An archaeobotanical investigation into the Chalcolithic economy and social organisation of central Anatolia

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Abstract

Limited knowledge about the 3000-year period between the Neolithic and the Bronze Age in central Anatolia, Turkey, prevents any understanding of change or continuity in crop production, consumption and crop husbandry techniques. This research aims to address this bias through the examination of archaeobotanical remains from the four central Anatolian Chalcolithic sites of Çatalhöyük West, Çamlıbel Tarlası, Canhasan I and Kuruçay and the consequent investigation of their crop economies. This work draws on multiple methods and techniques to understand the plant-related activities that occurred at the sites.

The four chosen sites bookend the Chalcolithic period (c. 6000-3000 cal BC) and provide the opportunity for exploring the interrelationship between crop choice, crop husbandry, settlement size, surrounding environment and social organisation. Differences in crop species such as hulled barley, glume wheats and pulses, particularly lentil and bitter vetch occur at all four sites with species choice community specific.

Multiple methods are used to disentangle the depositional processes, such as dung burning, that formed the assemblages, providing an indication of the origin of the archaeobotanical material and allowing inferences about the nature of weed seeds found. Crop processing activities are evident at all sites, with the dehusking of glume wheat contributing significantly to the archaeobotanical assemblage. The analysis of stable carbon and nitrogen isotopes of crops coupled with the functional ecology of arable weeds, indicate that crop husbandry techniques/regimes were site specific and were influenced by site size/population as well as environmental conditions. The identification of the crops grown and the methods used to cultivate and process them have implications for understanding the social context of such activities, and the broader socio-economic background of a period preceding the great changes in social structure seen in the Bronze Age.

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TABLE OF CONTENTS

Abstract **III**

Acknowledgements V

Table of contents VII

1 INTRODUCTION **1**

1.1 Southwest Asian context **4**

1.2 The Chalcolithic in Anatolia **7**

1.3 Chalcolithic Turkish Archaeobotany **10**

1.4 Sites examined **13**

1.5 Research questions **14**

1.6 Thesis outline **18**

2 ARCHAEOLOGICAL, ARCHAEOBOTANICAL AND ENVIRONMENTAL BACKGROUND OF ÇATALHÖYÜK, CANHASAN I, KURUÇAY AND ÇAMLıBEL TARLASı **21**

2.1 Çatalhöyük **21**

2.1.1 Excavation history 22

2.1.2 Dating 32

2.1.3 Environmental setting 34

2.2 Canhasan I **37**

2.2.1 Excavation History 37

2.2.2 Dating 46

2.2.3 Environmental setting 48

2.3 Çamlıbel Tarlası **50**

2.3.1 Excavation history 50

2.3.2 Chronology 57

2.3.3 Environmental setting 57

2.4 Kuruçay Höyük **60**

2.4.1 Excavation history 61

2.4.2 Dating 65

2.4.3 Environmental setting 67

2.5 Summary **69**

3 METHODOLOGICAL BACKGROUND **73**

3.1 Understanding archaeobotanical assemblages **73**
3.1.1 Charring 73
3.1.2 Dung burning 76
3.1.3 Crop processing 80

3.2 Identification of crop husbandry methods **88**
3.2.1 Weed ecology 89
3.2.2 Stable isotopes 93

4 METHODS **111**

4.1 Archaeobotanical methods **111**
4.1.1 Samples recovery 111
4.1.2 Scanning 113
4.1.3 Selection criteria 114
4.1.4 Sub-sampling 120
4.1.5 Sorting and identification 120
4.1.6 Quantification 122
4.1.7 Multiplication of sorted fractions 124
4.1.8 Definition of analytical units 125
4.1.9 Amalgamation of taxa 127

4.2 Analytical methods **129**
4.2.1 Correspondence analysis 129
4.2.2 Crop processing analysis 131
4.2.3 Dung burning analysis 137
4.2.4 Crop husbandry analysis – weed ecology based 141
4.2.5 Crop husbandry analysis - stable isotopes of carbon and nitrogen 143

5 ARCHAEOBOTANICAL OVERVIEW **159**

5.1 Çatalhöyük West **159**
5.1.1 Crops 162
5.1.2 Variation in crop composition 167
5.1.3 Wild taxa 170

5.2 Çamlıbel Tarlası **180**

5.2.1 Crops 183
5.2.2 Variation in crop composition 189
5.2.3 Wild taxa 192

5.3 Kuruçay 199
5.3.1 Crops 200
5.3.2 Variation in crop composition 205
5.3.3 Wild taxa 206

5.4 Canhasan I 207
5.4.1 Crops 208
5.4.2 Variation in crop composition 212
5.4.3 Wild taxa 214

5.5 Overall summary 215

6 SAMPLE COMPOSITION AND SPATIAL RELATIONSHIPS 217

6.1 Çatalhöyük West 217

6.2 Çamlıbel Tarlası 224

6.3 Canhasan I 234

6.4 Kuruçay 240

7 DUNG BURNING 243

7.1 Çatalhöyük West 243
7.1.1 Conclusion 255

7.2 Çamlıbel Tarlası 256
7.1.2 Conclusions 265

7.3 Canhasan I and Kuruçay 265

7.4 Overall conclusions 268

8 CROP PROCESSING 269

8.1 Çatalhöyük West 269
8.1.1 Crop-based analysis 270

8.1.2 Crop and weed proportions 275
8.1.3 Weed-based analysis 283
8.1.4 Conclusions 286

8.2 Çamlıbel Tarlası 289
8.2.1 Crop-based analysis 289
8.2.2 Crop and weed proportions 293
8.2.3 Weed-based analysis 298
8.2.4 Conclusions 300

8.3 Kuruçay 301
8.3.1 Crop-based analysis 301
8.3.2 Crop and weed proportions 304
8.3.3 Weed-based analysis 306
8.3.4 Conclusions 308

8.4 Canhasan 310
8.4.1 Conclusions 310

9 CROP-HUSBANDRY: ISOTOPIC EVIDENCE 313

9.1 Çatalhöyük (Late Neolithic East Mound and Early Chalcolithic West Mound) 314
9.1.1 Overall 314
9.1.2 Carbon 315
9.1.3 Nitrogen 322
9.1.4 Question of manuring 326
9.1.5 Temporal differences 328
9.1.6 Palaeodietary reconstructions 332

9.2 Çamlıbel Tarlası 334
9.2.1 Overall 334
9.2.2 Carbon 335
9.2.3 Nitrogen 341
9.2.4 Question of manuring 346
9.2.5 Temporal differences 348
9.2.6 Palaeodietary reconstructions 350

9.3 Conclusions 354

10 CROP–HUSBANDRY: WEED EVIDENCE 359

10.1 Çatalhöyük West **359**
10.1.1 Permanence of Cultivation 362
10.1.2 Sowing time 368
10.1.3 Intensity of cultivation 373
10.1.4 Combined results of weed-based and stable isotope analysis 375

10.2 Çamlıbel Tarlası **379**
10.2.1 Permanence of cultivation 381
10.2.2 Sowing time 384
10.2.3 Intensity of cultivation 388
10.2.4 Combined results of weed-based and stable isotope analysis 394

10.3 Kuruçay **394**
10.3.1 Permanence of cultivation 395
10.3.2 Sowing time 397
10.3.3 Intensity of cultivation 399

11 DISCUSSION AND CONCLUSIONS 403

11.1 What plants were cultivated or collected and were there differences between the sites? **403**
11.1.1 Glume wheat species 407
11.1.2 The importance of hulled barley 411
11.1.3 The importance of pulses 415
11.1.4 The use of flax 417
11.1.5 Wild species use 419

11.2 Fuel use and its implications **420**

11.3 The implications of crop processing and storage practices **422**

11.4 Consumption of plants **426**

11.5 Crop husbandry **428**

11.6 Future directions **437**

11.1 Final remarks **440**

12 APPENDIX **441**

12.1 Appendix - Calculation of discrimination during photosynthesis **441**

12.2 Chapter 4 tables 444

12.3 Chapter 5 tables 454

12.4 Chapter 6 tables 505

12.5 Chapter 9 tables 509

13 BIBLIOGRAPHY 517

List of tables

Table 1.1: Chronology of the region showing the absolute dates in cal. BC, the cultural term given to the period and the major sites mentioned in the text.. 1

Table 1.2: Sites within Turkey that have archaeobotanical data grouped by region , including the date of archaeological material studied, the number of samples, recovery method and proportion of the species from the total crop assemblage..... 11

Table 2.1: Layers of Canhasan I, providing information on period of occupation, the number of levels within each phase and the main attributes or significant changes for each layer. 40

Table 2.2: Phases of Çamlıbel Tarlası indicating the defining characteristics of each phase. 50

Table 2.3: Summary table of the dates, environmental conditions, site size, architectural forms, and known archaeobotanical research of Çatalhöyük West, Canhasan I, Kuruçay and Çamlıbel Tarlası 70

Table 4.1: Number of samples from each site divided into their specific phases, buildings and context. 118

Table 4.2: Samples from Çamlıbel Tarlası and Çatalhöyük West showing the proportions of the samples represented within the research. 125

Table 4.3. The number of samples and species included in the correspondence analysis of each site, the % of the assemblage the species occurred in, and which samples and species were removed due to being outliers. 131

Table 4.4: The number of grains to corresponding chaff type for the different cereals. 132

Table 4.5: Classification of size (small vs. big), aerodynamics (light vs. heavy) and tendency to remain in head (free vs. headed) of the taxa examined in this research. The table shows the difference that using a 1.5mm and 2 mm cut-off for the difference between small and big. 136

Table 4.6: The number of stable carbon and nitrogen isotope samples from Çatalhöyük and Çamlıbel Tarlası 146

Table 4.7: Samples from Çamlıbel Tarlası used for contaminant screening with FTIR. 147

Table 4.8: Trench, species and isotopic values of the outlying samples from Çatalhöyük and Çamlıbel Tarlasi, showing the results of re-analysis. 156
Table 5.1: Relative proportions of plant items in each Çatalhöyük West sample, sorted on proportion of crop material. 161
Table 5.2: Summary of the abundance and frequency of the crop categories from Çatalhöyük West samples 170
Table 5.3: Edible taxa in the Çatalhöyük West assemblage showing the total number of items found, the maximum within all samples, number of samples containing the taxa and the percentage of samples in which the taxa is present. 171
Table 5.4: The number of culm items in the Çatalhöyük assemblage, maximum number found in a sample and the ubiquity of culm in the assemblage. 175
Table 5.5: The count, maximum number of items per sample, total number of items and percentage of samples of frequent and rare wild taxa in the Çatalhöyük West assemblage. 176
Table 5.6. The relative proportions of plant items in each sample, sorted according to the percentage of crop material. 182
Table 5.7: Dimension (mm) of 29 Çamlıbel Tarlası flax seeds plus adjusted measurements to compensate for changes during charring (13% length, 21% breadth). 188
Table 5.8: Summary of the abundance and frequency of the crop categories from Çamlıbel Tarlası samples 191
Table 5.9: Edible taxa identified in the Çamlıbel Tarlası assemblage detailing the total number of items, largest number of items within a sample, and ubiquity 193
Table 5.10: The ubiquity, sum and maximum number of items per sample of the different culm types identified at Çamlıbel Tarlası. 193
Table 5.11: Wild taxa found in the Çamlıbel Tarlası samples indicating ubiquity and items count. Frequent and rare taxa are noted. 194
Table 5.12: Summary of the Kuruçay assemblage (25 samples containing 30+ items) detailing the total number of items, maximum number items and the ubiquity of the taxa identified by M.Nesbitt, and partially re-assessed in this study. 203
Table 5.13: Summary of the Canhasan I assemblage (37 samples containing 30+ items) detailing the total number of items, maximum number items and the ubiquity of the taxa identified by M.Nesbitt, and partially re-assessed in this study. 210
Table 7.1: Species found in dung (D), and attributed to dung burning (A) on Çatalhöyük East in comparison to their occurrence in the Çatalhöyük West samples.. 244
Table 7.2: Predicted group membership for the 41 Çatalhöyük West samples, run as (A) a group to be classified and (B) entered as a separate group using all seeds (C) and (D) show the same runs excluding the species *Descurainia sophia*. 246
Table 7.3: Summary of the fruiting time, habitat preference and seed size, with final classification of probability of being dung derived (dung class), of taxa from the Çatalhöyük West assemblage. 253

Table 7.4. Results of discriminant analysis of Çamlıbel Tarlası material when classified using Jones' (1983) ethnographic data (a), and (b) when entered as a separate group 259

Table 7.5. Summary of the fruiting time, habitat preference and seed size, with final classification of probability of being dung derived (dung class), of taxa from the Çamlıbel Tarlası assemblage.....263

Table 7.6: Resultant classification of the archaeological samples from discriminant analysis when (a) classified in reference to the ethnographic samples and (b) when entered with the ethnographic samples. 266

Table 8.1: Classification of the Çatalhöyük West samples as either spikelet derived or glume base dominated, based on the ratios of glume wheat grain to glume bases. Only samples containing 30 or more identified glume wheat items are included. 271

Table 8.2: Number of barley grains and rachis remains from Çatalhöyük West samples containing 30 or more barley items. The ratio of variety-specific grain to chaff is presented together with total barley per sample, with the interpretation of by-product class shown with reference to Jones' (1983) ethnographic data. 275

Table 8.3: Different taxon combinations examined in the Çatalhöyük West analyses.....278

Table 8.4: Results of discriminant analysis conducted on the Çatalhöyük West samples showing the different crop processing classification of the samples depending on which dung flora/additional species were removed. 284

Table 8.5: The proportion of glume wheat items within the Çatalhöyük West samples, compared to crop, and arable weed seeds, the resulting classification of the samples based on grain to chaff ratios, as will as with discriminant analysis. 287

Table 8.6: Number of grains, glume bases, total, ratio and interpretation of the ratio of the 56 samples containing more than 30 glume wheat items.....290

Table 8.7: Number of barley grains and chaff remains from Çamlıbel Tarlasi samples containing 10 or more barley items. The ratio, together with the interpretation of crop processing class, is shown with reference to Jones' (1983) ethnographic data.. 292

Table 8.8: Species excluded from the different version for each analysis below, with the reason for their exclusion detailed.....295

Table 8.9: Results of the discriminant analyses, providing the number of samples classified as winnowing, coarse sieving, fine-sieving by-product or fine sieving product. Different classifications are provided for the different classification runs that excluded particular groups of taxa. 299

Table 8.10: The dominant crop type of samples with 30 crop items, the proportion of glume wheat items compared to crop, and arable weed seeds and the resulting classification of the samples based on grain to chaff ratios. The proportion that flax weeds contribute to the assemblage and the two different classifications of the

sample as per Jones (1983) using only arable weeds, and only glume wheat weeds. 302
Table 8.11: Summary of grain to glume base/internode ratios and interpretation of the samples containing 30 plus of a single crop. 304
Table 8.12: Summary of the results of the discriminant analysis showing the different classifications grouped by dominant taxa 306
Table 8.13: Comparison of the different crop processing stages' classifications of the components from the Kuruçay samples. 309
Table 8.14: Proportions of grain and chaff in the Canhasan I samples containing at least 30 crop items of one species plus the species that dominates in these samples. The classification of clean product, spikelet, and glume base is delineated for the glume wheat samples, ratios of grain to internode are shown for the free-threshing cereals as well as the predicted crop processing class in comparison with Jones' ethnographic data.. 311
Table 9.1: Mean and standard deviation (sd) of the general categories of crops (barley, glume wheat, free-threshing wheat and pulses) for $\delta^{13}C$, $\Delta^{13}C$ and $\delta^{15}N$, for all Çatalhöyük samples (TP area, Trench 1 and Trench 5). 316
Table 9.2: Results of analysis of variance (ANOVA) tests on the $\Delta^{13}C$ values for different groups of species when various offsets are applied to barley. 319
Table 9.3: Results of a Tukey post hoc test on all wheat, pulse and barley categories, including barley with a 1, 1.5 and 2‰ offset applied. 319
Table 9.4: Results of a Tukey post hoc test on all species with barley given an 1‰ offset 319
Table 9.5. The standard deviation and coefficient of variability of the $\delta^{15}N$ values of the seven taxa examined from Çatalhöyük. 324
Table 9.6: Results of statisical anaylsis of the $\delta^{15}N$ of different crop combinations 324
Table 9.7: Results of statistical tests comparing crop taxa isotope ratios among phases. 330
Table 9.8: Results of statistical tests on the $\Delta^{13}C$ of species with 1 or more samples, within phase. 331
Table 9.9: Results of a Tukey *post hoc* test of the taxa (> 1 samples) from the ECI period with a 1‰ offset from barley applied and significant results when a 1.5‰ offset applied (in brackets) 331
Table 9.10: Mean stable isotope values and standard deviation (SD) for fauna and crops and the isotopic offsets (Δ) for $\delta^{15}N$ and $\delta^{13}C$ between them. Note: only the mean value is known for sheep/goat and cattle. Sheep and goat data from Pearson (pers. comm), cattle and sheep/goat from Middleton (pers. comm) 333
Table 9.11: Number of samples, mean and standard deviation (1σ) of $\delta^{13}C$, $\delta^{15}N$, and $\Delta^{13}C$ of the general crop categories from Çamlıbel Tarlası. 336

Table 9.12: Results of ANOVA conducted on various combinations of crop types when a 1‰, 1.5‰ or 2‰ offset is applied to the barley 338
Table 9.13: Results of a Tukey *post hoc* test on pulse, wheat and raw barley values as well as barley at the three offset levels 338
Table 9.14: Results of a Tukey *post-hoc* testing on taxa with >3 samples from Çamlıbel Tarlası, using a 1‰ offset on barley $\Delta^{13}C$ values.....338
Table 9.15: Results of a Tukey *post-hoc* test on all taxa from Çamlıbel Tarlası with more than 3 samples, using a 1.5‰ offset on barley $\Delta^{13}C$ values 338
Table 9.16: Results of statistical tests conducted in the $\delta^{15}N$ values of the cereal taxa from Çamlıbel Tarlası.....344
Table 9.17: Results of statistical tests conducted on lentil, bitter vetch and grass pea $\delta^{15}N$ values from Çamlıbel Tarlası samples 345
Table 9.18: Mean stable isotope values for humans, animals and crops, standard deviation (SD), and the isotopic offsets (Δ) for $\delta^{15}N$ and $\delta^{13}C$ between them.....351
Table 10.1: Potential derivation of the Çatalhöyük West taxa, including their ubiquity and percentage of total wild seeds. The lifecycle of the taxa and number of species is provided. 360
Table 10.2: The differing classification for flowering onset and duration used at the sites. The Germany classification refers to Bogaard et al. (2001)'s study on which the technique is based. 369
Table 10.3: Flowering onset, duration and resultant classification of sowing time for taxa from Çatalhöyük West samples.....372
Table 10.4: The 24 taxa used to investigate the intensity of cultivation at Çatalhöyük West. In the cases where taxa were not identified to species, the species available with functional data were used, producing an average value for that taxon. 373
Table 10.5. The number of taxa and items of taxa used in the discriminant analysis as well as the results of the discriminant analysis of the Çatalhöyük West samples, showing their classification as high- or low-intensity cultivation, with high or low probability. 377
Table 10.6: The wild species found in the Çamlıbel Tarlası assemblage, providing the number of potential species the taxa could represent, its ubiquity and proportion of total wild seeds, as well as its lifecycle, annual (a), perennial (p), and the habitat preferences of the perennial species (disturbed (dis) or non-disturbed (non-dis)) or the taxa classed as deriving from arable fields.....379
Table 10.7: The flowering onset, length of flowering and resultant classification of the species from Çamlıbel Tarlası.....387
Table 10.8: The 30 taxa used to investigate the intensity of cultivation at Çamlıbel Tarlası. In the cases where taxa were not identified to species, the species available with functional data were used, producing an average value for that taxon. 388

Table 10.9: The number of taxa and items of taxa used in the discriminant analysis as well as the results of the discriminant analysis of the Çamlibel Tarlası samples, shorted by intensity classification of high- or low-intensity cultivation, with high or low probability shown. **391**

Table 10.10: The flowering onset, length of flowering and resultant classification of sowing time for the species from Kuruçay. **398**

Table 10.11: The 12 taxa used to investigate the intensity of cultivation at Kuruçay. Where taxa were not identified to species, the species with available functional data were used, producing an average value for that taxa. **399**

Table 10.12: The sample, dominant crop taxa, number of weed taxa and seeds of such taxa used in the discriminant analysis as well as the results of the discriminant analysis of the Kuruçay samples, showing their classification as high- or low-intensity cultivation, with high or low probability. **401**

Table 11.1: Summary of the major components of the four examined sites providing the total number of items and their ubiquity in the samples containing 30+ items.. ..... **405**

Table 11.2: Turkish Chalcolithic sites with quantitative data published on species present, as well as the new quantities data from Çatalhöyük West, Canhasan I, Çamlıbel Tarlası and Kuruçay, detailing the proportion of the species from the total crop assemblage. **410**

Table 11.3: Summary of the different crop husbandry techniques practised at Çatalhöyük West, Çamlıbel Tarlası and Kurucay. **429**

Table 12.1: Unit number and flot number of samples, the merged samples and the name by which they are referred to in the text, their context, phase or building details. **444**

Table 12.2: The sites, lab code, sample name referred to in text, it unit and flot number species and phases of the 199 samples used for isotopic analysis. **447**

Table 12.3: Raw data table for Çatalhöyük West showing the items found. **454**

Table 12.4: Raw data table for Çamlıbel Tarlası showing the items found. **466**

Table 12.5: Raw data table for Kuruçay showing the items found. **493**

Table 12.6: Raw data table for Canhasan I showing the items found. **499**

Table 12.7: The 63 taxa included in the Çatalhöyük West correspondence analysis with the codes used in the graphical representation shown. **505**

Table 12.8: The taxa included in the Çamlıbel Tarlası correspondence analysis and the codes used to represent them. **506**

Table 12.9: The taxa included in the Canhasan I correspondence analysis and the codes used to represent them. **507**

Table 12.10: The taxa included in the Kuruçay correspondence analysis and the codes used to represent them. **508**

Table 12.11: $\delta^{13}C$, $\delta^{15}N$, and $\Delta^{13}C$ values for all samples from Çatalhöyük, showing the mean and standard deviation (1σ) of each species in the four phases of Late Neolithic (LN), Early Chalcolithic I (ECI), Trench 5 (T5) and Early Chalcolithic II (ECII). **509**

Table 12.12. Number of samples, mean, standard deviation and range of $\delta^{13}C$, $\delta^{15}N$ and $\Delta^{13}C$ for the crop species examined at Çamlıbel Tarlası. 512

List of Figures

Figure 1.1: Location of the sites mentioned in the text with the ellipses outlining the regions referred to in Table 1.2. 3
Figure 2.1: Site map of Çatalhöyük showing the location of the East and West Mound trenches mentioned in the text (map courtesy of the Çatalhöyük Project). 26
Figure 2.2: Plan of Trench 1, Çatalhöyük West, redrawn from Gibson and Last 2003. 27
Figure 2.3: Map of Trench 5, Çatalhöyük West, depicting the plan of the walls and buttresses within the trench and the names of each Building/Space. Redrawn from Biehl et al. 2012 30
Figure 2.4: Chronology of Central Anatolian sites mentioned in the text, relying on radiocarbon dates (black) and ceramic chronologies/excavation depth (grey). 33
Figure 2.5: Walter climate diagram of Çumra and Konya showing the monthly average rainfall and temperature 37
Figure 2.6: Plans of layer 5 (from French 1998). 42
Figure 2.7: Plans of layer 2b, showing structures discussed in the text (from French 1998). 43
Figure 2.8. Plans of layer 2A from Canhasan I showing structures mentioned in the text (from French 1998) 44
Figure 2.9. Plans of Canhasan I , layer1 showing structures mentioned in the text (from French 1998) 45
Figure 2.10: Re-calibrated radiocarbon dates of Canhasan I.. 48
Figure 2.11: Walter climate diagram for the town of Karaman. 49
Figure 2.12. Phase plan of CBTII (supplied by U-D. Schoop) 53
Figure 2.13: Phase plan of III (supplied by U-D. Schoop). 54
Figure 2.14 Phase plan of CBTIV (supplied by U-D. Schoop) 55
Figure 2.15: Walter climate diagrams for villages around Çamlıbel Tarlası highlighting the seasonal pattern of precipitation and mean temperature.. 60
Figure 2.16: Selected phases of occupation at Kuruçay, showing plans of level 9, 8, 7, 6 A, 6c, 6b, 6a and 3 (plans from Duru 2008). 63
Figure 2.17: Kuruçay radiocarbon dates recalibrated - in order of level (in brackets). 67
Figure 2.18: Walter climate diagrams from Isparta and Burdur (data from Erinç 1949). ... 69
Figure 3.1: The components separated upon threshing from the different types of cereals, diagram from Hillman (1981:131). 82
Figure 3.2: A simplified flow chart of the main crop processing sequence showing the products and by-products of each step. The descriptions of the by-product refers to the characteristics of weed seeds removed, developed by Jones (1984) and the crop remains removed based primarily on the processing of free-threshing wheat. 83

Figure 3.3: The watering bands hypothesised by Wallace et al. (2013) showing the nature of water available against $\Delta^{13}C$. 102
Figure 3.4: The nitrogen cycle (diagram by R. Stroud). 103
Figure 3.5: Graphical representation of manuring bands from Bogaard et al. (2013b) showing the three bands based on modern data of bulk wheat and barley samples from long-term agricultural experimental trails. The three bands represent the manuring rates of high, medium and low (residual) manuring per annum. 106
Figure 4.1: FTIR spectra for the three Çamlıbel Tarlası samples compared to modern grain artificially contaminated with carbonate 148
Figure 4.2: FTIR spectra for the three Çamlıbel Tarlası samples compared to modern grain artificially contaminated with nitrate. 149
Figure 4.3: FTIR spectra for the three Çamlıbel Tarlası samples compared to modern grain artificially contaminated with humics. 149
Figure 4.4: Comparison of Çamlıbel Tarlası (CBT) and the three trenches from Çatalhöyük: TP, Trench 1 (T1) and Trench 5 (T5). C:N ratios with ratios of modern grain and pulses. 153
Figure 5.1: Proportions of weed/wild, culm, *Celtis*, fruit/nut shell and tuber, pulse, free-threshing cereals and glume wheat items in the 42 Çatalhöyük West samples containing 30 or more items. 160
Figure 5.2: Proportions of crop catergories in the 42 Çatalhöyük West samples containing 30 or more crop items. 163
Figure 5.3: Proportions of the three glume wheat species' glume bases in the 40 Çatalhöyük West samples containing 30 or more glume bases. 164
Figure 5.4: Comparison of the grain (A) and grain and chaff (B) remains of cereal groups: barley, glume wheat and free-threshing wheat from the 42 Çatalhöyük West samples containing 30 or more cereal items. 168
Figure 5.5: Proportions of pulse, bread wheat, barley and glume wheat remains in the 42 Çatalhöyük West samples containing 30 plus crop items. 168
Figure 5.6: Proportion of barley grain and glume wheat chaff in the 40 Çatalhöyük West samples containing at least 30 such items. 169
Figure 5.7. *Phragmites* in a modern cereal fields near the site of Çatalhöyük. 174
Figure 5.8: Proportions of glume wheat, free-threshing cereal, pulse, fruit/nut, flax, culm and weed items in the 68 samples from Çamlıbel Tarlası containing 30 items or more. 181
Figure 5.9: Proportions of the various crop types in the 63 samples containing 30 or more crop items. 184
Figure 5.10: Proportions of the three identified species of glume wheat in the 52 Çamlıbel Tarlasi samples containing 30 or more chaff items. 185

Figure 5.11: Measurements from reported flax seed finds in South West Asia, against the Çamlıbel Tarlası flax seeds, as well as for reference the modern measurements for oil and fibre seeds 188

Figure 5.12: Comparison of the grain and chaff remains of the major crop groups from the 64 Çamlıbel Tarlası samples containing 30 or more cereal items. 189

Figure 5.13: (A) Proportions of barley, glume wheat and pulse seeds in the 52 Çamlıbel Tarlası samples containing 30 or more barley, glume wheat or pulse seeds. (B) the proportions of barley, glume wheat and pulse items in the 63 samples containing 30 or more of such items. 190

Figure 5.14: Proportion of glume wheat chaff, barley grain and pulse seeds in the 61 samples containing 30 or more items of the categories graphed. 191

Figure 5.15: Proportions of weeds, culm, fruits and nuts, flax, pulse, free-threshing cereals and glume wheat remains in the Kuruçay assemblage. 200

Figure 5.16: Proportion of pulse, glume wheat, free-threshing wheat, barley and flax in the 24 Kuruçay samples containing crop remains. 201

Figure 5.17: Composition of the Canhasan I samples containing 30 or more items. 208

Figure 5.18: Composition of crop material in the Canhasan I samples containing 30 or more crop items. 208

Figure 5.19: Proportion of glume wheat, free-threshing cereal and pulse items in the 30 Canhasan I samples containing 30 or more glume, free-threshing cereal and pulse items. 213

Figure 5.20: Proportions of glume wheat, free-threshing wheat and barley in the 30 Canhasan I samples containing 30 or more cereal items. 213

Figure 6.1: Plot of the results of correspondence analysis on 41 samples and 61 species from Çatalhöyük West; symbols show major categories. 218

Figure 6.2: Results of the correspondence analysis of Çatalhöyük West samples, showing samples represented as pie charts summarising composition in terms of major categories. 218

Figure 6.3: Results of correspondence analysis of Çatalhöyük West samples. Species shown, coded for major taxa groups with wild seeds displaying seed size in reference to crop processing. 219

Figure 6.4: Çatalhöyük West correspondence analysis, showing the samples coded for context type. 220

Figure 6.5: Correspondence analysis for Çatalhöyük West samples, the symbols representing the buildings from which samples were obtained. 220

Figure 6.6: Results of the correspondence analysis of all Çatalhöyük West samples but only displaying Building 98 samples. 222

Figure 6.7: Correspondence analysis plots of all Çatalhöyük West samples but only displaying Building 105 samples 223

Figure 6.8:Correspondence graph of the major groups of the 63 samples and 68 species from Çamlıbel Tarlası. 225
Figure 6.9: Results from the correspondence analysis of Çamlıbel Tarlası samples showing samples represented as pie charts summarising composition in terms of major categories....225
Figure 6.10: Plot of the species from the correspondence analysis of the 63 units and 68 taxa from the Çamlıbel Tarlası assemblage, coded showing the species' classification based on major groups and seed size……226
Figure 6.11: Plot of the correspondence analysis of the Çamlıbel Tarlası samples coded for (A) the four major occupation phases and (B) context types. 227
Figure 6.12: Plot of the Çamlıbel Tarlası correspondence analysis showing only CBTI samples coded for sample location.....228
Figure 6.13: Results of the correspondence analysis for the Çamlıbel Tarlası samples, showing only CBTII samples coded for (A) sample context, (B) structure the samples derived from and (C) samples represented as pie charts summarising composition in terms of major categories 230
Figure 6.14: Plan of CBTII at Çamlıbel Tarlası showing the location and composition of the samples, plan supplied by U-D. Schoop 231
Figure 6.15: Results of the correspondence analysis for the Çamlıbel Tarlası samples, showing only CBTIII samples coded for (A) sample context and (B) samples represented as pie charts summarising composition in terms of major categories 233
Figure 6.16: Plan of CBTIV at Çamlıbel Tarlası showing the location and composition of the samples, plan supplied by U-D. Schoop……233
Figure 6.17: Species plot showing the correspondence analysis of the 33 samples and 18 taxa from Canhasan, coded for the major taxa categories 234
Figure 6.18: Plot of the correspondence analysis of the Canhasan 33 samples and 18 taxa, showing samples represented as pie charts summarising composition in terms of major categories.....235
Figure 6.19: Layer 5 plan showing the location and composition of the samples.....237
Figure 6.20: Plan of Layer 2B from Canhasan I showing the location of, and the proportion of major categories in the samples 238
Figure 6.21: Plan of Layer 2A from Canhasan I showing the location and the proportion of major categories in the samples. 239
Figure 6.22: Correspondence analysis results for the 24 samples and 30 species from Kuruçay with the symbols showing the categories of major species (codes in Table 12.10). 241
Figure' 7.1: Discriminant analysis of Çatalhöyük West and Jones' (1983) ethnographical crop processing samples (A) classified with regard to the ethnographic data, and (B)

with the Çatalhöyük West samples entered as a separate group following Charles (1998). 247
Figure 7.2: Correspondence graphs of the 41 samples and 61 species of the Çatalhöyük West assemblage coded for (A) seed size with reference to ease of passage through sheep/goat/cattle gut, (B) seasonality of fruiting period with reference to harvest time, (C) habitat preference, and (D) final dung classification. 252
Figure 7.3: Results of the discriminant analysis of material from Çamlıbel Tarlası compared with Jones' ethnographic samples. (A) archaeological samples as classed with reference to the ethnographic data and (B) archaeological samples discriminated as a separate group with the ethnographic data. 258
Figure 7.4: Correspondence analysis plot coded by (a) fruiting time, (b) habitat, (c) seed size, and (d) dung class for 62 Çamlıbel Tarlası samples. 262
Figure 7.5: Results of the discriminant analysis of material from Kuruçay compared with ethnographic samples,(A) when the archaeological samples is classed with reference to the ethnographic data, and (B) when the archaeological samples are discriminated as a separate group with the ethnographic data. 267
Figure 8.1: Çatalhöyük West barley ratios based on form-specific items from samples with 30 or more barley items, shown against Jones' (1983) ethnographic data. 274
Figure 8.2: Triangular plots showing the proportions of weed seeds, glume wheat grain and glume wheat chaff of the 42 Çatalhöyük West samples containing 30 or more glume wheat items. 280
Figure 8.3: "Weediness" of the Çatalhöyük West samples showing the results of removal of specific groups of taxa 282
Figure 8.4: Results of discriminant analysis of the weeds' assemblage from the Çatalhöyük West samples in comparison to Jones' (1983) ethnographic data of know crop processing stages, showing the first two functions. 285
Figure 8.5: Comparison of Çamlıbel Tarlası samples' barley ratios (shown as solid symbols) against (A) Jones (1983) ethnographic data and (B) Jones' data adjusted to represent two-rowed barley forms. 293
Figure 8.6: Ratio of grain to glume bases to weed seeds from Çamlıbel Tarlası samples. 296
Figure 8.7: Weed to glume base ratios of the Çamlıbel Tarlası samples compared to the theoretical weed seed to glume base ratio of fine-sieving by-products of glume wheats (following Bogaard 2011). 297
Figure 8.8: Results of the four discriminant analyses conducted with the removal of specific weeds. 300
Figure 8.9: (A) Proportions of seeds, chaff and weeds in Kuruçay samples, flax samples included for comparison with (B) the proportion of Jones' (1990) ethnographic data for winnowing, coarse-sieving and fine-sieving by-product, and fine-sieving product of free-threshing cereals. 305

Figure 8.10: Comparison of the "weediness" of (A) the Kuruçay glume wheat samples against (B) the theoretical fine-sieving by-product of Jones's (1983) ethnographic data 306
Figure 8.11: Function 1 and 2 of the discriminant analysis results for the archaeological samples, classified with reference to the ethnographic data of Jones (1983). 307
Figure 9.1: The $\delta^{15}N$ and $\delta^{13}C$ values for all plant samples from Çatalhöyük (TP area of the East Mound and Trench 1 and 5 of the West Mound). 315
Figure 9.2: The $\Delta^{13}C$ values of general crop categories at Çatalhöyük showing the values (A) and the means and standard deviation (B) of the groups (mean of barley with a 1‰, 1.5‰ and 2‰ offset is included in graph b).....316
Figure 9.3: $\Delta^{13}C$ values (A) and mean (B) of Çatalhöyük crop species 318
Figure 9.4: The $\Delta^{13}C$ (A) and $\delta^{15}N$ (B) values for the einkorn samples divided on type: one-seeded versus two-seeded. 321
Figure 9.5: $\delta^{15}N$ values (A) and means (B) of the Çatalhöyük general crop categories. 323
Figure 9.6: $\delta^{15}N$ values of Çatalhöyük (A) and mean and standard deviation (B) of all species examined. 325
Figure 9.7.: $\Delta^{13}C$ and $\delta^{15}N$ values and means of barley within the three phases of Çatalhöyük: Late Neolithic (LN), Early Chalcolithic I (ECI) and Early Chalcolithic II (ECII).....329
Figure 9.8 $\Delta^{13}C$ and $\delta^{15}N$ values for seven crops through three phases: Late Neolithic (red), Early Chalcolithic I (blue), and Early Chalcolithic II (green).....330
Figure 9.9: The $\delta^{13}C$ and $\delta^{15}N$ results from the examined Çatalhöyük crops, with animal collagen results 334
Figure 9.10: $\delta^{15}N$ and $\delta^{13}C$ of all plant samples from Çamlıbel Tarlası. 335
Figure 9.11: $\Delta^{13}C$ values (A) of the four major categories and their means and standard deviations (B). 336
Figure 9.12: $\Delta^{13}C$ values of each species from Çamlıbel Tarlası are shown in Graph (A) while the means and standard deviation are shown in Graph (B). 341
Figure 9.13: $\delta^{15}N$ values (A) and means (B) of the general categories from Çamlıbel Tarlası samples. 342
Figure 9.14.: $\delta^{15}N$ values (A) and means (B) of all species examined from Çamlıbel Tarlası. $\delta^{15}N$ values (A) and means (B) of all species examined from Çamlıbel Tarlası. 346
Figure 9.15: $\Delta^{13}C$ and $\delta^{15}N$ mean values from the species with 3 or more samples, examined over the four phases of Çamlıbel Tarlası. 349
Figure 9.16: Crop $\delta^{15}N$ and $\delta^{13}C$ values together with human and animal results from Çamlıbel Tarlası.....350
Figure 9.17: Graph (A) shows the proportion of animal protein in the diet of an average human at CBT if all plant protein originated from cereals, (B) if plant protein was a 50:50 mix of cereal and pulses, while (C) and (D) if 75:25 and 25:75 of plant protein comprised of cereals and pulses. 353

Figure 9.18: Means and standard deviations of the various crops and animals together with human isotopic values, with the projected values for chaff of the four cereal types using a $\delta^{13}C$ offset of -1.9‰ for the wheats and – 1.7‰ for the barley and a $\delta^{15}N$ offset of -2.4 for both categories following Wallace, et al. (2013) and Fraser, et al. (2011). 354

Figure 10.1: (A) shows the percentage of Çatalhöyük West samples containing taxa with annual, perennial lifecycles from disturbed or non-disturbed habitats; black denotes the samples containing *Bolboschoenus* seeds as their only perennial (disturbed) taxa. (B) depicts the proportion seeds of such categories represent.. 363

Figure 10.2: Histogram (A) and (B) showing proportion of perennials in the Çatalhöyük West samples based on seed counts, (A) includes all samples with at least 10 weed seeds (n=30), (B) includes all samples containing at least 10 weed seeds after *Bolboschoenus* and *Descurainia* have been removed (n= 33).(C) and (D) show the proportion of perennials in the samples based on taxon counts, with (C) showing all samples with at least 10 weed taxa (n =11), while (D) shows all samples containing 10 or more weed taxa after *Bolboschoenus* and *Descurainia* have been removed (n =7). 366

Figure 10.3: (A) shows the distribution of the different modern field surveys in relation to the discriminant function extracted to distinguish between the high (black) and low (white) intensity crop husbandry regimes. Graph (B) depicts the relationship of the Çatalhöyük West samples to the discriminant function used to separate the high and low modern regimes as shown in (A). (C) displays the relationship of the Çatalhöyük West samples to the discriminant function of the modern fields, with *Bolboschoenus* removed from the analysis, while (D) shows the relationship of the samples to the discriminant function when *Descurainia* and *Bolboschoenus* are both removed from the analysis.....376

Figure 10.4: Bar chart (A) displays the percentage of Çamlıbel Tarlası samples that contain taxa with annual, perennial lifecycles from disturbed or non-disturbed habitats. Graph (B) presents the proportion that the seeds of such categories represent.....382

Figure 10.5: Histogram (A) displays the proportion of perennials based on seed counts in the Çamlıbel Tarlası samples containing at least 10 weed seeds (n= 63), (B) shows the proportion of perennials in the samples based on taxon counts including only samples containing 10 or more weed taxa (n =43). 383

Figure 10.6: (A) Distribution of the modern field surveys in relation to the discriminant function extracted to distinguish between the high (black) and low (white) intensity crop husbandry regimes.....390

Figure 10.7 Bar chart (A) displays the percentage of Kuruçay samples containing taxa with annual, perennial lifecycles from disturbed or non-disturbed habitats. Graph (B) presents the proportion represented by seeds of such categories.....396

Figure 10.8: Histogram showing the proportion of perennials based on seed counts in the Kuruçay samples containing at least 10 weed seeds (n=9). **396**

Figure 10.9(A) shows the distribution of the modern field surveys in relation to the discriminant function extracted to distinguish between the high (white) and low (black) crop husbandry regimes.. ..... **401**

Figure 11.1: Results of correspondence analysis of the assemblage from Çatalhöyük West and Çamlıbel Tarlası. (A) shows the taxon plot (n =17), and (B) the sample plot (n =104), coded by site. **406**

1 Introduction

Agricultural practices in central Anatolia during the Neolithic and the Bronze Age have claimed much scholarly interest, with limited attention focused on the intervening period: the sixth to the fourth millennia cal BC, or the Chalcolithic (see Table 1.1 for chronological divisions). Many societies of the Bronze Age have complex social structures, elite classes and developed cities, states and empires (Çevik 2007) and developments in agriculture during the Chalcolithic may have provided the basis for this. However any understanding of how this occurred is significantly hampered by limited archaeobotanical evidence.

Only five central Anatolian Chalcolithic sites have published archaeobotanical material although research is now increasing on this transitional period between the emergence and establishment of agriculture and the development of urban centres, states and empires (Schoop 2011c; Biehl et al. 2012). The long-term consequences of the agricultural transition in this region, and the underlying causes of the tremendous social changes of the third and second millennia BC, have yet to be addressed (Çevik 2007).

Table 1.1: Chronology of the region showing the absolute dates in cal. BC, the cultural term given to the period and the major sites mentioned in the text. Dates from Baird (2012).

Absolute chronology (cal. BC)	Cultural terminology	Sites
c. 7,000 – 6,700	Pre-pottery Neolithic C (PPNC)	
c. 7,000 – 6,000	Ceramic Neolithic	Çatalhöyük East
c. 6,000 – 5,400	Early Chalcolithic	Çatalhöyük West, Canhasan I
c. 5,400 – 4,500	Middle Chalcolithic	
c. 4,500 – 3,000	Late Chalcolithic	Çamlıbel Tarlası, Kuruçay (levels 6-3)
c. 3,000 –	Early Bronze Age	

In-depth research into Chalcolithic agricultural practices may help illuminate patterns of agricultural intensification and shifts towards specialisation that have been noted in other regions of the Near East (Sherratt 1981; Allen 1997; Fall et al. 2002). Changes in the organisation and labour-intensity of agriculture systems, if detected, would allow inferences to be made about the scale and social role of agricultural production (Halstead 1989; Netting 1993; Morrison 1994; Bogaard 2005). Information regarding agricultural intensification and labour organisation would further an understanding of the foundations of social change and the development of urban cultures (Halstead 1989; Netting 1993; Hayden 1995; Price 1995:130).

Central Anatolia is situated in modern day Turkey, on the Anatolian Plateau. The region is commonly 1000 m or higher in elevation, and is surrounded by Turkey's main mountain ranges – the Taurus mountains in the south and the Pontic mountains to the north. For this study central Anatolia has been defined as the region shaded in Figure 1.1.

This project examines archaeobotanical material from four central Anatolian Chalcolithic sites: Çatalhöyük West, Canhasan I, Kuruçay and Çamlibel Tarlası. This material is analysed with the aim of developing an understanding of the crops grown and the type of crop husbandry used. This allows inferences to be made about the nature of day-to-day plant-related activities on the sites, the mobilisation of labour throughout the agricultural year and the social context of agricultural activities (Hillman 1984a; Jones 1984; Miller 1984; Stevens 1996; Anderson and Ertuğ-Yaras 1998; Ertuğ 2000; Fuller et al. 2014). Examination of

the sites for temporal and/or spatial patterning in plant-related activities allows for inferences about specific household behaviours and activities. Relating such activities to the required social interactions may shed light on the changes in social organisation during this period preceding the emergence of overt social stratification.

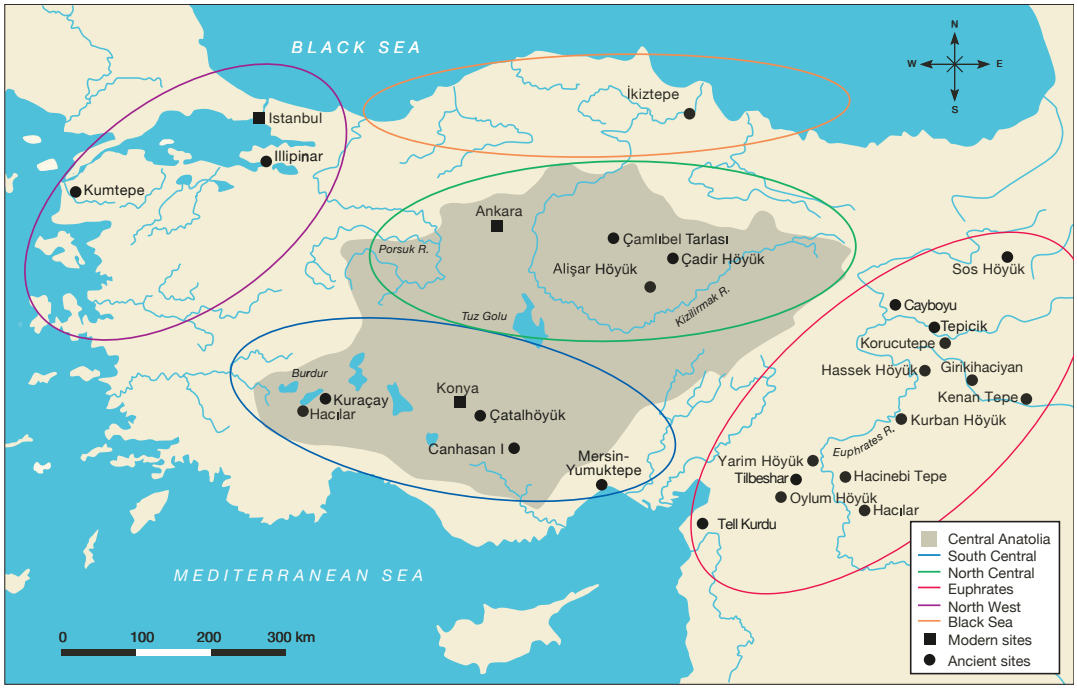


Figure 1.1: Location of the sites mentioned in the text with the ellipses outlining the regions referred to in Table 1.2.

Çatalhöyük West (8 ha) may allow for an understanding as to whether changes in settlement location, architecture type and an increased reliance on ceramics during this period accompanied changes in agricultural practices. Çatalhöyük West is 32 times larger than Çamlıbel Tarlası so an understanding of the effect of site size and associated community population on agricultural practices may be gained. This would allow inferences about the effect of availability of labour, the consequences of limited access to arable land, and the specific choices made by

communities and social units in order to produce crops in their environmental and social landscape.

Çamlıbel Tarlası (0.25 ha) can provide an insight into a small community's subsistence patterns (Schoop 2009; Schoop et al. 2009; Schoop 2011b; Pickard and Schoop 2013). This is of particular interest, as to date only limited archaeological work has been conducted on small Chalcolithic settlements on the Anatolian plateau. It is not known whether such communities had close ties with, or were reliant on, other communities and were therefore agriculturally self-sufficient or not. Any suggestion of specialisation at Çamlıbel Tarlası could provide a means of reconstructing networks that linked this settlement with others.

The sites of Canhasan I and Kuruçay, excavated in the 1960s and 1980s have had limited research conducted on their archaeobotanical assemblages, focussing on recording crops taxa present at the sites (Renfrew 1968; Nesbitt 1996). These sites provide excellent comparisons to the two main case studies. Canhasan I was contemporaneous with the occupation of the West Mound and are both located on the Konya plain (Fairbairn et al. submitted, Orton et al. in prep). The Kuruçay archaeobotanical material derives from the Late Chalcolithic occupation of the site, making in an ideal comparison for Çamlıbel Tarlası.

1.1 Southwest Asian context

Due to the allure of "firsts" in many activities such as domesticated plants and animals, pottery and rectilinear architecture, the Neolithic period has been

examined in depth in this region (Ozdoğan et al. 2011). An increasing number of sedentary communities emerged during this time, accompanying the domestication/adoption of plant species, including the core "Neolithic package" of wheat, barley and pulses, along with domesticated animals (van Zeist and de Roller 1995; Baird et al. 2012; Zohary et al. 2012). Settlements developed and expanded with architecture reflecting this new sedentary lifestyle reliant on agriculture: substantial permanent buildings and storage rooms in individual houses for produce (Flannery 1972a).

The adoption of agriculture, the beginning of ceramic usage, and in some cases the concentration of population, are common themes across Western Asia. The so-called 'mega-site' phenomenon of the Pre-Pottery Neolithic B (PPNB) occurs from southern Jordan to the Euphrates valley to the Anatolian plateau. This period sees the concentration of population into large sites, though the extent of contemporaneous settlement is generally unclear (Goring-Morris and Belfer-Cohen 2010). Many of these sites later collapsed at the end of the PPNB, either returning to a more dispersed occupation of the landscape or a reduced population (Simmons 2007). There are exceptions with some settlements continuing into the ceramic Neolithic with large populations at sites such as Abu Hureyra, 'Ain Ghazal and Çatalhöyük (Rollefson 1992; Moore et al. 2000; Cessford 2001).

Architectural changes have been noted during the Neolithic from small, round, single-roomed structures to larger multi-roomed rectilinear structures in some regions/sites (Flannery 1972a, 2002; Baird 2012). A subsequent trajectory of

change has been suggested for regions in Southwest Asia, due to expansion in the household unit from small nuclear families to larger extended family groups (Flannery 1972b, 1972a, 2002).

Examples of such temporal changes appear in the archaeological record of central Anatolia such as at the Konya plain sites of Boncuklu Höyük and Çatalhöyük. Here small, circular, single-roomed structures of the Early Neolithic at Boncuklu (Baird 2012) change to often larger, rectilinear structures at Middle and Late Neolithic Çatalhöyük (Hodder 2014b). Within the Çatalhöyük East sequence, a further temporal trend can be detected as these buildings change from single or double-roomed dwellings to multi-roomed houses in which outside spaces or yards are incorporated into the household unit (Hodder 2014b). These larger, more extensive households seem to develop and expand from older houses, some showing evidence of the merging of two households such as Building 52 at Çatalhöyük (Farid 2008). The incorporation of yard spaces into the domestic realm also reflects a temporal change in household arrangements at Çatalhöyük and the increasing isolation of the household unit (Bogaard et al. 2014).

These changes suggest a shift away from supra-household risk-buffering towards a greater internalisation of risk management where the risk is mitigated by the larger household structure and the potential increase in production and storage that accompanies this (Flannery 1972a, 2002). While such changes are neither uniform nor stable across the region, these broad trends in domestic architecture present a central social theory to test against archaeobotanical data. As the

predominant labour requirement of these periods is for agricultural production (both animal and crop based), changes seen in the settlement should be reflected in the agricultural techniques and methods used. A shift towards larger, more isolated households arguably corresponds to a number of food-related activities including the scale and intensity of production, storage and crop processing.

1.2 The Chalcolithic in central Anatolia

The long temporal span of the Chalcolithic is traditionally divided into the Early, Middle and Late Chalcolithic phases. Early Chalcolithic (c. 6100-5500 BC) sites have been commonly excavated due to continuity with Late Neolithic occupation: Çatalhöyük, Hacılar, Kuruçay and Köşk Höyük all have Neolithic roots as well as substantial Chalcolithic settlements (Mellaart 1965, 1970; Öztan 2003; Duru 2008). On the Konya plain (Figure 1.1), settlement patterns changed with a shift over the river at Çatalhöyük (Mellaart 1965; Biehl et al. 2012) and smaller settlements appearing on the plain, perhaps caused by population increase, or reflecting the colonization of the region by inhabitants of Çatalhöyük due to social changes within the community itself (Baird 2012). The Early Chalcolithic sees the development of painted ceramics and a distinctive architectural style – many sites have square to rectilinear houses with large internal buttresses (Mellaart 1970; Duru 1994; French 1998). In the southwest Lake District the site of Hacılar also shows no cultural break between the Late Neolithic and the Early Chalcolithic, instead, similar to Çatalhöyük, there is a steady increase in painted pottery over time (Schoop 2011c)(Franz, pers. comm.).

The limited research available on production and consumption in central Anatolian Early Chalcolithic communities suggests that these were farming communities, relying on cereals and pulses, sheep, goat and cattle (Helbaek, 1970; Orton 2011; Charles and Bogaard in prep). Wild foods were still procured as evidenced at Çatalhöyük West, Trench 1 with the collection of wild nuts; at other sites the hunting of wild animals still played an important social role (Charles and Bogaard in prep, Arbuckle 2012). The Neolithic trade networks continued, as evidenced by the movement of Cappadocian obsidian and flint in the landscape (Ostaptchouk 2012).

The Middle Chalcolithic period, c. 5500 to 4250 BC, sees discontinuity from the Early Chalcolithic, with a change in character over the whole of central Anatolia (Duru 2008; Schoop 2011c; Arbuckle 2012). This period is poorly understood with minimal settlements excavated. New ceramic forms appear and most sites have evidence of the production of metals (Schoop 2011c). Middle Chalcolithic settlements have been recorded in surveys (Gülçur and Firat 2005), and the few excavated reveal a variety of settlement/architecture forms, some reflecting past traditions, others new changes (Öztan 2002; Schoop 2011c). It has been postulated that, at least at the Cappadocian sites with their richer excavation record, the Middle Chalcolithic sees an increase in the variation of wealth and status within and between communities, possibly facilitated by an increase in trade networks (Arbuckle 2012). Wild animal procurement declined, with the used of domesticated fauna still centred around sheep/goat herding (Arbuckle 2012:308, Arbuckle et al. 2009). Control of domesticated animals within these settlements has been hypothesised as having an important social role, but also

that wool production increased in importance, providing a storable and tradable commodity (Arbuckle 2012:310).

The Late Chalcolithic period, c. 4,250-3,000 BC, is again limited in sites excavated; evidence is lacking of settlements from c. 4,250- 3,500 and there is limited continuity of Middle into Late Chalcolithic at sites (Düring 2010; Schoop 2011c). Northern areas of central Anatolia have however provided information about cultural developments during the later Late Chalcolithic; sites such as Alişar and Çadir Höyük provide evidence of a regional Late Chalcolithic ceramic tradition (Schoop 2011c). Surveys in this region have indicated a potential three-tiered settlement pattern with larger regional centres being the focus of specialisation in metalworking and bead production (Steadman et al. 2007). However metal and bead working is also evident at smaller sites, which means that these crafts were not solely the domain of larger sites (Schoop 2011b; Pickard and Schoop 2013). Some question the validity of the three-tiered settlement hypothesis, emphasising the limited archaeological record (Düring 2010:240). Trade is seen in the movement of Cappadocian obsidian and flints (Schoop 2015:61). Domesticated animals were exploited for primary and secondary products, with evidence of woollen textile production at Çadir Höyük, and milk production at Çamlıbel Tarlası (Arbuckle 2009, Arbuckle 2011:311, Schoop 2014, Pickard et al. 2016a:298).

The limited number of archaeological investigations at Chalcolithic central Anatolian sites makes it difficult to understand the social organisation during the period. Conflicting opinions as to social structures in this timeframe exemplify

the problem of a limited dataset. Arbuckle's (2011) theory of increasing social inequality driven by a change in management of sheep and the production of wool controlled by a 'managerial elite' conflicts with the view of Özdoğan (2002), who claimed that there is no evidence of a surplus-controlled economy or a ruling class controlling the economy. Schoop (2014) presented a model of the potentially increasing importance of wool/textile products during the Late Chalcolithic, but one focused on circulation rather than accumulation and based around household production.

1.3 Chalcolithic Turkish archaeobotany

Only 21 sites in Turkey have published archaeobotanical reports on Chalcolithic material and include only five sites from central Anatolia (divided into North and South in Table 1.2 and Figure 1.1)(Riehl and Kümmel 2005). This is compared to the 12 sites with archaeobotanical data in the Euphrates region of Turkey highlighting the limited information published on central Anatolian sites.

The sites that have been studied previously indicate that agriculture during the Chalcolithic involved the "typical" Neolithic crops: wheats, barleys and pulses. Cereals occur at all sites, particularly barley, and seem to be supplemented by pulses (Table 1.2). Variation in the type and number of pulse varieties seems to be a key difference between regions (Table 1.2).

Table 1.2: Sites within Turkey that have archaeobotanical data grouped by region , including the date of archaeological material studied, the number of samples, recovery method and proportion of the species from the total crop assemblage. X = <25%, xx 25-49%, xxx= 50-74%, xxxx = 75-100%. Regions refers to the areas highlighted in Figure 1.1, dates refer only to Chalcolithic phases. Sites with only presence/absence data noted with *and P for taxa present. Data collected from: Helbaek 1970; van Zeist and Bakker-Heeres 1975a; Van Zeist 1979; van Zeist and Waterbolk- van Rooyen 1995; Chernoff and Harnischfeger 1996; Miller 1996, 1998; Cappers 2001; Riehl and Kümmel 2005; Longford et al. 2009; Graham 2011.

					Barley				Free-threshing wheat		Glume wheat							Pulse					Oil
	Time period (cal. BC)	Region	Number of samples	Recovery method	Hulled grain	Naked grain	Indeterminate grain	Indeterminate rachis	Grain	Rachis	Emmer grain	Emmer glume bases	Einkorn grain	Einkorn glume bases	New type grain	New type glume bases	Glume bases indeterminate	Bitter vetch	Lentil	Pea	Chickpea	Grass pea	Flax
Ikiztepe	3500-3000	Black sea	?	Uncertain														XX XX					
Tell Kurdu	6000-5100	Euphrates	24	Flotation			X						X						X		XXX		X
Oylum Höyük	5200-3000	Euphrates	17	Wet sieving	X		XX				XX	X	X	X				X	X				X
Tilbeshar	5200-3000	Euphrates	12	Flotation			X	X	X		XX								X				X
Kurban Höyük *	5100-1600	Euphrates	32	Hand collection/ flotation			P												P		P	P	P
Girikihaciyan	~5100	Euphrates	44	Flotation	X				X		X		X				XXX	X	XX		X		X
Cayboyu	4800-3800	Euphrates	?	Flotation	X	X		X	X	X	X		X					X	XX	X			
Hacinebi tepe	4800-3800	Euphrates	52	Flotation	XX				X	X	X		X				XXX		X			X	X
Kenan tepe *	4700-4400	Euphrates	25	Flotation	P						P		P						P	P			P
Tepecik	~4000	Euphrates	6	Flotation	XX				X		XX		X					X		X			
Yarim Höyük	~4000	Euphrates	10	Flotation			X				XXX						XX						

					Barley				Free-threshing wheat		Glume wheat						Pulse					Oil
	Time period (cal. BC)	Region	Number of samples	Recovery method	Hulled grain	Naked grain	Indeterminate grain	Indeterminate rachis	Grain	Rachis	Emmer grain	Emmer glume bases	Einkorn grain	Einkorn glume bases	New type grain	New type glume bases	Glume bases indeterminate	Bitter vetch	Lentil	Pea	Chickpea	Grass pea	Flax
Korucutepe	4500-3000	Euphrates	6	Flotation	X				X		XX		X					X	X	X			X
*Hassek Höyük**	4500-3000	Euphrates	39	H_2O_2, wet sieving			P												P		P		
Yarim Höyük	3500-3100	Euphrates	10	Flotation							X						XXX		X				
Sos Höyük	3500-3000	Euphrates	1	Flotation	XX				XXX	X													
Çamlıbel Tarlası	3500-3000	North central	25	Flotation	XX				X		X	XXX	X	X	X	X	X	X	X	X	X	X	X
*Çadir Höyük **	3000-2800	North central	3	Flotation					P		P		P										
Ilipinar	6400-4200	North west	190	Flotation	X	X	XX	X	X		X	X	X					XX	X	X	X	X	X
Kumtepe	5200-3000	North west	38	Flotation	X	X		X			XX	X	X	X				X	X			X	X
*Hacılar**	6300-5700	South central	>12	Uncertain	P	P			P		P		P					P	P	P			
Çatalhöyük West (Trench 1)	6000-5000	South central	76	Flotation	X	X		X	X	X	X	X	X	X	X	X X		X	X	X	X		
*Kuruçay**	4000-3000	South central	25	Hand collection	P				P		P		P						P	P	P	P	P

1.4 Sites examined

The four sites examined 'bookend' the Chalcolithic period: Çatalhöyük West and Canhasan I were occupied at the beginning of the Early Chalcolithic and Kuruçay and Çamlıbel Tarlasi occupied during mid Late Chalcolithic (see Table 1.1). The sites also vary in the scale of community and climatic conditions, ranging from the very small, temperate Çamlıbel Tarlası to the large, semi-arid sites of Çatalhöyük West and Canhasan I. These sites provide the basis for an archaeobotanical synthesis of the Chalcolithic period in central Anatolia and allow comparison with other Anatolian regions during this period. They frame a new understanding of agricultural practice through the Chalcolithic by providing an analysis of sites at the beginning and end of this period as well as providing an opportunity for the contrast of sites of significantly different size. Comparison with data from other Chalcolithic sites possessing archaeobotanical material help frame a new understanding of the plant economy during the Chalcolithic.

These sites allow the contextualisation of the other published data on Chalcolithic Anatolia. Differences in the scale and environment of the sites are apparent and by comparison with surrounding sites of similar time periods, a temporal pattern of regional difference and/or temporal change may emerge. Çatalhöyük West has the advantage of being comparable with Canhasan I, in addition to the Neolithic East Mound, which according to recent dating may have still been occupied during the initial occupation of the West Mound (Orton et al. in prep). Due to the unique nature of Çamlıbel Tarlası – its small size – there are no directly comparable-sized sites that have been studied archaeobotanically. Kuruçay's

archaeobotanical material derives from the same period as Çamlıbel Tarlası, allowing some comparison.

The new data arising from this research, combined with published and available unpublished data, should shed significant light on the nature of plant use and agricultural practice during the Chalcolithic period. Inferences about the nature of social organisation as reflected by crop husbandry and production can then be made.

1.5 Research questions

The aim of this research is to understand the nature of agricultural production and consumption at the four sites and also across the wider Chalcolithic, and to assess the implications of this evidence for social organisation within the communities. A number of questions were established to help focus the research and allow a methodology to be developed. The questions concentrate on understanding the agricultural practices at the sites, with a focus on crop production, consumption and other plant-related activities. Three areas have been investigated in a logical order: formation processes, crop husbandry and social implications. Using this structure, the evidence and results as each question is answered contributes to the subsequent analysis required to address key research questions; an understanding of formation processes contributes to the analysis of crop husbandry and the social implications of both.

Relevant formation processes are activities and actions that lead to the deposition of archaeobotanical material into the archaeological record. These

processes include activities such as the disposal of crop processing by-products by burning and the burning of dung as fuel: both create charred botanical material. The detection and understanding of the presence and nature of such activities is necessary as they, by their very nature, bias the archaeobotanical record. It is the first step required to interpret the archaeobotanical assemblages of the study sites. Consequently a number of questions have been devised to ascertain the nature of such formation processes:

- Was dung burning practised on the sites?
- Do crop-processing remains contribute to the formation of the assemblage?
    - What is the dominant processing stage represented within the assemblages?
- What implications do these activities have for understanding on-site plant-related activity, including storage and consumption?

The two main case study sites, Çatalhöyük West and Çamlıbel Tarlası, have very difference climates, with semi-arid Çatalhöyük West receiving less rainfall than the temperate Çamlıbel Tarlası. As such hypotheses about the impact of aridity can be tested. It can be hypothesised that the inhabitants of sites in more arid environments may have needed to use alternative fuels such as dung to supplement limited wood fuel, while those at sites in more temperate environments would have had more available wood fuel and thus a reduced need to supplement their fuel with dung. Storage practices could have also been driven by environmental conditions, given Hillman's (1984b) research on glume wheats: storage in spikelets is commonly a wet climate adaption. Thus climatically wetter

sites would be expected to have stored glume wheats as spikelets, while at more arid sites these would have been stored as fully processed grain. Sites which deviate from the above hypotheses may be revealing the impact of social choice or other constraints such as labour availability (Jones et al. 1986).

Crop husbandry can be defined as the techniques and methods used to cultivate crops (Bogaard 2004b). Such actions, used by farmers to help the growth of crops and thereby increase yield or survival of the crop, can be detected in archaeobotanical data. Many researchers have investigated weed ecology and isotopic ratios in order to understand the nature of crop husbandry (Jones 2002; Jones et al. 2005; Fraser et al. 2011; Wallace et al. 2013; Wallace et al. 2015). By understanding the nature of crop husbandry and the techniques employed to cultivate the crop, wider social implications of these land use practices can be explored. To ascertain the nature of crop cultivation at the study sites key questions include:

- What crops were cultivated?
- What techniques were employed to cultivate crops?
    - What techniques for enhancing the growing conditions, for example, water management, manuring, and weeding of crops, if any, were practised?
    - Do these techniques vary between crops and/or phases and/or sites?

Investigation into crop husbandry can provide information relating to the scale of production, as well as the methods used to mitigate the impact of climate

(Halstead and Jones 1989:49, Halstead 2014). Strategic planting of drought tolerant crop species in drier parts of the landscape, and of more demanding species in wetter areas, would be expected at sites in more arid regions, whereas communities in more humid climates where rainfall was usually adequate for rainfed agriculture, would be expected to plant crops without reference to water limitations.

The size of a site may have a significant impact on the amount of labour available for cultivation as well as the accessibility of land and accessibility of resources. It could be hypothesised that farming at larger sites will have been impacted by their size, since proximity between cultivators and their fields would be reduced as the radius of cultivation increased around the site (cf. Jones 2005). Expansion of cultivated landscape would consequently introduce 'frictions of distance', with relatively intensively managed plots in closest proximity to habitation, and less labour intensive management further away. This hypothesis predicts the intensity of cultivation, seen via techniques such as functional weed ecology, would be relatively variable at large sites. Conversely, small sites where farmers had immediate access to their land would be expected to show a higher, less variable level of labour-intensity in cultivation practices.

The final area of investigation aims to understand the wider social implications of the answers to the above questions. To do so the nature of crop consumption and production within the communities needs to be understood temporally. How production and consumption differ between sites plays a key role in

understanding how farming practice articulated with social structure and labour mobilisation.

- Do the answers to the above questions provide information about the social organisation of the site and the utilization of labour?
    - Are there temporal differences within or between sites?

The questions and hypotheses posed above are designed to build a framework for understanding the nature of crop consumption and production in Chalcolithic central Anatolia.

1.6 Thesis outline

This thesis is organised as following. Chapter 2 explains the excavation background and current knowledge of the four study sites: Çatalhöyük West, Çamlıbel Tarlası, Canhasan I and Kuruçay. Chapter 3 explains the methodological background of both the methods used in this study and also in the body of literature surrounding investigation into crop processing, dung burning, and crop husbandry techniques. Chapter 4 details the methods used in this research, explaining the reasoning behind sample selection, the identification processes followed and the quantification strategy employed. It contains explanation of the techniques used to analyse the archaeobotanical data from the four sites, including the statistical procedures employed, the methods used to conduct the stable carbon and nitrogen isotope analysis, and the techniques used to analyse the weed flora found.

The results are divided over five chapters. Chapter 5 provides an overview of the composition of the four archaeobotanical assemblages. Chapter 6 explores the variability in sample composition, while Chapter 7 assesses the potential of dung burning as a taphonomic process in the formation of the assemblage. Crop processing and its impact on assemblage composition is detailed in Chapter 8, while Chapter 9 discusses the results of stable carbon and nitrogen isotope analysis conducted on the remains. Research on evidence of crop husbandry methods through the weed flora in the assemblages is presented in Chapter 10. Finally, Chapter 11 provides a comprehensive discussion of these findings, answering questions asked at the start of this research, and conclusions are drawn about the implications of the research.

2 Archaeological, archaeobotanical and environmental background of Çatalhöyük, Canhasan I, Kuruçay and Çamlıbel Tarlası

This chapter details the location, excavation history, chronology and environmental setting of the four sites examined in this study. The sites of Çatalhöyük, Canhasan, Çamlıbel Tarlası and Kuruçay are found in central Anatolia in Turkey (Figure 1.1). Canhasan and Çatalhöyük, located on the Konya plain and Kuruçay, located in the Burdur region, all fall within the south central region of the plateau. The fourth site, Çamlıbel Tarlası, is located further north in the Budaközü valley of the north central region.

2.1 Çatalhöyük

The site of Çatalhöyük is situated on the Konya plain, 50 km south-east of the provincial capital of Konya (Figure 1.1). The site consists of two mounds, the Neolithic East Mound (7100-6000 cal BC) and the Chalcolithic West Mound (6100-5500 cal BC)(Bayliss et al. 2015; Marciniak et al. 2015; Orton et al. in prep). This research focuses on the Chalcolithic levels of the West Mound, with additional attention to the late levels of the East Mound; recent work indicates overlapping occupation between the final settlement phases of the East Mound and the early occupation of the West Mound (Marciniak et al. 2015; Orton et al. in prep).

2.1.1 Excavation history

2.1.1.1 Mellaart excavations

The East Mound of Çatalhöyük has a rich excavation history. First excavated in the 1960s by James Mellaart, the site is famous for its architectural decorations and mother goddess figurines. Çatalhöyük was first noted during Mellaart and French's survey of the Konya plain in 1952, when evidence of mud brick and Neolithic pottery was found on the surface of the East Mound (Mellaart 1967). Mellaart returned to Çatalhöyük after his excavation at Hacılar in the Burdur region, aiming to close the chronological gap of the Middle Neolithic period existing at Hacılar. His excavation at Çatalhöyük revealed amazingly well-preserved Neolithic remains with painted walls and intricate objects such as carved bone-handled knives and human figurines (Mellaart 1967).

The East Mound was excavated from 1961 until 1965 during which large areas of Neolithic structures were exposed (Mellaart 1962, 1963, 1964, 1965, 1966). These mud brick structures, comprising single or multi-room complexes, contained a wide variety of decoration, including polychrome wall paintings, raised plaster motifs, animal depictions and inset animal bones, particularly the cranium and horn cores of wild auroch (*Bos primigenius*) (Mellaart 1967).

Archaeobotanical remains were uncovered in the Mellaart excavations. Hans Helbaek (1964:121) described them as the "best preserved finds of their kind ever recovered from such early periods" in this region, identifying the presence of einkorn, emmer, naked barley and pea and interpreting these crops as the

main agricultural products of the site. Other taxa such as bread wheat, bitter vetch and vetch were found in lower numbers. Wild taxa such as hackberry, acorn and wild plum were also evident in these early samples (Helbaek 1964).

The West Mound, located just 200 metres from the edge of the East Mound, received less of Mellaart's attention. Two trenches (I and II) were excavated at the end of the 1961 excavation season (Mellaart 1962). Mellaart (1962:44) described the results of these soundings as "unsatisfactory" as both trenches encountered courtyards and pits. However the ceramic material retrieved from the excavation allowed Mellaart to identify two phases of Early Chalcolithic pottery. Comparison with the material excavated the same year from Canhasan I led Mellaart to hypothesise that the occupation at both sites was contemporary (Mellaart 1962:44).

While Mellaart (1962) described the finds of Trench II and I as unsatisfactory because there were no structural remains, he later described the excavation of two walls with large internal buttresses and platforms in Trench II, as well as hearths, ovens and potential storage bins (Mellaart 1965:136). Mellaart described the excavated architecture as reminiscent of the architecture uncovered in the Canhasan I 2B level, as the layers at both sites contain internal buttresses (Mellaart 1965:136).

2.1.1.2 Hodder excavations

Renewed excavation at Çatalhöyük commenced under the direction of Ian Hodder in 1993 and the on-going excavation continues to provide a deeper

understanding of the Neolithic occupation of the site. Numerous remains of single and multi-roomed structures have been excavated on the East Mound (Hodder 2014a). Some of these buildings appear to have been purposefully burnt, possibly a symbolic act of closure, and within such burnt buildings storage rooms filled with primary deposits of charred crop remains have been recovered (Bogaard et al. 2013a:117; Twiss et al. 2013; Hodder 2014a:17). In addition, due to the systematic sampling strategy in place for the retrieval of archaeobotanical remains, flotation samples from all excavated contexts have been recovered and contain well-preserved remains (Bogaard et al. 2013a).

Examination of the archaeobotanical assemblages has been conducted by a number of researchers and indicates the utilisation of a wide crop suite (Fairbairn 2005; Fairbairn et al. 2005; Bogaard et al. 2009; Bogaard et al. 2013a; Filipović 2014). Glume wheats (emmer, einkorn and 'new type' glume wheat), as well as free-threshing wheat, naked barley, pea, lentil and bitter vetch, are the crop taxa commonly recovered (Fairbairn et al. 2005; Bogaard et al. 2013a). A plethora of wild taxa including collected edible food plants has also been found. This work led to an understanding of fuel usage and the burning of dung, especially in outdoor spaces, the harvesting and processing of crops and the utilisation of wild (possibly managed) species such as the oil seed *Descurainia sophia* (Fairbairn 2005; Bogaard et al. 2009; Bogaard et al. 2013a; Filipović 2014).

Various teams led by Hodder have excavated the East Mound but this research's analysis will focus primarily on the West Mound, touching only briefly on late

East Mound material: this background chapter will now focus only on relevant excavations.

The Team Poznań (TP) excavation, 2001 to 2008, investigated the later levels of the Neolithic East Mound. The TP area is located on the East Mound's highest elevation, between the South Area and Mellaart's old trenches (Figure 2.1). Excavation in this area revealed structures that differ from the earlier Neolithic buildings found in other areas. Some consisted of small rooms surrounding a central living space with none of the elaborate symbolic decoration found in houses of the earlier levels (Marciniak et al. 2015). Elaborately decorated burial chambers in the TP area (Marciniak and Czerniak 2007) replaced intramural burials, a common feature of the earlier occupation (Basak and Hager 2013). The clustered neighbourhood organisation of the earlier levels of Çatalhöyük East had by the late levels in the TP area given way to a more pronounced household-based architectural orientation; Marciniak and Czerniak (2007:122) inferred that such a change was symptomatic of the development of a domestic mode of production and consumption.

Archaeobotanical material from the TP excavation is currently under examination by Marek Polcyn: preliminary results indicate that hulled barley becomes increasingly more common during this period (Bogaard et al. 2013a:99). Archaeobotanical material from the TP area was included for isotopic analysis in this study to allow comparison between the two Mounds; the TP assemblage provides a connection between these two periods (see Chapter 9).

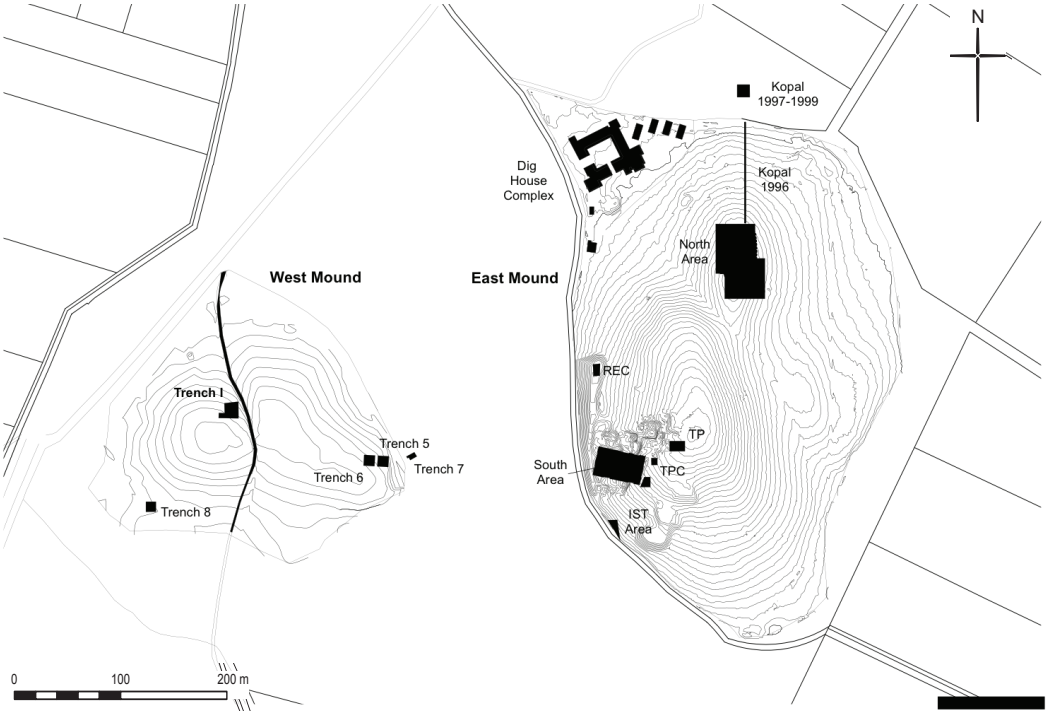


Figure 2.1: Site map of Çatalhöyük showing the location of the East and West Mound trenches mentioned in the text (map courtesy of the Çatalhöyük Project).

The West Mound has been excavated by several different teams, the first in 1961 when Mellaart (1962) excavated two trenches to identify the date and nature of the site. Last and Gibson (1998) first excavated in 1998, the results prompting continuing excavation until 2003. Erdoğu excavated on the northwest side of the mound (Erdoğu 2007) and Biehl and Rosenstock opened three trenches in 2005, excavating until 2013. The archaeobotanical material examined in this research comes from the latter, while isotopic samples come from both the Biehl and Rosenstock and Last and Gibson excavations.

Gibson and Last excavated on the West Mound in 1998, aiming to ascertain the state of preservation of the Mellaart trenches (Last 1998). This in turn led to a new campaign that continued until 2003, aiming to understand discoveries made during the 1998 season and, by expanding the excavation area, to fully explore

the corner of a structure uncovered in Trench I (Gibson and Last 2003). This excavation uncovered the remains of a building, labelled Building 25, the same building that Mellaart had discovered.

Building 25 was irregularly shaped, with a large central room flanked by small cell-like spaces (Figure 2.2) (Gibson and Last 2003). The central room, unlike the surrounding small rooms, was plastered, containing raised platforms, benches and a central large circular oven. This room also contained evidence of buttress-like features, a recurring theme in Chalcolithic architecture on the Konya plain. Trench II, located further down the slope, was also investigated, expanding the original Mellaart trench and revealing the remains of Early Chalcolithic structures as well as pits which appeared to cut through these early phases and contained pottery and botanical remains.

