general, groups of loom weights that derive from the same context could have functioned in the same setup. This is also true in the case of the loom weights that appear to have been stored together. This confirms that the loom weights, even if they were not in use, were kept in different sets, for production of different types of fabric. Furthermore, this result suggests that textile production in Quartier Mu was well planned and organised: the weavers knew which loom weights they needed for a specific setup.

Although the number of finds of loom weights from Quartier Mu is high, it is not possible to suggest how many looms were actually being used. In most cases, only a few loom weights are found together and even if they could have been used in the same loom setup, it is likely that these sets of weights would have contained more loom weights. It is also likely that the width of the fabric to be woven differed, depending on what type of textile was going to be produced and the purpose for which the finished product was intended.

In Building A, the concentrations of loom weights from room I 8 and room III 1 would be best suited for the production of textiles using very thin threads, that could be dense and/or open/weft faced. The result of the analysis of the loom weights from room III 1 indicates that they would not function optimally in the same loom setup and it is therefore likely that (excluding the two heavier weights) they belong to two different sets.

The loom weights from Building B suggest a varied production, but the majority would be best suited for a production of fabrics with warp threads requiring a tension of 5-10 g.

In contrast to the two main concentrations of loom weights from Building A, the majority of the loom weights found *in situ* in rooms VII 3 and VII 4 of Building D would have been most suitable for use with threads needing a tension of 15-25 g. Furthermore, the loom weights from the two rooms would function very well together in various loom setups (**fig. 5.22**).

			Warp threads per cm	
		Tension needed (g)	Tabby	2/2 twill
Building A	I 8	5-10	5.5-10.8	11.1-21.5
	III.1 a	5-10	10.9-21.3	21.9-42.6
	III.1 b	10	7.5-14.8	15-29.6
Building D	VII 3	15-25	4.2-6.6	8.4-13.2
	VII 4	15-25	4.2-6.6	8.4-13.2

Fig. 5.22. — Buildings A and D, clusters of loom weights and their suitability for different fabrics.

Both spherical and discoid weights were present among the low number of loom weights scattered across the ground floor of Building E (a probable storage magazine). These two types of weight would be suitable for the production of different types of fabric, since the discoid loom weights would be suitable for producing denser textiles, whereas fabrics made with the spherical weights would be more open or weft faced. However, all of the loom weights from the building would be best suited for use with very thin thread.

In the Potter's workshop, there are two main groups of loom weights: one consisting of spherical weights (recovered from rooms VIII 1, 3, 4 and 5) and the other, from rooms VIII 1, 2, 3 and 4, consisting of discoid loom weights. The two groups of loom weights would not be optimal for use in the same setup, but they would function very well in two different loom setups. This result suggests that at least two different types of fabric were being produced in this workshop. Although produced with the same type of thread, the fabrics would visually be very different; one would be more open or weft faced and the other would be denser, with a higher number of threads per cm.

Only a few loom weights were found scattered across the ground floor rooms of the Founder's workshop and the South workshop. However, they are of different types, which suggests that in these workshops the weavers may also have produced different types of textiles: not only with very thin threads needing 5-10 g tension, but also slightly thicker threads needing 15-25 g tension.

The group of torus loom weights with a small hole diameter from Building C would function best with threads requiring 15-20 g tension. Furthermore, with this type of yarn the fabric would be quite dense. It would also be possible to weave tabby fabrics that were balanced (the same number and type of warp as weft threads per cm^2) with this type of thread. A twill weave could even be warp faced (more warp threads than weft threads).

To conclude, the results of the analysis suggest that different types of fabric were being produced in different buildings, and even in different rooms within the buildings. In some locations, such as the Potter's workshop and Building A, it is most likely that fabrics with very thin threads were being manufactured. It is also interesting that the loom weights stored in Building D would have been more suitable for use with thicker thread. Although it is not possible to state whether both tabby and twill fabrics were being produced, the analysis confirms that the loom weights could have worked well in either tabby or twill setups.

The production of textiles is time consuming, especially in the kind of large scale and specialized production that is likely to have taken place in Quartier Mu. It is probable that many people were involved; not only spinners and weavers, but also those who prepared the fibres, dyed yarn or fabric, etc. Although it is not known how the textile production in Quartier Mu was organized, the results suggest that the production was specialized and that spinning (because of the lack of spindle whorls) took place somewhere else. The need for raw material would have been substantial. Just to produce 1 m^2 of a balanced tabby made with a very thin thread needing ca. 10 g tension and with only 7 threads per cm, one would need 1428 m of yarn[6], which would take approximately 41 hours to spin (processing not included)[7]. However, such a textile would be very open and the amount of weft yarn required is therefore likely to have been considerably larger. If, on the other hand, the weavers wanted to produce a tabby with the same thread but with 21 threads per cm, ca. 4284 m of yarn would be needed, which would take 122 hours to spin. It is also important to note that producing a fabric with this type of thread demands raw material of a high quality and very well prepared fibres. The warping, heddling and weaving would also have taken a considerable amount of time and it would also, of course, have been more time consuming to produce a twill than a tabby, since four layers of warp threads are needed, rather than two.

Although only the loom weights have been preserved, other types of equipment would have been required in a textile workshop: tools for winding the yarn on the shuttles (for example, a reel), equipment for warping, the loom with all its parts, shuttles, weaving beaters, pin beaters and possibly needles used for tapestry weaving. Yarn needed for the setup and heddling would also be kept in the workshop. All the small tools and the yarn were probably kept in baskets and/or chests. A knife may have been used to remove the finished fabric from the loom. If the fabrics were also tailored into different types of garments in the workshop or mended, tools would also be needed for this process.

The tools mentioned above are seldom preserved in the archaeological record, which makes it difficult to conclusively identify a textile workshop. If only loom weights are found in a room or an area, a workshop could easily be interpreted as, for example, a storage magazine. A consideration of the spatial context and the associated archaeological finds is therefore vital in attempting to ascertain where textile production is likely to have taken place on any given site.

It is likely that not only the loom weights, but also other textile tools would have been stored in the storage magazines; for example, looms that were not in use. Many baskets and/or chests with raw material and/or yarn may additionally have been stored there. It is impossible to calculate the amount of yarn that may have been kept in storage; it would have included yarn of many different qualities, but particularly very fine yarn. It is likely that some yarn was dyed in different colours, such as red, blue, yellow and purple.

It is also possible that finished textiles may additionally have been stored in some storage areas. In this case, the textiles would probably have been kept in a chest or in a place where they could be protected from the light and from vermin and moths, that could easily have destroyed the fabrics.

(6) For $1m^2$ of fabric the amount of warp thread required is equal to the number of warp threads per cm x the width of the fabric (cm); the amount of weft thread is equal to the number of weft threads per cm × length of the fabric (cm). However, even if both the warp and weft threads are taut, the threads will never be fully stretched when they cross over and under each other in the weave. Furthermore, in the last part of the warp there will always be some wasted warp yarn. Therefore an additional 2% has been added to the estimation of the total amount of required yarn.

(7) The spinning time is based on experimental spinning tests at the Danish National Research Foundation's Centre for Textile Research, Copenhagen University (ANDERSSON STRAND et NOSCH, à paraître).

The investigation of the loom weights from Quartier Mu has provided a new and important insight into textile production in the Bronze Age. Furthermore, the results confirm that textile production was organized and structured. The majority of the produced textiles would have been of a high quality, and would have demanded a specialized knowledge, and would also have taken a considerable amount of time to make. The results demonstrate that it would have been possible to produce both tabby and twill fabrics. It is likely that the production of textiles would have been an important industry and that the finished textiles would have been considered highly valuable products, not only in Quartier Mu, but also in the wider Aegean world.

Acknowledgements

We thank our colleague Ulla Lund Hansen for collaboration and the use of the results from the Vorbasse research programme supported by The Danish Council for Independent Research / Humanities (FKK). We also thank Karen Hanne Stærmose Nielsen who kindly let us use her illustrations and Anaya Sarpaki for providing a photograph of the Quartier Mu textile fragment discussed in Addendum 1. This research was carried out with the support of the Culture Programme of the European Union and the Danish National Research Foundation's Centre for Textile Research (DNRF64).

