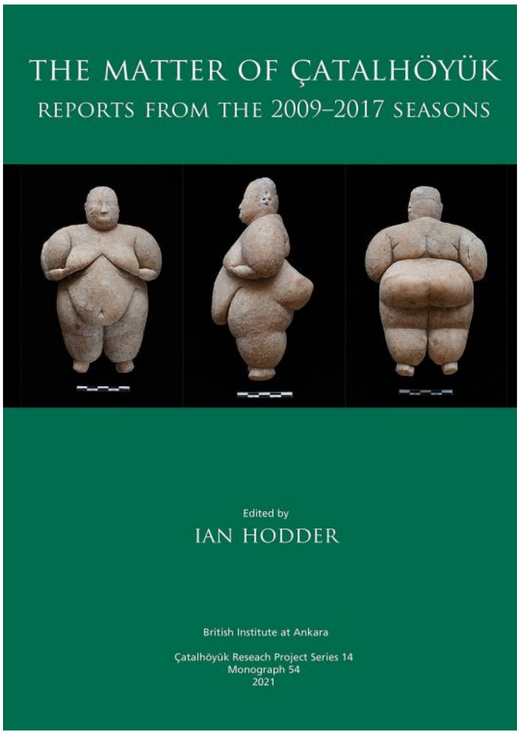
THE MATTER OF ÇATALHÖYÜK
REPORTS FROM THE 2009–2017 SEASONS
Edited by
IAN HODDER
British Institute at Ankara
Çatalhöyük Reseach Project Series 14
Monograph 54
2021

Chapter 16

Data analysis and integration at Çatalhöyük

Ceren Kabukcu*, Dominik Lukas and Camilla Mazzucato

* C.Kabukcu@liverpool.ac.uk

Introduction

The main aim of this chapter is to offer an integrative and generalised investigation of the wide range of datasets collected by members of the Çatalhöyük team. A total of 456 units were selected for study by all participating specialists aiming to provide a broad enough coverage of different context types, areas of excavation and occupation period on the East Mound (for the selection process see Chapter 1). The units selected for study, and the analyses presented here, include units predominantly from the 2010-2017 excavations, as well as some units from previous years. As previous analyses, and current applications by Mazzucato (Volume 15 Chapter 2) provide a far more detailed examination of the spatial patterning in the dataset, our main venues of interpretation focus on examination of patterns in the density distributions by occupation period and context types. Further integrative analyses were carried out on specific context types: midden and fill deposits and floor deposits. A further aim of our examination was to refine and improve data quality on some of the evaluated find categories. To this end, datasets of archaeobotanical remains, representing a mix of fuel, food and food preparation waste were evaluated under three main density categories.

Methodology

We sought to include in our analyses categories of finds reflecting a wide range of activities. For example finds which are used and discarded on a routine basis, such as the remains of food and fuel (e.g. archaeobotanical and faunal remains) were included in data synthesis. Secondly, we included finds which are used commonly across the site, are discarded routinely but tend to be more durable and more curated such as chipped stone and ground stone and lastly, find categories such as pottery, clay objects and figurines, which are normally found in lower densities, but represent unique use and discard activities. Count and weight data for each category were obtained from the specialist databases for chipped stone, faunal remains, ground stone, pottery, clay objects and figurines. Unit volume was calculated by using the recorded flotation volume and calculated sediment volume via the main excavation database, where detailed records of unit dimensions alongside the description of the excavated contexts are entered. Archaeobotanical remains were evaluated differently, as these represent the remains of routinely used fuel, plant food and food preparation waste. The most commonly found residues of fuel waste, wood charcoal and charred dung data were gathered on the basis of volume of charcoal and volume of charred dung per unit (and/or flotation sample). Count data for non-wood remains, to be used in density calculations, were made separately for cereal grain, pulse, nutshell, monocot culm, wild/weedy seeds and cereal rachis/chaff remains. The calculations for these follow the quantification protocol set out by Bogaard and co-authors

(2014; Volume 13 Chapter 5). The density calculations for archaeobotanical remains were made only on the soil volume recorded during flotation processing of soil samples.

Density distributions by context and temporal grouping of levels (i.e., Early, Middle and Late periods) for each data category were first evaluated separately. Following this, we aimed to apply integrative analytical techniques which would enable us to evaluate wider patterns in densities across find groups and how these relate to temporal and spatial patterns observed. The analytical techniques used and the presentation of our results follow previous work closely (e.g. Cross-May 2005; Mazzucato 2013). We chose to employ a predominantly descriptive quantitative methodology (including univariate and multivariate methods) due to the nature of the datasets. In the following sections we will discuss the results of univariate and multivariate analyses, while also providing information on some of our unsuccessful attempts at combining datasets and how these relate to the structure and nature of archaeological datasets. We also sought to understand if any discrepancies exist between count and weight densities for some find categories (e.g. chipped stone, ground stone, faunal remains).

Units included in the study

The units included in the present study reflect a semi-random selection of units across the excavated deposits (for further detail regarding the selection process see Chapter 1). Firstly, a group of units commonly studied by several specialists was included in the study and these consisted predominantly of either in situ and short-term activity deposits (e.g. fire features, floor deposits, clusters) or fill/midden type deposits yielding rich finds in most categories, providing an excellent interpretative potential. In addition, a number of other context types such as burial fills, building infill, building collapse and construction deposits were also selected for study, resulting in a list of priority units to be examined by all participating specialists, including also some units from excavations prior to 2009.

The final list of units selected represents a high number of units deriving from floor deposits and fire features, but at the same time a considerable number of deposits derive from fills (including building infill, bin and pit fills) and middens (see fig. 16.1). In addition a number of units derive from context types such as building collapse, burial fill, cluster and construction deposits (e.g. packing layers of platforms, walls etc.). The categories included in the study, as presented here, reflect an amalgamated simplification of context descriptions, deriving predominantly from the context descriptions provided by the excavators and the assigned context categories recorded in the Excavation Central database. In order to facilitate the quantitative investigation and interpretation of the datasets, we re-classified some context categories under more generalised terms. For example, all contexts comprising the fills of buildings, bins, pits and other types of 'cut' features are included under the fill category. However, we differentiated the burial fill category, as a significant number of units from this context type was also included in the priority units list. Similarly, fire features encompass hearths, ovens, fire spots, and in some cases, the in situ residues of single/short-term burning events (e.g. concentrated residues of fuel waste). Floor deposits encompass predominantly internal floors, but also include the floors of platforms, and in some cases floor deposits from external (e.g. courtyard/open area) contexts.

Amongst the studied units, the great majority derive from units from Levels South O and North G, some from South K and North F. The remainder of the units include a few from most other occupation periods at the site (see fig. 16.2). When these units are categorised according to the occupation period - more units belong the Middle period group, while there is still an even representation of units from Early and Late periods (see fig. 16.3). By area of excavation, more of the units examined come from the South area when compared to the North Area, and some derive from the TPC Area (see fig. 16.4).

Density distributions of find categories

Previous work on the datasets from Çatalhöyük revealed that the frequency distributions of densities of various find categories examined followed a typically right-skewed distribution (Cross-May 2005; Mazzucato 2013). In other words, across several of the find categories examined, the greater majority of the units had low (and very-low) density figures and much fewer units had higher density figures; often much higher than the group average. As the density distributions of faunal remains, ground stone, chipped stone and clay objects show (figs 16.5, 16.6, 16.7 and 16.8), the datasets contain very few units with unusually high concentrations of finds, and this situation holds true independent of whether density calculations are made on counts per litre or total weight of the finds per litre. Thus, the observed distribution patterns are unlikely to be the result of fragmentation during and after deposition of specific categories of finds. Additionally, all of the data categories mentioned thus far have been remains not reliant on burning and carbonisation for preservation. Interestingly and despite differences in taphonomic pathways, archaeobotanical remains which are preserved in a carbonised state, including wood charcoal and non-wood plant remains also follow a similar right-skewed distribution (figs 16.9 and 16.10). This type of distribution in the archaeobotanical remains is most prominent in wood charcoal, as it likely represents the waste from fuel use, and wild/weedy seeds and cereal rachis/chaff remains.

When evaluating density distributions by context type it is evident, particularly in some find categories that activity types are one of the defining factors behind the great range of variability observed in the right-skewed distributions. For example, when examining plant remains, particularly those deriving from fuel waste, rare deposits with very high densities are found in fire features and some cluster units (fig. 16.11). In such contexts, similar to the rest of the excavated deposits, density values are generally low, but rarely very high densities are also observed. On the other hand, non-wood archaeobotanical remains show a similar rare occurrence of high density in ‘cluster’ units (figs 16.12-16.14). Some of these units represent storage deposits in burnt buildings, thus representing rare short-lived events, as opposed to high density accumulations over the long term.

This pattern is more evident in faunal remains, where both count and weight densities show spikes in density (rare occurrence of high-density deposition in few units) in clusters (figs 16.15, 16.16). Interestingly ground stone densities display rare high values by count density in fire features, while by weight density very high values are observed in some floor deposits (figs 16.17, 16.18). In either case this is likely to be related to deposition and use in a limited time frame rather than a jump in deposition by discard due to the nature of the deposits in question. Pottery density, while notably low across the site, also shows some elevated values in clusters similar to faunal remains (fig. 16.19). On the other hand chipped stone count densities also show spikes in fire features, somewhat similar to ground stone density values (fig. 16.20).

Interpretation of ranges of density values through time necessitates taking into account the nature of the distributions. Following previous applications, we have performed logarithmic scaling of some of the density values (i.e., by taking the natural log of the raw density values). In faunal remains and ground stone (figs 16.21, 16.22), transformation of the datasets by taking the natural log (cf. Shennan 1997) yielded distributions most similar to a normal distribution.

Across all examined find categories, the untransformed density ranges are similar across occupation period (Early, Middle, Late). As mentioned, the distributions of density values are strongly influenced by the occurrence of rare spikes in density values observed only in a limited set of context types. The temporal comparisons of each find category can be seen in figures 16.23 to 16.29. One striking commonality across find groups is the limited numbers of 'spikes' in density during the later periods, represented in the boxplots as outliers placed outside the general spread of density values. While this could easily be interpreted as a temporal trend, thus suggesting a general decline in find densities through time, some caution is needed. As mentioned, such rare high density values are only observed in a limited set of contexts. For example, amongst the fire feature units only 7% belong to the Late period group, while 17% make up the Middle period group. Similarly, in clusters, of the 32 units included in the study, three belong to the Late and four to the Middle period group. Amongst the floor deposits, only 5% account for the Late period. Thus, it is possible that the full ranges of density values across all period groups cannot be accounted for with the dataset under study. The range of contexts and the representativeness of contexts through time notwithstanding, looking at the log transformed values of densities through time, it appears that any changes in density values through time are minimal (figs 16.30-16.32). Bartlett's test of homogeneity of variance performed on log-transformed density values for faunal remains, ground stone and chipped stone densities show no significant difference amongst period groups in faunal weight and count densities. In ground stone and chipped stone, Bartlett's tests point to no significant differences between groups in count densities, but significant differences amongst period groups in weight density values. We also performed Levene's test of homogeneity of variance in order to investigate further any shifts in density values through time, with the tests performed on untransformed datasets. Again, any possible changes in values of faunal remains (count and weight densities) are not significant. The only significant difference between period groups according to the Levene's test is observed this time in ground stone count density values. Thus, we conclude that there is no justifiable basis to argue for any shifts through time. One of the issues faced during the analysis is the low number of units from the Early and Late periods, which may be hindering interpretations of changes in density values across occupation periods more difficult.

Data integration across find categories

In order to explore relationships between find categories, their potential patterning through time and across space, we investigated two subsets of the dataset using multivariate descriptive techniques. Following from the earlier description of density values and their distributions, we chose midden and fill context types for one set of analyses and floor deposits for another set of analyses using Multiple Factor Analysis. MFA, a descriptive multivariate factor analysis technique, is well-suited to datasets containing multiple data groups, which sometimes contain data values in differing scales (Bécue-Bertaut, Pagès 2008; Escofier, Pagès 2008); thus for example count densities of chipped stone and volume densities of wood charcoal in the same units can be compared with greater ease. MFA, similar to other factor analysis methods such as Principal Components Analysis (PCA), provides a graphical representation of relationships between variables, as well as a depiction of the relative distances/dissimilarities between individuals (i.e. units) included in the analysis. Furthermore, MFA provides a summary of relationships between wider groups of variables. In this study, we grouped cereal grain and pulse density in one group (Bots large), wild/weedy seed density and cereal rachis/chaff density in one group (Bots small), chipped stone and ground stone in one group, and figurines and clay objects in one group.

One particular problem we aimed to overcome with the current dataset, as demonstrated in the description of the density distributions above, was the abundant observations of zero values and/or very low densities across several find categories in the great majority of units.

This situation, alongside the numerous missing values, meant that using more conventional techniques only a fraction of the units could be included in data integration. One motivation behind examining subsets of the dataset (see above - midden/fill and floor deposits) was to provide a reliable basis for transforming datasets to overcome abundant missing values and zeroes in the density values. Data transformation and scaling were carried out using the FactoMineR package (R version 3.5.0) prior to performing hierarchical clustering and MFA on the two subsets of the dataset.

The results of MFA on floor deposits representing the individual units in a biplot were plotted by occupation period (fig. 16.33), area of excavation (fig. 16.34), and building number (fig. 16.35). As the plots indicate, across occupation period there is very little variability in density values, as no clear clustering can be seen amongst individual units. The plot in fig. 16.34 on the other hand shows some minor patterning by area of excavation, although this does not appear to be a particularly robust trend. However, the plot of individuals by building numbers suggest, at least in some buildings, that density values across units show some affinity with one another. For example, various units from Building 132 appear to be more similar to one another. The first two dimensions of the MFA on floor deposits account for 54% of the cumulative variation in the dataset, which is driven predominantly by variation in archaeobotanical remains (including wood charcoal and the rest of the archaeobotanical remains) along Dimension 1 and figurine, clay object and pottery density in Dimension 2 (figs 16.36, 16.37).

When looking at the relationships amongst find categories in floor deposits, archaeobotanical remains are closely related, including wood charcoal density, small and large non-wood archaeobotanical remains (fig. 16.36). Figurine, clay object and pottery densities are also closely related. Faunal remains, ground stone and chipped stone contributions to any variability and/or patterning in the dataset is not captured by the current analyses.

The results of MFA on fill and midden deposits were also plotted according to occupation period (fig. 16.38) and area of excavation (fig. 16.39). Similar to variation in floor deposits, variation in fill/midden units does not seem to be related to occupation period. Instead, there appears to be a weak clustering between different areas of excavation, where the North Area samples are found predominantly in the lower part of the biplot (fig. 16.39) and the South/TPC samples in the upper part of the biplot. The 40.95% cumulative variation explained by the first two dimensions of the MFA are driven predominantly by non-wood archaeobotanical remains, faunal remains, ground stone and clay object density (figs 16.40, 16.41). Variations in values of figurine, pottery and chipped stone and to some extent wood charcoal density make minor contributions to the overall patterning observed here. In addition, the density values of charcoal and the remainder of the archaeobotanical remains are not as clearly and closely related as the patterns observed in floor deposits. Instead, cereal grain density in midden units appears to be more closely associated with faunal remains. In addition, clay object and ground stone densities also appear to be more closely associated.

Discussion

As demonstrated in previous analyses, distributions of find categories follow a similar pattern, independent of their preservation conditions (Cross-May 2005; Mazzucato 2013; see also Vasić Chapter 10 this volume). That is, a common right-skewed distribution of densities was observed for all examined find categories. Across context types, with regard to density, most deposits contain similar densities of materials. Some short-lived events (e.g. fire features, clusters and sometimes floor deposits) rarely also contain much higher densities of material. Such a distinction was also detected in previous work (cf. 'activity deposits' Mazzucato 2013).

We have been able to refine this further here by showing that some remains (e.g. those deriving from fuel waste) can show rare high-density values in fire features. At the same time, some remains, such as animal bone and pottery, also rarely show high-density values in cluster deposits. Interestingly both chipped stone and ground stone show a tendency for rare, high density deposition events in fire features. Whether this situation is related to discard of production waste and/or defunct artefacts in fire features or whether the density distributions across space signify cultural practices could be investigated further.

In examinations of temporal variability of density values, we were not able to detect significant changes, either through univariate or multivariate descriptive analyses. As mentioned, the most relevant patterns were detected in ranges of densities across different context types, drawing a distinction between primary deposits/activity areas vs. secondary deposits/waste discard areas. This observation appears to be in line with observations made by Vasić on density of various remains from HR (Chapter 10, this volume). Following on from a detailed examination of univariate density distributions, multivariate analyses were performed on two distinct context types with interpretative potential using MFA. Multivariate analyses on floor deposits highlighted the significant contributions of all classes of archaeobotanical remains, likely representing traces of routine activities, including remnants of fuel waste, crop cleaning waste and food preparation waste. On the other hand, patterning in the dataset was also driven by variations in the densities of scarcer find categories such as figurines, clay objects and pottery, potentially signifying short-term deposits on floors. Thus it is likely that with the subset of units under study we are able to depict variations in use and activity patterns in different buildings. Examinations of units included in the study suggested some weak relationships amongst units of the same building and a limited range of affinity amongst units in the same area of excavation (North vs South).

Multivariate analyses on midden/fill type deposits also highlighted similar patterns regarding temporal trends and spatial affiliation. Similarly, no clear temporal trends were observed in density values; and again similar to floor deposits, there were weak affinities amongst units of the same area of excavation (North vs South/TPC) which might suggest similar patterns and densities of discard in adjacent/associated spaces across the site. In these secondary deposits however, different relationships between find categories were observed. For example, the close association of pottery, figurine and clay objects in floor deposits is not matched by a similar association in middens. Similarly, the close correlation between wood charcoal and all classes of non-wood archaeobotanical remains is not replicated in middens/fills. Instead, some archaeobotanical remains associated with food preparation (e.g. cereal grain) are more closely affiliated with faunal remains in secondary deposits. Additionally in these deposits, discard patterns of ground stone and clay objects also appear to be more similar. It is likely that these wider patterns in find densities represent differences in the ranges of activities and discard patterns across different context types. These insights offer further refinement on observations of higher densities of remains from midden contexts as reported by several authors working on various data groups such as archaeobotanical remains (Bogaard et al. 2014), faunal remains (Martin, Russell 2000) and micromorphology (Matthews 2005a, b).