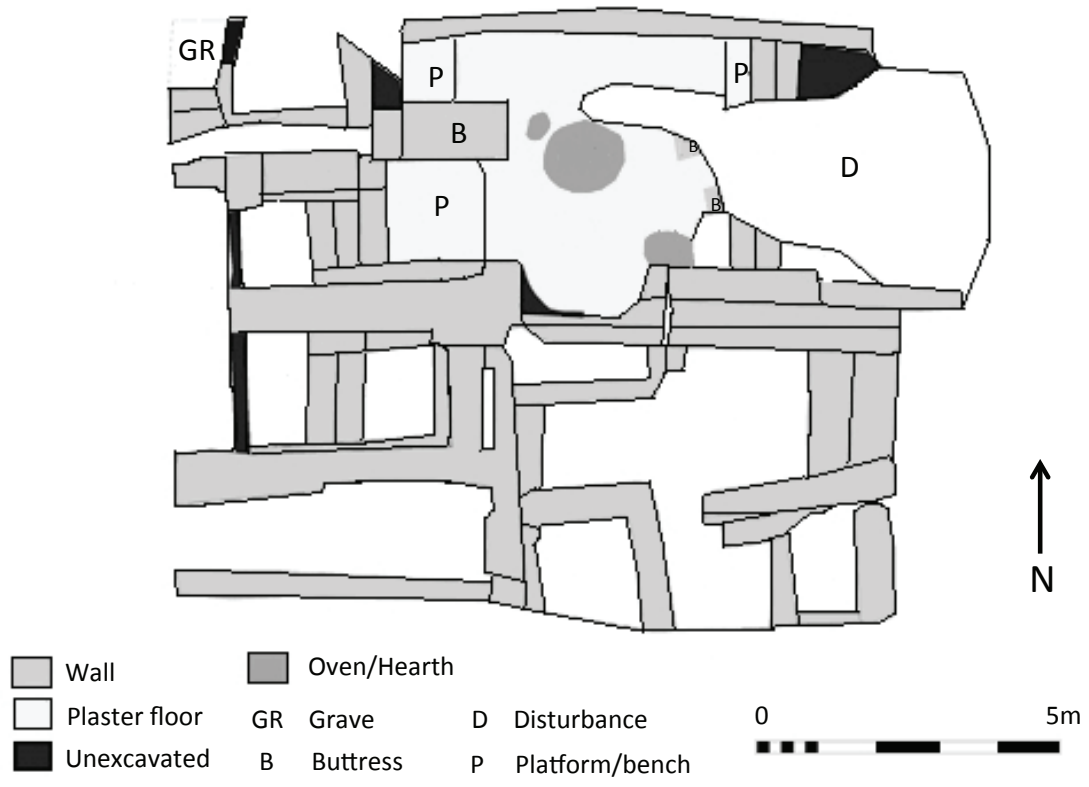


Figure 2.2: Plan of Trench 1, Çatalhöyük West, redrawn from Gibson and Last 2003.

Comparison was made between the West Mound Trench I architecture and that of the nearby site of Canhasan I, which contains the only comparable Chalcolithic architecture on the Konya plain. Building 25 was more asymmetrical and irregular than the Layer 2 buildings excavated at Canhasan I (see Section 2.2), its structure appearing to have evolved over time with successive room additions (Gibson and Last 2003). Gibson and Last (2003) suggested the presence of a second storey: the extant Building 25 remains consist only of a basement floor but the possible buttresses within the large room may have been used to support a second storey. Such architecture was inferred at Canhasan I, with remains of an upper storey to some of its buildings detected (French 1998).

Comparison of West Mound Trench I and the TP architecture reveals some similarities, such as the position of the oven and the deposition of sheep/goat horn cores (Marciniak and Czerniak 2007:123). The finds of buttresses in the TP excavation and the hints of such features in Building 25 are similar to features found in the excavations of Trench 5 of the West Mound and the 2B architecture of Canhasan I. Comparison of Building 25 with earlier East Mound architecture shows significant architectural differences: the rooms in Building 25 are very small but numerous while the East Mound buildings are larger and typically fewer in number. Whilst the early East Mound buildings contain plastered surfaces and decoration, limited evidence of such features was found in Building 25, the only plastered surfaces being those in the large room.

The results of the full analysis of the 80 archaeobotanically-rich West Mound Trench I and II samples await publication (Bogaard et al. 2013a; Charles and Bogaard in prep.). Research indicates that the main crops grown were naked and hulled barley, as well as three glume wheats (emmer, einkorn and 'new type') and four species of pulse (lentil, bitter vetch, pea and chickpea) (Charles and Bogaard in prep.). The increase in hulled barley, a taxon uncommon on the East Mound until the TP phases, is notable (Bogaard et al. 2013a).

Excavations led by Biehl and Rosenstock began in 2005 with the opening of Trenches 5 and 6 on the eastern side of the West Mound (Figure 2.1). Chalcolithic levels and architectural remains such as foundations and walls of early Chalcolithic dwellings were found. A third trench, Trench 7, was excavated in 2006 with two aims: understanding the stratigraphy of the site and investigating any evidence of a potentially older settlement (Biehl and Erdoğu 2006; Biehl and Rosenstock 2007). The archaeobotanical material analysed from the West Mound in this study originates from Trench 5.

Trench 5 revealed the architectural remains of eight potential structures (Figure 2.3). These mud brick buildings have large internal buttresses and comprise multiple construction episodes of mud brick. Plaster floors were found in four of the buildings, with multiple layers of re-plastering noted. Building 98, the largest of the buildings (~ 38 m^2), contained features such as architectural niches and basin-like structures.



Figure 2.3: Map of Trench 5, Çatalhöyük West, depicting the plan of the walls and buttresses within the trench and the names of each Building/Space. Redrawn from Biehl et al. 2012

There is limited evidence of occupation of the buildings: most of the artefactual evidence instead derives from the post-occupation fills. After the inhabitants abandoned the structures the internal spaces were used as refuse dumps with over 1.5 metres of repeated deposition of waste accumulating within the walls. Rigorous excavation has allowed insight into the depositional history of the buildings' infilling. It appears that the infilling varied in speed with some homogeneous fills of sizeable depth excavated, while smaller discrete lenses of material were also noted. Zooarchaeology provided a means to investigate the speed of infilling using the remains of articulated bones in particular lenses; the

inference from this evidence is that deposition on top of such a deposit occurred quickly, preventing weathering and preserving the bones in their articulated state (Rogasch et al. in press:13). The excavation of the fill deposits revealed finds suggestive of activity areas, working surfaces and caches of raw material, indicating the different activities and behaviours of the inhabitants before the buildings were abandoned (Rogasch et al. in press).

The architecture excavated in Trench 5 differs from that on the East Mound and in Trench I. While all are mud brick construction, the structures in Trench 5 are square to rectilinear in shape, with four large internal buttresses. Evidence of buttressed structures has been found in Trenches 5 and 6 as well as in Building 25 and in the TP area on the East Mound. However, it is the structures from Trench 5 that show similarities with the contemporary site of Canhasan I (French 1962). Preliminary research suggests that, due to the size of the internal buttresses, the excavated structures were the foundations of a second storey with the lower section used potentially for storage (Rogasch, 2013 pers. comm.). As mentioned above, similar hypotheses have been made regarding the Canhasan I buildings and Last and Gibson inferred that Building 25 shows evidence of a second storey (French 1998; Gibson and Last 2003). However, given the evidence of hearths in Building 25 it seems unlikely that the whole ground floor was for storage.

Preliminary analysis of the archaeobotanical remains from Trenches 5, 6 and 7 has been conducted indicating the high prevalence of glume bases in the

assemblage, together with hulled barley and glume wheat grains (Bogaard et al. 2012; Stroud 2013).

Examination of the faunal remains from the West Mound indicates a heavy reliance on domesticated animals, particularly sheep, goats and cattle (Orton pers. comm.). Jessica Pearson and Caroline Middleton conducted stable carbon and nitrogen isotope analysis of remains from Trenches I, II, 5 and 6. Pearson examined stable carbon and nitrogen isotope values of sheep and goat remains from Trench I and results revealed a wide range of values reflecting a wide range of consumption patterns, with some caprines solely C3 plant herbivores and other animals accessing C4 plants (Pearson pers. comm.). The West Mound results reflect a continuation of the East Mound trend detected by Pearson (2007), where an inferred increasing range of isotopic values indicates an increase in the distance caprines were herded. Caroline Middleton's results are awaiting publication.

2.1.2 Dating

Chronologically the TP area (6200-6000 cal. BC) is the oldest time period considered in this thesis, the main focus being the West Mound (Marciniak et al. 2015)(Figure 2.1). A recent Bayesian dating program indicates that the TP area was last occupied domestically between 6000-5954 cal BC, with the last activities within that area (burials) occurring at 5975-5930 cal BC (Marciniak et al. 2015).

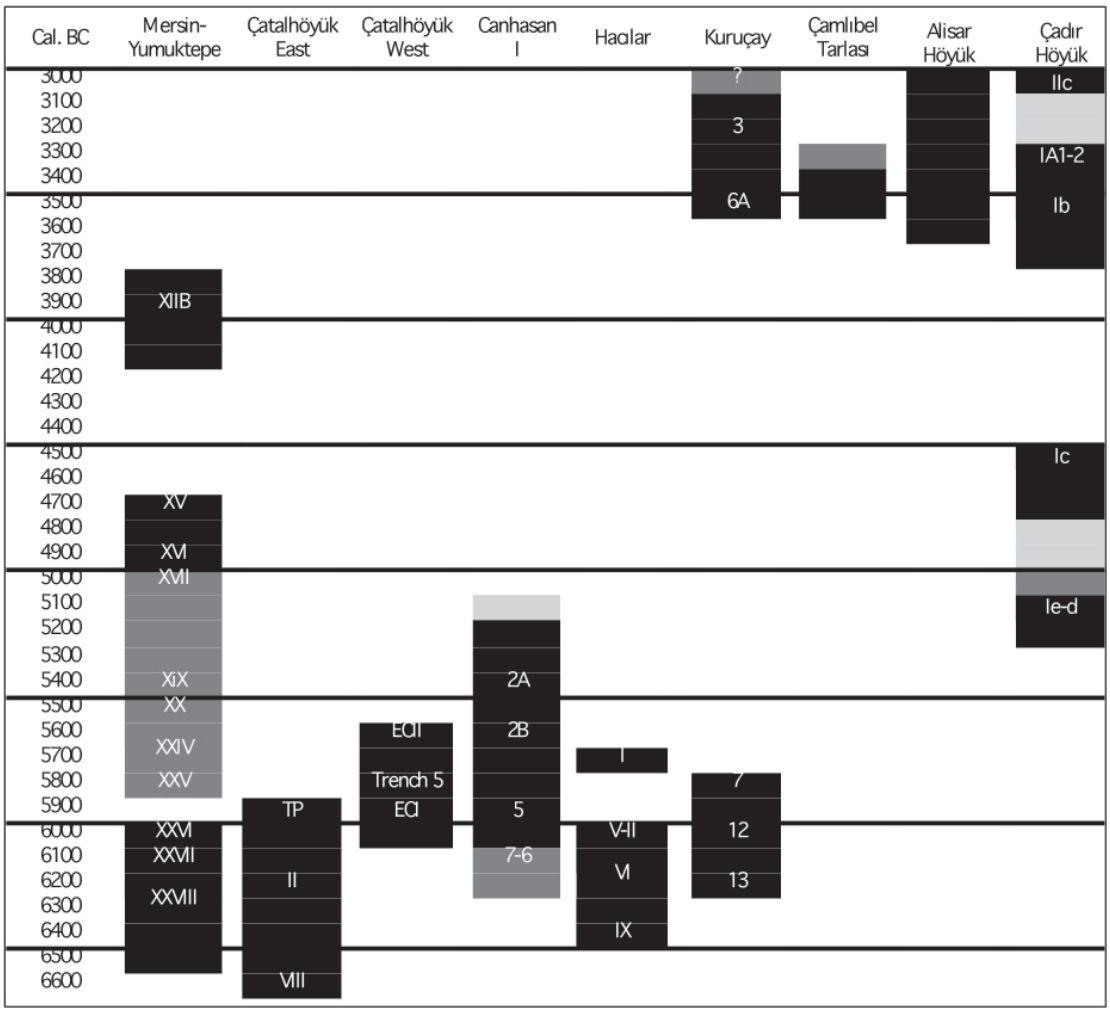


Figure 2.4: Chronology of Central Anatolian sites mentioned in the text, relying on radiocarbon dates (black) and ceramic chronologies/excavation depth (grey). (Data from: Stuckenrath and Ralph 1965; Barker and Mackey 1968; Gorny et al. 2002; Thissen 2002; Schoop 2005a; Higham et al. 2007; Schoop et al. 2009; Marciniak et al. 2015; Orton et al. in prep; Fairbairn et al. submitted).

Mellaart dated two phases within his West Mound trenches based on the ceramic assemblage: Early Chalcolithic I (ECI) and Early Chalcolithic II (ECII). Last and Gibson continued the use of such delineation, with Building 25 dating to the ECI and the pits in Trench II to the ECII. Material from both phases was radiocarbon dated: the ECI phase occurring 6000 – 5700 cal. BC and the ECII phase from 5750 to 5500 cal. BC (Higham et al. 2007).

In the current chronology of the West Mound, the ECI phase (6000-5700 cal BC) of Trench I is the oldest. Trench 5 has also been tightly dated to 5900-5800 cal

BC, corresponding with the ECI phase of Trench I (Higham et al. 2007; Orton et al. in prep)(Figure 2.4). The EC II phase (5750-5500 cal BC) of Trench II brings the occupation of the West Mound to a close (Higham et al. 2007).

The dating evidence indicates that the East and West Mounds were occupied simultaneously, with the final occupation phases of the East Mound overlapping the early occupation phases of the West Mound. The latest dated occupation activity evidenced on the East Mound dates to 6000-5945 cal BC, while the earliest occupation dates on the West Mound come from Trench 7 and suggest occupation before 6000 cal BC (6100-5900 cal BC). Caution does need to be taken regarding the Trench 7 dates, as it appears there is some mixing of the samples; the dates are not in chronological order (Orton et al. in prep). The dates from Trench 5 and Trench I, however, indicate occupation by 5900, with the preceding layer(s) beneath such occupation most likely overlapping with East Mound occupation.

2.1.3 Environmental setting

Topographically, Çatalhöyük is situated on the Konya plain, a flat expanse surrounded by the mountain ranges of Karadağ, Karacadağ and Hasan Dağ. Currently the site receives on average around 350 mm of precipitation rain per annum, with agriculture in the region supported by irrigation (FAO 2015).

The environmental reconstruction of the area surrounding Çatalhöyük has focused primarily on the Neolithic period, with debate centred on two main hypotheses. Roberts et al. (1996; 1999; Roberts and Rosen 2009) proposed that

the site was situated within a large continuous wetland, covering much of the Konya plain and which received seasonal flooding, sometimes resulting in isolation. Using this hypothesis the nearest cultivatable land is over 13 km south of the site, on low-relief terraces (Roberts and Rosen 2009). The alternative theory suggests that flooding was less intensive, with water travelling through the landscape in a series of anastomosing streams (Charles et al. 2014). Such a landscape left areas of cultivatable land exposed all year round as a series of hillocks, thus creating a mosaic landscape (Charles et al. 2014).

The 8.2 ka BP event is postulated as having caused significant drying within the region and is evidenced in regional sea core and speleothem records (Rohling et al. 2002; Göktürk et al. 2011) but evidence of the impact of this event on a local scale is limited. Sediment cores from the Konya plain indicate the cessation of lacustrine deposition, interpreted as the drying up of the lake (Fontugne et al. 1999). Roberts et al. (1996) found evidence of a large palaeochannel of the Çarsamba river flowing beside the West Mound during the Chalcolithic. Pollen records from the large lakes of Van and Zeribar provide a broad-scale reconstruction of the environment and climate during the period but offer limited local information, being over 100km from the site. Local lakes, such as Lakes Akgöl, and Eski Acıgöl, can provide a more nuanced picture although only on a regional scale. The cores suggest that the period leading up to the Chalcolithic was moist with a forest/grass steppe environment (Roberts et al. 2001; Eastwood et al. 2007). Regional reconstructions vary as to the extent of drying that occurred during the Chalcolithic (Roberts et al. 2001; Wick et al. 2003; Dean 2014).

Environmental reconstruction from anthracological data indicates that during the Chalcolithic there was a mosaic landscape made up of wetland and riparian species within open semi-arid woodland (Kabukcu 2015). Finds of riverine woodland species such as elm and willow/poplar indicate the continuation of a local riverine ecosystem past the 8.2Ka BP event and through the Early Chalcolithic occupation (Kabukcu 2015).

The harvest time of crops in the Konya region during the Neolithic was hypothesised by Filipović (2014) as June/July and there is little evidence to suggest that this would have changed significantly by the Chalcolithic. Construction of Walter climate graphs for Konya and Çumra indicates that the region enters water deficit during its annual cycle at the beginning of June and this would then allow for the commencement of the harvest (Figure 2.5). Also, modern irrigated fields around Çatalhöyük are harvested during June and July; taking into account that the past environment may have been wetter, it seems that the Chalcolithic harvest time would have been from late June through to July. Trends in precipitation shown in the Walter climate diagram are supported by charcoal analysis, suggesting the wetter months of the year occurred during the winter and spring periods, with limited rainfall during the summer months (Kabukcu, pers. comm).

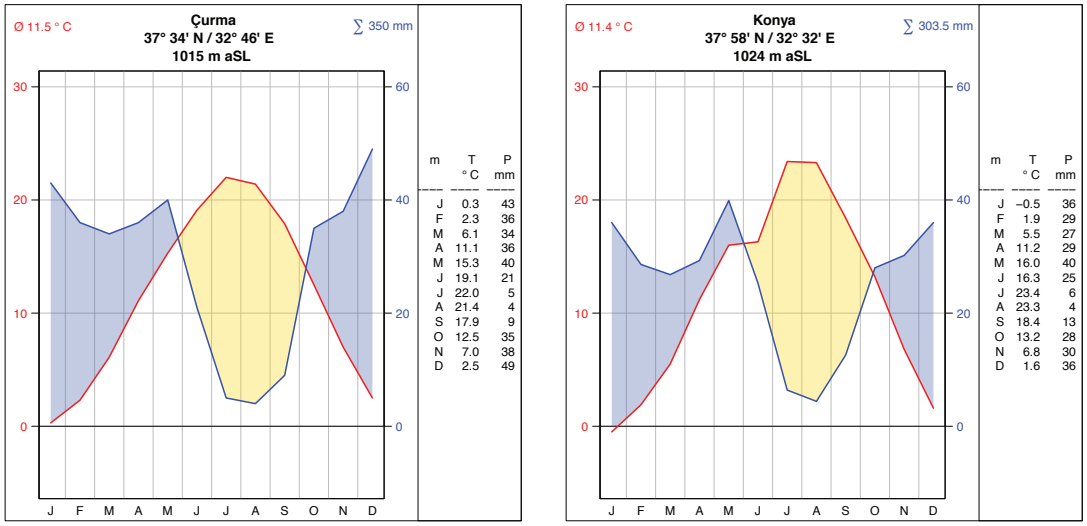


Figure 2.5: Walter climate diagram of Çumra and Konya showing the monthly average rainfall and temperature (Data obtained from Erinç 1949; de Meester 1970; climate-data.org 2016).

2.2 Canhasan I

Canhasan I is located in southern central Turkey, circa 13 km north-east of Karaman and 60 km south-east of Çatalhöyük on the Konya plain. David French excavated Canhasan I, the largest of the three mounds, from 1961 till 1967, revealing an extensive Chalcolithic settlement as well as Neolithic occupation. Subsequent excavation at Canhasan III revealed Neolithic occupation, contemporary with or preceding the occupation at Çatalhöyük (French 1970).

2.2.1 Excavation History

The summit of the mound of Canhasan I was excavated by French from 1961 to 1967. Canhasan I, along with the two other mounds near the village of Canhasan, had been noted by Mellaart (1954) in 1951 and then re-visited by Mellaart and French during their survey of the Konya plain in 1958 (Mellaart 1961). Discovery of Early Chalcolithic pottery during the surveys, in particular a polychrome sherd, led French to excavate Canhasan I, an excavation designed to complement those planned at Çatalhöyük in order to allow French and Mellaart to establish a

stratigraphic sequence for the Konya plain, with Canhasan I the focus of the Chalcolithic period (French 1962:29).

Excavation at the site uncovered eight phases with most attention given to Layer 2. Layers 7 to 4, through the ceramics recovered, were dated to the Neolithic (Table 2.1). The structures revealed in Layer 5 show striking similarities to the architecture of Çatalhöyük East, with finds of storage bins of charred grain and pulses; the small size of the exposed area limited any further conclusions (Figure 2.6). The architectural style changed after this phase, with buildings containing internal buttresses excavated in Layers 4-2. French (1998:24) described Layer 4 as an architectural re-shaping phase: a transitional period between the Neolithic Çatalhöyük-like architecture of Layer 5 and the Chalcolithic architecture of Layer 2. French (1998:25) noted that in Layer 4 the development of internal buttresses is seen but the "massiveness of the layer 2B walls" is not found. Layer 3 sees a continued development of architectural style similar to that of Layer 2B, with the development of a larger, standard size mud brick as well as an increase in wall width, making the walls more massive and similar in dimensions to those of Layer 2B (French 1998). Furthermore, a trend towards regularity in structure shape is seen with structures of more symmetrical dimensions excavated (French 1998).

Layer 2 was the focus of French's excavation, with the excavation of the features and structures carried out over five years. This layer was divided into two phases, 2A and 2B, with 2B the dominant horizontal horizon excavated.

Architecturally the structures of Layer 2B, eleven in total, contain massive internal buttresses commonly positioned symmetrically within the building (Figure 2.7). The buildings range in size from single-roomed square structures with one buttress per wall (Building 5, ~ 35 m^2), to multi-roomed buildings, commonly composed of one large room surrounded by smaller rooms with or without buttresses (Building 1 and 3, 140 m^2 and 148 m^2)(Figure 2.7) (French 1998:31-36). The walls of the buildings were commonly plastered and benches and bins constructed of mud brick were situated against the walls. A number of buildings contained postholes, hypothesized to have a structural role in holding the roof or second storey erect. Finds of roofing material were common within the buildings. Building 10 provided the evidence of a second storey: remains of ceiling construction material, together with a ledge in the walls the height of the buttresses containing impressions of the roofing material. The walls continued on from this, so providing for a second storey (French 1998).

Layer 2A was separated from 2B by French during excavation in 1961 with the discovery of stratigraphically separate soil deposits overlaying Layer 2B's house 6 (French 1998:43). Layer 2A was not a continuous deposit over the excavated area but instead was found in patches concentrated in the south-eastern and north-west corners of the excavation area. Six structures were excavated in part or totally (Figure 2.8). The smaller size of the mud bricks and the irregularity of the walls and corners of 2A buildings were in contrast to those of 2B (French 1998). Nevertheless features of 2B still occur in 2A; internal buttresses and the same wall alignments.

Table 2.1: Layers of Canhasan I, providing information on period of occupation, the number of levels within each phase and the main attributes or significant changes for each layer.

Layer	Period	# of levels	Attributes
Post Chalcolithic 1	Byzantine	1	Occupation level, pits and ceramics
PC 2	Roman		Ceramic presence
PC 3	Hellenistic		Ceramic presence
PC 4	Classical		Ceramic presence
PC 5	Iron Age	1	Pit features, ceramics
1	Late Chalcolithic	6	Buildings, open areas/courtyard, thin walls, no internal buttresses
2A	Middle Chalcolithic	3	6 buildings/parts of walls, smaller mud bricks, but use of buttress and the 2B wall orientation
2B	Middle/Early Chalcolithic	1	11 buildings/parts of buildings – thick walls, large internal buttresses
3	Early Chalcolithic	1	Partial walls. Beginning standard size mud bricks. Development of buttresses
4	Neolithic (latest)	1	Structural reshaping, possible buttresses
5	Neolithic	1, 5 phases	Çatalhöyük East like storage room and adjoining rooms
6	Neolithic	1	Single wall
7	Neolithic	1	Single wall

French commented on the nature of the 2A deposit, explaining that it contained "a wealth of minor or secondary layers, the minutiae of soil stratification but almost wholly without associated features", such as floors (French 1963:30). Evidence of thin lines of dust, sand, ash etc. was visible in the fill of Building 1 and it was clear to French such deposits were the rubbish from a Middle Chalcolithic settlement (French 1966:115). Such characterisation is similar to the waste deposits found in the buildings of Trench 5 on the West Mound of Çatalhöyük.

Layer 1, described as Late Chalcolithic, displays a change in architectural style, with buildings changing size and layout (Figure 2.9). Smaller mud bricks were used, with more areas of outside space between structures, including features such as ovens. The walls are not as symmetrical as the Layer 2B structures and

there are no internal buttresses. Instead, structures are divided into two spaces by an internal wall and in the northern area of the larger room a small partition was constructed to build bins of mud brick (French 1998:53). In the southern section of the excavation area more Layer 1 structures were uncovered. This area includes patches of well-preserved stratigraphy inside walls: the excellent preservation of this fill containing such large amounts of ash meant that all fill was sieved (French 1965:87; French 1998:54). Multiple phases of re-building were noted, as well as multiple ovens and hearths (French 1965).

Post Chalcolithic layers were excavated at Canhasan I, including Iron Age and Byzantine pits which in most cases cut through the Chalcolithic deposits underneath (French 1998). No detail is provided about these contexts in this research as no archaeobotanical samples from these layers were studied.

Archaeobotanical sampling at Canhasan I was limited during the first years of excavation to hand collection, or, in contexts that "favoured the recovery of bio-archaeological materials", dry sieving (French 1998:9). In 1965 dry sieving was introduced as a general policy using circa 1 mm sieves which "became the standard - but not entirely universal –operational tool" (French 1998:10). In the seventh year of excavation a more rigorous sieving method was employed, using sieve stacks of mesh measuring 10mm, 5mm and 1mm (French 1968:45). Such a method allowed samples containing large quantities of grain to be washed from the soil once it had been hand-searched (French 1968:45).

Preliminary work on archaeobotanical samples from Canhasan I was conducted by Jane Renfrew and Mark Nesbitt. Renfrew examined some of the first archaeobotanical samples excavated from Building 3, but details of this analysis remain unpublished. Results of her examination of two small sub-samples from Layer 5 are available (Renfrew 1968). These samples contained 14 six-rowed hulled barley grains and five indeterminate wheat grains (sample 2300), and 12 peas (sample 2200)(Renfrew 1968). Nesbitt conducted a more complete analysis of larger sub-samples of these and other samples but again the results of this work were never published.

Mark Nesbitt kindly granted permission for the re-examination of all the Canhasan material held by him, as well as permission for the use of his raw data tables and preliminary notes within this study.

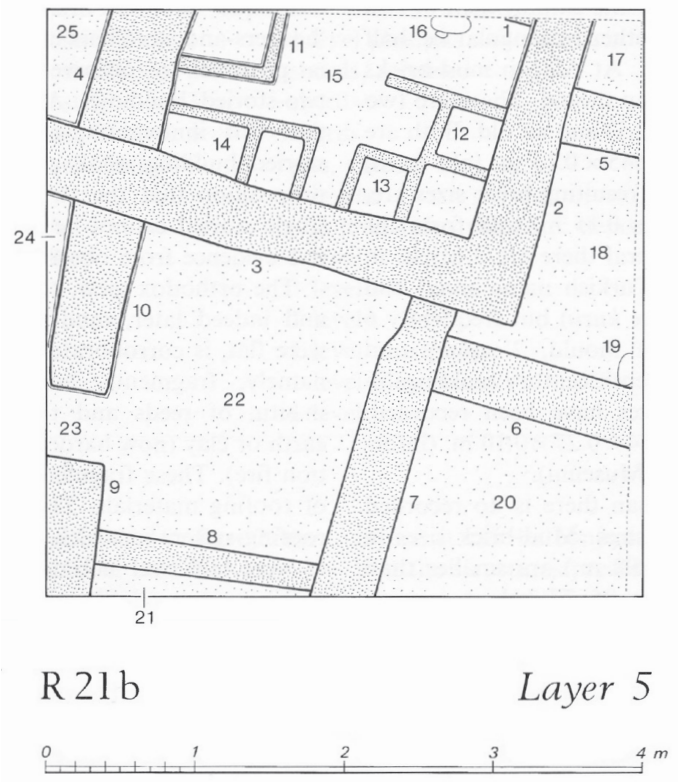


Figure 2.6: Plans of layer 5 (from French 1998).



Figure 2.7: Plans of layer 2b, showing structures discussed in the text (from French 1998).



Figure 2.8. Plans of layer 2A from Canhasan I showing structures mentioned in the text (from French 1998)



Figure 2.9. Plans of Canhasan I , layer1 showing structures mentioned in the text (from French 1998)

2.2.2 Dating

Canhasan I comprises 13 layers: four Neolithic, four Chalcolithic and five post Chalcolithic (Table 2.1). French dated the phases of the site through ceramic forms found and by comparison of such finds to the sites of Hacılar and Mersin (French 1962:34). Using such methods French postulated dates of ca.4600-5000 B.C for Layer 2B, equivalent to Mersin XXII-XX (French 1962; 1966:21; 1967:175). Layer 2A ceramics placed it around 4600- 4300 BC or Mersin XIX-XVII, while Layer 1 was 4000-3800 BC (French 1966:121; 1967:175). The Neolithic phases cover a period from 5000 till 5400 BC (French 1967:175).

Some material, primarily from Layer 2B, with one additional sample from 2A, was radiocarbon dated at the University of Pennsylvania (Stuckenrath and Ralph 1965). In addition, two samples were dated by the British Museum, again from Layer 2B (Barker and Mackey 1968). Re-calibration of the dates using OxCal, produces dates of occupation for 2B of around 6100-5550 cal BC (Figure 2.10), much older than the originally reported dates of 5083-4720 B.C (Stuckenrath and Ralph 1965:193). The date from Layer 2A (P-789) does not indicate a different younger chronological period; in fact, of the material dated, it is the second oldest (Figure 2.10). It is however possible that the older date of the 2A sample is the result of the re-use of 2B wooden beams within the structures of 2A (Schoop 2005a:144).

The absence of radiocarbon dates from older phases of Canhasan I limits deductions regarding these phases. A radiocarbon dating project on material from the Neolithic Canhasan III has been implemented by Andrew Fairbairn and

Douglas Baird; included in that project are three samples from Canhasan I material held by the author (Fairbairn et al. submitted). The three samples, from Level 5 contexts, provide new dates and allow for the refinement of the temporal location of Canhasan I and Canhasan III. The research produced dates for Level 5 of 6010-5890 cal BC (Fairbairn et al. submitted)(Figure 2.10). This, coupled with the new dates from Canhasan III, indicates a lengthy hiatus between the end of the occupation of Canhasan III and the start of Canhasan I (Fairbairn et al. submitted). Canhasan III sits firmly in the aceramic Neolithic, while Canhasan I was settled nearly 1000 years after Canhasan III's abandonment. The dates also confirm that the settlement of Canhasan I and Çatalhöyük West were contemporaneous (Figure 2.4).

Re-examination of the dates and ceramics by Schoop (2005a) confirmed French's conclusions regarding the contemporaneous nature of phases XXIV-XX of Mersin-Yumuktepe, the ECI and ECII phases of the West Mound, Çatalhöyük, and Layer 2B of Canhasan (Figure 2.4). Ceramic evidence shows significant parallels between these phases of Canhasan I, Çatalhöyük West and phases XXIV-XX of the Cilician site of Mersin-Yumuktepe (Schoop 2005a:147). The radiocarbon dates indicate similar time frames of occupation (Figure 2.4).

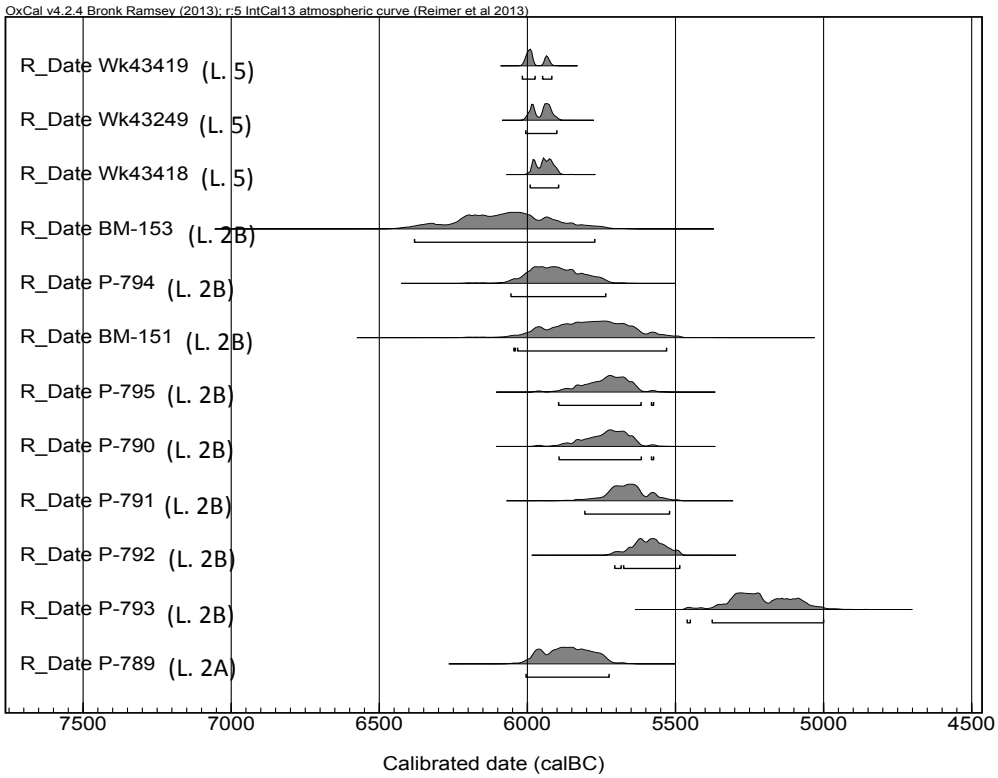


Figure 2.10: Re-calibrated radiocarbon dates of Canhasan I. Calibrated by the author using OxCal 4.2 (IntCal 13 calibration curve)(dates from Stuckenrath and Ralph 1965:193; Barker and Mackey 1968; Fairbairn et al. submitted).

2.2.3 Environmental setting

Canhasan I is located in the south-eastern region of the Konya basin, in the Karaman sub-basin (Figure 1.1). The site's location on the Ibrala (Selereki) alluvial fan, while having similar climatic conditions to Çatalhöyük, appears to have led to a different environment. This sub-basin is fed by rivers such as the Çamarluk and the Ibrala which over time deposited alluvium. Coring research by Roberts (1991) indicates that depositional conditions changed at the commencement of the Holocene to one of low energy action. This period saw the deposition of fine-grained, regular alluvial deposits, which with time would become rich agricultural substrates. Canhasan I was located on the boundary between this alluvial fan and the Pleistocene lake marl, providing access to fertile agricultural soils (de Meester 1970; Sherratt 2004).

Wood charcoal from Canhasan III indicates that during its occupation steppe-forest vegetation such as almond, juniper and hackberry, as well as riverine species including elm and willow/poplar, were used as both building and fuel material (Willcox 1978). The occurrence of a mix of riverine and steppe species suggests that both environments were within the local catchment (Willcox 1977).

The current climate around the site of Canhasan I was modelled using data from Karaman, a city 13km south-west of the site. This indicates that Karaman has a similar climate pattern to towns around Çatalhöyük, such as Çumra (Figure 2.11). Water deficiency begins in late May with a period of four months of high temperatures and limited rainfall. A similar harvest period would have been likely at Canhasan I, with the possibility, due to Canhasan I's location on the Ibrala (Selereki) fan, that water may have been more irregular in the past.

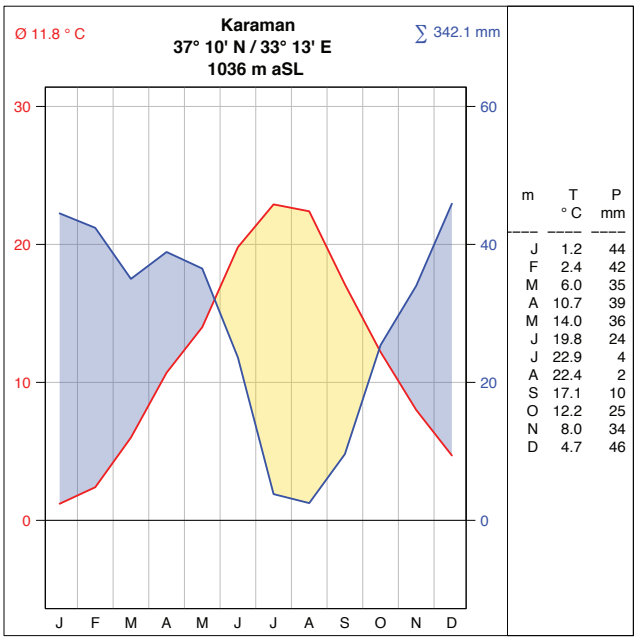


Figure 2.11: Walter climate diagram for the town of Karaman (data sourced from de Meester 1970).

2.3 Çamlıbel Tarlası

Çamlıbel Tarlası is a Late Chalcolithic site located about 200 km east of Ankara. This small site is situated on the slopes of a valley formed by the Karakeçili Deresi, a tributary of the Budakozu Deresi. It was excavated from 2007 to 2009 under the direction of Ulf-Dietrich Schoop as part of the Boğazköy Expedition of the German Archaeological Institute in conjunction with Edinburgh University. The site dates from 3590 to 3470 cal. BC with four phases (Schoop et al. 2009).

2.3.1 Excavation history

The site is very small, under 0.25 ha, and consists of four distinct periods of use (Table 2.2). The first phase, CBTI, contains no evidence of habitable structures; activity is concentrated on metallurgy with the discovery of bowl furnaces (Schoop 2015:50). In addition to this, a layer of ash and charred botanical remains, in some places up to 1 m thick, was excavated (Schoop 2015). The only structural find within this phase is the late addition of what has been interpreted as a storage structure by the excavator, leading to the assumption of cultivation on the site (Schoop 2015). Finds for charred seeds and silica sheen on flint blades has been used as evidence of agricultural activities (Schoop 2015: 51).

Table 2.2: Phases of Çamlıbel Tarlası indicating the defining characteristics of each phase.

Phase	Characteristic features
ÇBT IV	Architecture aligned in rows, large courtyards, evidence of metalworking
SPEU	Second phase of ephemeral use: seasonal presence, bowl furnaces
ÇBT III	Large free-standing buildings, tools of metalworking
FPEU	First phase of ephemeral use: seasonal presences, bowl furnaces
ÇBT II	Dense architecture with clusters of rooms, evidence of metal working, burials
ÇBT I	No habitation structures, potential “silo”, evidence of metalworking
Sterile soil	

During the CBTII phase metallurgic activities continued and the development of a community is indicated, with the introduction of six clustered habitation structures, some including household ovens, and the burial of children under the floors (Schoop 2015)(Figure 2.13). Stone was used to construct the posterior walls of the buildings which were cut into the slope of the hill, while the remaining free-standing walls were constructed of rammed earth (*pisé*): any evidence of wood or mud brick use is lacking (Schoop 2015). Storage of agricultural products is suggested by the presence of a structure interpreted as a granary with a suspended floor (Schoop 2015:52)(Figure 2.13). There is no evidence that these structures have multiple storeys (Schoop 2015:52). Ovens were commonly found, with four of the structures having large ovens (Schoop 2015:52).

The site was abandoned after this period, with nearly all artefacts removed from the buildings. In the ensuing abandonment phase (FPEU), the buildings disintegrated, with the presence of new bowl furnaces the only evidence of activity on the site, the interpretation being that the site was used in a similar fashion to that which occurred in CBTI (Schoop 2015:54).

During CBTIII, after the period of abandonment/ephemeral use, the development of different structures and a more dispersed community layout is apparent (Figure 2.13). One of the best-preserved and largest structures excavated was of this period and was nicknamed the "Burnt house". Ritual associations have been theorised regarding this structure, in which a plaster floor with inset cattle bones was found (Schoop 2015). At over seven meters long, this structure included

parts of the previous CBTII building, utilizing sections of its wall as pillar bases for supporting the roof: the practicality of such utilisation is questioned by Schoop, who suggested an intentional link with the older structure as opposed to a necessity (Schoop 2015:55). At the end of the structure's life it was burnt down, probably purposefully (Schoop 2015:61).

The change in the use of a specific feature is notable, with no internal ovens in the buildings of CBTIII (Schoop 2015). Large amounts of slag and crucible fragments indicating metallurgical activities during the period were also recovered (Schoop 2015). CBTIII ends with the burning of the large house, another period of periodic use ensuing (SPEU) with activities concentrated around new bowl furnaces (Schoop 2015:55).

CBTIV sees the rearrangement of the settlement layout and the construction of different rectangular structures that are less isolated. A large building in the south of the site had a floor constructed of flagstones. The use of a large oven to the south-east of this building seems to have provided a connection between the different structures around a central courtyard (Schoop 2015). In addition, the site was now enclosed inside a boundary wall (Schoop 2015). This phase ends differently to the preceding phases, with artefacts and tools not removed from buildings. After the cessation of occupation the site was used episodically for the burial of both adults and children (Schoop 2015:57).



Figure 2.12. Phase plan of CBTII (supplied by U-D. Schoop)

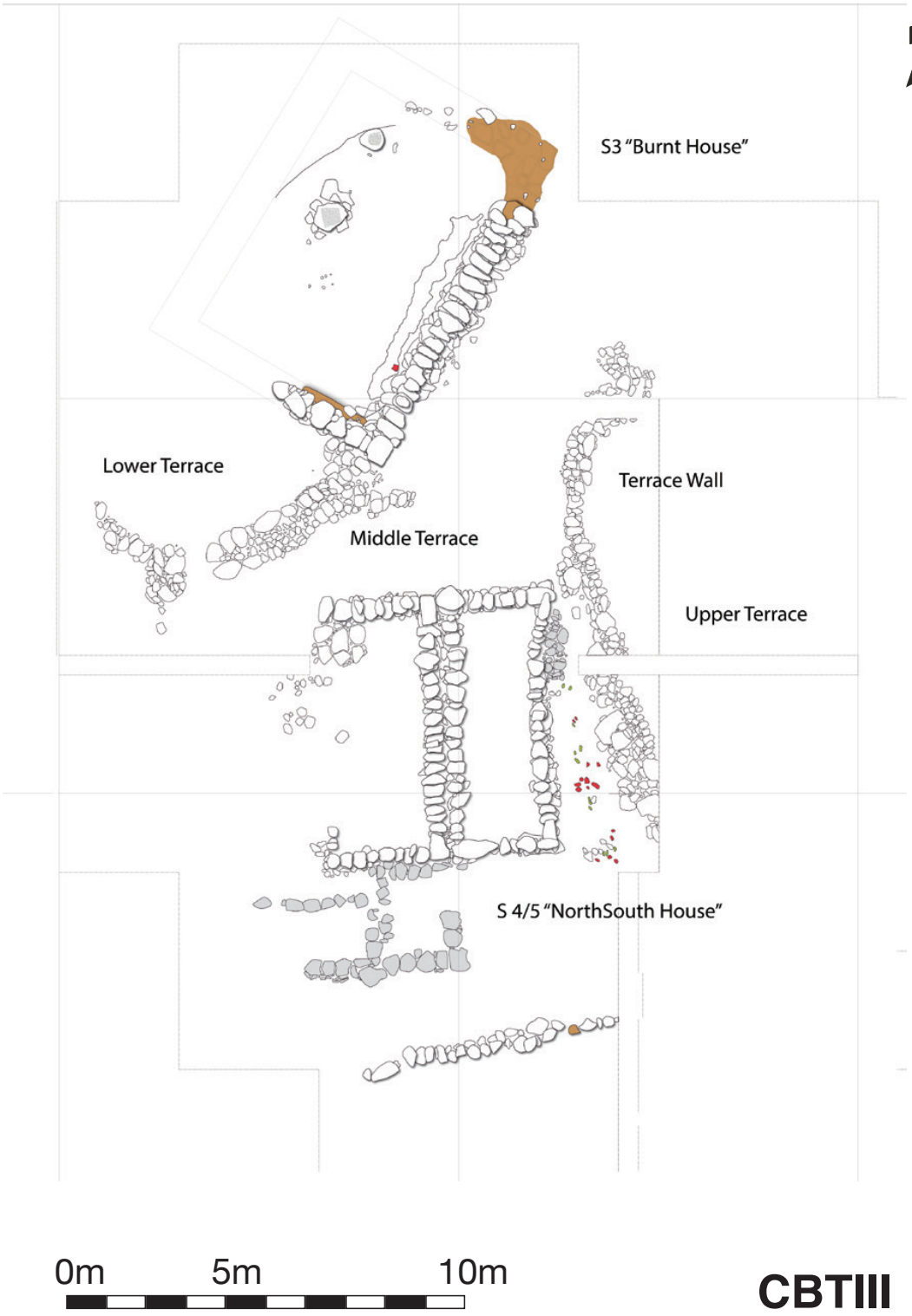


Figure 2.13: Phase plan of III (supplied by U-D. Schoop).



Figure 2.14 Phase plan of CBTIV (supplied by U-D. Schoop)

Archaeobotanical remains were recovered during the excavation using flotation. A preliminary analysis of 25 samples was conducted by Papadopoulou and Bogaard (2012) and indicates the presence of a crop suite of cereals, predominantly hulled barley and glume wheats such as emmer and einkorn, as well as five pulse species and flax.

Zooarchaeological analysis of the faunal material revealed a high number of domesticated species, with wild animals almost absent (Bartosiewicz and Gillis 2011). Pigs were numerous; more so than sheep and goats, but cattle remains

dominate the assemblage. These comprise over 50% of the faunal assemblage by weight, leading Bartosiewicz and Gillis (2011) to conclude that cattle contributed a high proportion of the meat intake of the inhabitants.

Stable carbon and nitrogen isotope analysis of faunal and human remains was conducted by Pickard et al. (2016a; 2016b) and Vaughan et al. (2013). The human and faunal values have a small offset between them, much less than a trophic level difference (4-6‰): this suggests inhabitants of Çamlıbel Tarlası gained less protein from meat than predicated by the zooarchaeology (Pickard et al. 2016a:303). Instead Pickard et al. (2016a) hypothesised that plants contributed significantly to the protein in the diet, with the high quantity of cattle bone not representing the consumption of large amounts of meat but rather the consumption of protein through protein-poor secondary milk products (Pickard et al. 2016a:304).

Preliminary analysis of archaeobotanical material from Çamlıbel Tarlası indicates the presence of a range of pulse taxa at the site (Papadopoulou and Bogaard 2012). It is therefore possible that the low trophic offset between the animals and humans is not due to low meat consumption, but the consumption of low $\delta^{15}N$ plant protein from pulses, which would mask the real intake of animal protein. As Pickard et al's (2016) results were based solely on the analysis of faunal and human remains, it is possible that the analysis of plant material within this study will help to clarify this issue (see chapter 9).

2.3.2 Chronology

Four radiocarbon dates based on short-lived plant species were obtained for both the youngest and oldest settlement phases of the site. The returned dates indicate a short period of occupation during the Late Chalcolithic (3590 to 3470 cal. BC)(Schoop 2009)(Figure 2.4). This suggests that the phases occurred within one or two generations, with the deposit accumulating quickly.

2.3.3 Environmental setting

The environmental and geographical situation of Çamlıbel Tarlası is different to the south central sites. Çamlıbel Tarlası is located on the slope of a small valley formed by the Karakecili stream, and is circa three kilometres away from the main alluvial plain of the Budakozu River. The geology of the region provides rich soils for the cultivation of crops; forested hill slopes would have provided timber, wild fauna and other resources including copper ore – a possible reason for the location of the site.

Geomorphological investigation shows that the present-day steep landscape of the site is heavily degraded and eroded. However, at the time of initial foundation of the settlement, it was located on a wide and stable hillside (Marsh 2010). Evidence of sediment movement at the site after settlement suggests that erosion started not long after the founding of the site, with the hillsides cleared to the north-east (Marsh 2010).

Palaeoclimatological reconstructions of the area are limited to broad regional studies. The end of the Chalcolithic saw the disintegration of the optimal climatic

conditions experienced in the Middle Chalcolithic and a period of drying occurred from 3300-3000 BC, (the 5.2 Ka event) (Kuzucuoğlu et al. 2011; Roberts et al. 2011). Evidence of fluctuations in the amounts of precipitation is detected in cave and lake records, with droughts interspersed with wetter conditions (Bar-Matthews and Ayalon 2011; Kuzucuoğlu et al. 2011). Vegetation reconstruction suggests that the region was forested (Dörfler et al. 2000).

Modern records show that the local region receives variable annual precipitation, with surrounding towns receiving between c.400 and 600 mm p.a. (Dündar 2009). One of the closest towns with a Turkish meteorological station, Yozgat, receives on average 591 mm annually; Alaca, a similar distance from the site (25 km), has an annual average of 398mm of precipitation (Dündar 2009). The closest town to the site is modelled to receive 451mm p.a. (climate-data.org 2016). The inferred annual precipitation at Çamlıbel Tarlası (using the geographical coordinates of the site) is 529mm (FAO 2015). Temperatures range from maximums of circa 26 °C in high summer to lows of -6°C in the winter.

Harvest time during occupation can hypothetically be extrapolated from modern data. The average temperature and rainfall per month was obtained for towns located within 30 km of the site. Rainfall data were obtained from a number of sources, with monthly values over differing years used from Alaca, Yogzat and Sungurlu (Dündar 2009). Monthly temperature was modelled for Alaca, Yogat and Sungurlu, in addition to the modelling of rainfall and temperature of the closest village to Çamlıbel Tarlası – Boğazkale (climate-data.org 2016).

Figure 2.15 indicates that towns around Çamlıbel Tarlası have an intersection of precipitation and temperature on the graph at the end of June, with July the first month during which there is a total water deficit and August the period of highest water deficit. This provides an indication that in the modern climate the earliest harvest should be at the start of July. Palaeoclimatic proxies indicate that the climate during the Chalcolithic occupancy of Çamlıbel Tarlası would have been similar to today; aridification did not commence until after abandonment (Roberts et al. 2001; Kuzucuoğlu et al. 2011; Clarke et al. 2015:104). Ethnographic accounts indicate that barley harvest began in July in the region, followed by lentil and chickpea and then finally wheat, which was harvested until the end of August (Yakar 2000). The Hittite texts of the Late Bronze Age state that July was the barley-harvesting period (Hoffner 1974). The evidence therefore suggests that the region's harvest time probably commenced in July and continued into August.

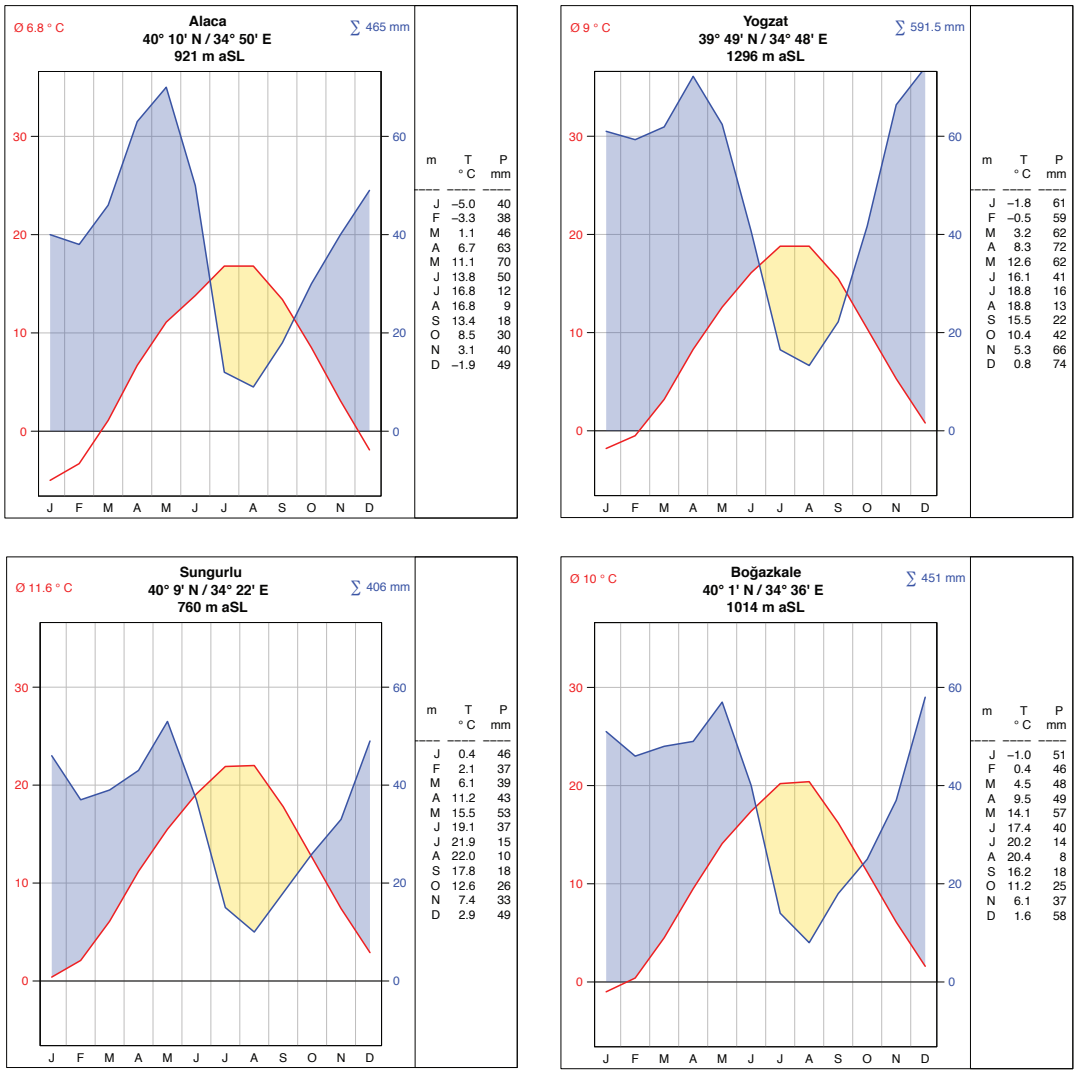


Figure 2.15: Walter climate diagrams for villages around Çamlıbel Tarlası highlighting the seasonal pattern of precipitation and mean temperature. (Data from Erinç 1949; Dündar 2009; climate-data.org 2016).

2.4 Kuruçay Höyük

Kuruçay Höyük is situated in the Lake District of central western Turkey, about 2-3 km south of Lake Burdur, (Figure 1.1) and was excavated between 1978 and 1988 by Refik Duru. The site is approximately 10 km away from the Neolithic/Chalcolithic site of Hacılar excavated by Mellaart in the 1950s and 1960s. Occupation at Kuruçay started in the Neolithic, with later occupation

phases in the Chalcolithic and Bronze Ages. Occupation was not continuous, with several hiatuses.

2.4.1 Excavation history

The site was excavated over 11 seasons under the direction of Refik Duru from the University of Istanbul. Kuruçay has 13 levels or phases, from the Neolithic through to the Bronze Age. Levels 12 and 13 are defined as Early Neolithic occupation layers. Level 13, which sits atop natural sediment, has no structural remains; occupation is inferred from the presence of pottery and bone/stone tools and was most likely ephemeral (Duru 2008:24). It is not until Level 12 that permanent occupation is evident at the site with the construction of structures with thick stone foundations and walls (Duru 2008:28). This period also sees the construction of a fortification wall containing semi-circular towers (Duru 2008:42). Duru (2008:15) stated that the occupation from this period until Level 8 was by the same cultural group, citing similarities in the architecture and pottery as evidence. After the destruction of Level 8 the architecture and artefacts change.

Excavation of Level 7 revealed a difference in the architecture of the settlement. The structures are square to rectangular, with stone buttresses and mud brick walls and are strikingly similar to those of the contemporary phase at Hacılar (II and I), as well as with the Early Chalcolithic structures excavated on the Konya plain at Çatalhöyük West and Canhasan I (cf. Figure 2.7, Figure 2.3, Figure 2.16 with Mellaart 1970). The structures at Kuruçay have internal buttresses, as at the other sites, with Duru (2008:47, Fig.89) noting the lack of doorways as potential

evidence of an additional storey on top, something also noted at the aforementioned sites. Level 7 was destroyed by fire, with all excavated structures showing burning, another similarity with the end of the same cultural phase at Hacılar (Duru 1994, 2008).

Kuruçay, similar to other nearby sites, was abandoned during the Middle Chalcolithic period, with settlement re-commencing during the Late Chalcolithic (Duru 2008:15). The Late Chalcolithic period at Kuruçay includes six settlement levels (6A, 6, 5, 4, 3A and 3)(Duru 1982; 2008:14). The Late Chalcolithic inhabitants have no artefactual links to the settlement of the Early Chalcolithic inhabitants, with new settlement structure and ceramics (Duru 2008:122).

Level 6A is one of the best-preserved phases, with over 24 structures/rooms excavated within the excavated 2000 m^2 (Duru 2008). The structures, built on stone foundations using mud brick, were of a square to rectangular design, sometimes with multiple rooms (Figure 2.16) (Duru 1982). There were no internal buttresses as in the Early Chalcolithic period, with the architecture distinct from the early occupation (Duru 1982). The walls and foundations were also much smaller in width, lacking the massiveness seen in the Early Chalcolithic period. Buildings commonly contained ovens, which appear to be a standard design: dome-shaped with a semi-circular ash pan in front of the opening (Duru 1982). During a later phase of 6A significant changes were made to the buildings, with doors filled in and additional buildings constructed in the courtyards and alleys of the settlement, so that it was "impossible to stroll inside the town" (Duru 1982:123).

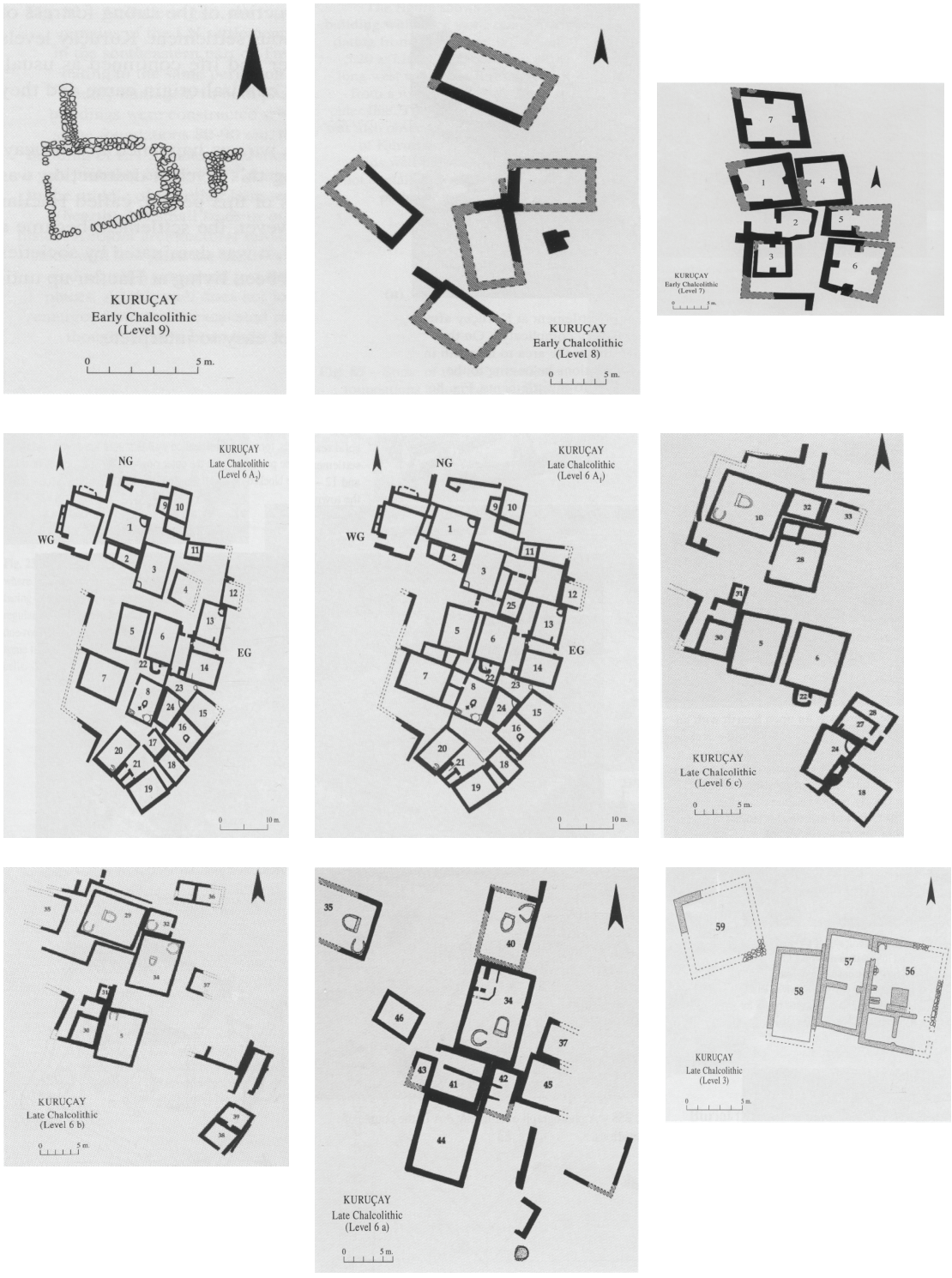


Figure 2.16: Selected phases of occupation at Kuruçay, showing plans of level 9, 8, 7, 6 A, 6c, 6b, 6a and 3 (plans from Duru 2008).

In Level 6, some of the destroyed houses of 6A were reused, with additional structures constructed over the other remains (Duru 1994). Certain houses are seen with enclosure walls around them, thus delineating their indoor and outdoor spaces (Duru 2008:128)(Figure 2.16). This level has three phases: 6c the oldest, 6b and then 6a the youngest. 6a was destroyed by fire, with 6b and 6c only partially burnt (Nesbitt 1996:134). Certain standard features are continuous such as the standard oven and hearths bounded on one side by a mud brick stele (Duru 2008). Levels 5, 4 and 3A have limited preserved architectural remains, with some structures in such poor condition they were not drawn (Duru 2008:130). Level 3 had greater preservation of structural remains but a limited area excavated (four structures)(Figure 2.16). Duru (2008:131) identified one building as a temple because of its non-portable artefacts and building plan: it consisted of three rooms, with a second building, the "temple storage", abutting its western wall. Nesbitt (1996) however claims the building is more likely a domestic structure. The youngest layers see occupation during the Early Bronze Age (Level 1-2) but the preservation of detailed structural remains is lacking, with only incomplete walls and one hearth uncovered (Duru 2008:158).

The phases of relevance to this research are the Late Chalcolithic Levels of 3, 6 and 6A from which the majority of archaeobotanical samples originate. These seem to derive solely from storage deposits hand-collected during excavation but limited information regarding the sampling strategy and context of the samples is available. A number of archaeobotanical samples have no contextual information, with Nesbitt (1996) hypothesising their derivation from Level 3, 6 or 6A, as these layers were extensively burnt. Two samples were attributed to Levels 4 and 5 but

Nesbitt doubts this, suggesting that due to the lack of documentation of burnt contexts from Level 4 or 5, it is more likely they derived from either Level 3,6 or 6A.

Mark Nesbitt conducted preliminary analysis of the archaeobotanical material from the site and noted that 50 samples were taken during the excavation, with only 25 of these containing high enough seed numbers to warrant closer examination (Nesbitt 1996:134). Nesbitt's (1996) preliminary analysis revealed that hulled barley and glume wheats were common crops and provided a coarse presence/absence of edible items found within the samples. A large number of pulse samples highlight the importance of these taxa, with lentil, pea and grass pea all occurring in large numbers in two or more samples. Nesbitt (1996:136) noted the absence of bitter vetch from the assemblage, a pulse taxa commonly found at Anatolian Chalcolithic sites. Flax seeds in large quantities were found in five samples originating from Levels 6a and 3, with the provenance of three of the samples unclear. The number of weed seeds in the flax samples is quite high, with a particular suite present: *Lolium* sp., *Silene* sp. and *Camelina sativa*. All of these are common flax weed flora in Europe today, and Nesbitt (1996:136) hypothesised that such samples showed a development of the unique flax weed flora which probably spread with flax into Europe.

2.4.2 Dating

Dating of the phases at Kuruçay is through comparative pottery and radiocarbon dating. Ceramic dates for layers at Kuruçay led Duru to conclude contemporary occupation occurred at Kuruçay and Hacılar during a number of phases (Duru

1994, 2008). Fourteen radiocarbon dates were obtained from material taken during the excavation; nine radiocarbon dates concentrate on the Chalcolithic period, with only five dates from contexts older than Level 6A (Duru 1994). Limited information regarding the context and material used for some makes it difficult to interpret the re-calibrated dates (Figure 2.17). Some dates appear too old for the level to which they are attributed, but there is clearly a concentration of older level dates (Level 13-11) between 6300-5700 cal. BC. Re-interpretation of the ceramic assemblages and radiocarbon dates for the region's sites by Schoop (2005a) indicates the possibility of a limited overlap between the Hacılar occupation phases and Kuruçay. Schoop's chronology, using both radiocarbon dates and ceramic evidence, sees the shifting of phases towards a younger dating framework, resulting in sites being younger than thought when excavated. Schoop's chronology places Level 13 within the Late Neolithic horizon, contemporaneous with the last phases of the Neolithic occupation at Hacılar (around 6100 cal. BC, or Hacılar VI)(Figure 2.4). Schoop decreased the age of Level 12 defined by Duru as Early Neolithic, re-defining it as transitional Late Neolithic/Early Chalcolithic with Levels 11-7 tightly clustered in the Early Chalcolithic period, contemporary in date with sites such as Çatalhöyük West and Layers 5-2B at Canhasan. Thissen's (2010) research agrees with the assignment of the early levels of Kuruçay to the end of the Neolithic/start of the Chalcolithic, contemporaneous with Çatalhöyük West.

Levels 6A-3 are Late Chalcolithic in date, with radiocarbon dates placing them around 3700-3100 cal. BC (Figure 2.17, Figure 2.4). Figure 2.17 shows three problematic radiocarbon dates from Level 7 and Level 6c that do not align with

their stratigraphic context. The two Level 7 dates are older and younger respectively than they should be, with one significantly out of alignment, around 4000 cal. BC. The third erroneous date comes from Level 6c. Overall the results, while problematic in some cases, indicate that the later levels of Kuruçay are in some part contemporaneous with the occupation of Çamlıbel Tarlası (Figure 2.4).

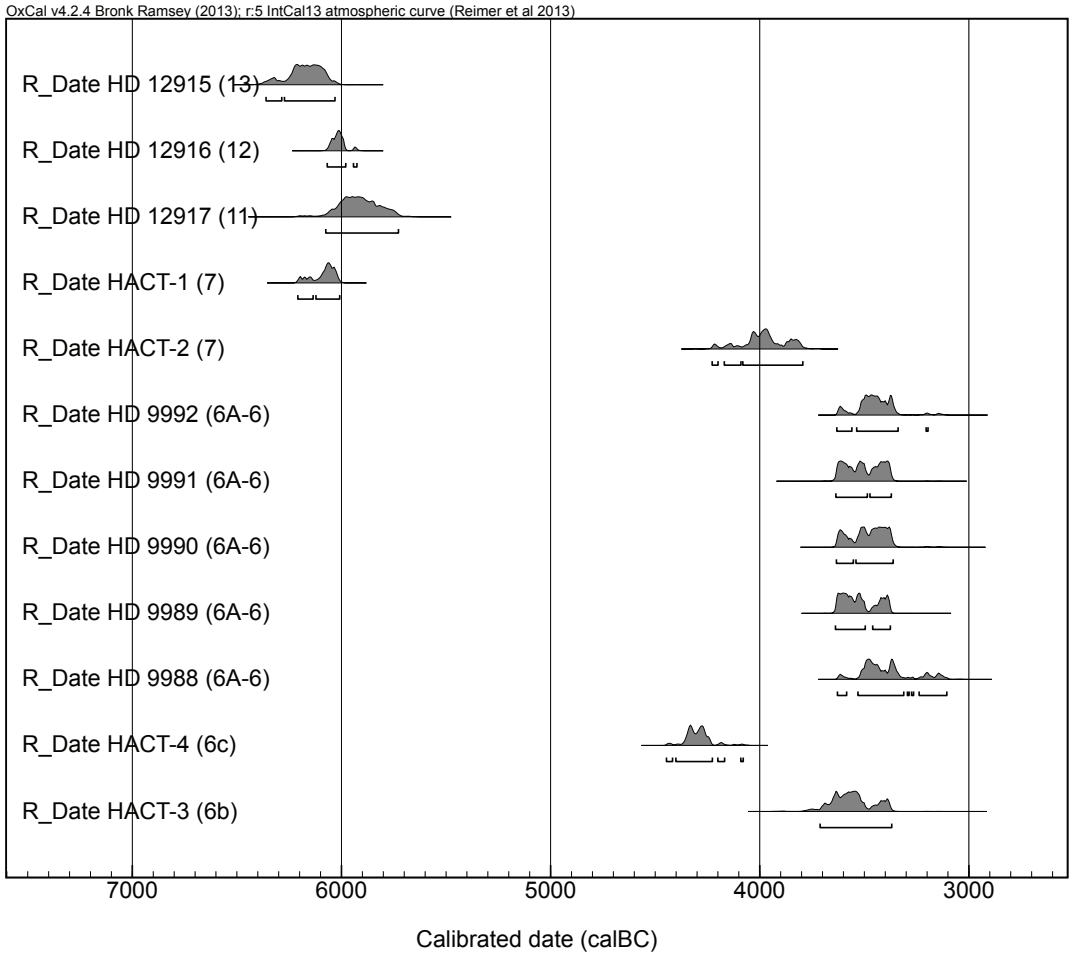


Figure 2.17: Kuruçay radiocarbon dates recalibrated - in order of level (in brackets). Calibrated by the author using OxCal 4.2 (IntCal 13 calibration curve)(data from Schoop 2005a).

2.4.3 Environmental setting

Kuruçay is located near Lake Burdur in the Burdur province of the Turkish Lake District. This region is characterised by basin and ridge topography, with valley bottoms containing lakes isolated from neighbouring lakes by high mountain

chains. Lake Burdur, visible from Kuruçay, is saline and potentially would have been so in the past, limiting it use for agricultural purposes (Mellaart 1970:xii; Nesbitt 1996:135). However, the lake today and also probably in the past, is of international importance for specific wildfowl with ducks over-wintering there (Green et al. 1996).

The region today is an important agricultural region, with fertile fields located on the ancient Pleistocene lakebed. Late Pleistocene drainage of the ancient lake exposed large areas of cultivatable land, purposed as the reason for the settlement of sites such as Hacılar (Cohen 1970). Such drainage, however, led to the increased salinity of the lake, with fresh water most likely only available from inflowing streams and rivers.

It is hypothesised that the region was largely forested, with some pollen data available for the later periods indicating continuing high amounts of tree pollen compared to non-arboreal pollen (van Zeist et al. 1975; Eastwood et al. 1998; Schoop 2005b). Deforestation and disturbance did not seem to occur in the region until the Middle Bronze Age around 2000 BC (van Zeist et al. 1975; Eastwood et al. 1998). Coring indicates that during the late Neolithic/ Early Chalcolithic the region saw a change from steppe vegetation to forests composed of oak, juniper and pine (van Zeist et al. 1975). Given the proximity to the lake, the site most likely had access to wetland environments.

The site is situated on the slope above the lake, surrounded by gullies and streams created by water running from the hills behind. Limited natural arboreal

vegetation survives around the site, with small pockets of pistachio and other wild trees in the eroded gullies and on the steep slopes of the mountainside.

The harvest time for the site of Kuruçay was investigated through modern climate data (Erinç 1949). Walter climate diagrams from the cities of Burdur and Isparta highlight the fluctuations of rainfall over the year, with July both the driest and hottest month (Figure 2.18). Water deficit begins at the beginning of June in Burdur and during June in Isparta. Burdur is located 15 km north-east of the site, Isparta 37 km north-east, so Burdur may be a closer replication of the climate surrounding the lake and at least indicates that plants would not need to set seed as a result of lack of water until June, possibly extending in to July.

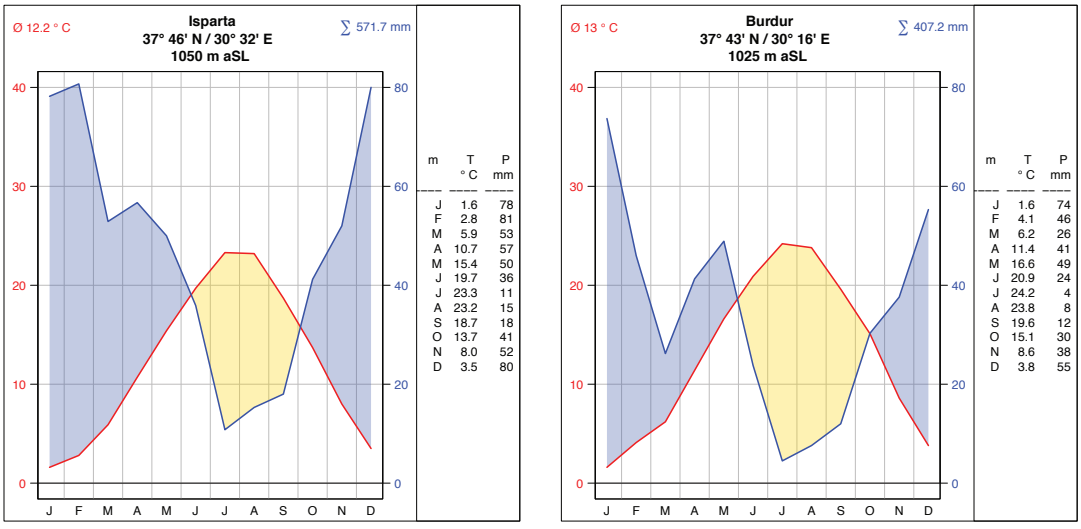


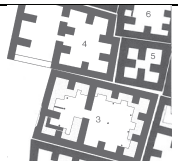
Figure 2.18: Walter climate diagrams from Isparta and Burdur (data from Erinç 1949).

2.5 Summary

The four sites examined in this research bookend the Chalcolithic period. Two cover the transition and beginning of the Chalcolithic (Çatalhöyük West and Canhasan I), while the others date to the final stages of the period (Kuruçay and

Çamlıbel Tarlası). The environmental conditions of the sites have similarities and differences, the two Konya plain sites are located on alluvium; rainfall is variable with Çamlıbel Tarlası located in wetter conditions and vegetation type differs (Table 2.3). Architectural similarities in style can be seen in the Early Chalcolithic settlements, while the later settlements present completely different building styles (Table 2.3). Previous archaeobotanical research has been conducted on all sites examined but to varying degrees. Crops identified in this previous research hint at regional differences but the conclusions were limited by the reporting of presence/absence data (Table 2.3). With such research in mind the following two chapters explain the methodology and methods used to refine such preliminary work and further explore plant use and crop husbandry at Çatalhöyük West, Canhasan I, Kuruçay and Çamlıbel Tarlası.

Table 2.3: Summary table of the dates, environmental conditions, site size, architectural forms, and known archaeobotanical research of Çatalhöyük West, Canhasan I, Kuruçay and Çamlıbel Tarlası. (P = only presence recorded, X = <25%, xx 25-49%, xxx= 50-74%, xxxx = 75-100% of assemblage). * denotes reported storage samples.

	Çatalhöyük West	**Canhasan I**	**Kuruçay (Late)**	**Çamlıbel Tarlası**
Period	Early Chalcolithic	Early Chalcolithic	Late Chalcolithic	Late Chalcolithic
Location	South Central	South Central	South Central	North Central
Vegetation	Wetland/ forest steppe	Wetland/ forest steppe	Forest/ ?wetland	Forest
Climate	Semi-arid	Semi-arid	Semi-arid	Temperate
Site size	8 ha	10 ha	1.5 ha	0.25 ha
Dominant architecture				
	Thick mudbrick walls internal buttresses, potentially two storey	Thick mudbrick, walls, internal buttresses, two storey	Stone foundations, thin mud walls, one storey	Rammed earth/stone, thin walled, one storey structures

	Çatalhöyük West	Canhasan I	Kuruçay (Late)	Çamlıbel Tarlası
Archaeobotany	Trench 1	Level 5	6/3	All levels
Barley	X	P	P*	X
Glume wheat	XXX	P	P*	X
Free-threshing wheat	X		P*	X
Lentil	X		P*	X
Pea	X	P	P*	X
Bitter vetch	X			X
Chickpea	X			X
Grass pea			P	X
Flax			P*	X

3 Methodological background

This chapter reviews the existing research used as a basis for the methods employed in this study, providing an overview of the theories behind the investigation. The depositional processes for archaeobotanical material are explored, focusing on the prominent pathways of crop processing and dung burning. The methodology used in the investigation of crop husbandry is explained, highlighting the advantages of the use of weed ecology and stable isotope ratios.

3.1 Understanding archaeobotanical assemblages

Archaeobotanical samples contain remains that have been incorporated into the archaeological record through any number of processes. These processes influence the composition of items that survive, and understanding the means by which material was preserved and deposited allows both detection and the avoidance of bias in interpretations. Understanding the nature of these taphonomic biases in turn assists in the investigation of the activities of crop processing, fuel use and crop husbandry (Dennell 1974; Hillman 1981; Jones 1984; Miller and Smart 1984; Jones 1987; Miksicek 1987; Charles and Bogaard 2003). These activities are all tightly interlinked, making an understanding of one difficult without an understanding of the others.

3.1.1 Charring

There are three main methods by which items become charred: accidental burning, rubbish disposal and deliberate use as fuel (van der Veen 2007). Food material can become charred due to accidental burning during preparation, such as spillage of grain during cooking, or burning during parching, or other

preparation techniques (van der Veen 2007). Material can also be exposed to the required temperature for charring through the razing of a structure or site (van der Veen 2007). Such cases provide the opportunity of in situ material, such as stores, to become preserved. The burning of rubbish is a common disposal method leading to the charring of material; ethnographic research indicates that disposing of unwanted later stage crop-processing by-products through incineration in household fires is common (Reddy 1998; D'Andrea and Haile 2002; van der Veen 2007). The third mode is through the use of items as fuel. When referring to carpological remains, this is commonly through the burning of dung in which small seeds are present as a result of their consumption by livestock (Bottema 1984; Miller 1984).

A large body of research into the effect of charring on the appearance and preservation of seeds exists: various temperatures produce a range of distortions, from cracking and splitting to changes in the dimension of the seed though puffing (Hubbard and al Azm 1990; Braadbaart 2008). Different conditions produce different distortions and many lab-based experiments have previously suggested that low oxygen conditions and a temperature exceeding 250°C for a short period of time replicated the material seen archaeologically, removing sugars and other organics susceptible to decay (Wilson 1984; Boardman and Jones 1990; Braadbaart et al. 2004a; Braadbaart et al. 2004b; Ferrio et al. 2004; Braadbaart 2008). Recent research testing the effect of duration and intensity of heating on cereal grains indicates a "charring window" of between 220-240°C for 2-3hr in a reducing environment is required to produce minimal distortions of crop seed dimensions and to allow for the items

to resist decay (Charles et al. 2015). Seeds charred at temperatures higher than 240°C became increasingly hard to identify, while the 220-240°C window is necessary to commence the Maillard reaction and thus degrade sugars and other components susceptible to decay (Charles et al. 2015).

Research has also highlighted the selective nature of charring (Green 1982; Wilson 1984; Boardman and Jones 1990; Hubbard and al Azm 1990). Glume bases have a higher survivability than free-threshing rachis, and grain survives as well or better than glume bases (Boardman and Jones 1990:10). Grains, due to their more robust nature, have higher survival rates than chaff remains and commonly the items characteristic of the early stages of crop processing such as free-threshing rachis and straw have the lowest survivability (Boardman and Jones 1990:10). This allows for the interpretation of high proportions of glume bases to limited grain as real differences and not an artefact of charring (Boardman and Jones 1990:10).

Weed seeds also have different survival rates, with some species prone to splitting and cracking (Wilson 1984). Research has provided an understanding of the different chemical attributes affecting preservation: oily seeds tend to burn, while seeds with a high moisture content are more likely to explode during charring than dry ones (Wilson 1984). Given that the archaeobotanical assemblage is partial at best, knowledge of such attributes of the taxa examined is necessary to provide an understanding of the selective bias of charring.