Addenda

1. In addition to the textile tools discussed above, a few fragments of mineralized textiles have been recovered from Quartier Mu (A. Sarpaki, *BCH* 131 [2007], p. 884). From a photograph of one of these fragments (**pl. 5.1 g**), it can be determined that the fabric is likely to be a tabby with ca. 20 threads per cm. The diameter of the thread is ca. 0.3 mm. It appears that the thread is S-spun in one thread system and Z-spun in the other, this may indicate that this textile was made of wool, either sheep or goat.

The fragment comes from a drain in the eastern part of Building A, going out from room I 19 to the Chaussée Est. The fineness of the thread and the thread count fit very well with the type of fabric that the analysis of the loom weights clearly indicates could have been produced with the thin discoid loom weights from Building A.

2. Two thread fragments were found when cleaning earth from the holes of the pebbles in May 2009. One fragment was recovered from the hole of a pebble from the group found in room IV 5 in Building B, the other was recovered from the hole of one of the pebbles from room VII 3 in Building D. Analyses carried out at the Directorate of Conservation of Ancient and Modern Monuments, Hellenic Ministry of Culture, demonstrate that these threads were spun from flax fibres (see *Appendice*, p. 119). When weaving on the warp-weighted loom, the warp threads are attached to a loop which is then fastened to the loom weight. The warp-threads are not tied directly through the hole of the loom weight, since this would create too much damage to the threads and would complicate the process of unwinding the warp during weaving. The loop thread has to be strong and smooth, so that the warp threads can pass through the loop without any problem (see **pl. V.1 b**). In general, a linen thread is considered to be most suitable for this purpose: a loop made of wool would break too easily and, because of the scales on wool fibres, would catch on the warp yarn. It is therefore highly possible that these threads are traces of the loop to which the warp threads were attached.

APPENDICE

FIBRE IDENTIFICATION ANALYSIS OF THE SAMPLES 72 M 669 AND 72 M 870, MU AREA, MALIA, CRETE

Christina MARGARITI*

The samples were collected from finds in association with stone loom weights excavated by the French School of Archaeology (archaeologist in charge J.-Cl. Poursat) at a Minoan coastal settlement in Malia, Crete, Greece.[1]

For the purpose of fibre identification several instrumental analytical methods of investigation were applied, namely stereo, optical and scanning electron microscopy. In more detail:

1. Stereomicroscopy

Sample 72 M 669 seems to be made of fibres. The very small dimensions did not allow for any yarn and/ or weave analysis (**pl. 5.2 a**). Sample 72 M 870 is also made of fibres, but no evidence of twisting or weaving was detected (**pl. 5.2 b**). Analysis was performed with an OLYMPUS SZ61 stereomicroscope.

2. Optical microscopy in transmission mode

A small piece of sample 72 M 870 was mounted semi-permanently on a microscope slide and analysed with an OLYMPUS CX41 optical microscope, at 400 times magnification (**pl. 5.2 c**). Study of the longitudinal view of the fibre showed a cylindrical shape and nodular thickening. These morphological features are characteristic of cellulosic bast fibres (such as flax and hemp).

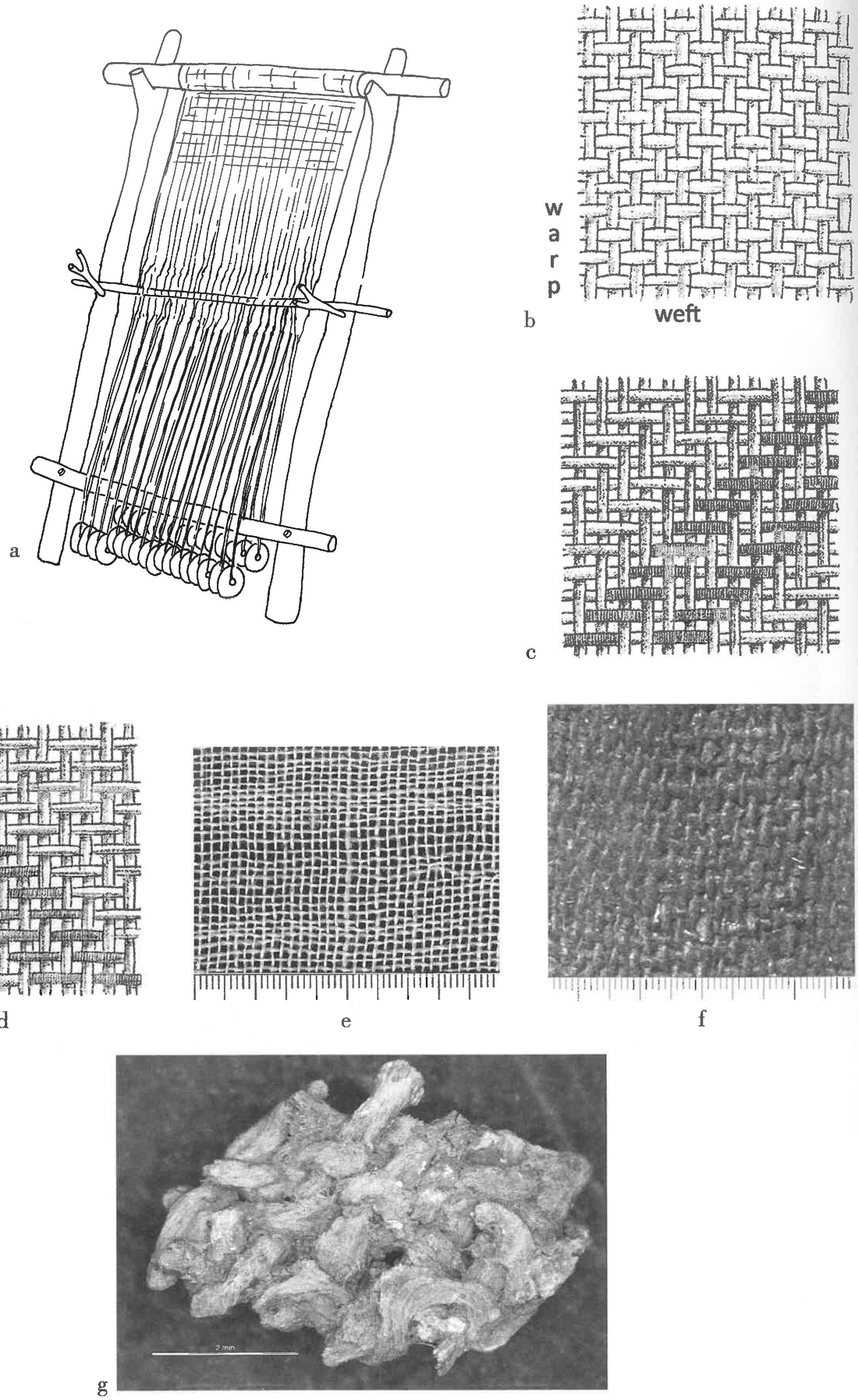
3. Scanning electron microscopy (SEM)

Small fractions of the samples were coated with carbon and analysed with a JEOL JSM-5310 scanning electron microscope. It became evident that both samples are made of the same type of fibres, bearing the characteristic morphological features of cellulosic bast fibres (as mentioned in section 2) (e.g. **pl. 5.2 d-e**). In sample 72 M 870 different diameters were detected ranging from 10-17μm, which indicates the presence of flax rather than hemp fibres (**pl. 5.2 f**).

* Textile Conservator, Directorate of Conservation of Ancient and Modern Monuments / Hellenic Ministry of Culture and Tourism, 81 Peiraios Avenue, 10553 Athens, Greece.

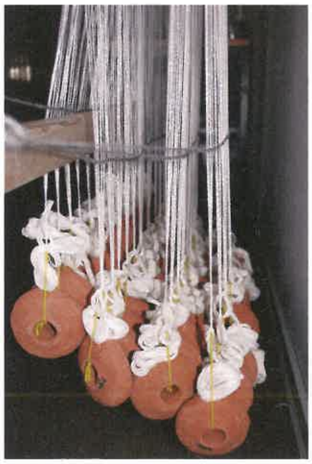
(1) Both samples were found in May 2009 when cleaning earth from the hole of "pebbles" from Building B (72 M 669, room IV 5) and Building D (72 M 870, room VII 3). Date : Middle Minoan II [J.-Cl. Poursat]. For this type of stone loom weights (type 15), see p. 91, 98.