Conclusions

In this chapter we aimed to look at cross-cutting relationships between find categories, their deposition and accumulation through time and across various context types. Our aim was to ultimately shed light on any patterning in activities and their material residues by taking into account multiple factors relating to use, discard and preservation of various finds. We demonstrated the commonality in deposition density across time periods investigated through the study, while depicting patterns across context types and areas of occupation. Building on previous work carried out to date on the datasets from the site, in this analysis we were able to make some refinements to find categories, dividing archaeobotanical remains of multiple origin (fuel, food, crop waste) into finer groupings. Similar approaches could also be applied to chipped and ground stone datasets, which may provide further insights into the use of space and discard of artefacts, production waste, etc. An interesting aspect of data integration was the detection of weak associations between units associated with the same building, suggesting consistency in discard and deposition patterns associated with specific households.

As demonstrated throughout this volume, there is clearly a change in the use and organisation of the site in the Late and Final periods (see Chapter 1). As noted by Tarkan (Chapter 4) there is an increase in pottery use overall and greater diversity of wares in the later phases of occupation, while there is a noticeable increase in the densities of edge tools in the ground stone assemblage(Tsoraki Chapter 13). In addition, various lines of evidence support the view that towards the later phases there is a general expansion in the use of the landscape for example for wood, clay and bead procurement alongside a range of shifts in raw material sources (this volume Chapters 4 and 10; Vol. 13 Chapter 4) and increasing levels of mobility (e.g., Vol. 13, Chapter 16). Interestingly, as discussed in this chapter, we have not detected significant temporal shifts in material densities to match any qualitative shifts in artifact types used or shifts in raw materials. Thus, it appears, despite apparent shifts in the materials themselves, the patterning of their use and discard may have remained largely similar through time.

References cited

Bécue-Bertaut, M. and Pagès, J., 2008. Multiple factor analysis and clustering of a mixture of quantitative, categorical and frequency data. *Computational Statistics and Data Analysis* 52: 3255-3268.

Cross-May, S. 2005. Statistical Integration of Contextual Data. *Changing materialities at Çatalhöyük: reports from the 1995-99 Seasons*. Çatalhöyük Research Project Volume 5. British Institute for Archaeology at Ankara Monograph 39, ed I. Hodder (Los Angeles, CA: Cotsen Institute of Archaeology Press): 23-44.

Escofier, B. and Pagès, J. 2008. *Analyses Factorielles Simples et Multiples: Objectifs, Méthodes et Interprétation*. 4th edition. Dunod: Paris.

Mazzucato, C. 2014. Sampling and Mapping Çatalhöyük. *Humans and Landscapes of Çatalhöyük: Reports from the 2000-2008 Seasons*. Çatalhöyük Research Project Volume 8. British Institute for Archaeology at Ankara Monograph 47, ed I. Hodder (Los Angeles, CA: Cotsen Institute of Archaeology Press): 31-64.

Shennan, S. 1997. *Quantifying Archaeology: Second Edition*. Edinburgh: Edinburgh University Press.

Figures

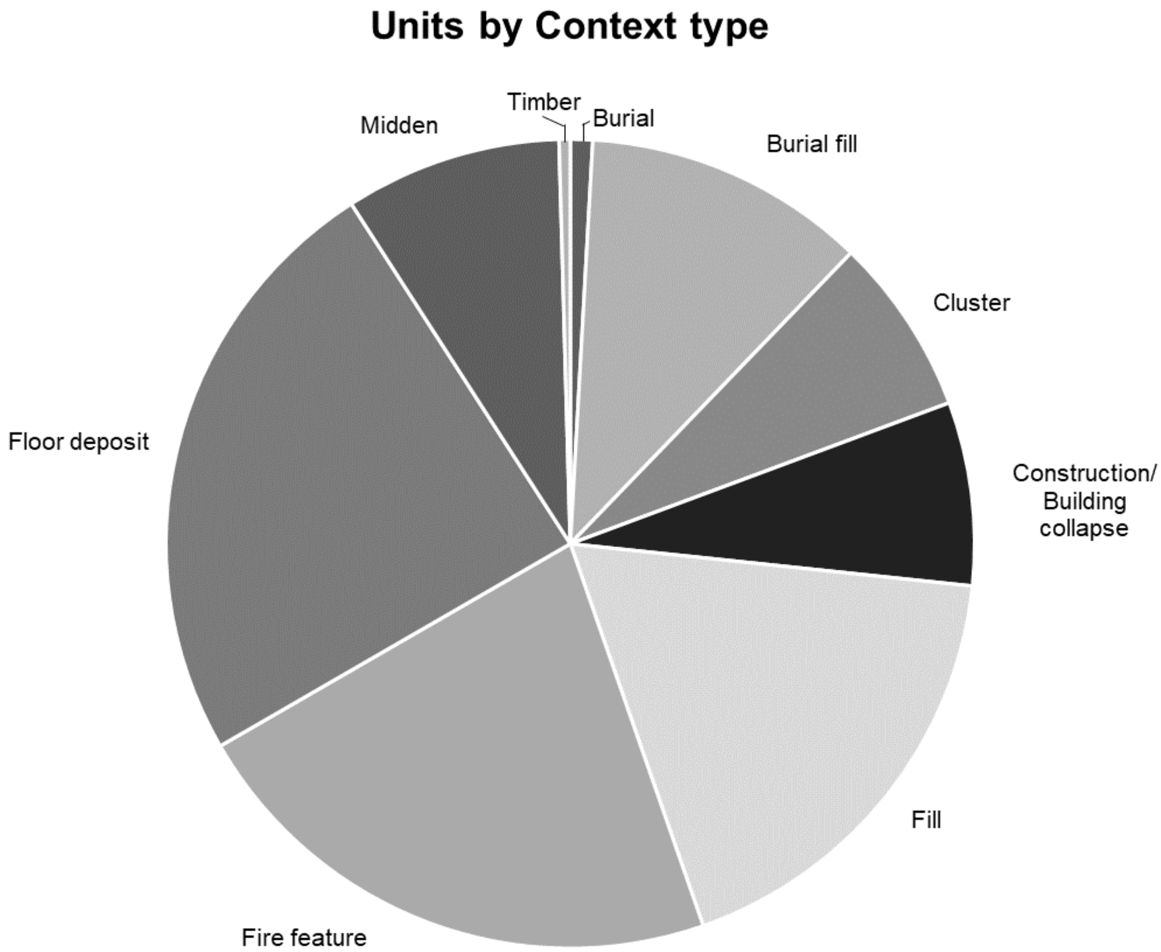

Figure 16.1 Units included in the study by context type

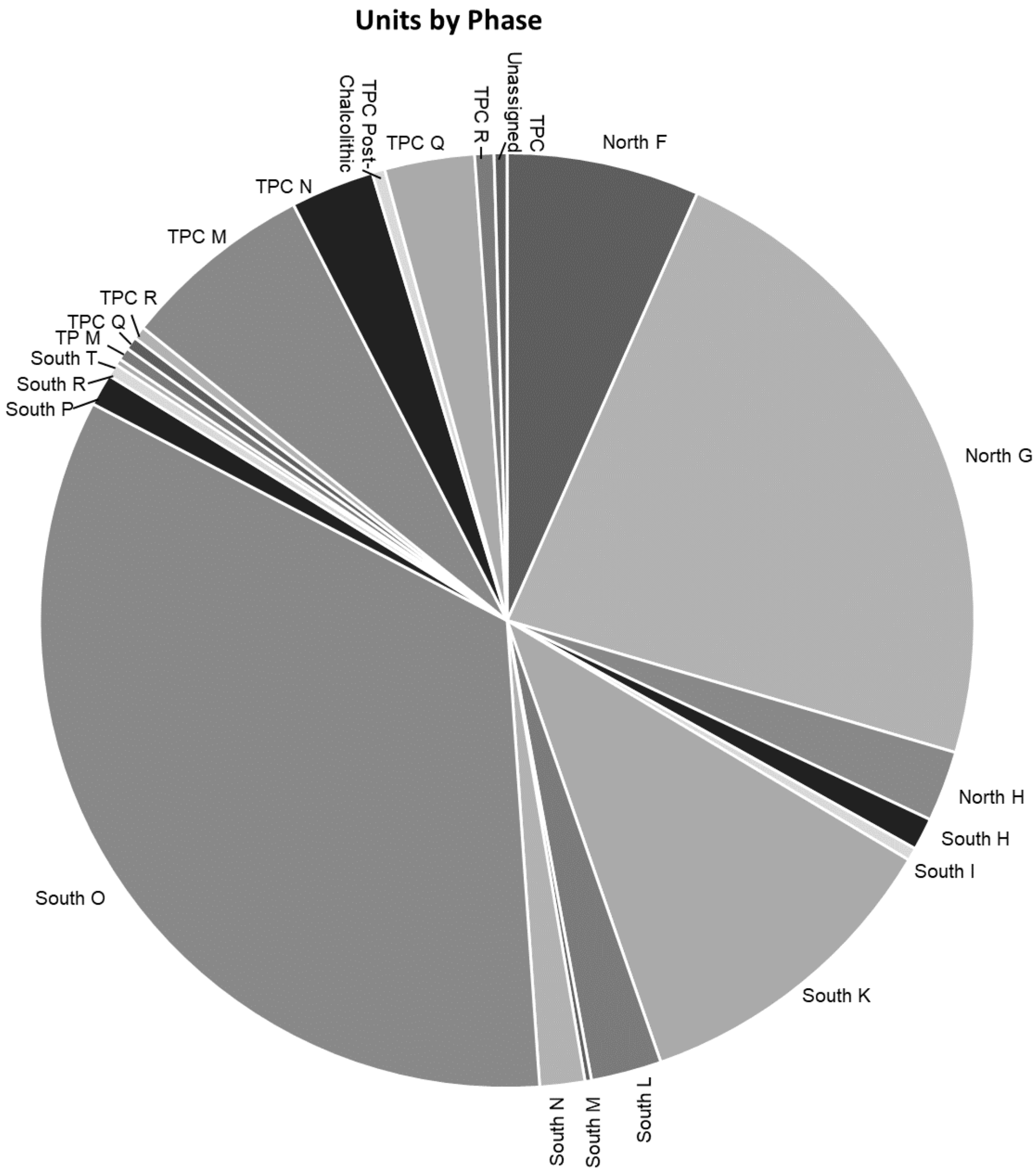

Figure 16.2. Units included in the study by level.

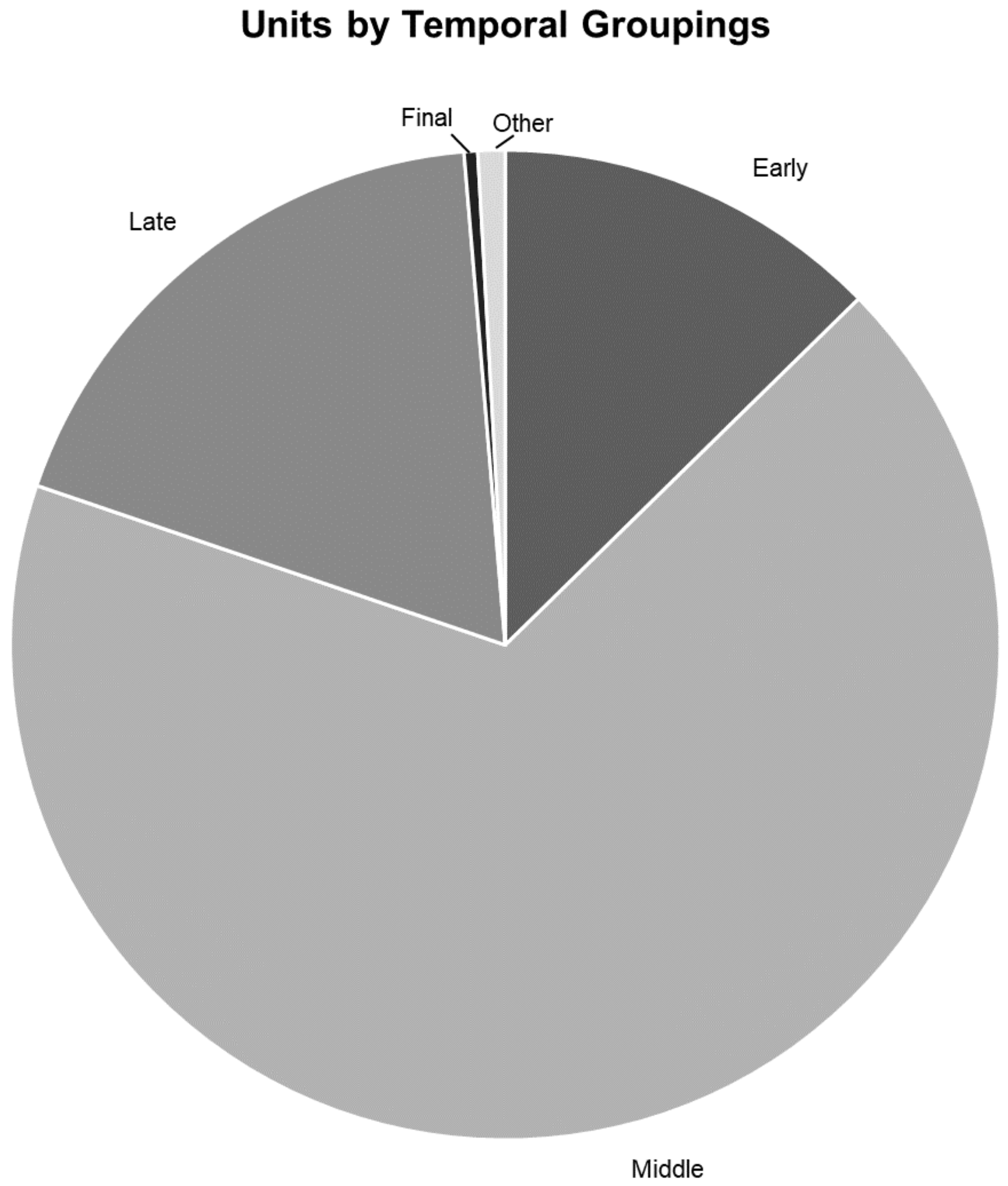

Figure 16.3. Units included in the study by period.

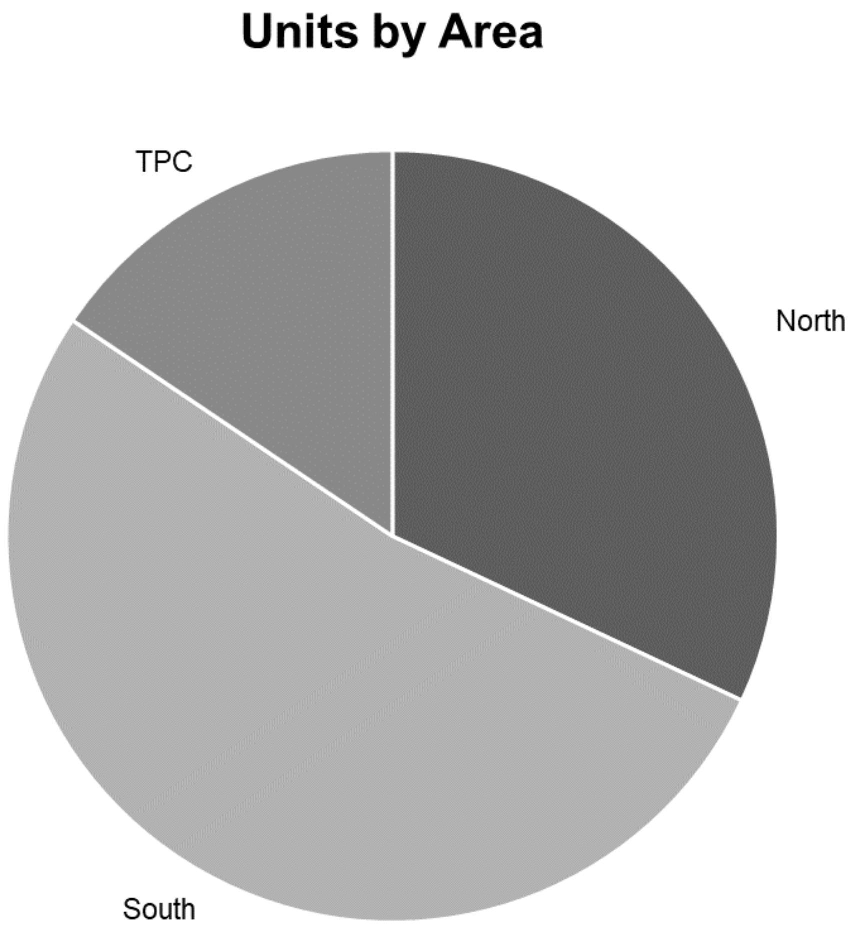

Figure 16.4. Units included in the study by area of excavation.

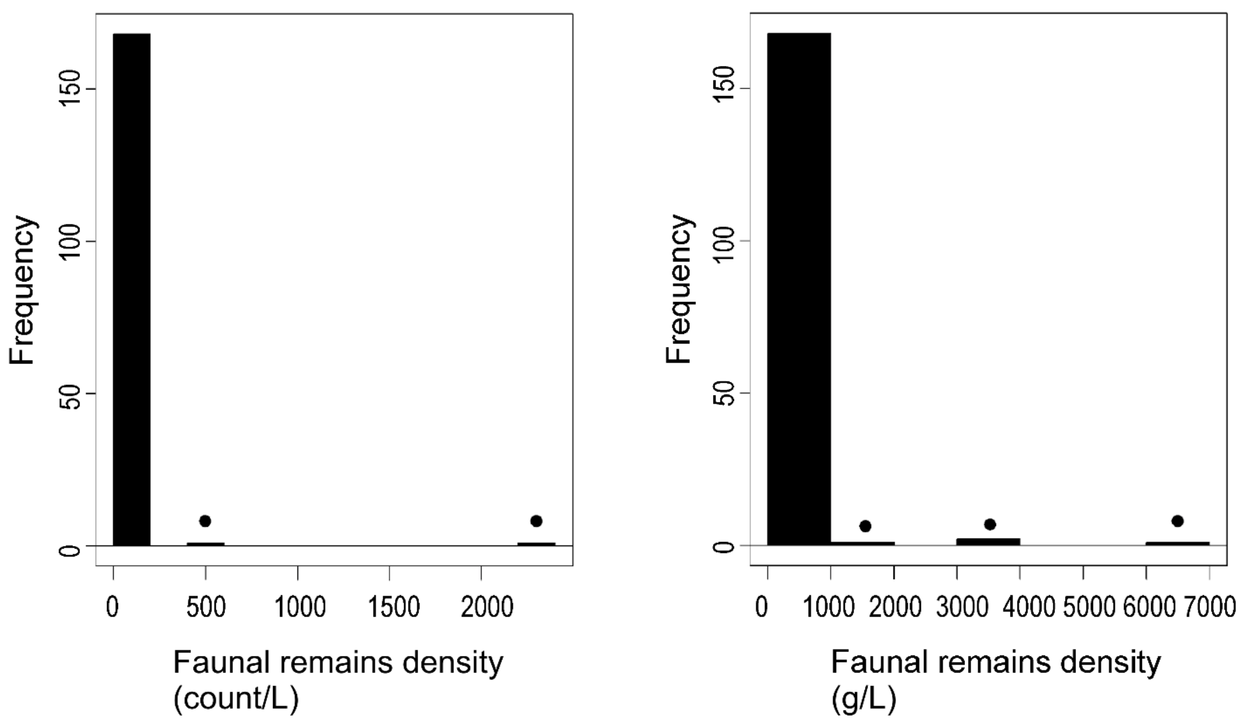

Figure 16.5. Faunal remains count density and faunal remains weight density histograms across all units included in the study.

