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NOTES ON THE STATISTICAL ANALYSIS OF SOME LOOMWEIGHTS FROM POMPEII

1. Introduction

Within the archaeological record there are many types of artefacts that attract very little attention even in the specialist literature. Generally this is because they are utilitarian items whose basic forms remain unchanged for centuries. As such they are neither useful for dating purposes, nor sufficiently attractive in themselves to generate interest from an art historical point of view. Yet even these apparently mundane items can provide useful information about the people who made and used them if analysed appropriately. It is the aim of the present paper to take just such an apparently unpromising item, and show how statistical analysis can provide useful information. The type chosen to illustrate this here is the loomweight, using data derived from the excavations in Insula VI.I, Pompeii, but the methodological approach could be applied to many other apparently mundane and "uninteresting" types.

Initial statistical analysis on the weights of the loomweights was undertaken in the field. Somewhat to our surprise the distribution of the weights appeared to be distinctly bi-modal. Subsequent analysis, reported here, appears to confirm this and, additionally, suggested patterns in the data associated with the shapes of the base and top of the loomweights. Full interpretation of the results in cultural and archaeological terms has to await the full analysis of the stratigraphy, but it is possible to advance some preliminary conclusions and these are offered in our concluding discussion. The focus of the present paper is on the statistical methods used to reach our conclusions about the loomweights. The aims of the paper may be summarised as follows:

a) The use of simple, and not so simple, statistical techniques is illustrated on a body of material that many might regard as unpromising, with the aim of showing what can sometimes be "teased out" of such data.
b) Rather more analyses than are strictly necessary to make our case are shown. This is deliberate. Apart from illustrating how our thinking progressed we want to illustrate different methods in sufficient detail to provide ideas for other researchers faced with similar data for other classes of object. This is related to the next aim.
c) All our analyses were undertaken using the powerful open source `R` system. This will be familiar to many readers of «Archeologia e Calcolatori», but perhaps not all. For the benefit of the latter, the appendix discusses the functions used in sufficient detail to allow interested readers to emulate our analyses. Mathematical detail is deliberately avoided, but references are provided that direct the reader to the necessary statistical theory.

d) Finally some preliminary interpretations are offered, some rather speculative. This paper is mainly about identifying patterns for a particular class of artefact. We are not aware that loomweights have been studied in the detail we go into before, so the paper may be of interest for this reason alone. Ultimately, however, it is the interpretation of the patterns observed that is important.

2. Data

Loomweights were used on warp-weighted looms to hold the warp thread under tension (Wild 1970, 61-65; Ciarallo, De Carolis 1999, 146, n. 140). Functionally their most important feature is their weight, as the front and back threads need to be kept under the same tension (Hoffman 1964, 42). In the archaeological literature there is a tendency to describe any weight with a perforation near the apex as a loomweight. Some authorities have argued against this, noting that they could have been used for other purposes and that much stricter criteria need to be in place before such an identification can be made (see for example Castro Curel 1985). Fortunately the examples in this study can be identified as loomweights with some degree of certainty as they are of the same type as those found *in situ* with the carbonised remains of what was interpreted as a loom in a portico of a house at Herculaneum (Maiuri 1958, 430). Whilst noting that some could have had other purposes, in this paper the objects will be referred to as loomweights for convenience so that the term "weight" may be reserved for use when aspects of how much the items weighed are being discussed.

The data in this paper are derived from examples recovered during the excavation of Insula VI.1 by the Anglo-American Project in Pompeii. This insula lies by the Herculaneum Gate and was one of the earliest areas stripped of volcanic debris in the late eighteenth century. It includes the famous House of the Surgeon (Casa del Chirurgo) as well as the House of the Vestals (Casa delle Vestali). Some of the wall and floor decorations were removed when it was originally excavated. The erosion it has suffered in the two centuries since then, including damage caused during the Second World War when it was hit by a bomb dropped by the Allies, means that very few of the original floor surfaces present at the time of the eruption in AD 79 now survive. This has enabled the project to excavate the insula within and around the standing walls to uncover its history from the fourth century BC when occupation commenced, up to the eruption (for a general account of the project see Jones, Robinson 2004a; Jones, Robinson 2004b provide a more detailed consideration of one area of the insula).

The excavations were concluded in 2006 and post-excavation analysis is now ongoing. During the 2007 season of work, 150 complete and fragmentary fired clay weights were recorded from the insula together with four from trial

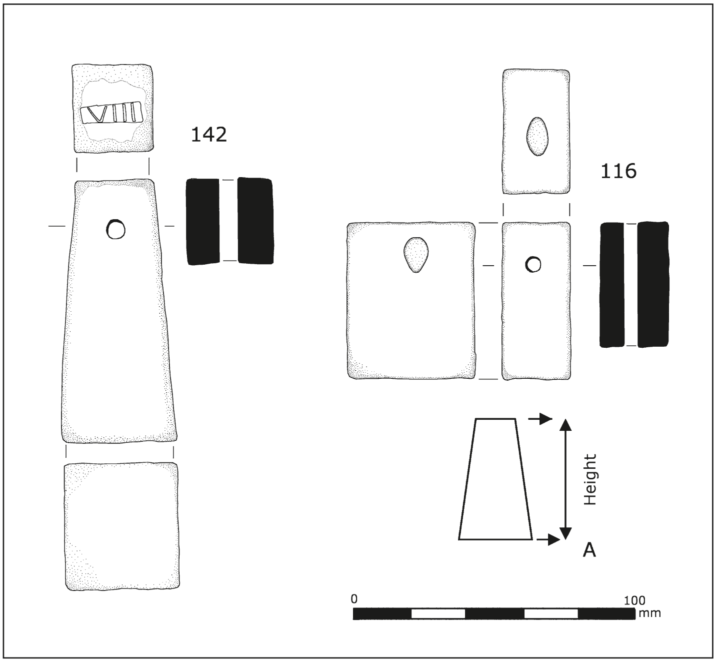

Fig. 1 – Examples of the ceramic loomweights discussed. Diagram A (not to scale) shows how the height was measured using the offset method.