3.1.2 Dung burning

The burning of dung is a common means by which plant material can enter the archaeological record. Research indicates that seeds that survive ingestion have either specific characteristics that allow for quick passage through the gut of animals, or hard seed coats to help resist digestion (Simao Neto et al. 1987; Cardoso et al. 2005). Size is an important factor in facilitating the passage through the gut of animals; anything measuring more than 1.18 mm is commonly digested by sheep and cattle, with multiple mechanisms including the size of the reticulo-omasal orifice influencing passage (Poppi et al. 1985; Gardener et al. 1993). Seeds possessing hard seed coats/lower permeability also tend to have a higher survival rate, as the seed coat prevents gastric juices digesting the seed (Peco et al. 2006). Cultivated taxa have different survivability rates depending on the consumer: grain and chaff rarely survive ingestion by sheep and goat, whereas cereal grain can pass through cattle undigested (Kaiser 1999; Valamoti and Charles 2005; Wallace and Charles 2013).

Ethnographic studies of dung burning have provided evidence that seeds do become charred through this method (Bottema 1984; Miller 1984; Reddy 1998). Such research highlights the carbonisation of seeds through dung burning but also cautions that other processes can be involved due to the multiple activities that occur around a hearth/fire spot.

Methods have been developed to identify the contribution of dung burning to an archaeobotanical assemblage (Miller and Smart 1984; Charles 1998). Miller and Smart (1984) proposed four conditions required for the burning of dung to have

occurred: limited wood fuel, presence of suitable livestock, the presence of burnt dung within the assemblage and/or seeds potentially consumed by animals, and archaeobotanical samples originating from hearths or the secondary remains of hearths. Miller and Smart (1984:20) acknowledged that there are cases of dung burning which do not fulfil the first criteria, and other situations where all criteria are met but dung was not burnt. While their method can suggest that dung burning contributed to an assemblage, it does not facilitate the identification of specific species likely to have been derived from dung burning, rather relying on modern consumption patterns to identify potentially consumed taxa.

Charles' (1998) set of protocols allows for the detection of dung burning within an assemblage by identifying the likelihood of species being incorporated through burning of crop-processing by-products. Any species that could not have entered through crop processing by-products is therefore indicative of a species that entered through alternative modes, potentially dung burning. Charles, building on Miller and Smart (1984), presented four criteria which together can provide evidence of dung burning: the presence of burnt dung within the assemblage, the biology and ecology of species, behaviour of weed assemblage in relation to crop processing, and evidence of mixing of different crop-processing stages/species with different crop-processing requirements. Assemblages that meet all four criteria provide robust evidence of dung burning.

Charles' first criterion builds on Miller and Smart's (1984) approach, using the identification of burnt dung in samples as evidence. Survival of burnt dung will

depend on both the species and form of the dung prior to burning, with sheep and goat pellets commonly retaining their form, while cattle dung, due to its less solid structure, tending to disintegrate during burning (Charles 1998:113). Charles' second criterion takes Miller and Smart's (1984) second point a step further. Instead of using weeds consumed by modern animals as an indication of the likelihood of consumption, Charles' method investigates the biology and ecology of the archaeological species. Palatability of species takes into account their defensive mechanisms (both chemical and physical) allowing specific species to be ruled out due to non-palatability. Additionally the fruiting time of the species is examined to gauge the likelihood of the taxon's collection through crop harvesting. Species falling outside this fruiting period must have a different taphonomic pathway – potentially dung burning.

Charles' third criterion examines the attributes of the seeds in an assemblage in relation to crop processing and the specific characteristics for which each processing stage selects. It tests whether the species within the sample have similar size, shape and aerodynamic properties to weed seeds removed during the different stages of crop processing. This uses Jones' (1983) method, that of discriminant analysis and ethnographic data to classify archaeological samples for their weed flora's size, tendency to remain in heads and aerodynamic properties (see Section 3.1.3). Instead of conducting the traditional Jones classification, in which the samples are classified in reference to the ethnographic data as one of four crop processing stages, Charles' method enters the archaeological sample as a separate group within the discriminant phase of the analysis. Thus during classification the archaeological samples are compared to

the ethnographic data as well as to each other, providing an understanding of how valid their original grouping is, and whether such a group has similar properties to the crop processing stages. If the samples' predicted group membership coincides with a crop processing stage, it suggests that the samples have more in common with ethnographic data, and potentially were derived from crop processing. Conversely, if the samples align with their original archaeological group and this is significantly removed from the ethnographic groups in terms of the discriminant score, it suggests they have more in common with each other and thus may have derived from a different taphonomic pathway.

The final method is to identify evidence suggestive of the mixing of crops not grown or processed together or the mixture of different stages of various crops' processing by-products (Charles 1998). This is done by understanding the relative proportions of grain to chaff in the samples, and investigating whether such ratios are the result of one specific crop's processing or the combination of two crops. While multiple crops can be grown together (maslin cultivation), such crops commonly require the same processing steps. The mixture of crops of different processing requires that they have unique attributes that will allow them to be separated. For example, ethnographic research shows that barley and free-threshing wheat can be separated through sieving, as barley grains are larger than those of wheat, while emmer and barley/wheat can be separated when emmer is still in spikelets, again due to size differences (Jones 1983b; D'Andrea and Haile 2002). An assemblage containing processing by-products from different crops requiring different processing indicates mixing and could be

due to the intentional addition of these remains to dung cakes or its use as fodder. The mixing of different crop processing by-products can be studied via the examination of ratios of grain to chaff, providing an indication of how these differ from the expected ratio and the overall proportion of crop taxa within the assemblage.

3.1.3 Crop processing

The processing of crops plays a huge role in the type of material preserved in the archaeobotanical record of farming societies; the actual act of processing a crop – that is, removing chaff and weed seeds from crop seeds – systematically biases the assemblage. The processing of cereals and pulses is well studied, with ethnobotanical research conducted in Turkey, Greece and Ethiopia detailing the actions required to process cereals and pulses (Jones 1983b; Hillman 1984b, 1985; D'Andrea and Haile 2002). The processing stages used depend on the crop species as well as the purpose of the cleaned product.

Cereals are divided into two groups based on their behaviour when processed. Free-threshing cereals (wheats and barleys – *Triticum aestivum, T. durum* and *Hordeum vulgare*), when threshed, separate into individual items of rachis, chaff and grain (Figure 3.1). Hulled barley, while free-threshing, behaves differently to naked barley: although threshing results in separation of rachis and individual grains, the grains still retain the attached lemma and palea (Figure 3.1). Consequently, additional processing is required to remove this chaff from the grain. Pulse species' processing follows the typical free-threshing cereal processing sequence consisting of threshing, winnowing, coarse sieving and fine

sieving (Figure 3.2). Additional processing such as soaking may be required, for example, to make some pulses that contain toxins fit for human consumption (Miller 2002:88).

Glume wheats (also called hulled wheats) when threshed break into spikelets and further processing is required to free the grain from its enclosing lemma, palea and spikelet fork (Figure 3.1). Consequently, a longer processing sequence is required for the glume wheats compared to the free-threshing cereals; glume wheats need to be dehusked to free the grains from the spikelets (Figure 3.2). Ethnographic accounts highlight multiple methods of dehusking, including pounding and grinding (Hillman 1984b:129; D'Andrea and Haile 2002:200; Peña-Chocarro and Zapata 2003:6; Peña-Chocarro et al. 2009:107).

Ethnographic accounts detail the stages and by-products of crop processing (Jones 1983b; Hillman 1985). After threshing, the subsequent steps are designed to remove the material separated during the threshing based on size, seed pod morphology and aerodynamics: winnowing removes small and light items such as the lemma and palea, as well as small and light weed seeds. Coarse sieving removes large and heavy pieces of chaff, including culm and rachis, in addition to weed seeds larger than the cereal grain size, or seed that remains in large pods. Fine sieving removes any remaining smaller pieces of chaff, as well as small but heavy weed seeds (Figure 3.2). The remaining material will contain a high proportion of cereal grain, as well as weed seeds that mimic the shape and weight of grains. Hand cleaning is commonly employed to remove such items.

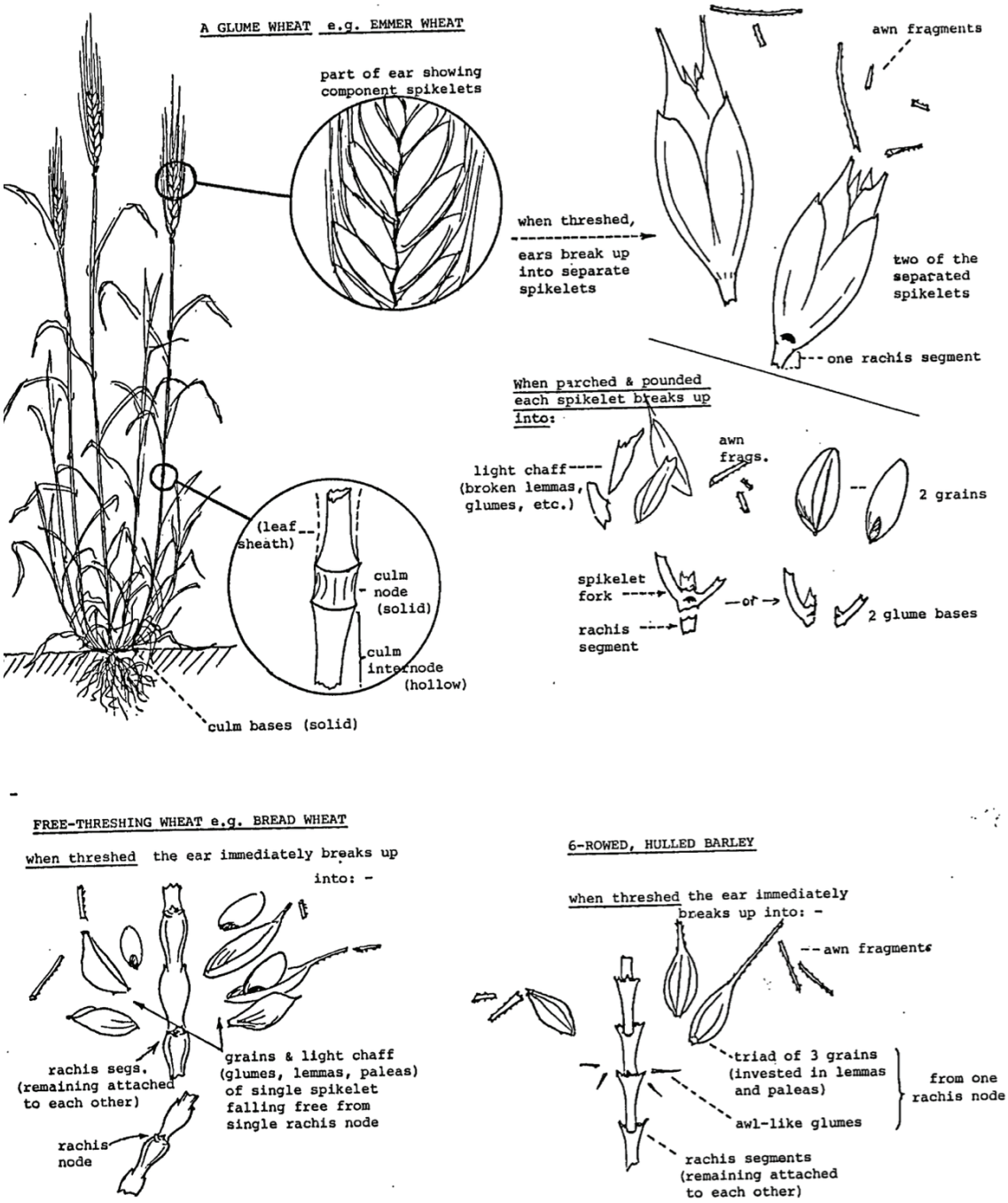


Figure 3.1: The components separated upon threshing from the different types of cereals, diagram from Hillman (1981:131).

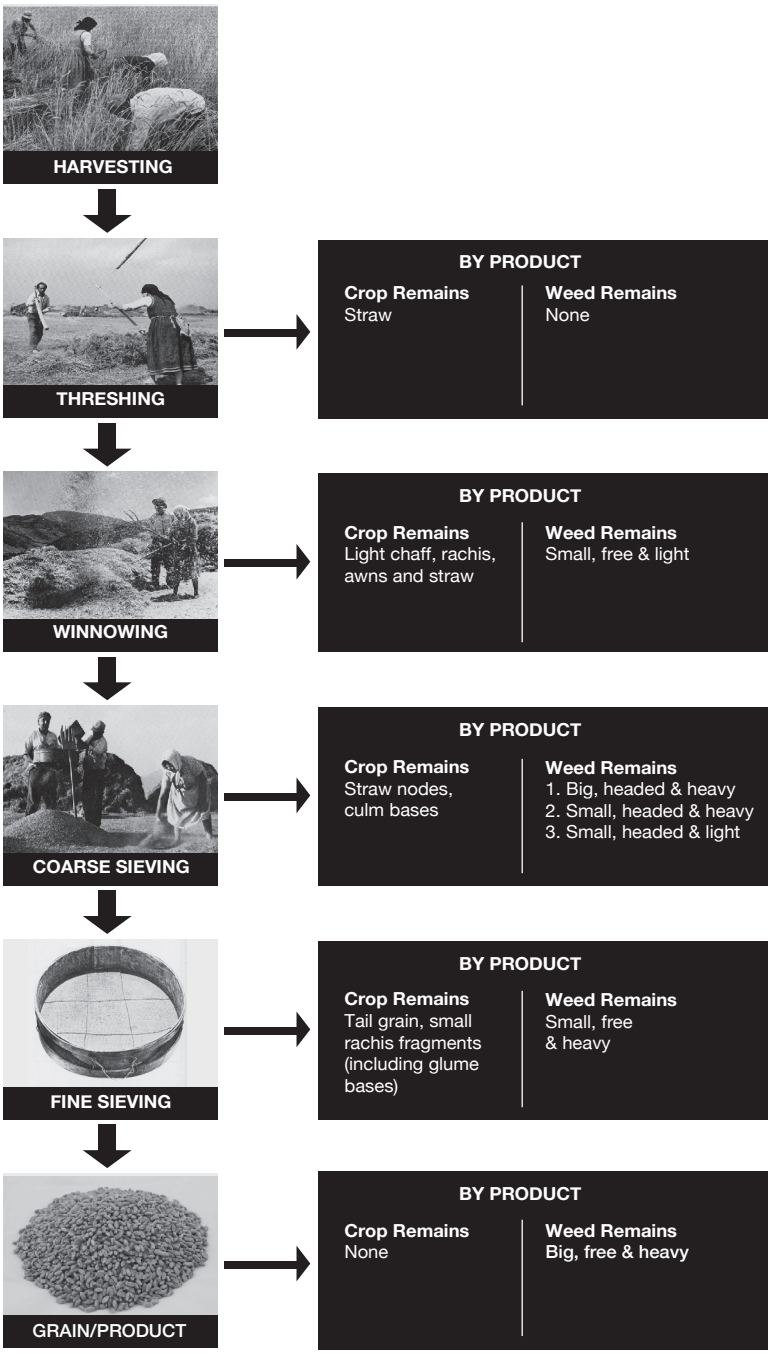


Figure 3.2: A simplified flow chart of the main crop processing sequence showing the products and by-products of each step. The descriptions of the by-product refers to the characteristics of weed seeds removed, developed by Jones (1984) and the crop remains removed based primarily on the processing of free-threshing wheat (Hillman 1985)(Images from Benaki 1978; MOG 2013.).

Ethnographic research indicates that the crop processing sequence is modified for the processing of glume wheats (Hillman 1984b; D'Andrea and Haile 2002) and so after threshing, glume wheat remains are winnowed/sieved to remove weed seeds and fragments of straw. Coarse sieving removes large weed

seeds/heads larger than the spikelets and fine sieving, although sometimes not conducted, removes the smaller weed seeds (Figure 3.2). Storage in the spikelet is common at this stage. After this, processes to remove the encasing lemma/palea complex are undertaken, with ethnographic research indicating the use of parching and then the pounding of the spikelets in a mortar and pestle to remove these items (Hillman 1984b; D'Andrea and Haile 2002). The pounded product is then subjected to winnowing, which removes the lighter lemma and palea that are now not attached to the grain. Coarse sieving then removes any unbroken spikelets and large weed seeds, and fine sieving removes weeds seeds, glume bases and any small tail grain - small grains from the top of the ear. Final contaminants are removed by hand sorting.

The cross-cultural applicability of the ethnographic models from Turkey, Greece and Ethiopia must be examined. The limited ways of removing crop contaminants have been noted, and the agreement of ethnographic work with ethnohistoric accounts of the basic crop-processing system highlights this limited variability (Hillman 1981; Jones 1984). However, this variability may be limited within the stages, but the tools used do differ. This has little effect on the resulting product/by-product as the tools are being used for the same activities (Jones 1984). The only minor difference is the size of the sieve mesh; this will impact on the size of items retained or discarded and is totally dependant on the size of the crop's seed/spikelet to be retained.

Due to the systematic way in which the crop-processing sequence removes contaminants, the properties relied upon to remove these items can be used to

detect the stage represented. Ethnographic research provides an understanding of when and what components are removed from the sequence and their specific attributes (Jones 1983b; Hillman 1984b, 1985; D'Andrea and Haile 2002). As a result a number of methods for detecting, as well as studies identifying, crop-processing by-products have arisen (for example, Dennell 1974; Hillman 1981; Jones 1983a; Hillman 1984a; Jones 1990; Stevens 2003).

The ratios of crop components (i.e. grain to chaff) in comparison to the known ratio of such items in a given spikelet has been used by many to detect biases indicative of crop processing (see, for example, van der Veen 1992; Stevens 2003; Bogaard 2011; Filipović 2014). When the results deviate from the natural ratio of grain to chaff for the particular species and cannot be explained due to differential charring preservation, it is suggestive of a mechanism such as crop processing influencing the sample's composition. Ratios of grain to chaff (rachis internodes for free-threshing cereals, glume bases for glume wheat) provide an indication of the crop processing stage from which the sample originated. High quantities of free-threshing chaff remains compared to grain are common in the early stages of crop processing, while chaff from glume wheat, but limited grains, is commonly removed during fine sieving (Hillman 1984b; Jones 1990).

Including the proportion of weed seeds alongside chaff and grain can enable more nuanced interpretation. Jones (1990) observed in her ethnographic samples that the processing stages of free-threshing cereals produced specific ratios of grain to rachis internode to weed seeds. Examination of the proportions of grain to chaff to weeds was not new; Dennell (1974) deduced that the different

composition of samples from Bulgarian sites was due to the different stages of crop processing represented by them. What Jones did however, was to provide quantitative data of the different components removed at each stage of crop processing, thus making it possible to compare the proportions found in archaeological samples to her data derived from known crop processing stages.

The disadvantage of using crop components in an analysis is that they may have very different preservation rates. For example, pulse chaff, consisting of pod fragments and stems, rarely survives and cereal chaff remains are less likely to survive than their grain counterparts (Jones 1984; Boardman and Jones 1990). Jones therefore developed a method utilising specific attributes of weed seeds to determine the crop-processing stage where size, aerodynamic properties and tendency to remain in head are used to classify weed seeds and allow the comparison with ethnographic data of known crop processing stages. Discriminant analysis is used to discriminate between the four crop processing stages in the ethnographic data. The archaeological samples are then entered and classified based on similarities to separated crop-processing stages (Jones 1983b, 1987).

Comparison with Jones' ethnographic data, on the basis of grain/chaff/weed seed ratios or of weed seed types (discriminant analysis), works well for free-threshing crops, as the ethnographic data focuses on the processing of free-threshing wheats, barley, oats, pea, lentil, grass pea and common vetch. The applicability of such comparison to assemblages containing high amounts of glume wheats must be assessed; some problems are encountered when

comparing glume wheat processing by-products with free-threshing remains. Chaff remains are removed at different stages; during free-threshing cereal processing, rachis remains are removed in winnowing or coarse sieving, but the chaff of glume wheats - glume bases - is not removed until the second fine sieving following pounding (Hillman 1984b; Jones 1983b). Thus comparing proportions of grain, weeds and chaff to ascertain a processing stage cannot be achieved directly using Jones' ethnographic data. Bogaard (2011:75) attempted to overcome this by manipulating Jones' free-threshing data to calculate potential proportions of weeds to glume bases in fine-sieved by-products of dehusked spikelets.

Additionally, the fact that the glume wheat samples go through the processing sequence twice means that the later stages of processing will be chaff-rich and weed-poor as many weeds will have been removed during coarse and fine sieving before pounding, unless they are the same size as the spikelets. Of course this is reliant on spikelets being sieved before dehusking, something which may vary. The only exception would be if one of the sievings prior to pounding was not conducted, or if seeds contained within a pod/head the same size as the spikelets were released; these seeds would be dispersed due to the act of pounding and would be available for removal during the post-pounding sieving. The advantage of Jones' weed analysis is the removal from the analysis of any crop component thus reducing errors in assignment of processing classes due to the different timing in chaff removal.

3.2 Identification of crop husbandry methods

Understanding how a crop was cultivated provides information about the amount of labour invested in cultivation and allows inferences as to the social structure available to supply that labour. High-intensity (-input) crop husbandry systems require labour for the manuring and weeding of plots. Such regimes have been called garden or intensive cultivation because of the production of relatively high quantities of produce from limited areas of land (Bogaard 2005; Jones 2005). Individual plant production is maximised due to the optimal growing conditions provided. The reverse is low-input cultivation: lower labour inputs result in lower yields per area. In such situations plants are not grown under optimal conditions and productivity is limited, but by cultivating larger areas of land, larger absolute yields - in comparison to high-input cultivation - can be obtained (Halstead 1987; Jones 1992; Jones et al. 1999; Bogaard 2005:179).

Understanding crop field conditions links directly to crop husbandry practices. One means of understanding crop husbandry practices such as intensity of cultivation, permanence of field locations, and sowing time is through the examination of the ecology of weeds found in archaeobotanical samples. The analysis of stable carbon and nitrogen isotopes of crop remains provides a method for inferring manuring and water availability of crops (Fraser et al. 2011; Wallace et al. 2013). This analysis provides a complementary method to weed ecology for understanding the conditions under which plants were cultivated (see, for example, Styring et al. 2016a; Bogaard et al. 2016b).

3.2.1 Weed ecology

Different methods borrowed from the discipline of ecology have been used to interpret the archaeobotanical remains of wild taxa found on archaeological sites. The synecological approach of phytosociology, and the autecological approach of Ellenberg numbers provide different ways to understand the growing conditions of weeds in an archaeobotanical assemblage. Functional ecology, another autecolgical approach, uses specific functional attributes of weed species to understand cultivation conditions.

Phytosociology classifies plant communities based on environmental conditions that gave rise to specific associations and floristic compositions (Jones 1992). Syntaxa (i.e. classes) are determined by the occurrence of a character species, usually a species that has high fidelity to a specific habitat therefore assisting in identification of associated species or the habitat conditions (Poore 1955; Westhoff and Van Der Maarel 1978; Jones 1992).

Phytosociology has been used to understand conditions in ancient crop fields and thus crop husbandry practices (Jones 1992; Fairbairn 2005). As wild plant groups have varied habitat requirements, the presence of specific character species in an archaeological arable weed assemblage can indicate specific conditions within the field. The phytosociological classes of Secalinetea and Chenopodietea have been used to identify sowing time, with Cheopodietea including species indicating spring-sown fields, while Secalinetea indicates autumn-sown fields, commonly occurring in winter cereals (Jones 1992). Chenopodietea character species, however, may also indicate intensity of

cultivation; species in this group also occur in gardens or "row" crops or on waste ground (Jones 1992).

Phytosociological interpretations are generalised since multiple causes can account for the occurrence of a particular character species. The presence of Chenopodietea species does not necessarily indicate spring-sown fields as some species can germinate in both autumn and spring. Moreover their presence may not be indicative of sowing time but rather cultivation techniques as these species commonly occur in gardens (Ellenberg 1988). Problems also arise with the use of phytosociology due to the assumption of uniform weed communities across different geographical and temporal scales (Hillman 1991; Jones 2002; Bogaard 2004b). This means that only very general syntax can be used as the more detailed syntaxonomic levels have changed composition, even within historical times (Jones 2002). Thus interpretations are ambiguous, limited to high syntaxa or class levels (Jones 2002). Additionally, due to taphonomic processes, archaeobotanical samples do not contain a field's entire weed flora, nor can it always be assumed that the weed seeds in a sample originated from a single field (Jones 1992). These difficulties limit the applicability of this method.

Ellenberg numbers, an autecological approach, allow generalisations to be made about vegetation based on climatic and edaphic variables such as temperature, light, soil moisture, soil nitrogen, soil pH etc. (Ellenberg 1988). Specific indicator species may be used; these species require specific environmental conditions and their occurrence can indicate a particular environment. Non-indicator species are allocated a number of indicator values based on the species' environmental

preferences (Jones 1992). Unfortunately the data used to construct the values were collected primarily from central Europe, which limits applicability in other regions (Bogaard 2002a). Furthermore there is no Ellenberg scale for soil disturbance, preventing any understanding of whether crops were weeded or tilled (Bogaard 2002a).

The common problem with both methods reviewed above is the inability to distinguish between a species' ecological requirements and its ecological tolerances (Charles et al. 1997; Bogaard 2004b:7). This is crucial as it allows an understanding not only of the conditions under which the plant is growing, but also which specific variables restrict it to that location. For example, the methods assume that a plant growing in a wet or shady environment is moisture- or shade-loving but do not provide any information as to which variable is actually controlling the occurrence of that species. A plant in a moist environment may not be growing there due to its need for high water availability but instead due to high soil nitrogen levels, or specific light levels (Charles et al. 1997:1151; Bogaard 2004b:6).

Functional ecology, in particular the Functional Interpretation of Botanical Surveys (FIBS), is another method used to differentiate between crop husbandry regimes based on weed flora (Charles et al. 1997; Bogaard et al. 1999; Jones et al. 1999; Jones et al. 2000a; Bogaard et al. 2001; Charles et al. 2002; Jones 2002; Bogaard et al. 2016a; Bogaard et al. 2016b). This method relies on botanical surveys of modern crop fields as well as information on the specific ecological characteristics of the weed species. These are predicted using functional traits

such as canopy height, leaf area, stomatal density and length of flowering period. Studies indicate that specific attributes positively or negatively correlate with growing conditions such as moisture, productive conditions, sowing time, and root disturbance (Jones et al. 1995; Charles et al. 1997; Bogaard et al. 1999; Jones et al. 2000a; Bogaard et al. 2001; Jones 2002; Jones et al. 2005). Research shows that some attributes relate to specific patterns regarding tolerance to stress and competitive strategies; attributes such as mean specific leaf area, maximum canopy height and leaf thickness relate to growth rate, and hence site fertility (Jones et al. 2000a; Bogaard et al. 2001; Charles et al. 2002). Length of flowering period and vegetative regeneration can be associated with the ability to regenerate under high disturbance conditions, while stomatal size, density and other specific cell attributes reflect adaption for drought tolerance (Jones et al. 2000a; Bogaard et al. 2001; Charles et al. 2002). The research conducted by the University of Sheffield and the University of Oxford provides modern studies of traditional farming regimes, with research in Spain, Provence and Morocco (Charles et al. 1997; Bogaard et al. 1999; Bogaard et al. 2001; Jones et al. 2005; Bogaard et al. 2016a; Bogaard et al. 2016b). Archaeological assemblages can be compared to such data sets using the functional attributes of the species, and then be classified using discriminant analysis to provide a comparative estimation of field conditions in the past.

The advantage of the functional ecological method is that it neither assumes that the habitat of a plant today is the same as in the past nor that the composition of ecological floras has remained constant. This method considers weed assemblages on the basis of functional attributes/traits rather than on species

per se. Thus it is the similarity between the functional attributes of archaeological assemblages and the functional attributes of a modern field that is examined, rather than similarity or difference in species composition. The problem of changes in the composition of floras or groups of species over time is removed and the translation between floras (particularly in this case crop weed assemblages), which are floristically distinct but may be growing in the same specific conditions due to functional attributes, is allowed. Changes in the ecology of a species over time are still a problem. However functional ecology's use of a set of species helps in this regard. Unlike the single character/indicator species of the other methods, the set of species used in functional ecology buffers against such problems – it is highly unlikely that all species will have changed in the same ecological way, thus limiting the ecological bias that may occur (Charles et al. 1997; Jones 2002).

3.2.2 Stable isotopes

The analysis of stable isotopes of carbon and nitrogen is also used to understand the conditions under which crops were cultivated. Research links the ratio of the stable isotopes of nitrogen to soil nitrogen composition, which can be anthropogenically enriched through the addition of manure to the soil, while the ratio of the stable carbon isotopes has been used as a proxy for water availability (for example Bogaard et al. 2007; Flohr et al. 2011; Fraser et al. 2011; Wallace et al. 2013; Szpak et al. 2014).

Isotopes are forms of an element that while having the same number of protons and electrons have different numbers of neutrons and consequently different

weights. The ability to use the ratio of the stable isotopes of the two elements of carbon and nitrogen is due to the fractionation that occurs during specific processes. Fractionation discriminates against either the heavier or the lighter isotope resulting in a ratio that is either elevated or depleted in a specific isotope. Water availability is linked to fractionation that occurs during the photosynthetic process, while manure application is linked to the loss of the lighter isotopes during the application of manure. The following section explains such processes in detail and the current frameworks developed to interpret stable isotope values in relation to crop husbandry regimes.

3.2.2.1 Carbon

The two stable isotopes of carbon occur in different proportions with ^{12}C the common form, and ^{13}C rare, comprising only 1.11% of all carbon atoms (O'Leary 1993). The different isotopes are used to varying degrees within the photosynthetic pathway, primarily due to fractionation. Fractionation occurs in a number of physical, chemical and biochemical processes within a plant and the fractionation that occurs during carbon dioxide fixation is the main factor that affects the isotopic composition of plant tissue (O'Leary 1993). Due to the heavier weight of ^{13}C and its stronger bonds, the plant discriminates against ^{13}C when ^{12}C is plentiful.

Photosynthesis and water loss

Plants take up atmospheric carbon dioxide to use in their photosynthetic process, ultimately producing sugars and starches. Photosynthesis can be divided into two major processes: light reactions and dark reactions. In light reactions, light energy is used to form adenosine triphosphate (ATP) and nicotinamide adenine

dinucleotide phosphate (NADPH) (Raven et al. 2005). These are co-enzymes that act as electron carriers. These co-enzymes are then used in the second process, the dark or carbon fixation reaction.

The dark reaction involves the fixation of carbon into simple sugars. The carbon dioxide required for this reaction is absorbed through plant leaf stomata; the subsequent fixing of the carbon dioxide is then dependent on which type of photosynthetic pathway the plant uses. There are three different pathways used by specific plant groups to fix carbon: the C_3 (Calvin cycle), C_4 (Hatch-Slack pathway) and CAM (Crassulacean Acid Metabolism) pathway; all produce different products as the first stable compound of the carbon fixation reaction. C_3 plants produce a three-carbon molecule called 3-phosphoglycerate (PGA) as the first stable compound (Raven et al. 2005). As all crops examined within this study are C_3, only this pathway is explained in detail.

Within the Calvin cycle the products of the light reactions are used to fix and reduce carbon, in the form of carbon dioxide, to produce simple sugars. In three stages, carbon from atmospheric carbon dioxide is combined with ribulose 1,5-bisphosphate (RuBP) which is fixed into phosphoglycerate (PGA), a reaction that is catalysed through the enzyme called Rubisco (RUBP carboxylase/oxygenase) (Raven et al. 2005). PGA is then, through the energy from the light reaction's products of ATP and NADPH, reduced into glyceraldehyde 3-phosphate (PGAL). The net gain of the cycle is one molecule of PGAL, the starting point for the synthesis of sugars such as sucrose or starch. The other 5 PGAL molecules

continue in the cycle to stage three: the regeneration of acceptor. In this step, ATP from the light reaction is used to form RuBP and the cycle starts again.

Instrumental to the absorption of carbon dioxide are the plant's stomata, pores that allow the absorption of air into the intercellular spaces of the leaf. The stomata also release oxygen, a product of photosynthesis, and allow water to diffuse from the plant, a detrimental side effect in water-limited environments. The loss of water through transpiration is a problem commonly faced by plants. The absorption of sunlight requires large surface areas but as a consequence also provides large areas for transpiration. For carbon dioxide to be absorbed into plant cells in solution, the gas must come into contact with the moist surface of a cell (Pei et al. 1998). This can expose water to an unsaturated atmosphere leading to evaporation. The plant's uptake of carbon dioxide and its loss of water are therefore linked, and it is this interconnection that plays an important role in the use of the stable isotopes of carbon to understand water availability.

Isotopic relationship to water stress

A plant's physiological response to water stress is to limit water loss and involves the closure of the stomata thus preventing most of the water loss; 90% of a plant's water loss is through the stomata (Pei et al. 1998). However, the closure of the stomata also stops the uptake of carbon dioxide, reducing photosynthesis. During such situations the plant has to rely on intercellular carbon dioxide for photosynthesis, either that remaining in the plant's air spaces, or the small amount produced during respiration. In conditions with high water availability the heavier isotope of carbon is discriminated against. In times of long stomatal

closure all intercellular carbon dioxide is utilised and such discrimination will not occur (O'Leary 1993). It is primarily this response to water stress that has enabled the use of the ratio of $^{13}C/^{12}C$ as a proxy for water availability. It must be remembered that fractionation also occurs with diffusion and so the ratio of intercellular $^{13}C/^{12}C$ will be different to the atmospheric ratio. Fractionation also occurs during other stages of the carbon fixation process.

Calculation of discrimination

$\delta^{13}C$ represents the ratio of $^{13}C/^{12}C$ in relation to a universal standard (the Pee Dee belemnite). This marine fossil, which is the universal standard against which all carbon isotopic ratios are measured, has a very high ratio of $^{13}C/^{12}C$ thus making most material negative in comparison. In plant science it has been argued that the notation convention, when measuring the carbon isotope discrimination of plants, should be Δ (Farquhar et al. 1989; O'Leary 1993). They argue the Δ (discrimination), unlike δ, is independent of the isotopic standard used in addition to being independent of air. In such notation, the main advantage claimed by Farquhar et al. (1989:507) is that it "expresses the consequences of biological processes, whereas composition [δ] is the result of both source isotopic composition and carbon isotope discrimination".

$\Delta^{13}C$ is obtained by Farquhar et al. (1982) through the equation:

$$\Delta‰ = \frac{\delta^{13}C_{air} - \delta^{13}C_{plant}}{1 + \delta^{13}C_{plant}/1000}$$

Equation 1

As Equation 1 is a simplified expression of the relationship, which does not account for other fractionations within the photosynthetic pathway such as the effect of dark respiration, other more complex definitions of Δ have been published. Farquhar et al. (1989) published other formulas to derive Δ but these have limited utility in archaeological studies; while McCarroll and Loader (2004) use Equation 2, it is difficult to apply this to archaeological material due to a high number of unknowns and the questions pertaining to its derivation (see Appendix 12.1). Generally the consensus within the plant science discipline is to use Farquhar et al.'s formula (Equation 1), and within archaeological science researchers are limited to formulas that do not require measures of attributes that cannot be obtained from ancient remains.

$$\Delta‰ = a + (b - a)(C_i / C_a)$$

Equation 2 where a is discrimination due to diffusion, b is discrmination due to carbonxylation and C_i and C_a are intercellular and ambient carbon dioxide concentrations (McCarroll and Loader 2004).

Modern studies

Previous studies have used modern field-based experiments to understand linkages between the measured isotopic ratio of cereal and pulse seeds and their growing conditions (Bogaard et al. 2007; Fraser et al. 2011; Bogaard et al. 2013b; Fraser et al. 2013b; Wallace et al. 2013). Research has shown a link between the water status of a plant and $\Delta^{13}C$. During optimal photosynthesis when a plant has ideal water availability, the heavier isotope of carbon is discriminated against. This discrimination is due to the chemical ease of using the lighter isotope in comparison to the heavier isotope (carboxylation discrimination). During times of water limitation, when the stomata of the plant are closed to minimise water

loss through transpiration, this discrimination is limited: the intercellular CO_2 cannot be replaced and as a consequence the heavier isotope must be used (Farquhar et al. 1982; Farquhar et al. 1989; Fiorentino et al. 2015). A plant photosynthesising under water-limited conditions will therefore have lower $\Delta^{13}C$ value than that of a plant photosynthesising under optimal water-available conditions (Farquhar et al. 1982; Araus et al. 1997a; Wallace et al. 2013). Thus the stable isotopic ratio of $^{13}C/^{12}C$ has increasingly been used in archaeology as a proxy for the water status of a plant and consequently water availability (for example: Araus et al. 1997b; Ferrio et al. 2005b; Riehl et al. 2008; Flohr et al. 2011; Wallace et al. 2013).

Higher water inputs, either via irrigation or rainfall, raise the $\Delta^{13}C$ ratio in plant tissues but the degree to which this happens is species dependent. Differences between free-threshing wheats (naked) and lentils have been noted and it has been shown that lentils are more sensitive to low water inputs than wheat (Wallace 2011). Wallace's controlled experiment using lentils and bread wheat provides a good starting point for determining the range of values expected in low, moderate and high water-availability environments. The impact of water availability on the $\Delta^{13}C$ of other pulses has had limited attention in archaeology although research indicates that broad beans react to water availability in similar ways to lentils (Wallace et al. 2013). Agronomic research on pulses, both experimental and field based, has limited archaeological utility. Most agronomic research, while providing information about the $\Delta^{13}C$ values of specific crops with differing water status, is based on the measurements of plant parts that do

not include the seed, hindering its direct application in archaeology as plant parts can have different isotopic ratios (Fraser et al. 2013b).

Research shows differences between the cereal species regarding the correlative nature of water availability and $\Delta^{13}C$. Reported differences of 1-2‰ higher $\Delta^{13}C$ values for barleys when compared to wheat correlate with the higher water use efficiency, phenology and the low water use of barley (Anyia et al. 2007). Values have been reported for other species although different plant parts have been measured (Knight et al. 1994; Roche et al. 2006; Heaton et al. 2009). Of interest are the glume wheat values; to date there have been no controlled experiments, similar to those reported by Wallace et al. (2013), to understand the relationship between $\Delta^{13}C$ and water availability for einkorn and emmer. Research has indicated that in field experiments differences are observed but these differences vary from study to study (see Araus et al. 1997b, for an overview). Most models make the assumption that the glume wheats behave in similar ways to that of free-threshing wheats (Araus et al. 1997b; Bogaard et al. 2013b; Vaiglova et al. 2014a).

Variability is noted between varieties of species. Research indicates that there is a 1-2‰ difference between two-row and six-row barley: two-row barley has a $\Delta^{13}C$ ratio ~1 ‰ higher than wheat and that of six-row barley is ~ 2‰ higher than wheat (Anyia et al. 2007; Wallace et al. 2013). Varieties bred for drought tolerance have lower $\delta^{13}C$ values and therefore higher $\Delta^{13}C$ values (Konvalina et al. 2013).

Interpretation methods

A set of watering bands has been proposed by Wallace et al. (2013) to visualise the relationship between $\Delta^{13}C$ and water availability (Figure 3.3). Research indicates that barley has a higher $\Delta^{13}C$ value when grown in optimal water conditions (Wallace et al. 2013) and so an offset between barley and wheat was implemented in Wallace's framework, thus shifting the threshold for well-watered barley higher (Figure 3.3). A smaller difference between the "poorly watered" bands of wheat and lentil was noted by Wallace et al. (2013), with lentil appearing drier than wheat under low-water conditions. The location of the well-watered wheat band, based on research conducted by Wallace, (2011; 2013) correlates with other research aiming to identify irrigated versus non-irrigated archaeological grains. Such research locates the start of irrigation at 17.5‰ (Araus et al. 1997b).

A criticism of these bands relates to their limited range: the 1‰ bandwidth means that a slight difference in values can push a taxon from one band to another. Another criticism is in the use of the terms "well watered", "moderately watered" and "poorly watered" used by Wallace et al. (2013). This use can be misleading as, for example, the term "poorly watered" suggests a failure in farming methods but instead is indicative of sub-optimal amounts of water resulting in limited growth (Wallace et al. 2013).

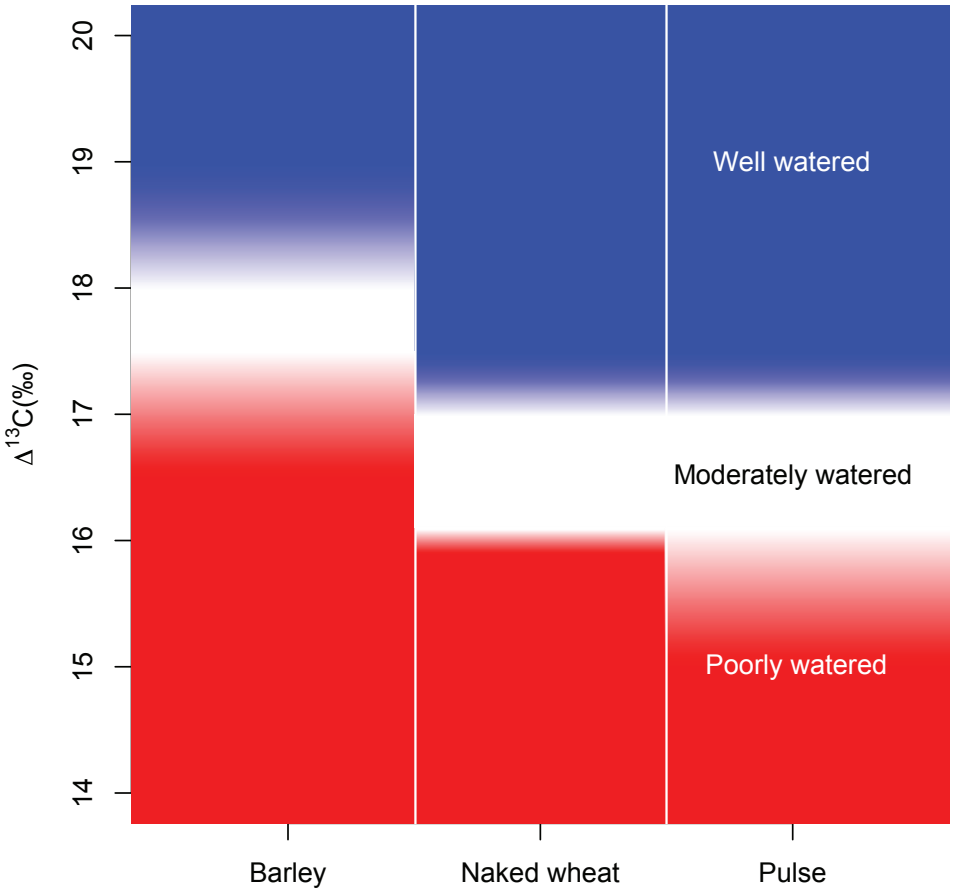


Figure 3.3: The watering bands hypothesised by Wallace et al. (2013) showing the nature of water available against $\Delta^{13}C$.

3.2.2.2 Nitrogen

Nitrogen (N) has at least 16 isotopes, but only two of these are stable isotopes: ^{14}N and ^{15}N. The common form of nitrogen (^{14}N) comprises ~99.636% of the earth's nitrogen, while ^{15}N is the rare stable isotopic form of nitrogen. Nitrogen is an essential element required in amino acids and nucleic acids and is thus extremely important for plant health.

Nitrogen is a macronutrient required by plants. It is a component of important compounds in plants, such as amino acids, proteins, chlorophyll, coenzymes,

nucleotides and nucleic acid. The majority of earth's nitrogen is found in the atmosphere, which is composed of 78% N_2. The majority of living organisms cannot use atmospheric nitrogen to make compounds like amino acids but instead utilise less abundant but more reactive nitrogenous compounds such as nitrate and ammonium.

The nitrogen cycle

Nitrogen is commonly a growth-limiting element for plants due to the restricted amounts available in the soil. A wide range of processes and factors influences and affects the composition and amount of inorganic nitrogen in soils. The nitrogen cycle highlights the major ways in which atmospheric nitrogen is converted into more reactive compounds that plants can utilise (Figure 3.4).

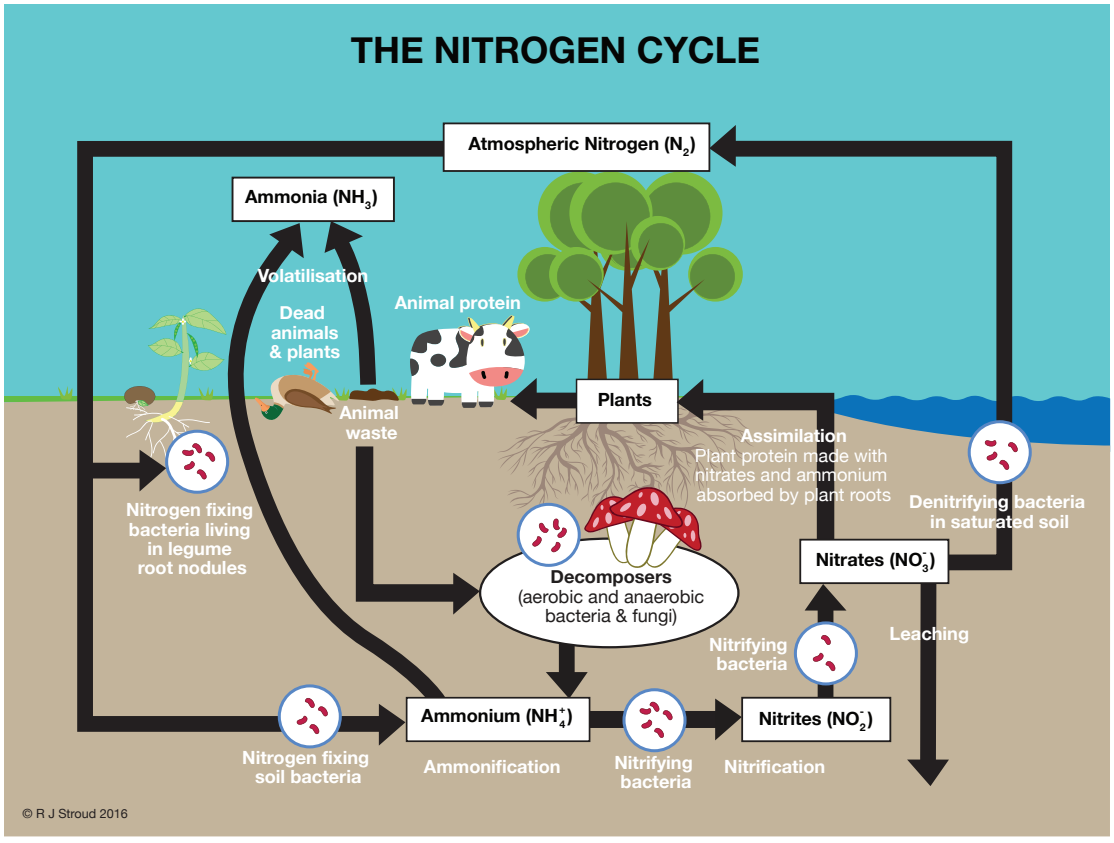


Figure 3.4: The nitrogen cycle (diagram by R. Stroud).

Nitrogen fixation is a process by which atmospheric N_2 is reduced to NH_4^+ through the use of the enzyme nitrogenase. Some plants have evolved a symbiotic relationship with nitrogen-fixing bacteria such as *Rhizobium* and *Bradyrhizobium,* which convert atmospheric nitrogen into compounds able to be utilised by plants (Raven et al. 2005). These plants are members of the Leguminosae family and support such bacteria with energy and carbon in exchange for nitrogen. The pulse crops are members of this family.

Plants that do not obtain nitrogen from such a relationship rely on other paths in the nitrogen cycle. Soil bacteria and fungi convert dead organic matter through a process called ammonification. Other bacteria can oxidise ammonia and ammonium ions into nitrite and then nitrate, a process called nitrification. Ammonium and nitrate are forms of nitrogen accessible to plants.

Denitrification is the major process through which nitrogen is lost from the soil, an anaerobic process, facilitated by microorganisms, in which nitrate and nitrite are reduced to nitrous oxide or nitric oxide. These forms are highly volatile and can reduce further to nitrogen gases and/or volatilise into the atmosphere (Knowles 1982). Denitrification can occur in the majority of soil aggregates possessing low oxygen levels (Knowles 1982).

The $\delta^{15}N$ (ratio of ^{15}N:^{14}N) of plants can be the result of a plethora of causal factors. The $\delta^{15}N$ ratio reflects the ratio of the source of nitrogen obtained by plants from the soil or the atmosphere. Climate, water, salinity and soil processes such as denitrification can all affect the $\delta^{15}N$ of the soil, as do specifically arable

activities such as the application of manure to improve fertility of fields (Heaton 1987; Handley and Raven 1992; Senbayram et al. 2008; Fraser et al. 2011). As cereals gain nitrogen from the soil, the source $\delta^{15}N$ values will be in part reflected in the plants (Bol et al. 2005).

The nitrogen cycle is complex with many input paths (Dawson et al. 2002). The anthropogenic application of manure to the soil increases the heavier isotope in the soil due to a larger proportion of the lighter isotope being volatilised in the form of ammonia (NH_3). The remaining ammonium is enriched in the heavier ^{15}N and later converted to an enriched ^{15}N nitrate, which the plant uses (Heaton 1986).

Modern studies

Modern studies indicate that the addition of manure to the soil can change the $\delta^{15}N$ of plants that obtain nitrogen through soil nitrogen by +2.6‰ to 8.0‰ (Bogaard et al. 2007). The amount of manure applied and its repetitive application to a field results in increased $\delta^{15}N$ values. A set of manuring bands has been suggested by Bogaard et al. (2013b) based on modern studies in temperate Europe (Figure 3.5). Within this framework $\delta^{15}N$ grain values below 3‰ indicate no manure or low residual enrichment from past manuring; $\delta^{15}N$ values between 3‰ and 6‰ indicate potential manuring and any $\delta^{15}N$ value above 6‰ shows intense long-term manuring.

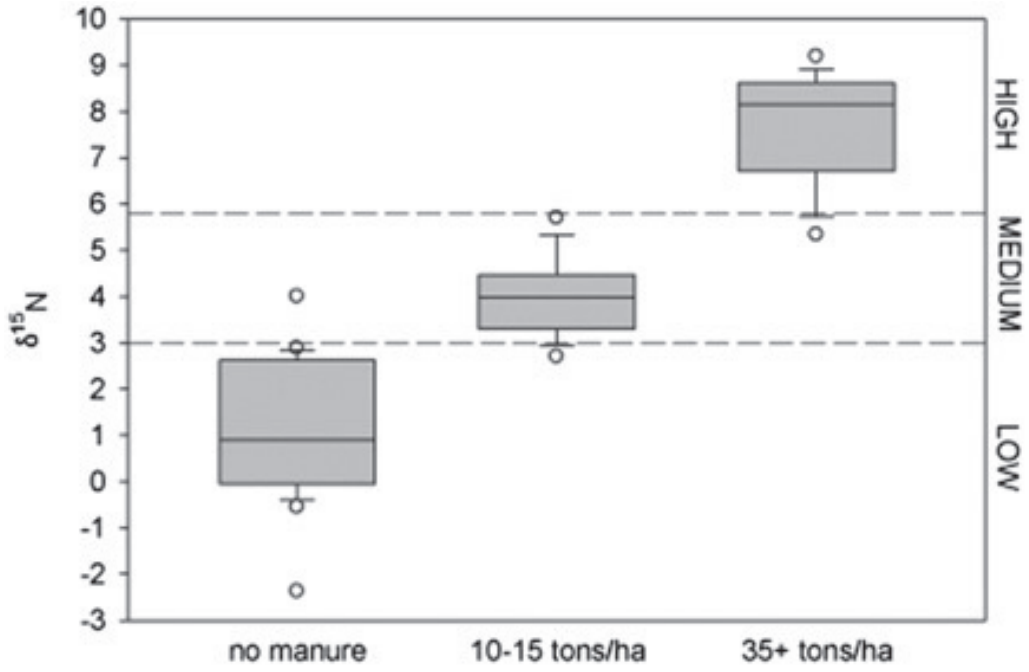


Figure 3.5: Graphical representation of manuring bands from Bogaard et al. (2013b) showing the three bands based on modern data of bulk wheat and barley samples from long-term agricultural experimental trails. The three bands represent the manuring rates of high, medium and low (residual) manuring per annum.

Pulses fix atmospheric nitrogen through a symbiotic relationship with soil rhizobium. If a pulse plant obtains 100% of its nitrogen from this relationship, theoretically its $\delta^{15}N$ will be close to 0‰, as $\delta^{15}N$ is measured against the universal standard of air although some fractionation has been noted to occur in the fixation process and between plant parts (Doughton et al. 1992). The degree to which a nitrogen-fixing plant will use soil versus atmospheric nitrogen can vary, including environmental conditions such as aridity or waterlogging, the species, landrace or varieties of plant in question, the strain of *Rhizobium* in the symbiotic relationship and the application of manure (Doughton et al. 1992; Treasure et al. 2015).

The effect of manure on this complex web has been studied. Fraser et al. (2011) show high application of manure (> 35t/ha) in field experiments has an effect of

raising the $\delta^{15}N$ of the pulse seed, but only by +0.7‰. Research by Treasure et al. (2015) indicates that higher levels of manuring (>70t/ha) can increase $\delta^{15}N$ values by 3‰ in pulse seeds. Results from traditional farms in Evvia, Greece show that intense application of manure results in significant enrichment of the soil, and consequently the enrichment of pulses up to 4‰ (mean 2.2‰)(Fraser et al. 2011).

Aridity has an effect on plant $\delta^{15}N$ in arid and semi-arid environments (Steward et al. 1995; Amundson et al. 2003; Swap et al. 2004; Hartman and Danin 2010). Research focused on regions outside this study's geographical boundary has indicated a correlation of plant $\delta^{15}N$ values and rainfall (Steward et al. 1995; Amundson et al. 2003; Swap et al. 2004). Hartman and Danin's (2010) research indicates that rainfall is correlated with N isotope values of C_3 plants in the Eastern Mediterranean. Their results produced a regression equation for the correlation of annual C_3 plants and rainfall of $\delta^{15}N = -3.19[\log(\text{mean annual rainfall})] + 19.09$ (Hartman and Danin 2010:846).

As aridity has an effect on $\delta^{15}N$, the application of Bogaard et al's (2013b) manuring bands to arid or semi-arid environments would result in an over estimation of the amount of manuring. Styring et al. (2016b) tested a method to interpret manuring intensity in (semi-) arid regions using the regression equation between unmanaged annual plants and rainfall developed by Hartman and Danin (2010). This method adjusts Bogaard et al's (2013b) manuring bands based on the amount of rainfall received using an adapted Hartman and Danin equation to account for the difference between leaves and grain (~1.4‰)

(Styring et al 2016b:11). Styring et al. (2016b) examined its utility in (semi-)arid enviroments through modern field work in Morocco and this research supported the applicability of such a method, with the adjusted manuring bands acommodating the known manuring levels of the sampled fields.

Understanding the natural availability of soil nitrogen without any anthropogenic input is important for the interpretation of archaeological isotopic data. Without an understanding of the natural baseline of the soil- available nitrogen it is difficult to interpret whether values represent manuring or the natural baseline enriched by different processes, such as aridity, seasonal wetting and drying, salinity and other soil processes. Understanding the $\delta^{15}N$ value of other species, in particular fauna from the same ecosystem, provides a way of contextualising plant $\delta^{15}N$ values in their ecosystemic context and thus adding additional evidence for or against manuring, in conjunction with the adjusted Bogaard et al (2013b) manuring bands.

To obtain an estimation of the $\delta^{15}N$ value of non-arable soils, studies have used an estimated herbivore forage value (Bogaard et al. 2013b). This value is obtained through faunal isotopic data: by subtracting the estimated trophic shift (3-5‰) from the mean wild herbivore values an estimate of the value of the herbivore forage can be gained (Hedges and Reynard 2007; Lee-Thorp 2008). The assumption made is that the measured animals would not have been feeding in arable habitats and consume forage from other environments, giving an estimate of the baseline of the available 'natural' soil N enrichment in $\delta^{15}N$ (Bogaard et al. 2013b:12590). Such a method assumes that the soil and the soil N

the vegetation consumed by the animals was compared to unmanured arable soil. As such an assumption may be limited in its validity at some sites– e.g. specific soils may have been targeted for arable use – it is important that elevation of ^{15}N above the forage values is not the sole measure of manuring and that it is used in conjunction with other measures such as the Bogaard et al, (2013b) manuring bands. Crops enriched significantly above the forage baseline are consistent with the application of manure but other environmental factors also need to be considered. The range of interpretations can be further narrowed by understanding the ecology of weed flora found within the archaeological samples as well as an understanding of the palaeoenvironmental setting of the site.

4 Methods

This chapter details the protocol followed when analysing the archaeobotanical datasets. It explains the on-site stages followed for recovery of material, the laboratory methods used for identification and quantification as well as the analytical method used to understand taphonomic processes and to investigate crop husbandry methods.

4.1 Archaeobotanical methods

Material from Çatalhöyük West and Çamlıbel Tarlası was selected and analysed in full; the two sites are paired when discussing sample selection, sample subsampling, identification, and other related topics. Material and data from Kuruçay and Canhasan I was provided by Mark Nesbitt who granted permission for its use in this study. Limited material from these sites is held in the UK and so Nesbitt's data provided the majority of information from these sites. Consequently different protocols were followed for Çatalhöyük West and Çamlıbel Tarlası than at Kuruçay and Canhasan I. Where possible the protocol followed by Nesbitt during his study is detailed, but the majority of the information in this section concentrates on Çatalhöyük West and Çamlıbel Tarlası.

4.1.1 Samples recovery

The data used in this study come from four sites. Due to divergent excavation dates and changes in sampling methodologies over time, a number of different techniques were used to recover the archaeobotanical material. The strategy used at the earlier excavated sites of Canhasan I and Kuruçay means that the samples were predominately either hand-collected from concentrations of visible

archaeobotanical remains uncovered during excavation, or the result of dry sieving (Duru 1994; French 1998). Canhasan I's sampling strategy changed over the excavation seasons as the newer methods of retrieving material, sieving and wet sieving, were introduced to the site (see Chapter 2).

A more systematic sampling strategy was used at the recently excavated sites of Çatalhöyük West and Çamlıbel Tarlası where all excavated contexts had material sampled for archaeobotanical remains. The amount sampled differed depending on the size of the context, with 30 litres of sediment per context collected as standard practice at Çatalhöyük. At Çamlıbel Tarlası, samples of c. 40 litres were taken from contexts (Papadopoulou and Bogaard 2012). Where large contexts such as floors that might have spatial variation in botanical remains occurred, the areas were gridded (1 m^2 at Çamlıbel Tarlası and 0.5 m^2 at Çatalhöyük West), allowing samples to be taken from each grid square.

Samples from Çatalhöyük West and Çamlıbel Tarlası were processed using flotation. A modified flotation machine similar to French's (1971) Ankara machine was used. At Çatalhöyük West the material that floated was collected in chiffon (~0.17 mm) with the heavy residue collected using a 0.5 mm mesh (Hastorf and Near 1997). The archaeobotanical material from the heavy residue was sorted from random sub-samples of the 4 mm, 2 mm and 1 mm fractions on-site by trained workers and later included in the archaeobotanical analysis.

The samples from Çamlıbel Tarlası were processed in a similar manner to those from Çatalhöyük West, with the light residue collected in chiffon of <0.3mm

aperture and the heavy residue collected by mesh of c. 1 mm aperture. On-site sorting of the heavy residue was conducted; any resulting archaeobotanical material was included in the subsequent analysis.

4.1.2 Scanning

All light residue samples (flots) from Çatalhöyük West and Çamlıbel Tarlası were scanned to gauge the abundance and density of contained botanical remains. For the Çatalhöyük samples, the scanning methodology followed the standard procedure set out on site (Bogaard et al. 2005a). By keeping the scanning methodology consistent, greater comparability between past and present samples is possible, allowing for the comparison of results between the two mounds by integrating them into the Çatalhöyük database.

The scanning process followed for the Çatalhöyük West flots is that set out by Bogaard et al. (2005a). A subsample of ~10 ml or less was scanned under a stereoscopic microscope. The number of identifiable items was recorded but only to the gross categories: glume wheat grain and chaff, barley, free-threshing wheat grain and chaff, the species of pulse seeds, and fruit/nut shell fragments. Cyperaceae seeds were counted in a separate category, while any other wild/weed seed was scored as just "weed seeds". The numbers of mineralised seeds were also recorded, in particular seeds from the Boraginaceae family, as well as *Celtis* seeds.

The scanning of the Çamlibel Tarlasi samples presented difficulties due to the pervasive presence of dense fibrous roots throughout the flotation samples.

These modern roots formed dense balls in the flotation samples, trapping the charred seeds, which then needed to be disentangled to allow for sorting. Due to the large number of samples (>300) and the difficulty of quick scanning due to the root balls, a faster scanning strategy was devised than that used at Çatalhöyük West. The samples were disentangled and the released material sieved at 4, 2, 1 and 0.3 mm. The 2 and 1 mm fractions were scanned and the number of items classed in ranges of 1-10, 10-30, 30-50, 50-100, 100-500 items. To speed the process, types of items present such as pulses, wheat, barley or cereal indeterminate grains, as well as glume bases and weed seeds were noted but not counted.

4.1.3 Selection criteria

Criteria were devised to select the best subset of samples from the Çamlıbel Tarlası and Çatalhöyük West assemblages in order to investigate the research questions posed. These criteria were based on a combination of archaeobotanical abundance and the archaeological context of the samples. It was decided that a sub-sample with circa 400 - 500 items (including at least 30 seeds of potential arable weeds) was sufficiently rich to represent the range and proportions of items within the total sample (van der Veen and Fieller 1982). This became the target for the abundance criteria. By multiplying the preliminary scanned sub-samples by their fraction, an indication of the approximate number of items within the samples was obtained. Çamlıbel Tarlası samples from gridded floors had the potential to be combined into larger units, allowing for some samples to be summed together and increasing the total number of items.

The extrapolation of results indicated that only a small number of samples from both sites contained the desired number of items. Consequently the target was reduced to 100 crop items and at least 30 weed seeds, which would still provide a robust sample size (van der Veen and Fieller 1982). The scanning also indicated that samples from Trench 8 and Trench 7 at Çatalhöyük West were poor in identifiable remains; these samples were therefore classed as low priority and removed from consideration for further analysis.

Archaeobotanical abundance, however, was not the only criterion used for sample selection. 'Use deposits' related to specific plant-related activities, were prioritised. Samples from Çamlibel Tarlasi were graded according to the excavator's stratigraphical classification. Çatalhöyük West samples that came from in situ or primary contexts were given high priority as these contexts contained as little mixing of activities as possible and appeared to represent brief activity periods. Consequently, samples described as lenses or ashy material were of high priority but as these contexts were limited in number, samples showing evidence of quick deposition were also classified as high priority. These samples contained evidence of articulated bone or clusters of other material. Additional high priority samples came from floors as these might yield evidence of activities carried out on them. Scanning also indicated that Çatalhöyük West samples derived from building material such as mud brick were some of the richest samples, but because of the multiple potential pathways for material to be included in mud brick, the use of these samples to investigate agricultural practices was problematic. Therefore samples from building materials were classed as low priority.

In addition to the number of samples selected based on the above criteria, another 25 samples were included in the analysis of Çamlıbel Tarlası samples. These had been analysed by Irini Papadopoulou for a Master's thesis at the University of Sheffield (Papadopoulou and Bogaard 2012). These samples were re-analysed so that identification criteria could be standardised and corrected and so that the additional 0.3 mm fraction, which was not sorted for Papadopoulou's thesis, could be analysed. A number of these samples did not fulfil the criteria and are included in the general overview but not in the statistical analysis.

A total 109 samples from Çamlıbel Tarlası and 64 from Çatalhöyük West were selected (Table 12.1). These samples came from a range of contexts: the Çatalhöyük West samples predominantly midden fill (Table 4.1) and the Çamlıbel Tarlası samples from the large "ash fill" which covered the site in the CBTI phase, as well as floors and external surfaces (Table 4.1).

The samples from Kuruçay and Canhasan I were in part already selected/sorted by the previous researcher, Mark Nesbit; in most cases only the raw datasets and limited archaeobotanical material were available for examination in this study. Limited contextual information also reduced selection by context; the samples from Kuruçay were limited to storage samples from a select number of levels. All 25 samples were used. The provenance of some Kuruçay samples was questioned by Nesbitt (1996), in particular the assignment of samples 19 and 22 to Levels 4 and 5 respectively, explaining that this was unlikely due to lack of burning within

these levels and suggesting that the samples were more likely to have originated from Levels 6 or 6A. In addition to these two samples, 10 other samples possessed no contextual information, with Nesbitt (1996:134) concluding that they most likely originated from Levels 6A, 6 or 3. As 6A was extensively burnt it was more probable that these 10 samples derived from that level (Table 4.1).

The 53 Canhasan I samples previously examined by Nesbitt derive primarily from Levels 2A and 2B, with only a limited number of samples from Levels 1 and 5 (Table 4.1). Again, contextual information was limited with at best a grid square location within a phase plan. Very limited information regarding the context type from which the samples originated could be found. Only two samples were discounted as they derive from post-Chalcolithic deposits. Nesbitt's notes suggest he concentrated on the richest samples containing 25 or more grains, but the data provided includes samples ranging from 11 items to 6467 items. Samples were discounted from statistical analysis if they contained less than 30 items.

Table 4.1: Number of samples from each site divided into their specific phases, buildings and context.

Site	Phase	Context	Number of samples	Phase number of samples	Number of Analytical Units	Total number of units
Çamlıbel Tarlasi	CBTI	Fill ("ash layer")	21	22	16	17
Çamlıbel Tarlasi		Fill	1		1	
Çamlıbel Tarlasi	CBT I/ CBTII	Fill	1	1	1	1
Çamlıbel Tarlasi	CBTII	Silo	3	27	3	21
Çamlıbel Tarlasi		Oven	2		2	
Çamlıbel Tarlasi		Internal floor	20		14	
Çamlıbel Tarlasi		Fill on floor	1		1	
Çamlıbel Tarlasi		Fill on floor, external	1		1	
Çamlıbel Tarlasi	CBTII post ab	Fill	1	1	1	1
Çamlıbel Tarlasi	CBTIII	Internal floor	27	41	10	21
Çamlıbel Tarlasi		External floors	12		9	
Çamlıbel Tarlasi		Fill on floor	2		2	
Çamlıbel Tarlasi	CBT III/CBTI IV	Fill	1	1	1	1
Çamlıbel Tarlasi	CBTIV	Internal floors	9	16	6	11
Çamlıbel Tarlasi		External floors	2		2	
Çamlıbel Tarlasi		Pit	1		1	
Çamlıbel Tarlasi		Fill on floor, external	3		1	
Çamlıbel Tarlasi		Fill	1		1	
Çamlıbel Tarlasi	**Total**		**109**	**109**	**73**	**73**
Çatalhöyük West	98	Fill	10	34	10	18
Çatalhöyük West		Floor	20		4	
Çatalhöyük West		Cluster	2		2	
Çatalhöyük West		Lens	2		2	
Çatalhöyük West	105	Fill	10	17	8	15
Çatalhöyük West		Cluster	1		1	
Çatalhöyük West		Lens	6		6	
Çatalhöyük West	106	Fill	1	3	1	3
Çatalhöyük West		Cluster	2		2	
Çatalhöyük West	107	Fill	2	2	1	1

Site	Phase	Context	Number of samples	Phase number of samples	Number of Analytical Units	Total number of units
Çatalhöyük West	125	Fill	4	6	4	6
Çatalhöyük West		Lens	2		2	
Çatalhöyük West	126	Floor	2	2	2	2
Çatalhöyük West	**Total**		**64**	**64**	**45**	**45**
Kuruçay	6/6A		2	2		
Kuruçay	6A	Room 24	2	3		
Kuruçay		"Shrine 1" (room8)	1			
Kuruçay	6c	Room 27	1	1		
Kuruçay	6a	Room 16	1	2		
Kuruçay		House 18	1			
Kuruçay	3	"Shrine 2"	3	7		
Kuruçay		House 57	4			
Kuruçay	Unknown	Unknown	10	10		
Kuruçay	**Total**		**25**	**25**		
Canhasan I	Level 5	Trench	4	4		
Canhasan I	2B	Baulk sieving	5	17		
Canhasan I		Trench	11			
Canhasan I		Unknown	1			
Canhasan I	2A	Baulk sieving	10	26		
Canhasan I		Trench	15			
Canhasan I		Unknown	1			
Canhasan I	2A/2B	Trench	1	2		
Canhasan I		Baulk sieving	1			
Canhasan I	Level 1	Baulk sieving	2	2		
Canhasan I	**Total**			**51**		

4.1.4 Sub-sampling

The preliminary scanning of the flots from Çamlıbel Tarlası and Çatalhöyük West allowed for a general understanding of the quantity of identifiable items within the samples. It also provided information as to whether samples were very rich and whether they would contain more than 541 items, the threshold set by van der Veen and Fieller (1982) to obtain a 98% probability that species' proportions would be representative of the whole sample. Scanning information was used to determine the need for sub-sampling, with samples that surpassed the targeted number of items sub-sampled to more manageable sizes. If samples appeared to exceed the target, their 2 mm and 1 mm fractions were randomly sub-sampled using a riffle box, to ½, ¼ or ⅛ of the total sample. Sub-sampling was the standard practice with the 0.3 mm sieve fraction because of the large quantity of material present; these fractions were commonly sub-sampled to ⅛ of the 1mm fraction sorted. However in some cases smaller amounts were sub-sampled due to the large amount of modern material contained in them, making sorting of the 0.3 mm extremely time consuming, particularly with the Çamlıbel Tarlası samples. Additional subsamples were sorted if the number of weed seeds within the entire sample did not reach the target of 30 items.

4.1.5 Sorting and identification

The samples were sorted under a stereomicroscope at the University of Oxford, with items identified using comparative material housed there and relevant literature (Jacomet 2006; Nesbitt 2006; Cappers et al. 2012). The Latin nomenclature follows Davis et al. (1965-1989). Additional examination of both herbarium specimens housed at the Konya herbarium at Selçuk University, and

modern seed collections at the British Institute at Ankara (BIAA) was needed to finalise identification of certain taxa.

Most of the material found in the samples was charred, with a little preserved by mineralisation. There were numerous seeds from the Boraginaceae family; their seed coats are rich in carbonate thus preserving them from decay. Such species were classified as mineralised. Other taxa that had been preserved through replacement mineralisation were identified following the charred material protocol.

Monocotyledonous culm material was frequently encountered; due to the lack of distinguishing characteristics for separating reed culm and (possible) cereal culm, research was conducted to determine their specific distinguishing traits. A protocol was developed that separated culm types based on culm node size, external morphology, and the cellular arrangement of vascular bundles (Stroud in prep).

For the assemblages from Kuruçay and Canhasan I, limited material was located within the UK and available for reassessment of identifications. For Kuruçay, Nesbitt provided all type specimens from the samples, allowing a comprehensive reassessment of the material with the exception of chaff material, of which there were limited items in the type collection. This allowed the identification of weed seeds previously not identified to species or genus level. Unfortunately all weeds classed as “Unidentified” were not in the type collection and thus could not be reassessed.

The majority of the Canhasan I material is currently housed in the Karaman Museum in Turkey, making the re-identification of the different crop types, as well as the species included in categories such as “miscellaneous weeds” and “weed grass”, not feasible during the present study. However two additional samples, not recorded by Nesbitt, were housed in the UK and were analysed for the present study by the author (samples 768, 922).

4.1.6 Quantification

Quantification of items was conducted using set criteria aiming to reduce the likelihood of over-estimation of plants/plant parts. The minimum number of individuals (MNI) was calculated by counting specific diagnostic zones. For grains, the apical and embryo ends were counted and the most abundant category used to total estimate numbers. For glume bases, spikelet forks were counted as two glume bases, while for individual glume bases, remains of the base had to be present for it to be recorded. Rachis internodes were counted based on the presence of the top of the internode, while culm nodes were counted by calculating what proportion of one whole node was represented.

Specific counting criteria were less important for wild plant seeds as the finding of numerous broken items of the same taxon was infrequent. *Bolboschoenus* seeds were counted based on the presence of the tip. The criteria used for the cereal grains were applied to any grass seeds found where the apical or embryo end was used to estimate the minimum number of individuals. In most other cases seeds were whole or only one fragment was present within the sample.

Charcoal in the samples was quantified based on volume, with charcoal fragments from the 4 mm and the 2 mm sieve fractions measured. For other items such as dung, tuber and charred matter, quantification was also recorded through volume: the assumption was that one 1 ml of tuber fragments equalled one whole *Bolboschoenus* tuber, following the protocol set by Bogaard et al. (2013a) and Filipović (2014). Whole tubers were recorded separately and then added to the converted volume of fragments to reach a final count.

Seeds from the Leguminosae family, particularly large ones, tended to be fragmented, making estimation of numbers difficult. The use of simply the presence of the hilum as a method of quantification was rejected due to the rarity of such attributes, even on whole seeds, being identified. The presence of half or greater of a pulse seed was counted as one if this was the only specimen of that taxon in the sample. Numerous fragments of pulse could not be identified to species: to calculate the number of seeds represented, the estimated numbers required to make one whole grass pea or pea seed (the largest pulses in the assemblage) was made.

In some taxa such as *Polygonum,* both the core and the shell were found separately. To avoid duplication, both categories were recorded separately and then the categories with the highest count in each sample were included in the final total. Culm nodes were counted. Due to the different sizes of fragments and the different circumferences of the nodes encountered, an estimation of the number of node fragments equalling one node was used, similar to the protocol followed for the pulse estimation.

Fruitstone fragments were again difficult to count due to the highly fragmented nature of the material and the lack of diagnostic zones on the shell. While stones commonly have a hilar scar, identification of such scars was rare and in many cases samples included fragments but lacked items with hilar scars. In such cases an estimation of the minimum number of individuals was made. This was based on criteria followed by Bogaard et al. (2013a) and Filipović (2014) to allow standardisation across the East and West Mound assemblages of Çatalhöyük. Thus 20 fragments of *Prunus/Amygdalus* stone/shell were assumed to be equivalent to one whole *Prunus/Amygdalus* stone/shell. Pistachio shell fragments, due to their smaller size, were assumed to consist of 15 fragments, this being equivalent to one whole shell.

Pod fragments were estimated by visually calculating how much of a pod was represented.

4.1.7 Multiplication of sorted fractions

Once sorting was complete the total number of items per sample was calculated. Scores of the different sieve fractions were summed together; in cases where a sub-sample had been sorted the scores were multiplied up. All samples were multiplied to 100%, or their highest fraction sorted, unless this required multiplying a sub-sample by more than eight. In such cases sieve fractions that had been 100% sorted were divided down. For example a sample with 100% of its 2 mm, 25% of its 1 mm and 3.125% of its 0.3 mm sieve fractions sorted would be treated thus: the 2 mm fraction would be divided by four, the 1 mm would remain the same, and the 0.3 mm would be multiplied by eight, resulting in 25%

of the total sample recorded. A consequence of this is that a total of 10 samples do not represent 100% of the sample; in these cases subsamples were multiplied up to make 50 or 25% of the total sample (Table 4.2).

Table 4.2: Samples from Çamlıbel Tarlası and Çatalhöyük West showing the proportions of the samples represented within the research.

% of sample represented	Number of samples	
	Çamlıbel Tarlası	Çatalhöyük West
100%	103	60
50%	4	3
25%	2	1
Total	109	64

4.1.8 Definition of analytical units

Amalgamation of samples was required to avoid the repetition of the same behavioural event, which would have resulted in the duplication of patterns. Caution was needed, however, to prevent conflation of distinct samples.

Due to the excavation protocol implemented at Çamlıbel Tarlası and Çatalhöyük West, multiple flotation samples were taken for what could be single behavioural events. Floors were gridded in metre square quadrants at Çamlıbel Tarlası and 0.5 m^2 grids at Çatalhöyük West to allow for investigation of spatial variability. However as gridding is arbitrary, multiple grid squares potentially could contain parts of the same behavioural event. In addition to multiple samples from floor contexts, some non-floor contexts had multiple flotation samples: such samples either represent different locations within the unit, or were taken at the author's request to increase the volume of sediment sampled. Furthermore, the excavation

of the two sites over multiple years resulted in samples from the same context being collected but recorded with different unit numbers.

To understand whether such samples represented multiple or single behavioural events, the density and composition of the samples were compared for any unit that had multiple flotation samples. Samples that contained significantly different densities and/or were compositionally different were not amalgamated, while samples with similar densities and composition were amalgamated on the assumption that they represented the same behavioural event. Of the 63 samples examined from Çatalhöyük West, 24 samples were part of six units and similarities in compositions and densities allowed the samples to be combined, reducing the number of Çatalhöyük West analytical units from 62 to 45 samples (see Table 4.1).

Examination of the Çamlıbel Tarlası samples indicated varying composition and densities resulting in differential amalgamation of floor samples (Table 12.1). A number of units were also combined after discussion with the excavator because of the common occurrence of the same floor having two unit numbers; this was due to excavation over multiple seasons. In total, 56 samples were merged to make 21 analytical units, with an additional 52 samples which had either not been merged or were from contexts from which only one sample had been taken/examined. This produced a total 73 analytical units (hence, 'samples') from Çamlıbel Tarlası (see Table 4.1).

From Kuruçay all 25 analytical units were included, while for Canhasan I the limited contextual/stratigraphic information made it impossible to judge whether any samples could be merged. Thus all 51 samples were included in the overall tables. As at Çamlıbel Tarlası and Çatalhöyük West, a number of the Canhasan samples produced less than 30 items. In such cases these samples were included in overall preliminary assemblage analysis, but excluded from any statistical analysis.

4.1.9 Amalgamation of taxa

To allow for the comparison between the samples and the use of statistical methods, identification categories were amalgamated. This was to ensure that any analysis did not interpret variances based on preservational inconsistency as opposed to compositional difference (Bogaard 2004b; Valamoti 2004; Filipović 2014). Consequently, any items identified to cf. (comparable to) level were merged with positively identified items of that taxon; if no positively identified items of that particular taxon had been identified the item remained as a cf. identification.

At all sites a large quantity of crop material could not be positively identified to species, primarily due to poor preservation but also as the consequence of charring resulting in shape deformation. This led to a high proportion of the identified crop items being classed in broad indeterminate categories such as cereal, wheat, and glume wheat or pulse indeterminate.

These indeterminate crop items were proportionally reassigned for inclusion in the statistical analysis of the samples, assuming that taxa in the indeterminate remains have the same proportions as positively identified taxa. On a sample-by-sample basis it was therefore possible to re-assign indeterminate items; the indeterminate classes identified closest to taxon re-assigned first, followed by the next, and so on to the least identified items (cereal indeterminate). For example, indeterminate 2-grained glume wheat grains were re-assigned to emmer and 'new-type' and 2-grained einkorn categories. The subsequent step saw the re-assignment of indeterminate (1-or 2-grained) glume wheat grains to the new totals for the emmer, 'new type' and 2-grained einkorn, as well as the original scores for 1-grained einkorn. Subsequent reassignments saw wheat indeterminate grain proportionally distributed between the new emmer, 'new type', 2-grained and 1-grained einkorn classes and the original free-threshing wheat. The final re-assignment of the cereal indeterminate remains included all new totals for all cereal classes. Similar procedures were followed for chaff remains and pulse items.

In the case where no positively identified item of a specific crop group was found in the sample, the indeterminate items remained in the category that had the most definitive identification level. To facilitate the re-assignment of indeterminate items the following formula was used:

$$p_x = a \times \left(\frac{x}{y}\right) + x$$

where p_x is the new total of species x, a is the total of the indeterminate category and y is the sum of the number of items counted for the species to which a needs reassignment (including species x).