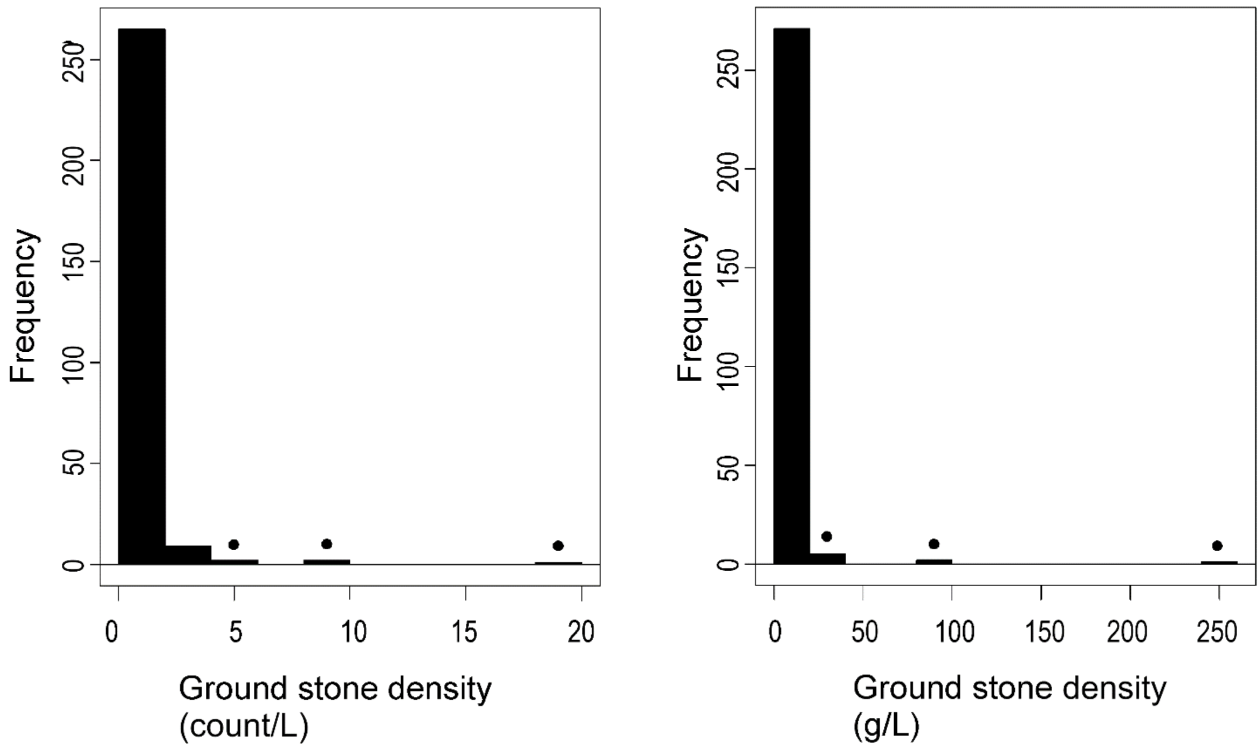

Figure 16.6. Ground stone count density and ground stone weight density histograms across all units included in the study.

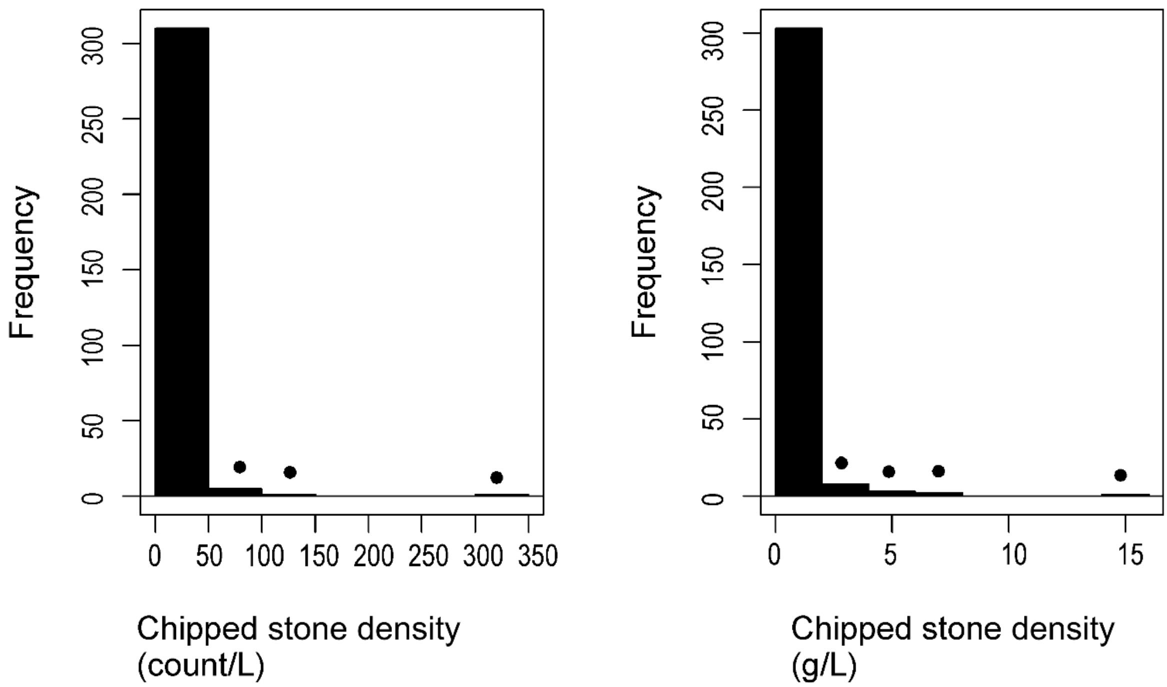

Figure 16.7. Chipped stone count density and chipped stone weight density histograms across all units included in the study.

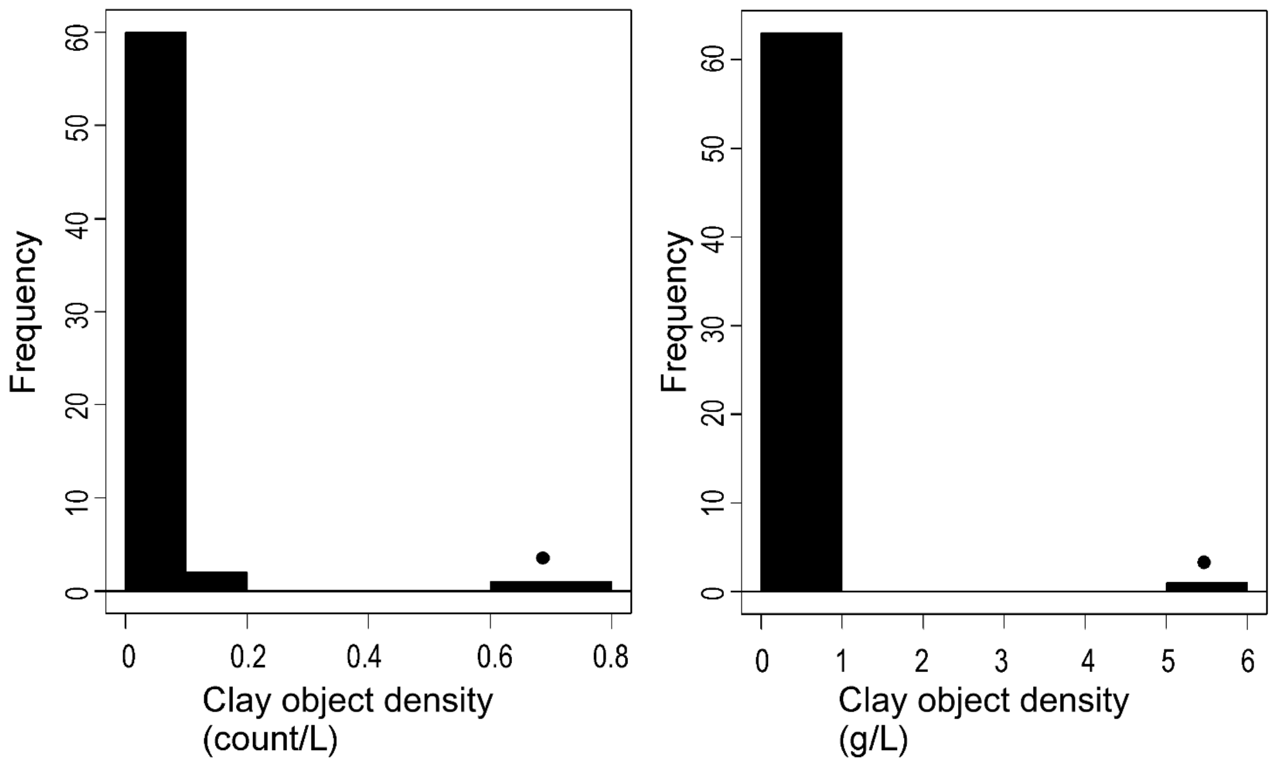

Figure 16.8. Clay objects count density and clay objects weight density histograms across all units included in the study.

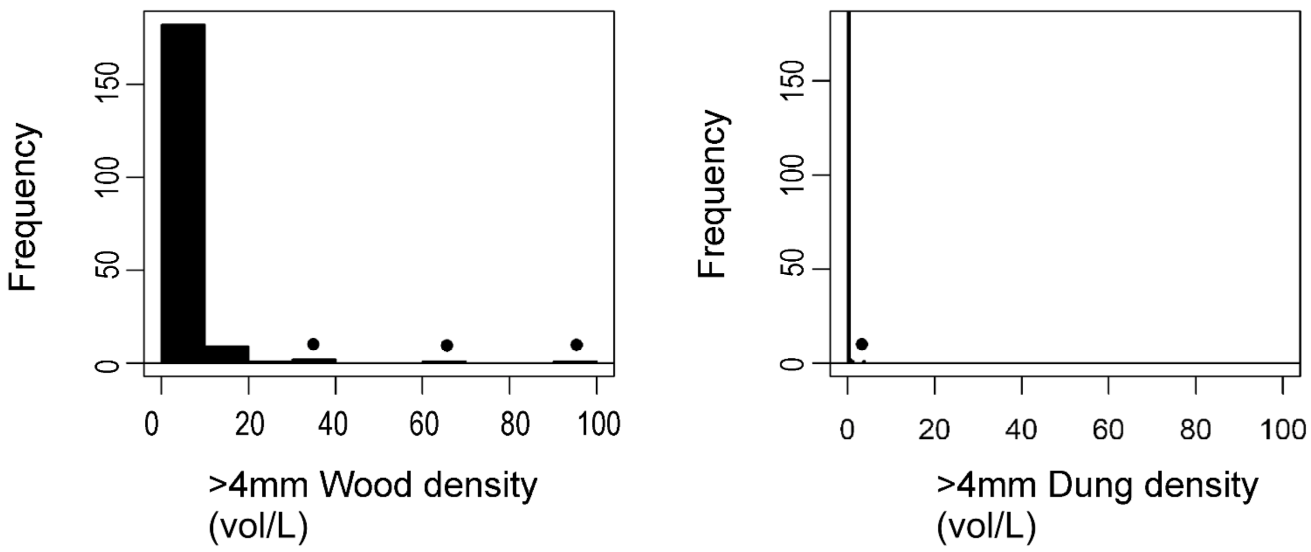

Figure 16.9. Wood charcoal density and charred dung remains density histograms across all units included in the study.

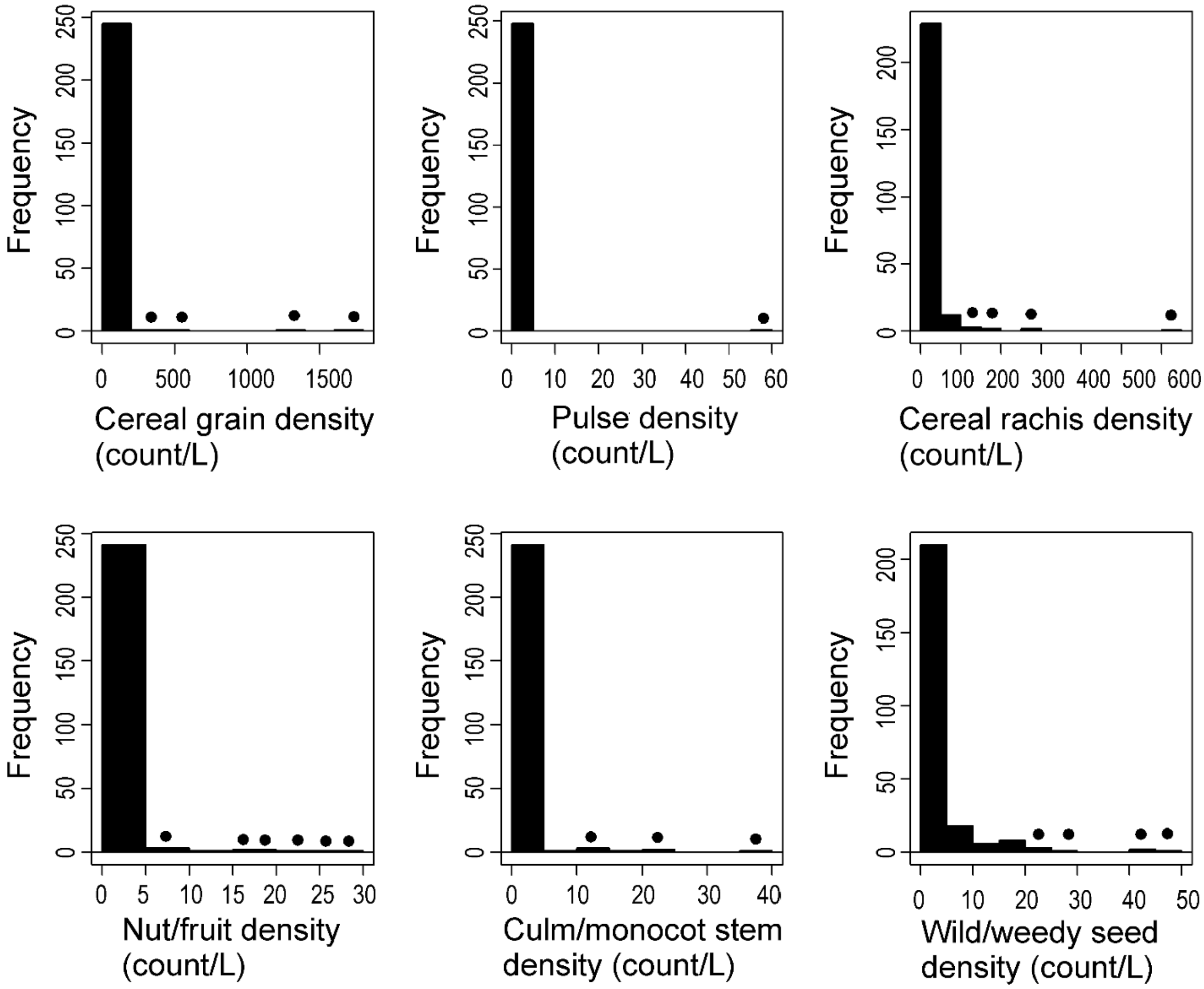

Figure 16.10 Archaeobotanical seed/non-wood remains density histograms across all units included in the study.

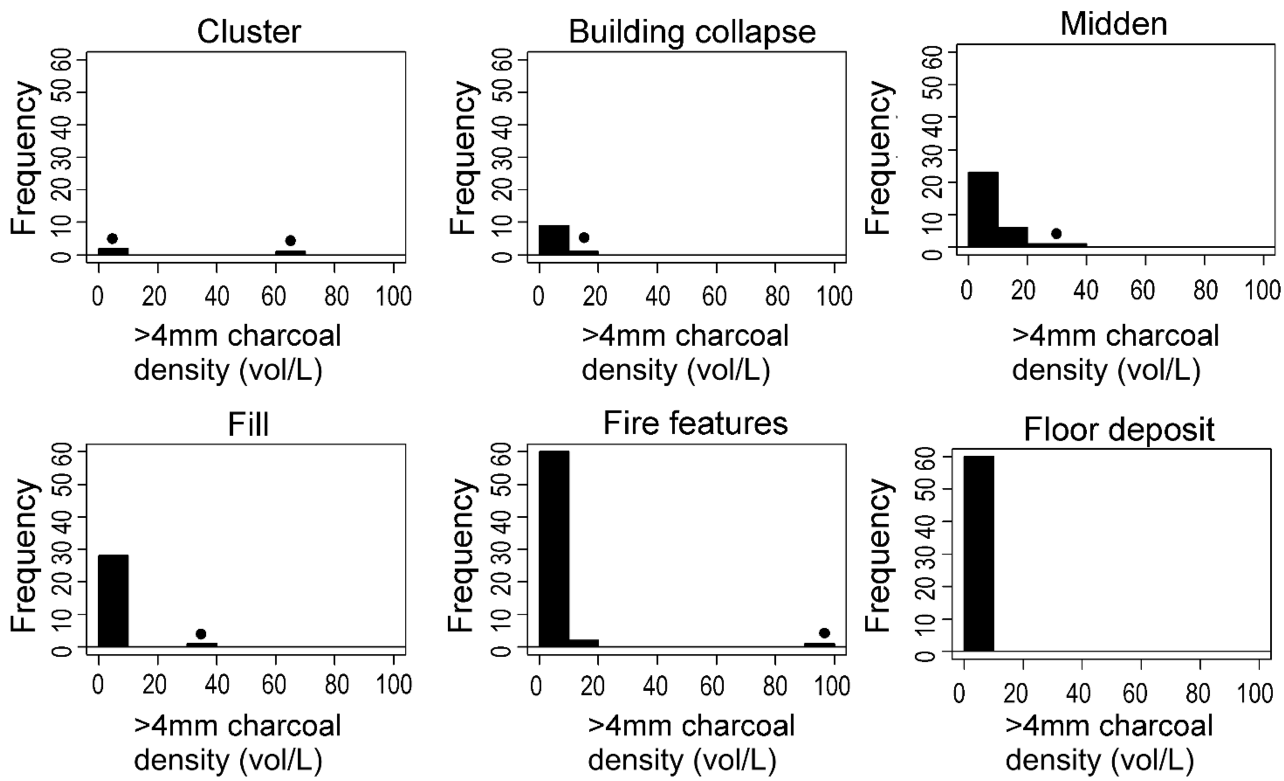

Figure 16.11. Wood charcoal density histograms for different context types included in the study.