excavations undertaken by the project in Insula V.2 in 2005. Most of the loomweights were of the typical truncated pyramidal form with a perforation running through the upper part (Fig. 1, n. 142). A small number had a pronounced square outline with a rectangular cross-section (Fig. 1, n. 116). A minority had been decorated generally with one or more circular dimples impressed or cut into the upper surface, but cross patterns and stamps were also present. The decoration on the upper part was always made before firing. Occasionally there were hollows on the bases but these had been cut after the item had been fired. Loomweights such as these were very common in the Mediterranean area for a long period. In Greece they are recorded from at least the eighth century BC (Davidson, Thompson 1943, 73), in Iberia they are recorded from the sixth century BC onwards (Castro Curel 1985, 232, fig. 3) whilst in Languedoc examples have been found from the fourth century BC (de Chazelles 2000, 121). Their use continued into the Roman Imperial period (Fig. 1).

Though loomweights were found throughout the insula, they showed a marked concentration in the area occupied by the Casa del Chirurgo. Stratigraphic information is not yet available for all parts of the insula, but fortunately the analysis for the Casa del Chirurgo is almost complete. This indicates that the loomweights were being regularly recovered throughout the stratigraphic sequence, from the earliest contexts up to those of the mid first century AD.

The protocol followed in recording them was that the loomweight was measured on scales that were accurate within 2 grams. The height and the measurements of the base and top were recorded to the nearest millimetre. Some of the tops and bottoms had rounded junctions with the sides rather than the edge being sharp. In such cases it was not always easy to see precisely where the edge should be measured. This problem was most marked on the tops of the smaller weights with the larger ones tending to have more sharply marked edges; but sharp edges did occur on small weights and rounded ones on larger. Given this uncertainty, if the top (or bottom) appeared to be square only one measurement was taken. If the section appeared to deviate from the square two measurements were taken.

After the initial recording when preliminary analysis suggested the weight of the pieces was bimodal, the height of all the complete loomweights was re-measured using an offset method (Fig. 1, A) to ensure consistency. Again it was not always possible to be entirely accurate as some bases were slightly rounded and did not sit flat. It will be appreciated that there is measurement error on all aspects of the data, but in the worst case scenario we estimate that this should be no greater than approximately 3 millimetres or grams. In what follows only the 95 complete loomweights are discussed. They were considered to be complete if they retained all of their edges. Minor chipping was ignored.

3. Statistical Analysis: results

3.1 *One-dimensional analyses of weights*

The histogram is a common choice for initial exploration of continuous data. The left-hand panel Fig. 2 shows our first attempt at this. There is apparently nothing unusual about the data, apart from some untypical small and large weights.

Default interval widths (bin-widths) were used giving rise to eight bins of equal width, 100 g. Our experience is that defaults in software often tend to over-smooth data. The right-hand panel of Fig. 2 shows a histogram using subjectively determined bin-widths of 25 g, with a kernel density estimate (KDE) superimposed.

This figure suggests that the data are bimodal. Before seeking an archaeological interpretation for this, confirmation of the “reality” of the effect was sought. There are six unusual weights, one very small and five greater than 400 g. For some subsequent analyses these are removed, and we shall refer to this as the “modified” data set.

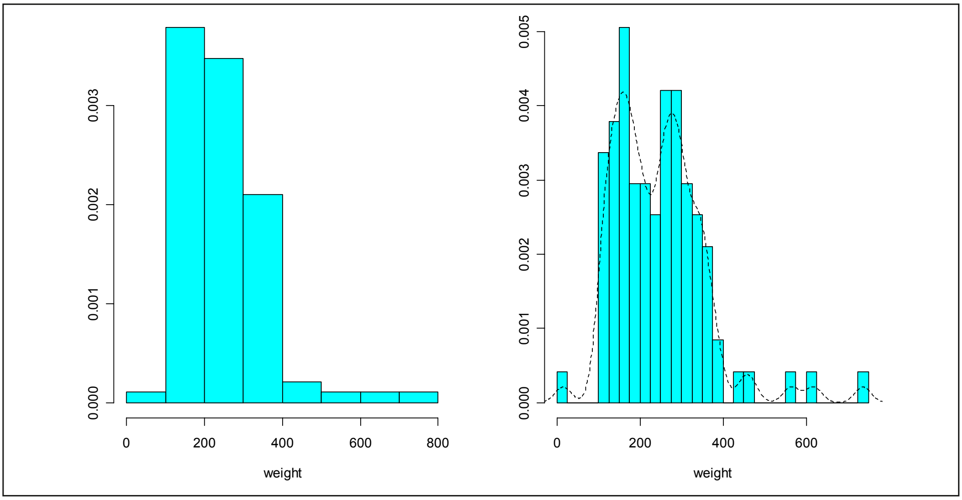

Fig. 2 – Two histograms using different bin-widths that show the distribution of weights of loom-weights from Pompeii. That to the right suggests the distribution is bimodal.