PL. 5.1



Textiles. *a*. The warp-weighted loom with a tabby setup with two rows of loom weights. Drawing by Annika Jeppsson (after Andersson 2003). – *b*. Warp and weft (after Stærmose Nielsen 1999) – *c-d*. Different types of twill – *c*. 2/2 twill – *d*. 2/1 twill (after Stærmose Nielsen 1999) – *e-f*. Two fabrics with the same number of warp threads per cm, but with different thread diameter – *e*. Open tabby (wool), with ca. 6 warp threads and 7.4 weft threads per cm^2, thread diameter ca. 0.5 mm – *f*. Tabby (wool), with ca. 6 warp and 5 weft threads per cm^2, thread diameter ca. 0.9 mm – *g*. Textile fragment (Building A). Tabby (wool?) with ca. 20 threads per cm, thread diameter ca. 0.3 mm.

a



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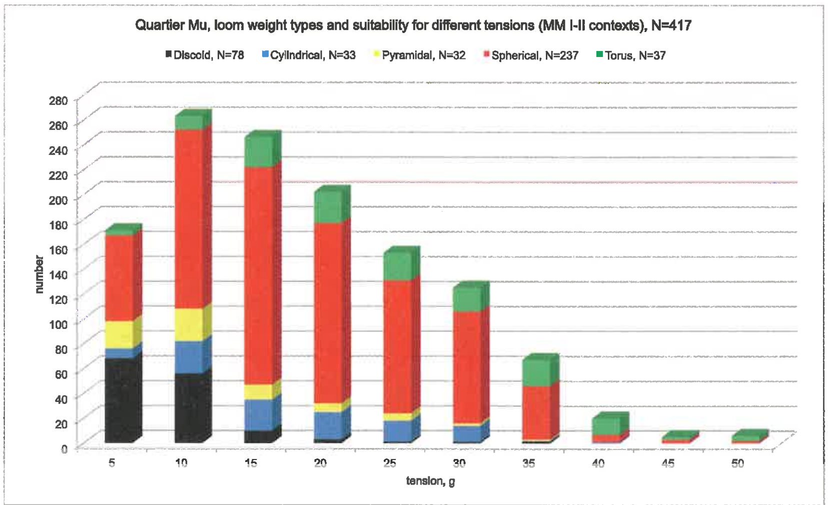
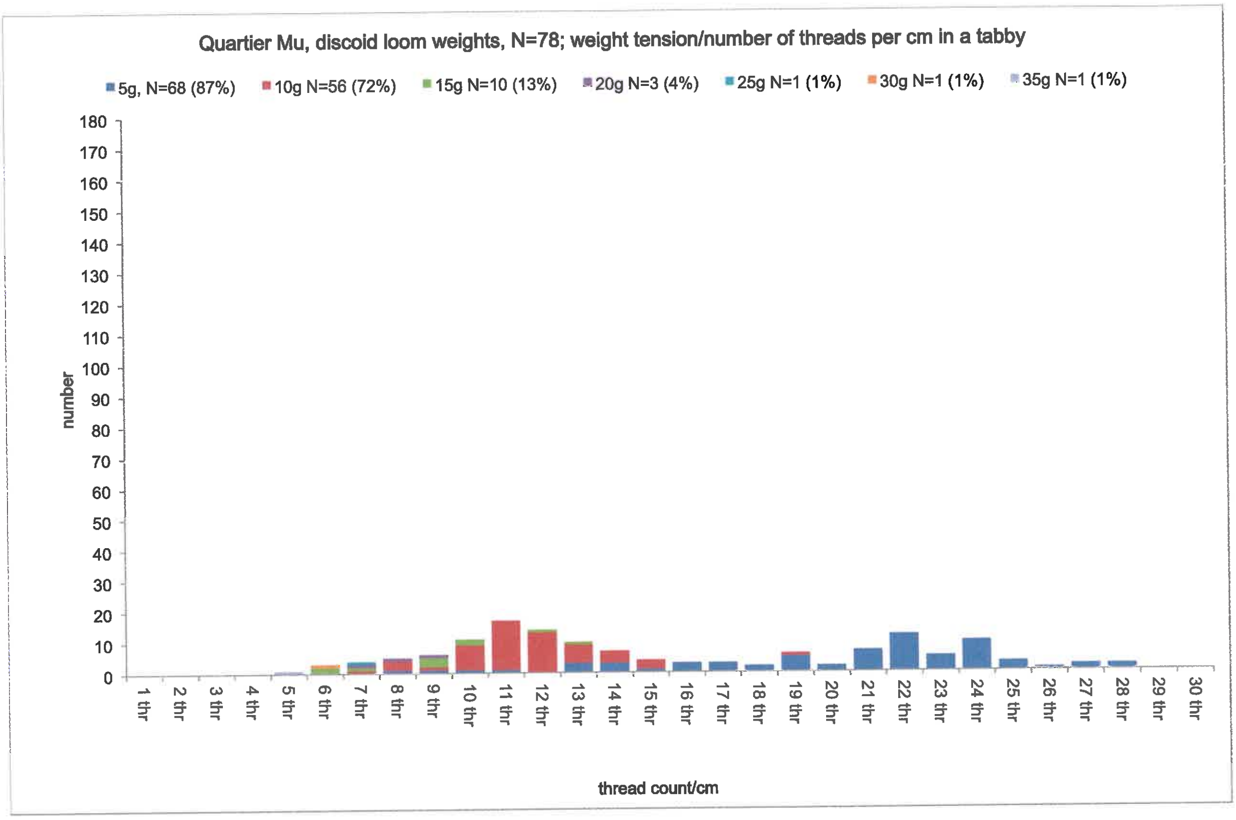
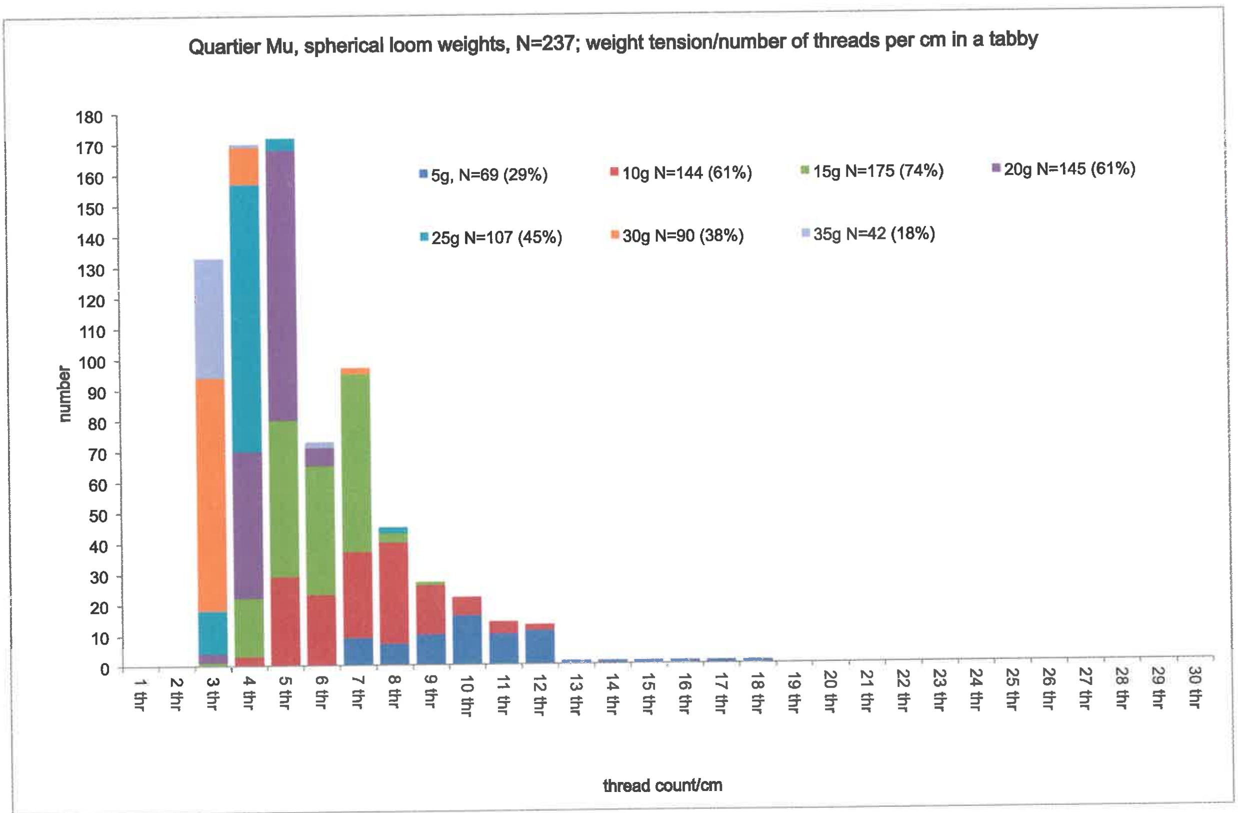