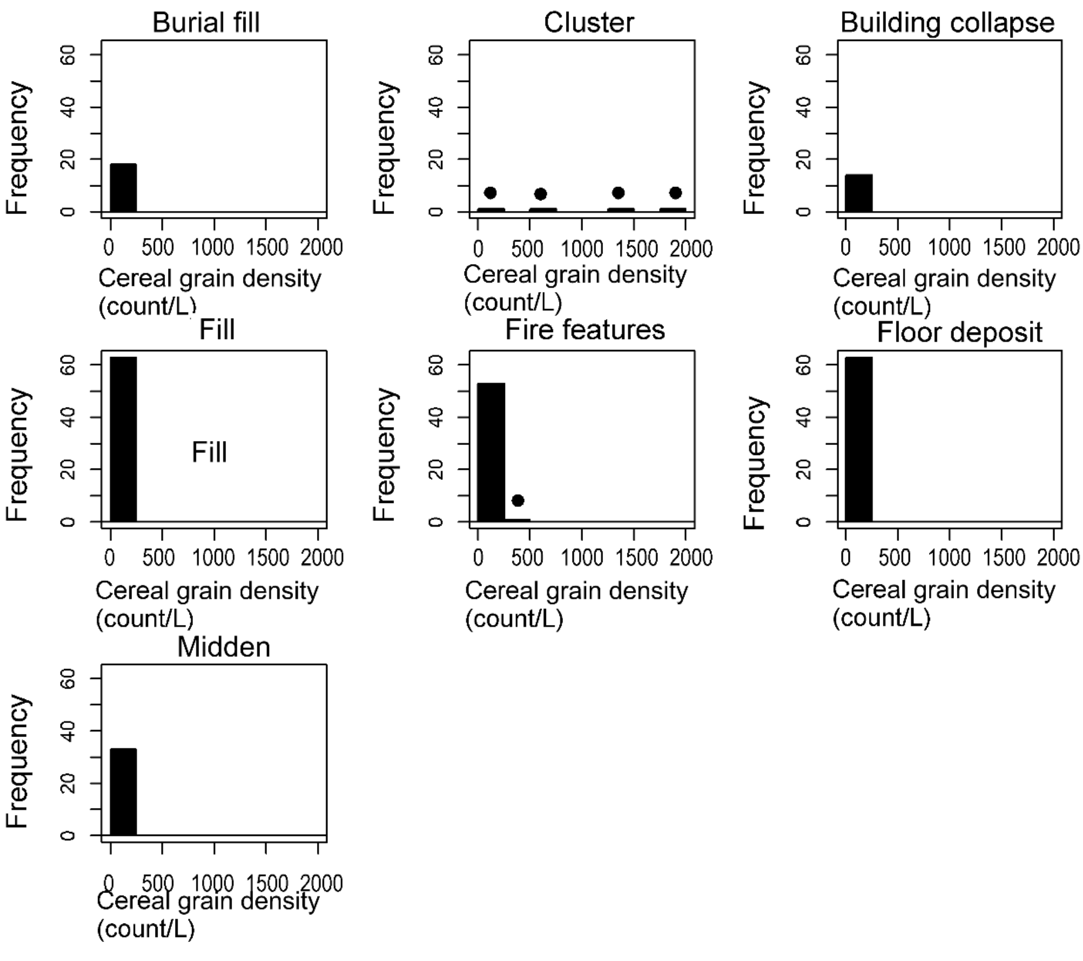

Figure 16.12. Cereal grain density histograms for different context types included in the study.

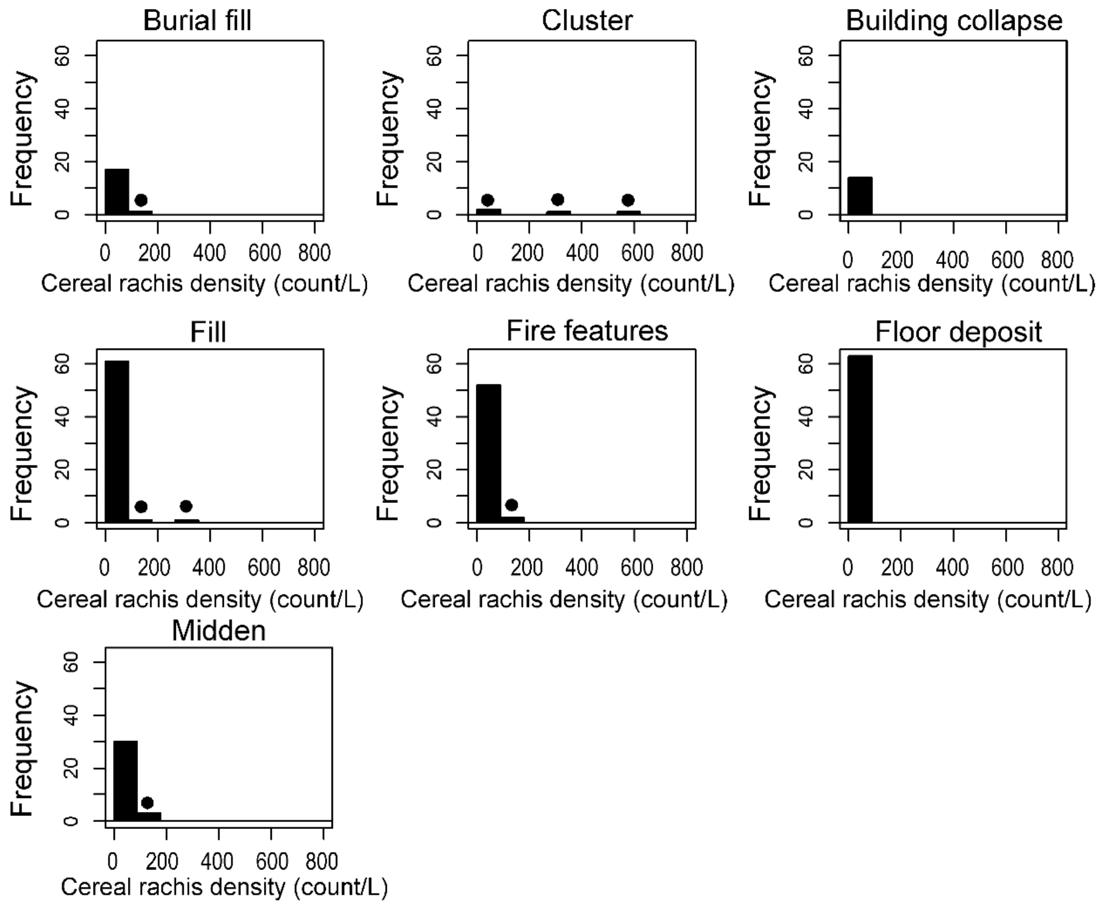

Figure 16.13. Cereal rachis/chaff remains density histograms for different context types included in the study.

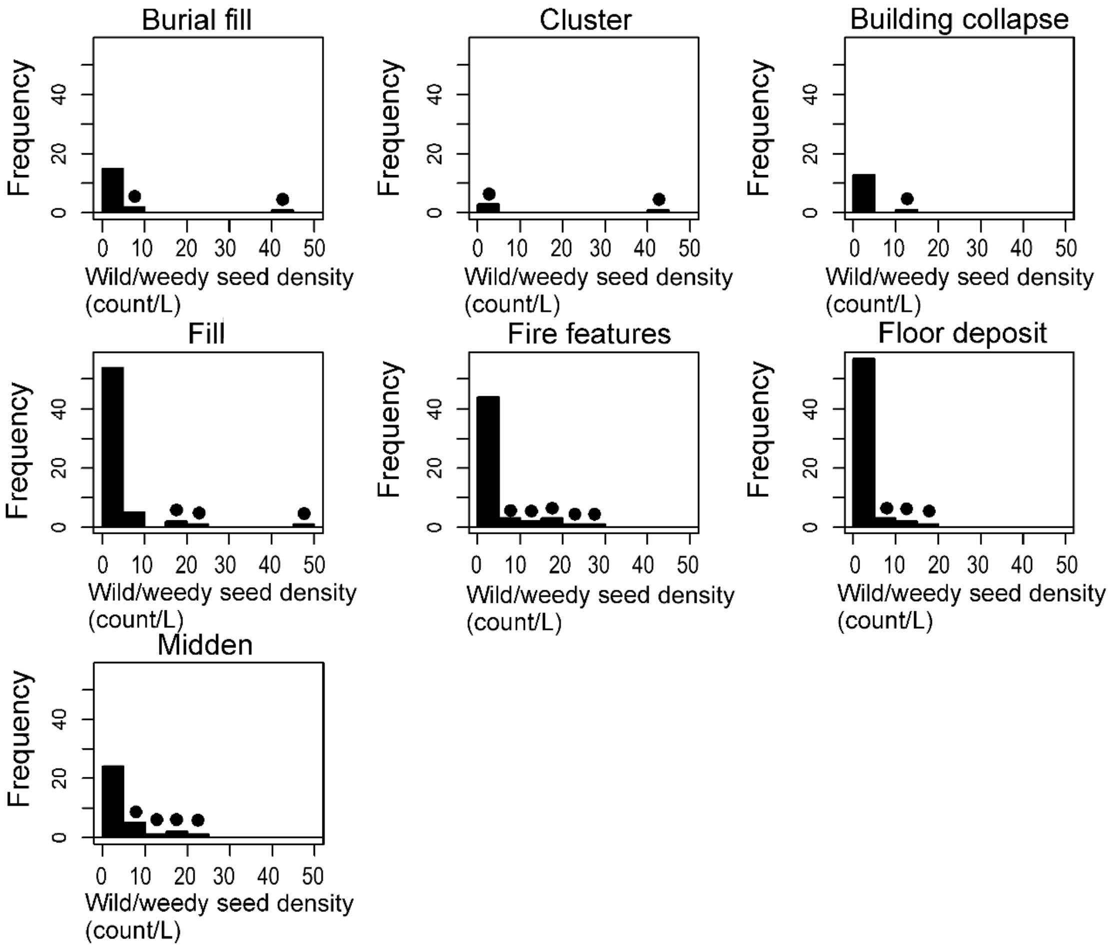

Figure 16.14. Small wild/weedy seed density histograms for different context types included in the study.

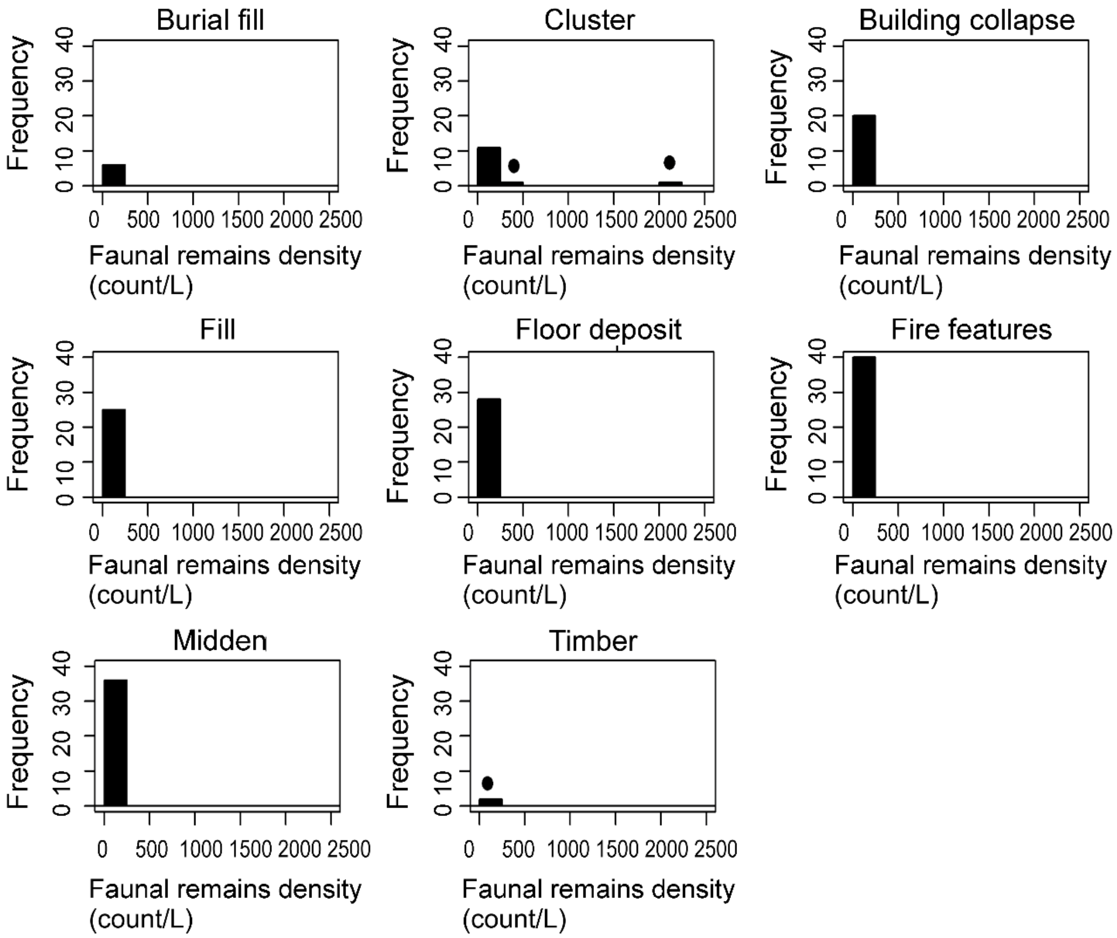

Figure 16.15. Faunal remains count density histograms for different context types included in the study.

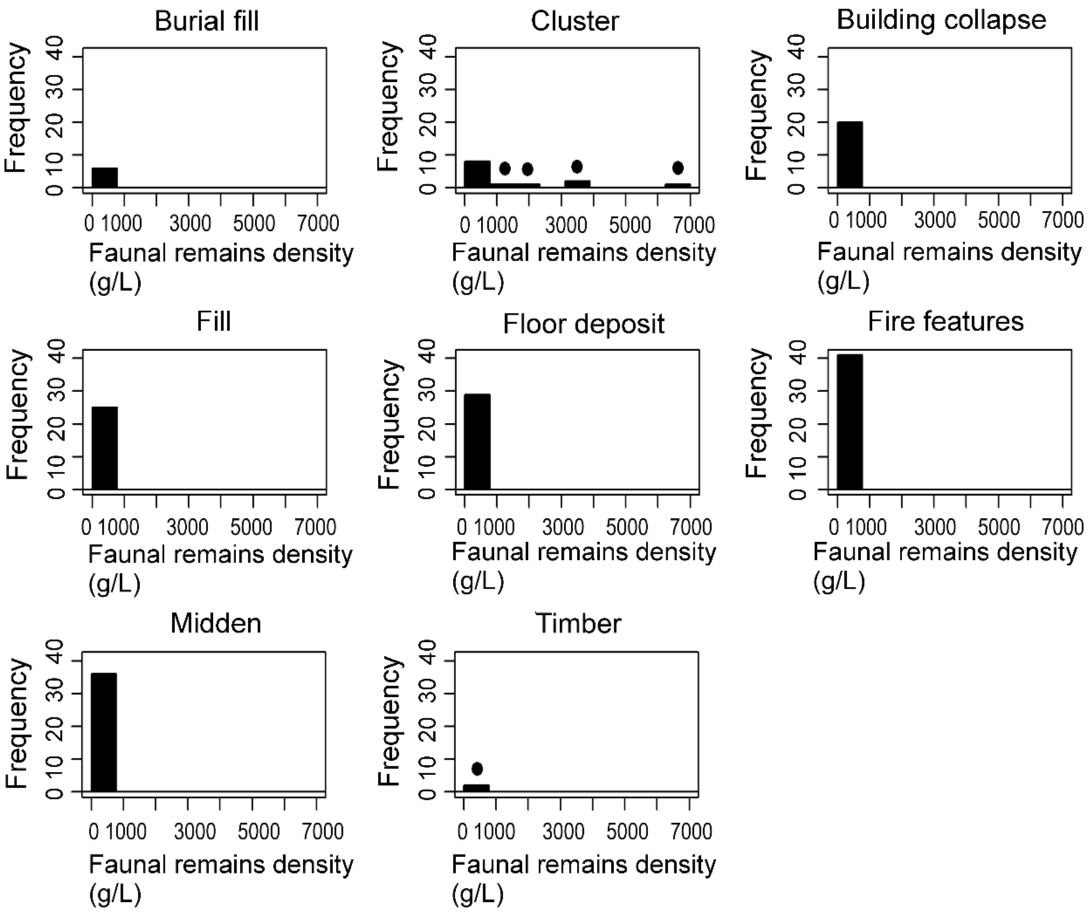

Figure 16.16. Faunal remains weight density histograms for different context types included in the study.