The KDE suggests that the modified data, excluding the six extreme values, can be approximated well by a mixture of two normal distributions. The software used to do this allows for a test of the number of normal components in the mixture, and provides estimates of the means and standard deviations of the components as well as the graphical representation shown in Fig. 3, which is based on the modified data.

The analysis confirms that a two-component normal mixture is optimal, and that these can be taken to have equal standard deviations, estimated as 41.5. The estimated means are 166.0 and 300.7, with 45 and 44 cases classified to the two groups. Cases with weights 230 g or less are assigned to the first group and cases with 239 g or more to the second group; the anti-mode in Fig. 3 is at about 235 g. This gives groups of size 46 and 49 if the rule is used to classify all the weights.

3.2 *Two-dimensional analyses: weight and height*

A quick way to look at the data (using all the loomweights) is to look at all possible bivariate plots, as in Fig. 4. In general the variables are positively correlated, as we would expect, though not strongly so in some cases. The largest correlation in the plots shown, of $r = 0.82$, is between weight and height, and for further analysis this will be the initial focus of attention (base *area* has a higher correlation which we discuss later). The patterns evident in the maximum and minimum dimensions of the top and bottom are also discussed later.

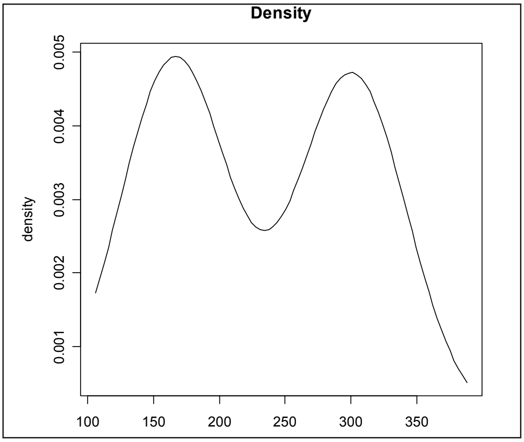

Fig. 3 – An estimated two-component normal mixture for the weights of the loomweights.

Fig. 5 is similar to the right-hand panel of Fig. 2 but for height (using bin-width 5 and bandwidth 18). This also shows bimodality. Fig. 6 is a plot of height against weight using the modified data, labelled according to the classification suggested by the mixture analysis for weight. Some weights could be reclassified to group 2 on the visual evidence. We return to this later.

It is possible to fit two-dimensional KDEs to the modified data and display the results in various ways, as in Fig. 7, which all suggest two main concentrations of data. Usually only one of these plots would be needed, but they are all shown for illustration. The plot of choice can be customised if desired. In Fig. 8, for the contour plot, the limits of the axes have been changed; the number of contour levels has been modified and labelling of the levels removed; and the contours have been overlaid on the plot of the data.

Visually the plots suggest a mixture of two bivariate normal distributions. Two (ellipsoidal) normal distributions of equal volume and shape, but different orientations, are adequate to describe the data. Different methods of displaying the results are shown in Fig. 9.

The upper left plot is of the Bayesian Information Criterion for different possible models, and is used to select the number and type of normal distributions fitted. The classification plot suggests, visually, that there are possibly three points allocated to the lower-left group that might better sit with the upper-right group. The larger dots in the classification uncertainty plot identify cases for which the classification is least certain; there are five "intermediate" cases here. The ellipses on the two plots correspond to the covariances of the components. By comparison with Fig. 6, there is a slight change (three cases) from the classification obtained when only weight is used.

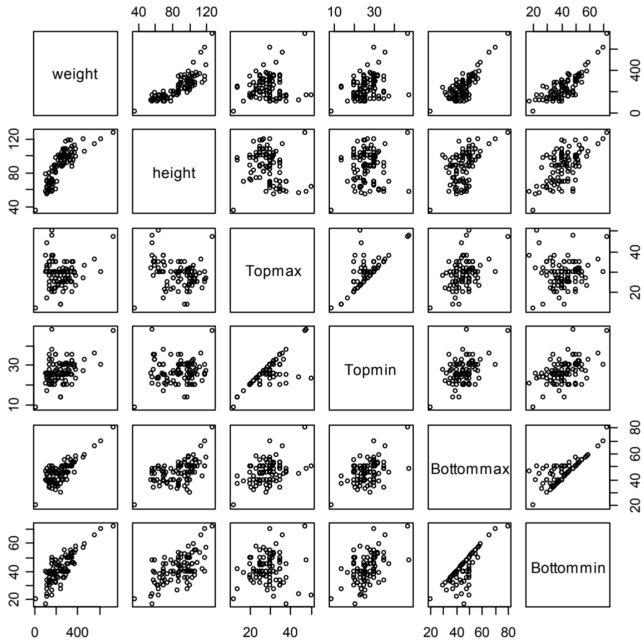

Fig. 4 – A "pairs" plot for six variables that characterise the loomweights, showing all possible bivariate plots. The upper triangle of plots is the same as the lower triangle, except that axes are interchanged. Treating the base and apex of the weights as rectangular, Topmax is the length of the larger sides of the rectangle at the apex and Topmin relates to the smaller side. Bottommax and Bottommin refer to similar dimensions for the base.