c

a-b. A 2/2 twill weave woven on a warp-weighted loom with four rows of loom weights. The fabric has 15 warp threads and 15 weft threads per cm. Fifteen warp threads are attached to each loom weight – ***a.*** the warp-weighted loom with the setup – ***b.*** the four rows of loom weights. Please note that the warp threads are fastened to a yarn loop that is attached to the loom weight; i.e. the warp threads are not directly attached to the loom weight. (By courtesy of Ulla Lund Hansen and the Vorbasse project, photo by Linda Olofsson).
c. Loom weight types and suitability for use with different tensions, MM I-II contexts (based on the loom weights recovered from the excavated buildings).

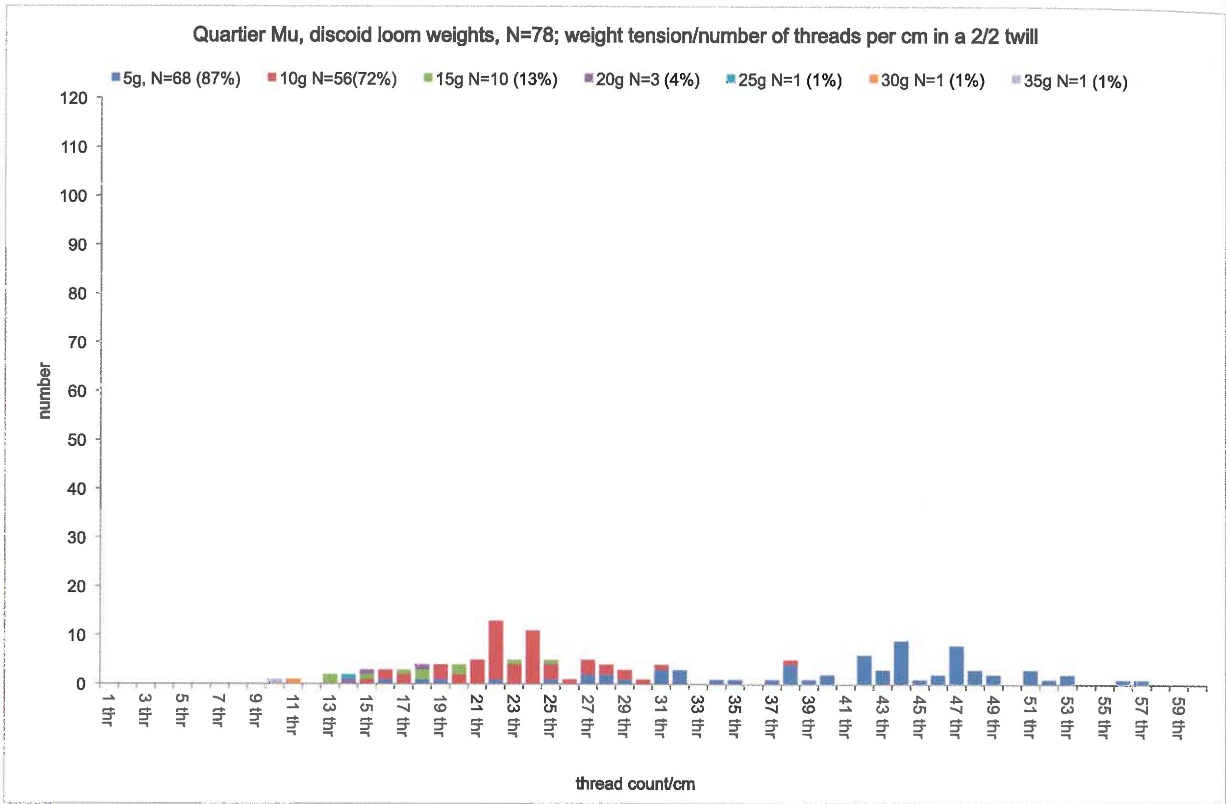


a

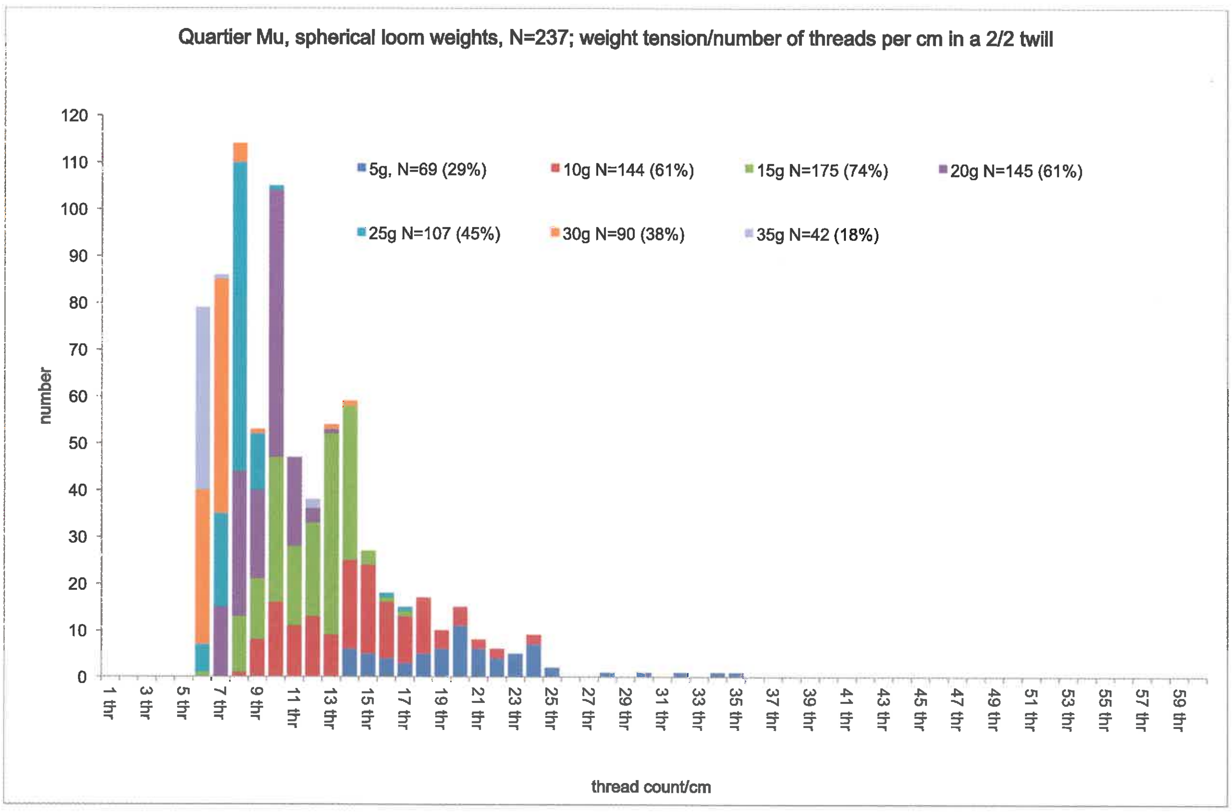


b

a. Discoid loom weights, MM I-II contexts: thread tension and the resultant thread count per cm in a tabby weave.
b. Spherical loom weights, MM I-II contexts: thread tension and the resultant thread count per cm in a tabby weave.