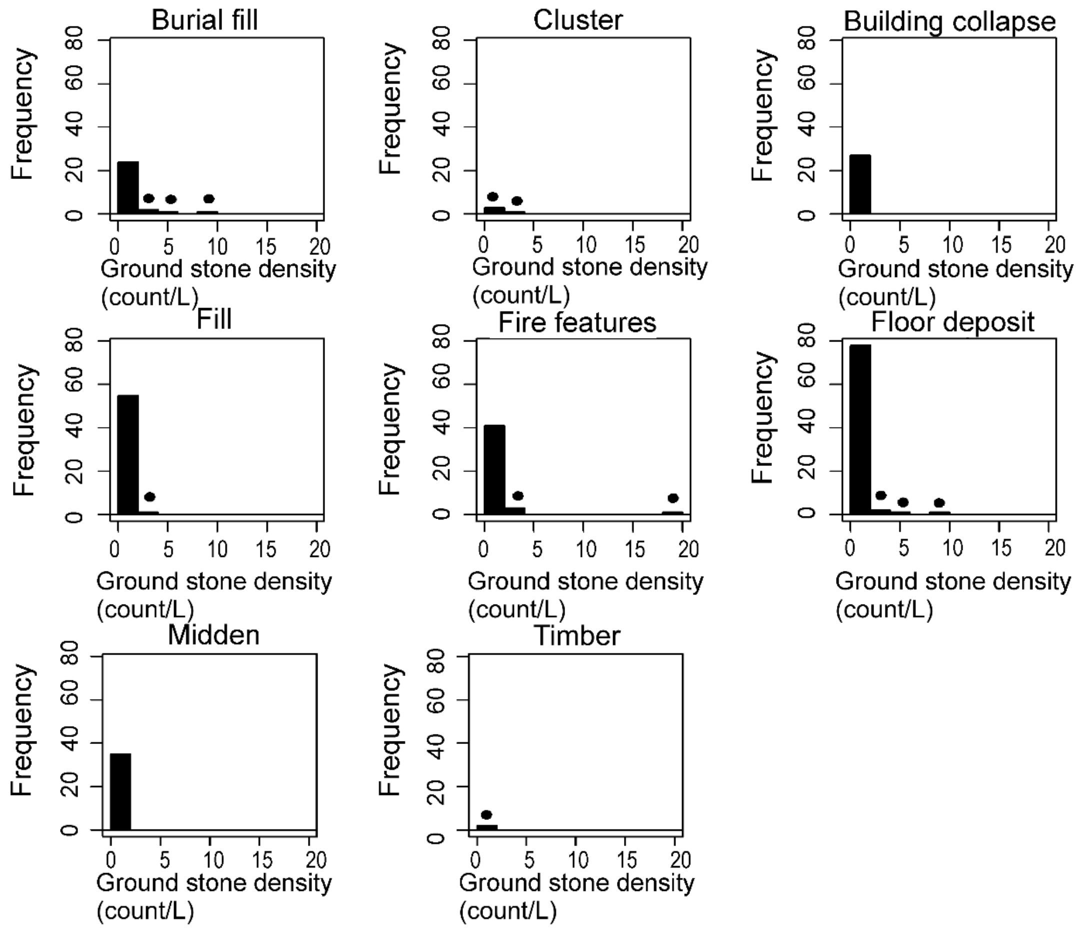

Figure 16.17. Ground stone count density histograms for different context types included in the study.

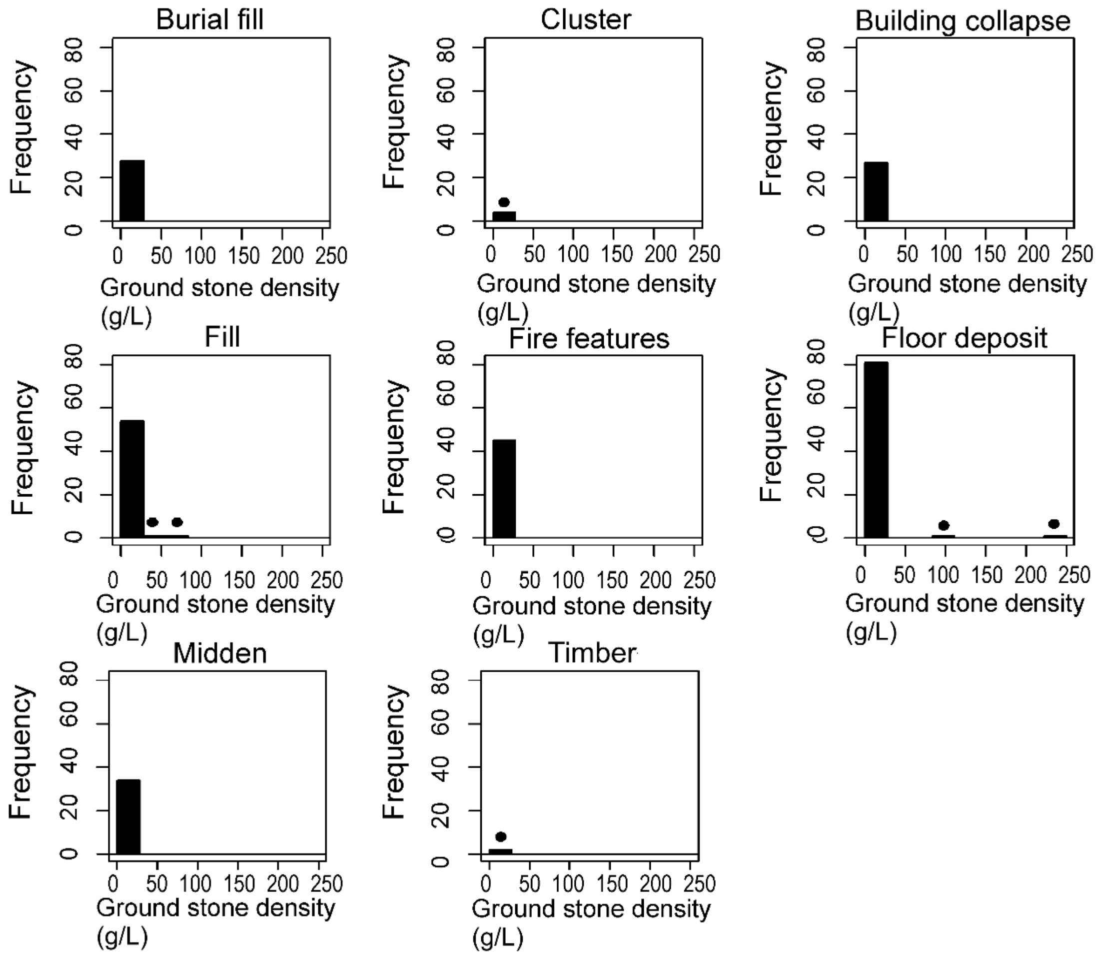

Figure 16.18. Ground stone weight density histograms for different context types included in the study.

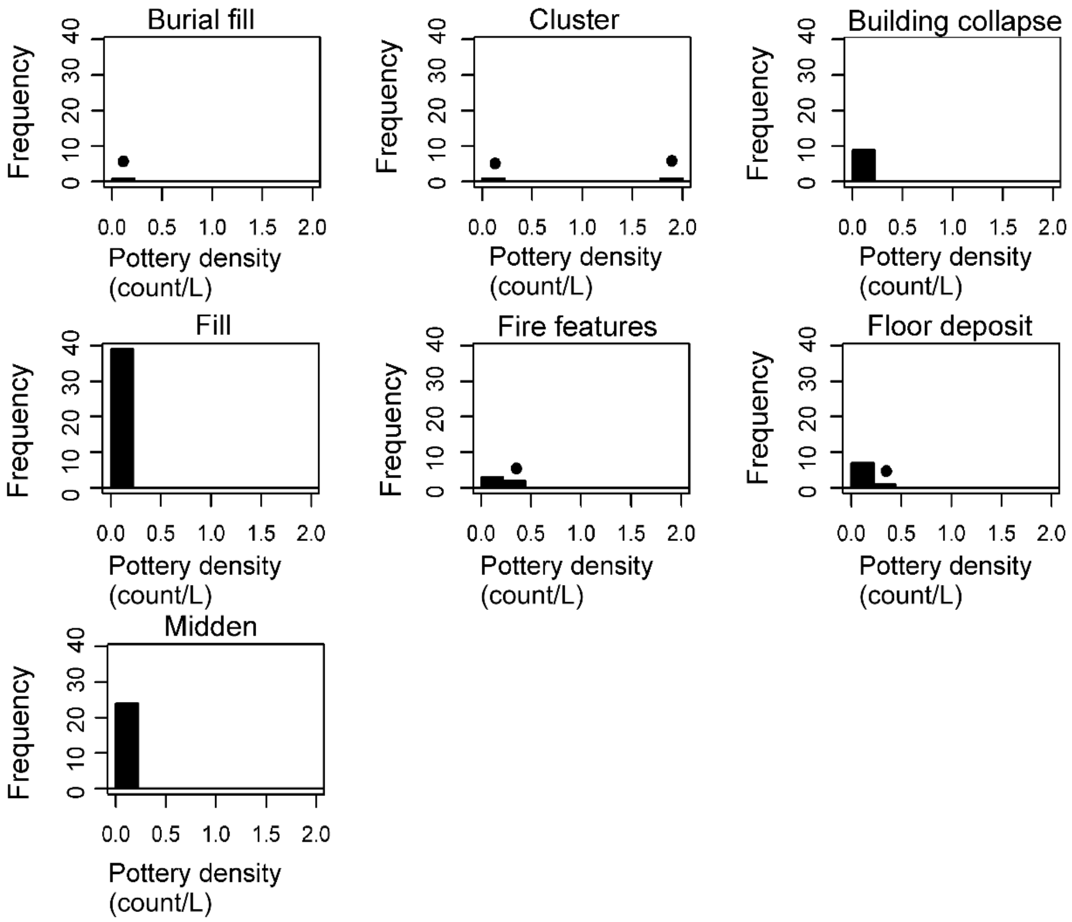

Figure 16.19. Pottery density histograms for different context types included in the study.

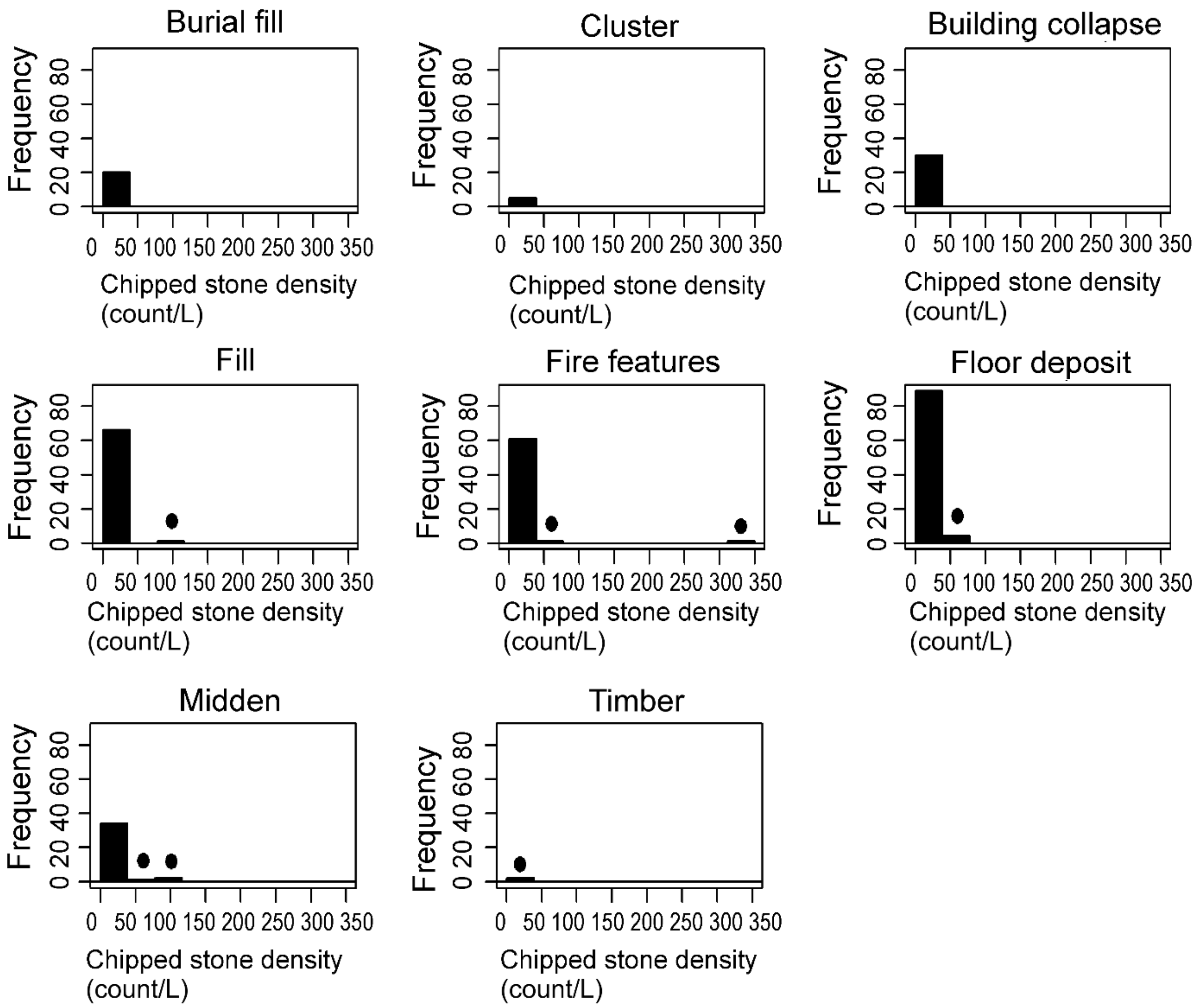

Figure 16.20. Chipped stone density histograms for different context types included in the study.

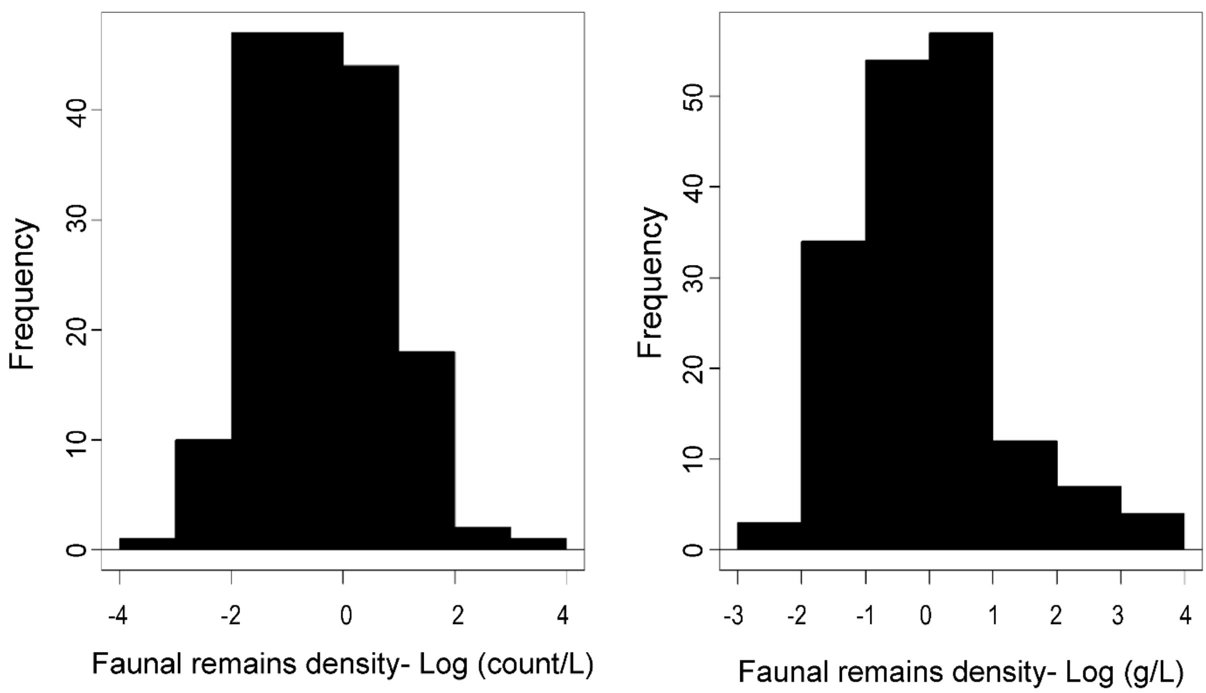

Figure 16.21. Histograms of natural log-transformed faunal remains densities across all units included in the study.

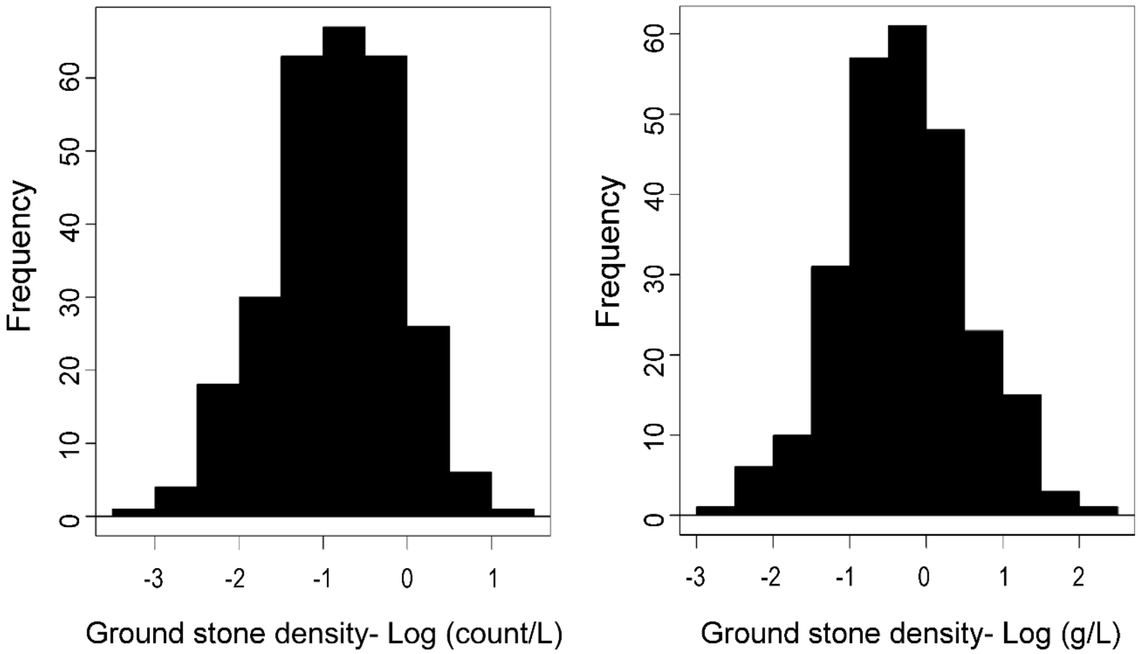

Figure 16.22. Histograms of natural log-transformed ground stone densities across all units included in the study.