Thus the cereals were amalgamated into just six classes: free-threshing wheat, einkorn, emmer, 'new-type', naked barley and hulled barley. The same procedure was used for the pulse species, as well as for any weed taxa that included categories where, due to preservation, two or more taxa could not be distinguished.

4.2 Analytical methods

A number of techniques were used to investigate the questions posed by this research including various methods to explore the assemblage, such as correspondence analysis. An understanding of the taphonomic processes that formed the assemblages was also required. Two main activities other than in situ burning of stores or cooking material were considered as the path by which items entered the archaeological record: crop processing and dung burning. As detailed in Chapter 3, various methods and techniques have been developed to detect the signatures of dung burning and crop processing in the archaeobotanical record.

4.2.1 Correspondence analysis

Correspondence analysis was conducted as a pattern-searching approach to elucidate potential links between either groups of species and/or samples. This is a multivariate ordination technique used to explore the similarities and differences in the composition of samples from individual sites and consists of plotting samples along four axes based on the combined species' composition. A

two-dimensional scatter plot is produced which displays the two axes that best account for the variation between the samples. Such representation can be used as a tool for generating hypotheses regarding the causes of inter-sample variation; samples and species can be coded based on extrinsic variables (e.g. sample context, species' seed size). Correspondence analysis is commonly used in ecology and archaeology as it provides a means to search for patterns within datasets containing multiple variables per sample. It has been used in archaeobotany to explain the reason for variation between samples (for example Charles and Bogaard 2003; Bogaard 2004a; Valamoti 2004; Bogaard et al. 2013a; Filipović 2014). Only charred material was considered, with correspondence analysis applied to datasets based on crop and wild/weed items.

Correspondence analysis was used to explore the sample composition from all sites. CANOCO for Windows was used with all graphs depicted showing axis 1 and 2 unless otherwise stated. Rare taxa within the assemblages posed a problem: they and their sample are represented as being highly different from the other samples/species which are in turn represented as having only limited differences. Decisions were made on a site-by-site basis, trying to maintain a balance between keeping as many samples and species as possible but avoiding the skewing of results if species occurring in limited samples were included. To avoid skewed results, only species that occurred in a certain number of samples (this was site dependant, see table 4.3), and only samples that contained 30 or more items, were analysed. Additionally, significant outliers were removed from the analysis to allow for examination of the variation within the majority of samples. Outliers, commonly species (or samples) occurring in high numbers (a high concentration

of one species) and in limited samples, obscure the results by being significantly different from the main samples. Thus when graphed no detail of the main samples can be seen. To allow for the examination of the majority of the samples/species, the outlying sample/species has been removed (see table 4.3 for details).

Table 4.3. The number of samples and species included in the correspondence analysis of each site, the % of the assemblage the species occurred in, and which samples and species were removed due to being outliers.

	Samples	Species	%	Samples removed	Species removed
Çatalhöyük West	41	61	9.5	10100	*Bromus* narrow type
Çamlıbel Tarlası	63	68	8	None removed *Bromus rigidus/diandrus*	
Canhasan I	33	18	6	2200	Grape, tuber, grass indet
Kuruçay	24	30	8	22	Culm node, *Poa* type, *Silene* type 2

4.2.2 Crop processing analysis

A number of methods were employed to understand potential crop processing activities represented in the assemblage. These fall into three groups, crop-based, crop-weed based and weed-based analysis. Such methods all rely in part on comparison with ethnographic research conducted by Jones (1983b, 1987).

Crop-based analysis was conducted through the comparison of ratios of grain to chaff components of the various cereal types represented in the assemblage. The logarithm of such a ratio (to the base 10) was compared to the same of the ethnographic data from Jones (1983b, 1987). This was conducted for any free-threshing cereal samples within the assemblage that had 30 or more items. The ratio of grain to the glume bases of glume wheat in the assemblages was also

calculated. Comparison to ethnographic data is not possible due to the absence of any such research but comparison to the expected ratios of samples composed of spikelets allows for the separation of glume-base dominated samples and grain-dominated samples (Table 4.4). The potential ratio of grain to glume base in a sample containing material from unprocessed spikelets is theorised as being between 0.3 and 1.5 as per Bogaard (2011). Such a range was theorised for a number of reasons. Samples containing a mixture of one and two seeded glume wheats result in a range of potential ratios. Furthermore glume bases do not survive charring as well as grains, biasing archaeological samples toward grain preservation (Boardman and Jones 1990). This ratio therefore takes into account the ratio expected for a whole einkorn spikelet (0.5) and that of two-seed glume wheats (1), with flexibility either side accounting for preservation and a higher margin above 1 to compensate for the bias against chaff.

Table 4.4: The number of grains to corresponding chaff type for the different cereals.

Class	Species	Natural numbers of grain to chaff
Glume wheat	Emmer, 'new type'	2 grain to 2 glume bases
Glume wheat	Einkorn	1 grain to 2 glume bases
Free-threshing	Bread wheat	2-6 grains to 1 rachis internode
Free-threshing	Barley – 2-rowed	1 grains to 1 rachis internode
Free-threshing	Barley – 6-rowed	3 grains to 1 rachis internode

Crop and weed-based analysis was conducted, comparing the ratio of grain to weeds to chaff of the dominant crop taxa in each sample, using triangular plots, following Jones (1990). This method assumes that weeds in a sample derive from the crop plotted. To understand with which crop the weeds were most likely associated, samples were classified based on the dominance of crops within them. An arbitrary cut off point of 70% was used following the tradition of, for example,

Bogaard (2002a) and Filipović (2014). The samples were classed on total items (grain and chaff remains) per crop category, glume wheat glume bases and the seeds of free threshing crops (e.g. pulses, flax, free-threshing cereals such as barley). If a sample's crop assemblage contained 70% or more of a single crop type, it was classed as being dominated by that crop.

Consideration was given as to whether specific wild taxa were arable weed seeds arising from crop processing or were included in a sample by other means. Arable seeds were determined through an understanding of the taxon's habitat preference (e.g. moisture requirements). Taxa believed to have come into the sample other than as a crop weed were excluded (e.g. collected crops, dung derived material).

As glume wheat material cannot be compared to Jones' ethnographic data (which is based on free-threshing cereals) and their proportions of grain, chaff and weed seed, an alternative method to understand comparative proportions of glume bases and weed seeds from fine-sieving by-product was used. Examination of the ratio of glume bases to weeds ("weediness") was conducted through the extrapolations of Jones' (1990) ethnographic data to a hypothetical glume wheat fine-sieving by-product, following Bogaard (2011) to allow for comparison of glume wheat assemblages. Due to the paired nature of the ethnographic data, the sample's different crop-processing stages can be combined to calculate the proportions of weeds and grain prior to fine sieving. To take into account the fact that glume wheats contain fewer grains per ear than free-threshing cereals (Percival 1921), the number of free-threshing grains was halved (Bogaard 2011).

The amalgamated pre fine-sieving grain numbers can be used to estimate the number of glume bases in the sample, with two-seeded glume wheat having a 1:1 ratio and one-seeded glume wheats a 1:2 ratio of grain to glume bases. The assumption is then made that all glume bases would be removed during fine sieving, and thus the weed count from the fine-sieving by-product can be paired with the estimated glume base number to provide a weed to glume base estimate.

Weed based analysis was conducted following Jones' (1983a, 1983b, 1984, 1987) protocol for determining the crop processing stage of archaeobotanical weed assemblages. The size (small vs. big), aerodynamic properties (light vs. heavy) and the tendency of the seed to remain within a head/capsule (free vs. headed) were ascertained. Only samples with 10 or more such weed items were used in the analysis and because of the specific details required, indeterminate classes or items identified to family were excluded if the morphological nature of the species contained in such a group overlapped one or more of the categories. For example, *Bromus* was not included unless identified to type due to the fact that the members of the genus fall in both the small, free and light categories as well as the big, free and heavy categories.

It is also necessary to consider what sized fine sieve(s) was used; commonly reported sizes are between 1.5 mm and 2 mm (Jones 1981; Charles and Bogaard 2003; 2011:155; Filipović 2014:151). As the size of the sieve used in the past is unknown, the seeds were classed using both sieve sizes to understand which taxa would change size class (Table 4.5). Size was determined as the breadth of the seeds if the seed had a length less than 3mm. When species with long thin seeds

were encountered such as *Eremopyrum*, *Taeniatherum* and *Stipa*, a visual assessment was made about whether the length of the seeds would reduce the chance of the seed travelling though a 1.5 or 2mm sieve. Such judgement relied on past researchers' studies as well as the location of whole seeds within the sample's fractions, which provide evidence of the movement of the seed through a 4mm, and 1mm sieve (Jones 1983b; Bogaard 2002a; Charles and Bogaard 2003, 2011). Only six taxa changed size class and both groups were run for the majority of statistical tests to see if any differences were evident. If no differences occurred then the 1.5 mm size class was presented.

Taxa were classed using their dimensions to produce two datasets; seeds greater than 2 mm as large in the first dataset, greater then 1.5 mm in the second dataset, those under these sizes classed as small. The majority of these seeds were classed based on classification of species with similar dimensions by Jones (1983b) in her original research. The aerodynamic nature of the taxa was based on past research; the tendency to remain in head/seeded pod was also determined using past research and the examination of reference material at the University of Oxford (Jones 1983b; Bogaard 2004b; Filipović 2014). The resultant data was transformed following the protocol described by Jones (1983b) and discriminant analysis was performed using SPSS for Windows. In some cases limited information as to an attribute of a particular species posed a problem, such as the case of *Phalaris* cf. *minor* and its aerodynamic nature: it was uncertain if this seed should be classed as light or heavy (Table 4.5). In such cases the analysis was run twice, once with such species classed as heavy and once with it classed as light.

The two outputs were compared and discussion ensued if any major differences were discerned. SPSS version 19.0 was used to perform the discriminant analyses.

Table 4.5: Classification of size (small vs. big), aerodynamics (light vs. heavy) and tendency to remain in head (free vs. headed) of the taxa examined in this research. The table shows the difference that using a 1.5mm and 2 mm cut-off for the difference between small and big.

Taxa	Classification using 1.5 mm and (2 mm)	Code
Adonis aestivalis L. Type	Big-Free-Heavy	BFH
Adonis microcarpa/annua	Big-Free-Heavy (Small-Free-Heavy)	BFH (SFH)
Adonis, cf.	Big-Free-Heavy (Small-Free-Heavy)	BFH (SFH)
Aeluropus Trin.	Small-Free-Light	SFL
Ajuga/Teucrium	Small-Free-Heavy	SFH
Alisma L.	Small-Free-Light	SFL
Alyssum L. type	Small-Headed-Light	SHL
Anagallis L. type	Small-Free-Heavy	SFH
Artemisia annua L. type	Small-Free-Light	SFL
Asperula arvensis L.	Small-Free-Heavy	SFH
Atriplex L.	Small-Free-Heavy	SFH
Avena type	Big	BHH
Bifora radians Bieb.	Big-Free-Heavy	BFH
Bolboschoenus glaucus (Lam.) S.G. Smith	Small-Free-Heavy	SFH
Bromus rigidus Roth/ *diandrus* Roth.	Small-Free-Light	SFL
Bromus L., narrow type	Small-Free-Light	SFL
Bromus hordeaceus L./*commutatus* Schrad.	Big-Free-Heavy	BFH
Bromus arvensis L.	Big-Free-Heavy	BFH
Carex L.	Small-Free-Heavy	SFH
Centaurea sp.	Big-Free-Heavy (Small-Free-Heavy)	BFH (SFH)
Malva L.	Small-Headed-Heavy	SHH
Chenopodium L.	Small-Free-Heavy	SFH
Chenopodium album L. type	Small-Free-Heavy	SFH
Chrysanthemum cf. *segetum* type	Small-Headed-Light	SHL
Conringia orientalis L.	Small-Free-Heavy	SFH
Convolvulus arvensis L. type	Big-Free-Heavy	BFH
Cruciata Millier, cf.	Big-Free-Heavy (Small-Free-Heavy)	BFH (SFH)
Descurainia sophia (L.) Webb	Small-Free-Heavy	SFH
Crypsis aculeata (L.) Aiton type	Small-Free-Light	SFL
Deschampsia P. Beauv.	Small-Free-Light	SFL
Eragrostis N.M. Wolf	Small-Free-Light	SFL
Eremopyrum (Ledeb.) Jaub. & Spach	Big-Free-Heavy (Small-Free-Heavy)	BFH (SFH)
Euphorbia L.	Small-Free-Heavy	SFH
Festuca L.	Small-Headed-Light	SHL
Galium L., large type	Big-Free-Heavy	BFH
Galium, small	Small-Free-Heavy	SFH
Geranium L.	Small-Free-Heavy	SFH
Heliotropium L.	Small-Free-Heavy	SFH
Hordeum murinum L. type	Small-Headed-Light	SHL
Hordeum spontaneum C. Koch type	Big-Free-Heavy	BFH
Hyoscyamus L. type	Small-Free-Heavy	SFH
Juncus L.	Small-Free-Light	SFL
Lallemantia, cf.	Big-Free-Heavy	BFH
Primulaceae	Small-Free-Heavy	SFH
Leguminosae, small-seeded	Small-Free-Heavy	SFH

Taxa	Classification using 1.5 mm and (2 mm)	Code
Lolium temulentum L.	Big-Free-Heavy	BFH
Lolium L., small type	Small-Headed-Light	SHL
Lavatera L. type	Small-Headed-Heavy	SHH
Onopordum type	Big-Free-Heavy	BFH
Phalaris cf. *minor* Retz.	Small-Free-Heavy	SFH
Poa type	Small-Free-Heavy	SFH
Polygonum aviculare	Small-Free-Heavy	SFH
Polygonum convolvulus L.	Big-Free-Heavy	BFH
Ranunculus cf. *arvensis* L. type	Big-Free-Heavy	BFH
Rumex L.	Small-Free-Heavy	SFH
Salsola L.	Small-Free-Heavy	SFH
Sideritis L. type	Small-Free-Heavy	SFH
Silene types	Small-Headed-Heavy	SHH
Ranunculus sceleratus L.	Small-Free-Heavy	SFH
Sporobolus R. Br. *(S. virginicus* (L.) Kunth type)	Small-Free-Light	SFL
Stipa L.	Big	BHH
Taeniatherum caput-medusae L.	Big-Free-Heavy	BFH
Thymelea cf. *passerina* (L.) Cosson & Germ. type	Small-Free-Heavy	SFH
Trigonella astroites type	Small-Free-Heavy	SFH
Vaccaria pyramidata Medik.	Small-Free-Heavy	SFH
Valerianella Mill.	Small-Free-Heavy	SFH
Verbascum types	Small-Free-Light	SFL
Verbena officinalis L.	Small-Free-Heavy	SFH
Vicia L./*Lathyrus* L.	Big-Free-Heavy (Small-Free-Heavy)	BFH (SFH)
Viola L.	Small-Free-Heavy	SFH
Ziziphora capitata L./*persica* Bunge	Small-Free-Heavy	SFH

4.2.3 Dung burning analysis

Potential explanations of patterns detected within the dataset were explored by examining burning of animal dung as a cause. Dung-burning analysis was conducted following Charles' (1998) protocol, based on the presence of dung in the assemblage: the behaviour of taxa in comparison with crop processing; the biology/ecology of taxa to assess their chances of growing within crop harvest/fields; and lastly, proportions of crop parts (grain and chaff) as an indicator of mixing.

The attributes of the seeds in the samples were assessed in relation to crop processing and the specific characteristics for which each processing stage selects. This was conducted using discriminant analysis and the ethnographic data of Jones (1983, 1987) and followed Charles' (1998) protocol. Rather than using Jones' (1983b) modern dataset to classify the archaeobotanical samples in discriminant analysis, the archaeobotanical samples were entered separately to the ethnographic groups. This allowed classification of the sample as either a crop processing stage or an archaeological sample, providing a means of distinguishing any differences from the ethnographic data. Such analysis can be used to evaluate the possibility that the assemblage is partly composed of seeds from dung burning and is not therefore just the product of crop processing (Charles 1998)(Chapter 3).

The harvesting period is an important factor in determining whether seeds could have been part of the crop harvest or whether they fruit outside the harvest period and therefore could have arrived on site via other means such as animal dung. Taxa which flower/fruit outside the crop harvesting period are less likely to have been incorporated in the harvest material, and consequently less likely to be on site from crop-processing activities. Determining harvest time was conducted through the examination of modern day environmental data as well as ethnographic records (see Chapter 2).

The flowering times of species that occurred in at least three samples was collated from the *Flora of Turkey* (Davis 1965-1989). This information was used to extrapolate the potential fruiting periods of the species, the hypothesis being

that the plants would contain fruits/seeds one month after the commencement of flowering and would continue to be in fruit/seed one month after the cessation of flowering. Fruiting and harvest times allowed the identification of species that fruited after the crop harvesting time and therefore were unlikely to have entered the archaeological record via crop processing, as they would not have set fruit. Thus dung burning may have been the mode by which they became charred.

Seed size was also assessed in the dung analysis, as it plays a key role in the survivability of seeds during animal digestion. Seeds smaller than the reticulo-omasal orifice of sheep, goats and cattle can pass through the gut quickly, reducing exposure to digestive processing and increasing their ability to survive in dung. Research on differing sized particles' resistance during passage through the reticulo-omasal orifice of sheep, goat and cattle has indicated that 1.18 mm is a good division between high and low resistance of particles (Poppi et al. 1985). The size of archaeological taxa was measured and ranked on size so as to understand the likelihood of their swift or slow passage through the gut of livestock. As many seeds are longer than wide, each taxon's dimensions were examined on a case-by-case basis and classed on the following protocol: seeds under 1.18 mm in all dimensions were classed as small (or "tiny", to differentiate from the crop processing classifications), seeds with length or breadth less than 1.18mm, and their other measurement greater than 1.18mm but less then 2 mm were classed as medium, while seeds with all dimensions greater than 1.18mm were classified as large. The size of the taxa was taken from the archaeological specimen measurements.

The habitat preference of all species occurring in three or more samples was collected following research by Bogaard et al. (2013a), in which wet vs. dry habitat preferences provided a separation of dung flora (wet habitats) and arable flora (dry habitats) at Çatalhöyük East. The *Flora of Turkey* habitat information was collated into nine categories, the aim being to understand the overall water conditions preferred by the species/genus. Species/genus were classed as preferring dry habitats if all recorded habitat preference fell within the dry categories and species which preferred wet habitats if habitat preference fell predominantly in the wet categories (Davis 1965-1989). If habitat preference overlapped, the species were recorded as wet/dry.

An overall score of the likelihood of a taxa being only dung-derived was thus calculated using these criteria of fruiting time, seed size and habitat preference. The likelihood of a taxon not growing in an arable field was scored using the habitat preference information: taxa preferring wet environments (non-arable) scored ten, wet/dry scored five and dry location scored zero. Similarly, seed size was graded with tiny seeds scoring ten, medium five and large seeds scoring zero, providing an indication of their potential survivability through an animal's gut. Fruiting times were used to indicate species which fruited only outside the harvest period, with late fruiting times given a score of ten and other times a score of five. It is acknowledged that animals could graze on plants from any environment and additionally are grazing throughout the year; they could consume seeds of any taxa. However, such scoring criteria were used to help distinguish taxa most likely to only be introduced via animal dung. Taxa with scores of 20 or above were ranked as having a high probability of being dung-

derived, and species with scores greater than ten but less than 20 as a moderate probability of being dung-derived.

4.2.4 Crop husbandry analysis – weed ecology based

To understand the different crop husbandry methods represented in the assemblages, analyses were conducted based on the ecology and functional attributes of the weeds in the samples.

In order to understand the permanency of the fields and sowing time of crops, the lifecycle, flowering time, and duration of flowering of arable taxa were collected. The protocol for determining the permanency of the fields followed (Bogaard 2002b), in which the lifecycle of species (annual versus perennial), as well as their preference for disturbed or undisturbed habitats was collated from the *Flora of Turkey* (Davis 1965-1989). All arable taxa had lifecycle details collected, with taxa that could be multiple possible species having all possible lifecycles recorded.

To understand the possible sowing season, the flowering onset month and length of flowering period were collated for taxa, which could be 10 or less possible species. Information on flowering onset and length was found in the *Flora of Turkey* (Davis 1965-1989) and taxa were then classified based on the length and onset of flowering time with reference to the harvest period, following Bogaard et al. (2001).

The intensity/labour input of cultivation, relating to the fertility and amount of mechanical disturbance used, was also investigated. Using discriminant analysis, the functional attribute scores obtained from modern weed studies of low and high intensity/input agricultural regimes were used to classify the archaeological weed assemblages (Jones et al. 2000a; Charles et al. 2002; Bogaard et al. 2016a; Bogaard et al. 2016b). Arable weeds identified to species, or to a genus level in which only five species were included, were used and only samples that contained 10 or more seeds of these species were examined.

Using field research, four functional attributes of the taxa present in the archaeobotanical samples were compared to the same attributes of weeds growing under modern high-intensity and low-intensity cultivation, with archaeobotanical samples classified on a spectrum between high- and low-intensity regimes. The FIBS (Functional Interpretation of Biological Surveys) database at the Department of Archaeology, University of Sheffield, provided the data on leaf area, ratio of leaf area per node, amphistomaty and canopy height and spread. These data were derived from modern research conducted at the University of Sheffield and the University of Oxford, including recent fieldwork in Haute-Provence, France, Evia in Greece, Asturias in Spain and Morocco (Charles et al. 2002; Jones et al. 2005; Bogaard et al. 2016a; Bogaard et al. 2016b)

The archaeological data was transformed into a format comparable with the modern surveys (Charles et al. 2002). The data was converted to presence/absence scores, and the average attribute values for each sample calculated by adding together the attribute values for each species present and

dividing this by the total number of species. Discriminant analysis was conducted on modern field data from Morocco, France, Spain and Greece in order to discriminate between high-and low-input regimes (Bogaard et al. 2016a; Bogaard et al. 2016b). Discriminant analysis then classified the archaeological samples into either high- or low-intensity categories based on the modern data, producing discriminant scores as to how closely the values fitted to the modern classes. Such data were then used to plot the samples against the scores for the known modern regimes. SPSS version 19.0 was used to perform discriminant analyses, using the 'leave-one-out' option.

4.2.5 Crop husbandry analysis - stable isotopes of carbon and nitrogen

The methods followed in the analyses of the stable isotopes of carbon and nitrogen from samples from Çamlıbel Tarlası and Çatalhöyük are elucidated in this section. Details are provided on sample selection, pre-treatment, analysis and post-analysis data transformation. Material from Çamlıbel Tarlası and Çatalhöyük West, Trench 5 was analysed. In addition, material from Trench 1, Çatalhöyük West, as well as the TP area of Çatalhöyük East was examined, allowing a comprehensive analysis of growing conditions during the later Neolithic and Early Chalcolithic at Çatalhöyük and the tracing of any changes therein.

4.2.5.1 Sample selection

Two criteria were used to select the samples for stable carbon and nitrogen isotope analysis from Çamlıbel Tarlası and Çatalhöyük: charring and number of items. Experiments have indicated that the charring temperature of a seed affects the stable isotopic ratio of both carbon and nitrogen (Braadbaart et al. 2004a; Fraser et al. 2013a; Styring et al. 2013; Nitsch et al. 2015). To limit the distortion

of the isotopic values, only seeds determined to have been charred within the optimal charring window (220-240 degrees C for 4-24hrs) were used (Charles et al. 2015; Nitsch et al. 2015). To ascertain this, seeds were chosen on the basis of limited charring distortions; distortions such as cracking and blistering are an indication of higher than optimal charring temperatures (Boardman and Jones 1990; Braadbaart et al. 2004a; Braadbaart et al. 2004b; Charles et al. 2015; Nitsch et al. 2015).

Another selection factor was the procurement of a high enough number of items to be amalgamated in a single sample in order to provide a statistically robust number of grains to represent the variability within an ear/pod and to provide enough material for both carbon and nitrogen analysis. As the isotopic ratio varies between grains in the ear, the aim was to obtain a statistically robust number of grains that would smooth this variability (Bogaard et al. 2007; Fraser et al. 2011). Nitsch et al. (2015) used ten seeds, as research indicated this would be representative of the variation seen within a single growing condition. This number could not be used in this research due to the limited numbers of recovered seeds: 26 samples from Çamlıbel Tarlası and only five from Çatalhöyük have 10 or more seeds of the same crop taxa. Consequently, while ten items per sample was the aim, samples were included with lower numbers. The justification for this action is that without the included samples only barley and pulses taxa produced enough items for analysis and the full isotopic variation between the species could not have been measured.

The use of samples with low numbers of seeds reduces confidence that the results represent average values of growing conditions; higher uncertainty surrounds the values and as such if samples with less than 10 grains are included, any difference less than 1‰ must be treated with caution (Nitsch et al. 2015). In addition to high number of seeds, samples were only analysed if they had a weight greater than 10 mg to ensure enough material was available to conduct separate carbon and nitrogen analysis.

To allow for a higher number of items per sample, samples with low crop items were merged with other samples from the same unit. In addition, unsorted flots from the sample's unit were examined for specific crop species and together these items formed the isotopic sample. In the majority of cases isotopic samples are referred to by their labcodes which, together with their corresponding sample/unit numbers, are presented in Table 12.2.

A total of 199 isotope samples were analysed from Çatalhöyük and Çamlıbel Tarlası (Table 4.6). Ten different crop species were examined: hulled barley, einkorn, emmer, 'new type' glume wheat, free-threshing wheat, bitter vetch, lentil, grass pea, pea and chickpea. Barley, einkorn and free-threshing wheat dominate the Çatalhöyük samples, while barley, bitter vetch and lentils dominate the Çamlıbel Tarlası samples due to these taxa being both more common and better preserved.

Table 4.6: The number of stable carbon and nitrogen isotope samples from Çatalhöyük and Çamlıbel Tarlası.

Site	Phase	Number of samples	Total
Çatalhöyük	Trench 5	40	78
	Trench 1	26	
	TP area	12	
Çamlıbel Tarlası	CBTI	64	121
	CBTI/CBTII	3	
	CBTII	20	
	FPEU	3	
	CBTIII	23	
	CBTIV	8	

4.2.5.2 Pre-treatment

Pre-treatment is commonly conducted to remove contaminants within the seeds that have entered during their burial. Contaminants such as nitrates, carbonates and humics will distort the results of isotopic analysis due to their different isotopic ratios, reflecting a combination of the seed and the contaminant rather than the isotopic signature of the seed itself. Pre-treatment protocols implemented by previous researchers can also distort the isotopic ratios (see Vaiglova et al. 2014b); consequently it is recommended that pre-treatment should only be undertaken if contaminants are present. Vaiglova et al. (2014b) used the technique of FTIR (Fourier Transform Infrared Spectroscopy) to obtain spectra of the absorption and emission of the seeds to detect possible contamination by carbonates, humics or nitrates. This technique can be used to screen samples, gaining an understanding of contaminants present, allowing pre-treatment to be tailored for the specific contaminants present and preventing the pre-treatment of seeds that are not contaminated.

Pre-treatment of the Çatalhöyük samples followed Vaiglova (in prep). This was to ensure continuity in the treatment of samples from the East and West Mounds of the site and to simplify comparison between them. As such the samples were

subjected to a weak acid pre-treatment following the protocol described below for Çamlıbel Tarlası.

FTIR was conducted on three samples from Çamlıbel Tarlası using the procedure presented by Vaiglova et al. (2014b) (Table 4.7). Only three samples were used in order to conserve the amount of material available for stable isotopic analysis. The three samples chosen had high numbers of seeds allowing both FTIR and isotope analysis to be conducted. Analyses were conducted on a Fourier Transform Infrared Spectrometer with Attenuate Total Reflectance (FTIR-ATR). The background noise was subtracted from the resulting data and a baseline correction was conducted using Agilent Resolution Pro. Once the spectra were normalised they were then compared with spectra of the artificially contaminated seeds from Vaiglova et al. (2014b).

Table 4.7: Samples from Çamlıbel Tarlası used for contaminant screening with FTIR.

Unit	Species	Number of seeds
313	Bitter vetch	5
325	Lentil	3
843	Lentil	3

Comparison between the archaeological samples and the modern contaminated samples indicated a very slight peak at one of the wavelengths associated with carbonate contamination: 870 cm^{-1}, comparable to around 5% or less carbonate contamination in the reference material (Figure 4.1). Comparisons of the spectra to those of seeds artificially contaminated with nitrates showed no similarities in the areas attributed to nitrate contamination in archaeological grain, 1085, 1450 and 3300 cm^{-1} wavelengths (Vaiglova et al. 2014b) (Figure 4.2). Comparison with

the seeds containing humic acid contamination showed a peak in a similar area on the archaeological grains; however further investigation reveals that this peak is slightly greater than the 1010 cm^{-1} wavelength used by Vaiglova et al. (2014b) to define humic contamination. There is no double peak and no evidence of a peak at 1080 nor 3690 cm^{-1} (Figure 4.3). The other peaks in the spectra, which are missing from the control samples, are most likely due to differences in charring time and temperature between the control samples and the archaeological samples (Styring et al. 2013), or contamination by a substance that has no impact on the ratio of stable carbon or nitrogen isotopes. Thus the decision was made to treat the Çamlıbel Tarlası samples with the same weak acid wash pre-treatment to remove carbonate contamination only, the same protocol followed for the Çatalhöyük samples (see below).

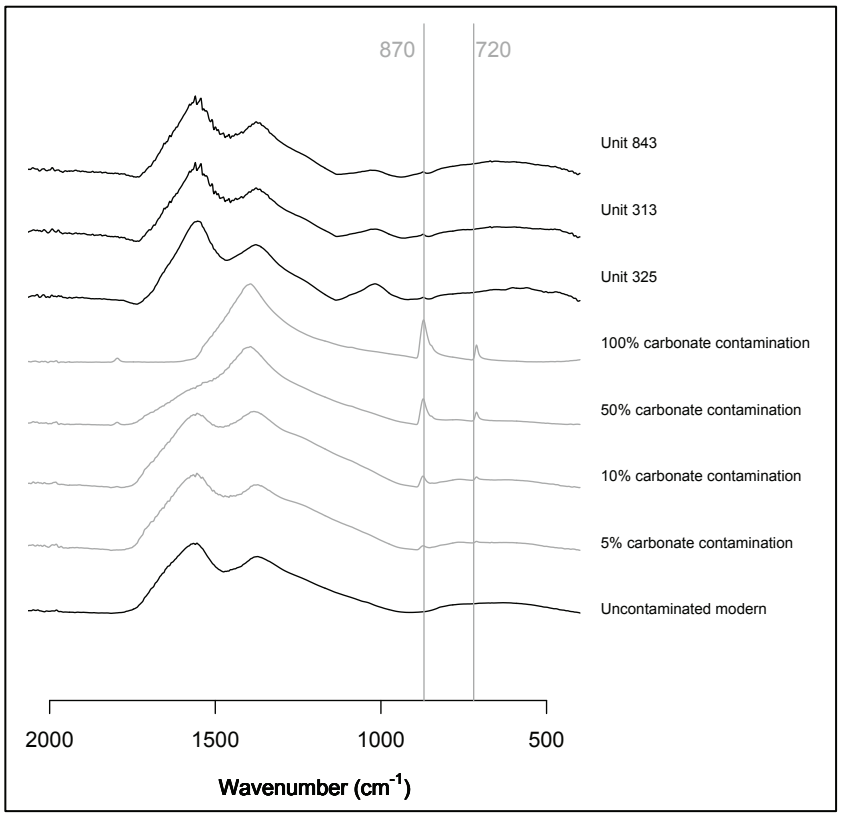


Figure 4.1: FTIR spectra for the three Çamlıbel Tarlası samples compared to modern grain artificially contaminated with carbonate (from Vaiglova et al. 2014b).

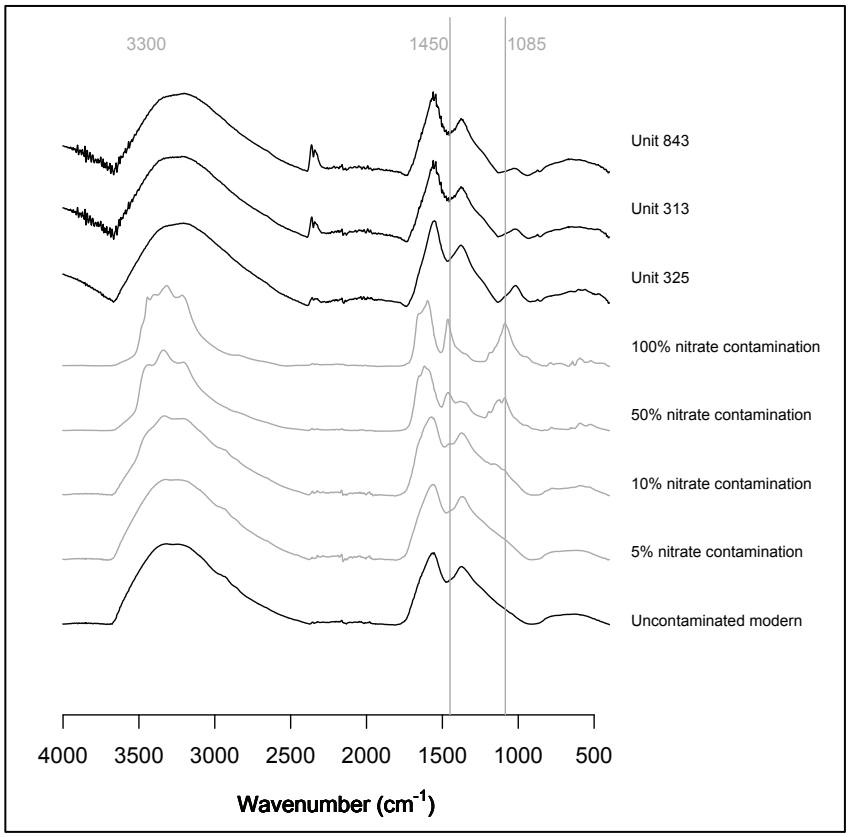


Figure 4.2: FTIR spectra for the three Çamlıbel Tarlası samples compared to modern grain artificially contaminated with nitrate (from Vaiglova et al. 2014b).

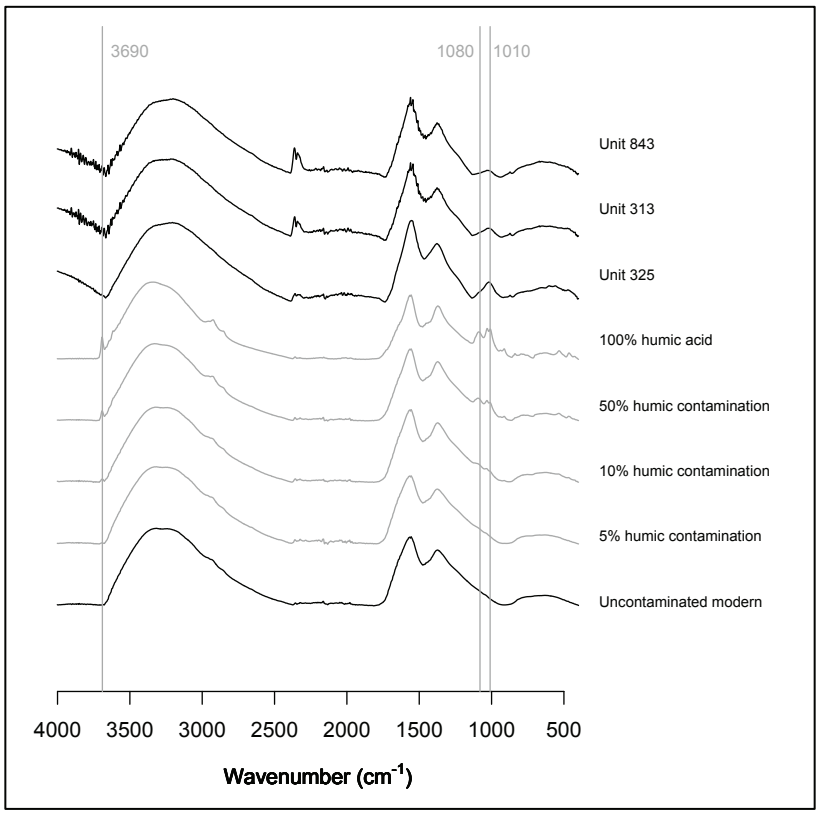


Figure 4.3: FTIR spectra for the three Çamlıbel Tarlası samples compared to modern grain artificially contaminated with humics (from Vaiglova et al. 2014b).

The pre-treatment protocol followed the recommendations from Vaiglova (2014b). Samples were weighed, crushed and then placed in glass test tubes. Pre-treatment for carbonate contamination involved the addition of circa 10 ml of 0.5 M HCL, then heating of the sample to 70 °C for 30-70 minutes until all effervescence had ceased. Samples were then centrifuged, the acid decanted, and distilled water used to rinse the samples until the liquid reached a pH of neutral (pH 7). As much water as possible was removed from the samples before freezing and then freeze-drying for 12- 24 hours until completely dry. The samples were re-weighed and weighed out into tin capsules for stable isotope analysis.

4.2.5.3 Isotopic measurement

The %C, %N, $\delta^{13}C$ and $\delta^{15}N$ of the samples were analysed at the University of Oxford on a Sercon EA-GSL mass spectrometer. The weights for each stable isotope run varied depending on species being analysed: cereals require less material for the carbon run compared to the pulses but require more material than the pulses for the nitrogen run. This is due to the composition of the seeds: pulses have a higher %N but lower %C than cereals. To ensure appropriate signal intensity for the mass spectrometer, the µg of C and N in the samples were matched to the standards used. Calculations were based on the known %C and % N of the standards and the reported range of %C and %N in Fraser et al. (2013a).

$\delta^{13}C$ and $\delta^{15}N$ were calculated with reference to the standards used and calibrated using an internal alanine standard. The ratios of $^{13}C/^{12}C$ were calculated as a $\delta^{13}C$ value with respect to the Vienna Peedee Belemnite scale using

the international standards of IAEA-CH6 and IAEA-CH7. The $^{14}N/^{15}N$ ratios were calculated as $\delta^{15}N$ values against atmospheric composition of N_2. This was achieved by comparison with the international standards of IAEA-N-2 and caffeine. The following equation was used:

$$\delta^a X(‰) = \left(\frac{\delta^a X_{sample}}{\delta^a X_{Standard}} - 1\right) \times 1000$$

a equals the isotope of element X.

The precision of the samples was calculated based on the uncertainty of the reference standards and the raw sample data following Kragten (1994). The mean precision for the carbon samples was ±0.18‰ and for the nitrogen samples ±0.29‰.

The C:N ratio was calculated using the following equation with the % C and % N obtained in the raw results:

$$C{:}N = \left(\frac{C\%}{N\%}\right) \times \left(\frac{14}{12}\right)$$

4.2.5.4 Data reliability

Understanding the reliability of the data is difficult, as unlike collagen the chemical composition of charred cereal grains and pulse seed is not clearly known. Instead, plant isotope studies have employed different methods to assess confidence in their reported values (see, for example, Bogaard et al. 2013b, Fraser et al. 2013b, Vaiglova et al. 2014a).

One method has been to compare the mean and standard deviation of the archaeological cereal and pulse populations' C:N ratio against modern experimentally charred cereal and pulse C:N ratio (Fraser et al. 2013b). However, problems could be encountered with the application of such a method to samples in this research. Carbon samples are run independently of the nitrogen samples with the reliability of the machine varying from day to day. Comparisons of the ratio of C:N is therefore flawed as the amount of C and the amount of N were in some cases measured on different days. Because separate carbon and nitrogen runs were performed, the calculation of the C:N ratio is inherently subject to error as each run had different sample errors. Moreover, there may also be weighing errors; inaccuracies result from the use of multiple weighing scales that vary in accuracy over time. Slight differences due to any one of these factors can result in major differences in the C:N ratio.

If the C:N ratio method cited by Bogaard et al. (2013b), and Vaiglova et al. (2014a) is employed, the results differ between the sites. When this method is applied to the Çatalhöyük samples from both late East Mound (TP area) and West Mound, results of the analysis indicate that there is a high proportion of nitrogen within the seeds. The ratio of carbon to nitrogen is skewed resulting in a lower C:N ratio than in the modern samples (Figure 4.4). As such there is a statistical difference between the Çatalhöyük cereal samples and the modern samples (Student t-test of equal variance $t(83)=-5.78$, $p<0.001$). If this method was employed, the cereal samples from Çatalhöyük would be deemed unfit data and discarded. Conversely, the majority of Çamlıbel Tarlası samples fall within the expected range. A student t-test with equal variance indicates no statistically significant difference between

the Çamlıbel Tarlası samples and the experimentally charred grains (t(68)=-1.3, p=0.2 for the cereals and t(82)=-1.15, p=0.15 for the pulses).

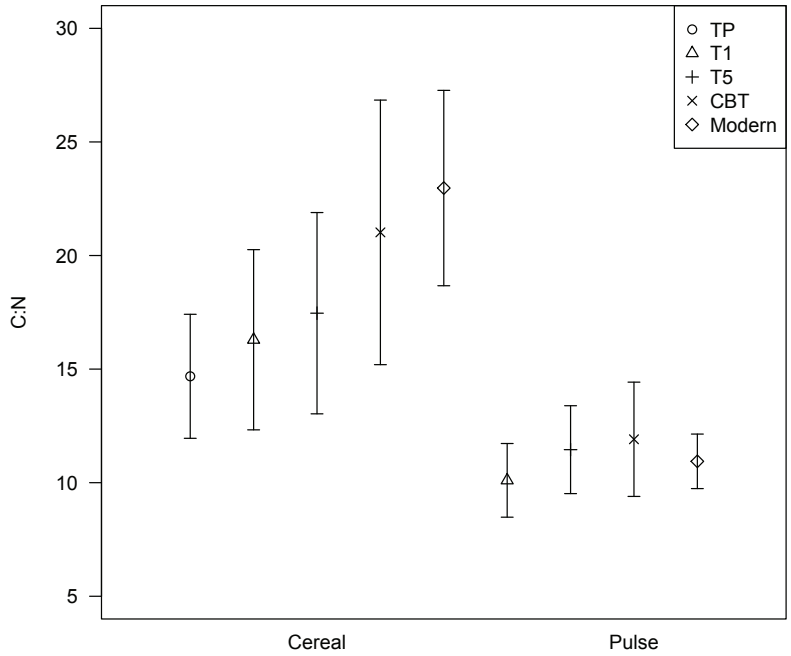


Figure 4.4: Comparison of Çamlıbel Tarlası (CBT) and the three trenches from Çatalhöyük: TP, Trench 1 (T1) and Trench 5 (T5). C:N ratios with ratios of modern grain and pulses (following Bogaard et al. 2013b; Vaiglova et al. 2014a; Styring et al. 2015).

Styring et al. (2015) applied a slightly different data cleaning method to the one used by Bogaard et al. (2013b) and Vaiglova et al. (2014a), and samples that fell outside the reported range of modern samples' C: N ratios were removed. If this type of comparison was used with the Çamlıbel Tarlası samples then a total of 27 samples (11 cereal and 16 pulse samples) would have to be removed. In the Çatalhöyük data the number is higher, with a total of 46 out of the 78 samples falling outside the modern range (from Fraser et al. 2013a). This is due to a very high %N in the Çatalhöyük samples.

Vaiglova at al. (2014a) examined potential contamination of archaeological seeds from Çatalhöyük East. Her work examined seeds using FTIR, in comparison with modern artificially contaminated seeds. The seeds from Çatalhöyük showed slight carbonate contamination but no nitrate contamination. Vaiglova's research also indicated that nitrate contamination is successfully removed by either a water wash or gentle acid treatment. Thus the Çatalhöyük samples in this study were pre-treated for carbonate contamination using acid and any nitrate contamination, if present, should have also been removed. Therefore, while the archaeological seeds' values are different from the modern values, this research suggests that the values are a true representation of the isotopic ratio produced during seed filling.

Another method researchers have employed to ascertain the reliability of the data is to exclude outlying samples, particularly in the case of single grain analysis (Lightfoot and Stevens 2012). In Lightfoot and Stevens' study, two samples were classed as statistical outliers; comparison with contemporary published data indicated values higher than any reported modern values and so these samples were removed. Other studies have used the presence of outliers as an indication that outlying samples should be re-measured at least twice (Wallace 2011:106).

Çatalhöyük has 10 samples classed as statistical outliers; Çamlıbel Tarlası has three (Table 4.8). A sample was classed as an outlier if its value was higher than the third quartile, or smaller than the first quartile by 1.5 times the interquartile range, relating to the data pertaining to that sample's species. A test re-run was conducted on an outlying barley sample (CW011) in the Çatalhöyük West dataset

for $\delta^{15}N$. The results suggest some validity in re-running outlying samples, as the new result was significantly different: its $\delta^{15}N$ changed from 2.12‰ to 7.31‰. Consequently all outliers were re-run another two times. Sample CW011's $\delta^{15}N$ value was the only significantly different result, with all other samples returning average values within 1‰ of the original. As such, the isotopic value used for these samples was the average of all three runs, with the exception of sample CW011 where the first values were disregarded and an additional re-run was conducted (Table 4.8).

The re-running of outlying samples indicated fluctuations of values for a single sample. While no sample's average differs by more than 1‰ from the original (with the exception of CWO11 $\delta^{15}N$) the results do indicate that any difference between samples of less than 1‰ may be due to machine variability. Of note is the higher variability in results for $\delta^{15}N$ compared with $\delta^{13}C$; $\delta^{13}C$ has a smaller variability (~ 0.2‰). Potentially this indicates that smaller differences in the carbon results may be due to real differences in the grain isotope values compared with small differences in $\delta^{15}N$ more likely due to the machine measurement or preparation error/variability.

Table 4.8: Trench, species and isotopic values of the outlying samples from Çatalhöyük and Çamlıbel Tarlasi, showing the results of re-analysis.

Site	Lab code	Species	Isotope	Original value	Repeat 1	Repeat 2	Repeat 3	Average	SD	Original value - average
Çamlıbel Tarlası	CBT007	Bitter vetch	$\delta^{15}N$ (‰)	3.50	2.29	2.36		2.72	0.68	0.78
Çamlıbel Tarlası	CBT024	Barley	$\delta^{15}N$ (‰)	8.30	8.46	7.89		8.22	0.30	0.08
Çamlıbel Tarlası	CBT060	Barley	$\delta^{15}N$ (‰)	7.80	7.31	7.83		7.65	0.29	0.15
Çatalhöyük West	CW011	Barley	$\Delta^{13}C$ (‰)	-23.98	-24.24	-24.28		-24.17	0.17	0.19
Çatalhöyük West	CW011	Barley	$\delta^{15}N$ (‰)	2.12	7.31	8.06	7.62	7.66	0.38	-5.54
Çatalhöyük West	CW024	Barley	$\delta^{15}N$ (‰)	18.50	19.00	18.77		18.76	0.25	-0.26
Çatalhöyük West	CWIT001	Emmer	$\Delta^{13}C$ (‰)	-24.26	-24.55	-24.56		-24.46	0.17	0.20
Çatalhöyük West	CWIT016	Einkorn	$\delta^{15}N$ (‰)	18.50	17.31	17.87		17.90	0.59	0.60
Çatalhöyük West	CWIT026	Free-threshing wheat	$\delta^{15}N$ (‰)	5.50	6.00	5.65		5.71	0.25	-0.21
Çatalhöyük West	TP002	'New type'	$\delta^{15}N$ (‰)	15.11	14.08	15.01		14.73	0.56	0.38
Çatalhöyük West	TP005	Barley	$\delta^{15}N$ (‰)	5.90	5.12	5.09		5.37	0.46	0.53
Çatalhöyük West	TP008	Barley	$\delta^{15}N$ (‰)	5.53	4.60	4.38		4.84	0.61	0.69
Çatalhöyük West	TP011	Emmer	$\delta^{15}N$ (‰)	18.26	17.11	16.69		17.35	0.81	0.91

4.2.5.5 Calculation of $\Delta^{13}C$

$\Delta^{13}C$ was calculated to allow for comparison with modern studies and between the two temporally separated sites. $\delta^{13}C$ was converted into $\Delta^{13}C$ to allow its representation independent of its CO_2 source, shown as $\Delta^{13}C$. Such calculations change the negative $\delta^{13}C$ values into a positive $\Delta^{13}C$ value. This follows the principles delineated by Farquhar et al. (1989).

$$\Delta^{13}C = \frac{\delta^{13}C_{air} - \delta^{13}C_{plant}}{1 + \delta^{13}C_{plant}/1000}$$

The value of the past air $\delta^{13}C$ was calculated using Ferrio et al. (2005a) data. Ferrio et al. (2005) constructed a smoothed curve of the $\delta^{13}C$ of atmospheric CO_2 from Antarctic ice core records from 16100 BC to 2010 AD. Their dataset allows the input of date ranges to extrapolate the $\delta^{13}C$ of air within that time range. The dates for Çamlıbel Tarlası (3470-3590 cal. BC) returned the mean air value of -6.37‰. Çatalhöyük West (6100-5500 cal. BC) returned the value of -6.66‰. While their data are only an approximation, due to potential spatial variability when using Antarctic ice cores and difficultly in dating precisely, the Ferrio et al. (2005a) data provide a way of estimating the atmospheric $\delta^{13}C$ during the occupation of Çamlıbel Tarlası and Çatalhöyük West.

4.2.5.6 Calculation of the forage value

The $\delta^{15}N$ value of forage consumed by animals was calculated to provide a proxy for the natural baseline for the environment (see, for example, Bogaard et al. 2013b). Comparison of these values provides an understanding of whether crops, and therefore crop field values were elevated compared to the surrounding natural environment, in turn indicating anthropogenic enrichment of crop fields.

Such calculations used the mean collagen value of herbivores from the sites. Where possible, wild herbivore values were used but at Çatalhöyük this was not possible and domesticated herbivore values had to be used. By subtracting the average trophic offset (4‰) from the mean herbivore value (Lee-Throp 2008), the lower limit of the forage value was calculated. To take into account the fact that animals are more likely to be consuming leaves, roots, stems and twigs than seeds/grain, an upper limit accounted for the difference between grain and rachis by the addition of +2.4‰ to previously calculated value. This offset is based on Fraser et al. (2011:2799) who indicate that the $\delta^{15}N$ value of cereal rachis is consistently less than cereal grain by 2.4 ± 0.8‰.

5 Archaeobotanical overview

This chapter provides an overview of composition of samples at the four study sites. Specific attention is paid to the spectrum and relative proportions of the identified crop taxa, as well as to major wild taxa and their relative proportions in comparison with crops.

5.1 Çatalhöyük West

As explained in Chapter 4, samples initially were selected for analysis if they contained at least 100 charred crop items and 30 charred weed/wild items, or at least 100 charred weed/wild items, or if the archaeological context suggested in situ activities. As many samples did not meet these criteria, 30 crop items became the new cut off. Three of the 45 samples did not contain 30 crop items, and although included in the assemblage and summary tables (Table 5.2, 12.3), were removed from statistical analysis that compared between samples to prevent the low number presenting skewed patterns. Samples with less then 30 items are not likely to be representative of the archaeobotanical record from which they came.

Figure 5.1 summarises the relative proportions of the major archaeobotanical categories in the Çatalhöyük West samples and reveals a predominantly even mixture of crop and weed items. Only four samples contain 70% crop items of the total charred crop and weed/wild remains while three samples contain 70% or greater weed/wild items (Figure 5.1,Table 5.1). The remaining 35 samples contain a mixture of crop and weed material below the 70% threshold. Reducing the arbitrary cut-off level to 60% resulted in 15 samples classed as crop-rich, nine samples as weed-rich and the remaining 18 samples as mixed. As there appears

to be a mixture of sample types it is very important to gain an understanding of the taphonomic processes that formed the samples. The high weed proportions in the samples hint at possible mixing of different activities. Before any understanding of crop processing or crop husbandry can be conducted further exploration of whether the wild taxa represent arable weeds is required.

Examination of the percentage composition of the major crop types was also conducted using the 70% arbitrary cut-off point. Table 5.1 shows the results of such classifications, and highlights the dominance of glume wheats in the assemblage. All samples were classified as glume wheat dominated, of relevance to further chapters, especially crop processing and crop husbandry determinations, as it indicates that glume wheats are most likely associated with some assemblage weeds.

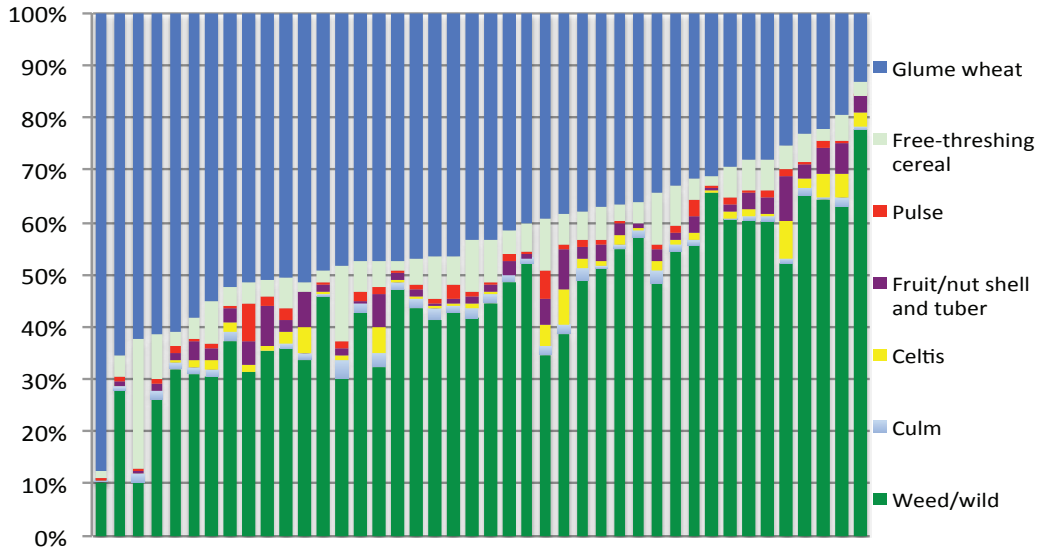


Figure 5.1: Proportions of weed/wild, culm, *Celtis*, fruit/nut shell and tuber, pulse, free-threshing cereals and glume wheat items in the 42 Çatalhöyük West samples containing 30 or more items.

Table 5.1: Relative proportions of plant items in each Çatalhöyük West sample, sorted on proportion of crop material.

Sample	%Crop	% Weed/ wild	Dominant class	% Glume wheat	% Barley	% Free-threshing wheat	%Pulse items	Dominant crop class
9602	**89**	11	Crop	98	0	1	0	Glume wheat
9573	**89**	11	Crop	71	19	9	1	Glume wheat
9562	**72**	28	Crop	93	4	1	1	Glume wheat
9495	**72**	28	Crop	87	12	0	1	Glume wheat
10099	69	31	Mixed	89	7	2	1	Glume wheat
u18341	69	31	Mixed	75	12	11	2	Glume wheat
9564	67	33	Mixed	94	4	0	2	Glume wheat
11100	67	33	Mixed	82	7	0	11	Glume wheat
9563	66	34	Mixed	86	6	6	2	Glume wheat
9613	62	38	Mixed	92	5	2	0	Glume wheat
8461	62	38	Mixed	91	6	0	3	Glume wheat
10279	62	38	Mixed	88	9	0	2	Glume wheat
11041	62	38	Mixed	86	5	5	3	Glume wheat
11088	61	39	Mixed	72	14	4	10	Glume wheat
9600	60	40	Mixed	93	7	0	1	Glume wheat
9524	57	43	Mixed	86	11	0	3	Glume wheat
u31114	57	43	Mixed	85	7	3	6	Glume wheat
10265	57	43	Mixed	84	6	8	2	Glume wheat
11092	57	43	Mixed	80	16	2	2	Glume wheat
8953	56	44	Mixed	89	7	3	1	Glume wheat
11094	54	46	Mixed	95	4	0	1	Glume wheat
10111	54	46	Mixed	85	13	0	2	Glume wheat
10110	54	46	Mixed	83	11	5	1	Glume wheat
9471	52	48	Mixed	96	4	0	1	Glume wheat
8360	50	50	Mixed	88	7	3	3	Glume wheat
9591	49	51	Mixed	76	22	0	2	Glume wheat
9603	48	52	Mixed	85	12	0	3	Glume wheat
9341	47	53	Mixed	87	10	2	1	Glume wheat
11097	46	54	Mixed	83	7	8	2	Glume wheat
8911	45	55	Mixed	78	17	2	3	Glume wheat
9619	42	58	Mixed	91	8	0	1	Glume wheat
9358	41	59	Mixed	91	8	1	0	Glume wheat
11089	41	59	Mixed	81	8	2	9	Glume wheat
u31210	38	62	Mixed	82	11	4	4	Glume wheat
11087	38	62	Mixed	81	13	3	3	Glume wheat
9519	37	63	Mixed	81	17	0	2	Glume wheat
11053	37	63	Mixed	79	8	8	4	Glume wheat
11093	34	66	Mixed	93	6	0	1	Glume wheat
11096	31	69	Mixed	81	18	0	2	Glume wheat
Floor 16977	29	**71**	**Weed**	86	10	0	4	Glume wheat
Floor18376	29	**71**	**Weed**	79	9	10	2	Glume wheat
10100	17	**83**	**Weed**	82	16	1	1	Glume wheat

5.1.1 Crops

Ten crop taxa were positively identified: emmer (*Triticum dicoccum* Schübl.), einkorn (*Triticum monococcum* L.), 'new type' glume wheat (*Triticum* sp.), bread wheat (*Triticum aestivum* L.), hulled barley (*Hordeum vulgare* L.), naked barley (*Hordeum vulgare* L. var. *nudum*), pea (*Pisum sativum* L.), lentil (*Lens culinaris* Medik.), bitter vetch (*Vicia ervilia* (L.) Willd.) and grass pea (*Lathyrus sativus* L.).

'New type' glume wheat refers to a type of glume wheat the true taxonomic name of which is uncertain. First identified as morphologically distinct glume bases when compared to einkorn and emmer in Greece by Jones et al. (2000b), 'new type' glume wheat items have features similar to *Triticum timopheevi* Zhuk. Preserved remains of whole spikelets were identified in Austria, allowing the identification of the grain (Kohler-Schneider 2003) and this species has been identified in South West Asia, occurring in material from the East Mound of Çatalhöyük (Bogaard et al. 2013a).

Cereals are the dominant crop remains in the assemblage, occurring in all samples but differing dramatically in quantities. Six cereal taxa were identified as both chaff and grain remains: emmer, einkorn, 'new type' glume wheat, hulled barley (two-rowed), naked barley (two-and six-rowed) and bread wheat. Glume wheat chaff is the dominant crop component in the assemblage (Figure 5.2).

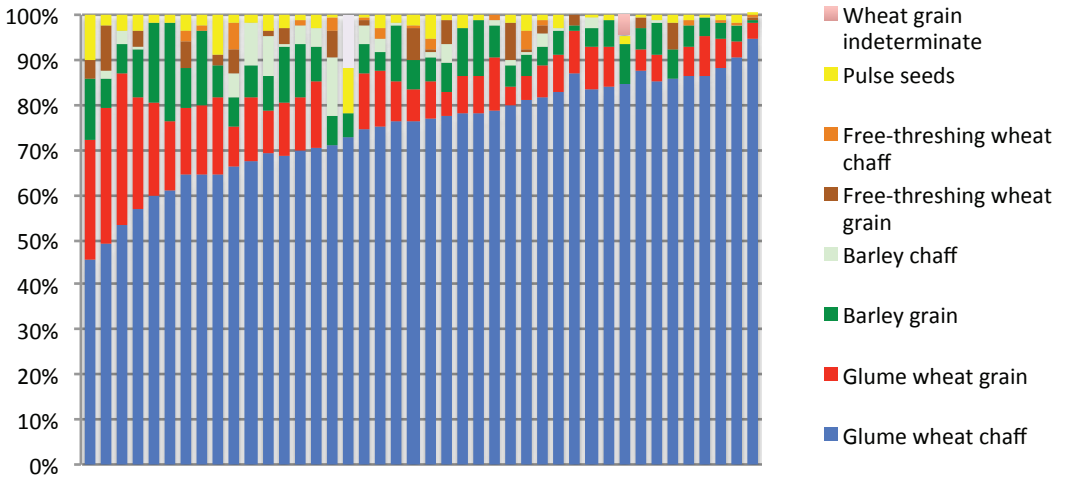


Figure 5.2: Proportions of crop catergories in the 42 Çatalhöyük West samples containing 30 or more crop items.

Emmer and 'new type' glume bases are the dominant glume wheat components, each occurring in 89% of the samples; einkorn glume bases are only a minor occurrence (Figure 5.3, Table 5.2). Experimental research has indicated that einkorn glume bases, due to their gracile nature, are less likely to preserve via charring (Boardman and Jones 1990) and so their limited ubiquity in the assemblage (22% of the 45 samples) could, at least in part, reflect charring bias. The majority of the samples contain a mixture of 'new type' and emmer and slightly more than half contain more 'new type' glume bases than emmer glume bases (Figure 5.3).

Terminal spikelets were identified in 64% of the Çatalhöyük West samples. These glume bases presumably come from either 'new type' or emmer, as the terminal spikelet of einkorn is infertile and very small and highly unlikely to survive charring (Percival 1921:172; Weide 2015).

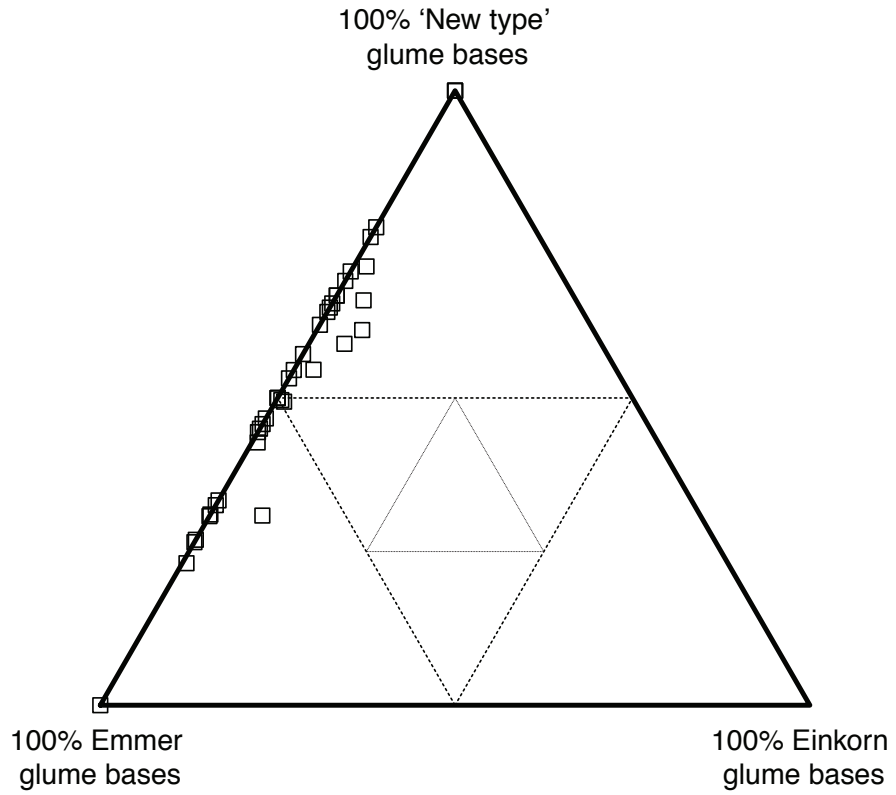


Figure 5.3: Proportions of the three glume wheat species' glume bases in the 40 Çatalhöyük West samples containing 30 or more glume bases.

Glume wheat grains occur frequently in the Çatalhöyük West assemblage, but are limited in number in comparison to their corresponding chaff. 'New type' and emmer grains occur in relatively low numbers, 82 and 215 grains respectively, compared to the 442 identified einkorn grains. Two types of einkorn were identified, one- and two-seeded einkorn, with one-seeded einkorn grain dominating in numbers (Table 5.2). Einkorn grains occur in 62% of samples, with 51% of samples containing one-seeded einkorn and 16% containing two-seeded einkorn. In comparison, emmer and 'new type' grain have been positively identified in 36% and 18% of samples, respectively.

The relatively high frequency of einkorn grain contrasts with the rarity of its chaff. This is possibly due to the ease of positive identification as the convex ventral side of one-seeded einkorn, as well as its pointed apical end, means that small fragments can easily be distinguished from the other two-seeded glume wheats. Similar small-sized fragments of emmer and 'new type' grains, in particular the apical ends, are difficult to distinguish from each other and from free-threshing wheats and therefore are more commonly identified as wheat indeterminate.

Three free-threshing cereal taxa represented by both grain and chaff remains were identified in the Çatalhöyük West samples: hulled barley, naked barley and free-threshing wheat. Hulled barley grains are the most ubiquitous crop seed occurring in 82% or 37 of the 45 samples (Table 5.2). Naked barley grain occurs in only 20% of the West Mound samples, with free-threshing wheat, 172 grains, occurring in 44% of the samples.

Examination of naked and hulled barley grains revealed no twisted grain and so rachis remains was used to indicate the presence of six- and two-rowed barley varieties following criteria developed by Charles et al. (2010). Six-rowed naked barley rachis was identified in 33% of samples but six-rowed hulled barley rachis was absent from the assemblage. Two-rowed naked barley rachis (20%) and hulled barley rachis were also identified (24%). Due to the primary identification criteria relying on the presence or absence of the central floret's glume bases it is difficult to positively differentiate between two-rowed hulled and naked barley rachis. Modern hulled barley rachis internodes, once threshed, do not contain

these stubs. Such absences in archaeological material are possibly due more to preservation issues than type; poor preservation could lead to confusion between naked and hulled two-rowed barley rachis. The smoothness of the grain pads was relied upon to identify two-rowed hulled barley rachis.

Naked barley rachis occurs more frequently in the samples than its corresponding grain, differing from hulled barley, which was more frequently found as grain rather than chaff (Table 5.2). This difference in grain to rachis quantities between the two barley types is suggestive of a behavioural cause rather than a taphonomic bias. Grains survive the charring process more successfully than chaff remains (Boardman and Jones 1990:10), and so the dominance of naked barley rachis over naked barley grains should not be related to survivability. The identification of only 32 naked barley grains compared to 96 naked barley rachis internodes potentially indicates the remains of crop processing within the assemblage.

Free-threshing wheat rachis remains, positively identified as bread wheat, occur in 38% of the samples: it is assumed that all free-threshing wheat grains are bread wheat grains.

Lentil and pea are the dominant pulse taxa in the Çatalhöyük West assemblage, occurring in 51% (23 samples) and 27% (12 samples) of the samples, respectively (Table 5.2). Bitter vetch and grass pea are found less frequently: thirteen bitter vetch seeds and two grass peas were positively identified. Only one

fragment of pulse pod was positively identified and so offers no additional information.

The Çatalhöyük West samples have limited contextual differentiation as the majority of them are derived from secondary midden deposits. Any variation in composition due to spatial difference is explored in Chapter 6 using correspondence analysis.

5.1.2 Variation in crop composition

Figure 4 shows the dominance of glume wheat in the Çatalhöyük West assemblage, a consequence of the high number of glume bases present, contributing over 77% of the crop material present (Figure 5.4a). Such large quantities of glume wheat chaff indicate its role as an everyday crop. While not denying the high importance of the glume wheats within the crop suite, examination of simply the grain remains illustrates the hidden importance of hulled barley in the assemblage (Figure 5.4b). Of the 42 samples, hulled barley grain occurs in 82% or 37 samples, compared to glume wheat grain in 84% or 38 samples (Table 5.2). Glume wheat grain numbers are higher than hulled barley, with 744 grains compared to 504 hulled barley grains but the fact remains that hulled barley is not a minor crop in the assemblage.

The Çatalhöyük West assemblage has limited quantities of pulse and free-threshing wheat compared to glume wheat and barley remains (Figure 5.5). The four pulse taxa are less ubiquitous and occur in much lower numbers than the cereal remains (Table 5.2). Lentil is the most ubiquitous of the pulse taxa

occurring in 51% of samples, compared to 82% for hulled barley. Research indicates that different conditions are not required for the preservation of cereal grains and pulse seeds and therefore the limited number of pulse seeds is not the result of bias due to different preservation requirements (Boardman and Jones 1990; Braadbaart et al. 2004b; Braadbaart 2008; Charles et al. 2015). This difference therefore reflects 'real' differences in production and consumption practices for cereals versus pulses.

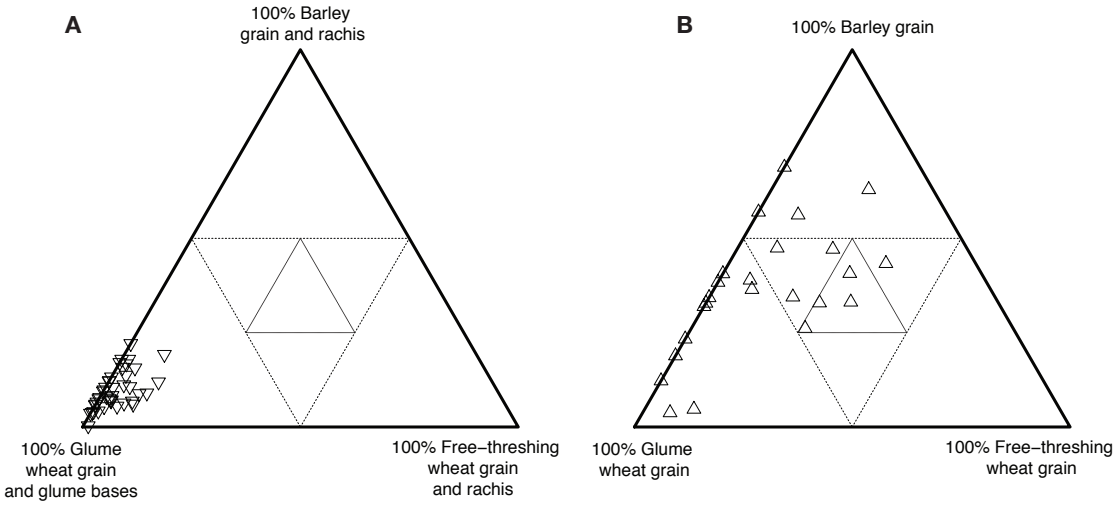


Figure 5.4: Comparison of the grain (A) and grain and chaff (B) remains of cereal groups: barley, glume wheat and free-threshing wheat from the 42 Çatalhöyük West samples containing 30 or more cereal items.

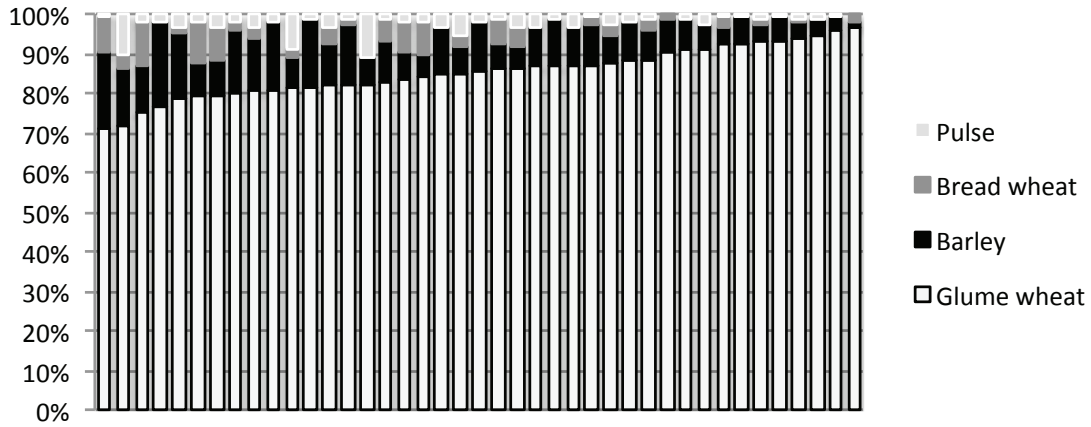


Figure 5.5: Proportions of pulse, bread wheat, barley and glume wheat remains in the 42 Çatalhöyük West samples containing 30 plus crop items.

Removal of chaff remains when comparing species reduces the crop processing/preservation biases but may introduce an additional bias favouring free-threshing cereals. Removal of the chaff in some samples results in no glume wheats registering in the analysis, but the actual existence of glume wheat chaff in the samples indicates the presence of glume-wheat, but non-preservation of its grains, during this behavioural episode.

A different approach would be to compare the most abundant items of each taxon. For the West Mound, this results in comparison of barley grain with glume wheat chaff, revealing the high quantity of this chaff compared to the small number of free-threshing cereal grains (Figure 5.6). The problem with this comparison is obvious; it compares different components. The grain is a consumable product; the likelihood of its loss and subsequent charring is significantly lower than that of by-products, such as chaff, and thus there will be an inherent bias against its preservation in the archaeobotanical record. Conversely, grain survives charring better then chaff, introducing a selection for grain remains over chaff remains. Such biases make interpretation of the results problematic.

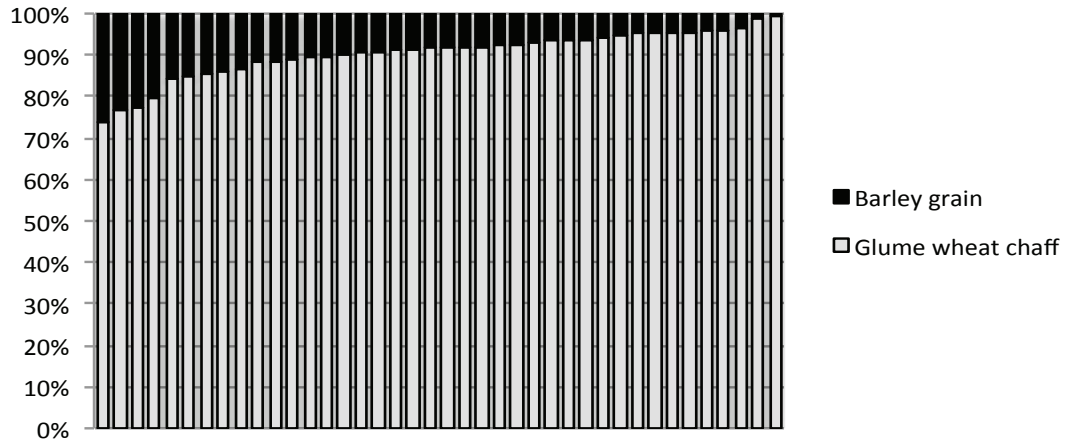


Figure 5.6: Proportion of barley grain and glume wheat chaff in the 40 Çatalhöyük West samples containing at least 30 such items.

Table 5.2: Summary of the abundance and frequency of the crop categories from Çatalhöyük West samples, * includes all items including indeterminate classes.

Cereals	Item	Total items	Maximum	Ubiquity	
				Count	(%)
Einkorn, one-seeded type	Grain	320	61	23	51
Einkorn, two-seeded type	Grain	122	43	7	16
Einkorn	**Grain**	442	104	28	62
Emmer	Grain	215	30	16	36
"New Type" glume wheat	Grain	82	22	8	18
Total glume wheat*	**Grain**	**842**	**104**	**38**	**84**
Free-threshing wheat	Grain	172	40	20	44
Wheat indeterminate	Grain	19	11	4	9
Naked barley	Grain	32	9	9	20
Hulled barley	Grain	510	43	37	82
Total Barley *	**Grain**	**577**	**49**	**43**	**96**
Cereal indeterminate	Grain	1	1	1	2
Chaff					
Einkorn	Glume base	58	18	10	22
Emmer	Glume base	3359	581	40	89
"New Type" glume wheat	Glume base	3589	223	40	89
Total glume bases*	**Glume base**	**7006**	**762**	**43**	**96**
Bread wheat	Rachis	106	43	17	38
Naked 2-row barley	Rachis	22	4	11	24
Naked 6-row barley	Rachis	83	24	17	38
Hulled 2-row barley	Rachis	74	24	13	29
Total barley rachis*	**Rachis**	**179**	**38**	**25**	**56**
Pulse					
Bitter vetch	Seed	13	4	6	13
Lentil	Seed	122	18	23	51
Pea	Seed	42	8	12	27
Grass pea	Seed	2	2	1	2
Pulse indeterminate	Seed	20	4	12	27
Total pulse*	**Seed**	**200**	**25**	**40**	**89**

5.1.3 Wild taxa

5.1.3.1 Edible plants

A number of potentially edible wild food species, three nut/fruit taxa and the oil seed species *Descurainia sophia* (L.) Webb, were identified within the assemblage. Other remains of potential food taxa were either limited in identification and/or of limited indication as to actual use as food, reducing conclusions regarding the use of such species.

Celtis seeds or hackberry were found in 87% of the samples. These seeds readily preserve due to their siliceous nature and therefore have been excluded from calculations of total weed/wild items. Comparison of such items with charred remains is problematic as charred material will be underrepresented. However the intentional use of hackberry is probable as this genus is still utilised in Turkey today (Ertuğ-Yaras 1997).

Fragments of fruit stone are a common component of the assemblage; identified were the heavily sculptured *Prunus divaricata* (Ledeb.) type fruit stone as well as remains of *Pistacia* species' nutshell (Table 5.3). Only one fig (*Ficus* sp.) seed was identified within the assemblage. East Mound samples contained a small number of fig seeds and this limited occurrence could indicate either unintentional collection or limited potential contact with fire resulting in low preservation. A limited quantity of acorn (*Quercus* sp.) nutshell and caps were identified in the Çatalhöyük West samples.

Table 5.3: Edible taxa in the Çatalhöyük West assemblage showing the total number of items found, the maximum within all samples, number of samples containing the taxa and the percentage of samples in which the taxa is present.

Latin	English	Total items	Max.	Ubiquity	
				Count	(%)
Amygdalus L./*Prunus* L.	Almond/plum stone fragments	71	23	28	62
Bolboschoenus glaucus (Lam.) S.G. Smith	Club rush seed	1469	124	44	98
Bolboschoenus glaucus (Lam.) S.G. Smith	Club rush tuber	32	5	25	56
Celtis L.	Hackberry nutlets, silicified	314	93	39	87
Descurainia sophia (L.) Webb	Wild mustard seed	2110	296	38	84

Latin	English	Total items	Max.	Ubiquity	
				Count	(%)
Ficus sp.	Fig seed	2	1	2	4
Pistacia terebinthus L. type	Pistachio nutshell	42	8	25	56
Prunus divaricata Ledeb. type	Wild plum sp., stone fragments	17	2	15	33
Quercus L.	Acorn cap	7	2	6	13
Quercus L.	Acorn nutshell	3	1	3	7
	Indeterminate nut shell	10	1	10	22
	Indeterminate nutshell/fruit stone	8	2	7	16

Seeds from wild mustard (*Descurainia sophia* (L.) Webb) are in 84% of the samples and contribute 30% of the total wild/weed assemblage. This small-seeded crucifer has been found in East Mound storage bins and it is hypothesised that it was utilised for oil as well as flavouring in cooking (Townsend and Guest 1980; Bogaard et al. 2013a). It is also possible that this species is a crop weed and could have been introduced into the archaeological record through the disposal of crop processing waste or accidental spillage of cooking material. The taphonomic pathway by which this species was incorporated into the assemblage is explored further in later chapters.

The nutlets of club rush (*Bolboschoenus glaucus* (Lam.)) are the most ubiquitous of the wild/weed taxa in the assemblage (Table 5.3). The large quantity at the site, in conjunction with finds of club rush tubers, indicate the use of multiple parts of this plant. Past research has linked the occurrence of the seeds with the plant's use as a foddering material – mineralised and charred seeds have been found in a number of penning contexts on the East Mound (Fairbairn et al. 2005; Filipović 2014). Research also indicates the possible use of this species for human consumption, grinding the nutlets to make gruel or bread (Wollstonecroft et al.