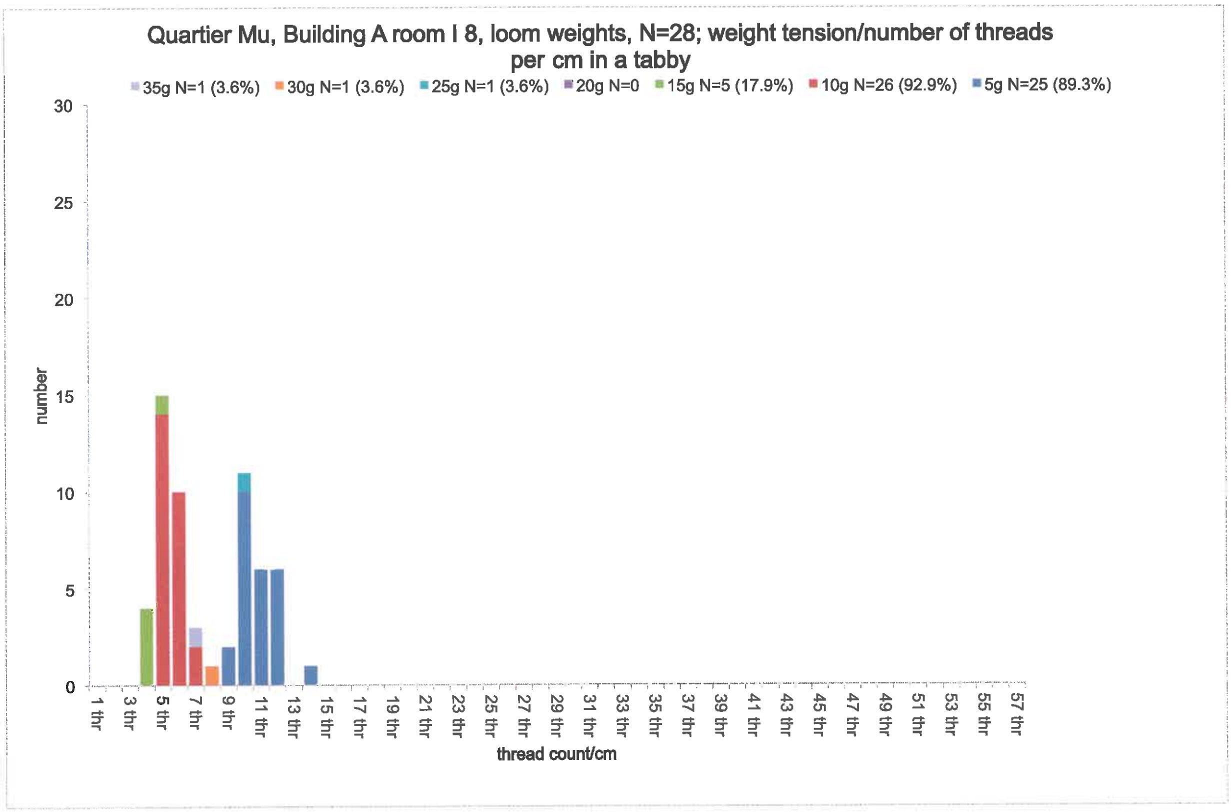


a



b

a. Discoid loom weights, MM I-II contexts: thread tension and the resultant thread count per cm in a 2/2 twill.
b. Spherical loom weights, MM I-II contexts: thread tension and the resultant thread count per cm in a 2/2 twill.



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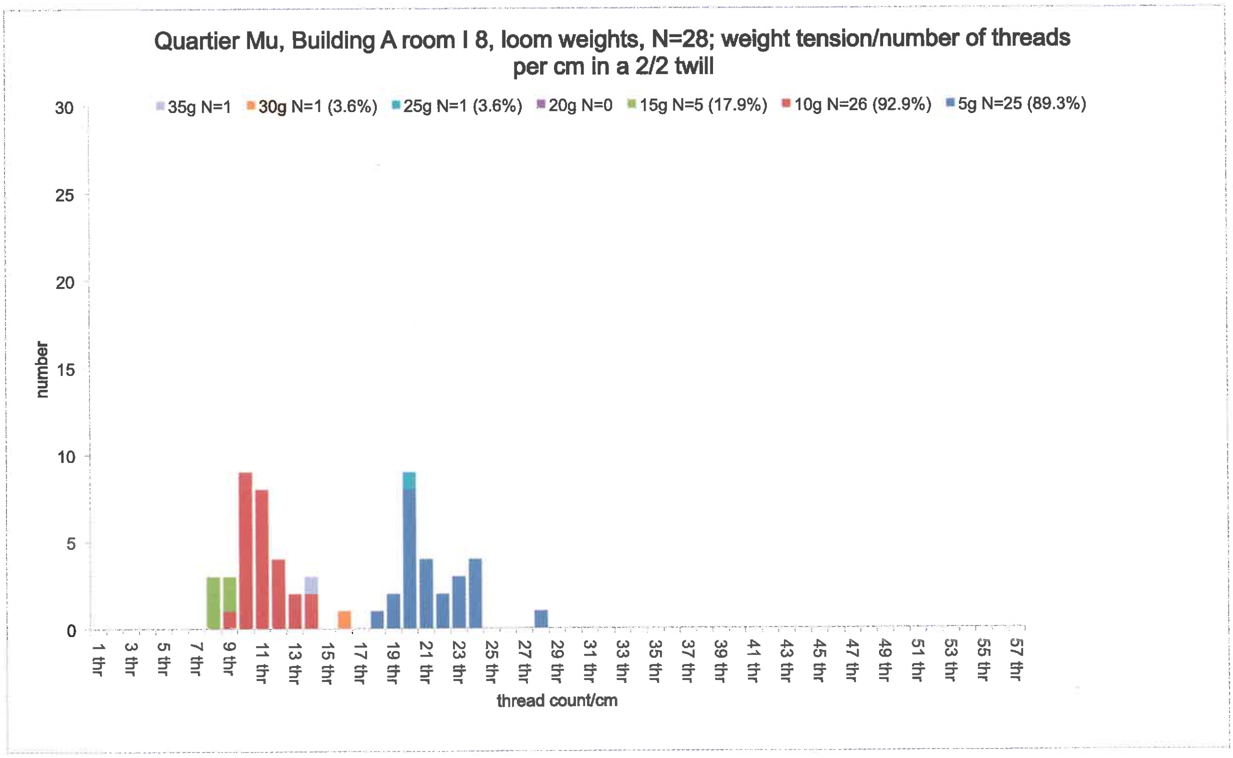
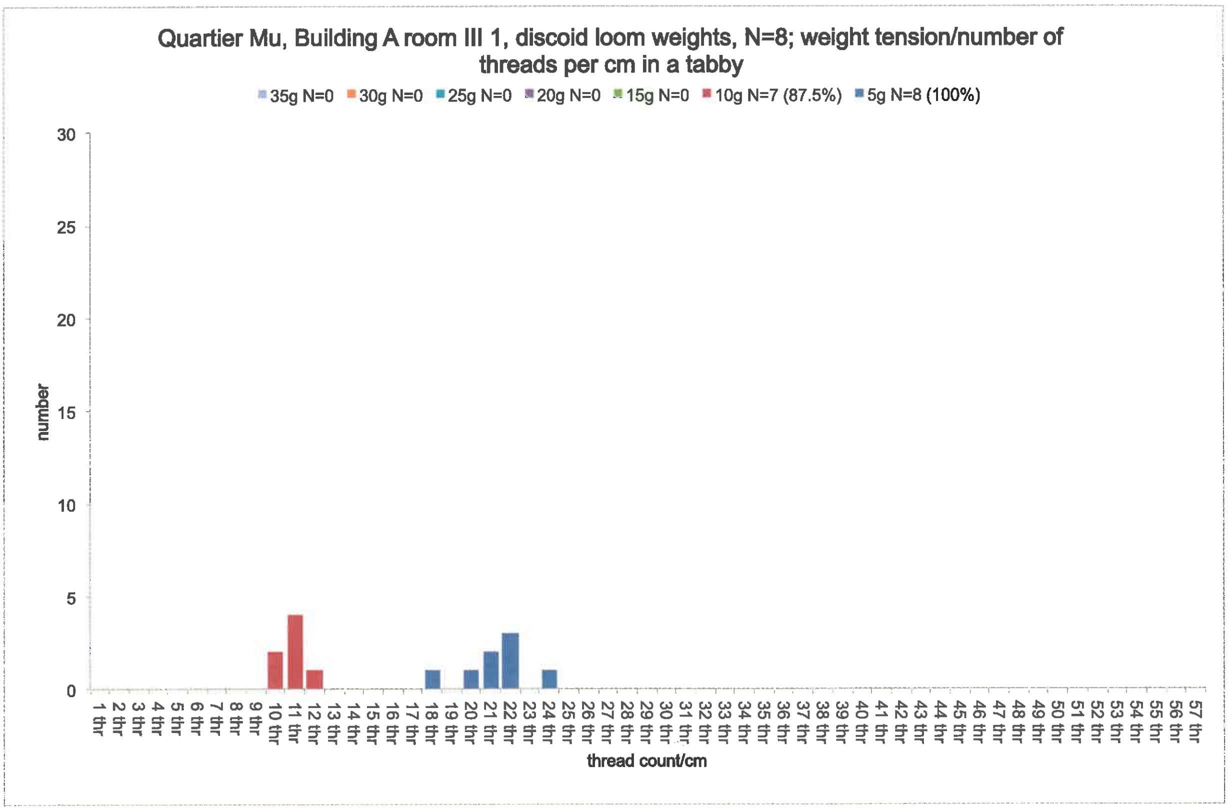