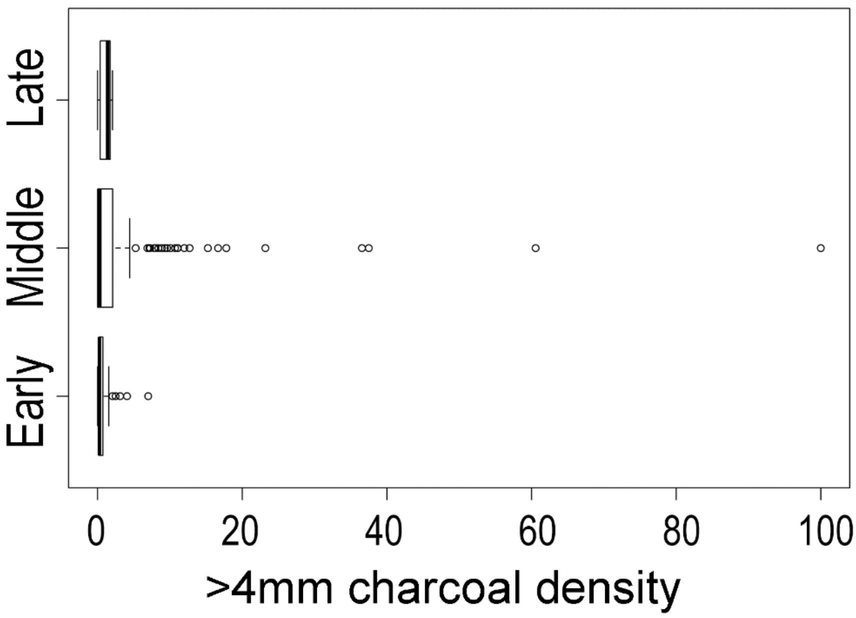

Figure 16.23. Wood charcoal density boxplots by period.

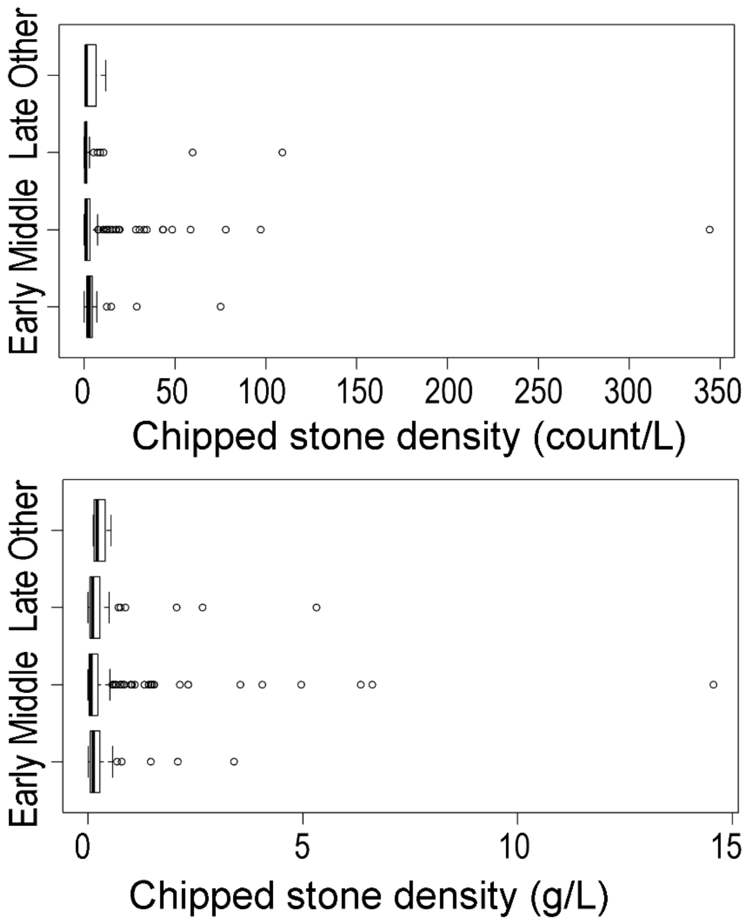

Figure 16.24. Chipped stone count and weight density boxplots by period.

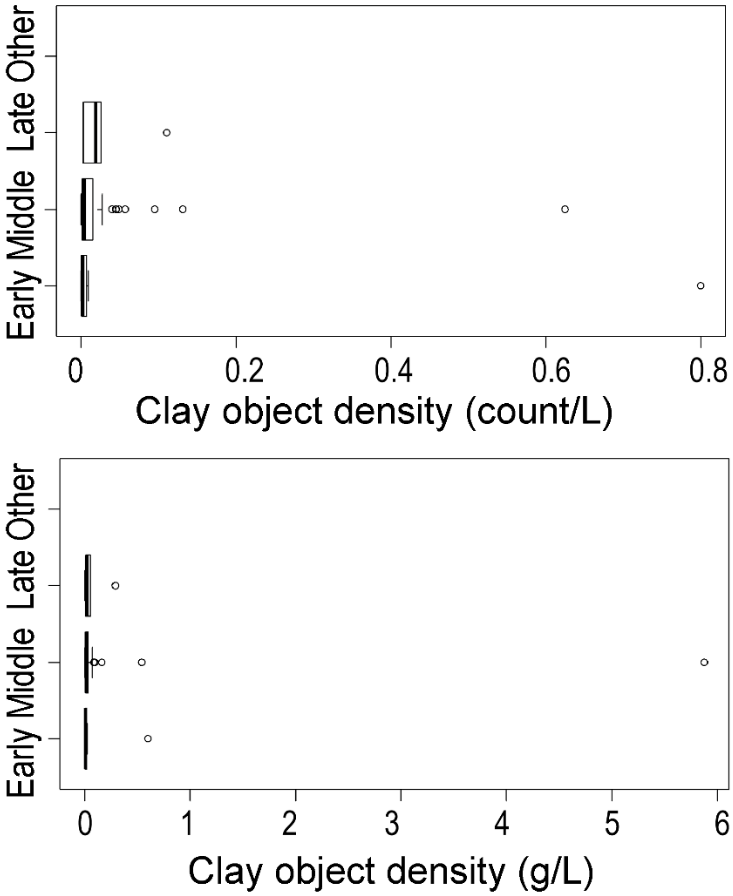

Figure 16.25. Clay object count and weight density boxplots by period.

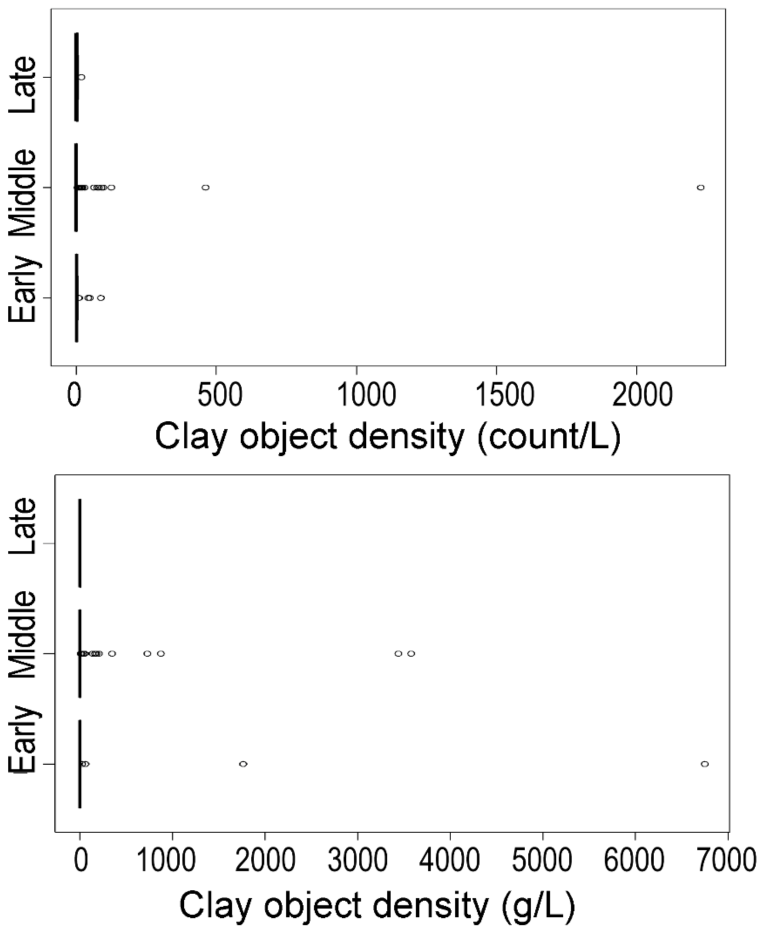

Figure 16.26. Faunal remains count and weight density boxplots by period.

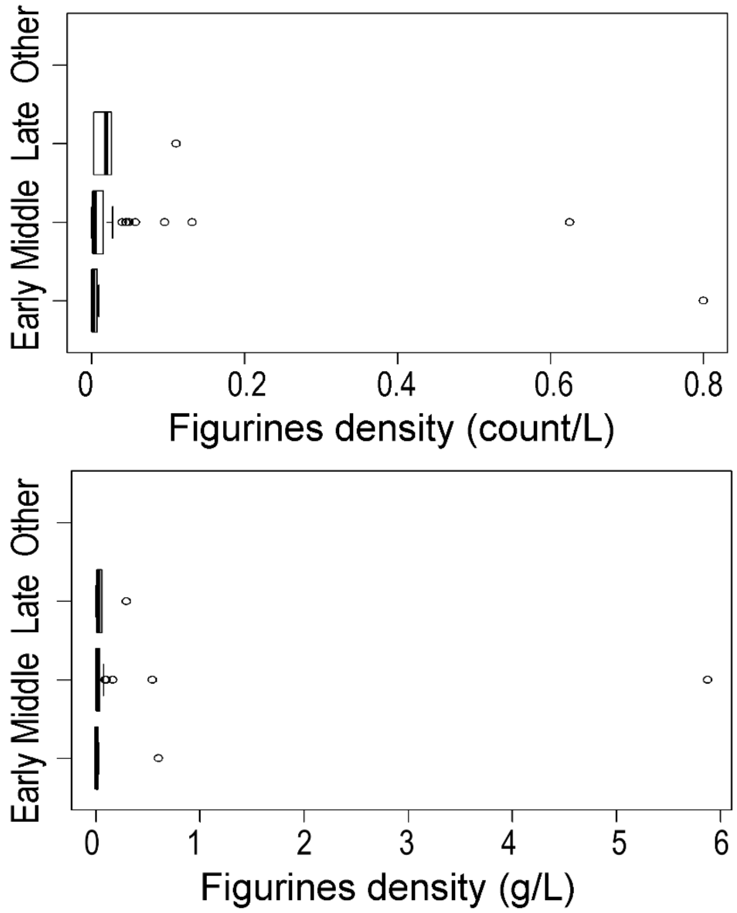

Figure 16.27. Figurines count and weight density boxplots by period.

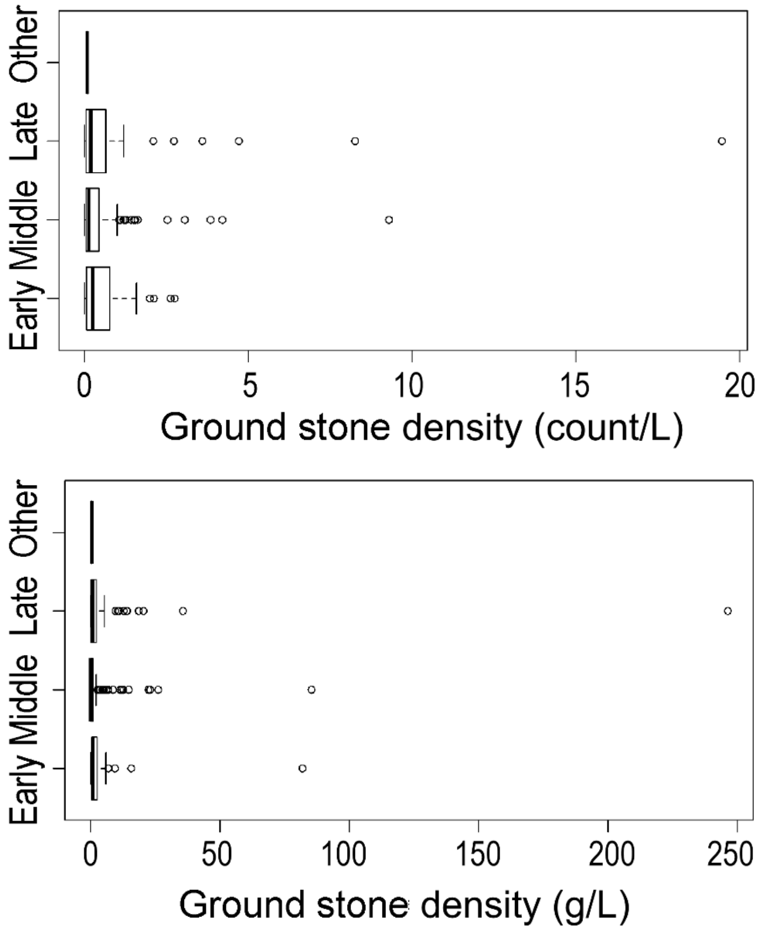

Figure 16.28. Ground stone count and weight density boxplots by period.

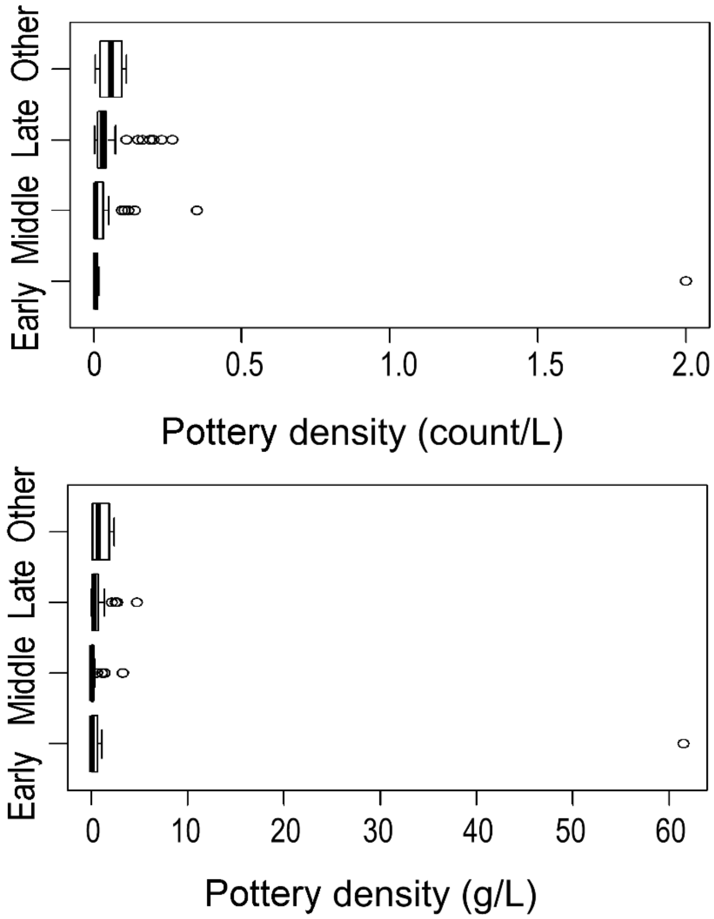

Figure 16.29. Pottery count and weight density boxplots by period.

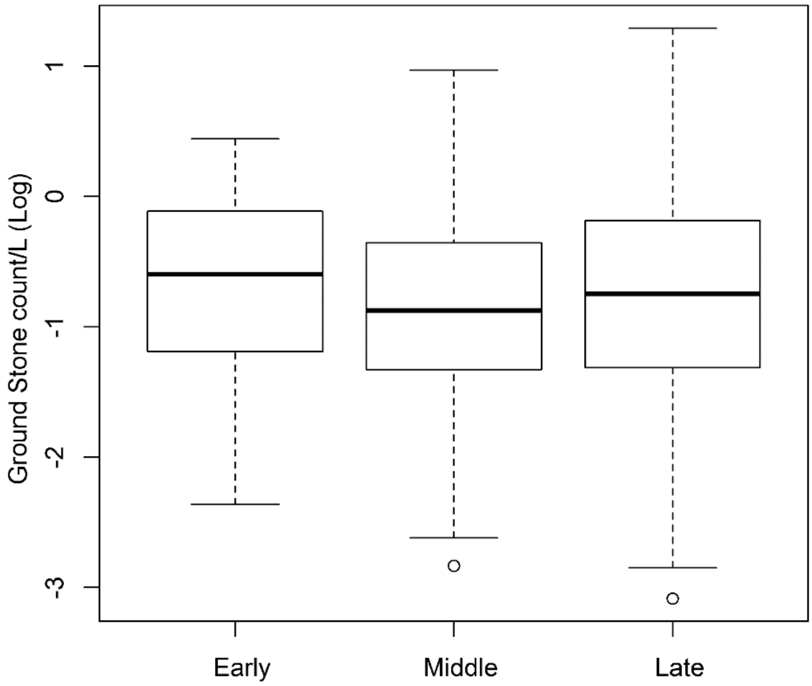

Figure 16.30. Boxplots of natural log-transformed ground stone densities by period.

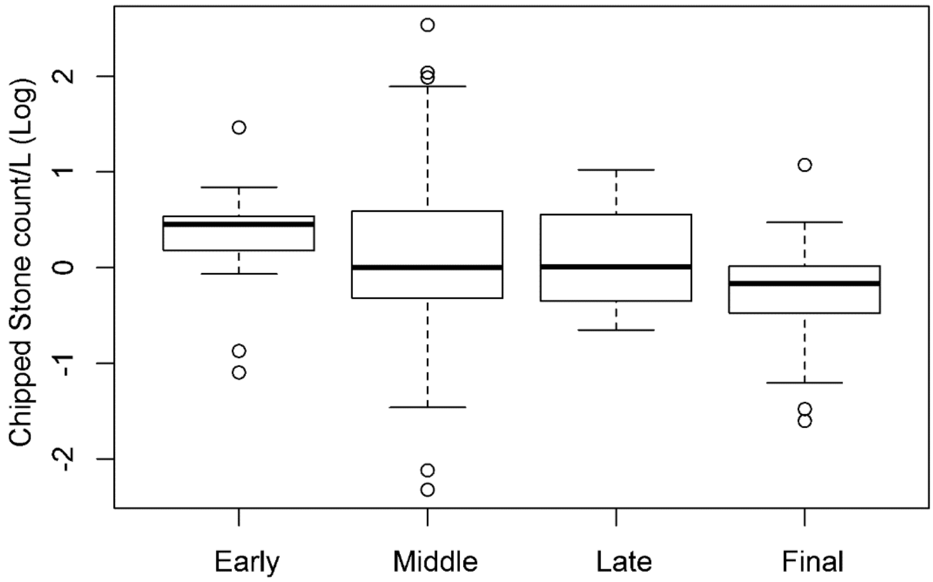

Figure 16.31. Boxplots of natural log-transformed chipped stone densities by period.