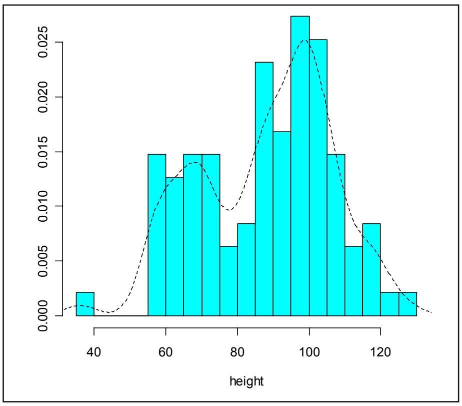

Fig. 5 – A histogram for the heights of the loomweights with a kernel density estimate superimposed.

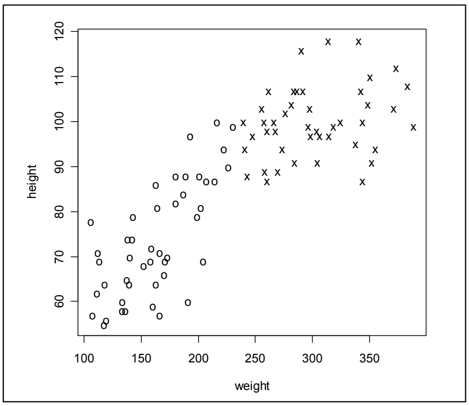

Fig. 6 – A plot of height against weight, with cases labelled by the classification suggested by the mixture analysis.

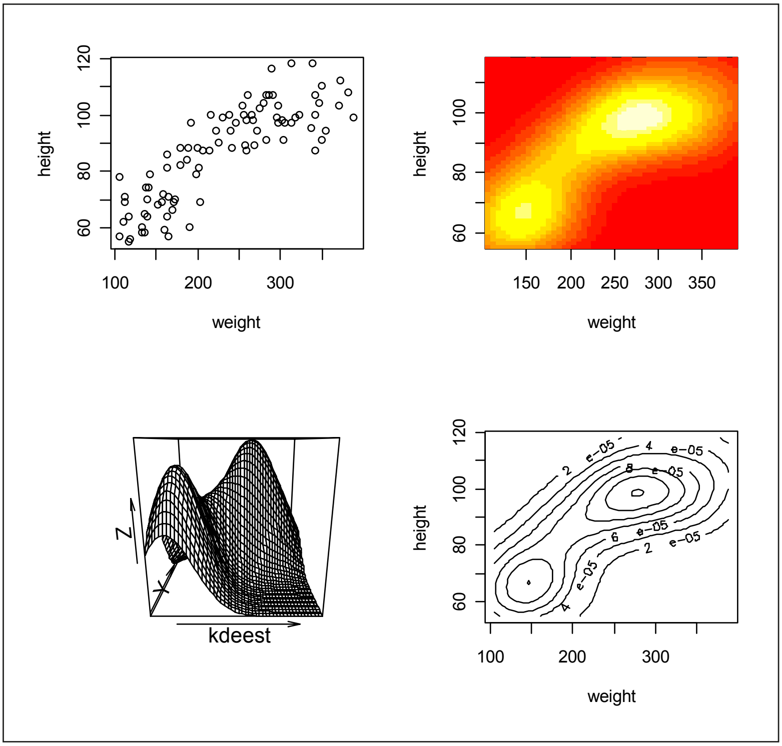

Fig. 7 – Different ways of displaying the relationship between height and weight. The raw data is to the upper-left; an image plot is to the upper-right; a perspective plot is to the lower left; a contour plot is to the lower-right.

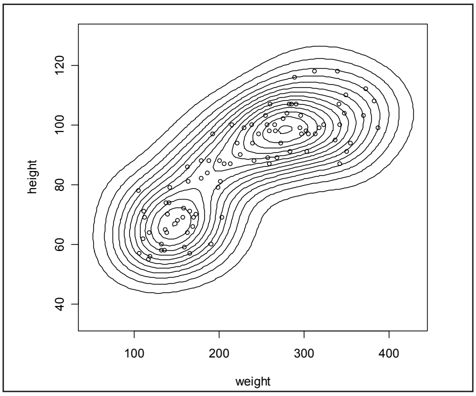

Fig. 8 – A customised version of the contour plot shown in Fig. 7.