b

Building A, room I 8, MM II, loom weights: thread tension and the resultant thread count per cm. *a*. In a tabby weave. *b*. In a 2/2 twill.



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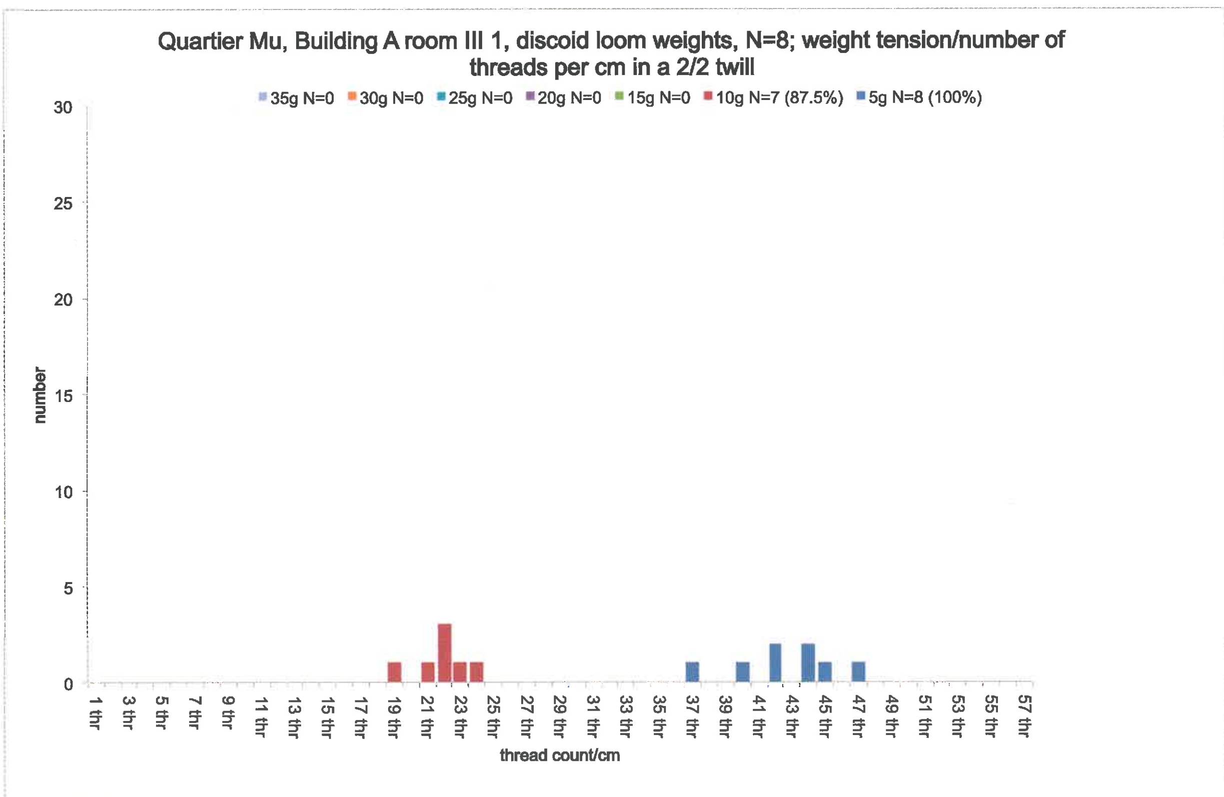
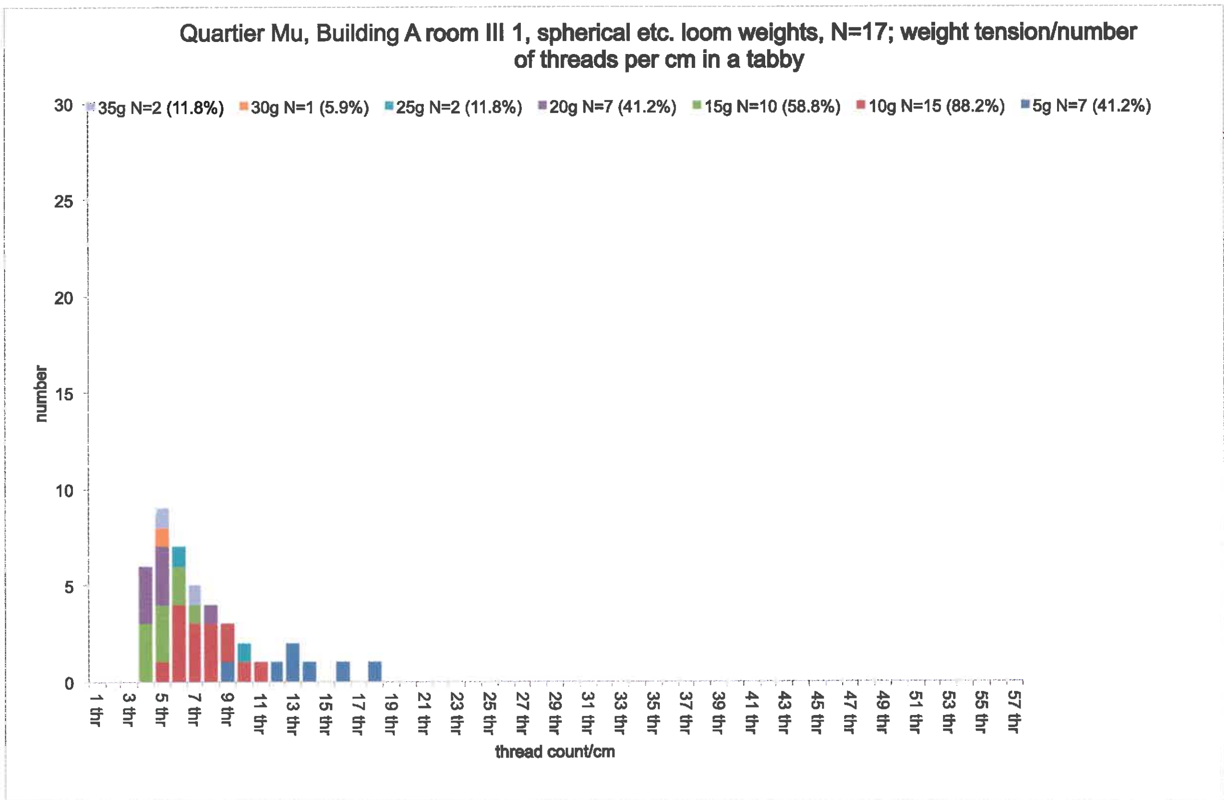
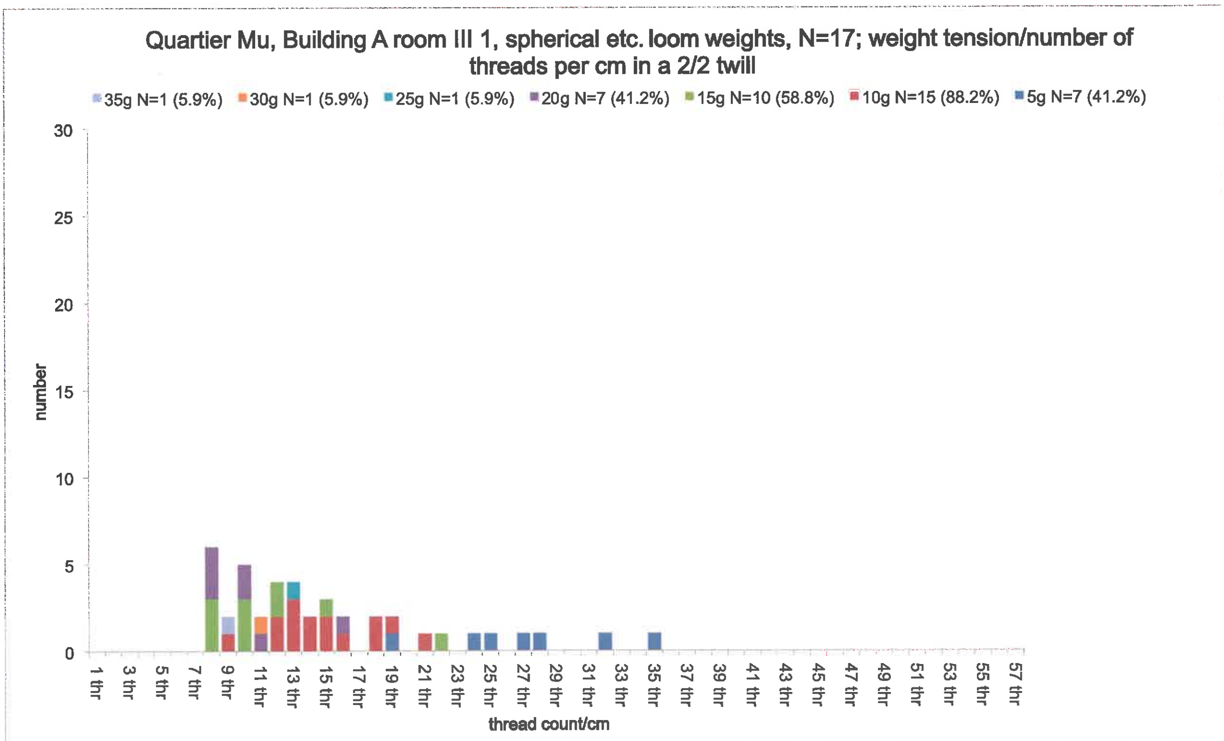