2008). Nutlets occur in dung on the East Mound and current statistical analysis of that assemblage indicates the co-occurrence of the club rush nutlets with other dung-derived flora; this species most likely entered the assemblage through foddering as opposed to human consumption (Fairbairn et al. 2005; Bogaard et al. 2013a). The lack of penning contexts on Çatalhöyük West limits this area of investigation and this species' relationship to dung-derived flora is investigated in Chapter 6.

In addition to potentially edible nutlets, a large number of tuber fragments from club rush were found in the West Mound assemblage, occurring in 56% of samples. It is currently debated as to whether this plant had a culinary purpose or an economic use. Ethnographic researchers have commented on the incorporation of tubers into mud bricks as a kind of temper, while archaeological evidence has highlighted the presence of consumed tubers in animal dung remains (Matthews 2005; Erkal 1999). While the club rush seeds and tubers are palatable, it is difficult to assign their presence on the site as solely due to use as human food.

5.1.3.2 Culm

The culm nodes found in the assemblage were divided into two morphological groups: reed type and cereal type (see Chapter 4). Both the rhizome and culm nodes of reed (*Phragmites*) as well as the base and nodes of cereal straw were identified. Reed culm is highly ubiquitous within the assemblage (87%, Table 5.4), continuing a trend identified in East Mound assemblages (Fairbairn et al. 2005; Bogaard et al. 2013a). East Mound phytolith research indicates a range of

uses for reed, including matting, roofing and basketry. While *Phragmites* commonly occurs in wetland/waterlogged conditions, it will also exploit other environments (Davis 1965-1989), can be invasive, colonising disturbed conditions via vegetative growth and today can be seen in fields surrounding Çatalhöyük (pers. observation)(Ryan 2009) (Figure 5.7).



Figure 5.7. *Phragmites* in modern cereal fields near the site of Çatalhöyük. Photo courtesy of A. Bogaard.

Cereal culm and bases are also common in the West Mound assemblage and occur in 49% of samples (Table 5.4). One hypothesis is that cereal culm increased in use from the East to West Mound, indicating both a high reliance on cereal culm as a raw material and a diminishing use of reed, as examination of East Mound assemblages indicates limited occurrence of cereal-like culm (Bogaard et al. 2013a). Past identification of cereal culm was reliant solely on size, or size and gross morphology (Fairbairn et al. 2005; Bogaard et al. 2013a) and consequently it is possible that such figures under-represent cereal culm within the East Mound assemblage. However previous work on the Trench 1 assemblage from the West Mound detected a shift towards more cereal culm, even when using the old criteria (Bogaard pers. comm.). Differences in the occurrence of culm in the record may reflect a change in the harvesting method from ear-harvesting to

lower straw-harvesting. It is also possible that the increase in culm presence indicates the occurrence of different crop processing waste in the assemblage, and may represent a shift from disposal of early stages of crop processing off-site to the use of such by-products on-site.

Table 5.4: The number of culm items in the Çatalhöyük assemblage, maximum number found in a sample and the ubiquity of culm in the assemblage.

	Total items	Maximum	Ubiquity	
			Count	(%)
Cereal culm/bases	83	33	23	51
Reed culm	105	8	40	89
Culm indeterminate	26	8	13	29
Total Culm	214	38	41	91

5.1.3.3 Other wild/weed taxa

One hundred and seven different categories of wild/weed plants were identified in the assemblage. Twenty-three of these were indeterminate categories or items identified only to family level. An additional 12 categories described mineralised or siliceous remains, while five categories described pod remains. A wide range of wild taxa were identified including wetland/marshy species (e.g. *Bolboschoenus* sp., *Carex* sp.) and crop weeds/ruderals such as *Polygonum* sp., *Rumex* sp. and *Galium* sp. High numbers of small-seeded grasses and crucifers are notable in the assemblage such as *Sporobolus* sp., *Crypsis* sp., *Aeluropus* sp. and *Descurainia sophia*) (Table 5.5).

The ubiquity and total numbers of the weed/wild assemblage taxa were examined (Table 5.5). Only those taxa identified to genus level were included, a total of 58 categories. Arbitrary cut-offs were applied; anything occurring in more than 50% of the samples was classed as frequent, anything 10-50% classed as

common, anything below 10% as rare. This resulted in 10 taxa classed as frequently occurring, 19 classed as common and 29 classed as rare (Table 5.5). At this preliminary stage no taxon was defined as weed or wild. Instead, the general growing habitat required, current distribution within Turkey together with other research on assemblages that included such taxa, was delineated for the family groups of frequently occurring taxa.

Table 5.5: The count, maximum number of items per sample, total number of items and percentage of samples of frequent and rare wild taxa in the Çatalhöyük West assemblage.

Taxa	Total items	Max.	Ubiquity	
			Count	(%)
Frequent				
Bolboschoenus glaucus (Lam.) S.G. Smith	1469	124	44	98
Descurainia sophia (L.) Webb	2110	296	38	84
Sporobolus R. Br. (*S. virginicus* (L.) Kunth type)	645	41	35	78
Crypsis aculeata (L.) Aiton type	355	48	27	60
Artemisia annua L. type	323	72	25	56
Aeluropus Trin.	323	40	25	56
Rumex L.	108	17	25	56
Polygonum aviculare	230	31	24	53
Leguminosae , small wild	110	19	24	53
Galium L., large type	35	5	23	51
Common				
Taeniatherum caput-medusae L. grain	68	12	21	47
Juncus L.	180	24	19	42
Atriplex L.	87	9	15	33
Hordeum murinum L. type	26	8	13	29
Vaccaria pyramidata Medik.	27	8	12	27
Carex L.	43	8	10	22
Salsola L.	25	8	10	22
Taeniatherum caput-medusae L. rachis	39	16	9	20
Polygonum indeterminate	25	8	9	20
Vicia L./*Lathyrus* L.	15	7	9	20
Bromus hordeaceus L./*commutatus* Schrad.	13	4	8	18
Eragrostis N.M. Wolf	73	16	7	16
Chenopodium album L. type	25	8	7	16
Adonis aestivalis L. type	9	2	7	16
Lavatera L. type	8	2	7	16
Alisma L.	46	16	6	13
Deschampsia P. Beauv.	36	8	6	13
Festuca L.	7	2	6	13
Convolvulus arvensis L. type	5	1	5	11
Rare				
Chenopodium L.	33	9	4	9
Sideritis L. type	27	8	4	9

Taxa	Total items	Max.	Ubiquity	
			Count	(%)
Polygonum convolvulus L.	13	6	4	9
Bromus L. indeterminate	11	8	4	9
Centaurea sp.	10	8	3	7
Hordeum L. indeterminate	10	8	3	7
Eremopyrum sp. (Ledeb.) Jaub. & Spach	3	1	3	7
Malva L.	16	8	2	4
Sonchus type	16	8	2	4
Bromus L., narrow type	12	8	2	4
Galium, small	9	8	2	4
Heliotropium L.	9	8	2	4
Anagallis L.	3	2	2	4
Adonis microcarpa/annua	2	1	2	4
Hordeum L./*Lolium* indeterminate	2	1	2	4
Thymelea cf. passerina (L.) type	2	1	2	4
cf. *Valerianella* Miller	8	8	1	2
Conringia orientalis L.	8	8	1	2
Euphorbia L.	8	8	1	2
Hyoscyanus type	8	8	1	2
Silene sp.	8	8	1	2
Verbena officinalis L.	8	8	1	2
Viola L.	4	4	1	2
Chrysanthemum cf. *segetum* type	2	2	1	2
Hordeum spontaneum C. Koch type	1	1	1	2
Lolium/Taeniatherum L.	1	1	1	2
Stipa L.	1	1	1	2
Ranunculus cf. arvensis L. type	1	1	1	2
Ziziphora capitata L./persica Bunge	1	1	1	2

Club rush, (*Bolboschoenus glaucus*), occurs in 98% of the samples. As mentioned in section 5.1.3, the taphonomic pathways by which this species may have entered the archaeobotanical record include routes such as fodder, raw material utilisation and potentially food for humans.

Carex sp. nutlets are commonly found in the assemblage, occurring in 22% of the samples but in low numbers, never higher than eight seeds per sample (Table 5.5). *Carex* sp., like many of the Cyperaceae family, is adapted to damp and waterlogged conditions but ranges in habitats from wet to dry (Davis 1965-1989).

Of note is the occurrence of mineralised Cyperaceae seeds; eight indeterminate Cyperaceae seeds and one seed identified to *Carex* sp. The occurrence of mineralised seeds suggests their derivation from waterlogged or manure-rich deposits.

The most seeds identified were from a small seeded crucifer, *Descurainia sophia*, the second most frequently-occurring species (Table 5.5). As detailed in section 5.1.3.1, it is possible that this species was purposefully cultivated/collected as an oil-seed crop on the East Mound. However additional uses/modes of entrance into the archaeobotanical record include occurrence as a crop weed. The species is widespread throughout Asia and Europe, occurs in Turkey today in "waste places" (Davis 1965-1989:486) and is abundant around the site today (personal obs.).

Four different Crucifer pod type remains were identified in the Çatalhöyük West samples but identification to species/genus was not possible. Crucifer pod remains occurred in 36% of the samples; the striated pod type the most frequent, in 24% of samples.

A number of other crucifer types were identified but not to species level. Classified based on size criteria, these two groups, large and medium types, also fall in the frequently-occurring category. The only other crucifer identified to species in the assemblage, (*Conringia orientalis* L.), was identified in one sample.

The seeds of the small-seeded grass genera such as *Sporobolus* R.Br, *Crypsis* Aiton and *Aeluropus* Trin, occur frequently and in abundant numbers in the assemblage, with *Sporobolus* the third most frequent, occurring in 78% of samples (Table 5.5). *Sporobolus* and *Aeluropus* genera comprise perennial species that inhabit moist and wet conditions such as marshy areas and irrigated fields (Davis 1965-1989). Crypsis species are annual grasses also occurring in moist conditions around lakes, marshes and abandoned fields (Davis, 1965-1989:582).

Large-seeded grasses, such as *Taeniatherum caput-medusae* (L.) Nevski*, Hordeum murinum* (L.) and *Bromus hordeaceus* L./*commutatus* Schrad. are classed as commonly occurring. The grain of *Taeniatherum* is present in 47% of the samples and chaff was also identified, occurring in 20% of samples. *Taeniatherum* is a steppe grass and can occur in fields and waste ground (Davis, 1965-1989).

Rumex and *Polygonum* species were identified in the Çatalhöyük West assemblage. *Polygonum aviculare* L. occurs in over 50% of samples while *Polygonum convolvulus* L. is rare, occurring in only four samples (9%). A keeled *Rumex* species was recognised in the assemblage and like *Polygonum aviculare,* it is frequently present in the assemblage, occurring in 56% of samples.

5.1.3.4 Mineralised

A number of mineralised seeds were found in the assemblage such as *Celtis* seeds and the remains of Boraginaceae species such as *Buglossoides arvensis* (L.). These seeds are naturally biomineralised, the plant producing a hard seed coat from biogenic carbonates (Jahren et al. 2001; Pustovoytov et al. 2004). *Lemna*, an

aquatic plant, occurs in high numbers in some samples (400 seeds), with 1899 seeds identified. This plant also naturally produces biomineralised seeds (Davis 1965-1989:65).

A small number of seeds have been preserved through replacement mineralisation, including members of the Cyperaceae family such as *Carex* sp., as well as examples of mineralised *Polygonum* sp., Labiatae sp. and *Fumaria* sp., seeds. In all cases these items occurred in only one sample.

As mineralised material may have entered the archaeobotanical record through multiple pathways and is preserved in such a way that results in non-exposure to the selective bias imposed by charring, the decision was made to exclude mineralised remains from statistical analysis so that only charred material was compared.

5.2 Çamlıbel Tarlası

Seventy-three samples from Çamlıbel Tarlası were selected for full analysis with samples deriving coming from archaeologically significant contexts and/or archaeobotanically rich deposits. Ten of the selected samples contain less than 30 crops items: these samples are included in the overall table (Table 12.4) but excluded from any statistical analysis to prevent distortion of results.

Figure 5.8 summarises the relative proportions of the majority of archaeobotanical categories in the Çamlıbel Tarlası assemblage and demonstrates the varying proportions of crop and weed/wild remains in the samples. Only

eight samples contain greater than 70% crop items and only four samples have 70% or more weed/wild remains (Table 5.6). The remaining samples contain a mixture of crop and wild/weed material. If the threshold is reduced to 60%, 15 samples are weed-dominated, 23 crop-dominated and the remaining 26 samples are of mixed composition. The high weed proportions within the samples hint at possible mixing; before any understanding of crop processing or crop husbandry can be gained further exploration is required to understand whether the wild taxa represent arable weeds.

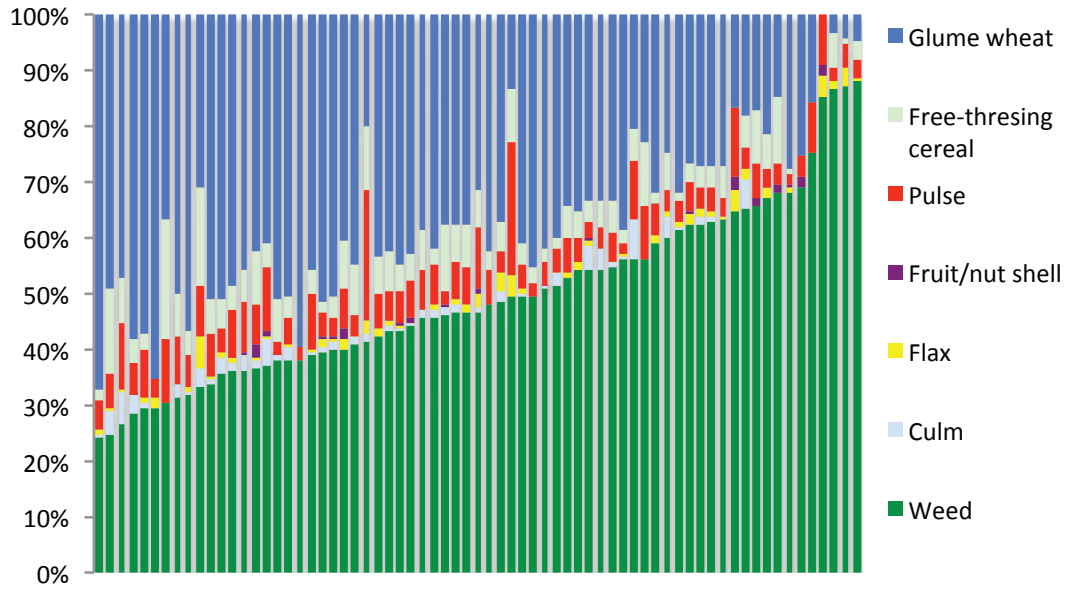


Figure 5.8: Proportions of glume wheat, free-threshing cereal, pulse, fruit/nut, flax, culm and weed items in the 68 samples from Çamlıbel Tarlası containing 30 items or more.

Examination of the relative proportions of the major crop types was also conducted, using the 70% arbitrary cut-off point. Table 5.6 shows the results of such classifications, and highlights the dominance of glume wheats in the assemblage. Fifty-two samples are classified as glume wheat dominated, something that is explored below. This is of relevance to later chapters, especially

crop processing and crop husbandry determinations, as it may suggest "weeds" in the samples are associated with the processing/cultivation of them.

Table 5.6. The relative proportions of plant items in each sample, sorted according to the percentage of crop material.

Sample	% Crop	% Weeds	Dominant class	% Glume wheat	% Pulse	% Flax	% Free-threshing wheat	% Barley	Dominant crop class
310	76	24	Crop	90	6	1	0	3	Glume wheat
425	74	26	Crop	69	8	1	3	18	Glume wheat
74/3	71	29	Crop	95	3	2	0	0	Glume wheat
m466	71	29	Crop	83	11	1	0	4	Glume wheat
396	70	30	Crop	53	17	0	0	31	Mixed
400	71	29	Crop	86	8	0	0	6	Glume wheat
200	70	30	Crop	76	13	0	0	11	Glume wheat
406	71	29	Crop	70	17	1	0	12	Glume wheat
m440	68	32	Mixed	85	8	1	2	4	Glume wheat
377/365	66	34	Mixed	79	11	1	2	8	Glume wheat
m439	63	37	Mixed	77	16	1	0	7	Glume wheat
422	63	37	Mixed	37	39	4	0	20	Mixed
424	63	37	Mixed	79	13	1	0	7	Glume wheat
370	64	36	Mixed	54	5	11	0	30	Mixed
337	65	35	Mixed	72	11	1	0	16	Glume wheat
321	64	36	Mixed	76	15	0	0	9	Glume wheat
311	63	37	Mixed	84	6	1	0	8	Glume wheat
421	62	38	Mixed	84	4	0	0	12	Glume wheat
50	61	39	Mixed	85	7	1	0	7	Glume wheat
358	60	40	Mixed	88	5	1	0	6	Glume wheat
223	60	40	Mixed	89	5	2	0	4	Glume wheat
324	58	42	Mixed	78	8	3	0	12	Glume wheat
392	58	42	Mixed	78	6	0	1	15	Glume wheat
46	59	41	Mixed	72	10	3	0	15	Glume wheat
226	61	39	Mixed	72	19	1	0	8	Glume wheat
139	56	44	Mixed	80	9	1	0	9	Glume wheat
m887	56	44	Mixed	78	8	1	1	12	Glume wheat
405	56	44	Mixed	79	12	1	0	9	Glume wheat
357	54	46	Mixed	64	17	5	0	14	Mixed
88	54	46	Mixed	81	12	2	0	5	Glume wheat
186/202	54	46	Mixed	73	14	0	0	13	Glume wheat
m632	53	47	Mixed	73	11	3	0	14	Glume wheat
54	53	47	Mixed	82	12	0	0	7	Glume wheat
75	53	47	Mixed	74	11	2	1	12	Glume wheat
132	51	49	Mixed	90	4	0	0	6	Glume wheat
210	54	46	Mixed	73	4	0	0	23	Glume wheat
238	50	50	Mixed	83	8	1	0	8	Glume wheat
m877	49	51	Mixed	86	8	1	0	5	Glume wheat

Sample	% Crop	% Weeds	Dominant class	% Glume wheat	% Pulse	% Flax	% Free-threshing wheat	% Barley	Dominant crop class
79	49	51	Mixed	80	2	6	0	12	Glume wheat
213	48	52	Mixed	30	41	9	0	20	Mixed
35/38	47	53	Mixed	74	13	1	0	12	Glume wheat
48	48	52	Mixed	79	9	0	0	12	Glume wheat
180	47	53	Mixed	87	9	1	0	4	Glume wheat
90	46	54	Mixed	76	10	1	0	13	Glume wheat
209	45	55	Mixed	80	7	3	0	10	Glume wheat
325	45	55	Mixed	80	12	3	0	5	Glume wheat
411	44	56	Mixed	90	3	2	0	5	Glume wheat
204	43	57	Mixed	83	4	3	0	10	Glume wheat
49	39	61	Mixed	86	7	3	0	5	Glume wheat
224	38	62	Mixed	75	8	1	0	16	Glume wheat
365	39	61	Mixed	71	7	3	0	19	Glume wheat
306	37	63	Mixed	75	9	5	0	11	Glume wheat
45	40	60	Mixed	56	29	0	0	15	Mixed
423	36	64	Mixed	78	6	5	0	10	Glume wheat
419	36	64	Mixed	77	10	3	4	7	Glume wheat
60	34	66	Mixed	87	13	0	0	0	Glume wheat
19	33	67	Mixed	52	20	0	0	28	Mixed
361	31	69	Mixed	90	3	3	0	4	Glume wheat
427	32	68	Mixed	70	5	5	1	20	Glume wheat
42	30	70	Weed	66	9	6	0	19	Mixed
17	12	88	Weed	26	10	11	19	33	Mixed
415	12	88	Weed	42	27	4	0	28	Mixed
428	10	90	Weed	44	10	34	0	12	Mixed

5.2.1 Crops

Thirteen crop taxa were identified in the Çamlıbel Tarlası assemblage: emmer, einkorn, 'new type' glume wheat, hulled barley, free-threshing wheat, lentil, bitter vetch, grass pea, pea, chickpea (*Cicer arietinum* L.), Cyprus vetch (*Lathyrus ochrus* L.) and flax (*Linum usitatissimum* L.). Five cereal taxa are present, consisting of emmer, einkorn and 'new type' glume wheats, free-threshing wheat and hulled barley. Grain and chaff remains of each taxon were encountered; glume wheat glume bases dominate the crop assemblage (Figure 5.9).

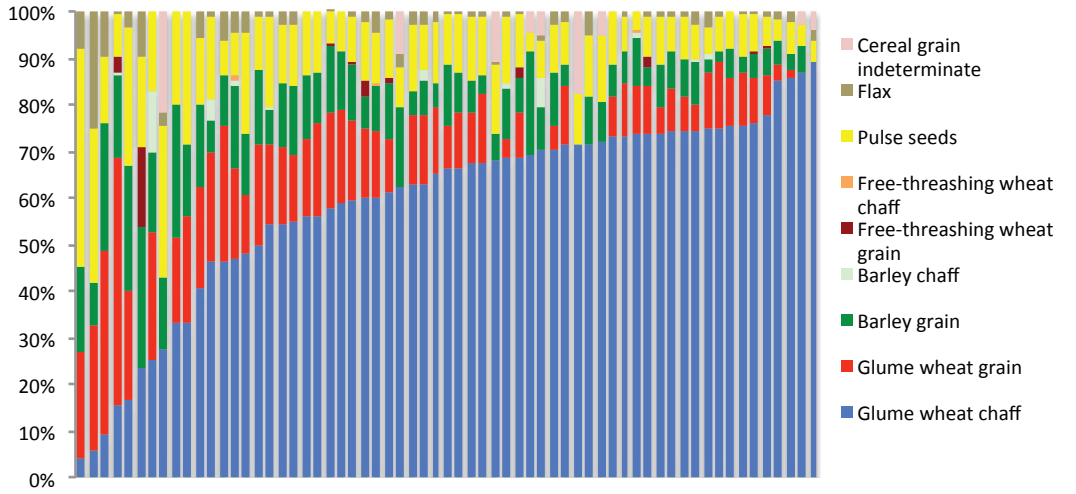


Figure 5.9: Proportions of the various crop types in the 63 samples containing 30 or more crop items.

Glume bases occur in 96% of samples and often in high numbers, up to 874 glume bases in a sample (Table 5.8, Figure 5.9). The glume bases are principally emmer, with einkorn and 'new type' being less common (Figure 5.10). Two samples are exceptions to the trend of emmer chaff dominance and are composed of over 80% 'new type' chaff, with emmer chaff being totally absent (sample 324 and 60). However, this is a rare occurrence; 49 of the 52 samples containing 30 or more glume bases comprise over 50% emmer chaff. The other exception is sample 411, where einkorn chaff occurs in relatively high numbers: 42% emmer glume bases compared with 48% einkorn glume bases. Terminal glume bases were identified in the assemblage and occur in over 50% of the samples.

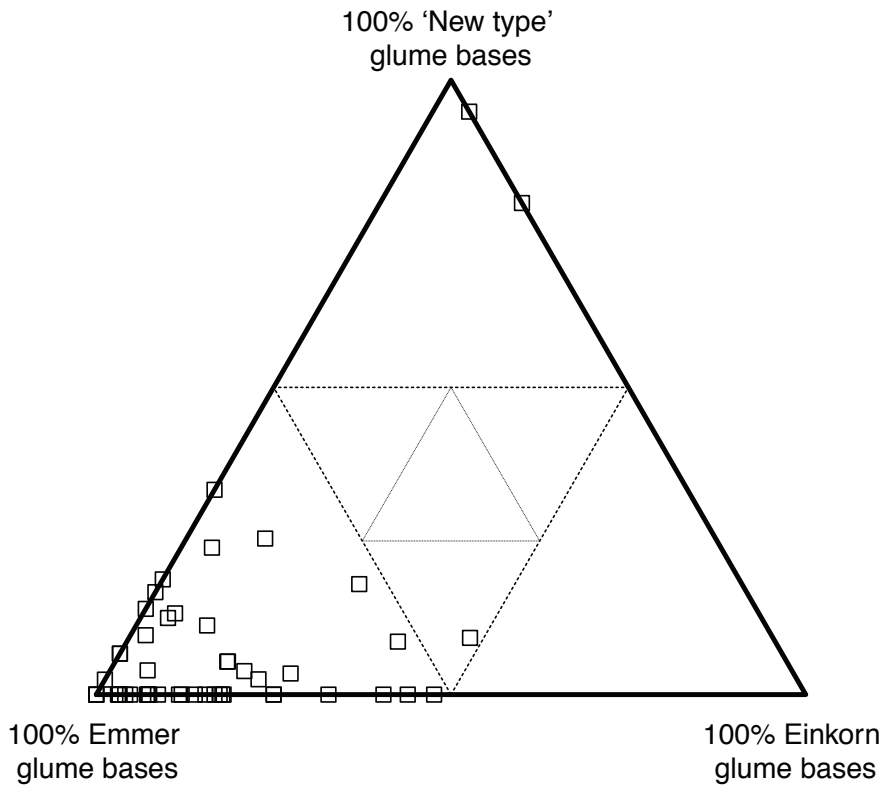


Figure 5.10: Proportions of the three identified species of glume wheat in the 52 Çamlıbel Tarlasi samples containing 30 or more chaff items.

Glume wheat grains are dominated by the highly ubiquitous einkorn (70%). Emmer grains are found in lower numbers and in fewer samples, while 'new type' was identified in 11 samples (Table 5.8). Both one- and two-seeded einkorn were identified, one-seeded being the more common variety (Table 5.8).

The chaff remains of the glume wheat taxa do not display the same pattern as that of the grain remains: emmer dominates in the chaff remains, while einkorn is the more ubiquitous and numerous glume wheat grain found (Table 5.8). This disparity between chaff and grain could have resulted from factors including taphonomic processes and selective bias introduced through human actions, including crop processing and personal choice.

It is possible the glume wheats were grown separately, or together as a maslin crop. The mixture of emmer glume bases and einkorn grain suggests that these two crop types are the dominant species. Possibly 'new type' was of lesser status, but its dominance in two samples is not supported by such a theory and could represent individual dehusking. The limited grain numbers of 'new type' support less extensive use but its presence as glume bases in 36% of samples indicates a more extensive use than suggested by these grain numbers. However, the quantity of 'new type' glume bases is significantly less than that of emmer, illustrating the dominance of emmer over the other crops.

Two free-threshing cereal species were identified at Çamlıbel Tarlası: free-threshing wheat and hulled barley. Hulled barley grain is one of the principal crop components at the site, occurring in 86% of the samples as 1269 grains (Table 5.8). Rachis remains of hulled barley are limited and fragmentary, occurring in 19% of samples (44 internodes) and all samples contain barley grain remains. Hulled barley appears to be chiefly two-rowed based on rachis remains; however four twisted grains were noted in addition to one rachis fragment tentatively identified as six-rowed hulled barley. It appears that barley at the site consisted of a mixture of two- and six-row, the two-row form predominating.

Free-threshing grains are occasionally found in the assemblage, occurring in 11 samples (15%, 60 grains). Rachis remains are even less common, with only three positively identified free-threshing wheat rachis internodes observed (Table 5.8). All rachis remains were identified as bread wheat.

The pulse suite at Çamlıbel Tarlası is diverse, with six domesticated pulse species identified: lentil, bitter vetch, pea, grass pea, Cyprus vetch (*Lathyrus ochrus*) and chickpea (*Cicer arietinum*). Pulse seeds occur in 97% of the samples but always in low numbers. Lentil (88% of samples) and bitter vetch (74% of samples) are the two most common pulse taxa. Grass pea occurs in less than 30% of samples and in limited numbers, 54 seeds (Table 5.8). Chickpea, Cyprus vetch and pea have less then 30 identified seeds and occur in less than 20% of the samples (Table 5.8). Pulse pod fragments were identified, occurring in 16% of the samples.

The Çamlıbel Tarlası assemblage has a high number of flax seeds, the plant being potentially cultivated for its oil-rich seeds and/or fibre. Only one tentative fragment of flax capsule was identified but the seeds are common (74% of the samples, 240 seeds) and measurements fall within the lower end of the domesticated seed range; the lower limit of domesticated *Linum ustatissimum* is 3.0mm (Zohary et al. 2012). Seed size is used by researchers to infer use of the crop for either oil or textiles; modern cultivars commonly have small seeds when used for textiles, with the large seeded varieties favoured for oil extraction (Zohary and Hopf 2000; Herbig and Maier 2011; Valamoti 2011). Comparison with other published flax seed measurements from the region shows that while Çamlıbel Tarlası seed are small compared to modern seeds they are comparable in size to measurements reported from other Southwest Asian sites (van Zeist and Bakker-Heeres 1982)(Figure 5.11, Table 5.7). While it could be that the seeds from Çamlıbel Tarlası are from flax cultivated for textiles, it is also possible that the small size of the seed represents the fraction of small seeds lost during

processing. Some authors are critical of the use of size as an indictor of flax use, especially in the case of charred seeds, which due to the oily nature distort significantly upon charring (Karg 2011). From such evidence it is difficult to assign the usage of this crop.

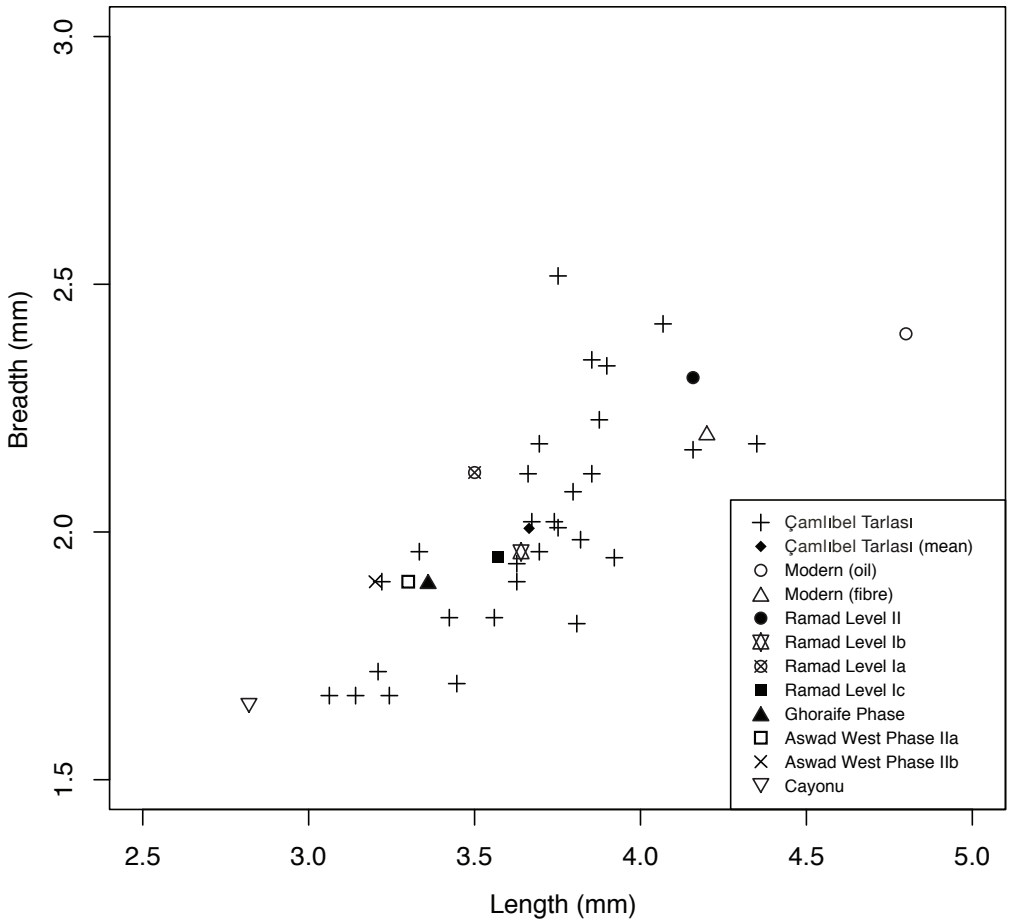


Figure 5.11: Measurements from reported flax seed finds in South West Asia, against the Çamlıbel Tarlası flax seeds, as well as for reference the modern measurements for oil and fibre seeds (Data from van Zeist and Bakker-Heeres 1975b; van Zeist and Bakker-Heeres 1982; Herbig and Maier 2011).

Table 5.7: Dimension (mm) of 29 Çamlıbel Tarlası flax seeds plus adjusted measurements to compensate for changes during charring (13% length, 21% breadth)(van Zeist and Bakker-Heeres 1982).

	Length (mm)	Corrected length	Breadth (mm)	Corrected breadth
Minimum	2.7	3	1.4	1.7
Average	3.3	3.7	1.7	2
Maximum	3.8	4.4	2.1	2.5

5.2.2 Variation in crop composition

Figure 5.12 shows the dominance of glume wheats in the assemblage, due to the high proportion of glume bases comprising 65% of crop material.

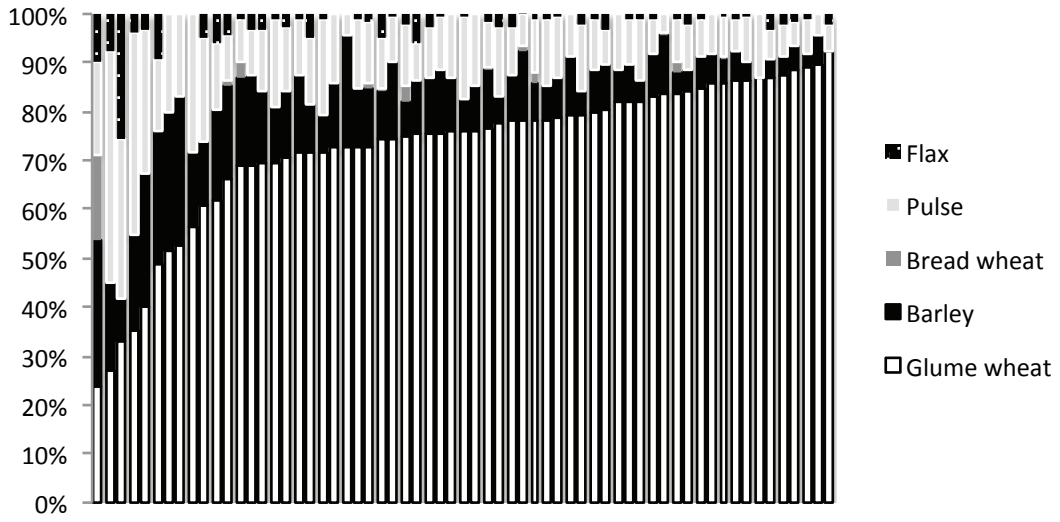


Figure 5.12: Comparison of the grain and chaff remains of the major crop groups from the 64 Çamlıbel Tarlası samples containing 30 or more cereal items.

Comparison of the seeds of the major crop groups (glume wheats grain, barley grain and pulse seeds) indicates that the dominance of glume wheats was principally due to the high number of glume bases (Figure 5.13). When only grains/seeds are compared, the three categories have similar proportions of grain in the majority of samples (Figure 5.12b), differing from the results of Çatalhöyük and highlighting the high ubiquity of pulses in the Çamlıbel Tarlası assemblage. Three samples differ, containing no glume wheat grain but high proportions of either pulse (sample 422, 68% and sample m439, 71%) or barley remains (sample 210, 84%)(Figure 5.13). The inclusion of chaff remains in the comparison results in the overwhelming dominance of glume wheat remains (Figure 5.13b).

While three samples show no glume wheat grain, they do contain glume wheat chaff. These samples also contain wheat indeterminate grain that could not be proportionally re-assigned due to the lack of positive identification. It is highly probable, given the very low amount of free-threshing wheat in the whole assemblage, that these indeterminate grains are glume wheats. The inclusion of the wheat indeterminate grains results in the three samples having a more similar proportion to the other samples in the assemblage (Figure 5.13a).

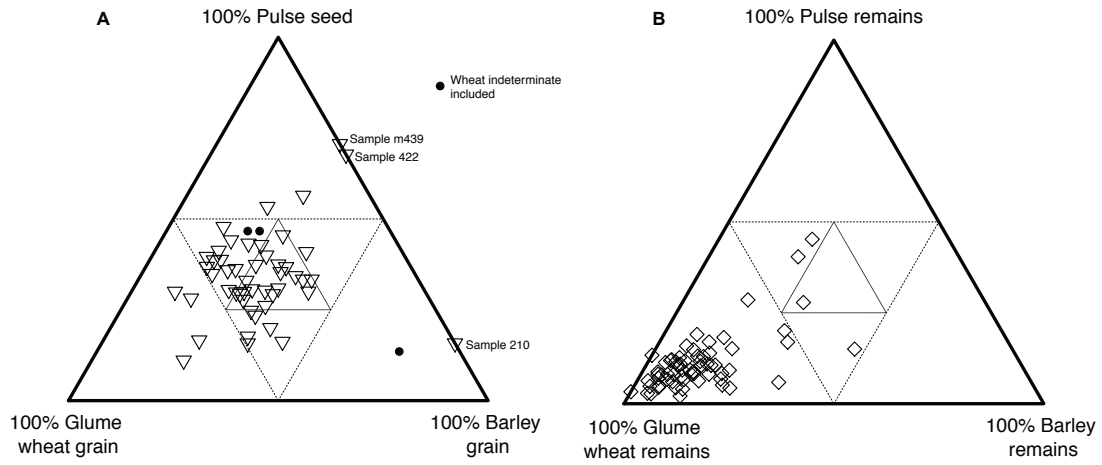


Figure 5.13: (A) Proportions of barley, glume wheat and pulse seeds in the 52 Çamlıbel Tarlası samples containing 30 or more barley, glume wheat or pulse seeds. Closed circles denote the three labelled samples upon the inclusion of wheat indeterminate grains in the glume wheat proportions. (B) the proportions of barley, glume wheat and pulse items in the 63 samples containing 30 or more of such items.

Comparison of glume wheat chaff to pulse and barley seeds allows an examination of the more frequent items of each group. Glume wheat appears to dominate the assemblage, possibly reflecting differences in crop processing rather than limited use of barley and pulse taxa over glume wheat types (Figure 5.14).

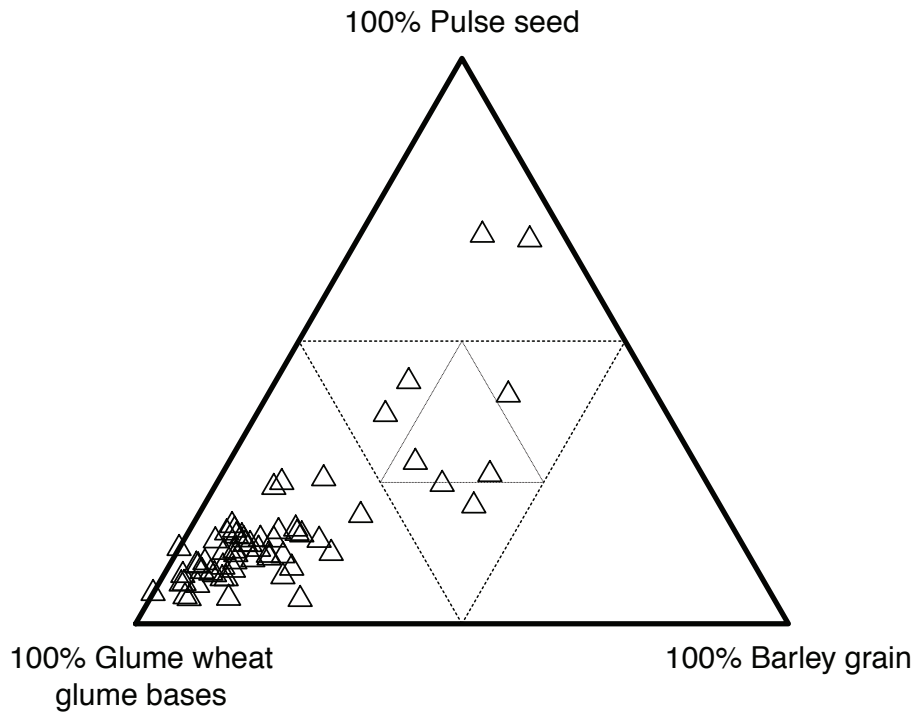


Figure 5.14: Proportion of glume wheat chaff, barley grain and pulse seeds in the 61 samples containing 30 or more items of the categories graphed.

Table 5.8: Summary of the abundance and frequency of the crop categories from Çamlıbel Tarlası samples, * includes all items including indeterminate classes, items in bold are totals.

	Item	Total items	Maximum	Ubiquity	
				Count	(%)
Cereal					
Hulled barley	grain	1266	184	62	93
Bread wheat	grain	59	16	10	15
Einkorn	grain	1408	181	49	73
Emmer	grain	335	80	20	30
'New Type' glume wheat	grain	60	41	4	6
Glume wheat*		**1910**	**262**	**54**	**81**
Wheat*		**1987**	**262**	**63**	**94**
Cereal*		**1991**	**262**	**64**	**96**
Chaff					
Emmer	glume base	6768	689	57	85
Einkorn	glume base	1319	280	44	66
'New Type' glume wheat	glume base	625	70	26	39
Glume bases*		8713	874	63	94
Hulled 2-row barley	rachis	44	8	14	21
Bread wheat	rachis	3	1	3	4

	Item	Total items	Maximum	Ubiquity	
				Count	(%)
Pulses					
Lentil	seed	649	38	61	91
Bitter vetch	seed	408	46	52	78
Grass Pea	seed	54	12	20	30
Chick pea	seed	29	6	14	21
Pea	seed	21	3	11	16
Cyprus vetch	seed	3	1	3	4
Pulse*	**seed**	**1175**	**89**	**67**	**100**
Other					
Flax/linseed	seed	232	32	50	75

5.2.3 Wild taxa

5.2.3.1 Edible plants

Seeds of edible fruits and nut species were identified in the Çamlıbel Tarlası assemblage. Fruit stones or nut shells were identified in a limited number of samples (15%) but the fragmentary nature of the remains prevented the identification of species. Hackberry and acorn were only identified through the occurrence of one single fragment (Table 5.9). Seeds of blackberries (*Rubus fruticosus*) were identified, occurring in 25% of samples but at low numbers, the maximum being four. Blackberry seeds occur in a wide range of archaeological contexts, from floor deposits through to the ash layer in CBTI but no high concentration of the seeds has been recorded, resulting in the ambiguous evidence of collection for food versus accidental incorporation into the archaeobotanical assemblage.

Table 5.9: Edible taxa identified in the Çamlıbel Tarlası assemblage detailing the total number of items, largest number of items within a sample, and ubiquity (expressed as total number of samples found in and percentage of samples).

	Total items	Max	Ubiquity	
			Number of samples	%
Blackberry (*Rubus fruticosus* type)	38	4	18	25
Nut shell	2.25	2	2	3
Fruit stone	1.25	1	2	3
Indeterminate fruit stone/ nut shell	9	2	8	11
Acorn shell, cf.	1	1	1	1

5.2.3.2 Culm

Culm nodes and bases of both cereals and reed types were identified in the samples. Identification of culm to type demonstrates a relatively high proportion of the cereal culm to reed culm type (Table 5.10). Cereal culm nodes/bases occur in over 62% of samples compared to reed culm type in 16% of samples. A culm node type with the specific external morphology of external ridging was identified with limited evidence as to its actual species. This culm is therefore separated in ubiquity calculations but it is notable that this culm type is more prevalent than the reed culm type (25%).

The dominance of the cereal culm could indicate a harvesting method where the straw is harvested for further use. The presence of cereal culm bases may also indicate a harvesting method involving, or leading to, the uprooting of cereal plants.

Table 5.10: The ubiquity, sum and maximum number of items per sample of the different culm types identified at Çamlıbel Tarlası.

	Total items	Maximum	Ubiquity	
			Number of samples	%
Cereal culm/bases types	264	29	45	62
Reed culm/rhizome types	37	9	13	18
Ridged culm types	32	5	18	25
Culm indeterminate	33	10	7	10

5.2.3.3 Other Wild taxa

The wild/weed flora of Çamlıbel Tarlası is diverse consisting of 161 different categories. Of this, 19 classes described mineralised remains, 14 pod remains and 34 indeterminate or family classes (Table 12.4).

Examination of the weed flora on the basis of ubiquity and number gives a general account of which taxa are frequent, common or rare. If the 50% and 10% cut-offs are applied then 12 taxa are classified as frequent, 11 as common and 34 as rare (Table 5.11).

Table 5.11: Wild taxa found in the Çamlıbel Tarlası samples indicating ubiquity and items count. Frequent and rare taxa are noted.

Taxa	Total items	Maximum	Ubiquity	
			Count	%
Frequent				
Lolium L., small type	6796	533	65	97
Galium, large types	446	50	59	88
Phalaris cf. minor Retz.	1123	196	53	79
Vicia L./*Lathyrus* L.	302	28	46	69
Bifora radians Bieb.	175	20	46	69
Asperula arvensis L.	241	44	42	63
Thymelea cf. passerina (L.)	193	20	41	61
Polygonum aviculare	564	116	41	61
Bromus arvensis L.	254	74	38	57
Ranunculus arvensis L. type	106	15	35	52
Polygonum convolvulus L.	187	60	34	51
Vaccaria pyramidata Medik.	173	34	34	51
Common				
Stipa L.	154	21	33	49
Silene, type1	379	112	32	48
Lolium temulentum L.	122	36	27	40
Leguminosae , small	137	31	24	36
Anagallis L. type	296	129	19	28
Rumex L.	40	9	17	25
Polygonum sp. Indeterminate	36	7	12	18
Heliotropium L.	48	17	11	16
Cruciata Millier, cf.	18	4	11	16
Sporobolus R. Br.	116	24	11	16
Silene, small	88	24	9	13
Sideritis L. type	52	8	9	13

Taxa	Total items	Maximum	Ubiquity	
			Count	%
Ajuga/Teucrium	10	4	8	12
Ziziphora capitata L./*persica* Bunge	65	24	8	12
Hordeum murinum L. type	12	4	8	12
Bromus L. indeterminate	15	8	7	10
Silene, type 2	58	24	7	10
Lallemantia, cf.	14	4	7	10
Lavatera L. type	9	2	7	10
Taeniatherum caput-medusae L.	10	3	7	10
Bromus L., narrow type	24	16	7	10
Rare				
Carex L.	14	8	6	9
Ranunculus sceleratus L.	41	8	6	9
Trigonella astroites type	31	16	5	7
Atriplex L.	8	4	5	7
Galium L. indeterminate	7	2	5	7
Chrysanthemum cf. segetum type	6	2	4	6
Convolvulus arvensis L. type	12	6	4	6
Verbascum type 1	33	16	4	6
Verbascum type 2	40	16	4	6
Eragrostis N.M. Wolf	40	16	4	6
Hordeum indeterminate	6	2	4	6
Centaurea sp.	2	1	3	4
Valerianella Miller.	3	1	3	4
Alyssum type	3	1	3	4
Hordeum spontaneum C. Koch type	12	6	3	4
Avena sp.	4	2	3	4
Chenopodium L.	16	8	2	3
Chenopodium album L. type	16	8	2	3
Conringia orientalis L.	12	8	2	3
Medicago sp.	9	8	2	3
Poa type	4	2	2	3
Galium L./*Asperula* L.	2	1	2	3
Hyoscyanus type	9	8	2	3
Salsola L.	1	1	1	1
Artemisia annua L. type	8	8	1	1
Onopardum type	3	3	1	1
Bolboschoenus glaucus (Lam.) S.G. Smith	1	1	1	1
Geranium L.	4	4	1	1
Malva L.	8	8	1	1
Fumaria L.	1	1	1	1
Crypsis aculeata (L.) Aiton type	4	4	1	1
Adonis sp.	1	1	1	1
Galium L., small	4	4	1	1
Sherardia arvensis L., cf.	1	1	1	1

The weed flora at Çamlıbel Tarlası is dominated by the seeds of a small-seeded *Lolium* sp. occurring in 97% of the samples and in large quantities (maximum

533)(Table 5.11). This is the most ubiquitous and numerous taxon at the site with over 6,800 seeds identified and is present as both the small and larger-seeded species. *Lolium*, particularly *L. remotum,* and *L. temulentum,* are found in crop fields as flax weeds and cereal weeds respectively. The high quantities of small-seeded *Lolium,* together with the knowledge of flax cultivation at the site, raise the question of whether the small-seeded *Lolium* is a weed of flax. This question is further addressed through correspondence analysis in Chapter 6. It is notable that weed seeds found in flax storage samples at Kuruçay are the same small-seeded Lolium (identified as *Lolium* cf. *remotum* by Nesbitt (1996)) as the Çamlıbel Tarlası specimens, while the *Silene* seeds are of comparable morphology.

Other frequently occurring grasses in the assemblage include *Phalaris* cf. *minor*, and *Bromus arvensis* type. *Phalaris* cf. *minor* Retz., the second most frequent grass, is an annual grass commonly found on "hill slopes, phrygana, fields, roadsides, and as a weed in gardens" (Davis 1965-1989:369). *Bromus* species, common crop weeds today (Davis 1965-1989), occur in the assemblage and facilitated by a newly developed *Bromus* identification key by Laura Green of the University of Oxford, were identified to potential species. The larger, round-ended type, identified as *Bromus arvensis* L. occurs in 57% of the samples with up to 73 seeds per sample. The smaller, narrow-ended type, identified as *Bromus rigidus* Roth./*diandrus* Roth. occurs in limited numbers in 10% of samples.

Three *Silene* types are commonly occurring taxa, found in 48%, 13% and 10% respectively of the samples (Table 5.11). Of interest is the relationship between *Silene* species and flax cultivation with a number of *Silene* species noted as flax

weeds. Storage of flax seeds in Greece and Turkey has provided evidence of the relationship between small-seeded *Lolium*, *Silene* and flax cultivation (Nesbitt 1996; Valamoti 2011) and this is further explored in chapter 8.

A number of *Silene* pods were present in the assemblage but in some cases identification to anything below genus level was not possible. However two intact capsules containing seeds were identified, which allowed direct association with assemblage seeds. Capsules fragments occurred in 38% of samples.

Vaccaria pyramidata was found in 51% of the samples. This frequent weed is found in many assemblages in the Near East and is currently found in fields and cultivated land in Turkey (Davis 1965-1989)

Lathyrus/Vicia types are frequent in the Çamlıbel Tarlası samples occurring in 69% of the samples; some samples have over 40 identified specimens. Small-seeded legumes occur and are common, occurring in 36% of the samples. Other Leguminosae species such as *Medicago radiata* type and *Trigonella astroites* occur but are classed as rare within the assemblage.

Species of the Rubiaceae family are found in high numbers. A large-type *Galium* sp. occurs being the second most ubiquitous weed taxon (78%). *Asperula arvensis* is frequent, occurring in 63% of samples with a total of 241 seeds. *Cruciata* cf. *laevipes* Opiz is present in over 10% of the assemblage but occurs in low numbers, never more than four seeds in a sample. Other members of this family

occur in low numbers and are classed as rare taxa (cf. *Sherardia arvensis*, and *Galium verum* type).

Both *Polygonum aviculare* (61%) and *Polygonum convolvulus* (51%) were identified (Table 5.11) as was a keeled *Rumex* sp. found in 25% of the samples. These seeds are common in the archaeobotanical assemblage of the Near East.

Ranunculus arvensis occurs in segetal habitats (Davis 1965-1989) and is present in 52% of the samples at low levels (35 samples).

A limited number of crucifer taxa were identified but not to species and while some are classed as common in the assemblage, the majority are rare. Pods of crucifers were also identified in the assemblage and occur in 9% of samples.

The seeds of *Bifora radians* occur in 69% of the samples. *Bifora*, a member of the Apiaceae family, commonly grows on waste ground and field edges and is a common weed of cereals in Europe today (Davis 1965-1989). *Bifora* is common and frequent in the samples (Table 5.11), with a total 20 seeds found in a weed-rich sample from sample m877, deriving from the northern area of the ash layer from CBTI.

Ajuga/Teucrium type is a commonly occurring Labiatae type (12%) but with low quantities of seeds per sample; other Labiatae types occur in low numbers. A number of mineralised labiate seeds were identified, but not to genus.

5.2.3.4 Mineralised seeds

Members of the Boraginaceae family in addition to one *Celtis* fragment, were found preserved due to biomineralisation, in which the plants, when alive, produce mineral deposits within their fruits (Shillito and Almond 2010). Replacement mineralised seeds, where the original organic material of the seed is replaced by precipitated minerals (Shillito and Almond 2010) were found in 17% of samples. The recognisable species included *Ranunculus* sp*., Polygonum* sp., *Carex* sp. and Labiatae seeds. Contextual information indicates that such specimens commonly occurred in the ash fills of CBTI in addition to samples from a tentatively identified "silo". Small numbers occurred in floor contexts from CBTII and CBTIII.

5.3 Kuruçay

Crop remains dominate the twenty-five samples re-examined from Kuruçay, all o containing 30 or more crop items. The Kuruçay material represents storage samples only, collected from a highly visible concentration of archaeobotanical material (see Chapter 2). Weed/wild taxa occur but at very low levels relative to large quantities of crop remains, reflecting the storage context of the samples (Figure 5.15). This assemblage was analysed by M. Nesbitt who published a primary report on the relative occurrences of the crop species and important wild taxa (Nesbitt 1996). Mark Nesbit granted permission for his raw data to be used in this research and the minimal material located in the United Kingdom was re-examined to confirm identifications.

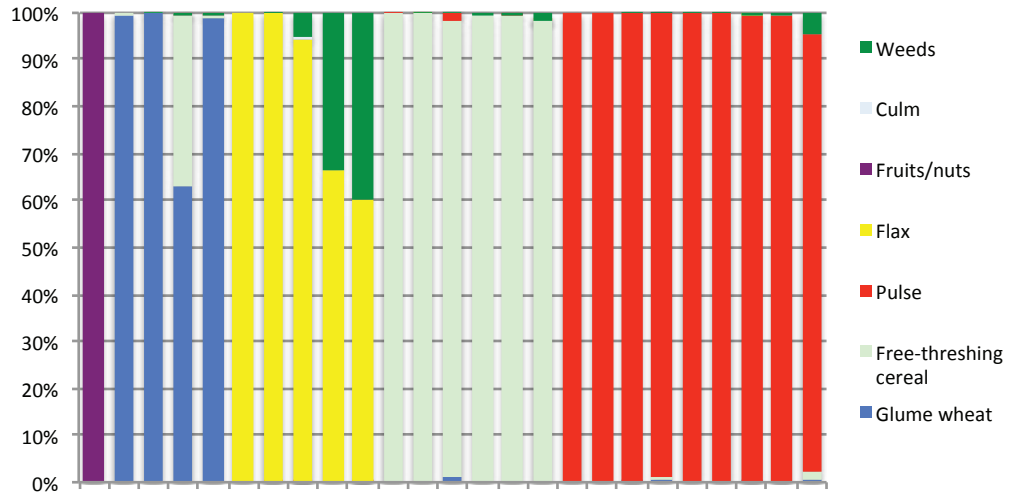


Figure 5.15: Proportions of weeds, culm, fruits and nuts, flax, pulse, free-threshing cereals and glume wheat remains in the Kuruçay assemblage.

5.3.1 Crops

Nesbitt (1996) reported the presence of nine crops at Kuruçay: emmer, einkorn, free-threshing wheat, hulled barley, lentil, grass pea, pea, chickpea and flax. Examination of his unpublished data also shows the presence of a single naked barley grain in the assemblage not reported in Nesbitt (1996) and re-examination of samples located in the UK indicated the presence of naked barley rachis as well as 'new type' glume wheat grain and chaff.

Cereal remains occur in 16 out of 25 (64%) Kuruçay samples, ranging from being the dominant crop to a minor contaminant. Six cereal taxa are represented as both grain and chaff: emmer, einkorn, 'new type', hulled barley (two- and six-rowed), naked barley (two- and six-rowed) and bread wheat. While the chaff of all taxa is present, it is their grain that dominates the assemblage.

Glume wheat remains occur in nine samples but in varying amounts (Figure 5.16). Three samples contain over 98% glume wheat remains, a combination of

glume bases and grain (samples 10, 11 and 14). The other six samples comprise either a combination of glume wheat and barley (sample 15, 60% glume wheat), or contain very low amounts of glume wheat remains (less than 1%)(Figure 5.16).

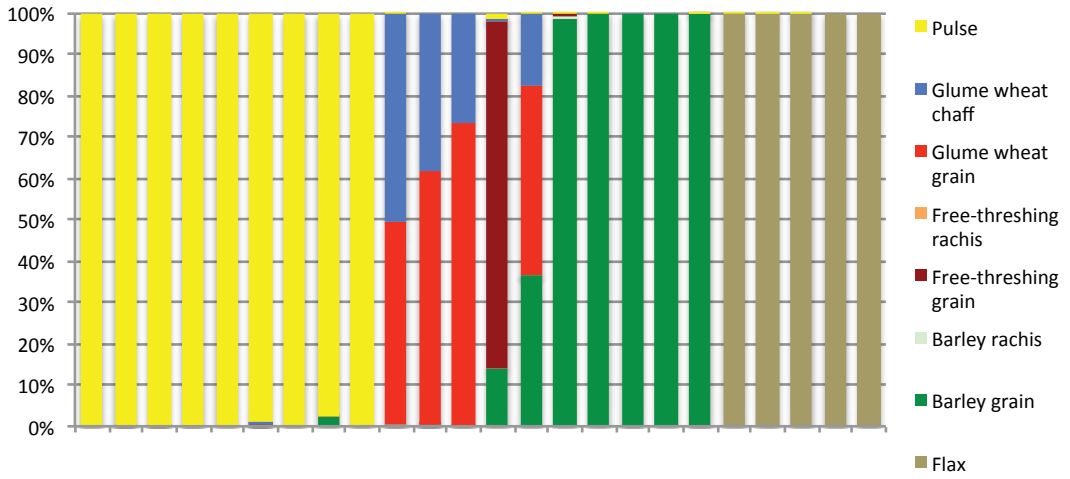


Figure 5.16: Proportion of pulse, glume wheat, free-threshing wheat, barley and flax in the 24 Kuruçay samples containing crop remains.

Due to the limited quantity of Kuruçay material in the UK, a complete re-examination of all the glume wheat chaff and grains was not possible. The identification of 'new type' grains and chaff, previously identified as emmer by M. Nesbitt, indicates inclusion in the assemblage. The proportions of this taxon in the samples remains unknown until material housed in Turkey can be re-assessed. It is most likely that the majority of 'new type' grains and chaff remains were mistaken for a robust type of emmer chaff and an elongated two-seeded emmer grain, something which appears to have been common before 'new type' was recognised in 2000 (Jones at al. 2000). Nesbitt recorded emmer as the dominant glume wheat in both chaff and grain, with einkorn occurring in only small quantities and always mixed with emmer. Due to the uncertainty surrounding 'new type' quantities in the assemblage it is not possible to explore fully the

composition of the glume wheat samples on a taxa basis; these samples have been left as gross categories of glume wheat grain and glume wheat chaff.

Nesbitt (1996) reported the presence of six-rowed hulled barley and free-threshing wheat in the Kuruçay assemblage and his raw data indicates the presence of a single grain of naked barley. Re-examination of the barley chaff as part of the present research documented the occurrence of all four types of barley: two- and six-rowed hulled barley and two- and six-rowed naked barley. The amount of chaff remains is very low, appearing as contaminants, principally in samples 12 and 47, with single rachis internodes also occurring in the other eight samples (32%).

Free-threshing wheat grains were recorded in five samples (Nesbitt, unpublished) and Nesbitt (1996) noted the occurrence of free-threshing wheat in an additional two samples. Re-examination indicated that one report is due to the presence of a grain classed as emmer/free-threshing wheat: following protocol (Chapter 4) this has now been proportionally re-assigned to emmer due to the lack of presence of free-threshing wheat in the sample. The additional record of free-threshing wheat is due to the presence of chaff remains.

Nesbitt (unpublished) recorded the occurrence of only three free-threshing wheat rachis remains but re-examination of material has increased that count to seven. Nesbitt identified rachis remains of hexaploid bread wheat and tetraploid macaroni wheat (*Triticum durum*). A record of free-threshing wheat in sample 15 is due to a fragment of what Nesbitt identified as a "classic tetraploid internode"

(Nesbitt, unpublished). Re-examination of the rachis remains confirmed the presence of the hexaploid bread wheat chaff, but the tetraploid rachis fragment evidently is in Turkey.

Four pulse taxa were reported from Kuruçay: lentil, pea, grass pea and chickpea (Nesbitt 1996). Lentil, pea and grass pea occur in large numbers in specific samples but only three chickpeas in two samples were identified by Nesbitt, suggesting that chickpea is a contaminant. Lentil is the most ubiquitous, occurring in 14 samples (56%)(Table 5.12). Lentil dominates in four of the 14 samples in which it occurs, comprising over 90% of items found in those four samples. In the remaining ten samples, lentil occurs in very low amounts, never more than 1% of the total items. Pea and grass pea occur in eight of the 25 samples (32%). Pea comprises over 90% of items in two samples, the remaining six samples containing a low level (<1%) of items. Grass pea occurs in large numbers in three samples (>98%) but in the remaining samples it only occurs as one or two seeds (>1%).

Table 5.12: Summary of the Kuruçay assemblage (25 samples containing 30+ items) detailing the total number of items, maximum number items and the ubiquity of the taxa identified by M.Nesbitt, and partially re-assessed in this study.

Taxa	Total items	Maximum	Ubiquity	
			Count	%
Cereal grain				
Glume wheat grain	13564	6078	7	28
Free-threshing wheat grain	2448	2398	5	20
Hulled barley grain	30130	15914	13	52
Naked barley grain	1	1	1	4
Cereal Chaff				
Glume wheat indeterminate glume bases	7526	3094	8	32
Free-threshing wheat rachis	7	4	3	12
Hulled barley rachis	21	18	4	16
Naked barley rachis	14	12	3	12
Culm node	6	2	5	20
Pulse				

Taxa	Total items	Maximum	Ubiquity	
			Count	%
Lentil	36207	18097	14	56
Pea	7164	4004	8	32
Grass pea	9238	4518	8	32
Chick pea	3	2	2	8
Oil-seed crops				
Flax	40964	15218	8	32
Collected				
Pistacia terebinthus/atlantica	300	298	3	12
Wild				
Conringia orientalis L.	2	1	2	8
Camelina sativa (L.) Crantz	1069	763	6	24
Lepidium L. type	551	408	3	12
Vaccaria pyramidata Medik.	455	387	4	16
Silene, type 1	4744	3687	5	20
Silene type 2	1	1	1	4
Galium L., large type	196	131.8	9	36
Asperula arvensis L.	12	4	6	24
Vicieae	36	17	4	16
Lolium L., small (*Lolium remotum* type)	3422	2128	5	20
Gramineae indeterminate	23	7	6	24
Taeniatherum caput-medusae L.	39	33	4	16
Stipa L.	6	3	3	12
Festuca L.	9	8	2	8
Bromus L., narrow type	3	1	3	12
Poa, bulblet	53	52	2	8
Medicago, cf.	4	3	2	8
Gramineae indeterminate culm nodes	4	2	2	8
Lathyrus L./*Vicia* L.	3	3	1	4
Galium/Asperula	8	8	1	4
Galium, small trigonous type	3	3	1	4
Cruciata sp, cf.	2	2	1	4
Anthermis type	1	1	1	4
Rosa type	1	1	1	4
Camelina microcarpa Andrz.	4	4	1	4
Lapsana/Sonchus, cf.	2	2	1	4
Leguminosae, indeterminate	3	3	1	4
Cheaerophyllum type	3	3	1	4
Cyperaceae	1	1	1	4
Boraginaceae, mineralised	25	25	1	4
Valerianella Miller	1	1	1	4
Hordeum murinum L. type	1	1	1	4
Hordeum indeterminate, wild	2	2	1	4
Lolium temulentum L.	1	1	1	4
Lolium/Hordeum	1	1	1	4
Avena, cf.	1	1	1	4
Aegilops sp.	1	1	1	4
Triticum boeoticum	11	11	1	4
Bruchid beetles	15	12	3	12
Unidentified	534	216	14	56

Flax seeds were identified in the Kuruçay assemblage (Nesbitt 1996) occurring in high numbers in four samples and low quantities in another four. The four

samples with high concentrations of flax seeds each contain over 7000 or more seeds; sample 18 contains 15,218. The flax samples contain differing proportions of flax to weed seeds; sample 23 contains 100% flax seeds, but samples such as 21, while containing over 10,000 flax seeds, also contain over 5,000 weed seeds. Flax samples are the weediest of the samples (Figure 5.15) and contain specific weed taxa uncommon in the pulse and cereal samples: *Camelina sativa, Lepidum* type*, Silene* type 1 and a small-seeded *Lolium* (identified as cf. *remotum* by Nesbitt). The weediness of the samples may indicate that flax is only processed to a certain point and then stored. The weediness also highlights the potential of the Kuruçay samples to help in further elucidating the methods of crop processing and modes of storage.

5.3.2 Variation in crop composition

The crop composition of the samples highlights the storage nature of the remains. Most samples contain high proportions of one crop taxon, with low numbers of weed or crop contaminants. Sample 15 is of note as it contains a mixture of barley grains and glume wheat grains and chaff; excluding the chaff this sample comprises 44% barley (1948 grains) and 56% glume wheat (2464 grains). Sample 14 contains 85% free-threshing wheat, the only sample dominated by this crop. Its purity, however, is not as high as the glume wheat or barley samples as it also contains 14% barley. Pulse and flax samples are also represented as predominantly single taxon samples (Table 12.5). Flax samples contain limited other crop remains but many contain high numbers of weed seeds.

5.3.3 Wild taxa

5.3.3.1 Edible plants

Kurucay has one sample of pure *Pistacia terebinthus/atlantica* type nuts, 298 nuts in sample 22, indicating the use of this taxon for consumption, something still occurring in Turkey today. An additional single occurrence of *Pistacia* nuts was recorded in two other samples.

5.3.3.2 Culm

Nesbitt identified cereal culm nodes in the assemblage but as this material is still in Turkey, it could not be re-assessed using the new identification criteria.

5.3.3.3 Other wild taxa

The Kuruçay samples contain a range of different wild taxa that have been re-examined to produce taxonomically refined identifications. Thirty-nine types were assigned to the remains, with three identified only to family level. Of the other 36 types, 10 occur frequently and the remainder occur in only one or two samples (Table 5.12). *Galium* and *Asperula* types were the most frequent taxa occurring in 36% (9 samples) and 24% (6 samples) of the samples respectively.

A small-seeded Lolium, identified during preliminary analysis as *Lolium* cf. *remotum* Schrank, by Nesbitt, occurs in large quantities in the flax samples but is not identified in *The Flora of Turkey* (Davis 1965-1989). The dimensions of charred modern seeds of all Turkish *Lolium* species, as well as *Lolium remotum,* were measured in an attempt to ascertain the potential species but differentiating between the different species was limited.

Camelina sativa, *Lolium* cf. *remotum* and *Silene* type 1 occurred in over 20% of samples and are the site's most abundant weed types with the most prevalent, *Silene*, having a total of 4743 seeds recorded (Table 12.5). *Taeniatherum*, *Vaccaria* and *Stipa* are also frequent taxa. The remaining taxa were commonly found as single specimens; the exception to this is over 50 *Poa* bulbils in sample 47.

5.4 Canhasan I

Fifty-one samples from Neolithic/Chalcolithic contexts at Canhasan I were analysed by Mark Nesbitt. As these results are unpublished, Nesbitt's original score sheets were examined in this research, together with the re-identification, as mentioned previously, of select reference material stored in the UK; only samples from Neolithic/Chalcolithic contexts are discussed here. Limited identification of the weed flora had been conducted by Nesbitt but these items were not available for re-examination and weed taxa will only be mentioned briefly (Table 12.6).

Only 31 of the samples contain 30 crop items or more. Such samples are crop-dominated (Figure 5.17), a factor most likely arising from the sampling strategy and techniques employed (see Chapter 2).

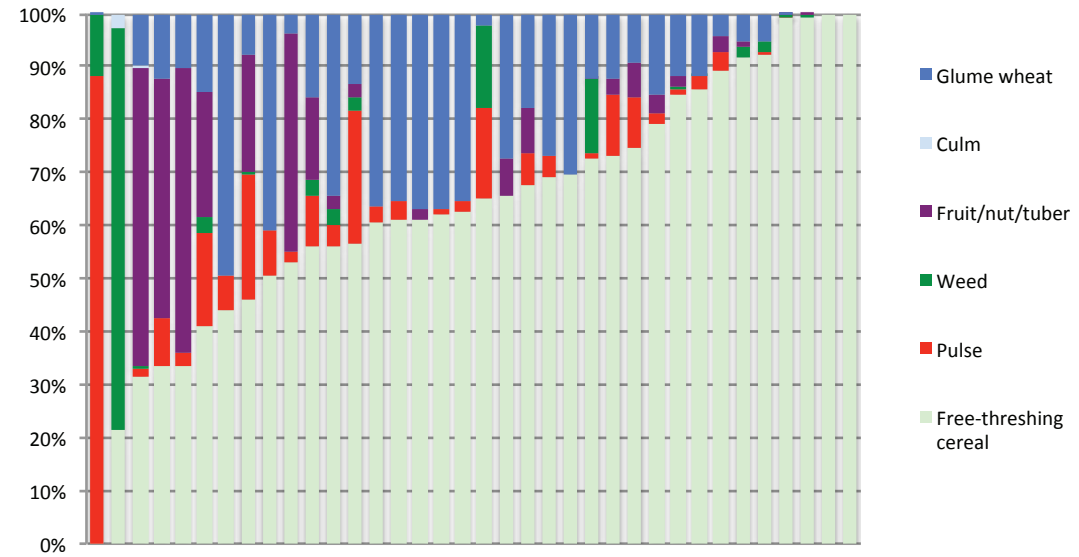


Figure 5.17: Composition of the Canhasan I samples containing 30 or more items.

5.4.1 Crops

Eight crop taxa were recorded by Nesbitt in the Neolithic/Chalcolithic Canhasan I samples: emmer, free-threshing wheat, hulled and naked barley, pea, lentil, bitter vetch and rye.

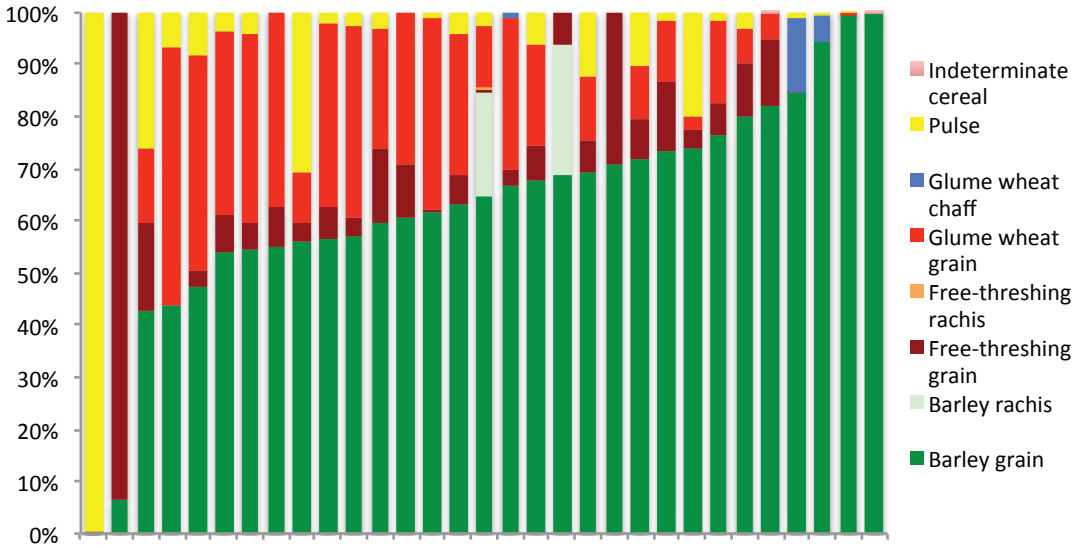


Figure 5.18: Composition of crop material in the Canhasan I samples containing 30 or more crop items.

Emmer grain and chaff were recorded by Nesbitt as the second most common grain type within the assemblage, occurring in 30 of 37 samples (81%) and in some cases in high numbers, for instance 158 grains in sample 2017/2018.

Examination of the material in the author's possession indicated that there are 'new-type' grains in the emmer samples. As it appears that the glume wheat material from Canhasan I is a mixture of emmer and 'new type', comparisons of the differing compositions of the two glume wheats cannot be made; 'new type' was not a recognised species when this assemblage was first analysed by Nesbitt. Consequently the glume wheats are merged into an emmer/'new type' category. Of note is the absence of einkorn in the Canhasan I assemblage. The only recorded einkorn comes from a high concentration of one and two-seeded items in a sample believed to be derived from a younger non-Chalcolithic context. This has not been included in any analysis.

Nesbitt recorded limited chaff remains. Emmer chaff occurs in only three samples (6%), of which one sample produced only two glume bases. The other two samples, 55 and 137, contain more than 50 glume bases but no emmer grains: these samples have high concentrations of hulled barley grains. The lack of glume wheat chaff is notable, but is probably not an absence in the archaeological record, but instead an artefact of the excavation practices and methods employed during the Canhasan I excavation during the 1960s. Archaeobotanical samples during the excavation of Canhasan I were either hand collected or the result of the sieving (both dry and wet) of sediment through a stack of 10 mm, 5 mm and 1 mm sieves (French 1968). Anything smaller than 1mm will have been lost and

may explain the lack of glume bases in the samples. It is notable that the two samples with high numbers of chaff remains are samples that were hand-collected within the trench and are not the result of sieving.

Four free-threshing cereals were identified in the Canhasan I samples: free-threshing wheat, naked and hulled barley and rye (*Secale cereale* var*. cereale*). Free-threshing wheat was identified in both grain and chaff remains. Re-examination of the rachis confirms Nesbitt's identification of bread wheat (*Triticum aestivum*), occurring in only one sample, whereas free-threshing wheat grains occurred in 41 samples, making it as prevalent as emmer (81%, Table 5.13).

Table 5.13: Summary of the Canhasan I assemblage (37 samples containing 30+ items) detailing the total number of items, maximum number items and the ubiquity of the taxa identified by M.Nesbitt, and partially re-assessed in this study.

Taxa	Total items	Maximum	Ubiquity	
			Count	%
Chaff				
Hulled barley rachis	266	248	2	5
Bread wheat rachis	5	5	1	3
Emmer (/'new type') glume bases	393	325	3	8
Grain				
Emmer (/'new type') grain	1024	158	30	81
Free-threshing wheat grain	409	98	32	86
Naked barley grain	209	172	6	16
Hulled barley grain	13110	5020	37	100
Pulse				
Pea	5851	5691	23	62
Bitter vetch	4	1	4	11
Lentil	39	21	7	19
Indeterminate pulse	10	8	3	8
Other				
Cereal culm	11	10	2	5
Wild food				
Tuber	24	14	4	11

Taxa	Total items	Maximum	Ubiquity	
			Count	%
Pistacia terebinthus L.	616	516	18	49
Grape	28	20	3	8
Prunus divaricata Ledeb. type	4	2	3	8
Capparis sp.	763	763	1	3
Weeds				
Misc. Weed	142	95	8	22
Galium sp.	306	280	4	11
Vaccaria pyramidata Medik.	99	49	4	11
"Small weed vetches"	19	14	2	5
"Large weed vetches"	23	14	3	8
"Grass vetchling"	3	2	2	5
"Clover group"	84	84	1	3
Weed grass grain	41	39	3	8
Weed grass spikelet base	9	9	1	3
Aegilops sp. grain	1	1	1	3
Aegilops sp. internode	2	2	1	3
Triticum boeoticum	2	1	2	5

One rye grain only was identified positively by Mark Nesbitt. Two other grains were identified as cf. rye: re-examination indicates a possibility that these are badly preserved 'new type' grains. As such they were classed as *Triticum/Secale* and later re-assigned as wheat during proportional reassignment.

Nesbitt identified both naked and hulled barley grains. Hulled barley grains are the dominant crop in the assemblage, found to various degrees in all samples; sample 2203 contained over 5,000 barley grains (Table 5.13). Naked barley is less frequent and less abundant, occurring in six (16%) of samples (Table 5.13). Counts of twisted and straight grains recorded by Nesbitt indicate the presence of six-rowed naked and hulled barley. Limited rachis remains were found, occurring in only two samples, 2046 and 624. Sample 2046 has a high number of rachis internodes (248), which Nesbitt identified as two-rowed hulled barley. This

identification was confirmed by the re-examination of a small amount of the chaff remains held by the author.

Three pulse taxa were identified in the Canhasan I samples: bitter vetch, pea and lentil. Pea is the most ubiquitous, occurring in 63% of samples. Pea seeds dominate one sample, with Nesbitt recording over 5,600 peas in sample 2200: pea seeds occur in low numbers in the other samples. Lentil occurs in seven samples (19%) and only four bitter vetch seeds were recorded (Table 5.13). The limited quantity of bitter vetch raises the question of its purposeful cultivation or its inclusion in the archaeobotanical assemblage as a weed.

5.4.2 Variation in crop composition

The Canhasan I samples comprise three different crop groups: free-threshing cereals, glume wheats and pulses. Comparison of their proportions in the samples highlights the dominance of free-threshing cereals in the assemblage (Figure 5.19).

Examination of the ratios of cereals in the assemblage indicates that this dominance is due to the high proportion of barley in the samples. Only two of the 30 samples contain more than 50% of a cereal other than barley. Sample 2170 contains a high proportion of free-threshing wheat (56 grains, 93% of the items) and sample 2006 contains a higher amount of glume wheat material than barley material (37 emmer grains to 34 barley grains). There are however samples which contain large amounts of nearly pure barley remains (samples 2203, 55, 137, 1855).

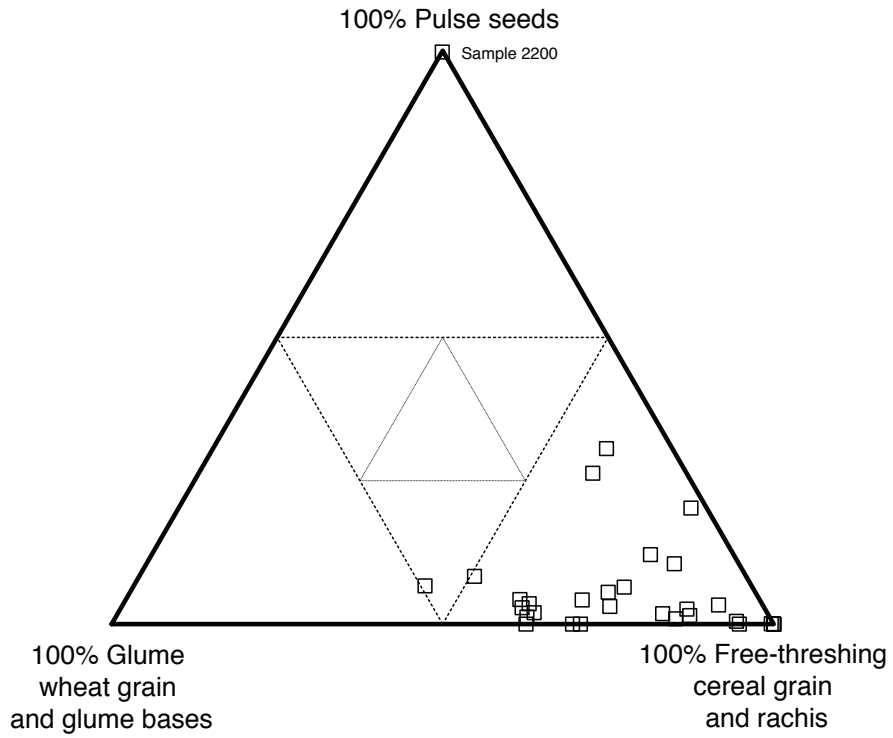


Figure 5.19: Proportion of glume wheat, free-threshing cereal and pulse items in the 30 Canhasan I samples containing 30 or more glume, free-threshing cereal and pulse items.