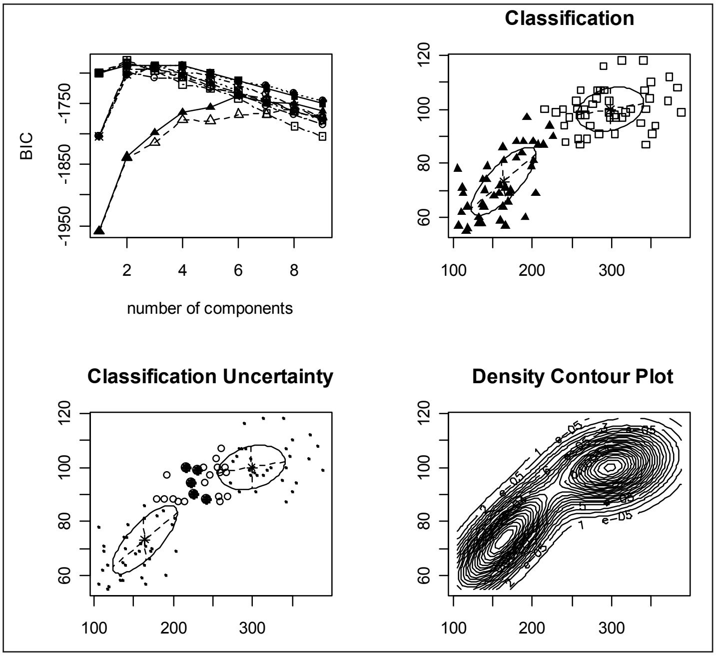

Fig. 9 – Assuming that the height/weight data can be modelled using a mixture of bivariate normal distributions, this figure shows different ways of displaying the results.

3.3 *Other dimensions*

Returning to Fig. 4 it can be seen that the plots of the maximum and minimum dimensions for the bottoms and tops of the loomweights show distinctive linear features. These correspond to loomweights where the top or bottom was square. For non-square bottoms the minimum difference between the two sides was 2 mm – in two cases – but usually exceeded 5 mm. For non-square tops, which are smaller than the bottoms, there were more instances of small differences in the dimensions, including one of 1 mm.

Fig. 10 shows a plot of the maximum to minimum ratios for the tops against those for the bottoms. The plot has been jittered – that is each point is displaced by a small random amount – so that the "blob" in the (1, 1) position corresponds to the 52 of the sample with square tops and bottoms.

The 8 cases vertically above the (1, 1) position have square bottoms and rectangular tops, with the reverse the situation for the 13 cases horizontally along from the (1, 1) co-ordinate. The dashed line is that on which points would fall (ignoring jittering) if the ratios were the same for both top and bottom. There are 22 loomweights that have neither a square bottom nor top. More than half are close enough to this line to suggest that a deliberate attempt might have been made to have the tops and bottoms *exactly* identical in shape. The dotted line corresponds to the situation where the ratio for the bottom is 1.5 times that for the top. Most of the remaining cases lie close to this line (we emphasize that, given the numbers involved, these observations are tentative).

If the ratio of the ratios is computed it should be close to 1 if the tops and bottoms have (almost) the same shape; 65/95 lie between 0.95 and 1.05, which implies that 13/22 of the loomweights noted above are close to having rectangular tops and bottoms of exactly the same shape.

Analyses so far suggest that, on the basis of weight and height, it is possible to divide the loomweights into two size classes. To relate this, if possible, to the shape information discussed above a tentative typology can be suggested which is:

Type 1 = square bottom and top (e.g., Fig. 1, n. 142);
Type 2 = rectangular (non-square) bottom and top of similar relative dimensions;
Type 3 = square bottom and rectangular top;
Type 4 = square top and rectangular bottom (e.g., Fig. 1, n. 116);
Type 0 = other.
There is some suggestion in Fig. 11 that the heaviest of the weights (about > 375 g) tend to be of Type 1.

An alternative way to look at the data is to cross classify by size. For the present purposes we slightly modify the classifications suggested by the mixture models, to take into account visual evidence, and do not separate out the unusual values. Call these classes "Small" and "Large"; the modified classification is shown in Fig. 12. The cross classification gives the Tab. 1.

A conventional chi-squared test gives $X^2 = 15.28$ on 4 D.F. with a *p*-value of 0.0041 (using Monte Carlo simulation give a *p*-value of 0.001). There is thus a clear association between the size-based and type-based classifications.

The type-based classification was derived on the basis of aspects of shape (of bottoms and tops) using ratios that eliminate size effects. That is, the two classifications, while related, were derived independently. The most obvious feature of the table is that all but one of the Type 4 loomweights (square top, rectangular bottom) is "large". Type 0 tends to be "small" but there are relatively few of them. There are more large Type 1 weights than small ones, but given the different groups sizes this is not unexpected; under the hypothesis of no association about 30 would be expected, which differs little from the observed 32.

The chi-squared test can be insensitive to interesting features of the data. As noted from Fig. 11, a disproportionate number of the larger weights are of Type 1 (and possibly 4). This can be seen graphically in Fig. 13. The horizontal dashed line, at 0.55, is the proportion of loomweights with square

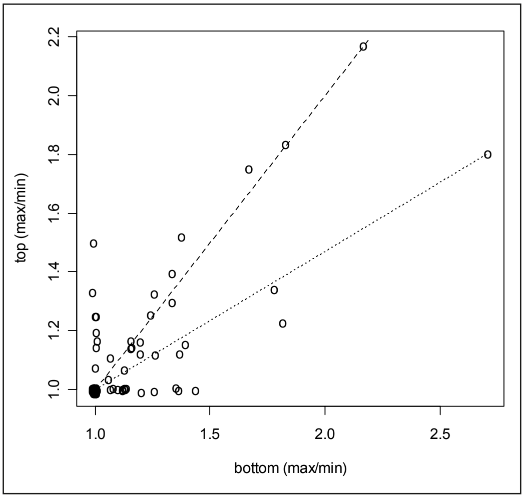

Fig. 10 – A plot of the maximum to minimum ratio of the tops of the loomweights against a similar ratio for the bottom of the loomweights.