b

Building A, room III 1, MM II, discoid loom weights: thread tension and the resultant thread count per cm. *a*. In a tabby weave. *b*. In a 2/2 twill.

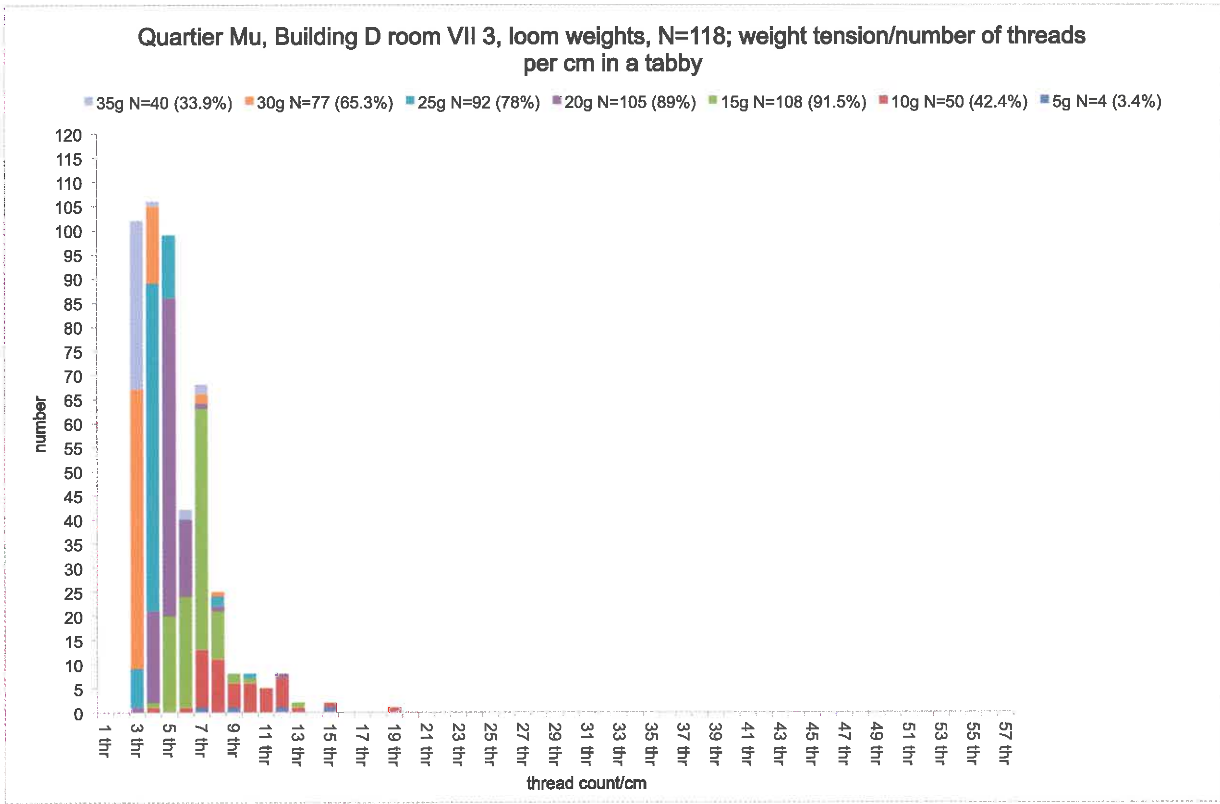


a

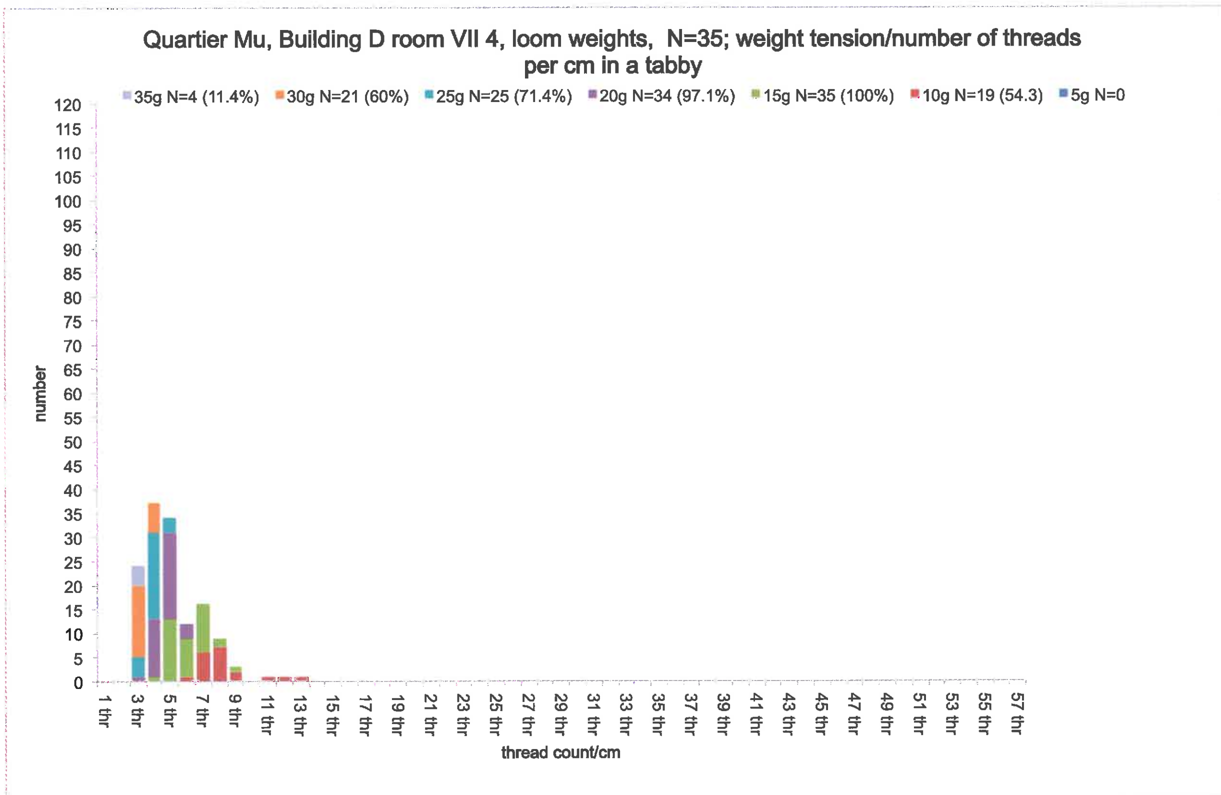


b

Building A, room III 1, MM II, spherical etc. loom weights: thread tension and the resultant thread count per cm. *a*. In a tabby weave. *b*. In a 2/2 twill.