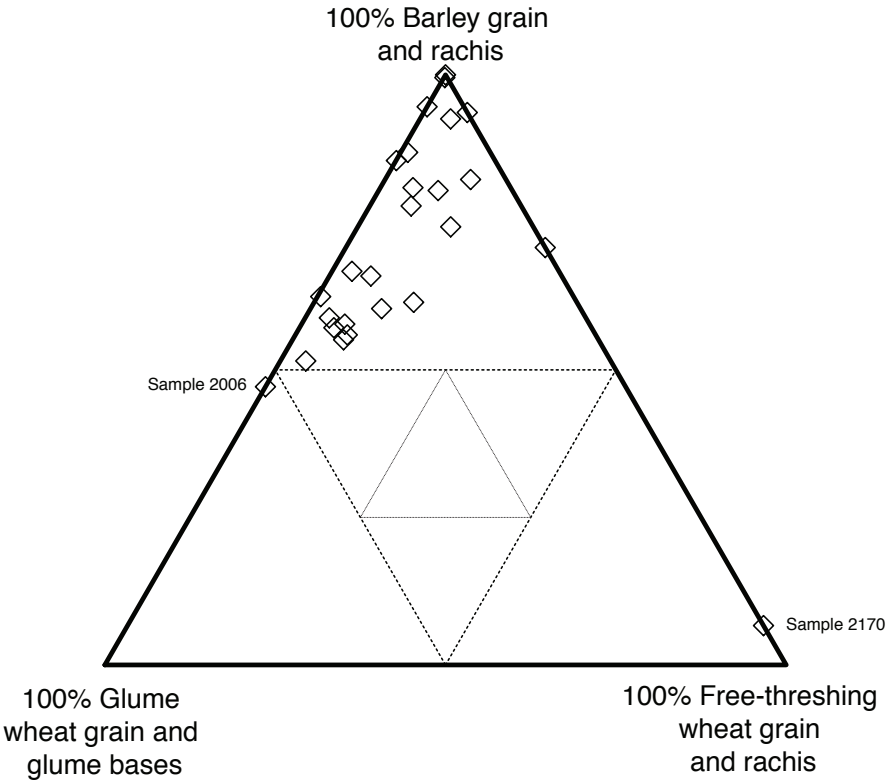


Figure 5.20: Proportions of glume wheat, free-threshing wheat and barley in the 30 Canhasan I samples containing 30 or more cereal items.

5.4.3 Wild taxa

5.4.3.1 Edible plants

Potentially edible taxa were identified in the assemblage; Nesbitt identified *Pistacia terebinthus/atlantica,* grape (*Vitus* sp.), and *Prunus* remains. *Pistacia* remains occur in 57% of the samples with one large deposit found in sample 1980 (516 nuts). *Prunus* fruit stone remains were identified at low levels in four samples; comparison by the author of drawings of the Canhasan I fruit stone remains with Çatalhöyük West material indicated the same taxa: a strongly ridged/sculptured fruit stone. Thus *Prunus* from Canhasan I has been labelled as *Prunus divaricata* type.

Grape seeds were found in three samples, all dating to layer 1 and may suggest a late introduction into the diet. However the limited number and the potential intrusiveness of this taxa needs to be examined via dating before any further conclusion can be made. One other taxon that appears to have been collected is *Capparis* sp. (caper); sample 2200 contains 763 caper seeds, which Nesbitt (unpublished) hypothesized were a purposeful collection for consumption.

5.4.3.2 Other wild taxa

Nesbitt (unpublished) wrote that no systematic attempt was made to identify the weed flora from Canhasan: only broad categories were recorded, with unknown taxa grouped in a miscellaneous weed category. All weed portions of samples still reside in Turkey and re-examination of them was not within the scope of this research.

Nesbitt recorded taxa such as *Galium* sp., *Vaccaria pyramidata*, small and large weed vetches and *Aegilops sp*. These occur infrequently in the assemblage, with only two weed categories occurring in more than 10% of the samples: large weed vetches (12%) and the miscellaneous weed category (16%).

5.5 Overall summary

The assemblages of the four sites present similarities and differences in composition. Glume wheats, hulled barley and pulses are an important component in all four assemblages, yet variation in the proportions of specific taxa can be seen between the sites. A wider range of pulse taxa occurs at Çamlıbel Tarlası compared to Çatalhöyük West, with pulses also more ubiquitous. The effect of different sampling methods has a significantly impact on the retrieval of material, in particular from Canhasan I where there is a limited number of small items such as glume bases and weed seeds. This is most likely a consequence of large mesh size used in sample retrieval.

6 Sample composition and spatial relationships

This chapter aims to identify and interpret the main compositional trends in the four sites' assemblages using the ordination technique correspondence analysis. The resulting plots of taxa and samples were coded according to attributes such as taxon category, context, phase and crop-processing classification. Additionally, in order to explore spatial variation, pie charts were plotted on site plans to assess patterning.

6.1 Çatalhöyük West

Figures 6.1-6.2 reveals the analysis of 41 samples and 61 taxon categories (see Chapter 4 for thresholds; Table 12.7 for codes of taxa included, *Bromus, narrow* type was removed as an extreme outlier). Chaff dominates samples dispersed towards the positive or right end of horizontal axis 1, while wild/weed taxa, crop seeds and collected taxa are concentrated in samples located towards the negative or left end of the axis. The oil-rich seeds of *Descurainia* are concentrated in samples towards the left-hand side of the plot, in contrast to glume base concentrations on the right-hand side, suggesting that these two categories were generated by separate activities and tended to enter the record by different routes. On the vertical axis 2, relatively large-seeded wild taxa are concentrated towards the positive or top, in contrast to small-seeded taxa plotted towards the negative or bottom of the axis (Figure 6.3). There is a slight tendency for cereal grain to be concentrated towards the positive end of axis 2, perhaps in association with larger seeded wild/weed taxa although the pattern is weak (Figures 6.2-6.3).

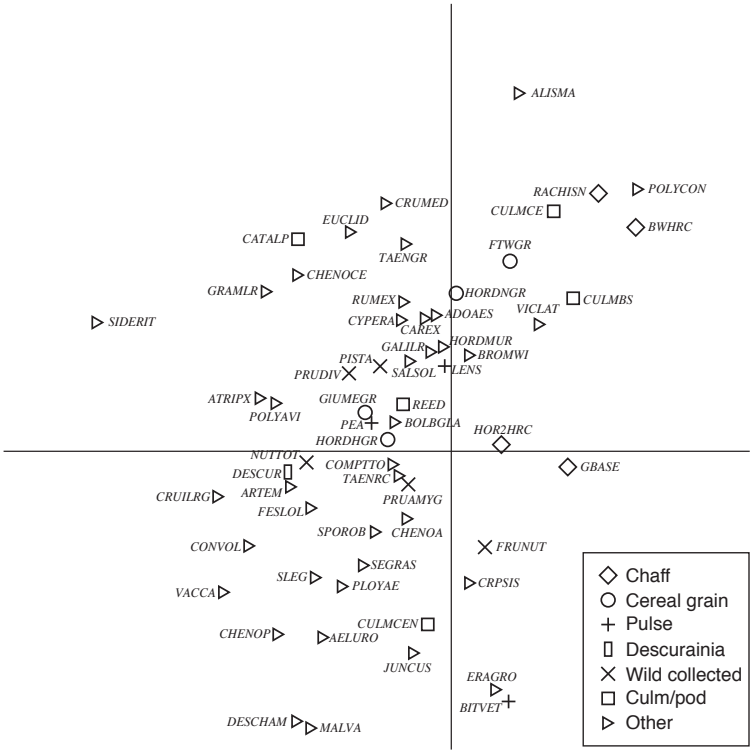


Figure 6.1: Plot of the results of correspondence analysis on 41 samples and 61 species from Çatalhöyük West; symbols show major categories.

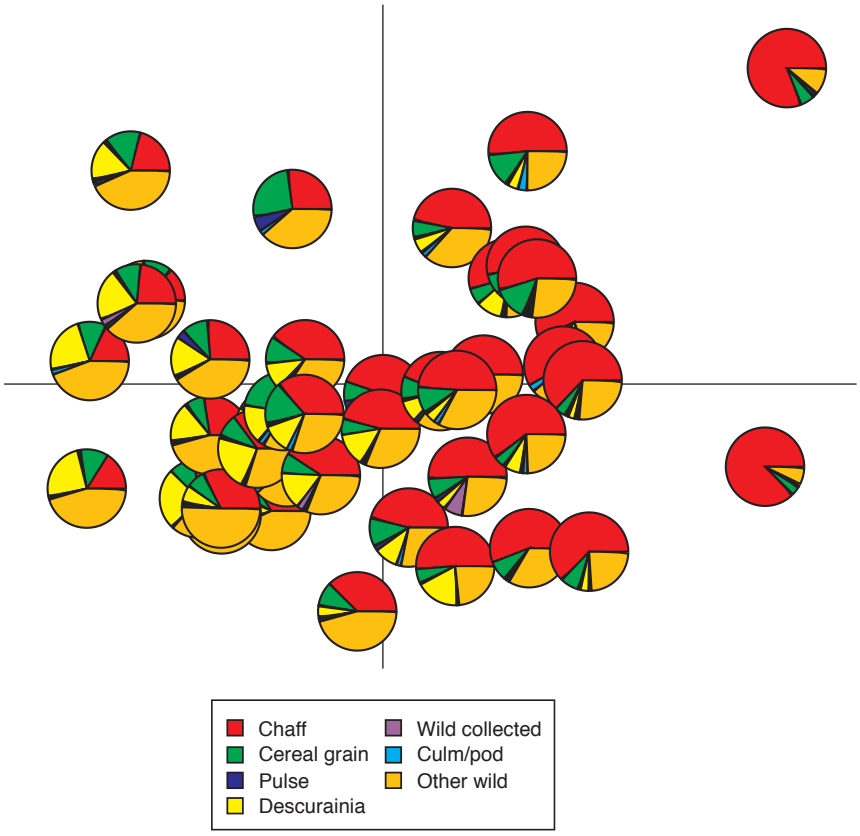


Figure 6.2: Results of the correspondence analysis of Çatalhöyük West samples, showing samples represented as pie charts summarising composition in terms of major categories.

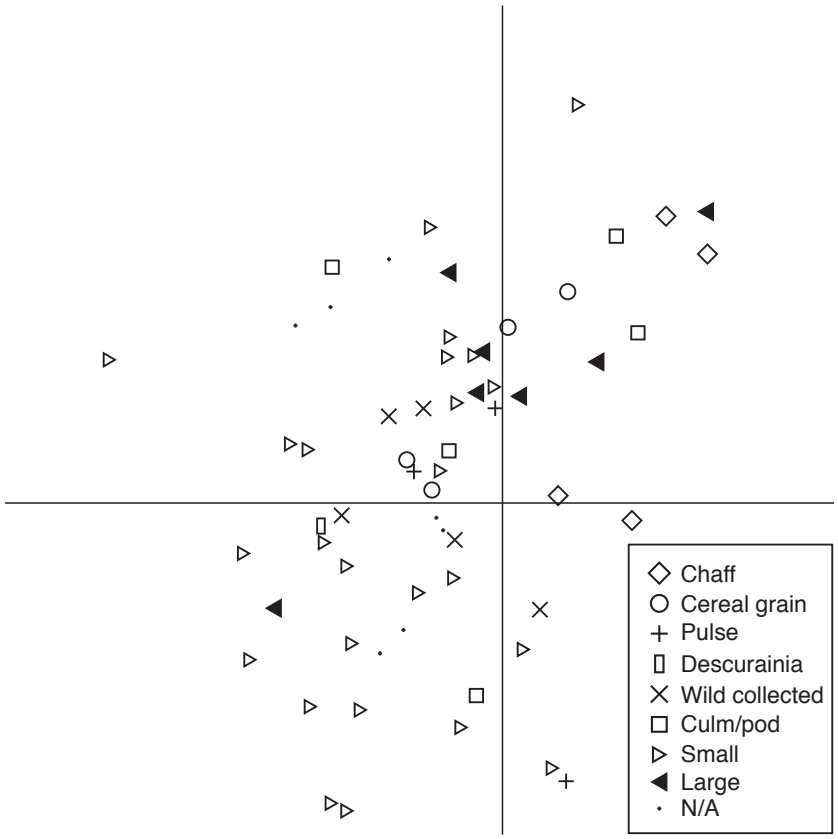


Figure 6.3: Results of correspondence analysis of Çatalhöyük West samples. Species shown, coded for major taxa groups with wild seeds displaying seed size in reference to crop processing.

All samples derive from midden deposits within which occurred clusters of specific items, concentrated lenses of burning and the floors of the building. Examination of the samples' compositions from these contexts reveals they range from glume base-rich to weed-rich (Figure 6.4). Cluster samples are focussed towards the bottom or negative end of axis 2, while the lens samples form two distinct groups, either glume base-rich/low *Descurainia* (positive end of axis 1) or *Descurainia* -rich samples (negative end of axis 1). Context does not appear to play a role in sample composition, most likely due to the limited range of contexts in the assemblage.

Figure 6.5 indicates little clear difference between the buildings, though it must be borne in mind that these deposits represent midden deposition in abandoned rooms rather than occupation deposits. The two buildings with the majority of the samples, 98 and 105, both have variable sample compositions.

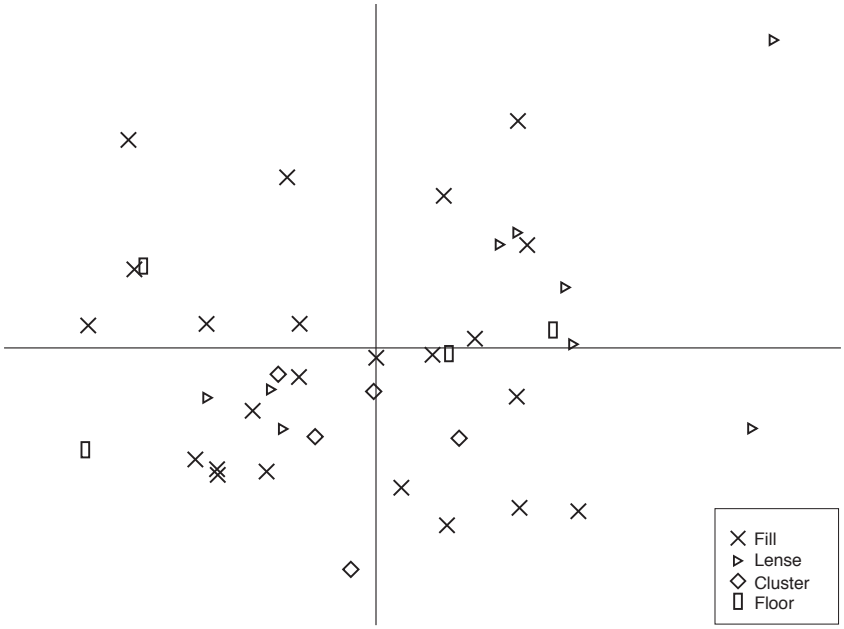


Figure 6.4: Çatalhöyük West correspondence analysis, showing the samples coded for context type.

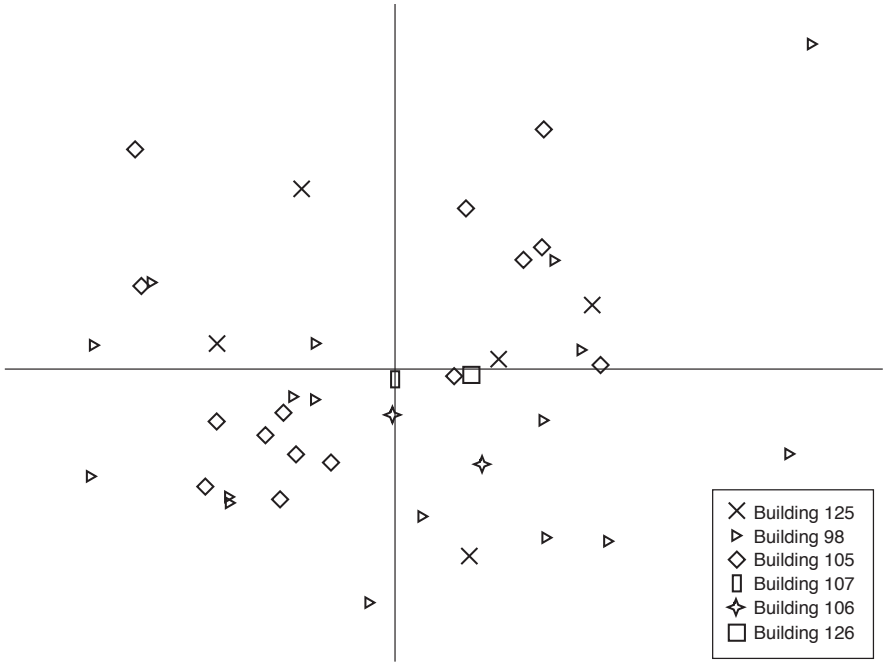


Figure 6.5: Correspondence analysis for Çatalhöyük West samples, the symbols representing the buildings from which samples were obtained.

Using the analysis of all samples but displaying only samples from building 98 highlights two lens samples dominated (>75%) by glume bases (Figure 6.6). Other samples from this building have a range of compositions and so there is limited patterning. The samples from 105 also present limited patterns based on context (Figure 6.7). Generally the patterns within the buildings, or lack thereof, reflect the overall results. There is mixed clustering due to stratigraphic positions; some samples adjacent stratigraphically are grouped together, for example 9619 and 9603 but others differ completely in composition, such as 9519, which is stratigraphically above 9600 (Figure 6.7).

To summarize, difference in composition pivots on the proportions of glume bases compared to *Descurainia* within the samples at Çatalhöyük West. Sample composition is highly variable, with context not a causal factor. There appears to be no significant difference in the composition of samples found in each building, suggesting, with a caveat, that the samples are of a mixed secondary nature, the activities the samples represent are common across the sampled area.

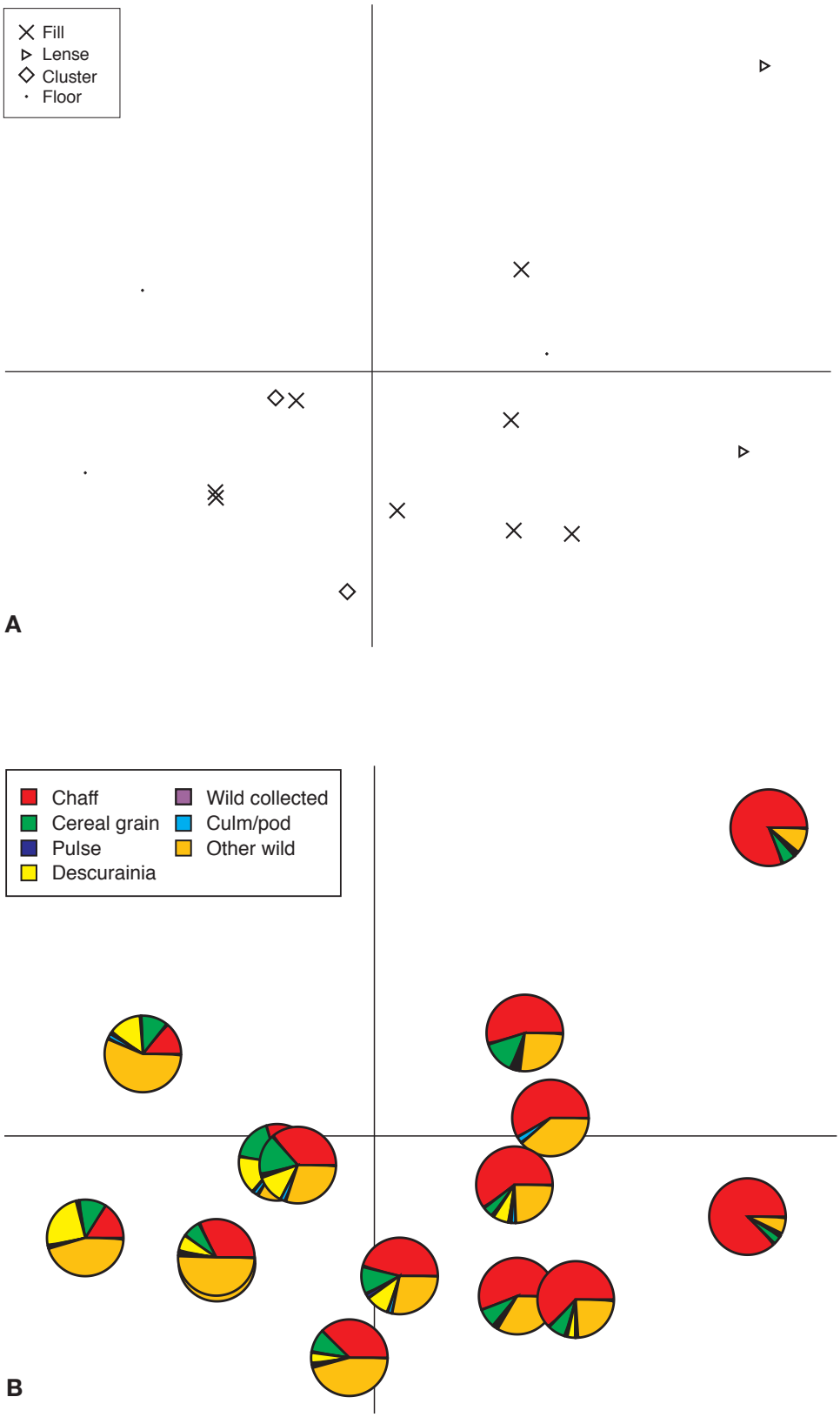


Figure 6.6: Results of the correspondence analysis of all Çatalhöyük West samples but only displaying Building 98 samples. Graph (A) depicts the samples coded for context type and graph (B), samples represented as pie charts summarising composition in terms of major categories.

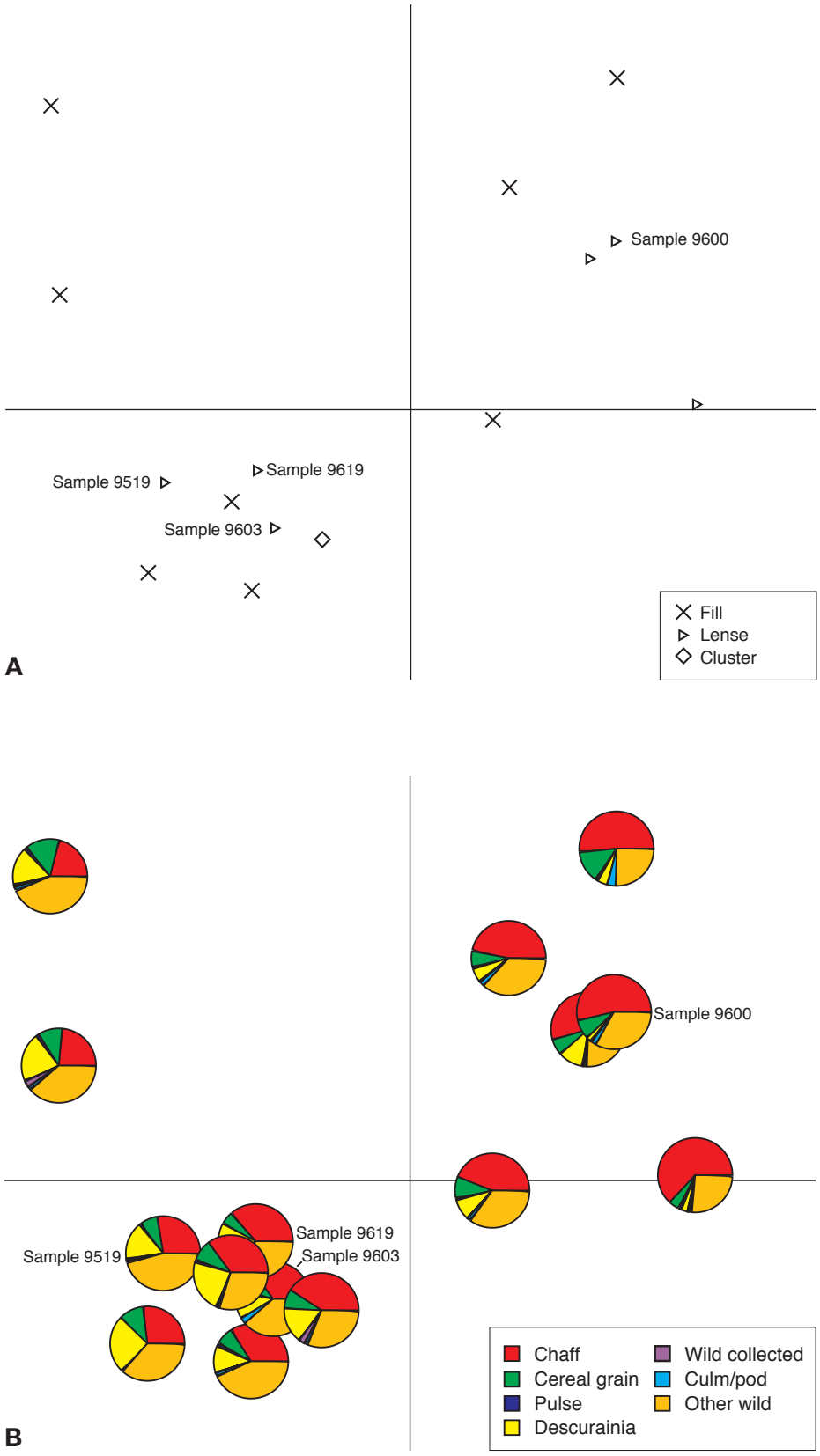


Figure 6.7: Correspondence analysis plots of all Çatalhöyük West samples but only displaying Building 105 samples. Graph (A) presents the samples coded for context, Graph (B) shows samples represented as pie charts summarising composition in terms of major categories compositions.

6.2 Çamlıbel Tarlası

Figures 6.8-6.9 show the analysis of 63 samples and 68 taxon categories (see Chapter 4 for thresholds, Table 12.8, for codes of taxa included, *Bromus rigidus*/*diandrus* removed as an extreme outlier). The major trends shown on axis 1 distinguish flax-related samples at the positive end from samples rich in glume bases and/or other crop material at the negative end. Figure 6.8 reveals that the flax-related group includes a distinctive set of weed species: small seeded *Lolium*, *Silene* type 1 and a medium crucifer. On axis 2, samples with relatively high proportions of glume, wild and/or flax categories are located towards the bottom of the graph at the negative end of this axis. The clustering of the cereal and pulse seeds towards the top of the graph, compared to the glume bases in the bottom left quarter, may reflect differences in their modes of entrance into the archaeological record. Cereal grain, together with some pulse species may have entered the record through accidental charring during food preparation. Glume bases, associated with a large number of pod remains and wild taxa, may be the result of burning of crop processing by-products.

As noted above, a key finding in Figure 6.8 is the group of weeds positioned near the flax seeds as small-seeded *Lolium*, *Silene* type 1, and medium crucifers have been noted as flax weeds in the Kuruçay assemblage (see Chapter 5 and Nesbitt 1996). Many Çamlıbel Tarlası samples are dominated by either small-seeded *Lolium* or glume bases (see Figure 6.9), possibly indicating two different processing mechanisms at play: the processing of flax seed versus the processing of cereal/pulse crops (cf. Papadopoulou and Bogaard 2012).

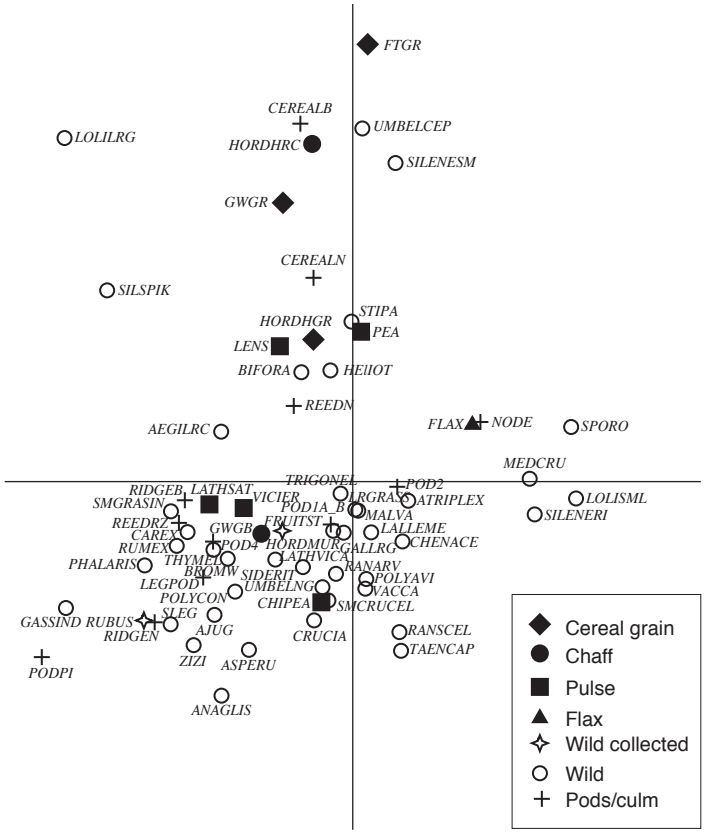


Figure 6.8:Correspondence graph of the major groups of the 63 samples and 68 species from Çamlıbel Tarlası. See Table 12.8 for species codes.

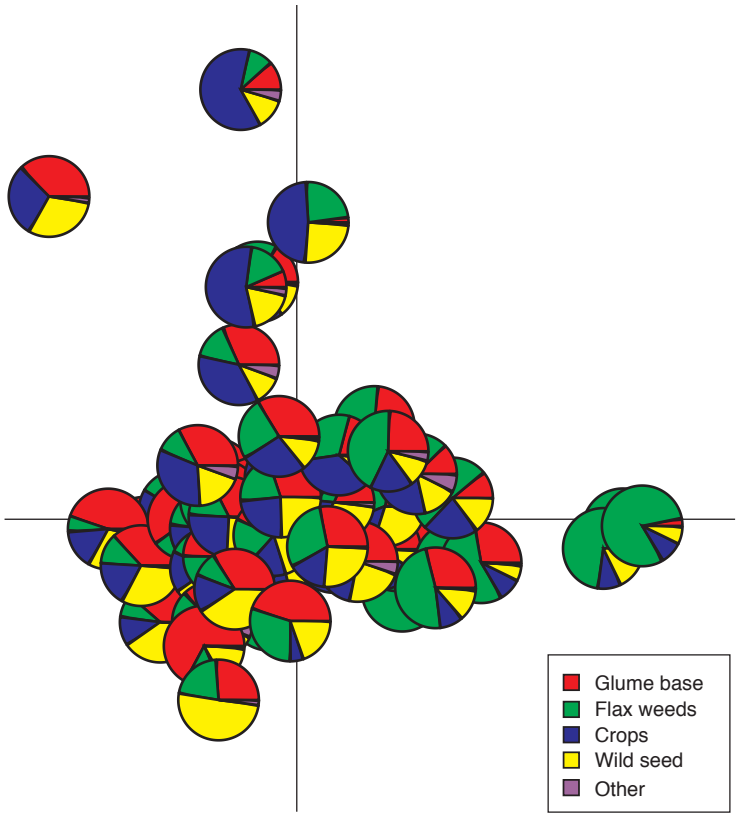


Figure 6.9: Results from the correspondence analysis of Çamlıbel Tarlası samples showing samples represented as pie charts summarising composition in terms of major categories.

The location of bitter vetch and grass pea is notable, occurring in the glume base/wild-dominated bottom left portion of the graph and away from the crop grain and lentil seed material that possibly originated from cooking residue (Figure 6.8). The possibility that chickpea was a crop contaminant has been raised (Chapter 5) and its location at the bottom of the graph would support such an assertion. Figure 6.10 shows that when weed flora are coded by seed size, bitter vetch, grass pea and chickpea are positioned in the cluster dominated by small seeded weeds, a common characteristic of fine sieved by-products. However, there are also large-seeded weeds in this group so the interpretation is not clear-cut. Bitter vetch requires soaking or boiling to remove toxins so it is possible that its processing and preparation occurred separately to the grains (Graff and Rodríguez-Alegría 2012:38).

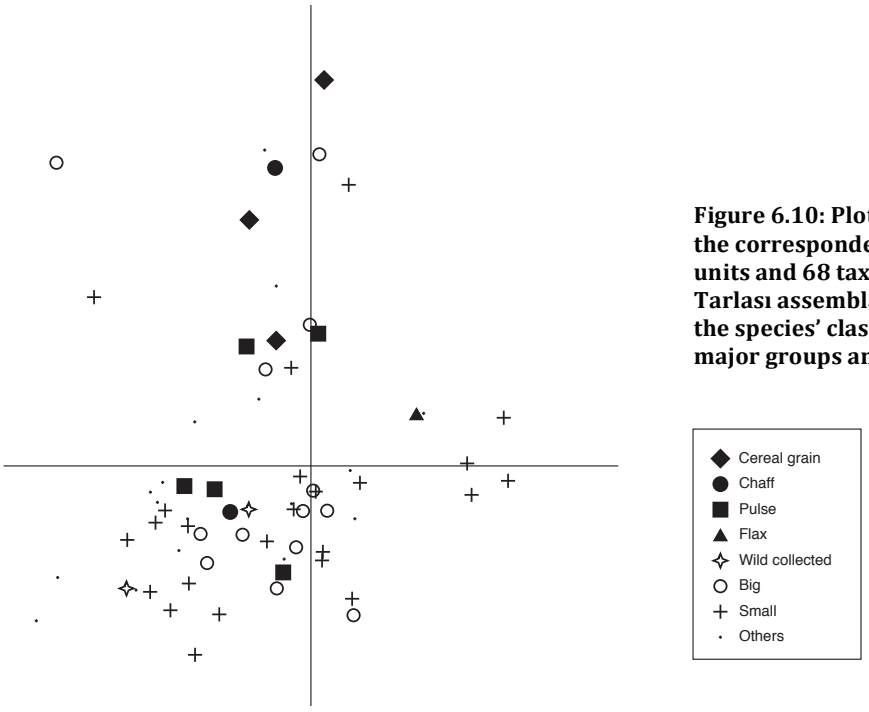


Figure 6.10: Plot of the species from the correspondence analysis of the 63 units and 68 taxa from the Çamlıbel Tarlası assemblage, coded showing the species' classification based on major groups and seed size.

Coding of the samples by occupation phase (Figure 6.11a) demonstrates that the CBTI and CBTII samples have diverse compositions. CBTIV samples cluster more tightly, CBTIII to a lesser extent. CBTIV samples tend to occur in the glume base-

dominated left-hand side of the graph, containing lower proportions of what is assumed are flax weeds (Figure 6.9) It is possible that flax cultivation declined in the later site occupation, or that flax processing waste was used differently. Context appears to play a minor role in sample patterning (Figure 6.11b), though it is notable that flax-rich samples occur in the two oven contexts.

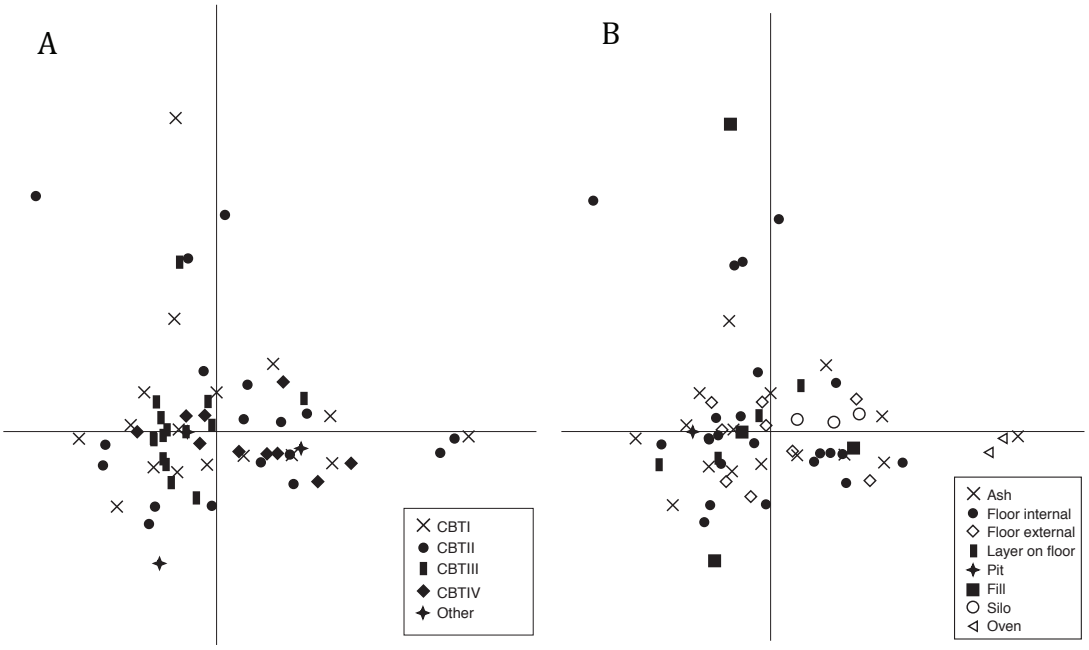


Figure 6.11: Plot of the correspondence analysis of the Çamlıbel Tarlası samples coded for (A) the four major occupation phases and (B) context types.

To investigate the patterning within individual occupation levels, the correspondence analysis of the entire assemblage was coded to show individual phases, together with the plotting as pie charts of individual sample compositions on phase plans where available. CBTI has no permanent structures, with the excavator of the site attributing occupation during this level to episodic use (Chapter 2). This level has an array of sample compositions, all originating from a large feature of burnt material called the "ash layer". There is a separation of samples from north and south regions of the ash layer (Figure 6.12); glume bases and weed seeds dominate the northern region of the deposit, while the southern

region contains more flax/associated flax weeds. Sample 425 from the southern region is the exception, containing large amounts of cereal grain. The large quantity of "domestic" material, such as dehusking waste, suggests that the absence of structures in the archaeological record is misleading; structures were possibly located higher up the slope, with the domestic material washed downwards to its final location. Furthermore the quantity of "domestic" material excavated sheds doubt on the hypothesis that during this period the site was used ephemerally; it instead suggests a more routine and probably permanent occupation at the site.

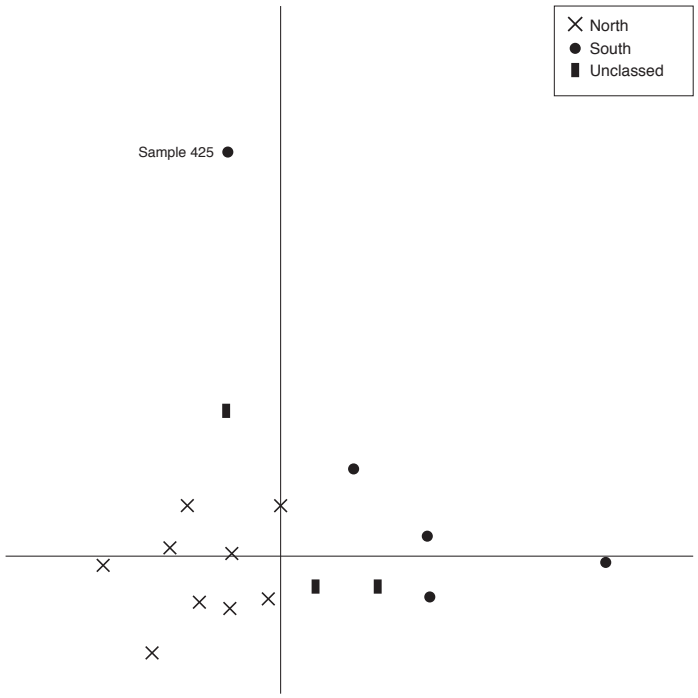


Figure 6.12: Plot of the Çamlıbel Tarlası correspondence analysis showing only CBTI samples coded for sample location.

Plotting of CBTII samples coded by structure indicates differentiation in composition both within and between structures (Figure 6.13). Oven samples contain high proportions of flax weeds to the near exclusion of glume bases; a similar pattern is repeated in the sample from Structure 29 in which the oven was located (Figure 6.14). The three samples from the "silo"(Structure 28) have

similar compositions with the other sample from the same room (Figure 6.14). This suggests that the silo fill is not specifically related to its storage function. The majority of the other samples from this phase contain high proportions of glume bases, while three notable samples (200, 396, 213) have high proportions of cereal grains (Figure 6.13). The floor contexts from the three main structures (Structure 9, 11 and 25) have samples divided between high crop seed composition and high glume base composition, suggesting that within a given structure, different activities are reflected in different floor areas (Figures 6.13-6.14). Differentiation within Structure 25 could be explained by the grain-rich sample occurring in the west room of the building while the two other samples occurred inside and just outside the east room, whereas in Structure 9 the differences observed most likely relate to the two phases of occupation represented; the third phase floor samples are grain rich, while the old floor samples contain limited crop seed material (Figures 6.13-6.14). Differences still do occur within this occupation phase; sample 200 contains very low quantities of flax related material, while nearly one quarter of sample 186/202 is comprised of flax-related material (Figure 6.14). Differences also occur among the older floor samples from Structure 9 – sample 74/3 has few crop seeds and a high proportion glume bases, while sample 180 contains a high proportions of flax weeds and crop seeds and a lower proportion of glume bases (Figure 6.14). Structure 11 samples are contemporary with each other and highlight the spatial variability seen on a single floor: samples high in dehusking waste and samples limited in such waste and composed of nearly 50% crop seeds (sample 213) both occur. The floor samples represent living surfaces and thus most likely reflect an actual occupation pattern.

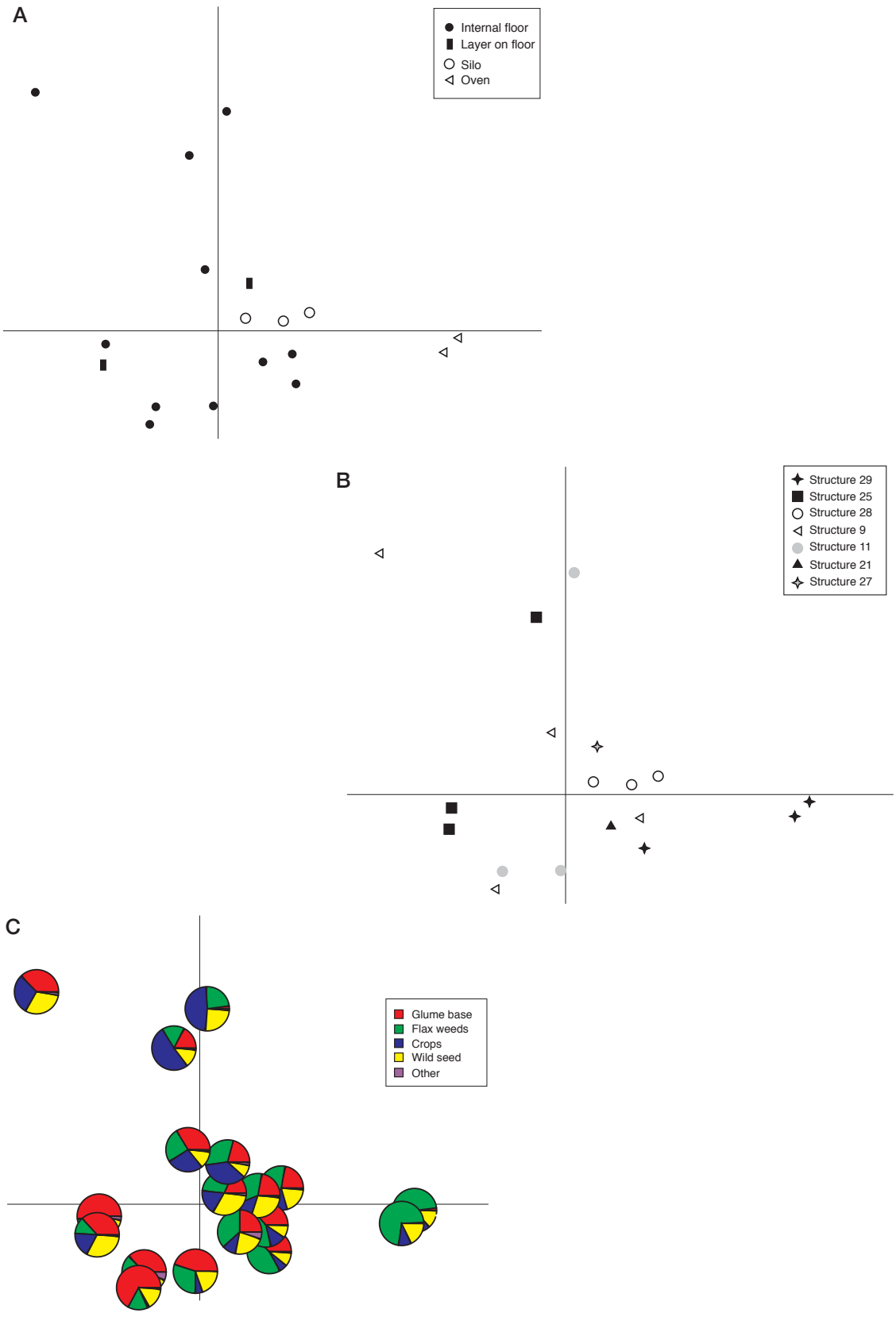


Figure 6.13: Results of the correspondence analysis for the Çamlıbel Tarlası samples, showing only CBTII samples coded for (A) sample context, (B) structure the samples derived from and (C) samples represented as pie charts summarising composition in terms of major categories

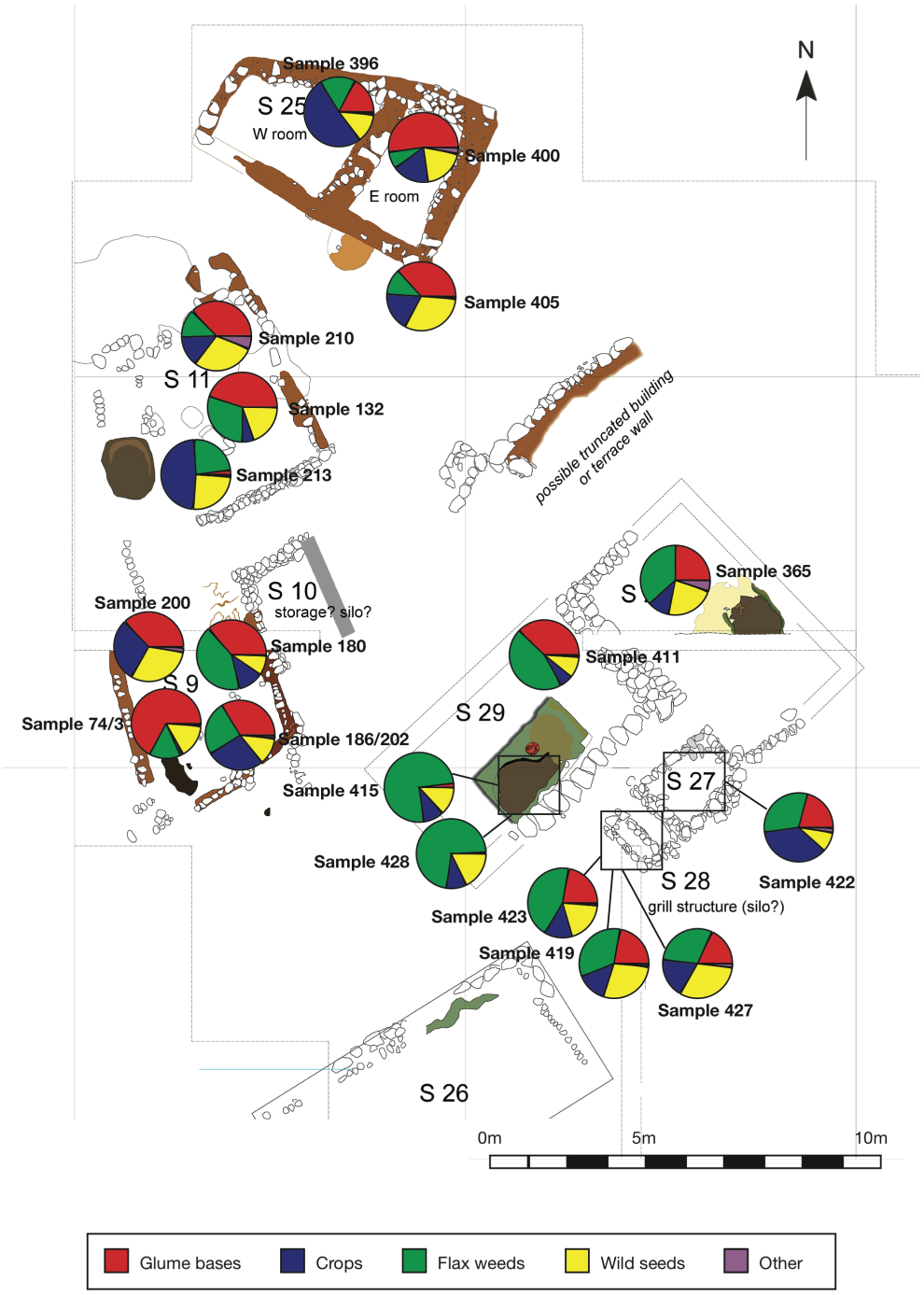


Figure 6.14: Plan of CBTII at Çamlıbel Tarlası showing the location and composition of the samples, plan supplied by U-D. Schoop

One structure of CBTIII provided samples rich enough for examination: the "Burnt House" which was interpreted as a special house (Structure 3)(Schoop 2011a). This structure contains material of a domestic nature. The samples show limited patterning based on internal and external location (Figure 6.15). There

are multiple floors and comparison of samples from this occupation level highlight only one anomalous sample. Floor five contains sample 370 which is comprised of high proportions of grain compared to glume bases, while the other samples from this sub-phase have higher proportions of glume bases. Overall the samples from this level are dominated by dehusking waste.

In the analysis of the whole Çamlıbel assemblage (Figure 6.11), CBTIV samples cluster together (separate phase plot not shown). This level contains two structures and large external areas (Figure 6.16). Plotting of samples as pie charts on the phase plan indicates limited patterning based on differences between internal and external floors. There is sample variation based on the proportions of glume bases compared to flax weeds, but no corresponding spatial pattern (Figure 6.16).

To summarise, the Çamlıbel Tarlası assemblage is dominated by flax weed seeds and dehusking waste. The association of particular weeds with flax seeds, similar to such occurrences at Kuruçay, indicates the existence of a flax weed flora at Çamlıbel Tarlası and highlights a continuum in sample composition from flax weed-dominated through to glume wheat- dehusking remains dominated. Context indicates a weak association of flax weeds with oven deposits, particularly during the CBTII phase, whereas floor samples highlight the spatial variability of composition, reflecting differential use of space for plant-related activities.

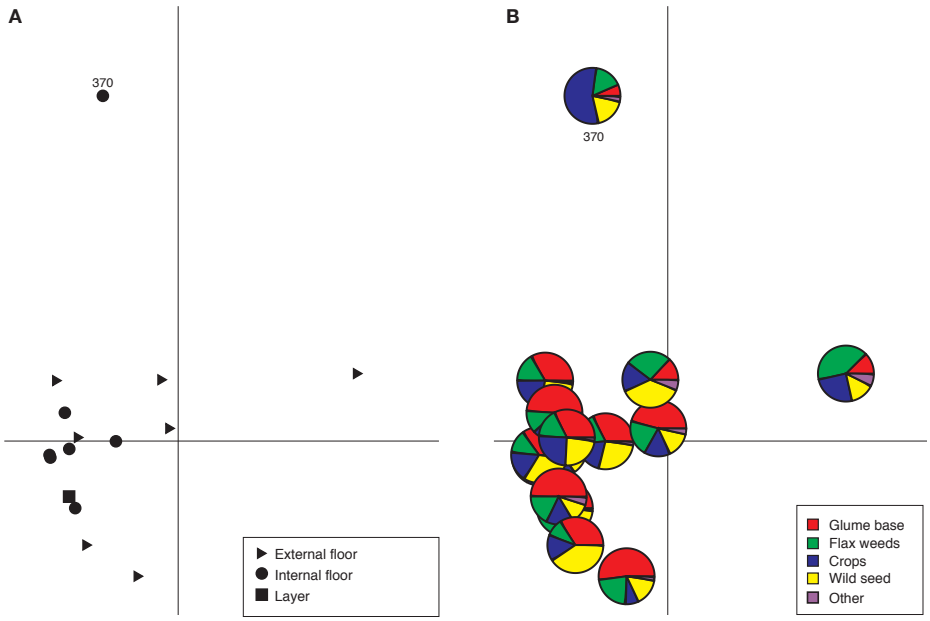


Figure 6.15: Results of the correspondence analysis for the Çamlıbel Tarlası samples, showing only CBTIII samples coded for (A) sample context and (B) samples represented as pie charts summarising composition in terms of major categories.

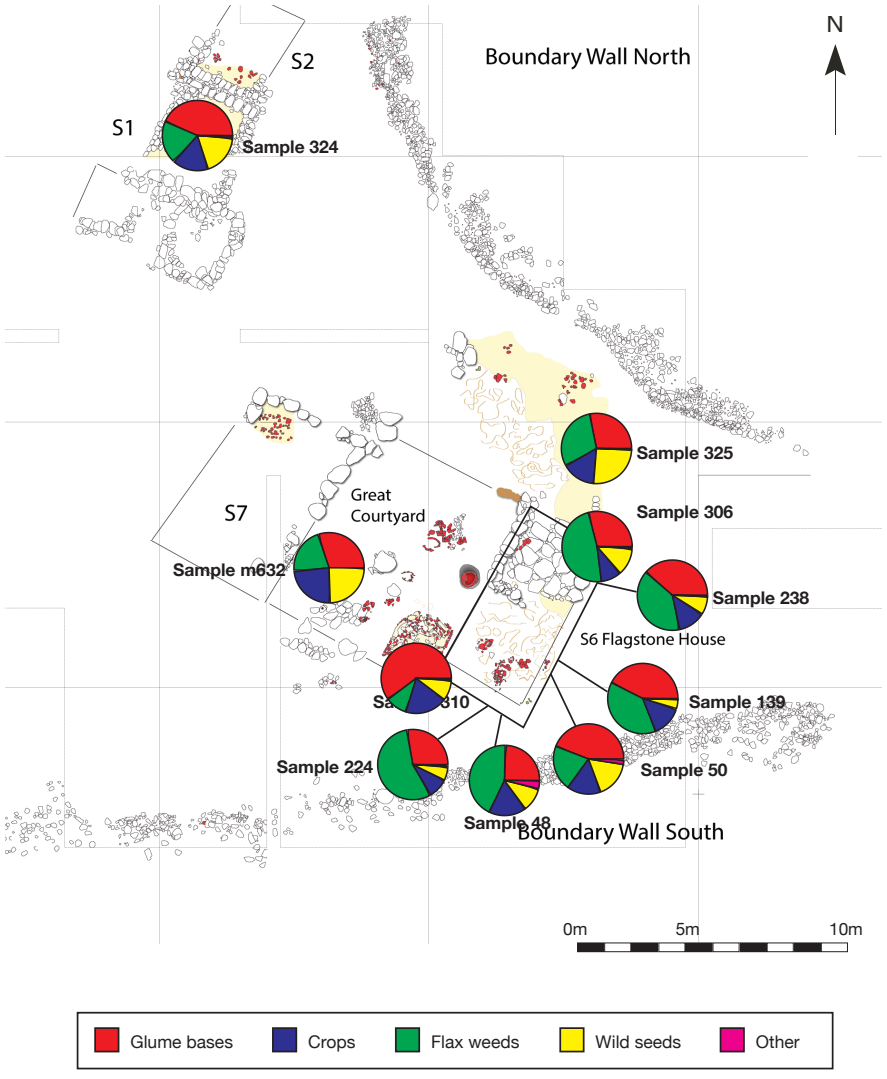


Figure 6.16: Plan of CBTIV at Çamlıbel Tarlası showing the loctation and compostion of the samples, plan supplied by U-D. Schoop

6.3 Canhasan I

The samples from Canhasan I reveal a strong possibility that composition is in part biased by the sampling strategies employed to retrieve the material (see Chapter 2). The samples appear to be biased against the retrieval of small-sized material, with glume bases and rachis remains limited in the assemblage (Chapter 5). Such items are restricted to samples that were collected as sediment, not by sieving where a >1 mm sieve was used. Figures 6.17-6.18 show the results of correspondence analysis of 33 samples and 18 taxa. Sample 2203 was removed as it was an extreme outlier due to a high concentration of pea seeds, while grape was an extreme outlier on the species plot and thus also removed. The major trend on axis 1 distinguishes samples rich in wild/collected taxa (e.g. *Pistacia*) from other samples (Figures 6.17-6.18). On axis 2, free-threshing wheat grain and glume wheat grain concentrations are distinguished from barley and collected wild plants.

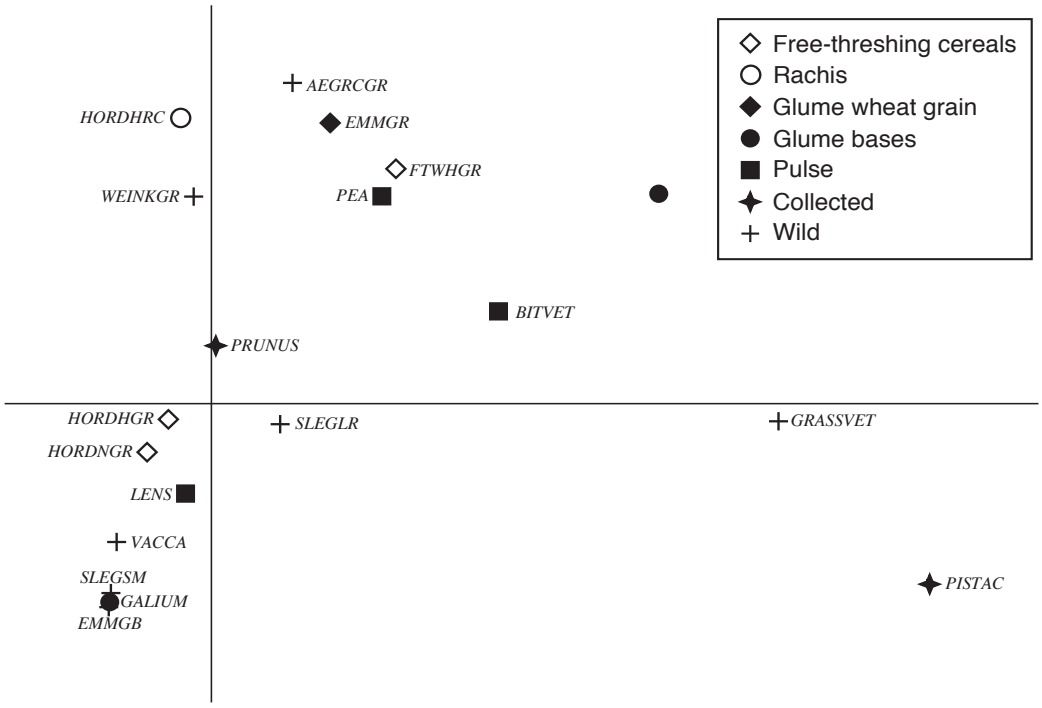


Figure 6.17: Species plot showing the correspondence analysis of the 33 samples and 18 taxa from Canhasan, coded for the major taxa categories (species coded described in Table 12.9).

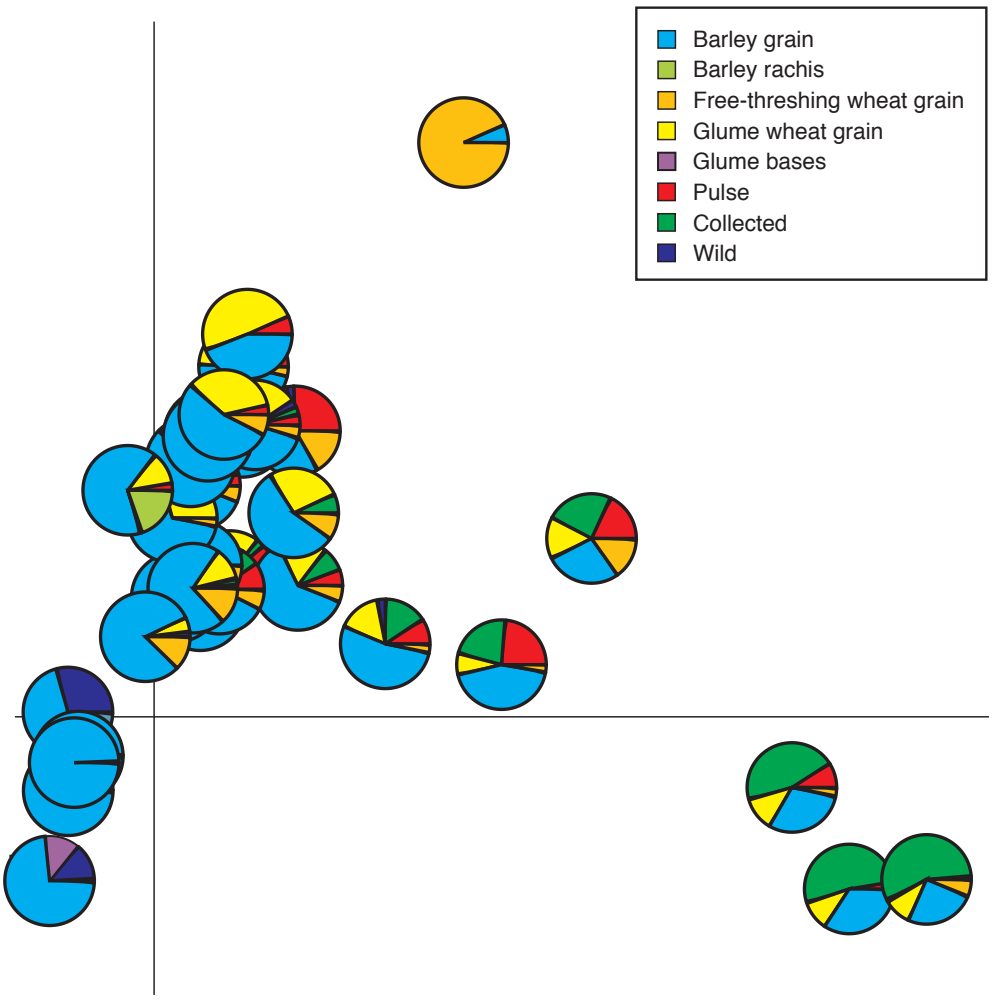


Figure 6.18: Plot of the correspondence analysis of the Canhasan 33 samples and 18 taxa, showing samples represented as pie charts summarising composition in terms of major categories.

Despite limited information on the wild/weed taxa because of the lack of species identification by M. Nesbitt (see Chapter 5), there does appear to be some clustering of specific crop types; barley grain is located near *Galium,* small seeded legumes and *Vaccaria*, while the emmer and free-threshing wheat grains cluster near *Aegilops* (Figure 6.17). The different associated crop components from multiple taxa make such associations unclear.

Contextual information is limited, but it appears that the majority of samples originate from the fill within the houses, similar to the depositional situation at Çatalhöyük West. The potential for investigation into contextual differences in composition is limited. Spatial patterning in composition was investigated for the three main levels represented in the assemblage by plotting samples on phase plans (level 1 not shown)(Figures 6.19-6.21). Level 5 shows some spatial variability among the storage room samples (Figure 6.19). Level 2B samples appear similar with the exception of sample 2170, which is high in free-threshing grain (Figure 6.20). There also appears to be an increase in the proportion of pulse seeds and collected wild taxa between levels 2b and 2A (cf. Figure 6.20 and 6.21). Interpretation of such a trend is difficult as a number of such samples are from the dry-sieving of baulks, appearing to favour the retrieval of large sized species due to a large dry sieve mesh size.

To summarise: assessing the Canhasan I assemblage is problematic due to the sample retrieval methods used during excavation hampering assessment of whether absences of small items are real or artificial. Nonetheless, samples are separated on proportion of barley grains in addition to the quantity of wild items. Contextually there appears to be some spatial difference in samples but the limited contextual data hampers understanding of the true context type represented by the samples.

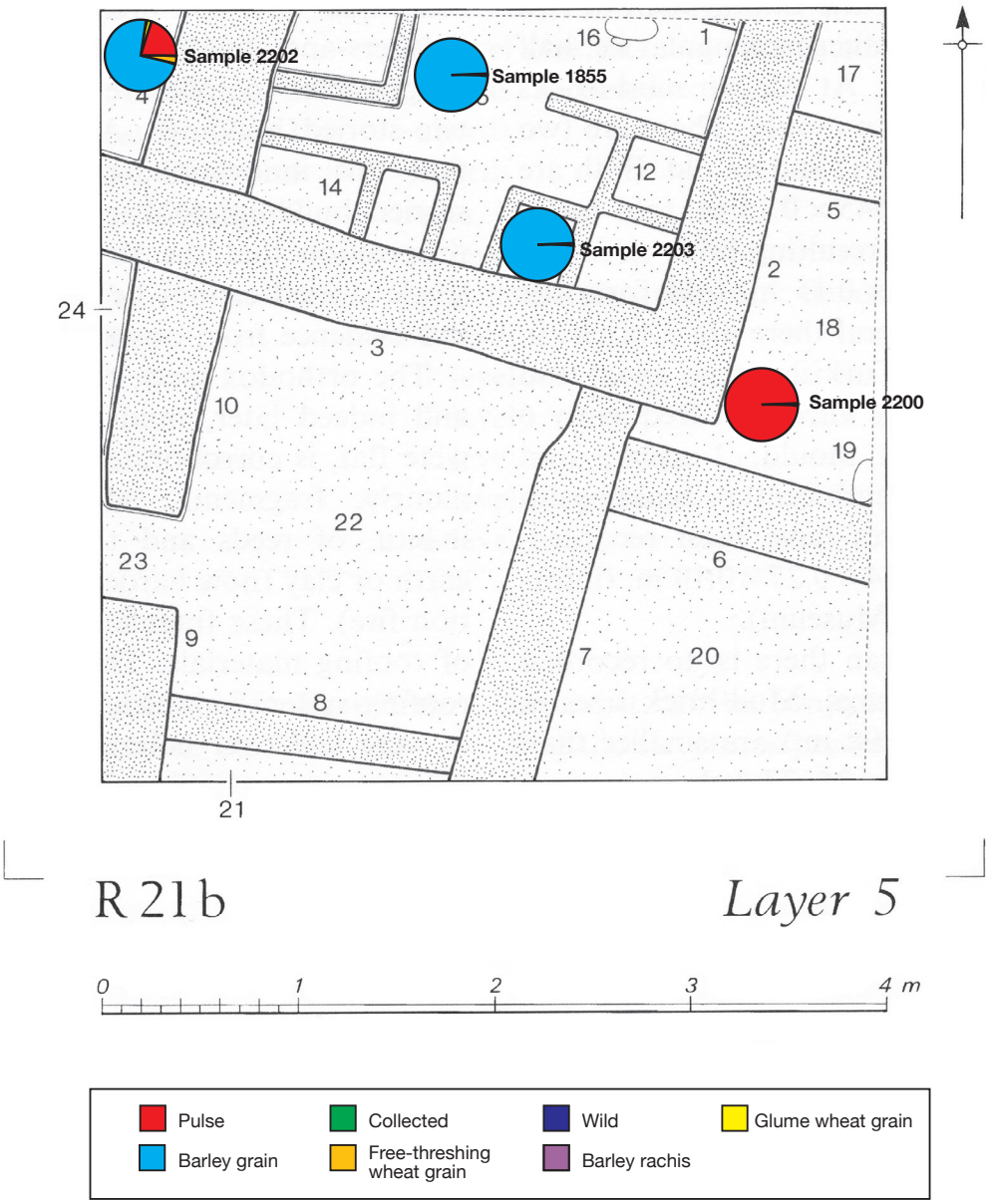


Figure 6.19: Layer 5 plan showing the location and composition of the samples

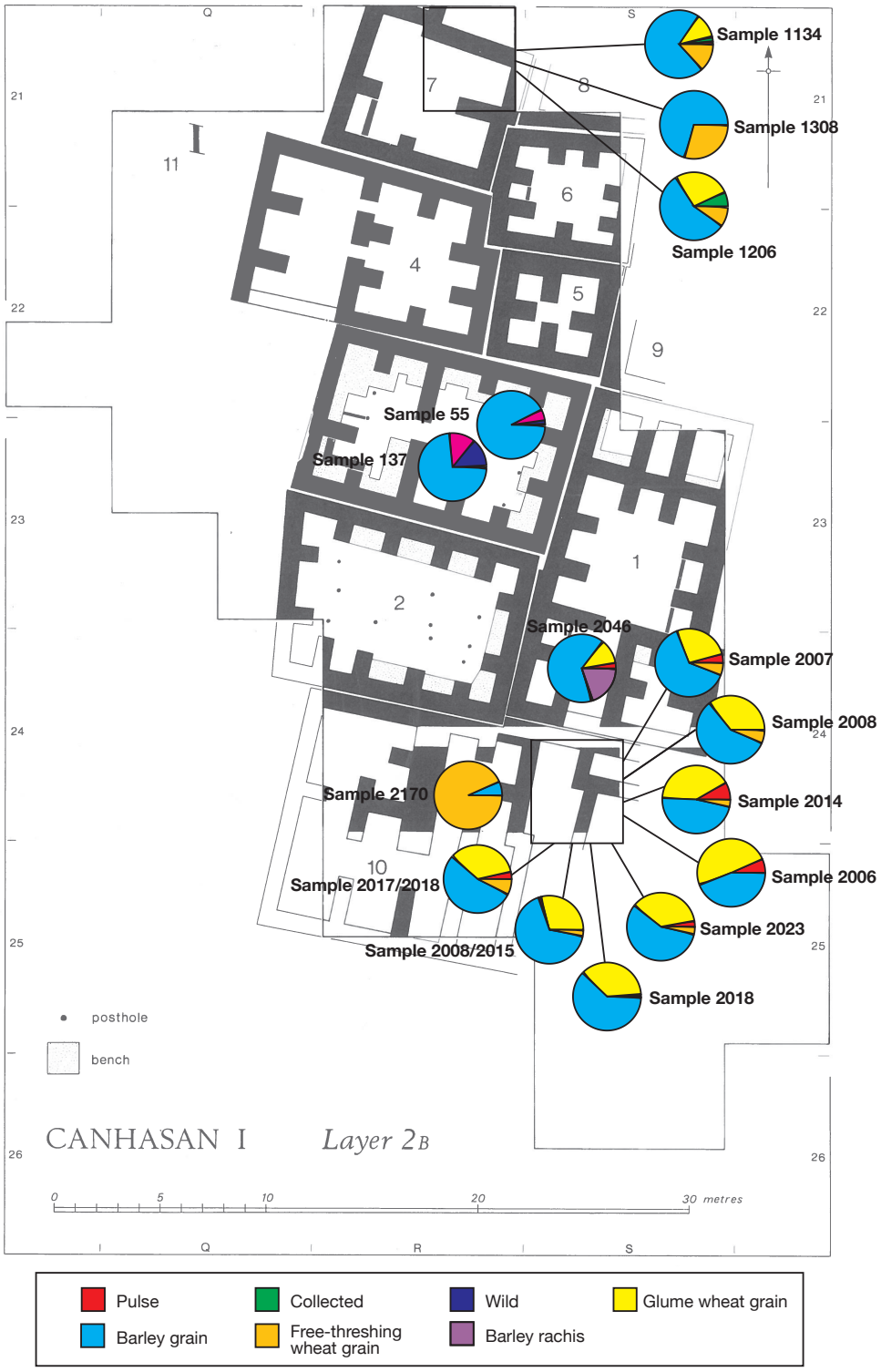


Figure 6.20: Plan of Layer 2B from Canhasan I showing the location of, and the proportion of major categories in the samples

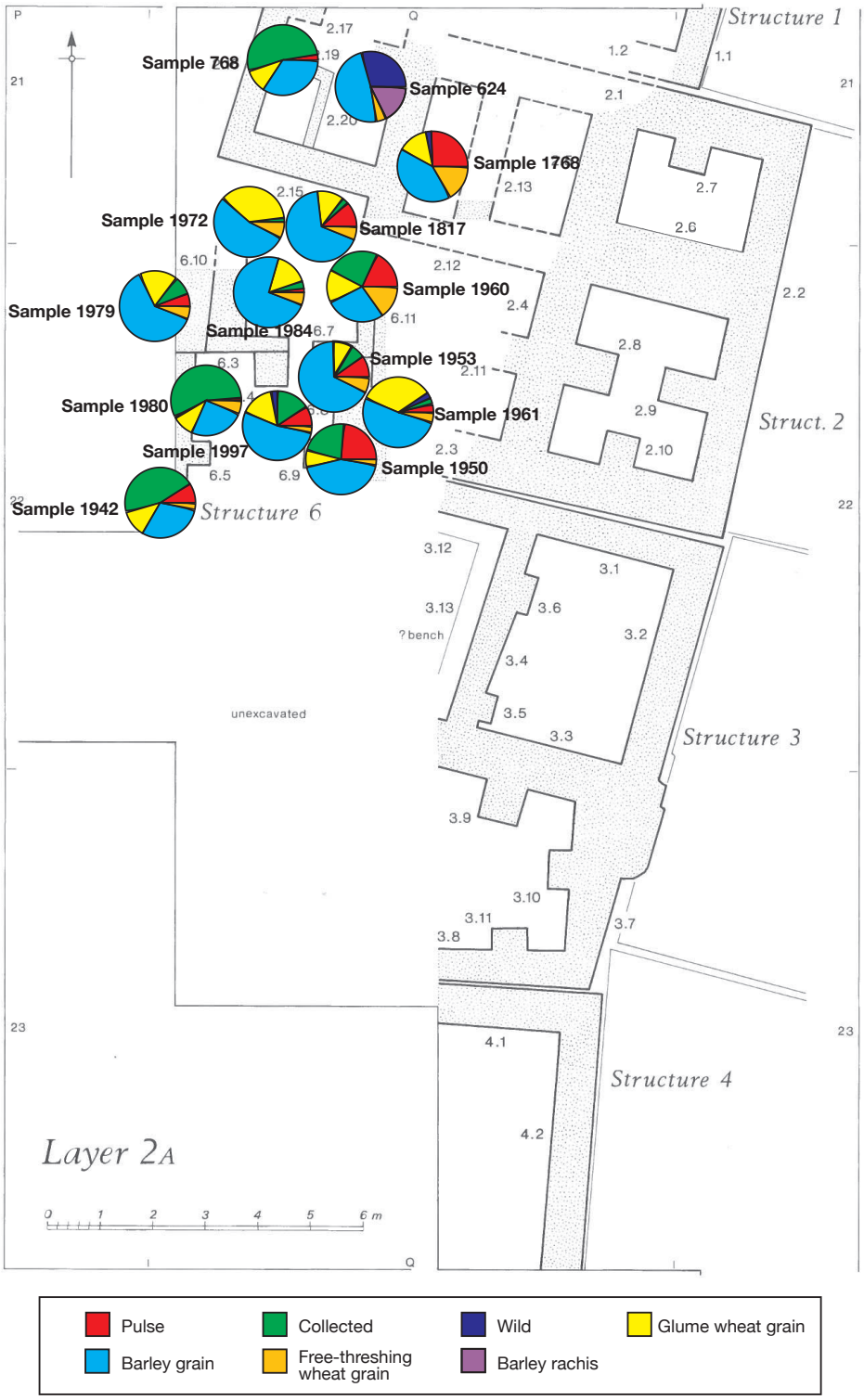


Figure 6.21: Plan of Layer 2A from Canhasan I showing the location and the proportion of major categories in the samples.

6.4 Kuruçay

The unique storage nature of the samples from Kuruçay provides an opportunity to examine the weed flora associated with various crop types. There are limited weed seeds in the samples with the exception of the weed-rich flax samples (see Chapter 5). Figure 6.22 shows the analysis of 24 samples and 30 species from Kuruçay; sample 22, consisting of only Pistacia is not included. The analysis indicates a specific association with flax seeds of *Silene* sp. type 1, small-seeded *Lolium*, *Camelina sativa*, *Lepidium* sp. and *Vaccaria pyramidata* (Nesbitt 1996). While some of these species occur in other samples, particularly high proportions occur in the flax samples, identifying the association. The same taxa types are also seen in close association with flax at Çamlıbel Tarlası (see above).

The weed flora of the pulse and cereal crops indicate that different weed groups were associated with these different crops. There is limited scope for weed flora to be associated directly with any one pulse taxon, as chickpea occurs as a contaminant of lentil and grass pea, while *Asperula* sp. contaminates both pea and lentil. There is a slightly tighter link between *Medicago* sp. and pea but it also occurs in low numbers and in only one cereal sample. Large *Galium* sp. clearly occurs with a number of different taxa, with a particularly high number of seeds found in one pea sample (sample 8)(Figure 6.22).

Figure 6.22 also shows a separation between glume wheat samples and barley samples, with specific weed species occurring in conjunction with specific crops. *Stipa* sp., *Lolium/Festuca* and *Conringia orientalis*, together with small numbers of *Camelina sativa*, occur in glume wheat samples. Barley contains a number of crop

contaminants: pea, lentil and flax as well as *Taeniatherum* grain and *Poa* bulbils. *Vaccaria* and large *Galium* sp. are split between the glume wheat and barley groups. Interestingly, the free-threshing wheat sample contains *Asperula*, a species that was also observed in lentil and pea samples (see Table 12.5).

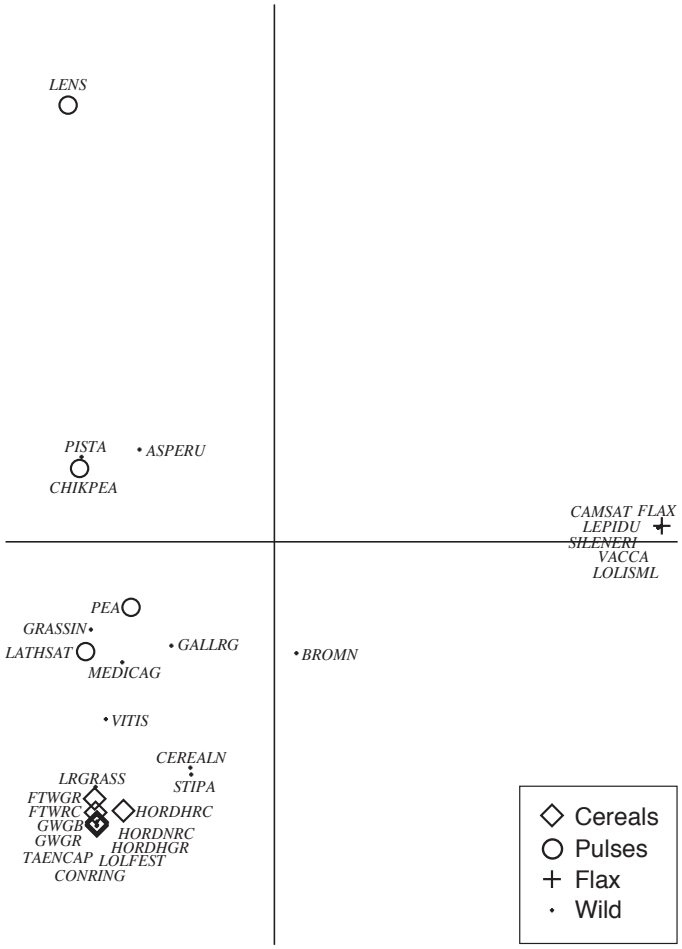


Figure 6.22: Correspondence analysis results for the 24 samples and 30 species from Kuruçay with the symbols showing the categories of major species (codes in Table 12.10).