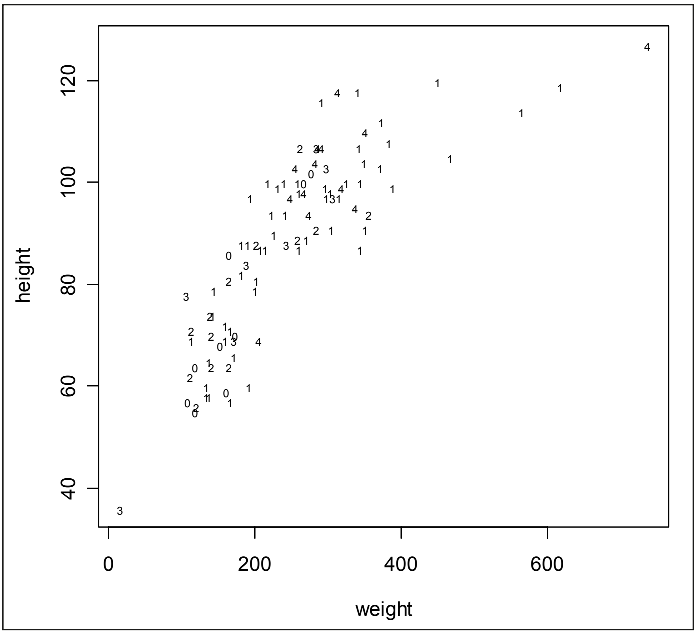

Fig. 11 – A plot of height against weight, labelled according to the shape typology suggested by Fig. 10.

Size	Type					Total
	0	1	2	3	4	
Large	2	32	4	4	12	54
Small	7	20	9	4	1	41

Tab. 1 – A cross-classification of size by shape type, based on the classifications described in the text.

tops and bottoms. Between about 100 g and 280 g (only one weight is less than 100 g) the proportion of Type 1 loomweights greater than any given weight is not markedly different from the proportion in the sample. As the weight threshold is increased beyond 280 g the proportion of Type 1 weights increases, the non-monotonic nature of the increase at larger weights being attributable to Type 4 weights. For example, 72% of the 25 weights greater than or equal to 300 g are Type 1 and 92% are Type 1 or 4.

Some thought was given to the problem of predicting weight from other variables that might be present on damaged loomweights (of which we have 58). A height measurement is not usually available for these, but 34 have complete bases, and consideration was given to using these for prediction, in the form of base area.

For the data set of complete loomweights the correlations of base area and height with weight are 0.88 and 0.82 respectively; for the modified complete data the correlations are 0.73 and 0.84, suggesting that the unusual data are particularly influential for the base area data. Excluding the unusual data the correlation of 0.73 implies that about 50% of the variation in weight can be "explained" by base area (assuming a linear model holds), so that predictions will not be very precise.

This is confirmed by Fig. 14, for the modified data, which shows a plot of weight against base area, with the linear regression line, and a non-linear (loess) smoother superimposed. The latter is very close to the regression line, suggesting that a linear model is acceptable, but the spread of weight values at any give base area is evident. Formal calculation of prediction intervals confirms that they are wide within the relevant base area range, so the aim of prediction from damaged weights using base area was not pursued.

4. Discussion

As mentioned in the introduction, the analysis of the stratigraphy, pottery etc. has not advanced sufficiently for it to be possible to date the majority of the loomweights by their context. In the case of those from the Casa del Chirurgo it is possible to isolate small groups from contexts of different dates. There is a group of five from features and levels that pre-date the building of

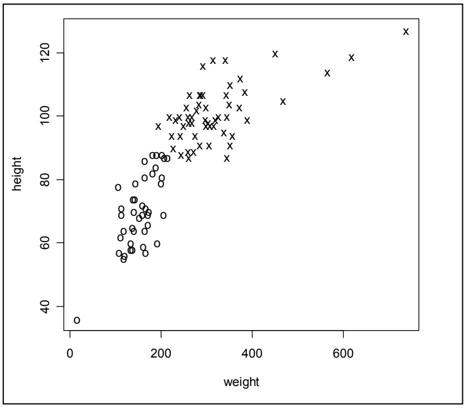

Fig. 12 – Similar to Fig. 6 but using all the data and with a modified size classification.

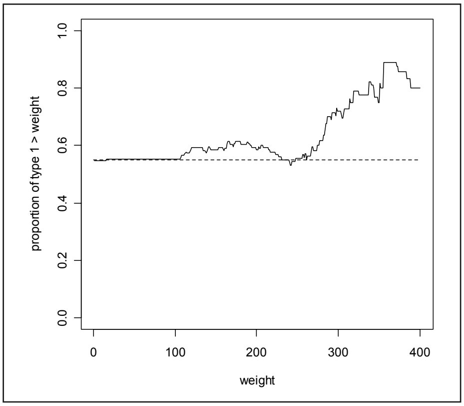

Fig. 13 – A graphic that suggests that Type 1 loomweights, with square tops and bottoms, are disproportionately likely to be of a heavier weight.