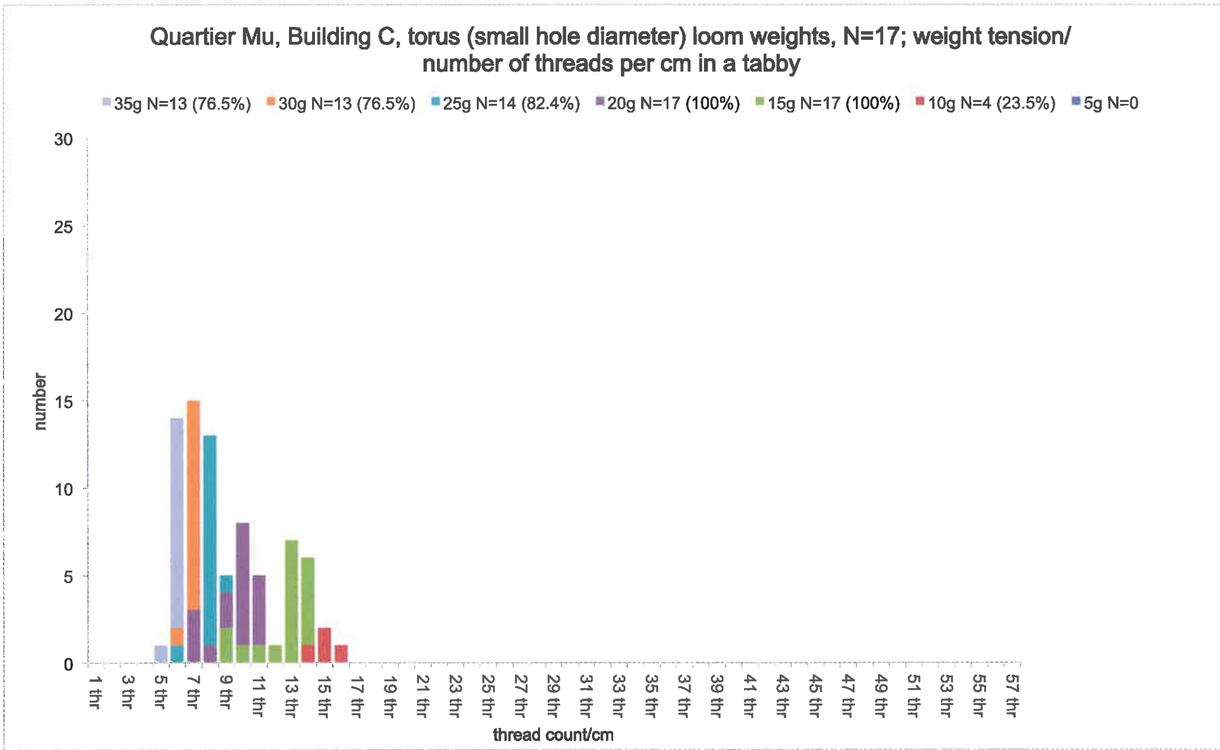


a

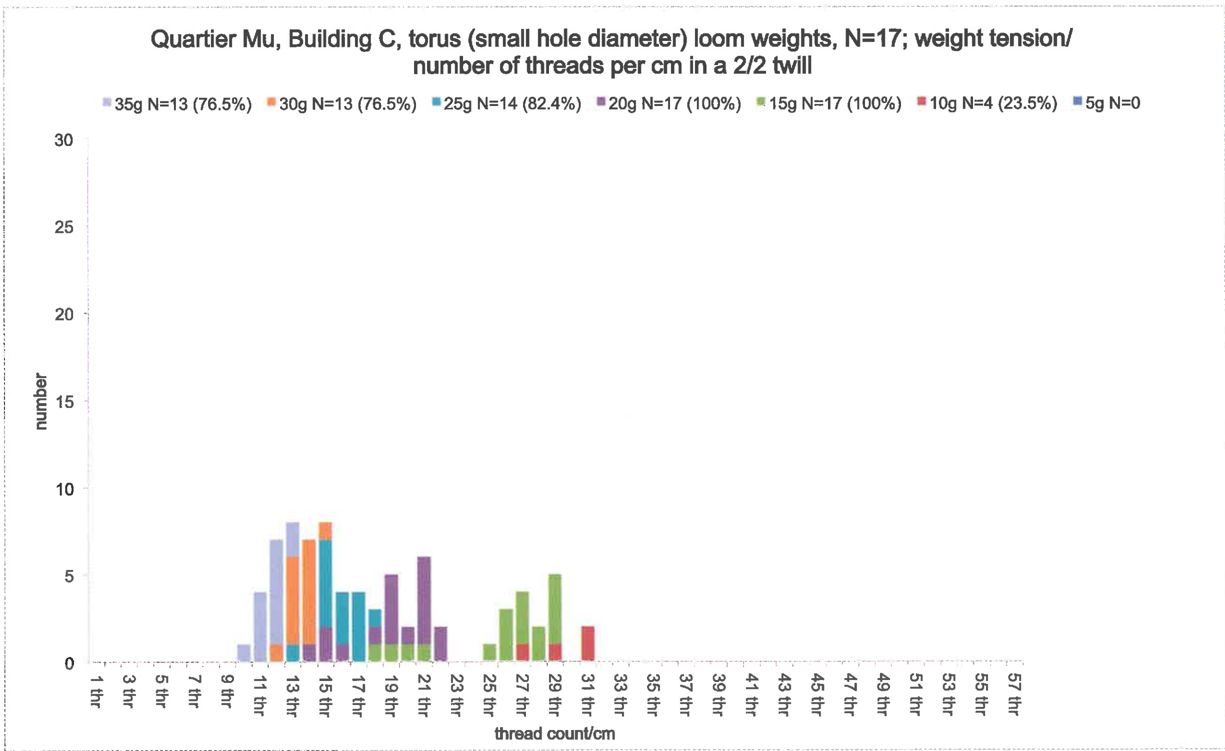


b

Building D, MM II, loom weights: thread tension and the resultant thread count per cm in a tabby weave. ***a.*** Room VII 3. ***b.*** Room VII 4.



a



b

Building C, MM II, torus loom weights with a small hole diameter: thread tension and the resultant thread count per cm. *a*. In a tabby weave. *b*. In a 2/2 twill.