Contamination from secondary crop species occurs in the samples. Limited patterning of specific contaminants for specific crops could be detected in the pulse species, while the cereal taxa were principally contaminated by barley. There is no evidence for mixed cultivation of pulse crops together, since each crop is dominated by different taxa. There are several cereal-dominated samples that

contain mixtures of crop taxa. Glume wheats appear to have been cultivated together and in some instances it appears that the mixed glume wheats may have been cultivated with barley (e.g. sample 21). There is also a possibility of the cultivation of free-threshing wheat with barley, evident in the admixture in sample 16. The proportions are borderline in comparison with ethnographic examples of maslin crops, making it difficult to determine if such a mixture was intentional or not (Jones and Halstead 1995).

To summarise; the analysis of the Kuruçay samples highlights specific crop weed flora associated with the cultivation of flax, something noted by Nesbitt (1996) in his preliminary report. Other crop types have associated weeds but not as distinctly as the flax weed flora. The occurrence of these associated flax weeds reflects the similar findings of the Çamlıbel Tarlası assemblage.

7 Dung burning

This chapter investigates, using multiple strands of evidence, the influence of the burning of dung on the assemblages. This analysis, which incorporates information on the ecology of species in the assemblage, discriminant analysis and correspondence analysis, provides a means of assessing whether a species was incorporated into the assemblage through dung burning as opposed to crop processing.

7.1 Çatalhöyük West

Dung-derived material has been detected at the Neolithic Çatalhöyük East by a number of authors (Fairbairn et al. 2005; Bogaard et al. 2013a; Filipović 2014). Their research found evidence that dung fuel was used and contributed significantly to the archaeobotanical record, predominantly through the charring of tiny-seeded wild taxa (Bogaard et al. 2013a; Filipović 2014). A number of species have been linked to dung burning (Table 7.1) and if this practice continued on the West Mound a continuation of that specific dung taxa suite is possible. Examination of the West Mound data indicates the presence of 10 of the dung-derived species from the East Mound, suggesting that dung may have been a means by which some species entered the archaeobotanical record. The validity of this hypothesis is tested here by examining criteria developed by Charles (1998), focusing on the presence of dung, the behaviour of taxa in comparison with crop processing, the biology/ecology of taxa that indicates limited chances of inclusion in crop harvest/fields, and the proportions of crop parts, grain and chaff, as an indication of mixing (see Chapter 4). Additional steps are taken to examine the likelihood of survival through consumption by animals, including

seed size, while an examination of the growing habitat of species, in particular wet versus dry habitats, was used following Bogaard et al. (2013a) findings from the East mound of Çatalhöyük (see Chapter 4).

Table 7.1: Species found in dung (D), and attributed to dung burning (A) on Çatalhöyük East in comparison to their occurrence in the Çatalhöyük West samples. East Mound data from Fairbairn et al. (2005), Bogaard et al. (2013a) and Filipović (2014).

Taxa	Çatalhöyük East	Çatalhöyük West
Sporobolus	D	X
Polygonum aviculare	D	X
Chenopodium	D	X
Bolboschoenus glaucus	D	X
Carex	D	X
Crypsis	D	X
Small-seeded legumes	A	X
Aeluropus	A	X
Suaeda	A	
Ziziphora	A	X
Juncus	A	X
Eragrostis	A	X
Artemisia annua type	A	X
Atriplex	A	X
Eleocharis	A	
Rumex	A	X
Alopecurus	A	

The first criterion of Charles (1998) is the presences of preserved dung such as in the form of burn pellets. The West Mound assemblage does not contain preserved dung pellets, which may not necessarily indicate an absence of dung burning but may instead reflect the ease (or otherwise) by which dung disintegrates. If burnt dung has disintegrated, this would be reflected in large numbers of seeds from tiny-seeded species that have escaped from the disintegrating dung.

Charles' (1998) second criterion is the behaviour of the samples in comparison with ethnographic crop processing data. Dung burning is suggested when samples deviate from the known composition of crop processing stages, and form

a distinct coherent separate group of wild taxa (Charles 1998). Weed species were classified into physical types based on their crop processing attributes (size, aerodynamics and tendency to remain in a head) as per Jones (1984), and entered as a separate group in discriminant analysis as per Charles (1998) (see Chapter 4). Unlike Jones' use of such analysis, Charles' method does not use the ethnographic data to classify the archaeological samples but instead uses the ethnographic data *and* the archaeological sample data to obtain discriminant scores – the archaeological data becoming a fifth group alongside the four crop processing groups. Thus instead of assigning the archaeological samples, through comparison, to the four crop processing stages, the analysis instead includes a fifth group, to which the archaeological samples can be re-assigned.

Only two Çatalhöyük West samples were not re-classified in the archaeological group but instead classed as fine-sieving by-products (Table 7.2). Figure 7.1 shows the large distortion between the ethnographic data and the archaeological samples; the archaeological samples form a distinctly separate group, with the overall configuration of the ethnographic data distorted. Such results do not identify dung *per se*, but indicate that the samples are more similar to each other than the crop processing samples, due to some shared factor(s) e.g. taphonomy. This is a likely indication that the samples contain "weed" seeds derived from other sources e.g. dung burning.

It is possible that such a difference is the result of the inclusion of "weed" seeds that were not accidently incorporated into the assemblage but instead deliberately collected. The West Mound assemblage includes a large quantity of *Descurainia sophia,* a small-seeded mustard which was stored in large amounts on the East Mound (Bogaard et al. 2013a). This raises the possibility that this collected taxon could be the cause of the deviation in the discriminant analysis. Therefore the analysis was run on a dataset that excluded *Descurainia Sophia* but this had little impact on the results thus indicating another factor is driving this difference (Table 7.2).

Table 7.2: Predicted group membership for the 41 Çatalhöyük West samples, run as (A) a group to be classified and (B) entered as a separate group using all seeds (C) and (D) show the same runs excluding the species *Descurainia sophia*.

		Predicted Group Membership				
		Çatalhöyük	**Winnowing by-product**	**Coarse-sieving by-product**	**Fine-sieving by-product**	**Fine-sieving product**
A	#	n/a	36	0	5	0
	%	n/a	88	0	12	0
B	#	39	0	0	2	0
	%	95	0	0	5	0
C	#	n/a	38	0	3	0
	%	n/a	93	0	7	0
D	#	37	1	0	3	0
	%	90	2.5	0	7.5	0

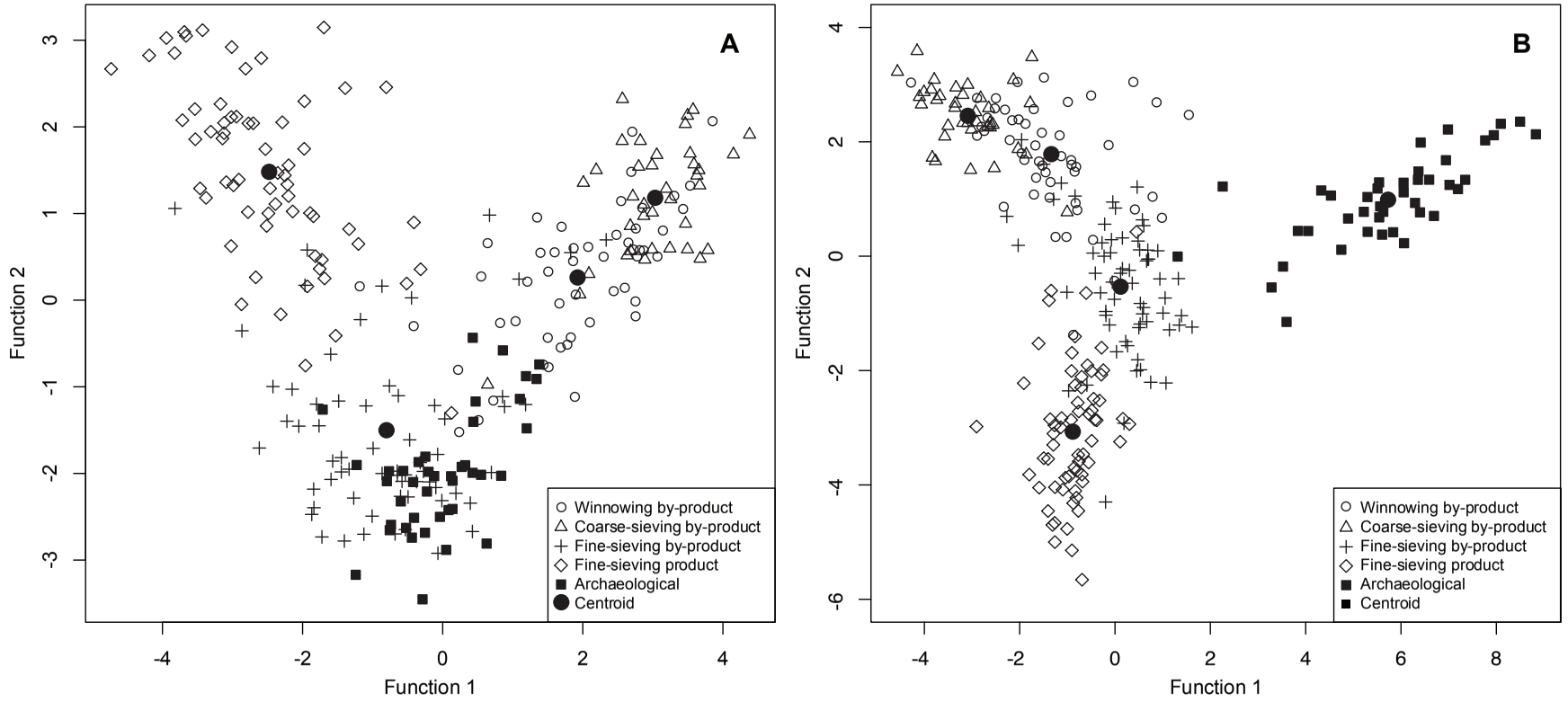


Figure 7.1: Discriminant analysis of Çatalhöyük West and Jones' (1983) ethnographical crop processing samples (A) classified with regard to the ethnographic data, and (B) with the Çatalhöyük West samples entered as a separate group following Charles (1998).

The third criterion of Charles' (1998) method is to understand whether the samples represent a mixture of different crop types possessing different processing requirements. Glume bases dominate the Çatalhöyük West assemblage, with low numbers of other crop remains (Chapter 5). All 41 Çatalhöyük West samples included in the dung analysis contained over 70% glume wheat, indicating limited mixing of crop types. There are specimens from crops that require different processing actions (i.e. hulled barley and free-threshing wheat) but glume wheats are strongly dominant. The good preservation of the glume bases provided no evidence of digestive action; glume bases have limited survivability in dung due to the digestive actions of animals' guts (Wallace and Charles 2013) but it is possible that glume bases were added to dung cakes and subsequently entered the archaeological record.

The fourth criterion of Charles (1998) uses the biology and ecology of taxa to determine the likelihood of animal consumption. Flowering time and palatably were Charles' (1998) variables, and research has further built on this idea to include seed size and habitat requirements (see Chapter 4, Bogaard et al. 2013a).

Davis' (1965-1989) *Flora of Turkey* provides the flowering times of the taxa, with fruiting time estimated to commence one month after the beginning of flowering (Filipović 2014). It must be noted that these fruiting periods are not region-specific and broadly encompass all fruiting times for the whole of Turkey. In the assemblage there are no seeds of taxa with fruiting times occurring outside the harvest period which would have excluded their arrival on the site via harvested crops; all of the taxa fruit during the harvest period.

Taxa preferring conditions not readily available in crop fields are potentially derived from other habitats. Research on the Neolithic East Mound of Çatalhöyük indicates a contrast between species found in drier habitats and those of wetlands: the latter are more commonly those identified as dung-derived species based on other criteria (Bogaard et al. 2013a). Twelve of the West Mound species are described as growing in wet habitats with eight occurring only in wet environments (Table 7.3). Wet habitat species can invade arable land; species such as *Phragmites* invade well-watered fields today on the Konya plain (pers. observation) so it is possible that while some species are recorded as preferring wet habitats, they could also occur within arable fields.

Research on the selective processes to which seeds are exposed in herbivores' gut indicates that very small (tiny) seeds are more likely to survive consumption (Gardener et al. 1993); seed size can thus provide an additional criterion for determining potential dung-derived taxa. The West Mound assemblage contains a number of taxa that have tiny seeds; these taxa also fruit during, but especially after, the harvest periods and can occur in wet habitats (Table 7.3).

The likelihood of a seed being ingested and surviving was scored (see Chapter 4 for protocol). The results identify 12 species with a high chance of being consumed and surviving (Table 7.3). All but two of these taxa are hypothesised to be dung-derived in the Çatalhöyük East assemblage, where in some cases they were found within preserved dung pellets (Bogaard et al. 2013a; Filipović 2014). *Deschampsia* and *Salsola* are two highly scoring species that are not part of the Çatalhöyük East dung-derived flora. *Salsola* falls in the potentially dung-derived

group due to a preference for wet habitats and its lateness in fruiting. Small-seeded legumes and *Zizphora* were ranked as possible dung-derived flora by researchers on the East Mound (Filipović 2014), but within this research are listed with a low possibility of only arriving on site via dung: this is due to their large seed size and their utilization of drier habitats (potentially arable fields). While it is possible that animals consumed these seeds, this research indicates that their occurrence on the site cannot be attributed solely to dung material as another entrance to the assemblage is via crop processing by-products.

Five species were ranked with a moderate score due to their larger seed size coupled with either a preference for dry habitats, or early/intermediate fruiting times over the more typical wet habitat and late fruiting characteristics of the highly scoring species. These moderate-scoring species could have been consumed by animals, but conversely could have grown in arable environments and entered the assemblage through crop processing. Species such as *Polygonum aviculare* and *Polygonum convolvulus* are known modern day crop weeds.

Further clarification of potential dung-derived species can be conducted using correspondence analysis (see Chapter 6 for overall assemblage analysis). The same data set, species and samples as used in Chapter 6 were used in this analysis. Coding the plots with the examined variables of fruiting time, seed size and habitat, as well as the final classifications, reveals some relevant patterns. Seed size produces the strongest pattern showing a clustering of tiny-sized seeds at the negative end of axis 2, while medium to large seeds cluster with the crop remains (Figure 7.2a). Fruiting time produces limited patterning, potentially a

result of the lack of detail in the available data regarding the actual fruiting times in the region of Çatalhöyük (Figure 7.2b). Habitat-related patterning reveals a number of species with wet habitat requirements possibly overlapping with a group of dry habitat taxa from either animal foraging or crop cultivation (Figure 7.2c). When the final dung classifications are coded, the graph shows clustering of potential dung-derived species in the bottom half of the graph, away from the majority of crops (Figure 7.2d). There are exceptions to this; *Alisma* occurs at the top of the graph, removed from other weed seeds. Species such as *Rumex*, *Salsola, Atriplex* and *Artemisia* form groups within or near crops, potentially suggesting that such species are both crop and dung-derived. Conversely *Artemisia*'s close association with *Descurainia* may suggest an alternative route.

Several species have close associations with the dung-derived group and may indicate dung-derived species overlooked in the analysis. Small-seeded legumes in the dung-derived classification were given a low score, predominantly due to their dry habitat preference and undefined flowering period which made it hard to rule out their fruiting during crop harvest. However, this category has been attributed as a dung-derived taxon at Çatalhöyük East (Bogaard et al. 2013a; Filipović 2014) and the correspondence analysis suggests that it should also be considered a dung-derived weed on the West Mound, located as it is near the main cluster of dung-derived species (Figure 7.2d).

Taxa moderately likely to be dung-derived (Table 7.3: *Polygonum convolvulus, P. aviculare, Chenopodium* sp., and *Bolboschoenus glaucus*) occur throughout Figure 7.2d. The analysis does indicate the close association of *Chenopodium* sp. with the

main dung-derived group, while *Polygonum convolvulus* appears to correlate with crop processing waste of free-threshing cereals.

Because the West Mound samples originated chiefly from midden contexts, there is no spatial relationship with where the items were originally burnt. This lack of primary contexts means that the "crop or dung" separation seen in the samples is inherently weaker than that detected on the East Mound of Çatalhöyük (Bogaard et al. 2013a; Filipović 2014).

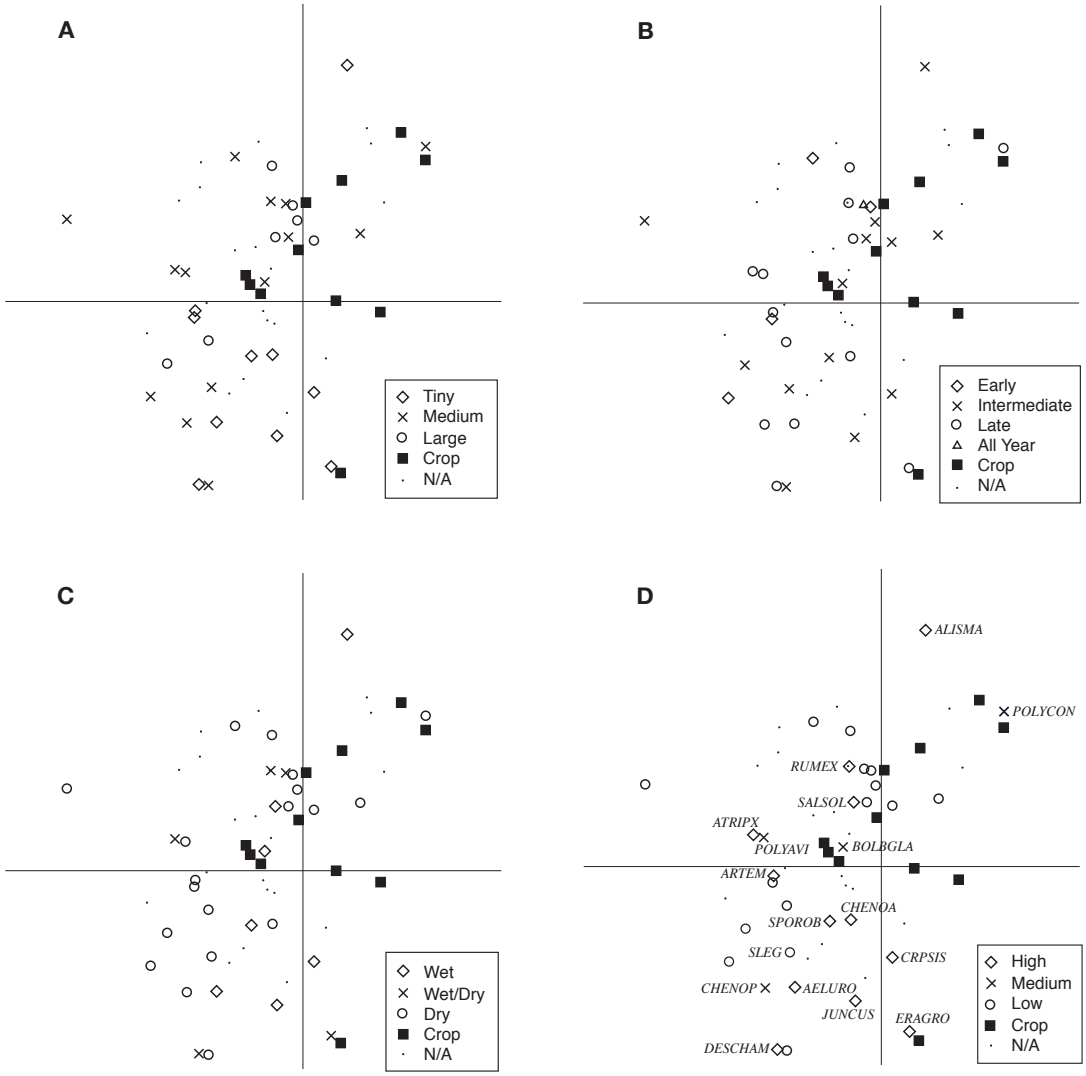


Figure 7.2: Correspondence graphs of the 41 samples and 61 species of the Çatalhöyük West assemblage coded for (A) seed size with reference to ease of passage through sheep/goat/cattle gut, (B) seasonality of fruiting period with reference to harvest time, (C) habitat preference, and (D) final dung classification.

Table 7.3: Summary of the fruiting time, habitat preference and seed size, with final classification of probability of being dung derived (dung class), of taxa from the Çatalhöyük West assemblage.

Species	Ubiquity	% of total weeds	Habitat	Seed size	Fruiting period	Dung class
Sporobolus R. Br. (S. virginicus (L.) Kunth type)	77.8	8.1	Wet	Tiny	Intermediate	High
Crypsis aculeata (L.) Aiton type	60.0	4.4	Wet	Tiny	Intermediate	High
Juncus L.	42.2	2.3	Wet	Tiny	Intermediate	High
Alisma L.	13.3	0.6	Wet	Tiny	Intermediate	High
Aeluropus Trin.	55.6	4.1	Wet	Tiny	Late	High
Salsola L.	22.2	0.3	Wet	Large	Late	High
Eragrostis N.M. Wolf	15.6	0.9	Wet/Dry	Tiny	Late	High
Deschampsia P.Beauv.	13.3	0.5	Wet/Dry	Tiny	Late	High
Rumex L.	55.6	1.4	Wet/Dry	Medium	Late	High
Atriplex L.	33.3	1.1	Wet/Dry	Medium	Late	High
Chenopodium L.	15.6	0.3	Wet/Dry	Tiny	Late	High
Artemisia annua L. type	55.6	4.1	Dry	Tiny	Late	High
Anagallis L. type	4.4	0.0	Wet/Dry	Tiny-med	Intermediate	Moderate
Polygonum aviculare	53.3	2.9	Dry	Medium	Late	Moderate
Chenopodium album L. type	8.9	0.4	Dry	Medium	Late	Moderate
Polygonum convolvulus L.	8.9	0.2	Dry	Medium	Late	Moderate
Bolboschoenus glaucus (Lam.) S.G. Smith	97.8	18.5	Wet	Medium	Intermediate	Moderate
Leguminosae, small wild	53.3	1.4	Dry	Medium	Intermediate	Low
Galium aparine L. type	51.1	0.4	Dry	Medium	Intermediate	Low
Taeniatherum caput-medusae L.	46.7	0.9	Dry	Large	Late	Low
Hordeum murinum L. type	28.9	0.3	Dry	Large	Intermediate	Low
Vaccaria pyramidata Medik.	26.7	0.3	Dry	Medium	Early	Low
Carex L.	22.2	0.5	Wet/Dry	Medium	Non grouped	Low
Vicia L./*Lathyrus* L.	20.0	0.2	Dry	Medium	Intermediate	Low
Bromus hordeaceus L./*commutatus* Schrad.	17.8	0.2	Dry	Large	Intermediate	Low
Adonis aestivalis L. type	15.6	0.1	Dry	Large	Early	Low
Lavatera L. type	15.6	0.1	Dry	Medium	Intermediate	Low

Species	Ubiquity	% of total weeds	Habitat	Seed size	Fruiting period	Dung class
Convolvulus arvensis L. type	11.1	0.1	Dry	Large	Intermediate	Low
Sideritis L. type	8.9	0.3	Dry	Medium	Intermediate	Low
Centaurea sp.	6.7	0.1	Dry	Large	Intermediate	Low
Eremopyrum (Ledeb.) Jaub. & Spach	6.7	0.0	Dry	Large	Intermediate	Low
Adonis microcarpa/annua	4.4	0.0	Dry	Medium	Early	Low
Bromus, narrow type	4.4	0.2	Dry	Large	Intermediate	Low
Malva L.	4.4	0.2	Dry	Tiny	Intermediate	Low
Galium verum L. type	4.4	0.1	Dry	Tiny	Intermediate	Low
Heliotropium L.	4.4	0.1	Dry	Large	Late	Low
Thymelea passerina (L.) Cosson & Germ. type	4.4	0.0	Dry	Medium	Year round	Low
Ranunculus arvensis L. type	2.2	0.0	Dry	Large	Intermediate	Low
Valerianella Miller	2.2	0.1	Dry	Medium	Early	Low
Chrysanthemum cf. *segetum* type	2.2	0.0	Dry	Medium	Early	Low
Conringia orientalis L.	2.2	0.1	Dry	Medium	Early	Low
Euphorbia L.	2.2	0.1	Wet/dry	Medium	Intermediate	Low
Hordeum spontaneum C. Koch type	2.2	0.0	Dry	Large	Intermediate	Low
Silene sp.	2.2	0.1	Dry	Medium	Intermediate	Low
Verbena officinalis L.	2.2	0.1	Dry	Medium	Late	Low
Viola L.	2.2	0.1	Wet/Dry	Medium	Intermediate	Low
Ziziphora sp.	2.2	0.0	Dry	Medium	Intermediate	Low
Festuca sp.	13.3	0.1	Dry	Large	Late	Low
Descurainia sophia (L.) Webb	84.4	26.5	Dry	Tiny	Early	Low

7.1.1 Conclusion

The Çatalhöyük West samples contain seeds that are not derived from the crop-processing sequence. Such seeds are commonly tiny, and the majority have been identified at other Near Eastern sites, including Çatalhöyük East, as dung-related taxa. The ecological and biological attributes of such species reflect the preference of many for non-arable environments. Unfortunately the limited geographic detail about fruiting time prevents the definitive exclusion of the possibility that these taxa were derived from harvested crops. Twelve species were classed as highly likely to have originated from dung material, with an additional five species as moderately likely (Table 7.3). It is possible that some species were derived from a combination of dung burning and crop processing residue. Examination of correspondence graphs indicates close association of *Artemisia* with *Descurainia*. *Rumex, Salsola* and *Atriplex* occur outside the main cohesive grouping of dung material; this could represent the grazing of crop weeds and therefore the entrance into the record through both dung and crop routes. *Polygonum aviculare*, *Carex* and *Bolboschoenus* occur in dung pellets on the East Mound of Çatalhöyük (Bogaard et al. 2013a; Filipović 2014). The lower 'dung' score of these species, derived using the methods outlined above, originates primarily from the larger seed size of these species and, for some, the inability to assign a fruiting time. Given the similar trends with regards to dung flora found between the East and West Mounds, the occurrence of these species in dung on the East Mound, highlights the likelihood that on the West Mound, their occurrence is at least in part due to dung burning. The dung flora detected indicates the grazing of non-arable habitats and while the results do not exclude the grazing of stubble in

fields as the method cannot distinguish between weeds from crop harvesting and arable weeds from dung burning, the results do provide important information regarding the labour involved in the collection of manure for fuel or fertilizer (see chapter 11).

7.2 Çamlıbel Tarlası

Dung burning has been detected at a number of Near Eastern sites and the Çamlıbel Tarlası assemblage includes taxa that have, at these sites, been linked to dung burning (Charles 1998; Charles and Bogaard 2011; Bogaard et al. 2013a). To investigate the possibility that items entered the archaeobotanical record through the burning of dung, investigations were conducted following Charles's (1998) criteria (see Chapters 3 and 4).

Burnt dung was identified in the Çamlıbel Tarlası assemblage but contained no observable seeds. Dung was found in 11 samples in differing quantities, commonly present at a low level (Table 12.4).

Examination of whether the wild taxa were consistent with expectations of specific stages of the crop processing sequence was conducted through the use of Jones' (1987) ethnographic data and discrimination analysis. When the archaeological data are entered as a separate group in discriminant analysis, a majority of samples relate more to each other than to the modern analogy (Table 7.4). However there is no extreme difference between the archaeological and modern data, with the graph looking very similar to the initial classification graph (Figure 7.3, cf. Figure 7.1). It is probable that some of the taxa included in the

assemblage derived from processes other than crop processing. It is also possible that flax-processing waste could be the reason for the difference between the modern crop processing samples and the archaeological data as the ethnographic samples are based on cereal and pulse processing and therefore do not account for flax processing. Overall, the limited distortion of the basic crop processing pattern produced by the ethnographic samples suggests that Çamlıbel Tarlası samples have more in common with a crop processing signature than other sites influenced by dung burning (cf. Charles 1998).

The possibility that the samples contain mixed crop processing stages or incompatible crop types was also investigated. As seen in Chapter 5 and 6, glume bases dominate the majority of samples and glume bases are the crop processing waste of glume wheats. Only 13 samples containing 30 crop items have less than 70% glume wheat material and are therefore suggestive of mixed processing origin. However, due to their high oil content, the input of flax seeds into such a ratio is limited because of a preservation bias and there may be a more general mixing of crop processing material from flax production and glume wheat waste. Conversely, the discriminant analysis of the material from Çamlıbel Tarlası when entered as a separate group reveals limited deviation from the ethnographic sample classifications (Figure 7.3). Again it can be argued that the Çamlıbel Tarlası assemblage fits the crop processing model and shows limited input from taxa derived from alternative sources (cf. Charles 1998). To support such a theory examination of the ecology and biology of the weed flora is required.

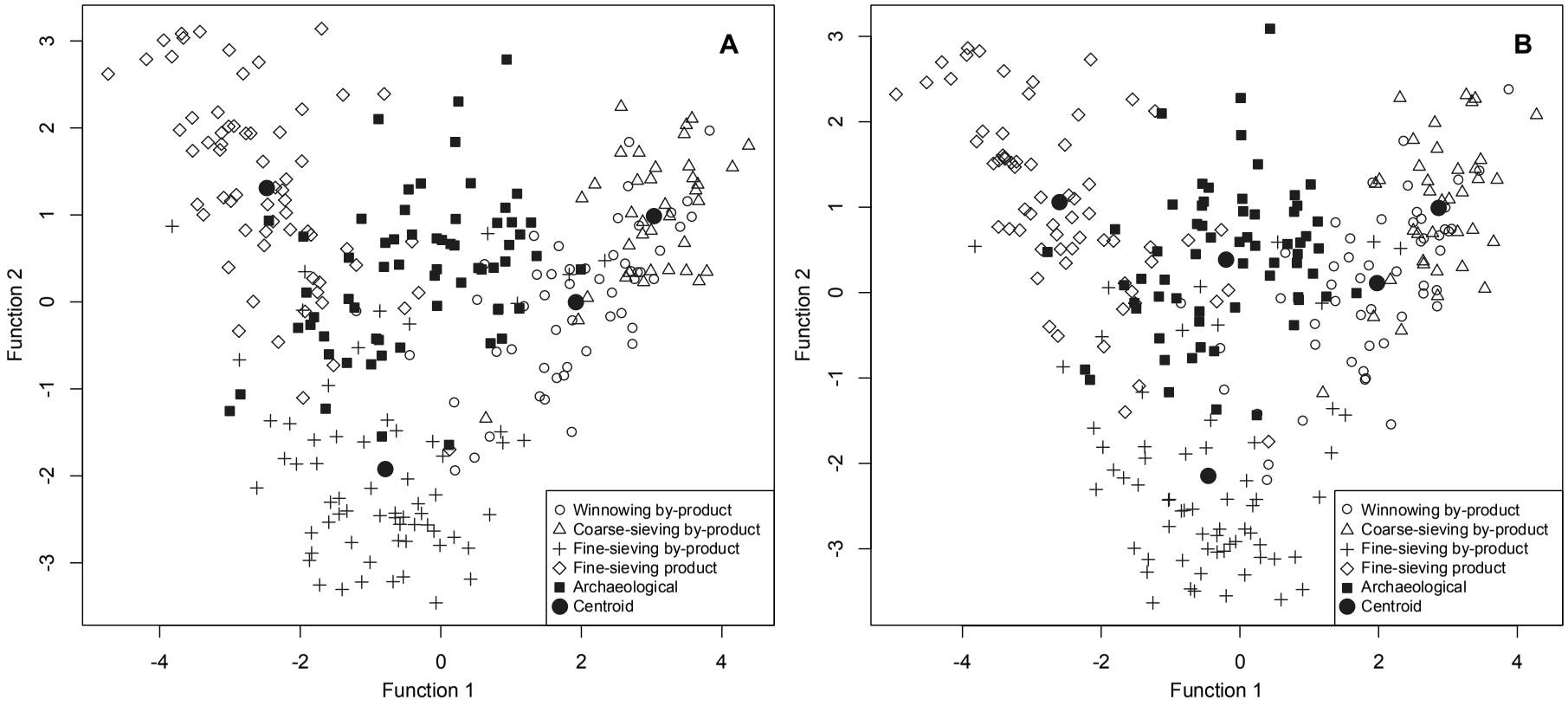


Figure 7.3: Results of the discriminant analysis of material from Çamlıbel Tarlası compared with Jones' ethnographic samples. (A) archaeological samples as classed with reference to the ethnographic data and (B) archaeological samples discriminated as a separate group with the ethnographic data.

Table 7.4. Results of discriminant analysis of Çamlıbel Tarlası material when classified using Jones' (1983) ethnographic data (a), and (b) when entered as a separate group

		Predicted Group Membership				
		Çamlıbel Tarlasi	Winnowing by-product	Coarse-sieving by-product	Fine-sieving by-product	Fine-sieving by-product
a	#	n/a	30	2	11	20
	%	n/a	47.6	3.2	17.5	31.7
b	#	53	6	1	2	1
	%	84	9.5	1.6	3.2	1.6

The fruiting time of all taxa in the assemblage was investigated. The majority of species from Çamlıbel Tarlası have early/intermediate fruiting times; species such as *Bifora radians,* a modern crop weed, fall in the early fruiting period. Only one species (*Polygonum aviculare*) fruits later in the year but it cannot be ruled out as harvested with crops as its fruiting period is within the potential harvest period at the site. Four species are listed as early, fruiting before the harvest time period (Table 7.5) but it is possible that the seeds of species such as these remained on the plant until harvest; their fruiting theoretically ends only a month before harvest time. All species, based on the data available, could still possess fruit during the harvest period and thus their inclusion in the assemblage could result from crop processing.

Examination of the ecological niche of the Çamlıbel Tarlası species indicates similarity in habitat preference. Table 7.5 shows the majority of species occurs in dry habitats with only a limited number of taxa appearing in wet locations. Species such as *Sporobolus* occur predominantly in the latter and are unlikely to have entered the archaeological record through the burning of crop processing waste from cereals; more likely they were introduced to the site and burnt through the use of dung as fuel. There is limited wet habitat in the landscape

around Çamlıbel Tarlası in comparison to Çatalhöyük, with wet habitats confined to river and stream banks and no large expanse of wetland habitat detected during palaeoenvironmental studies (Dörfler et al. 2000). Thus the examination of the difference between wet and dry habitats may have limited utility in differentiating sheep grazing locations, as animals would have had to graze on other vegetative communities. It is of note that 53 of the 62 taxa have arable fields as one of their habitat preferences (Davis 1965-1989).

Seed size plays a role in the survivability of seeds during animal digestion. Tiny seeds smaller than the reticulo-omasal orifice of sheep/goats pass through the gut quickly, reducing exposure to digestive processing and increasing the ability to survive. Such species could therefore be contained in dung. The size of all archaeological seeds was measured and ranked (see Chapter 4) and Table 7.5 shows the results of such classification.

Examination of the overall combined scoring of the biology and ecology of the taxa (see Chapter 4) indicates only three species classed with a high probability of surviving consumption by animals and not deriving from crop fields (Table 7.5). These are *Sporobolus*, *Crypsis,* and *Artemisia,* which are tiny-seeded and either occur in wet habitats not conducive to crop cultivation or fruit after crops would have been harvested. These have been noted as dung-derived species at other sites in the Near East, such as Çatalhöyük East (Bogaard et al. 2013a) (Table 7.1). Proportionally, these species contribute 1% to the weed/wild assemblage (Table 7.5); this limited inclusion may in turn indicate limited dung burning on the site. Nine species fall within the moderate range of scores, and include some more

common assemblage taxa such as *Polygonum aviculare*. The majority of species in this range have tiny seeds, with the exception of *Polygonum aviculare*, classed as moderate due to its late flowering, and these species significantly contribute 12% to the overall number of wild/weed seeds. However, it is difficult to determine whether their inclusion within the assemblage is due to dung burning, crop processing or a combination of the two.

Correspondence analysis conducted in Chapter 6 was coded using ecological variables relevant to possible dung derivation (Figure 7.4). The conclusions are limited; many of the species designated as highly probable to have survived animal digestion occurred only in one or two samples and thus did not fulfil the requirements for inclusion in the correspondence analysis. Examination of the habitat of the remaining species indicates limited clustering (Figure 7.4). *Carex*, *Rumex* and *Phalaris*, all listed as wet/dry species, do group together with reed rhizome and this may indicate a connection, but they are also in proximity to crops such as bitter vetch and grass pea. Fruiting time also provides limited information, with the only late-fruiting species (*Polygonum aviculare*) occurring in the midst of the majority of weed species (Figure 7.4). Similar conclusions are drawn when seed size is coded, as *Sporobolus* is the only tiny species included; other tiny-medium sized species occur with no discernable pattern (Figure 7.4). Final classification of species does not reveal grouping of the "high probability" taxa, as only one can be plotted (Figure 7.4).

The results on the whole reflect the limited ubiquity of potential dung-derived flora in the Çamlıbel Tarlası assemblage and indicate that dung burning does not

appear to have influenced the variation in samples significantly; rather it is crop processing that appears to be the dominant factor, an inference to be explored further in Chapter 8.

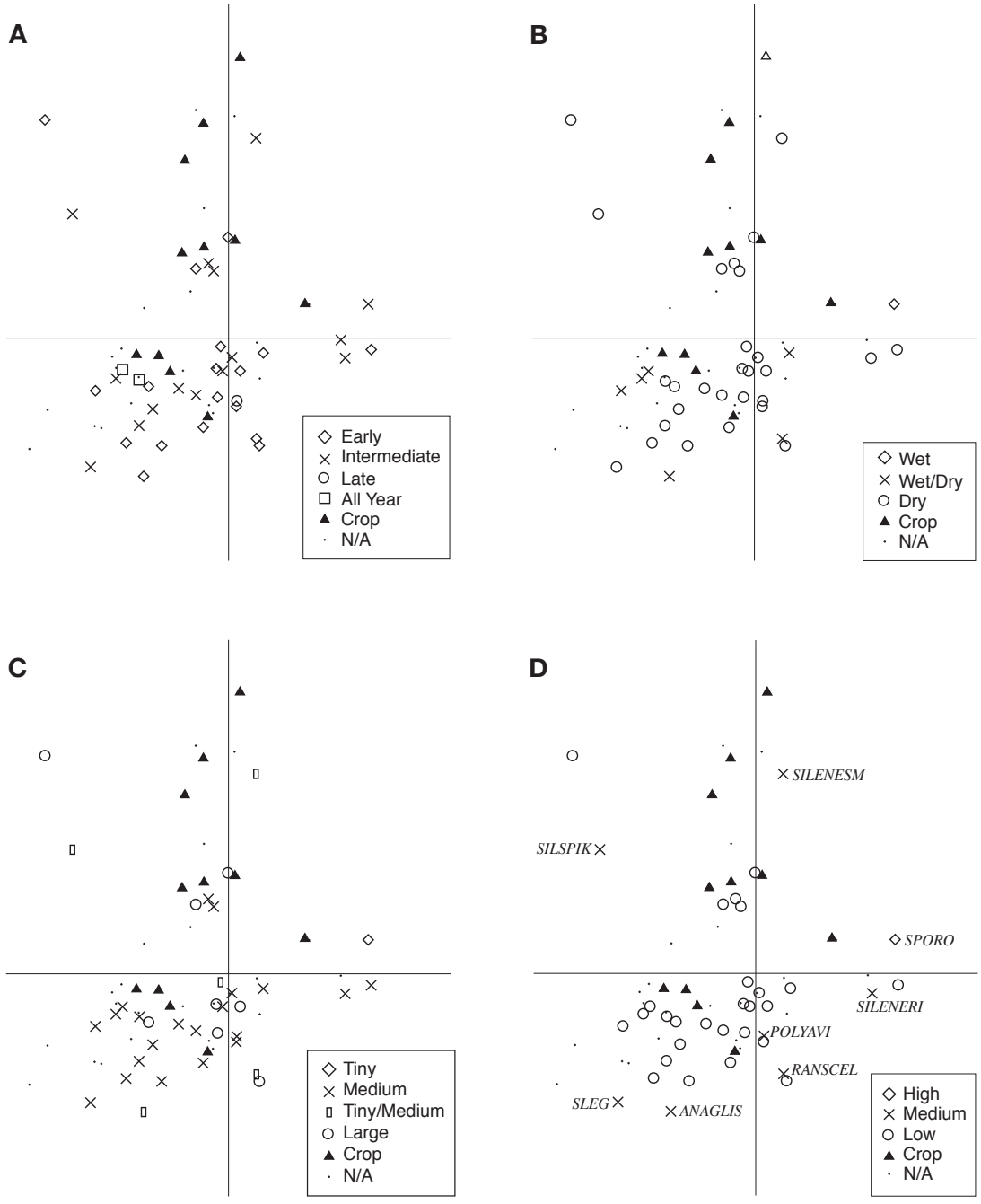


Figure 7.4: Correspondence analysis plot coded by (a) fruiting time, (b) habitat, (c) seed size, and (d) dung class for 62 Çamlıbel Tarlası samples.

Table 7.5. Summary of the fruiting time, habitat preference and seed size, with final classification of probability of being dung derived (dung class), of taxa from the Çamlıbel Tarlası assemblage.

Taxon	Ubiquity	% of total wild seeds	Habitat	Size	Fruiting time	Dung class
Crypsis aculeata (L.) Aiton type	1.4	0.03	Wet	Tiny	Intermediate	High
Sporobolus R. Br. (S. virginicus (L.) Kunth type)	15.1	0.87	Wet	Tiny	Intermediate	High
Artemisia annua L. type, cf.	1.4	0.06	Dry	Tiny	Late	High
Chenopodium L.	2.7	0.12	Wet/Dry	Tiny	Intermediate	Moderate
Eragrostis N.M. Wolf	5.5	0.30	Wet/Dry	Tiny	Intermediate	Moderate
Poa type	2.7	0.03	Wet/Dry	Tiny	Early	Moderate
Bolboschoenus glaucus (Lam.) S.G. Smith	1.4	0.01	Wet	Medium	Intermediate	Moderate
Polygonum aviculare	56.2	4.23	Dry	Medium	Late	Moderate
Verbascum, type 2	5.5	0.25	Dry	Tiny	Intermediate	Moderate
Verbascum, type 1	5.5	0.30	Dry	Tiny	Intermediate	Moderate
Anagallis L. type	26.0	2.22	Wet/Dry	Tiny-med	Early	Moderate
Ranunculus sceleratus L.	8.2	0.31	Wet/Dry	Tiny-med	Early	Moderate
Atriplex L.	6.8	0.06	Wet/Dry	Medium	Early	Low
Carex L.	8.2	0.11	Wet/Dry	Medium	All year	Low
Phalaris cf. minor Retz.	75.3	8.46	Wet/Dry	Medium	Early	Low
Rumex L.	23.3	0.30	Wet/Dry	Medium	Intermediate	Low
Salsola L.	1.4	0.01	Wet/Dry	Medium	Year round	Low
Trigonella astroites type	6.8	0.23	Dry	Tiny-med	Early	Low
Galium verum L. type	1.4	0.03	Dry	Tiny	Early	Low
Malva L.	1.4	0.06	Intermediate	Tiny-med	Dry	Low
Silene sp. Type 3	12.3	0.66	Dry	Tiny-med	Intermediate	Low
Leguminosae, small wild	35.8	0.86	Dry	Tiny-med	Intermediate	Low
Silene sp. Type 2	9.6	0.44	Dry	Tiny-med	Intermediate	Low
Hyoscyamus L. type	2.7	0.07	Dry	Medium	Early	Low
Ajuga/Teucrium	11.0	0.08	Dry	Medium	Intermediate	Low
Alyssum L. type	4.1	0.02	Dry	Medium	Intermediate	Low
Asperula arvensis	58.9	1.81	Dry	Medium	Early	Low
Centaurea sp.	4.1	0.02	Dry	Medium	Intermediate	Low
Adonis L., cf.	1.4	0.01	Dry	Medium	Early	Low
Cruciata Miller cf.	15.1	0.14	Dry	Medium	Early	Low

Taxon	Ubiquity	% of total wild seeds	Habitat	Size	Fruiting time	Dung class
Chenopodium album L. type	2.7	0.12	Dry	Medium	Intermediate	Low
Chrysanthemum cf. *segetum* type	5.5	0.05	Dry	Medium	Early	Low
Conringia orientalis L.	2.7	0.09	Dry	Medium	Early	Low
Fumaria L.	1.4	0.01	Dry	Medium	Early	Low
Galium, large	83.6	3.37	Dry	Medium	Intermediate	Low
Hordeum indet	5.5	0.05	Wet/Dry	Large	Intermediate	Low
Vicia L./*Lathyrus* L.	64.4	2.27	Dry	Medium	Intermediate	Low
Lavatera L. type	9.6	0.07	Dry	Medium	Intermediate	Low
Lolium, small seeded (*L. remotum Schrank* type)	95.9	51.20	Dry	Medium	Early	Low
Polygonum convolvulus L.	47.9	1.42	Dry	Medium	Intermediate	Low
Sherardia arvensis L., cf.	1.4	0.01	Dry	Medium	Intermediate	Low
Sideritis L. type	12.3	0.39	Dry	Medium	Intermediate	Low
Silene sp. Type 1	43.8	2.84	Dry	Medium	Intermediate	Low
Thymelaea cf. *passerina* (L.)	60.3	1.54	Dry	Medium	All year	Low
Vaccaria pyramidata Medik.	46.6	1.29	Dry	Medium	Early	Low
Valerianella Miller	4.1	0.02	Dry	Medium	Early	Low
Ziziphora cf. tenuior/taurica type	11.0	0.49	Dry	Medium	Early	Low
Lallemantia, cf.	9.6	0.11	Dry	Large	Early	Low
Avena L.	2.7	0.02	Dry	Large	Early	Low
Hordeum spontaneum C. Koch type	4.1	0.09	Dry	Large	Late	Low
Bifora radians Bieb.	63.0	1.31	Dry	Large	Early	Low
Bromus rigidus Roth/ *diandrus* Roth.	9.6	0.18	Dry	Large	Intermediate	Low
Bromus arvensis L.	53.4	1.92	Dry	Large	Early	Low
Convolvulus arvensis L. type	5.5	0.09	Dry	Large	Intermediate	Low
Heliotropium L.	15.1	0.36	Dry	Large	Intermediate	Low
Hordeum murinum L. type	11.0	0.09	Dry	Large	Early	Low
Lolium temulentum L.	37.0	0.92	Dry	Large	Early	Low
Onopardum type	1.4	0.02	Dry	Large	Intermediate	Low
Ranunculus arvensis L. type	47.9	0.79	Dry	Large	Early	Low
Stipa L. type	45.2	1.15	Dry	Large	Early	Low
Taeniatherum caput-medusae L.	9.6	0.07	Dry	Large	Early	Low

7.1.2 Conclusions

Whether dung burning introduced taxa into the archaeobotanical record at Çamlıbel Tarlası is uncertain. In contrast to Çatalhöyük West, where dung burning appears to have had a pervasive effect on the whole assemblage, likely dung-derived taxa at Çamlıbel Tarlasi are rare and the impact of dung burning appears to have been low. The occurrence of burnt dung in a number of samples is supporting evidence for the burning of dung but no seeds could be seen. However, taxa attributed to dung burning at other Near Eastern sites do occur in the Çamlıbel Tarlası samples. The wetter habitat requirements of tiny-seeded grasses such as *Sporobolus* and *Crypsis* may indicate the burning of dung. It is unlikely such an environment would be present in cereal fields and may indicate animal grazing along riverbanks. However given the low presence of such species, in contrast to the results at Çatalhöyük West, dung burning at Çamlıbel Tarlası is not certain and if it did take place, its effect on the archaeobotanical assemblage appears limited.

7.3 Canhasan I and Kuruçay

The Canhasan I and Kuruçay assemblages provide limited means to investigate the influence of dung burning. Canhasan I material has limited identification of the weed species in the samples, as the original assemblage identifications by M. Nesbitt concentrated on the crop material (see Chapter 5). This is compounded by the fact that sampling strategies for the assemblage differ to those implemented at Çatalhöyük West and Çamlıbel Tarlası. Flotation was not carried out and the retrieval method used is biased against the collection of the tiny-seeded taxa indicative of dung fuel use. Investigation into the dung burning in

this assemblage was therefore not conducted, due to an inability to assign a reason for absences of taxa within the assemblage, i.e. real or an artefact of collection.

The Kuruçay material consists entirely of storage deposits; large quantities of dung-derived material would not be expected unless contamination from surrounding deposits had occurred. Most samples consist of predominantly one crop type, but sample 15 differs as its mixture of barley and glume wheat remains required different processing and the sample most likely reflects mixing in storage. The pulse and barley samples have high similarities with the ethnographic data, both when classified and when discriminated, with limited deviation between the two types of classifications (Figure 7.5, Table 7.6).

The sample's weed flora return low dung–derivation scores when habitat, seed size and fruiting period are calculated. Only the *Festuca* type is classed as a moderate possibility of dung-derivation owing to its late fruiting classification, but this taxon still fruits during the harvest period. There is limited evidence to suggest that any of the taxa are dung-derived.

Table 7.6: Resultant classification of the archaeological samples from discriminant analysis when (a) classified in reference to the ethnographic samples and (b) when entered with the ethnographic samples.

		Predicted Group Membership				
		Kuruçay	**Winnowing by-product**	**Coarse-sieving by-product**	**Fine-sieving by-product**	**Fine-sieving product**
a	#	n/a	0	4	1	4
	%	n/a	0	44.4	11.1	44.4
b	#	4	0	0	1	4
	%	44.4	0	0	11.1	44.4

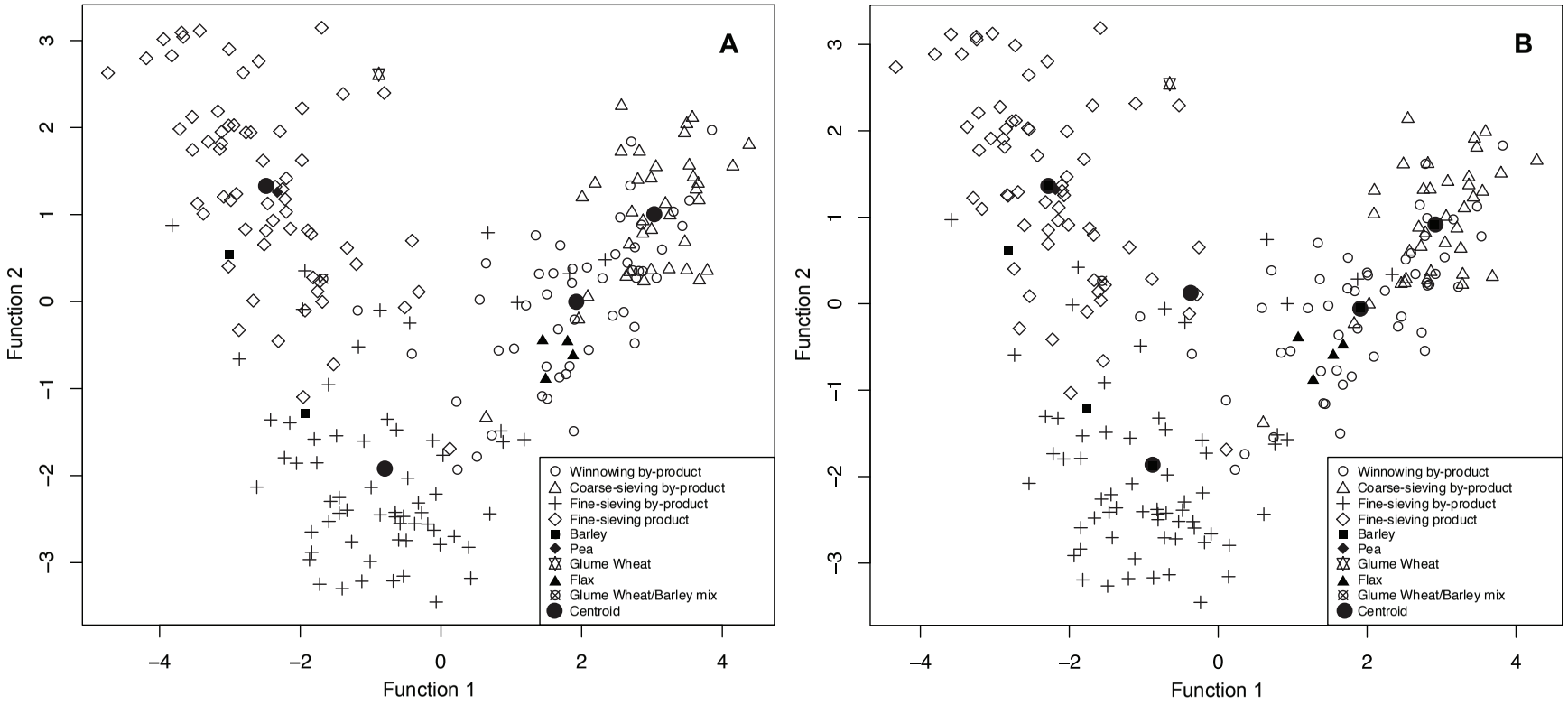


Figure 7.5: Results of the discriminant analysis of material from Kuruçay compared with ethnographic samples,(A) when the archaeological samples is classed with reference to the ethnographic data, and (B) when the archaeological samples are discriminated as a separate group with the ethnographic data. Samples coded based on samples' dominant crop taxa.

7.4 Overall conclusions

Çatalhöyük West and Çamlıbel Tarlası present very different results with regards to the importance of dung-derived wild taxa. The composition of the Çatalhöyük West assemblage is significantly affected by dung-derived material and shows a continuation of dung burning from the Neolithic. In contrast Çamlıbel Tarlası provides limited evidence of solely dung-derived seeds and may reflect its environmental situation - higher rainfall, forest vegetation and small-sized site; wood may have been plentiful and the fuel of choice. Kuruçay samples have no evidence of dung inclusion, unsurprising given their storage contexts. The Canhasan I assemblage presents problems due to the lack of weed seed identification and sample retrieval methods used, thus preventing any conclusion about the use of dung as a fuel on that site.

The results indicate that when further analysis is conducted on crop processing and crop husbandry, specific species will need to be removed as they originate from dung burning and could not have been incorporated into the assemblage through crop processing. Such a step is particularly important at Çatalhöyük West, where dung-derived species form over 28% of the total weed flora within the assemblage. Moreover, another 22 % of weed flora in the assemblage could have come from dung and crop processing, highlighting the potential mixed nature of samples due to their secondary contexts.

8 Crop processing

This chapter investigates the effect of crop processing on the archaeobotanical assemblages at the sites. The research aims to answer the question: does the samples' composition represent one stage of crop processing or reflect a mixing of different crop processing by-products? By understanding the taphonomic processes whereby items find their way onto the archaeological sites, together with the storage and processing methods of crops, inferences regarding the social aspect of such activities can be explored. Crop processing analysis also provides an understanding of the filtering process the weed assemblage has undergone, providing a foundation for further analysis of crop husbandry.

As set out in Chapter 4, three methods are used to interpret the archaeobotanical remains: crop-based, combined crop and weed-based and weed-based analysis. Crop-based analysis uses the ratio of seed to chaff to indicate the probable crop processing stage of samples and a further step is the inclusion of potential weed flora within the ratios, thus allowing for comparison with ethnographic research. The weed-based analysis developed by Jones (1984, 1987) is independent of the crop content of the samples. This analysis, using the size of the seed, the tendency to remain in a head and aerodynamic properties, when compared to ethnographic data allows the prediction of the crop processing stage to which the samples best conform.

8.1 Çatalhöyük West

In Chapter 5 the calculation of the sample proportions of crop and weed/wild reveal which samples are crop dominated, weed dominated or mixed. Samples

predominantly contain a mixed proportion of crop to weed/wild items, while glume wheat remains dominate the crop proportion of all samples. The results of Chapter 7 show that the samples contain a proportion of dung-derived material, indicating a mixing of dung and crop material. However the analysis also indicates which weeds were more likely to be derived from arable fields, allowing for the removal of non-arable weeds. The analyses below therefore focus primarily on glume wheats as, due to their dominance in the assemblage, the likelihood is high that the arable weed taxa present relate to the processing of this crop type.

8.1.1 Crop-based analysis

As previously stated, the grain to chaff ratio of Çatalhöyük West samples illustrates the dominance of glume bases over glume wheat grain (Chapters 5-6). The assemblage ratio of glume wheat grains to glume bases is 0.12. Of the 42 glume wheat-rich samples - samples containing 30 plus glume wheat items- 37 have a ratio of grain to chaff of less than 0.3, with four of these samples containing only glume bases and no glume wheat grain (Table 8.1). The remaining five samples have a ratio higher than 0.3 but less than the 1.5 threshold set for cleaned grain, similar ratios to those broadly theorised for spikelet concentrations. However, the samples fall at the low end of the spikelet ratio range and thus may represent chaff by-product with higher than usual proportions of grain (e.g. due to mixing). Overall, the chaff of glume wheats dominates the assemblage and the ratios indicate that this crop processing waste most likely derives from the de-husking of spikelets and is therefore the principal activity represented in the samples.

Table 8.1: Classification of the Çatalhöyük West samples as either spikelet derived or glume base dominated, based on the ratios of glume wheat grain to glume bases. Only samples containing 30 or more identified glume wheat items are included.

Sample	No. of items	Grain	Chaff	Ratio	Class
Floor 16977	156	60	96	0.63	Spikelet
Floor 18376	37	14	23	0.61	Spikelet
11088	49	18	31	0.58	Spikelet
u31210	338	104	234	0.44	Spikelet
11096	89	23	66	0.34	Spikelet
11089	113	23	90	0.26	Glume base
9591	74	15	59	0.25	Glume base
11092	146	28	118	0.24	Glume base
11053	147	28	119	0.24	Glume base
9519	100	17	83	0.21	Glume base
9603	110	19	91	0.2	Glume base
11087	100	15	85	0.17	Glume base
9341	207	30	177	0.17	Glume base
10100	66	10	56	0.17	Glume base
8360	32	5	27	0.17	Glume base
9358	123	16	107	0.15	Glume base
8911	192	23	169	0.14	Glume base
u18341	551	64	487	0.13	Glume base
10111	96	10	86	0.12	Glume base
11093	92	9	83	0.11	Glume base
9524	82	8	74	0.11	Glume base
9600	229	23	206	0.11	Glume base
9495	127	13	114	0.11	Glume base
9613	166	16	150	0.11	Glume base
u31114	384	37	347	0.11	Glume base
9471	114	11	103	0.1	Glume base
8461	221	21	200	0.1	Glume base
11097	119	10	109	0.09	Glume base
8953	332	25	307	0.08	Glume base
9562	317	23	294	0.08	Glume base
11094	317	21	296	0.07	Glume base
9619	152	10	142	0.07	Glume base
10110	201	13	188	0.07	Glume base
11041	376	22	354	0.06	Glume base
10099	223	12	211	0.06	Glume base
10265	95	5	90	0.05	Glume base
9564	389	15	374	0.04	Glume base
9602	789	27	762	0.04	Glume base
11100	66	0	66	0	Glume base
10279	38	0	38	0	Glume base
9563	172	0	172	0	Glume base
9573	121	0	121	0	Glume base

Free-threshing cereals are a minor crop component in the assemblage. Examination of the ratios of grain to chaff of these cereals, bread wheat and barley, was restricted by the low number of samples containing 30 or more crop items. Only one sample contained 30 plus items of bread wheat; its ratio of 0.93, reflecting a high proportion of chaff material, suggests crop processing by-product material, as the ratio of grain to rachis of bread wheat is approximately 3. The ethnographic study conducted by Jones (1990) provides an indication of the grain to chaff ratio for each crop processing stage. Comparison with the Çatalhöyük West free-threshing wheat sample shows a ratio comparable with coarse sieving and fine-sieving by-product. However the limited quantity of material in the Çatalhöyük sample suggests some mixing of rachis and grain.

Examination of the barley remains is also limited by small quantities of material. Only six samples contain more than 30 barley items. The ratios ranged from very high (44) to very low (0.48), reflecting the differing proportions of barley components (Table 8.2). Three samples have a ratio greater than expected of unprocessed six-rowed barley (3), while the remaining three fall below this line.

Interpretation of the barley results is complicated by the fact that two subspecies of barley occur in the assemblage: two-rowed (*H. vulgare* subsp. *distichum*) and six-rowed (*H. vulgare* subsp *vulgare*). Both forms occur as a naked barley type, while the hulled type only occurs as a two-rowed variety (see Chapter 5). The ratios of grain to chaff of the two subspecies differ due to the different number of grains per rachis internode; six-rowed barley has a ratio of 3:1 while two-rowed has a ratio of 1:1. Examination of the assemblage indicates that very few samples

contain both the rachis and grain of the same variety, due to the high amount of naked barley rachis compared to its grain and conversely the high grain count but limited rachis remains of hulled barley (Table 8.2).

Only one sample has greater than 30 naked barley items and is dominated by rachis remains, resulting in a very low grain to chaff ratio (sample u18341, ratio 0.2). Examination of the hulled barley remains produces more samples reflecting the higher prevalence of hulled barley grains in the assemblage. Four barley-rich samples have ratios that are the opposite of naked barley due to a high amount of grain compared to rachis. All except one hulled barley sample have a ratio greater than one.

Comparison with Jones' ethnographic data is possible although she examined six-rowed hulled barley, not the mixture of two, six-rowed naked, and two-rowed hulled barley found at Çatalhöyük West. Some authors have adjusted the ethnographic samples to compensate for the difference in barley types examined, dividing by three the number of barley grains to achieve a theoretical value for two-rowed barley (Charles and Bogaard 2003; Valamoti 2004). Others, hypothesising that the selective bias of charring against preservation of chaff negates the species difference, have left their samples unadjusted (Filipović 2014).

Comparison of the two methods' results reveals limited differences, with the adjusted ratio resulting in three samples classified differently (Table 8.2). The majority of the samples are classified as fine-sieving by-products, with few in the

coarse-sieving by-product or winnow/coarse-sieving by-product classification (Figure 8.1). The classification of specific varieties' grain to chaff or total barley grain to chaff also has limited impact on the results (Table 8.2). Whichever approach is used, the majority of samples have a ratio reflecting that of a fine-sieving by-product.

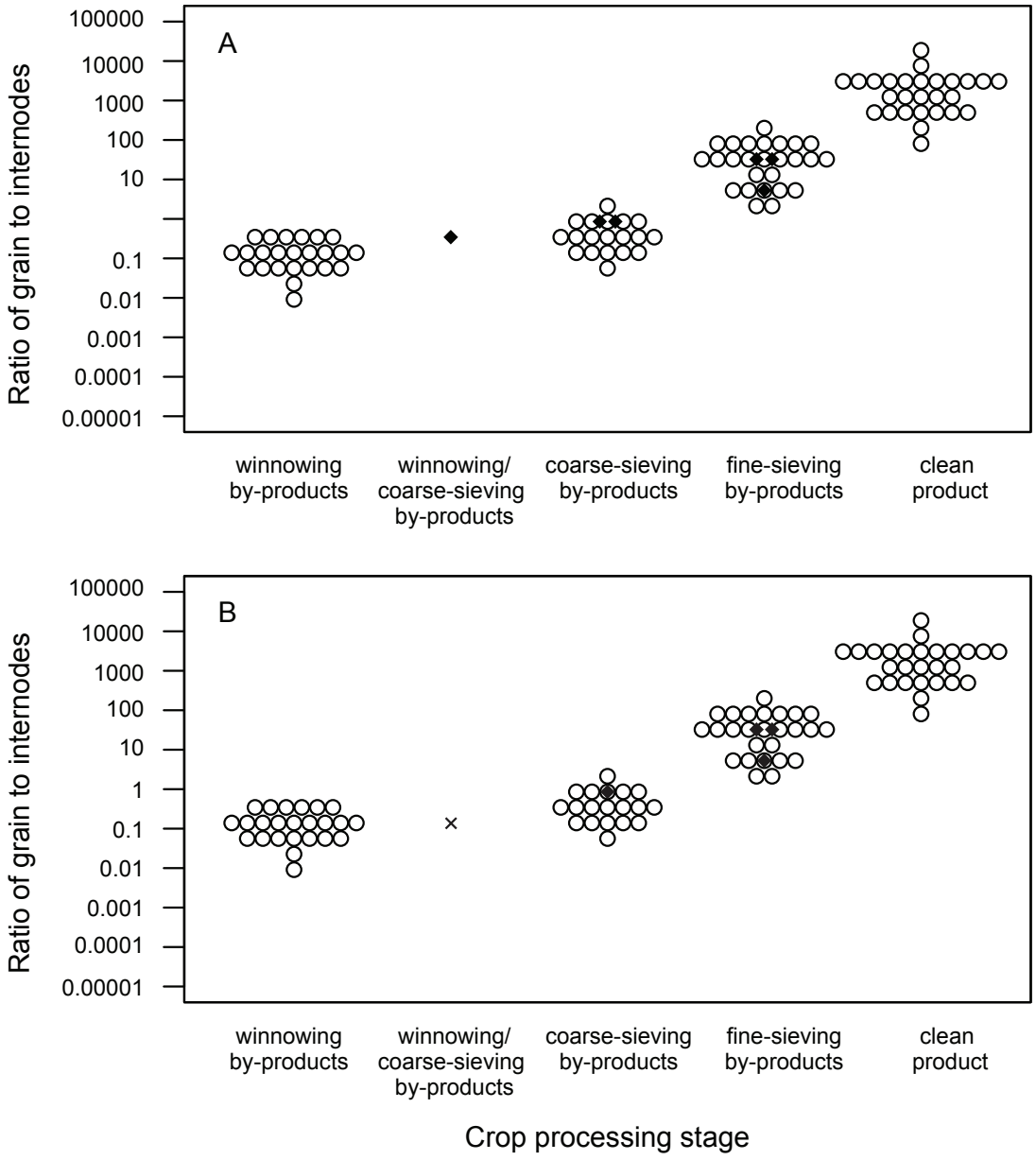


Figure 8.1: Çatalhöyük West barley ratios based on form-specific items from samples with 30 or more barley items, shown against Jones' (1983) ethnographic data. Graph (A) depicts Jones' (1983) data with the archaeological samples shown as solid symbols indicating comparable ratios while Graph (B) shows Jones' data with the solid symbols representing the archaeological samples' ratios based on varietal type: x denotes the naked barley sample, all others are hulled barley.

Table 8.2: Number of barley grains and rachis remains from Çatalhöyük West samples containing 30 or more barley items. The ratio of variety-specific grain to chaff is presented together with total barley per sample, with the interpretation of by-product class shown with reference to Jones' (1983) ethnographic data. The adjusted classification is with reference to Jones' (1983) data adjusted for two-rowed barley forms.

	Summed hulled and naked barley remains' ratios						
Sample	**Variety**	**Total items**	**No. of grain**	**No. of chaff**	**Ratio**	**By-product classification**	**By-product classification adjusted for two-rowed forms**
9573		33	11	22	0.48	Winnowing/ Coarse-sieving	Coarse-sieving
8911		43	19	24	0.79	Coarse-sieving	Fine-sieving
u18341		86	48	38	1.26	Coarse-sieving	Fine-sieving
u31114		30	25	5	4.91	Fine-sieving	Fine-sieving
11092		30	30	0	30	Fine-sieving	Fine-sieving
u31210		44	43	1	43.47	Fine-sieving	Fine-sieving
	Variety specific ratios						
u18341	Naked	33	5	28	0.2	Winnowing/ Coarse-sieving	Winnowing/Coarse-sieving
8911	Hulled	43	19	24	0.79	Coarse-sieving	Coarse-sieving
u18341	Hulled	52	42	10	4.18	Fine-sieving	Fine-sieving
11092	Hulled	30	30	0	29.94	Fine-sieving	Fine-sieving
u31210	Hulled	35	35	0	34.77	Fine-sieving	Fine-sieving

8.1.2 Crop and weed proportions

Examination of combined crop and weed remains can also be used to understand the impact of crop processing on sample composition. Research by Jones (1990) indicates that proportions of chaff, grain and weed remains are specific to particular crop processing stages; examination of such ratios may therefore help to highlight sample similarities and differences. As noted in Chapter 3, Jones' ethnographic study was conducted on free-threshing crops; differences occur when chaff remains are removed from glume wheats compared to free-threshing cereals. This limits comparisons between Jones' ethnographic data and the archaeological samples but the method does provide an understanding of the proportion of grain, chaff and weed components in the samples and, through

other non-quantitative ethnographic accounts, potential assignment of the processing stage can be attempted.

An additional problem is that this method assumes that weed seeds found in the samples arise from a specific crop or maslin cultivation, not the result of either the mixing of crop processing remains of multiple crop taxa cultivated independently, or from other activities such as dung burning. Consequently only samples containing 70%+ of one crop type were examined. The dominance of glume wheat material in Çatalhöyük West samples meant that all samples with 30 or more items were applicable.

To account for the seed material from processes other than crop processing, the likelihood of the crop processing origin of the taxa was assessed. The species ranked with a high probability of being dung-derived (see Chapter 7) are here excluded as non-arable weeds. What is uncertain is the nature of the species possessing a medium potential for dung derivation. Such species could be both crop and dung-derived and so the analyses were conducted to account for each scenario.

The species classed as being moderate dung-derived possibilities are also potential crop weeds. A prominent species is *Bolboschoenus glaucus*, highly ubiquitous in the assemblage, occurring in 98% of the samples as well as contributing 18% of the charred wild assemblage. Understanding its pathway onto the site is therefore particularly important. It is possible that *Bolboschoenus,* given the wet environment of Çatalhöyük, invaded crop fields (Ryan 2009:310).

Bolboschoenus will form dense stands in conditions of high water availability such as beside rivers and in riverine flood plains but is also well adapted to summer-dry habitats, and will occur near villages (Wollstonecroft et al. 2011:462). Storage deposits of cereals on the East Mound have contained *Bolboschoenus* seeds but dung remains on the site have also contained *Bolboschoenus* seeds, researchers attributing this partially to dung burning (Bogaard et al. 2013a; Filipović 2014). *Bolboschoenus* has been identified as a food resource, providing starchy tubers as well as seeds (Wollstonecroft et al. 2008). Tubers have also been found incorporated in mud brick as a temper and on the East Mound there is evidence of the stem's use for basketry (Ryan 2009). Four major pathways by which the seeds entered the site are suggested: as food, in dung, as a crop weed, or when used in basketry/building material. All four pathways for *Bolboschoenus* are possible; there is no clear-cut evidence for a single method of entrance for this species and the analysis below was conducted with and without *Bolboschoenus* (Table 8.3).

As discussed in Chapter 7, relatively few wild species - other than dung derived- can be ruled out as arable weeds on ecological grounds. Woody perennials such as hackberry, pistachio, oak, almond, and other *Prunus* species are more likely a collected resource, not a weed; young saplings would be unlikely to set seed that could be collected during the harvest.

Table 8.3: Different taxon combinations examined in the Çatalhöyük West analyses

Group	Species excluded	Additional species excluded	Reason
No high dung classed species	*Aeluropus* Trin.		Ranked as highly likely to be from dung burning
	Alisma L.		
	Artemisia annua L. type		
	Atriplex L.		
	Chenopodium L.		
	Crypsis aculeata (L.) Aiton type		
	Deschampsia		
	Eragrostis N.M. Wolf		
	Juncus L.		
	Rumex L.		
	Salsola L.		
	Sporobolus R. Br.		
No high dung classed species, and *Bolboschoenus*		*Bolboschoenus glaucus* (Lam.) S.G. Smith	Potential other mode of entrance
No high dung classed species, and *Descurainia*		*Descurainia sophia* (L.) Webb	Potentially collected food (as per Çatalhöyük East)
No high dung classed species, and *Bolboschoenus* and *Descurainia*		*Descurainia sophia* (L.) Webb and *Bolboschoenus glaucus* (Lam.) S.G. Smith	Alternative routes of entry
No high or moderate dung classed species	*Aeluropus* Trin.		Ranked as highly or moderately-likely to be dung derived
	Alisma L.		
	Artemisia annua L. type		
	Atriplex L.		
	Chenopodium L.		
	Crypsis aculeata (L.) Aiton type		
	Deschampsia		
	Eragrostis N.M. Wolf		
	Juncus L.		
	Rumex L.		
	Salsola L.		
	Sporobolus R. Br.		
	Anagallis type		
	Bolboschoenus glaucus (Lam.) S.G. Smith		
	Chenopodium album L. type		
	Polygonum aviculare		
	Polygonum convolvulus L.		
No high or moderate dung classed species, and *Descurainia*		*Descurainia sophia* (L.) Webb	Potentially collected

The final species arguably not an arable weed is *Descurainia sophia*. This wild mustard is highly ubiquitous within the assemblage and comprises 25% of the charred wild assemblage. Excavations on the East Mound have found storage deposits of this taxon, likely being valued for its oil content. It is not possible to determine whether or not this practice continued on the West Mound due to lack of storage contexts. Habitat requirements do not allow *Descurainia* to be ruled out as a crop weed and personal observation has seen it growing in crop fields in Turkey today. The analysis below was therefore conducted with and without its inclusion to help determine the path or paths by which this species entered the assemblage (Table 8.3).

Figure 8.2 shows the proportions of glume bases, grain and weed seeds of the different versions of the dataset detailed in Table 8.3. It demonstrates the impact of the inclusion of *Bolboschoenus* and *Descurainia sophia.* Their removal significantly reduces the proportion of weeds in the samples, revealing a more distinctly glume base-dominated assemblage with all but six samples (five if dung combination 2.1 is used) containing at least 50% of glume bases. These samples, concentrated towards the glume base corner, suggest residue from de-husking and could therefore relate to fine-sieving by-product.

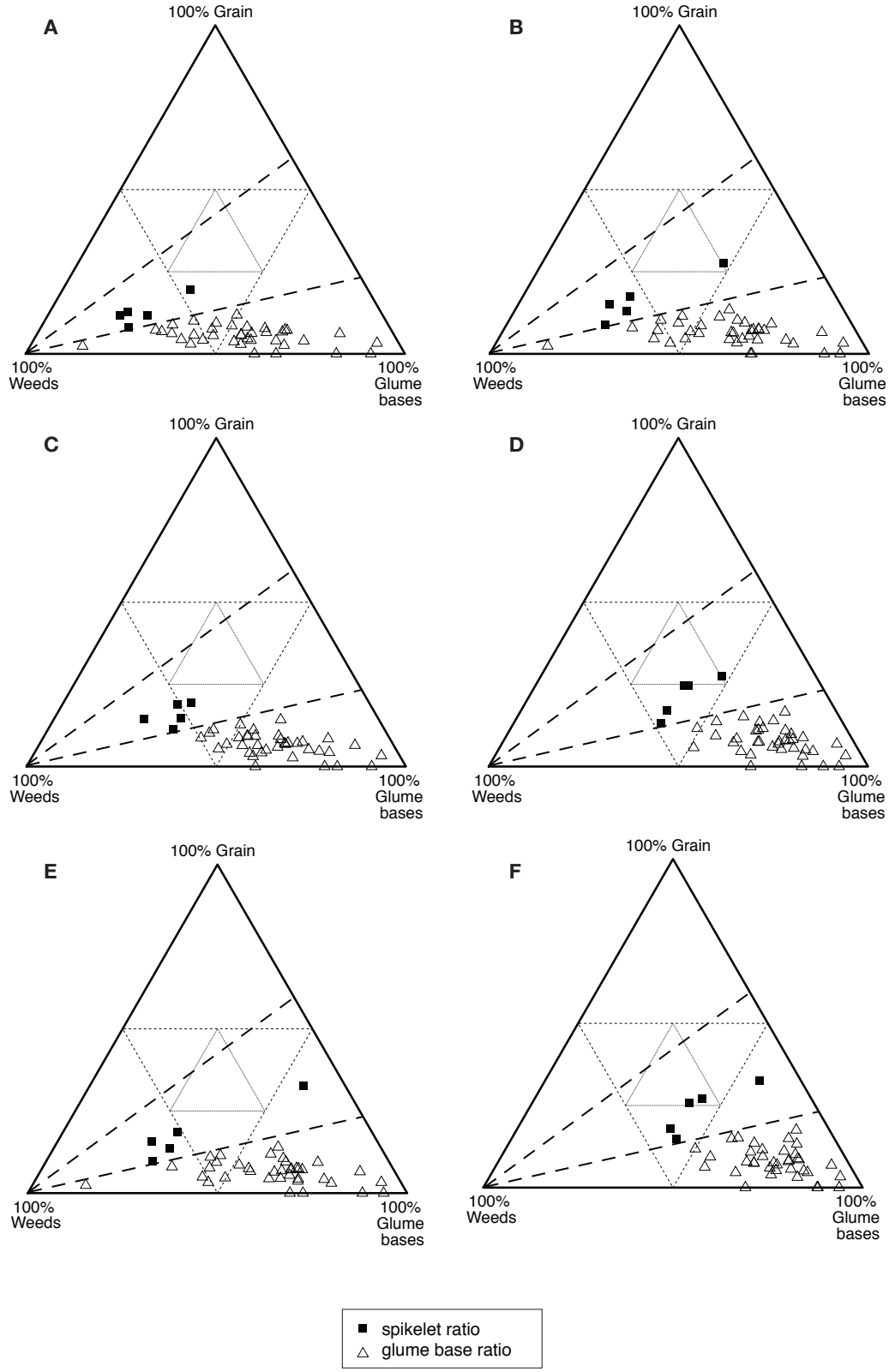


Figure 8.2: Triangular plots showing the proportions of weed seeds, glume wheat grain and glume wheat chaff of the 42 Çatalhöyük West samples containing 30 or more glume wheat items. Dotted lines indicate the lower and upper cut-offs for the spikelet-like ratios following Bogaard (2011). The black squares highlight samples classed as spikelet samples. Graph (A) weed seeds excluding high possibility dung-derived taxa, (B) excluding potential (high) dung taxa and *Bolboschoenus*, (C) excluding potential (high) dung taxa and *Descurainia*, (D) excluding potential (high) dung taxa, *Bolboschoenus* and *Descurainia*, (E) excluding high and moderate potentially dung-derived taxa, and (F) excluding high and moderate potentially dung-derived taxa and *Descurainia*.

The spikelet samples are some of the most weed-rich samples; in particular samples 11096 and 31210 have the highest proportions of weeds even when *Descurainia* and *Bolboschoenus* are excluded. The location of the spikelet samples in Figure 8.2 highlights their limited deviation from the bulk of the samples. This indicates that the spikelet samples do not represent 'real' spikelets, unsurprising given their non-storage contexts, but instead indicate a degree of mixing. Such samples are not clean enough to represent semi-clean spikelet stores and instead may represent mixtures or fine-sieving waste from pounded spikelets in which higher amounts of grains were lost.

Manipulation of Jones' (1990) free-threshing ethnographic data to calculate hypothetically the quantity of weeds contained in fine-sieving by-products should the crop have been glume wheats, was conducted to provide a comparison with the glume wheat rich Çatalhöyük West samples (Bogaard 2011)(Chapter 4). The crop fields that Jones (1983b) studied in Amorgos were very weedy; the West Mound samples are even weedier. The removal of the different combinations of taxa (Table 8.3) does reduce the number of very weedy samples, however no combination of species' removal reduces this weediness to the level of the Amorgos samples, nor produces a similar range of ratios. These results indicate either that the fields at Çatalhöyük were extremely weedy, that the hypothetical ratios over-estimate glume bases and/or an additional path for seed deposition is also represented in the refined assemblage.