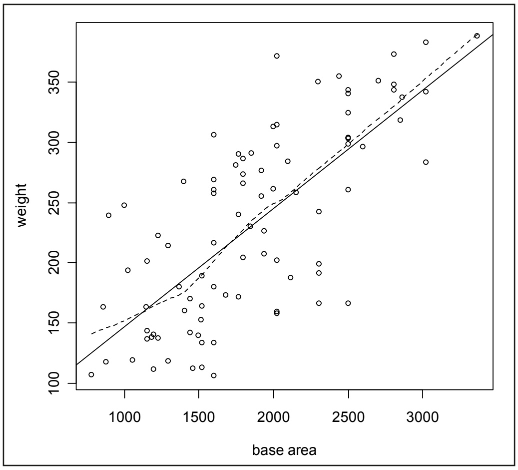

Fig. 14 – A plot of weight against base area, for the modified data that omits unusual data. The solid line is a fitted linear regression used to investigate how well base area can predict height if the loomweight is incomplete. The dashed line is a non-linear smoother. It is close to the regression line, suggesting that more complicated methods of prediction are not required.

the house in *c.* 200 BC. Five were also found in a pit dug to extract building material to extend the *triclinium*. This was re-filled with domestic rubbish dated to about 100 BC. Finally nine can be dated to the mid first century AD

Group	Date	Small				Large			Total
		0	2	3	1	1	3	4	
1	Pre *c.* 200 BC	2	2	-	1	-	-	-	5
2	*c.* 100 BC	-	-	-	3	2	-	-	5
3	*c.* 62-79 AD	-	-	1	3	3	1	1	9
Total		2	2	1	7	5	1	1	19

Tab. 2 – Independently dated loomweights from the Casa del Chirugo.

as they were recovered from make-up and levelling layers below the final floors in the Casa del Chirugo, and in one case was incorporated into such a floor. This phase of rebuilding is believed to have been undertaken between the earthquake, conventionally dated to AD 62, and the eruption in AD 79. These are summarised in Tab. 2 according to the weight and shape types defined above.

We stress that this is a very small sub-set of the data but as can be seen there does appear to be a progression from small to large loomweights with time and a suggestion that what might be called the "non-standard" shapes, i.e. the Type 2 ones with the rectangular tops and bottoms of similar dimensions, and the ones that did not fit into any of the four main types (classified as Type 0), were of early date.

Amongst the Group 2 loomweights (of *c.* 100 BC) there is one large outlier (467 g). The Group 3 loomweights (mid first century AD) include three outliers; the miniature one of 15 g and two large ones (564 and 634 g). The examples which fall into the modified data set are plotted in Fig. 15 (the top left plot of Fig. 7) with the points labelled according to which Group they fall into. As well as labelling the weight axis by modern gram measures (bottom edge), it has been labelled according to Roman *unciae* measures along the top edge. The problems of establishing the precise weight of the Roman pound (*libra*) have been rehearsed by Crawford. Various weights have been calculated ranging from 320 g to 327.45 g (Crawford 1974, 591 and *addenda*). The higher level is normally preferred (e.g. *RIB* II.2, 1-2; *DNP* 5.147). Here we follow Crawford in using a measure of 27 g for one *uncia* (there were 12 *unciae* to the *libra*).

It is known that the Roman pound of this weight was in use in the mid first century in Pompeii because a steelyard has been found there with an inscription that certified it was in accordance to the weight standard established in Rome in the year AD 47 by the *aediles Marcus Articuleianus* and *Gnaeus Turranius* (Ward-Perkins, Claridge 1976, 249, n. 248; Ciarallo, De Carolis 1999, 299, n. 370). The *unciae* scale would thus be suitable for the loomweights of Group 3. In the third century BC, however, it would appear that what constitutes a Roman *libra* was not so stable. At different points during that century the Roman *aes* coinage was based on both what

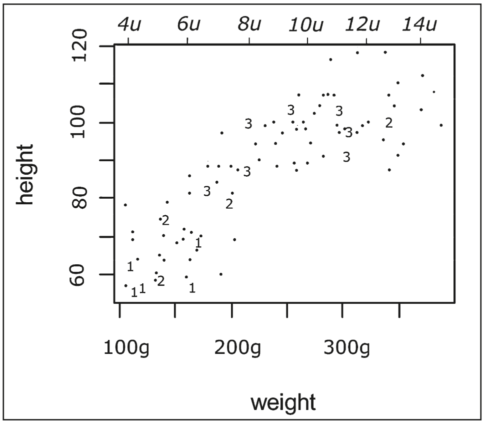

Fig. 15 – A plot of the modified dataset labelled with the Casa del Chirugo groups summarised in Tab. 1.

was to become the accepted Roman pound and on the Oscan pound of *c.* 273 g (SUTHERLAND 1974, 25-27), and Roman measures were not dominant through Italy as they were to be three centuries later. It is thus possible that for the Pompeian makers and users of the Group 1 loomweights, an *uncia* weighed something else (Fig. 15).

Allowing for these problems with calculating the Roman *libra*, it is very noticeable that the third century BC loomweights (Group 1) cluster between 4 and 6 *unciae* and the mid first century AD ones of Group 3 range between 6 and 12 *unciae*, possibly suggesting that their makers were working towards producing loomweights of specific weights and that these changed with time. Considerably more independent dating evidence is needed than that currently available to us, but there is the possibility that the weight of the loomweights might have chronological significance at Pompeii. If there was a shift in the size of the loomweights with time then other questions can be explored such as whether there were changes in the nature of the textiles being produced. The increasing standardisation of the shape with time might also point to an increasing level of centralisation in the production of these artefacts.