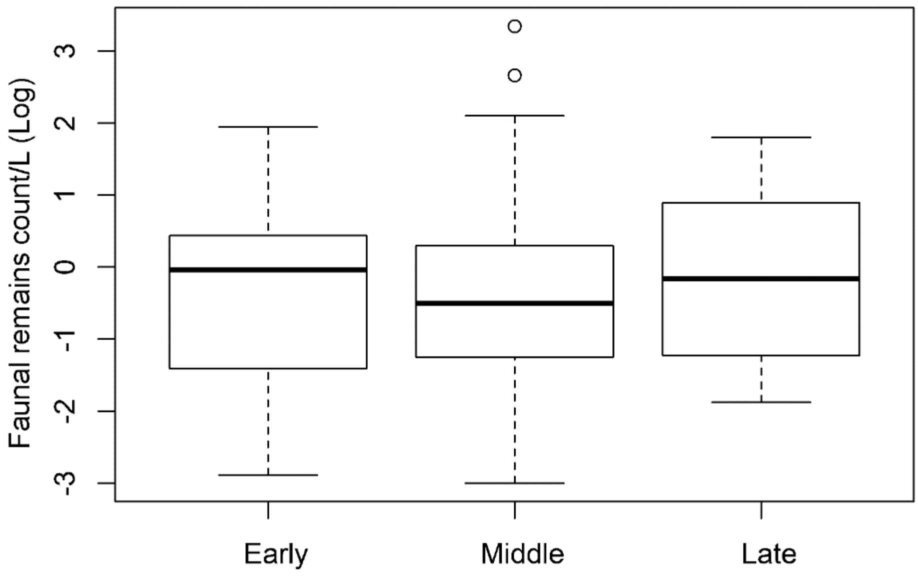

Figure 16.32. Boxplots of natural log-transformed faunal remains densities by period.

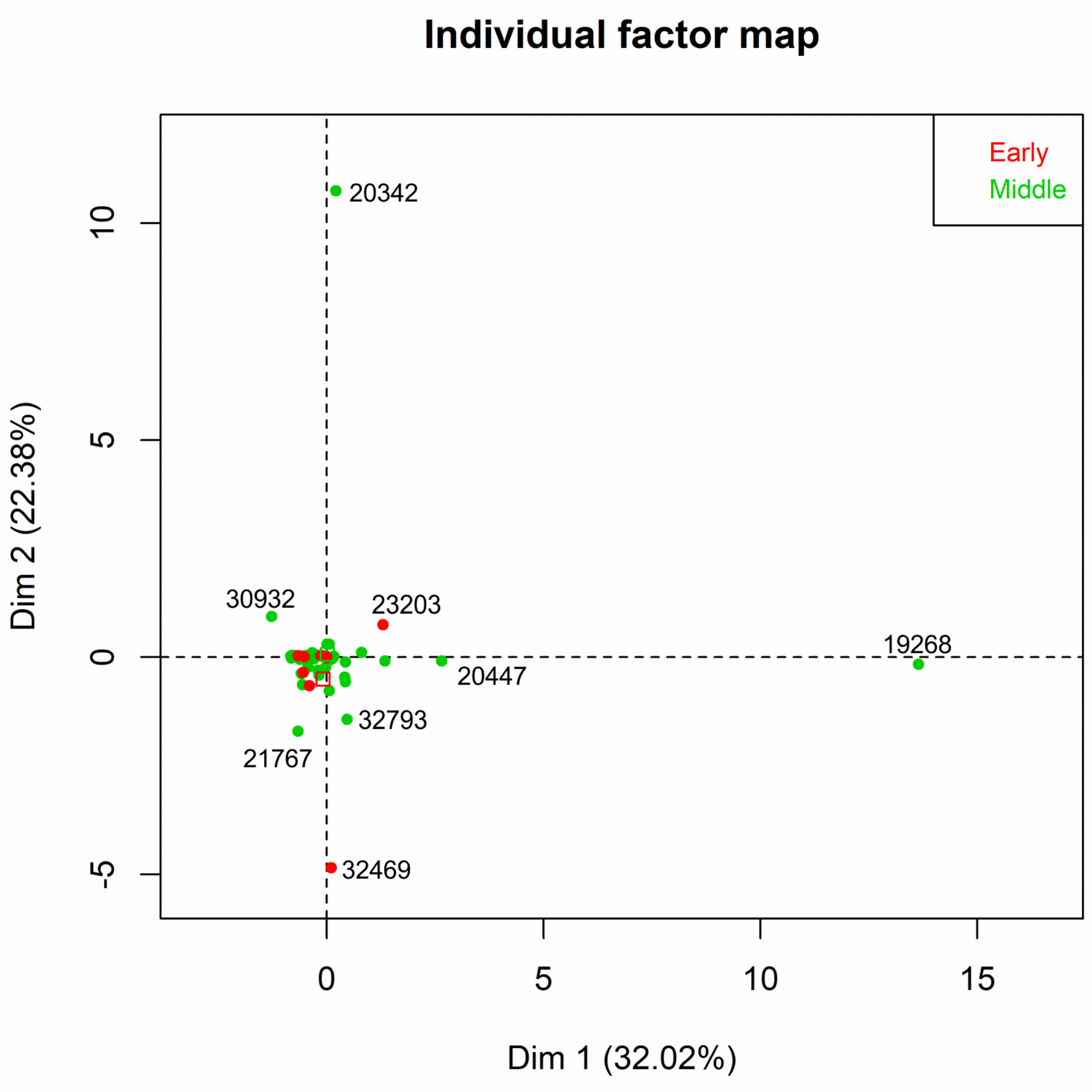

Figure 16.33. Biplot of individual units (individuals factor map), results of MFA on units from floor deposits (plotted by period).

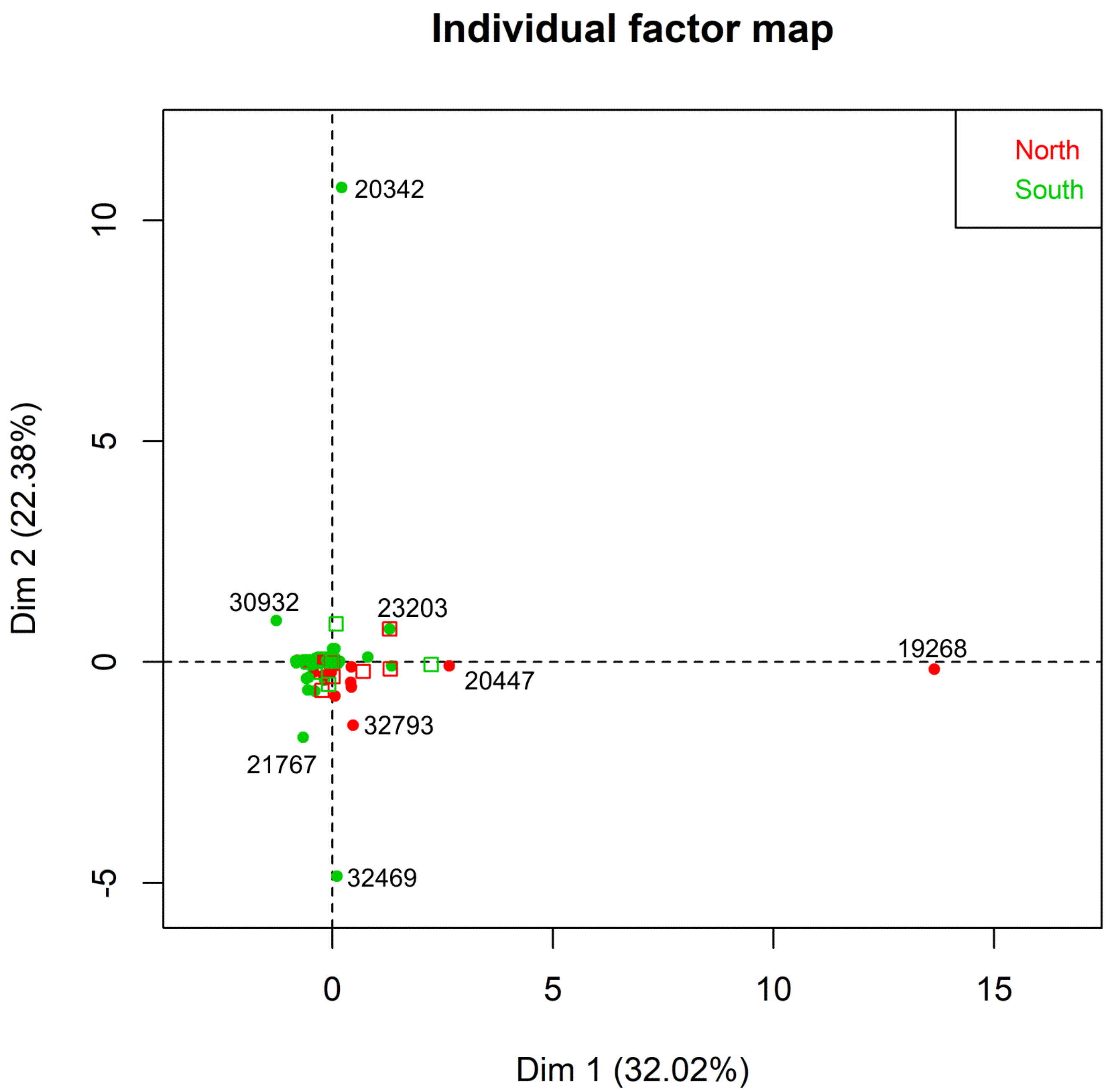

Figure 16.34. Biplot of individual units (individuals factor map), results of MFA on units from floor deposits (plotted by excavation area).

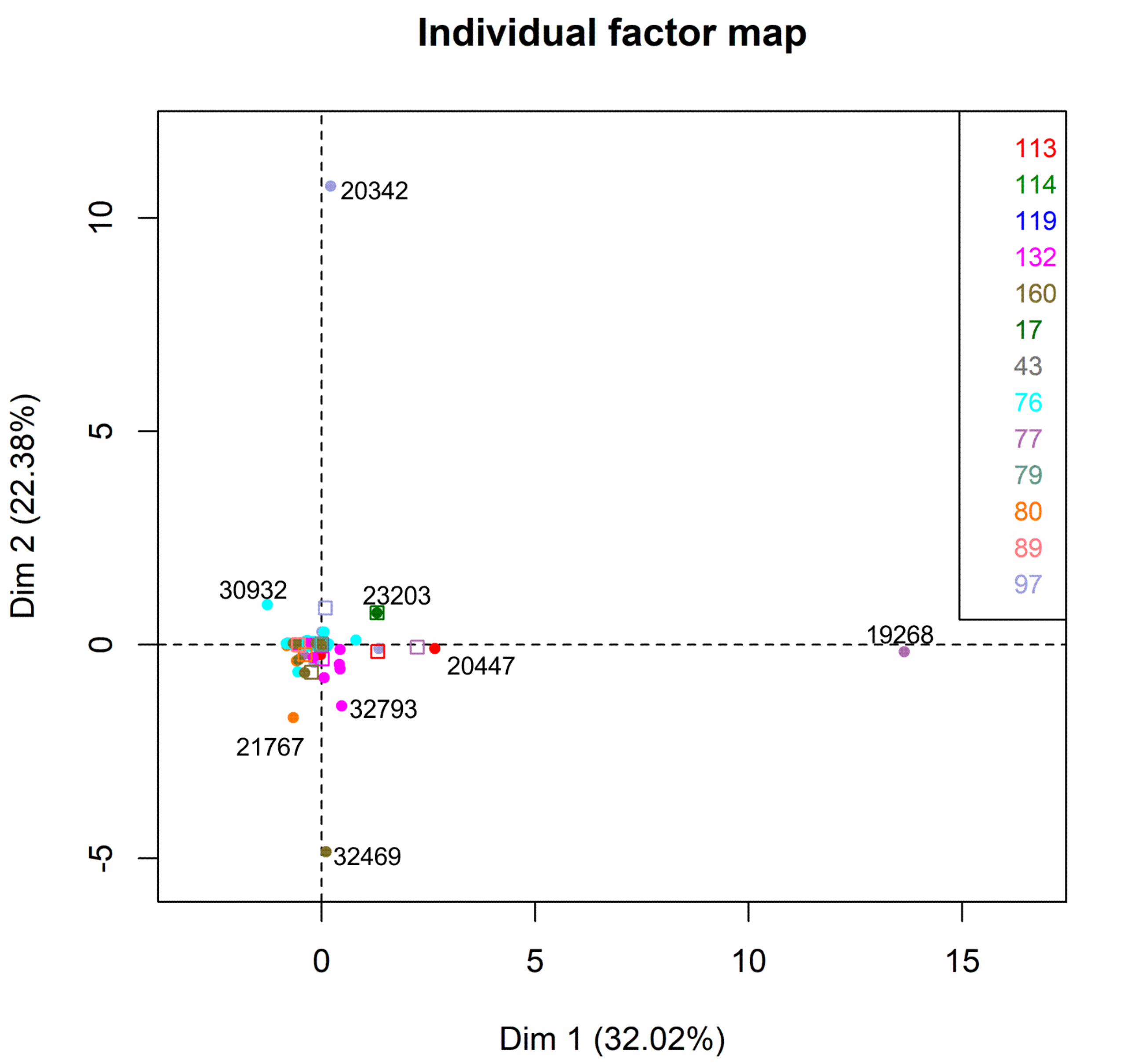

Figure 16.35. Biplot of individual units (individuals factor map), results of MFA on units from floor deposits (plotted by building).

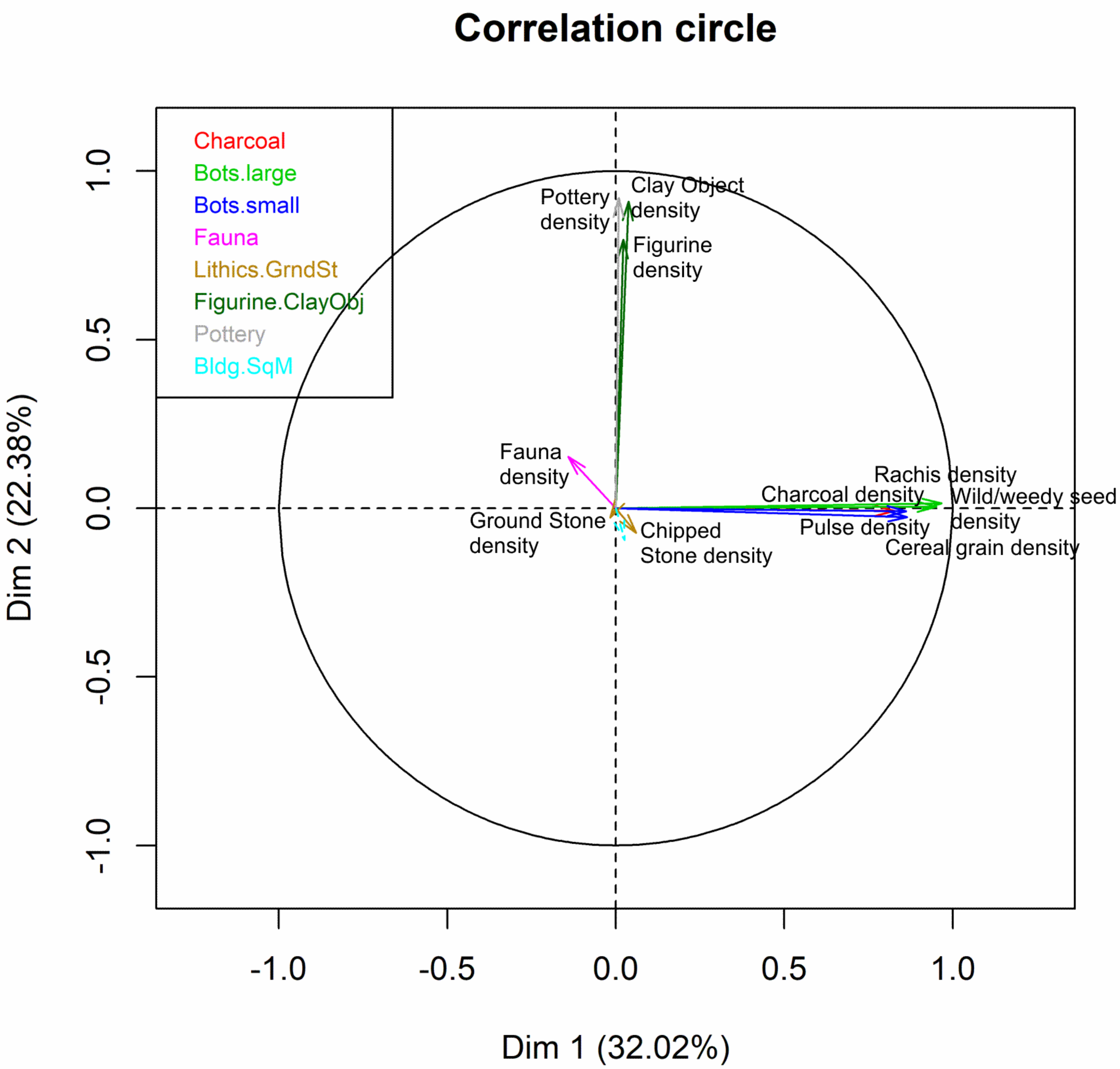

Figure 16.36. Plot of variables, results of MFA on units from floor deposits.