If the pattern is reproduced elsewhere in the insula, loomweights may move into the category of find that is chronologically sensitive and, as we noted in the introduction, more attention is always devoted to such finds. More information about them is recorded when they are catalogued and this allows more detailed analysis to be undertaken, so that the artefact can contribute more fully to our understanding of the people who made and used them. In preparing this paper, for example, we have been surprised at how often comparable loomweights have been published without their weights being recorded, yet as we have shown weight is probably the most important element to record.

Finally it is useful to reflect in the light of this paper, that had the analysis stopped after using the default software interval width for the histogram shown in Fig. 2, we would not have uncovered the patterns within the data. We hope that this will encourage others to go beyond the default choices when they too have apparently unpromising datasets like this.

Acknowledgements

We are most grateful to Pietro Giovanni Guzzo, Antonio D'Ambrosio and all their colleagues in the Soprintendenza Archeologica di Pompei for their continued support and encouragement of the Anglo-American Project, and for the permission to work on the artefacts from the insula. The Anglo-American Project is directed by Rick Jones and Damian Robinson and we thank them for inviting H.E.M. Cool to analyse the finds. We are very grateful to Damian and to Michael Anderson (Field Director) for discussions about this material and for providing contextual information relating to the Casa del Chirurgo. A special thanks goes to Kelly Leddington and Katie Huntley who were H.E.M. Cool's assistants in 2007 and who recorded the loomweights. Ms Leddington and Ms Huntley were funded by a grant from the Society of Antiquaries of London, and we are most grateful to the society for their support. We also thank Jessica Billing, Sarah Lloyd and Stuart Ward (students at the field school in 2007) who provided additional assistance. Penelope Walton Rogers most kindly responded to our queries about the use of loomweights and pointed us to literature we were unaware of.

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Appendix

Computational Details

`R` is a powerful open source statistical software system. Open source software is of increasing interest in archaeology (Pescarin 2006); apart from being free, `R` has the additional advantages that many statisticians would regard it as "state-of-the-art", and it is regularly updated. A good starting point is K. Hornik, *The R-FAQ*, available at http://cran.r-project.org/doc/FAQ/. This is updated as newer versions of `R` become available, but the URL is a constant. The FAQ includes information on how to obtain and install `R`, and lists some books available about it.

`R` is currently the software of choice for many applied statisticians. A major strength of `R` is that there are numerous packages developed by such statisticians that can be used for a wide range of statistical analyses – many of them quite specialised. Packages not distributed with `R` are readily downloaded.

For Fig. 2 the histograms were obtained using the `truehist` function from the `MASS` package, associated with the book of Venables, Ripley (2002). This is plotted on a relative frequency density scale, rather than a frequency scale. For the KDE and its superimposition on the histogram, the code in Venables, Ripley (2002, 437) was emulated, using a subjectively chosen bandwidth of 80. This is a bit less than that suggested by the Sheather-Jones estimate (Sheather, Jones 1991) used in Venables and Ripley's example.

For Fig. 3, version 3 of the `mclust` package was used, closely following the examples in Fraley, Raftery (2006, 32-34). Particular use was made of the `Mclust` and `mclustBIC` functions. This paper directs readers to sources that discuss the relevant statistical theory. Venables, Ripley (2002, 437-442) also provide relevant code, partly to illustrate features and functions available in `R`.

Fig. 4 used the pairs function; Fig. 5 is similar to the right-hand panel of Fig. 2; Fig. 6, 10-12 and 14 use the `plot` function with the `text` function used to control plotting symbols, and the `abline` and `lines` functions used to superimpose lines of various kinds. In Fig. 10 the `jitter` function was used to accomplish jittering. In Fig. 14 the regression line was computed using the `lm` function and added to the plot using `abline`; the loess smoother was computed and superimposed following the code given in Venables, Ripley (2002, 230) using the `loess.smooth` function..

Fig. 7 follows the example in the help file for `kde2d` from the `MASS` package, using $n = 50$ for the `kde2d` function and defaults for the `image`, `persp` and `contour` functions. For Fig. 8, in `kde2d`, $n = 100$ was used with upper and lower limits for weight of 50 and 430, and limits of 35 and 130 for height. These need to be set to be the same in the `plot` function for weight against height. Compared to the contour plot in Fig. 7, more levels are used and labelling of contour height is removed. In the `contour` function the argument `add = TRUE` is used to overlay it on the previously created plot.

For Fig. 9 the `Mclust` and `plot.Mclust` functions from the `mclust` package were used exactly as described in Fraley, Raftery (2006, 4-7).

Fig. 13 was produced using a function written by one of us (M.J.B.).

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ABSTRACT

Recent work, in the field, on the dimensions and weights of loomweights from excavations in Insula VI.I, Pompeii suggested – to our surprise – that there was structure in the form of evidence of bi-modality in the weights. The paper has two purposes. One is to illustrate a variety of statistical methods that were used to confirm the validity of our observations. The other is to discuss what the archaeological implications of this might be. A more general point is that if more attention is given to what are often regarded as 'uninteresting' artefacts some interesting results may emerge - specifically, it can be asked whether loomweights have chronological significance for interpreting archaeological sites (at Pompeii at least).