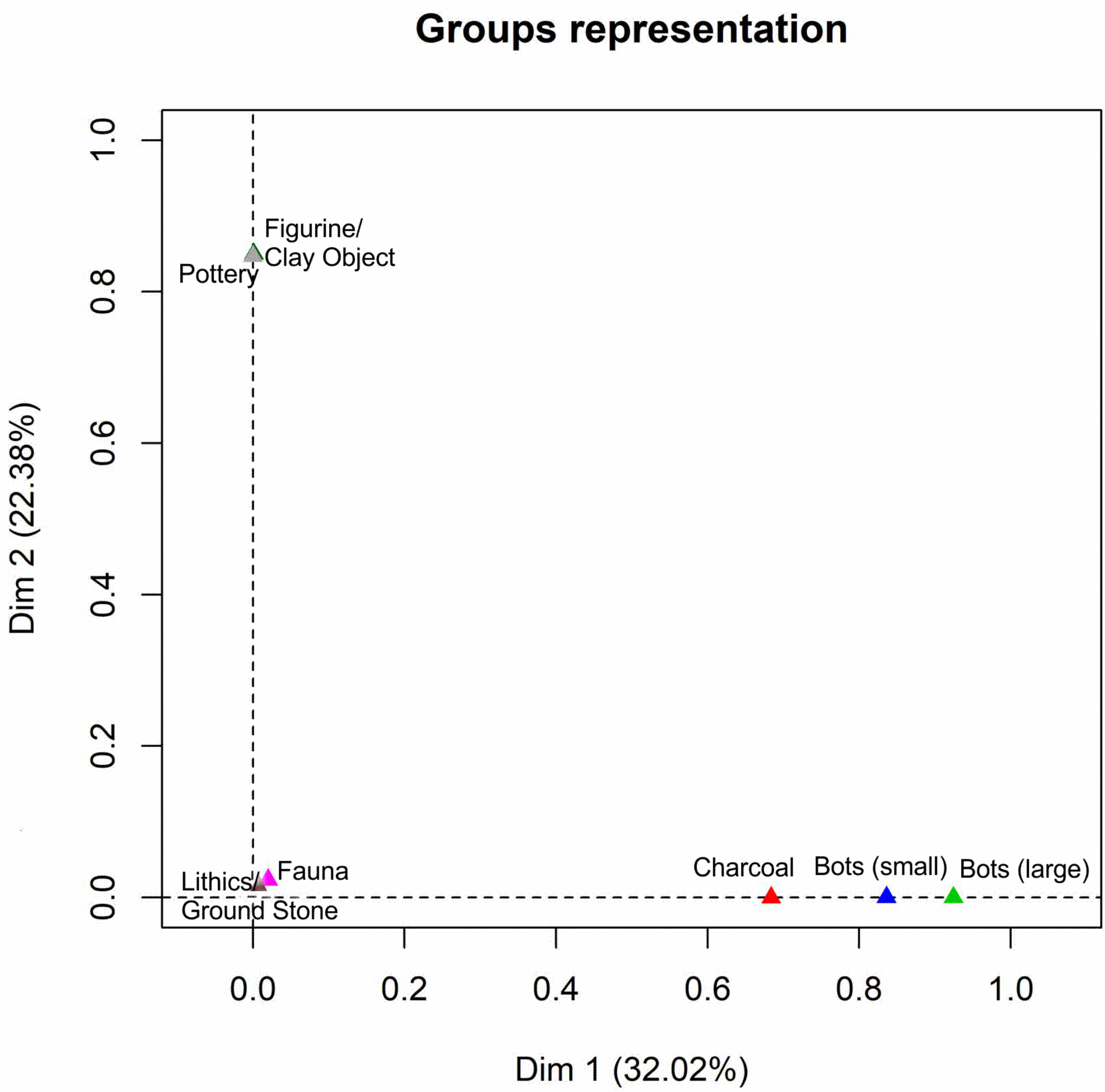

Figure 16.37. Biplot of groups of variables, results of MFA on units from floor deposits.

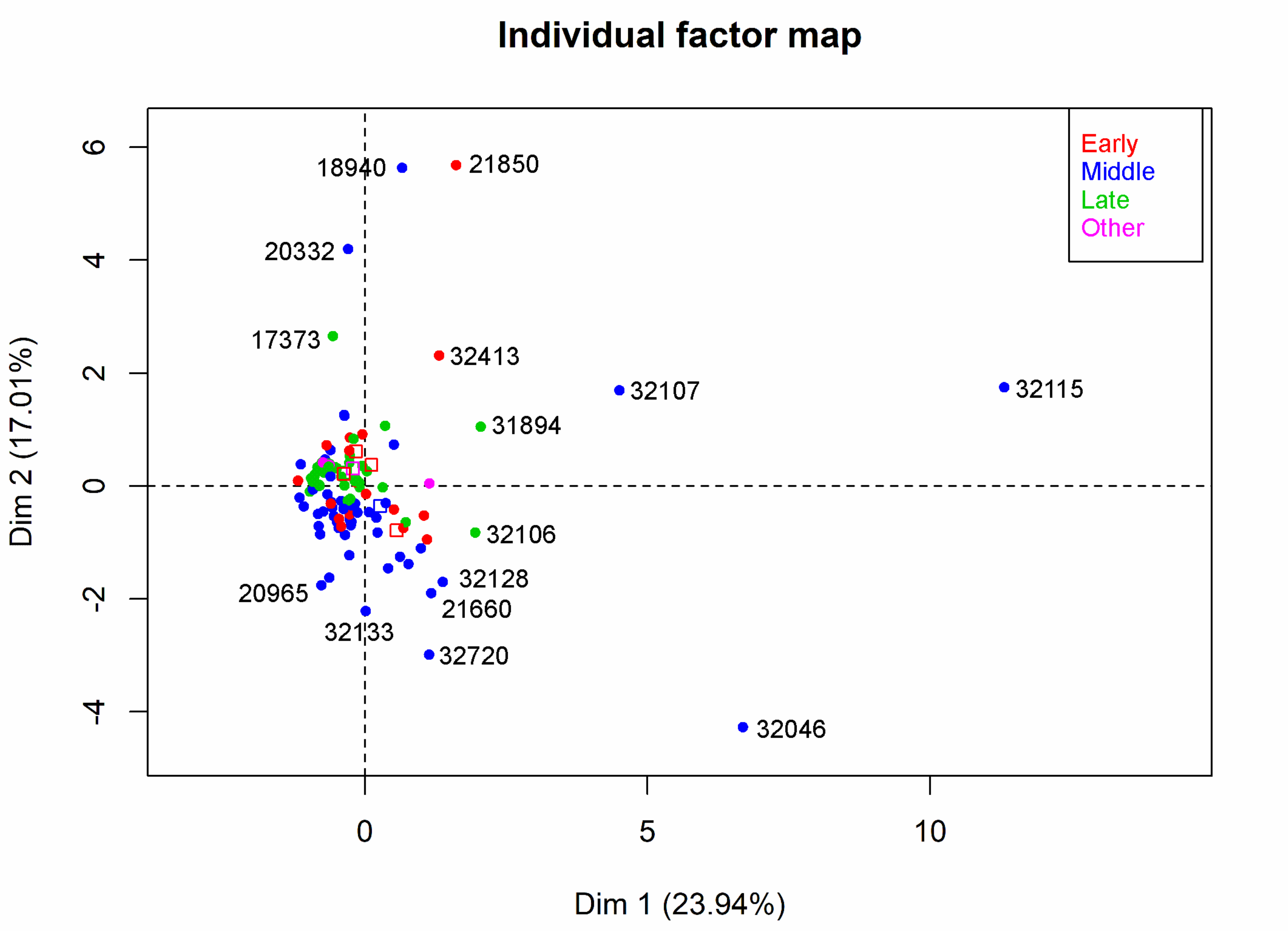

Figure 16.38. Biplot of individual units (individuals factor map), results of MFA on units from midden deposits (plotted by period).

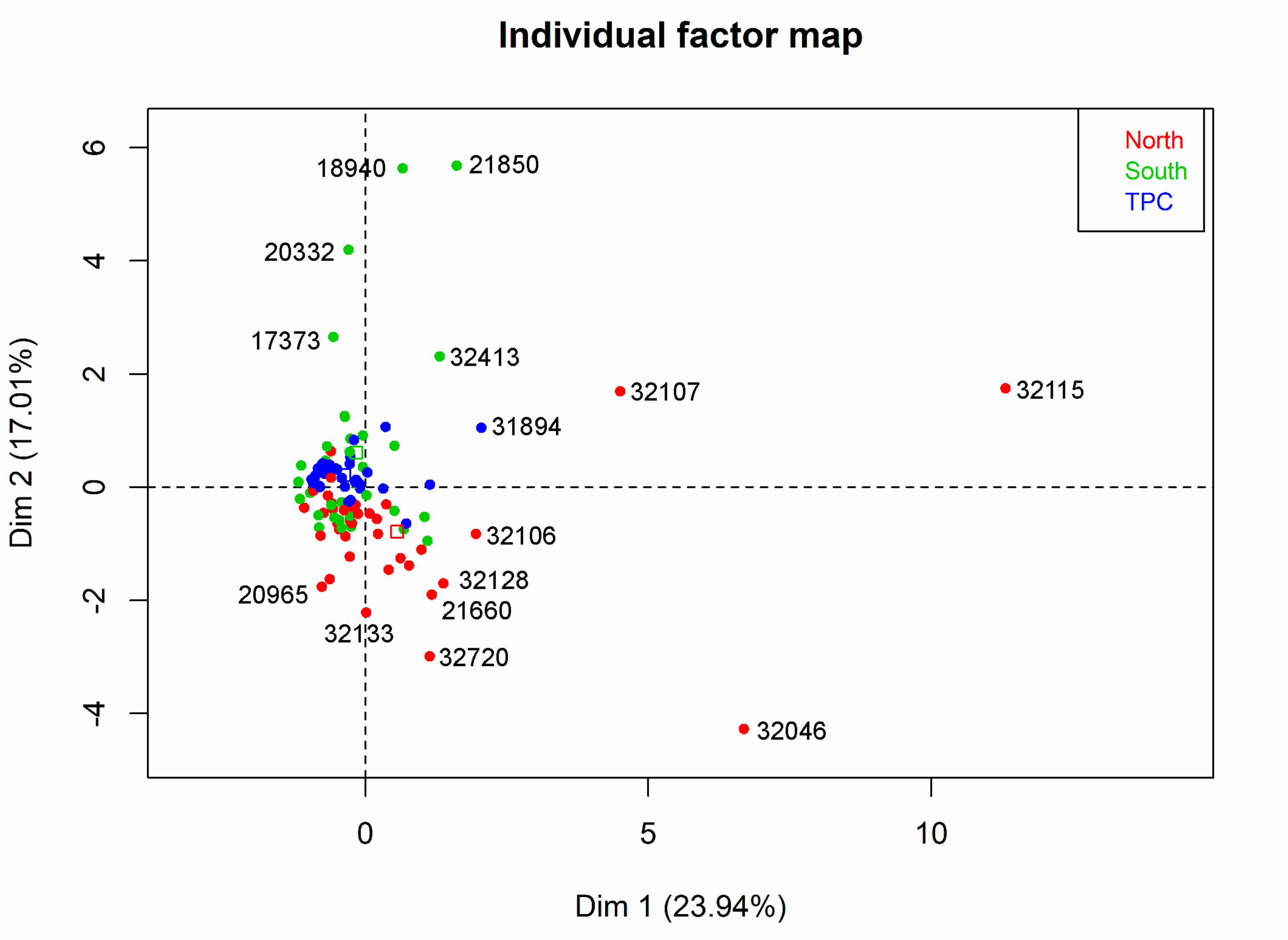

Figure 16.39. Biplot of individual units (individuals factor map), results of MFA on units from midden deposits (plotted by excavation area).

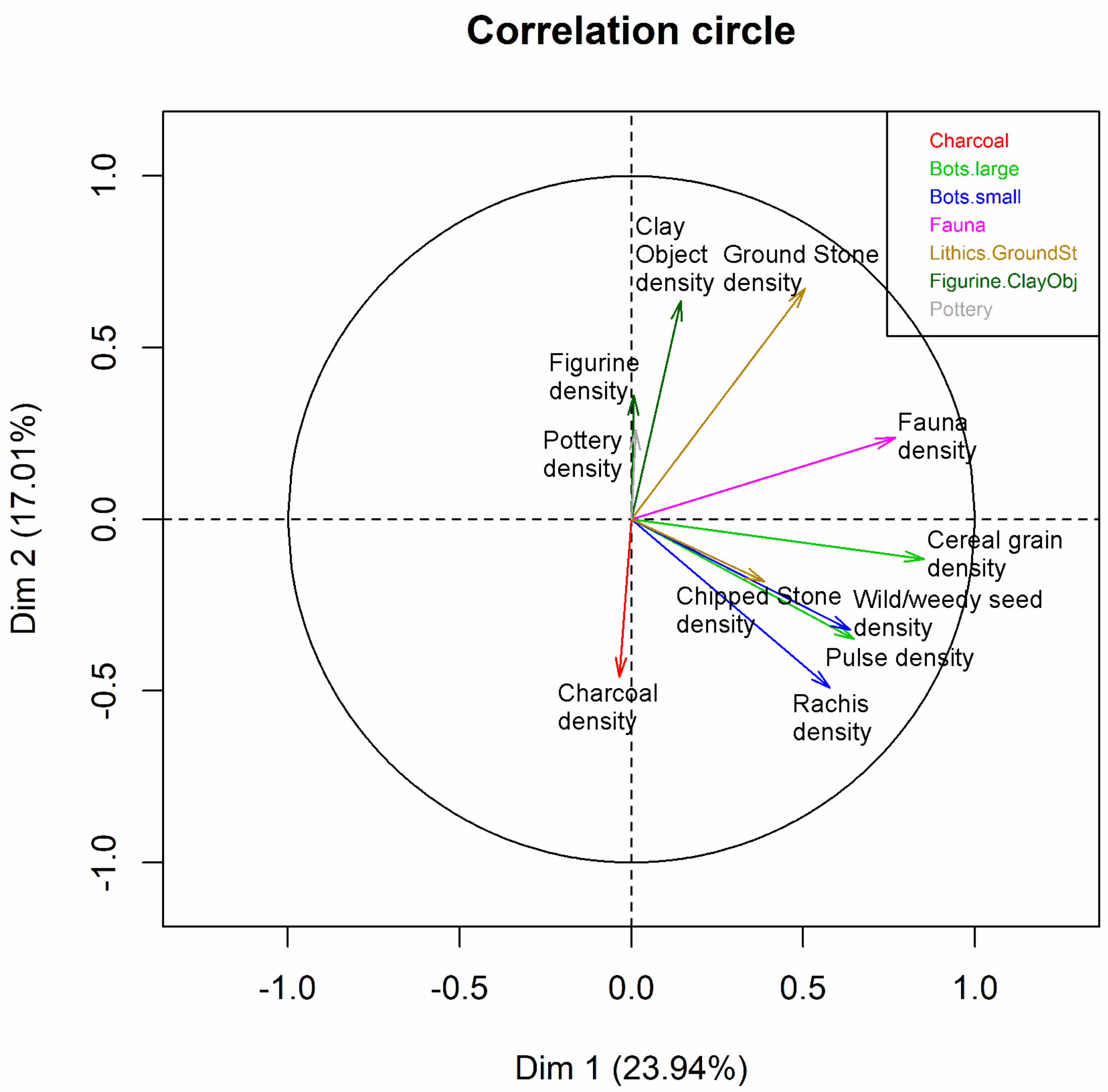

Figure 16.40. Plot of variables, results of MFA on units from midden deposits.

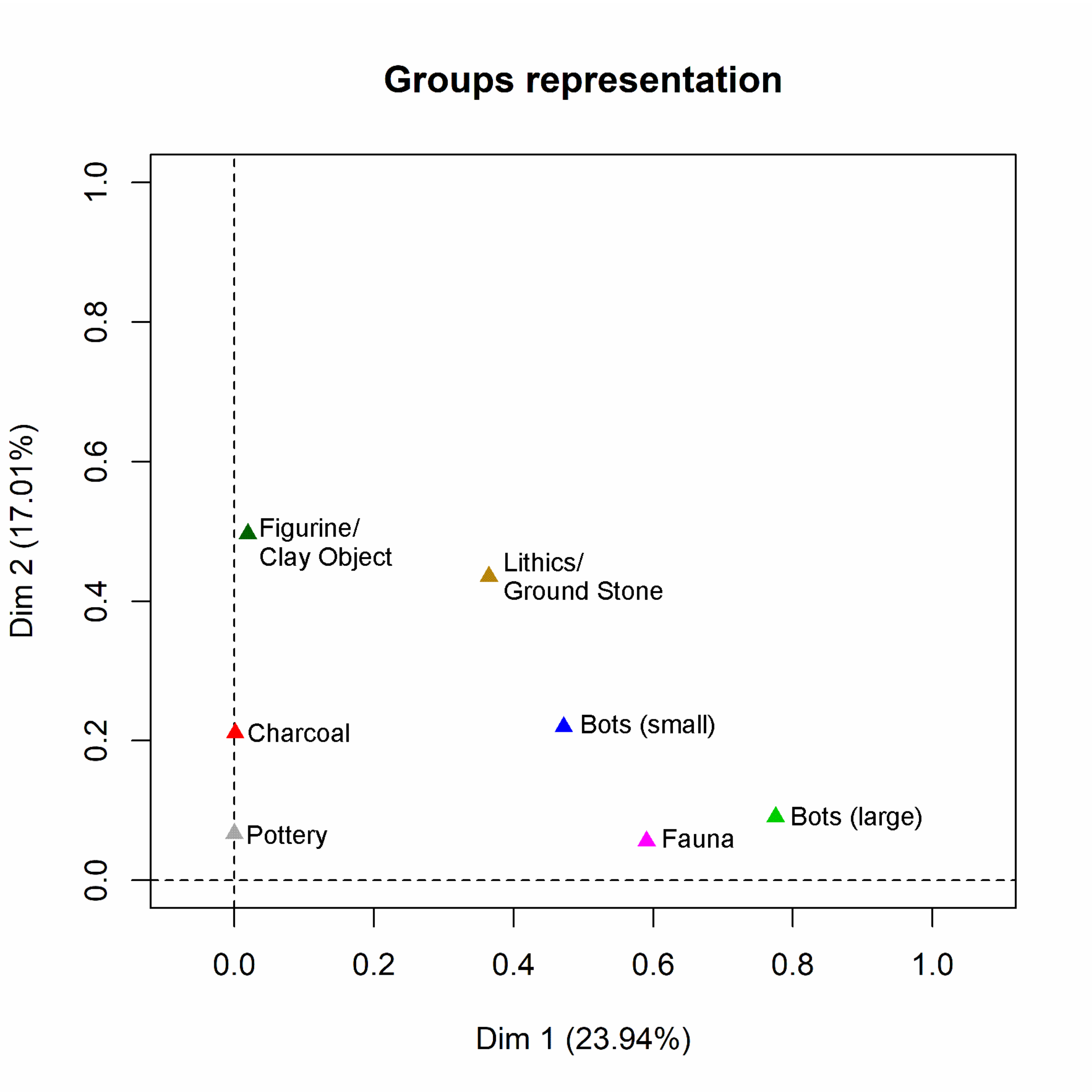

Figure 16.41. Biplot of groups of variables, results of MFA on units from midden deposits.