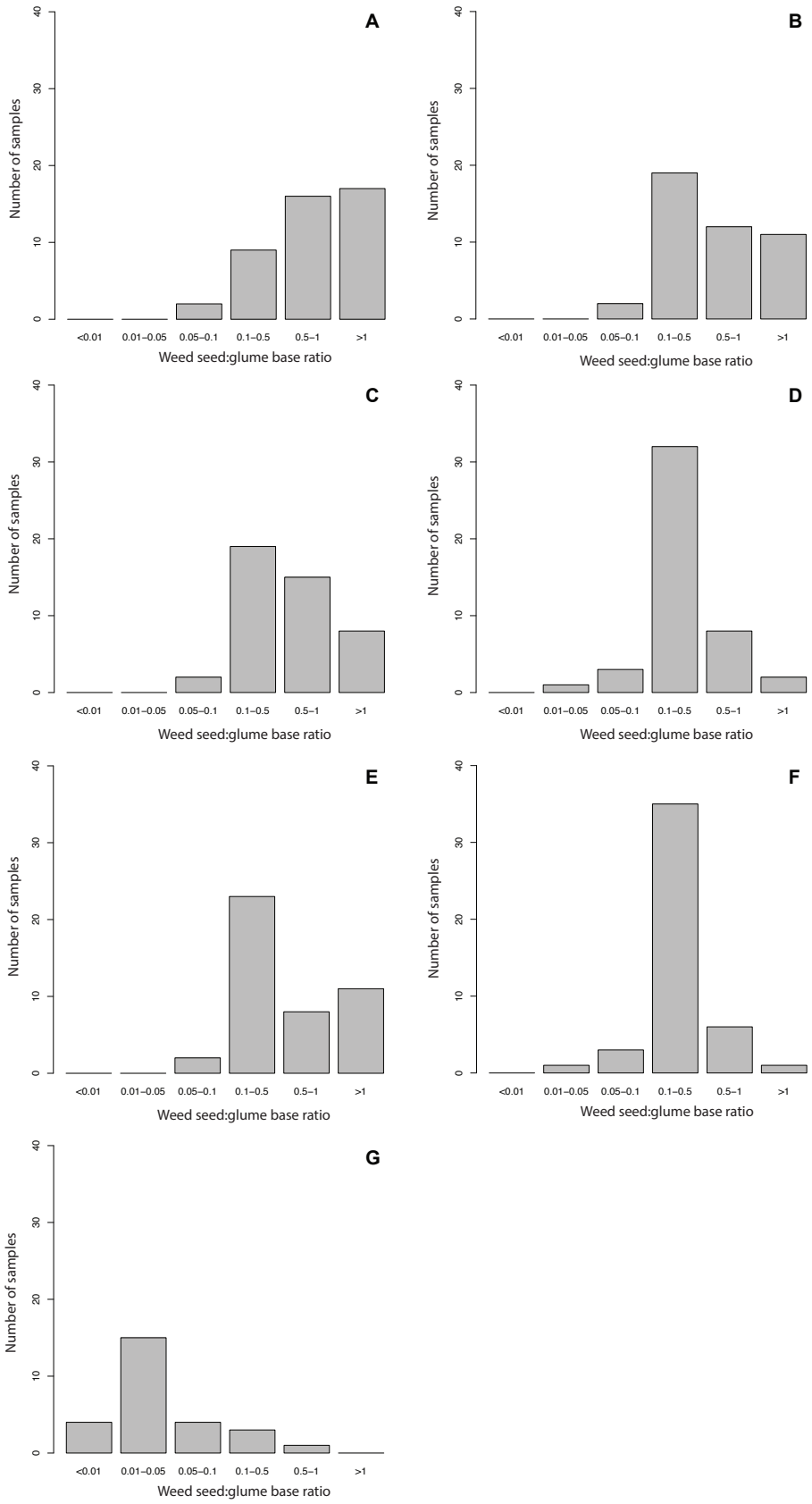


Figure 8.3: "Weediness" of the Çatalhöyük West samples showing the results of removal of specific groups of taxa;(A) excluding taxa classed as high chance of being dung derived, (B) excluding "high dung" taxa and *Bolboschoenus* , (C) excluding "high dung" taxa and *Descurainia*, (D) excluding "high dung" taxa and both *Bolboschoenus* and *Descurainia*, (E) excluding high or moderate dung flora, (F) excluding high, moderate dung flora or *Descurainia*, compared to (G) the manipulated data from Jones (1983).

8.1.3 Weed-based analysis

The final method uses discriminant analysis in conjunction with ethnobotanical data compiled by Jones (1990) to assess crop processing stages on the basis of physical weed seed types. Size (small vs. big), headedness (free vs. headed) and aerodynamic properties (light vs. heavy) of the weed seeds were used to classify the species as one of seven groups thus providing a comparison with the ethnographic data independent of crop content. Though (ethnobotanical) free-threshing cereals and (archaeobotanical) glume wheats are being compared, the removal of crop items makes such comparison less problematic. While glume wheats require the additional processing stage of pounding, the other processing stages are the same for both cereal types. As the aim of crop processing was to remove weed seeds of specific sizes and shapes, these seeds, regardless of the crop being processed, should still be removed at comparable stages. One caveat is the fact that glume wheat may undergo these stages twice, once while within spikelets and again after de-husking. Consequently it could be hypothesised that the by-product of processing after de-husking would contain low numbers of small seeds due to them having been removed during the first winnowing (see Chapter 3 for more detail).

Table 8.4 shows the five different classifications including or excluding specific taxa. When all highly ranked dung flora have been removed the samples are all classified as fine-sieving by-products, a classification in agreement with the above analyses. This highlights the impact of the removal of dung flora as shown in Chapter 7, where the majority of samples are classified as winnowing by-products when the dung flora are not removed (see Chapter 7, Figure 7.1).

The additional removal of *Descurainia* and *Bolboschoenus,* both classed as small/free/heavy, results in reduction of seeds typical of fine-sieving by-products and changes nine of the 33 samples from fine-sieving by-products back to winnowing or to product. As mentioned above the result of winnowing by-product or product when such taxa are removed is inconsistent with the amount of glume bases within the assemblage. When just one of these species is removed the impact is reduced meaning that the results are ambiguous regarding the validity of *Descurainia* and *Bolboschoenus*' inclusion or exclusion and are equally ambiguous regarding the correctness of excluding species within the moderate dung-derived category; exclusion changed only two samples' classification (Table 8.4). A sample classified as winnowing by-product due to the removal of a species may suggest either that the species removed is a crop weed that should not be removed, or that the sample is highly mixed. The limited changes in the classification of specific samples after the removal of specific species can be interpreted as a consequence of an underlying robust signature of weed seeds possessing the same characteristics as fine-sieving by-product. This observation is in accordance with the results of the crop-based and crop and weed-based analysis described above.

Table 8.4: Results of discriminant analysis conducted on the Çatalhöyük West samples showing the different crop processing classification of the samples depending on which dung flora/additional species were removed. * The "all weed" classification refers to the analysis conducted in Chapter 7 and includes all species including dung-derived taxa.

Dung flora group removed	Additional species removed	Winnowing by-products	Coarse-sieving by-products	Fine-sieving by-products	Fine-sieving products
All weeds*		36	0	5	0
No high dung taxa		0	0	40	0
	Descurainia	0	0	38	2
	Bolboschoenus	1	0	39	0
	Descurainia & *Bolboschoenus*	4	0	24	5
No high/moderate dung taxa		2	0	37	0
	Descurainia	6	0	13	5

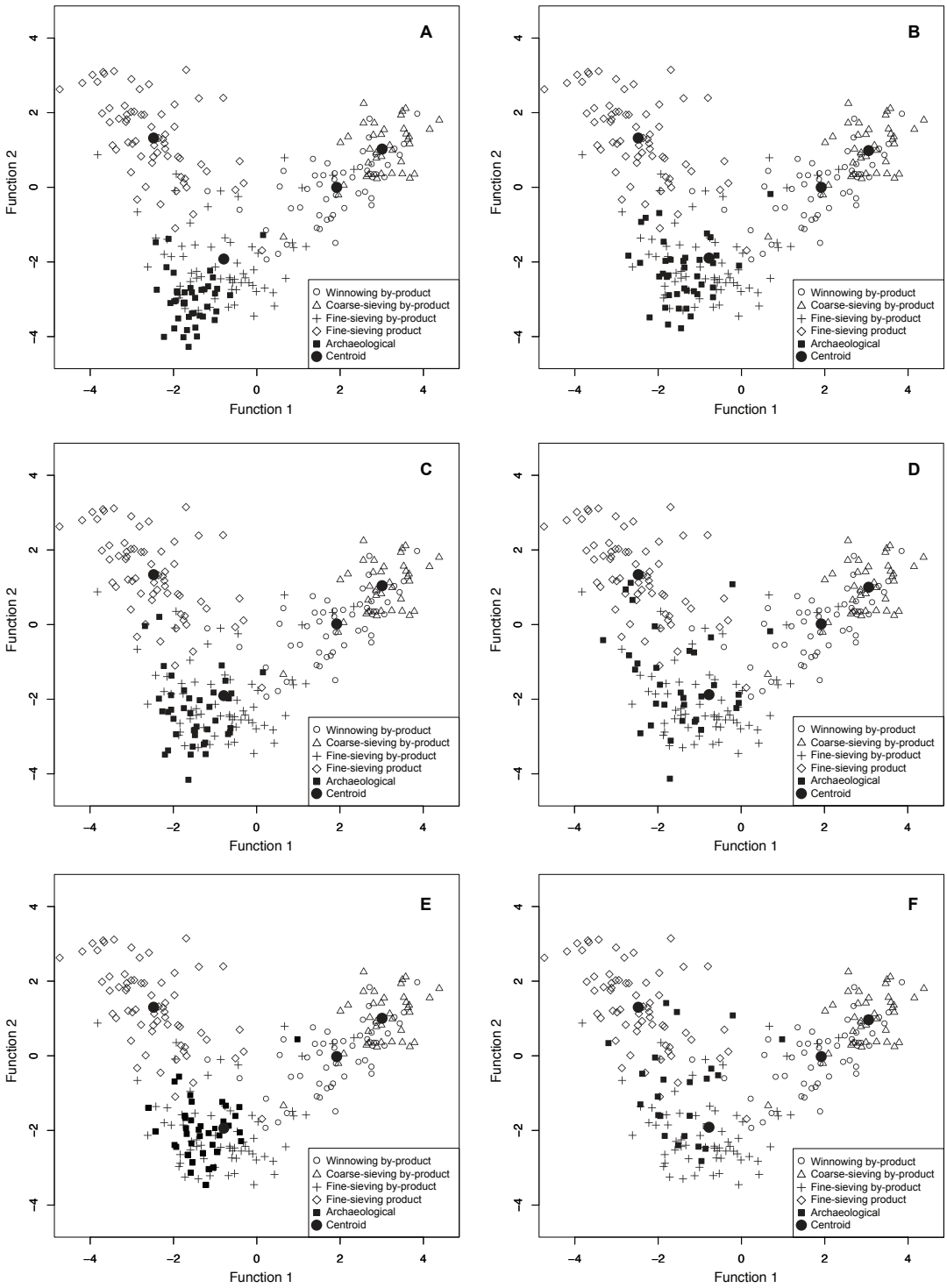


Figure 8.4: Results of discriminant analysis of the weeds' assemblage from the Çatalhöyük West samples in comparison to Jones' (1983) ethnographic data of know crop processing stages, showing the first two functions. Graph (A) uses a Çatalhöyük West weed data set (archaeological) excluding high dung classed taxa, (B) uses weeds excluding high dung taxa and *Bolboschoenus*, (C) uses weeds excluding high classed dung taxa and *Descurainia*, (D) uses weeds excluding high classed dung, *Bolboschoenus* and *Descurainia*, (E) uses the Çatalhöyük West data set, excluding high and moderate dung taxa, while (F) excludes high and moderate dung taxa in addition to *Descurainia*.

8.1.4 Conclusions

Table 8.5 summarises the findings concerning crop-processing stage(s) represented in the samples. This builds on the results from Chapters 5 and 7 and this Chapter. Dehusking waste of glume wheats dominates the Çatalhöyük West assemblage, with the majorities of samples classed as glume base dominated. The free-threshing cereals provide limited crop components and predominantly showed ratios similar to fine-sieving by-products. The glume wheat samples classified as spikelet-like have high numbers of weed seeds and display limited differences to the samples classed as glume-base dominated, suggesting that these are not the result of the charring of whole spikelets, rather a mixing of by-product and product material. The mixture of different crop types, glume vs. free-threshing, as well as collected material and dung-derived taxa, indicate that there is a mixture of sources for the plant remains. The high proportion of weed seeds seen in some samples may reflect such mixing. The removal of dung-derived flora had a significant impact on the proportion of weeds in the samples, and the results indicate that dung-derived flora and arable flora can be separated. When the dung-derived flora are removed, the overwhelming signature in the assemblage is one of fine-sieving by-products, for both glume wheats and free-threshing cereals. Such a ubiquitous signal could be the consequence of routine cleaning of dehusked glume wheats, most likely reflecting the storage of glume wheat spikelets that were only partially cleaned, with piecemeal processing to a clean product occurring when the grain was required. The mixing in the samples does indicate possible conflation of multiple activities, however overall the results indicate that the majority of the arable weeds most likely derived from glume wheat processing and thus the cultivation of this crop.

Table 8.5: The proportion of glume wheat items within the Çatalhöyük West samples, compared to crop, and arable weed seeds, the resulting classification of the samples based on grain to chaff ratios, as will as with discriminant analysis.

Sample	% glume wheat from total crop items	% glume wheat from all arable weeds	Spikelet/ Glume base ratio classification	Barley	Jones classification (not including high dung taxa)	Jones classification (not including high dung, *Descurainia* or *Bolboschoenus*
9602	98	90.4	Glume base		Fine-sieving by-products	Fine-sieving by-products
9471	96	55.0	Glume base		Fine-sieving by-products	N/A
11094	95	52.8	Glume base		Fine-sieving by-products	Fine-sieving by-products
9564	94	63.9	Glume base		Fine-sieving by-products	**Fine-sieving products**
11093	93	38.1	Glume base		Fine-sieving by-products	Fine-sieving by-products
9562	93	73.7	Glume base		Fine-sieving by-products	N/A
9600	93	59.8	Glume base		Fine-sieving by-products	Fine-sieving by-products
9613	92	58.7	Glume base		Fine-sieving by-products	N/A
8461	91	62.7	Glume base		Fine-sieving by-products	Fine-sieving by-products
9619	91	41.4	Glume base		Fine-sieving by-products	**Fine-sieving products**
9358	91	58.6	Glume base		Fine-sieving by-products	N/A
10099	89	67.5	Glume base		Fine-sieving by-products	N/A
8953	89	53.9	Glume base		Fine-sieving by-products	**Fine-sieving products**
10279	88	54.3	Glume base		N/A	N/A
8360	88	48.5	Glume base		Fine-sieving by-products	N/A
9341	87	48.1	Glume base		Fine-sieving by-products	Fine-sieving by-products
9495	87	60.7	Glume base		Fine-sieving by-products	**Winnowing**
11041	86	58.3	Glume base	Fine-sieving by-product	Fine-sieving by-products	Fine-sieving products
9563	86	67.7	Glume base		Fine-sieving by-products	Fine-sieving by-products
Floor 16977	86	27.6	Spikelet		Fine-sieving by-products	Fine-sieving by-products
9524	86	57.2	Glume base		Fine-sieving by-products	N/A
10111	85	45.6	Glume base		Fine-sieving by-products	Fine-sieving by-products
u31114	85	51.2	Glume base	Fine-sieving by-product	Fine-sieving by-products	Fine-sieving by-products
9603	85	46.4	Glume base		Fine-sieving by-products	Fine-sieving by-products
10265	84	50.1	Glume base		Fine-sieving by-products	Fine-sieving by-products
11097	83	40.5	Glume base		Fine-sieving by-products	Fine-sieving by-products
10110	83	46.2	Glume base		Fine-sieving by-products	**Winnowing**

Sample	% glume wheat from total crop items	% glume wheat from all arable weeds	Spikelet/ Glume base ratio classification	Barley	Jones classification (not including high dung taxa)	Jones classification (not including high dung, *Descurainia* or *Bolboschoenus*
11100	82	52.0	Glume base		Fine-sieving by-products	**Fine-sieving products**
10100	82	15.3	Glume base		Fine-sieving by-products	Fine-sieving by-products
u31210	82	31.4	Spikelet	Fine-sieving by-product	Fine-sieving by-products	Fine-sieving by-products
11089	81	37.6	Glume base		Fine-sieving by-products	Fine-sieving by-products
9519	81	32.1	Glume base		Fine-sieving by-products	Fine-sieving by-products
11096	81	26.6	Spikelet		Fine-sieving by-products	Fine-sieving by-products
11087	81	36.5	Glume base		Fine-sieving by-products	Fine-sieving by-products
11092	80	49.8	Glume base	Fine-sieving by-product	Fine-sieving by-products	Fine-sieving by-products
11053	79	32.4	Glume base		Fine-sieving by-products	Fine-sieving by-products
Floor 18376	79	26.4	Spikelet		Fine-sieving by-products	Fine-sieving by-products
8911	78	39.6	Glume base	Coarse-sieving by-product	Fine-sieving by-products	Fine-sieving by-products
9591	76	38.5	Glume base		Fine-sieving by-products	**Winnowing**
u18341	75	51.6	Glume base	Fine-sieving by-product	Fine-sieving by-products	**Fine-sieving products**
11088	72	39.8	Spikelet		Fine-sieving by-products	Fine-sieving by-products
9573	71	66.5	Glume base	Winnowing/coarse-sieving by-product	N/A	N/A

8.2 Çamlıbel Tarlası

The Çamlıbel Tarlası assemblage was analysed following the same protocol employed for the Çatalhöyük West assemblage. The results of Chapter 5 indicate a high proportion of weeds in the samples and the majority of samples dominated by glume wheat remains. The results of Chapter 6 and 7 show that the samples contain a mixture of flax weed seeds as well as glume wheat dehusking waste (glume bases), providing an indication of which weeds were more likely to have derived from arable fields, as well as from the cultivation of flax. The analyses below therefore focus primarily on glume wheats, due to their dominance within the assemblage (51 of the 64 samples). However the importance of flax as a contributor to the assemblage cannot be overlooked simply because of its lack of numbers, most likely a consequence of charring bias against oily seeds. The high proportion of glume bases, as well as small-seeded *Lolium* and *Silene* seeds in the samples indicates that the Çamlıbel Tarlası assemblage is most likely comprised of a mixture of two crop processing activities and therefore two weed floras.

8.2.1 Crop-based analysis

As detailed in Chapter 5, glume wheat remains dominate 51 of the Çamlıbel Tarlası samples, while the remaining 13, of which only six contain 30 or more glume wheat items, are classified as mixed. Overall the assemblage has a high proportion of glume bases compared to glume wheat grains, a ratio of 0.22. On a sample by sample basis, the glume wheat samples have a high proportion of glume base remains compared to grain, with only three samples containing more grain than chaff (Table 8.6). Forty-two of the 56 glume wheat-rich samples are classified as glume base samples, indicating a derivation from a crop processing

stage that preferentially removed high amounts of glume bases, such as sieving of pounded spikelets. Eight samples contained a ratio higher than 0.3, falling in the "spikelet" range, indicating a similar ratio of grain to glume bases and possibly representing semi-clean stored spikelets.

Six glume wheat-rich samples classified as mixed provide different results. One sample produced a ratio comparable with clean grain, four are classed as spikelet samples and one as a glume base sample. These samples have differing proportions of glume wheat items in comparison to other crops while glume wheat remains dominant in all samples except 415. Sample 425 is of note, classified as mixed, containing only 69% glume wheat and classified as clean product because of its limited glume bases (Table 8.6).

Table 8.6: Number of grains, glume bases, total, ratio and interpretation of the ratio of the 56 samples containing more than 30 glume wheat items

Sample	Main species	No. of grains	No. of glume bases	Total glume wheat items	Ratio grain to glume bases	Spikelet/ glume base classification
79	Glume wheat	153	249	402	0.62	Spikelet
406	Glume wheat	42	82	124	0.51	Spikelet
337	Glume wheat	21	48	69	0.43	Spikelet
427	Glume wheat	17	41	58	0.41	Spikelet
392	Glume wheat	262	734	996	0.36	Spikelet
200	Glume wheat	21	60	81	0.35	Spikelet
226	Glume wheat	57	177	234	0.32	Spikelet
186/202	Glume wheat	7	24	31	0.30	Spikelet
m632	Glume wheat	13	42	55	0.30	Glume base
m887	Glume wheat	71	253	324	0.28	Glume base
46	Glume wheat	19	72	91	0.26	Glume base
419	Glume wheat	18	74	92	0.25	Glume base
209	Glume wheat	22	91	113	0.24	Glume base
325	Glume wheat	11	44	54	0.24	Glume base
423	Glume wheat	31	130	161	0.24	Glume base
m466	Glume wheat	23	104	127	0.22	Glume base
88	Glume wheat	27	126	153	0.22	Glume base
310	Glume wheat	42	217	259	0.19	Glume base
75	Glume wheat	29	154	183	0.19	Glume base
405	Glume wheat	36	200	236	0.18	Glume base
49	Glume wheat	62	349	411	0.18	Glume base

Sample	Main species	No. of grains	No. of glume bases	Total glume wheat items	Ratio grain to glume bases	Spikelet/ glume base classification
424	Glume wheat	26	158	184	0.17	Glume base
361	Glume wheat	18	112	130	0.16	Glume base
50	Glume wheat	23	144	167	0.16	Glume base
180	Glume wheat	20	140	160	0.14	Glume base
m440	Glume wheat	27	200	227	0.14	Glume base
421	Glume wheat	30	221	251	0.14	Glume base
90	Glume wheat	13	97	110	0.14	Glume base
377/365	Glume wheat	22	164	186	0.14	Glume base
400	Glume wheat	42	318	360	0.13	Glume base
m877	Glume wheat	110	874	984	0.13	Glume base
311	Glume wheat	21	176	197	0.12	Glume base
54	Glume wheat	18	152	170	0.12	Glume base
358	Glume wheat	61	537	598	0.11	Glume base
238	Glume wheat	13	122	134	0.10	Glume base
139	Glume wheat	15	195	210	0.08	Glume base
204	Glume wheat	11	144	155	0.07	Glume base
324	Glume wheat	5	74	79	0.07	Glume base
35/38	Glume wheat	3	54	57	0.06	Glume base
411	Glume wheat	10	225	235	0.04	Glume base
223	Glume wheat	6	279	285	0.02	Glume base
74/3	Glume wheat	0	88	88	0.00	Glume base
306	Glume wheat	0	43	43	0.00	Glume base
224	Glume wheat	0	93	93	0.00	Glume base
60	Glume wheat	0	52	52	0.00	Glume base
m439	Glume wheat	0	97	97	0.00	Glume base
132	Glume wheat	0	60	60	0.00	Glume base
321	Glume wheat	0	92	92	0.00	Glume base
210	Glume wheat	0	84	84	0.00	Glume base
365	Glume wheat	0	65	65	0.00	Glume base
425	Mixed	255	76	331	3.35	Clean
415	Mixed	20	14	34	1.45	Spikelet
396	Mixed	16	15	31	1.07	Spikelet
19	Mixed	11	20	31	0.56	Spikelet
42	Mixed	18	35	53	0.53	Spikelet
357	Mixed	38	150	188	0.25	Glume base

The reliability of the ratio of the free-threshing cereal types in the Çamlıbel Tarlası samples is limited due to the paucity of remains; no sample contains 30 or more free-threshing wheat items. Barley, more prevalent than free-threshing wheat also consists mostly of grain with little rachis. This is reflected in the ratios, with all samples of 30 or more items producing ratios of greater than seven (Table 8.7).

Comparison to the ratios in Jones' (1990) ethnographic research indicates that the majority of the Çamlıbel barley samples have similar ratios to fine-sieving by-products; only four samples are not classed as such (Table 8.7, Figure 8.5). Sample 392 has a ratio occurring between fine-sieving by-product and clean product, while samples 406 and 224 appear in the gap between fine-sieving and coarse-sieving by-product. Sample 396 occurs at the high end of the coarse-sieving range. As all rachis remains from Çamlıbel were identified as two-rowed, comparison with the adjusted ethnographic data is justified. This only slightly changes the interpretation, with all except five samples classed as fine-sieving by-product; the remaining samples are either between fine-sieving by-product and clean grain (4) or clean grain (1) (Figure 8.5,Table 8.7).

Table 8.7: Number of barley grains and chaff remains from Çamlıbel Tarlasi samples containing 10 or more barley items. The ratio, together with the interpretation of crop processing class, is shown with reference to Jones' (1983) ethnographic data. The adjusted classification is with reference to Jones' (1983) data adjusted for two-rowed barley forms.

Sample	No. of grains	No. of internodes	Sum	Ratio	Crop processing classification	Adjusted crop processing classification	Dominant crop
392	184	0	184	184.4	Fine-sieving by-p /clean product	Clean product	Glume wheat
75	30	0	30	29.7	Fine-sieving by-product	Fine-sieving by-product	Glume wheat
421	32	4	36	7.9	Fine-sieving by-product	Fine-sieving by-product	Glume wheat
358	38	2	40	18.8	Fine-sieving by-product	Fine-sieving by-product	Mixed
425	83	4	87	20.8	Fine-sieving by-product	Fine-sieving by-product	Mixed
357	41	0	41	41.1	Fine-sieving by-product	Fine-sieving by-p /clean product	Glume wheat
m887	50	1	51	50.2	Fine-sieving by-product	Fine-sieving by-p /clean product	Glume wheat
m877	57	0	57	56.9	Fine-sieving by-product	Fine-sieving by-p /clean product	Glume wheat
79	58	0	58	57.8	Fine-sieving by-product	Fine-sieving by-p /clean product	Glume wheat

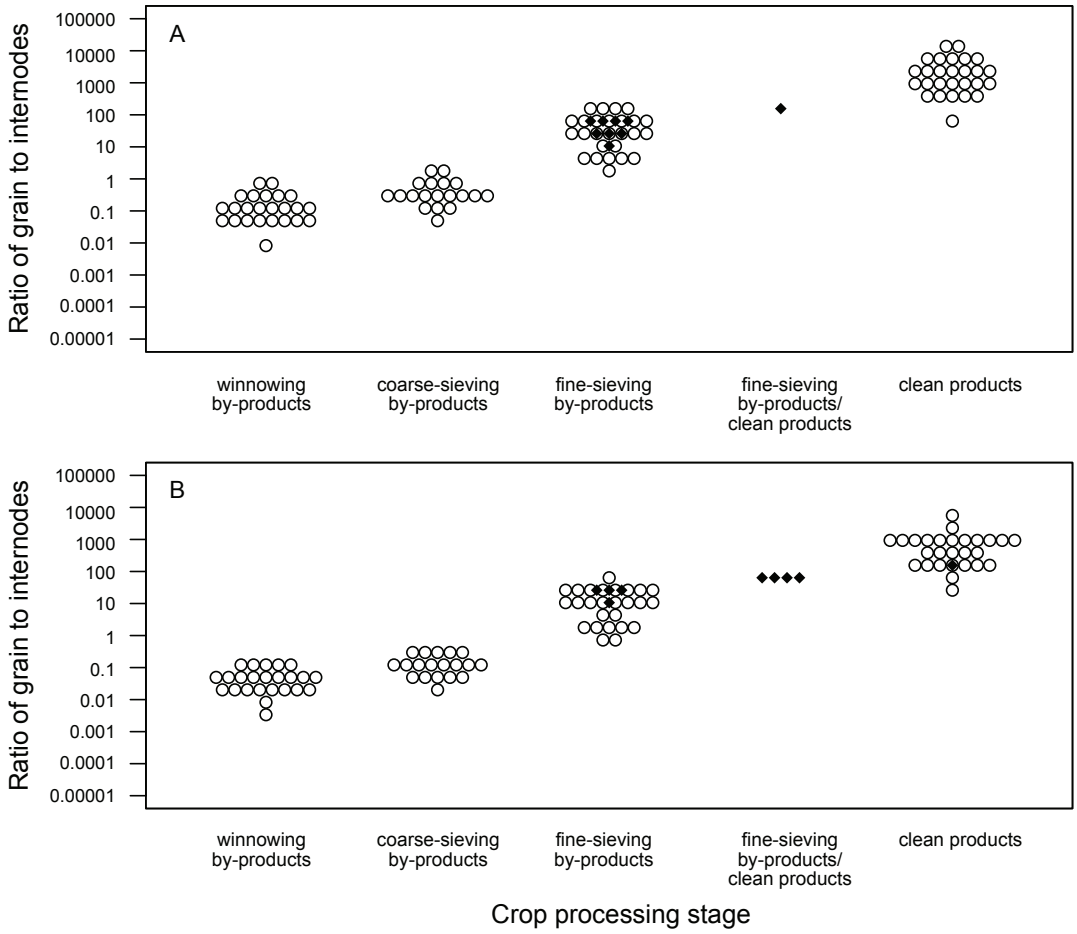


Figure 8.5: Comparison of Çamlıbel Tarlası samples' barley ratios (shown as solid symbols) against (A) Jones (1983) ethnographic data and (B) Jones' data adjusted to represent two-rowed barley forms.

8.2.2 Crop and weed proportions

Few wild taxa could be excluded as arable weeds based on habitat preference and vegetative form other than those species classed as dung-derived (see Chapter 6). Woody perennials such as *Rosa*, *Rubus* and *Prunus* species are unlikely to have entered the assemblage through harvesting and subsequent crop processing since they are unlikely to set seed in annual crops. These taxa may be collected plants, or become incorporated into the assemblage through wood fuel use.

Other wild taxa that can be excluded as arable weeds are those classed as having a high potential of dung-derivation (see Chapter 7). Overall these taxa represent a minor proportion of the total assemblage and will no longer be included in the analysis. A larger proportion of the wild taxa consists of those classed as being moderately possible dung-derived species, in particular *Polygonum aviculare,* a known modern arable weed. Similar to the Çatalhöyük situation there are multiple pathways by which such species could have entered the record. Due to the uncertain origin of this and other moderate classed species, analyses were conducted on datasets that included and then excluded the moderate dung-derived species (Table 8.8).

As the Çamlıbel Tarlası assemblage contains a mixture of glume wheat dominated as well as mixed samples, the association of the weed seeds to one particular crop is strongest in the samples classed as glume wheat dominated. Such dominance of one particular crop type in specific samples supports the inference that the weed seeds in the majority of samples potentially derived from one crop's cultivation. All samples were included in the analysis and samples of mixed classification are highlighted.

Graphical representation following Jones (1990) illustrates similarity in the proportion of glume bases to weeds in all samples classed as glume-wheat dominated, including "spikelet" samples, although spikelet samples tend to be the more weed dominated (Figure 8.6). The samples classified as mixed occur predominantly outside the cluster of glume base-dominated samples, reflecting the tendency for mixed samples to have a high grain to glume-base ratio. The

single sample resembling a cleaned product (69.5% glume wheat) also contains a relatively high proportion of weed remains compared to glume bases.

Table 8.8: Species excluded from the different version for each analysis below, with the reason for their exclusion detailed.

Group	Species excluded	Additional species excluded	Reason
No high dung classed species	*Artemisia annua* L. type		Highly likely to be from dung burning
	Crypsis aculeata (L.) Aiton type		
	Sporobolus R. Br.		
No high dung classed species or flax weeds		*Lolium*, small type	Potential flax weeds
		Silene type 1	
No high or moderate dung species	*Artemisia annua* L. type		Highly and moderately likely to be from dung burning
	Crypsis aculeata (L.) Aiton type		
	Sporobolus R. Br.		
	Bolboschoenus glaucus (Lam.) S.G. Smith		
	Ranunculus sceleratus L.		
	Polygonum aviculare		
	Poa type		
	Eragrostis N.M. Wolf, type		
	Chenopodium L.		
	Anagallis type		
No high or moderate dung species or flax weeds		*Lolium*, small type	Potential flax weeds
		Silene type 1	

Removal of the moderately potentially dung-derived flora has limited effect on the proportions of the samples so the source of additional weeds is probably elsewhere (Figure 8.6). It is possible that the predominant weed species in the samples, small-seeded *Lolium*, as well as *Silene* type 1 are derived from flax/linseed cultivation and are thus obscuring the results (see Chapter 5 and 6). These species are closely associated with flax and other potential flax weeds in the correspondence analysis (see Chapter 6), and are the same taxa found within storage deposits of flax at the site of Kuruçay (see Chapter 5). Thus is it possible that these species represent an underlying flax weed signature that has become mixed (to varying degrees) with the remains of glume wheat crop processing. Removal of the flax weed flora has a marked effect as *Lolium* comprises over 50% of the weed assemblage (Figure 8.6).

Overall, the assemblage is weedy as evidenced in comparison to the theorised glume wheat fine-sieving by-product data (Figure 8.7). Removal of the probable flax weeds and dung-derived taxa, while shifting the proportions towards the ethnographic samples, does not result in a distribution of ratios similar to that expected of glume wheat fine-sieving by-products. Three potential factors may have contributed to these results: the fields were weedy; there is a combination of different activities, be it crop processing stages or crop types; or the theorised fine-sieving by-product model used over-estimates the survival of glume bases in the assemblage.

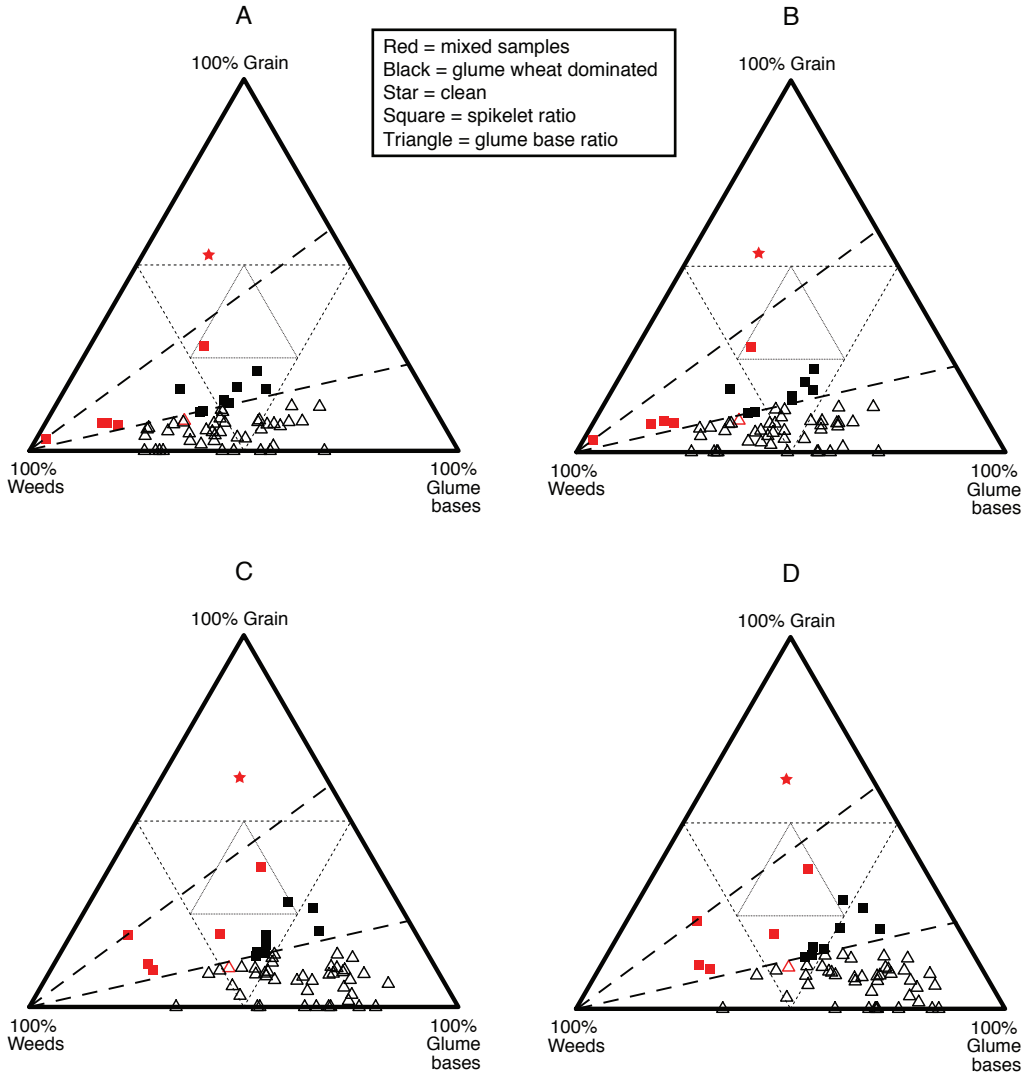


Figure 8.6: Ratio of grain to glume bases to weed seeds from Çamlıbel Tarlası samples. Graph (A) depicts weed seed numbers without taxa ranked as high dung-derived material; (B) weeds without high and moderate dung-derived taxa; (C) high dung-derived taxa and flax weeds removed and (D) high and moderate dung-derived and flax taxa removed.

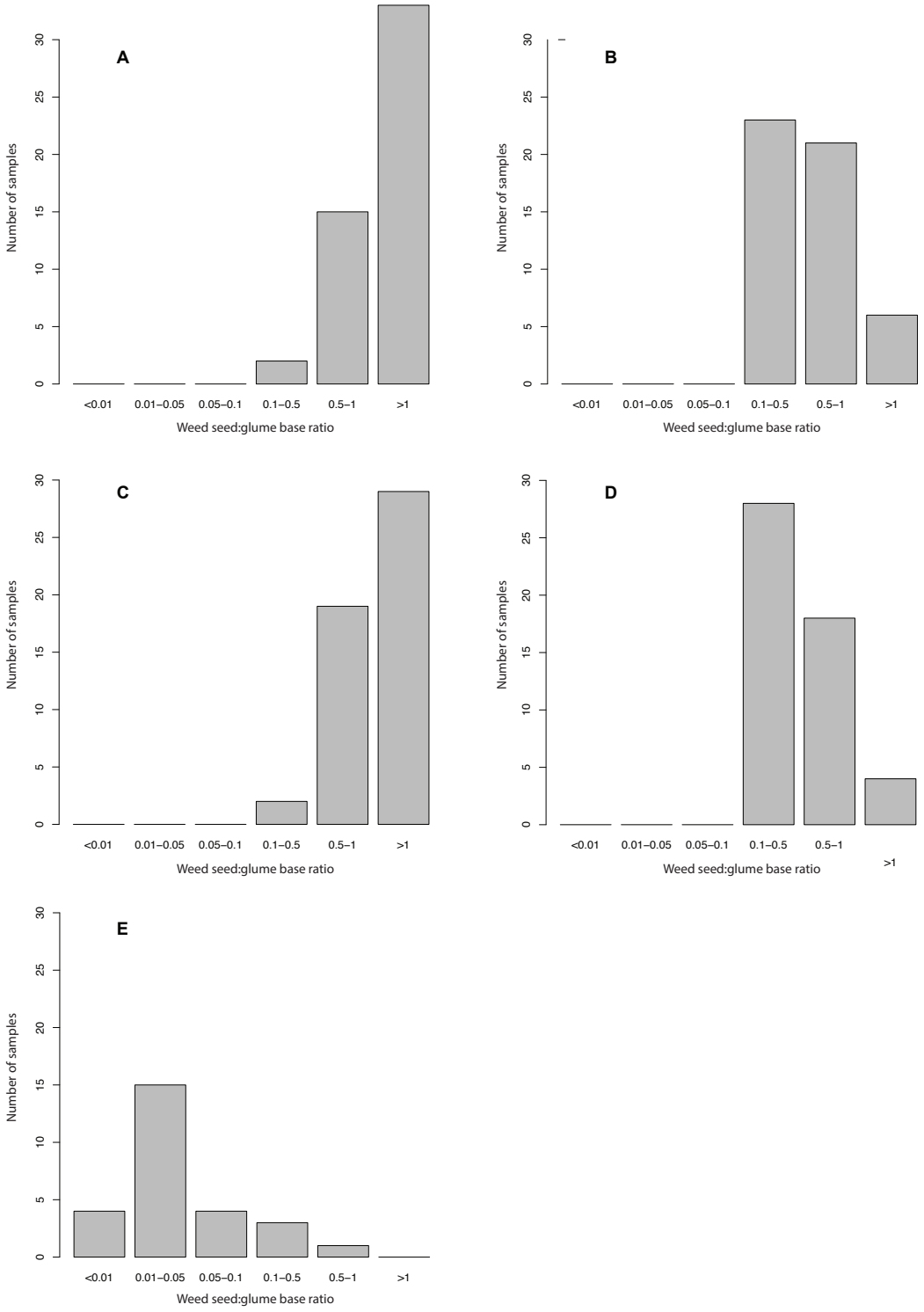


Figure 8.7: Weed to glume base ratios of the Çamlıbel Tarlası samples compared to the theoretical weed seed to glume base ratio of fine-sieving by-products of glume wheats (following Bogaard 2011). Graph (A) depicts the ratios when all taxa classed as high dung species are removed; (B), the ratios when all high and moderate dung-derived species are removed;(C) the ratios when high dung-derived and flax weeds are removed and (D) shows the ratios when high and moderate dung-derived species and flax weeds are removed. Graph (E) shows the manipulation of Jones (1983) data.

8.2.3 Weed-based analysis

Comparison on the basis of physical weed seed types of the Çamlıbel samples with the ethnographic data collected by Jones (1983) was conducted using discriminant analysis. The 63 samples used contained ten or more classifiable weed seeds and had 30 plus crop items. Classification was conducted on four datasets (see Table 8.8).

Figure 8.8 demonstrates the limited difference removal of high ranked dung-derived flora makes (compare with graph 7.3, Chapter 7). Furthermore the removal of medium-scored potential dung- derived taxa increased the number of samples classified as fine-sieving products (also see Table 8.9). The difference that the inclusion of small-seeded *Lolium* has on sample classification is notable. *Lolium*, classed as a small, headed and light, has the characteristics of weeds removed through winnowing; its inclusion in the analysis results in the high number of samples classed as winnowing by-products. Removal of this species, along with *Silene* type 1, results in a majority of samples classed as fine-sieving products or by-products and high probability scores (Table 8.9).

Classification of samples as winnowing by-products is problematic for the glume base-dominated samples. Winnowing while in spikelet form would result in a by-product containing many small light seeds but few glume bases. This is not the case with the Çamlıbel Tarlası samples, which have high proportions of glume bases. Ethnographic research by Hillman (1984b:145) noted that the winnowing of pounded spikelets removes any remaining light weed seeds as well as light chaff such as awns, lemma and palea; the denser glume bases are removed by fine

sieving. Experimental work by Bogaard (2002a) using a seed buoyancy machine noted that while some glume material can be removed via winnowing, fine-sieving is still required to remove the heavier chaff items. Thus the winnowing by-product of glume wheat (dehusked or otherwise) should have limited glume bases within it. The samples classed as winnowing by-products have high numbers of glume bases but their classification as winnowing by-products is due to the presence of flax weeds in the assemblage. Exclusion of the flax weeds classifies all glume wheat-dominated samples as fine-sieving products or by-products, with the exception of sample 427, which remains a winnowing sample (Table 8.9).

Table 8.9: Results of the discriminant analyses, providing the number of samples classified as winnowing, coarse sieving, fine-sieving by-product or fine sieving product. Different classifications are provided for the different classification runs that excluded particular groups of taxa.

		Glume wheat dominated		Mixed samples			<30 crop items	Total
Data set used	**Crop processing stage**	**Glume base**	**Spikelet**	**Glume base**	**Spikelet**	**Clean**		
High dung flora excluded	*Winnowing*	18	1	0	5	1	4	29
	Coarse sieving	0	1	0	0	0	1	2
	Fine sieving	20	3	1	0	0	1	25
	Product	4	3	0	0	0	0	7
High and moderate dung flora excluded	*Winnowing*	15	2	0	5	1	3	26
	Coarse sieving	5	1	0	0	0	2	8
	Fine sieving	11	0	0	0	0	1	12
	Product	11	5	1	0	0	0	17
High dung and flax flora excluded	*Winnowing*	1	0	0	1	1	0	3
	Coarse sieving	0	0	0	0	0	0	0
	Fine sieving	33	5	1	3	0	6	48
	Product	8	3	0	1	0	0	12
High and moderate dung, and flax flora excluded	*Winnowing*	0	0	0	1	0	0	1
	Coarse sieving	0	0	0	0	0	0	0
	Fine sieving	11	0	0	2	0	1	14
	Product	31	6	1	2	1	3	44

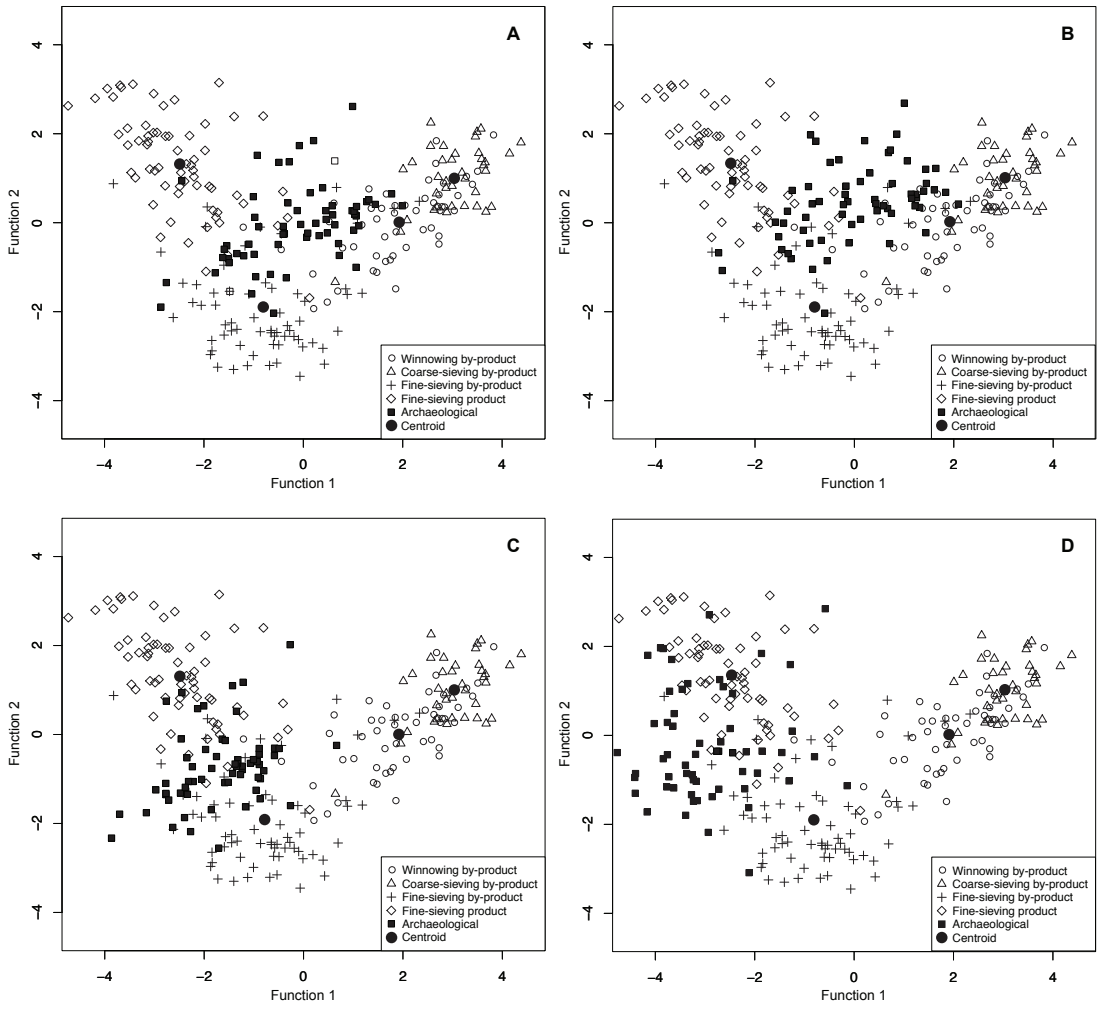


Figure 8.8: Results of the four discriminant analyses conducted with the removal of specific weeds. Graph (A) depicts the analysis of the dataset excluding high ranked dung-derived flora; (B), the removal of high ranked dung–derived and flax weeds removed; (C), excluding high and moderately ranked dung-derived species and (D), excluding high, moderate, and flax weeds.

8.2.4 Conclusions

Table 8.10 summarises the crop-processing stage(s) represented in the samples, building on the results from Chapters 5 and 7, and this Chapter. The ratio of crop items indicates a glume-base-rich assemblage, with free-threshing cereals such as barley having ratios indicating fine-sieving by-products. Research into the proportion of grain, chaff and weeds in the samples highlights the possibility that samples classified as spikelets based on grain to glume base ratios, instead contain high proportions of weeds and most likely reflect mixing and not spikelet

samples. The glume wheat-dominated samples, when compared with ethnographic data on the attributes of the weed taxa, present a high number of winnowing samples, something at odds with their high glume-base numbers. Investigation of the impact of possible mixing with other residue from flax processing found that the removal of potential flax weeds 'corrected' the classification of samples to fine-sieving by-products. This highlights the multiple activities represented within the Çamlıbel Tarlası samples, relating to processing flax and glume wheats. But the results also indicate that the two different crop weed floras (glume wheat and flax) can be separated.

8.3 Kuruçay

The Kuruçay assemblage, due to its storage contexts, provided the opportunity to investigate stored remains less likely to be the result of mixed crop processing activities. The same methods used for the Çatalhöyük and Çamlıbel Tarlası assemblages were followed.

8.3.1 Crop-based analysis

As shown in Chapter 5 the samples from Kuruçay range in dominant species, from three glume wheat samples, to five barley samples, one free-threshing wheat, nine pulse and five flax. One sample is mixed, containing glume wheat and barley grains.

Table 8.10: The dominant crop type of samples with 30 crop items, the proportion of glume wheat items compared to crop, and arable weed seeds and the resulting classification of the samples based on grain to chaff ratios (N/A indicates less than 30 glume wheat items). The proportion that flax weeds contribute to the assemblage and the two different classifications of the sample as per Jones (1983) using only arable weeds, and only glume wheat weeds.

	Crop	Glume wheat			%of flax weeds in total arable weeds	Jones classifications	
Sample	>70% of total crop items	% of total crop items	% of crop and arable weeds	Spikelet /glume base		Only arable weeds (no dung)	No flax or dung weeds
74/3	Glume wheat	95	64	Glume base	48	Fine-sieving by-products	Fine-sieving by-products
411	Glume wheat	90	40	Glume base	82	**Winnowing by-products**	Fine-sieving by-products
310	Glume wheat	90	68	Glume base	42	Fine-sieving by-products	Fine-sieving by-products
361	Glume wheat	90	29	Glume base	76	**Winnowing by-products**	**Fine-sieving product**
132	Glume wheat	90	44	Glume base	61	**Fine-sieving product**	**Fine-sieving product**
223	Glume wheat	89	55	Glume base	60	Fine-sieving by-products	Fine-sieving by-products
358	Glume wheat	88	54	Glume base	45	Fine-sieving by-products	Fine-sieving by-products
180	Glume wheat	87	42	Glume base	82	**Winnowing by-products**	Fine-sieving by-products
60	Glume wheat	87	24	Glume base	30	Fine-sieving by-products	Fine-sieving by-products
m877	Glume wheat	86	43	Glume base	18	Fine-sieving by-products	Fine-sieving by-products
49	Glume wheat	86	34	Glume base	66	Fine-sieving by-products	Fine-sieving by-products
400	Glume wheat	86	60	Glume base	27	Fine-sieving by-products	Fine-sieving by-products
50	Glume wheat	85	54	Glume base	59	**Winnowing by-products**	Fine-sieving by-products
m440	Glume wheat	85	61	Glume base	58	**Fine-sieving product**	**Fine-sieving product**
311	Glume wheat	84	56	Glume base	67	**Winnowing by-products**	Fine-sieving by-products
421	Glume wheat	84	53	Glume base	18	Fine-sieving by-products	Fine-sieving by-products
m466	Glume wheat	83	61	Glume base	50	**Fine-sieving product**	**Fine-sieving product**
238	Glume wheat	83	43	Glume base	82	**Winnowing by-products**	Fine-sieving by-products
204	Glume wheat	83	36	Glume base	80	**Winnowing by-products**	**Fine-sieving product**
54	Glume wheat	82	43	Glume base	57	Fine-sieving by-products	Fine-sieving by-products
88	Glume wheat	81	47	Glume base	36	Fine-sieving by-products	Fine-sieving by-products
139	Glume wheat	80	46	Glume base	88	**Winnowing by-products**	Fine-sieving by-products
209	Glume wheat	80	37	Glume base	24	Fine-sieving by-products	Fine-sieving by-products
325	Glume wheat	80	32	Glume base	52	Fine-sieving by-products	Fine-sieving by-products
79	Glume wheat	80	40	Spikelet	75	**Fine-sieving product**	**Fine-sieving product**
424	Glume wheat	79	51	Glume base	60	**Winnowing by-products**	Fine-sieving by-products
48	Glume wheat	79	32	Spikelet	80	**Winnowing by-products**	Fine-sieving by-products
405	Glume wheat	79	45	Glume base	30	Fine-sieving by-products	Fine-sieving by-products
377/365	Glume wheat	79	54	Glume base	56	**Fine-sieving product**	**Fine-sieving product**
392	Glume wheat	78	46	Spikelet	69	Fine-sieving by-products	Fine-sieving by-products
423	Glume wheat	78	29	Glume base	71	**Winnowing by-products**	Fine-sieving by-products

	Crop	Glume wheat			%of flax weeds in total arable weeds	Jones classifications	
Sample	>70% of total crop items	% of total crop items	% of crop and arable weeds	Spikelet /glume base		Only arable weeds (no dung)	No flax or dung weeds
m887	Glume wheat	78	45	Glume base	40	Fine-sieving by-products	Fine-sieving by-products
324	Glume wheat	78	47	Glume base	54	**Winnowing by-products**	Fine-sieving by-products
419	Glume wheat	77	31	Glume base	62	Fine-sieving by-products	Fine-sieving by-products
m439	Glume wheat	77	47	Glume base	55	**Winnowing by-products**	**Fine-sieving product**
321	Glume wheat	76	50	Glume base	59	**Winnowing by-products**	Fine-sieving by-products
90	Glume wheat	76	39	Glume base	69	**Winnowing by-products**	Fine-sieving by-products
200	Glume wheat	76	53	Spikelet	0	**Fine-sieving product**	**Fine-sieving product**
306	Glume wheat	75	29	Glume base	80	**Winnowing by-products**	**Fine-sieving product**
224	Glume wheat	75	27	Glume base	87	**Winnowing by-products**	Fine-sieving by-products
75	Glume wheat	74	42	Glume base	47	Fine-sieving by-products	Fine-sieving by-products
35/38	Glume wheat	74	46	Glume base	33	Fine-sieving by-products	Fine-sieving by-products
m632	Glume wheat	73	40	Glume base	49	Fine-sieving by-products	Fine-sieving by-products
210	Glume wheat	73	42	Glume base	37	**Winnowing by-products**	**Winnowing by-products**
186/202	Glume wheat	73	49	Spikelet	86	**Coarse sieving by-products**	Fine-sieving by-products
226	Glume wheat	72	45	Spikelet	27	Fine-sieving by-products	Fine-sieving by-products
337	Glume wheat	72	50	Spikelet	36	Fine-sieving by-products	Fine-sieving by-products
46	Glume wheat	72	42	Glume base	41	Fine-sieving by-products	Fine-sieving by-products
365	Glume wheat	71	26	Glume base	63	**Winnowing by-products**	Fine-sieving by-products
406	Glume wheat	70	51	Spikelet	56	**Fine-sieving product**	**Fine-sieving product**
427	Mixed	70	24	Spikelet	39	**Winnowing by-products**	**Winnowing by-products**
425	Mixed	69	53	Spikelet	43	**Winnowing by-products**	**Winnowing by-products**
42	Mixed	66	21	Spikelet	40	**Winnowing by-products**	Fine-sieving by-products
357	Mixed	64	32	Glume base	42	Fine-sieving by-products	Fine-sieving by-products
45	Mixed	56	22	N/A	72	**Winnowing by-products**	Fine-sieving by-products
370	Mixed	54	35	Spikelet	48	Fine-sieving by-products	Fine-sieving by-products
396	Mixed	53	37	Spikelet	55	**Winnowing by-products**	**Fine-sieving product**
19	Mixed	52	17	Spikelet	78	**Winnowing by-products**	Fine-sieving by-products
428	Mixed	44	5	N/A	82	**Winnowing by-products**	Fine-sieving by-products
415	Mixed	42	5	Spikelet	89	**Winnowing by-products**	Fine-sieving by-products
422	Mixed	37	18	N/A	75	**Winnowing by-products**	Fine-sieving by-products
213	Mixed	30	15	Spikelet	47	**Coarse sieving by-products**	Fine-sieving by-products
17	Mixed	26	3	N/A	92	**Winnowing by-products**	Fine-sieving by-products

Table 8.11: Summary of grain to glume base/internode ratios and interpretation of the samples containing 30 plus of a single crop.

Sample No.	Dominant species	Glume wheat		Barley		Free-threshing wheat	
		Ratio	Class	Ratio	Class	Ratio	Class
6	Pulse	1.1	Spikelet	29.5	Fine-sieving by-product		
8	Pulse			70	Fine-sieving by-product		
10	Glume wheat	0.96	Spikelet	37	Fine-sieving by-product		
11	Glume wheat	1.6	Spikelet				
12	Barley			251	Product	30	Fine-sieving by-product
14	Glume wheat	2.8	Product	3	Fine-sieving by-product		
15	Mixed	2.6	Product	1948	Product		
16	Free-threshing wheat			404	Product	600	Product
17	Barley			1420	Product		
25	Barley			6076	Product		
46	Barley			1202	Product		
47	Barley			884	Product		

8.3.2 Crop and weed proportions

Proportions of grain, chaff and weeds in the Kuruçay samples highlight the cleanliness of the cereal samples, with weeds contributing only 7% to the assemblage (Figure 8.9). The flax samples are the weediest of the Kuruçay stores, some containing 30% weed seeds (Figure 8.9). Unfortunately there is no ethnographic crop processing research with which the flax material can be compared. Experimental research indicates that flax seeds can be separated from their capsule via light pounding or grinding (Maier and Schlichtherle 2011), while an ethnographic account from Turkey reports flax being harvested for its seeds, threshed on a threshing floor using a threshing sledge and then sieved (Ertuğ-Yaras 2000).

Six Kuruçay samples are dominated by free-threshing cereals, allowing the direct comparison to Jones' (1990) ethnographic data. The cleanliness of the barley and free-threshing wheat samples means that they all fall clearly within the cleaned crop ranges of Jones' ethnographic data (Figure 8.9b).

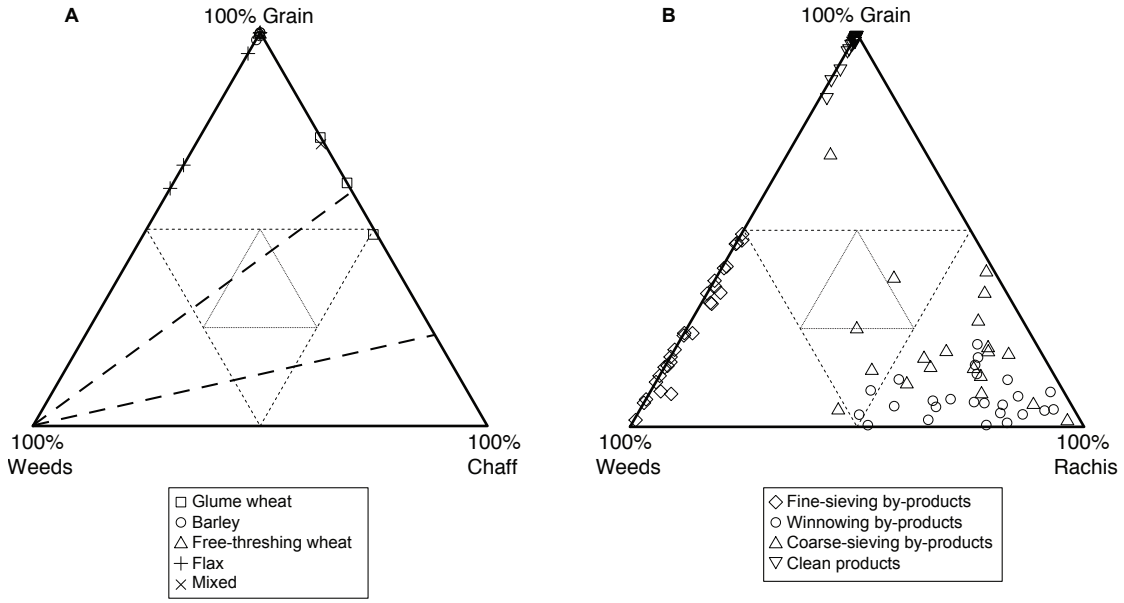


Figure 8.9: (A) Proportions of seeds, chaff and weeds in Kuruçay samples, flax samples included for comparison with (B) the proportion of Jones' (1990) ethnographic data for winnowing, coarse-sieving and fine-sieving by-product, and fine-sieving product of free-threshing cereals.

Comparison of the overall "weediness" of the Kuruçay glume wheat samples to Jones' theorised fine-sieving by-product weed proportions was conducted to allow comparison with the other sites. The Kuruçay glume wheat samples have a lower ratio than the hypothetical ratios of fine-sieving by-products, concentrated below 0.01 (Figure 8.10) and emphasising that these samples are products, not by-products, of fine sieving.

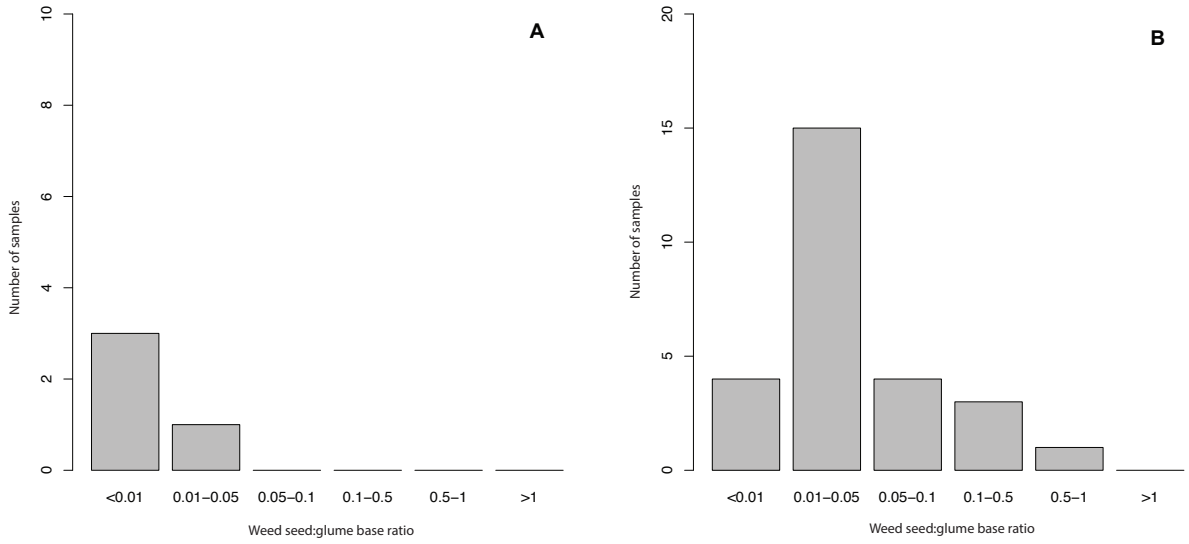


Figure 8.10: Comparison of the "weediness" of (A) the Kuruçay glume wheat samples against (B) the theoretical fine-sieving by-product of Jones's (1983) ethnographic data

8.3.3 Weed-based analysis

All samples, including those dominated by flax and pulse, with 10 plus weeds were compared. The majority of samples conform to their expected class – fine-sieving products (Figure 8.11,Table 8.12).

Table 8.12: Summary of the results of the discriminant analysis showing the different classifications grouped by dominant taxa

Crop processing stage	Dominant species				
	Pulse	Flax	Barley	Glume wheat	Mixed
Winnowing by-product		2			
Coarse-sieving by-product		2			
Fine-sieving by-product			1		
Fine-sieving product	1		1	1	1

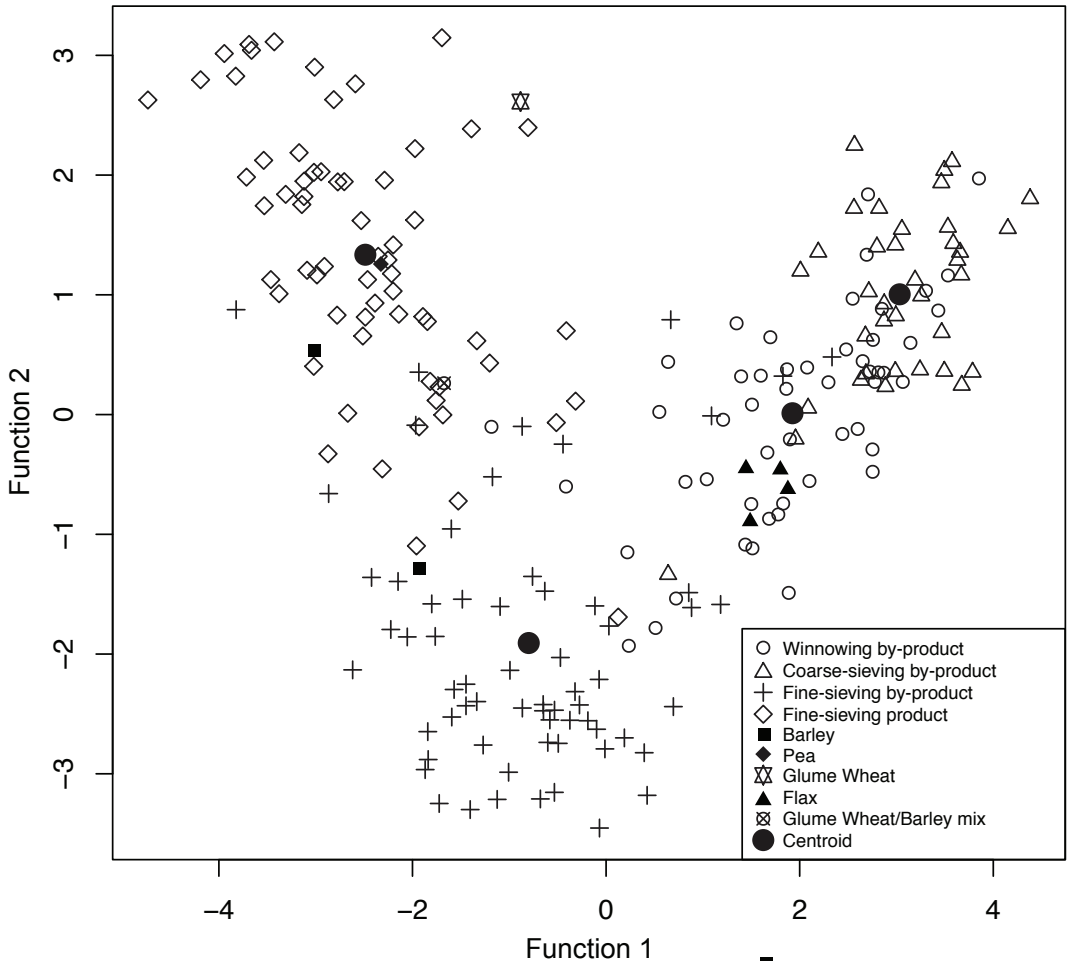


Figure 8.11: Function 1 and 2 of the discriminant analysis results for the archaeological samples, classified with reference to the ethnographic data of Jones (1983).

The classification of the flax samples using Jones' method, while potentially problematic was conducted for comparison with the processing of other crop types. It highlights a number of factors. Research on the traditional processing of linseed is limited, but some research records a processing sequence of threshing and then sieving (Ertuğ-Yaras 2000). While the graphical representation (function 1 and 2) shows the flax samples overlying the winnowing by-product, two of the samples are actually classed as coarse-sieving by-product, a result of function 3 (not shown). The dominant proportion of seeds in the flax samples come from taxa with specific attributes: small-seeded *Lolium* is an excellent flax

seed mimic with regard to size, while the *Silene*, classed as headed, occurs within capsules of similar size to flax capsules. The removal of flax and *Silene* seeds from their capsules can also be conducted through pounding. *Vaccaria*, *Camelina* and *Lepidium* are all small and may suggest that the sieving removed larger items. In conclusion the results of analysis of the flax samples highlights the possibility that winnowing was not a processing stage for flax. Given the classification of the weeds contained therein as winnowing by-product together with ethnographic accounts indicating sieving is conducted to remove capsule fragments, it suggests that the storage samples are the product of threshing and sieving. Further research is needed on the processing sequence to understand how the remaining weed contaminants would have been removed.

8.3.4 Conclusions

The results from the Kuruçay material are consistent with their storage contexts. The pulse samples are very clean and suggest storage of clean product, the exception being two samples contaminated with the cereal components of fine-sieving by-product (Table 8.13). Two of the glume wheat samples were stored as spikelets, again largely free of weeds, inferring storage after winnowing and sieving of the spikelets, with de-husking most likely occurring on a piecemeal basis when needed. The flax samples, contrary to the other crops, contain high numbers of weed seeds of distinctive shape/size, reflecting the difference in the processing of flax material.

Table 8.13: Comparison of the different crop processing stages' classifications of the components from the Kuruçay samples.

Sample	Dominant species	Ratio interpretation			Jones (1983) classification	Probability
		Glume wheat	Barley	Free-threshing wheat		
6	Pulse	Spikelet	Fine-sieving by-product			
8	Pulse		Fine-sieving by-product		Product	1
10	Glume wheat	Spikelet	Fine-sieving by-product		Product	1
11	Glume wheat	Spikelet				
12	Barley		Product	Fine-sieving by-product	Product	0.99
14	Glume wheat	Product	Fine-sieving by-product			
15	Mixed (barley/glume wheat)	Product	Product		Product	0.87
16	Free-threshing wheat		Product	Product		
17	Barley		Product			
21	Flax				Coarse-sieving by-product	0.83
20	Flax				Winnowing by-product	0.54
19	Flax				Winnowing by-product	0.81
18	Flax				Coarse-sieving by-product	0.83
25	Barley		Product			
46	Barley		Product			
47	Barley		Product		Fine-sieving by-product	0.88

8.4 Canhasan I

Interpretation of the crop processing status of the Canhasan I assemblage is hindered by recovery methods (see Chapter 2). The low amount of chaff in the assemblage is questionable. Examination of the grain to rachis/glume base was severely hampered due to uncertainty as to whether the absence of chaff was real or a sampling phenomenon. Table 8.14 shows the classification of the samples based on their grain and chaff ratios. The majority of free-threshing cereals are classified as fine-sieving products due to low numbers of grains in comparison with Jones' ethnographic data. Five barley samples contain high quantities of barley grain classified as clean product, and four of these samples originate from storage contexts. Excavation notes however record Sample 814b deriving from the sieving of baulk material from Layer 1 and highlights the possibility that this sample's high grain amount is due not to an in situ concentration, but instead the sieving of a large volume of material. Glume wheat remains are limited, with two samples containing high numbers of glume wheat bases; they are hand-collected samples with a high density of barley grain (Table 8.14). No sample is dominated by glume wheat and the classification of clean product highlights the mixed nature of the samples, and/or the effect of the recovery methods.

8.4.1 Conclusions

Because of the inability to distinguish between real absences and artefacts of the recovery method, coupled with Nesbitt's limited identification of the weed items in the assemblage to species, no further analysis was conducted on the Canhasan I material. Any conclusion regarding the crop processing activities represented in the assemblage is highly problematic given the recovery bias present.

Table 8.14: Proportions of grain and chaff in the Canhasan I samples containing at least 30 crop items of one species plus the species that dominates in these samples. The classification of clean product, spikelet, and glume base is delineated for the glume wheat samples, ratios of grain to internode are shown for the free-threshing cereals as well as the predicted crop processing class in comparison with Jones' ethnographic data. * free-threshing wheat samples contained no rachis internodes.

Sample	Dominated by	Barley				Glume wheats				Free-threshing wheat*	
		Grain	No. of internode	Ratio	Class	No. of grain	No. of glume bases	ratio	Class	No. of grains	Class
137	Barley	1918	0	1918	Product		325		Glume base		
55	Barley	1154	0	1154	Product		66		Glume base		
814b	Barley	644	0	644.1	Product	41		40.6	Clean	98	Fine-sieving
1134	Barley	147	0	147	Fine-sieving						
2046	Barley	820	248	3.3	Fine-sieving	151		151.1	Clean		
1308	Barley	58	0	58	Fine-sieving						
2203	Barley	5192	0	5192	Product						
1855	Barley	1684	0	1684	Product						
1953	Barley	41	0	41	Fine-sieving						
1984	Barley	42	0	42	Fine-sieving						
2170	Free-threshing wheat									56	Fine-sieving
2017/2018	Mixed	243	0	242.7	Fine-sieving	158		158.2	Clean	33	Fine-sieving
2008	Mixed	228	0	227.6	Fine-sieving	141		141.5	Clean		
1980	Mixed	232	0	232.3	Fine-sieving	91		90.5	Clean	55	Fine-sieving
2018	Mixed	200	0	199.7	Fine-sieving	119		118.8	Clean		
2008/2015	Mixed	105	0	104.7	Fine-sieving	46	2	22.9	Clean		
2023	Mixed	60	0	60	Fine-sieving	38		38.4	Clean		
2007	Mixed	60	0	60	Fine-sieving						
2006	Mixed	33	0	33	Fine-sieving	37		37	Clean		
1961	Mixed	38	0	38.3	Fine-sieving						
1206	Mixed	32	0	32	Fine-sieving						
1950	Mixed	55	0	55	Fine-sieving						
2202	Mixed	62	0	62	Fine-sieving						
624	Mixed	49	18	2.7	Fine-sieving						

9 Crop-husbandry: Isotopic evidence

This chapter presents the results of stable isotope analysis of charred archaeological plant remains from Çatalhöyük West Mound, plus samples from the late Neolithic TP area on the summit of the East Mound, and Çamlıbel Tarlası. The results are presented below on a site basis, focusing on carbon and then nitrogen; the data are then analysed temporally for patterns in isotopic values within and between crops. Finally, an integrated picture of the stable carbon and nitrogen isotope values is presented with comparison to available faunal isotope data from these sites. The aim of such isotopic analysis is to investigate crop growing conditions and farming practices, one of the key questions investigated in this thesis (Chapter 1, section 1.5). In particular, this chapter considers the following questions:

1. How variable was crop water status, as reflected in the stable carbon isotope ratios ($\delta^{13}C$ values), at each site? Are there differences between species and/or crop types suggestive of preferential watering and hence water management in some form?

2. Do crop stable nitrogen isotope ratios ($\delta^{15}N$ values) point to soils enriched in ^{15}N, for instance relative to forage values inferred from those of associated herbivores, and/or in particular crops, and indicate manuring? Are there other possible causes of elevated crop $\delta^{15}N$ values?

3. Do any temporal trends detected in the above suggest changes in agricultural choice and crop husbandry?

4. Do the results indicate the likelihood of consumption of particular crops by animals and/or humans?

9.1 Çatalhöyük (Late Neolithic East Mound and Early Chalcolithic West Mound)

9.1.1 Overall

Crop stable carbon and nitrogen isotope results from both the TP area of the East Mound and the West Mound of Çatalhöyük show several notable clusters (Figure 9.1). Barley has a restricted range of $\delta^{13}C$ values and to some extent $\delta^{15}N$ values compared to other cereals. Pulses, as expected for atmospheric nitrogen fixers, have low $\delta^{15}N$ values compared to cereals. Of note are the significantly high $\delta^{15}N$ values for all species. $\delta^{15}N$ values reported elsewhere from archaeological and modern grains are below 11‰, with the exception of Moroccan oases where aridity and manuring result in higher values (Styring et al. 2016b). The highest reported pulse values are below 5‰, (Bogaard et al. 2007; Aguilera et al. 2008; Fraser et al. 2011; Lightfoot and Stevens 2012; Bogaard et al. 2013b; Fraser et al. 2013a; Vaiglova et al. 2014a), with the exception of one modern study in which beans fertilized with seabird guano reached 19‰ (Szpak et al. 2014).

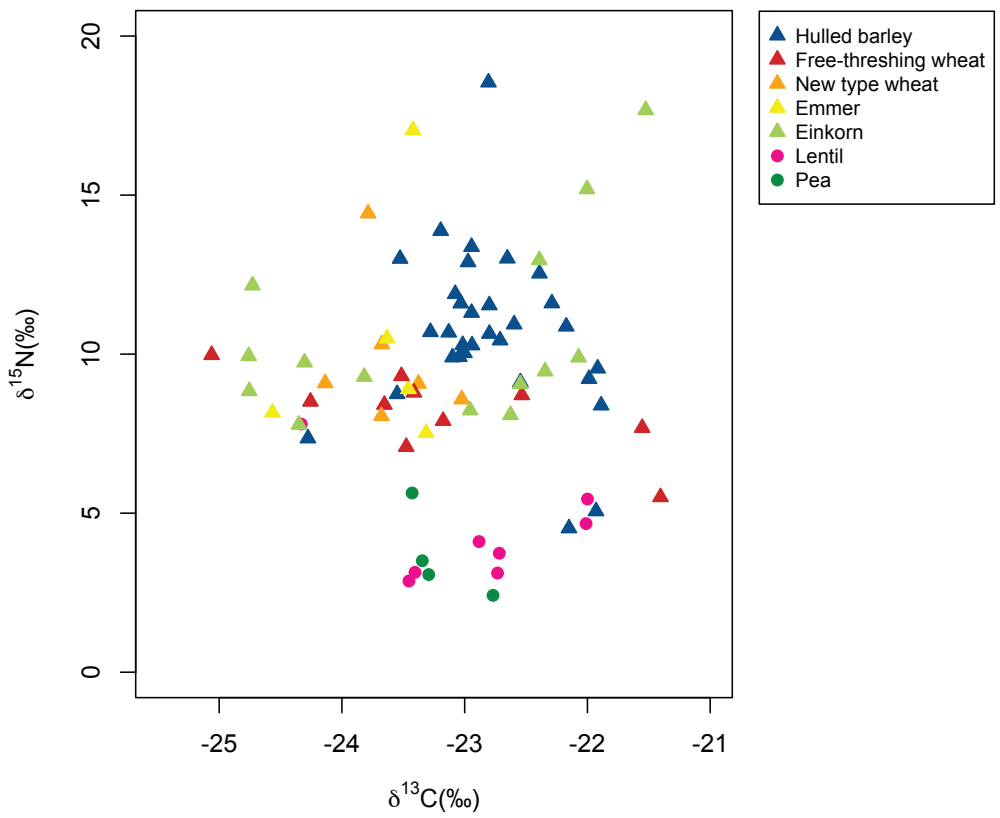


Figure 9.1: The $\delta^{15}N$ and $\delta^{13}C$ values for all plant samples from Çatalhöyük (TP area of the East Mound and Trench 1 and 5 of the West Mound).

9.1.2 Carbon

The $\Delta^{13}C$ values ($\delta^{13}C$ independent of CO_2 source, see Chapter 4) for all measured Çatalhöyük samples show high variability but similar means across the general categories of glume wheats (17.2±1‰), free-threshing wheat (16.9±1.2‰) and pulses (16.8±0.7‰), with barley (16.5±0.6‰) slightly lower (Figure 9.2,Table 9.1). An analysis of variance (ANOVA) indicates significant variation between these groups ($F(3,74)=3$, $p=0.04$) with a Tukey *post hoc* testing indicating that barley is statistically different from glume wheats ($p=0.025$). Standard deviations within the groups are variable with differing ranges: barley is tightly constrained in comparison to the highly variable free-threshing wheat (Figure 9.2, Table 9.1).

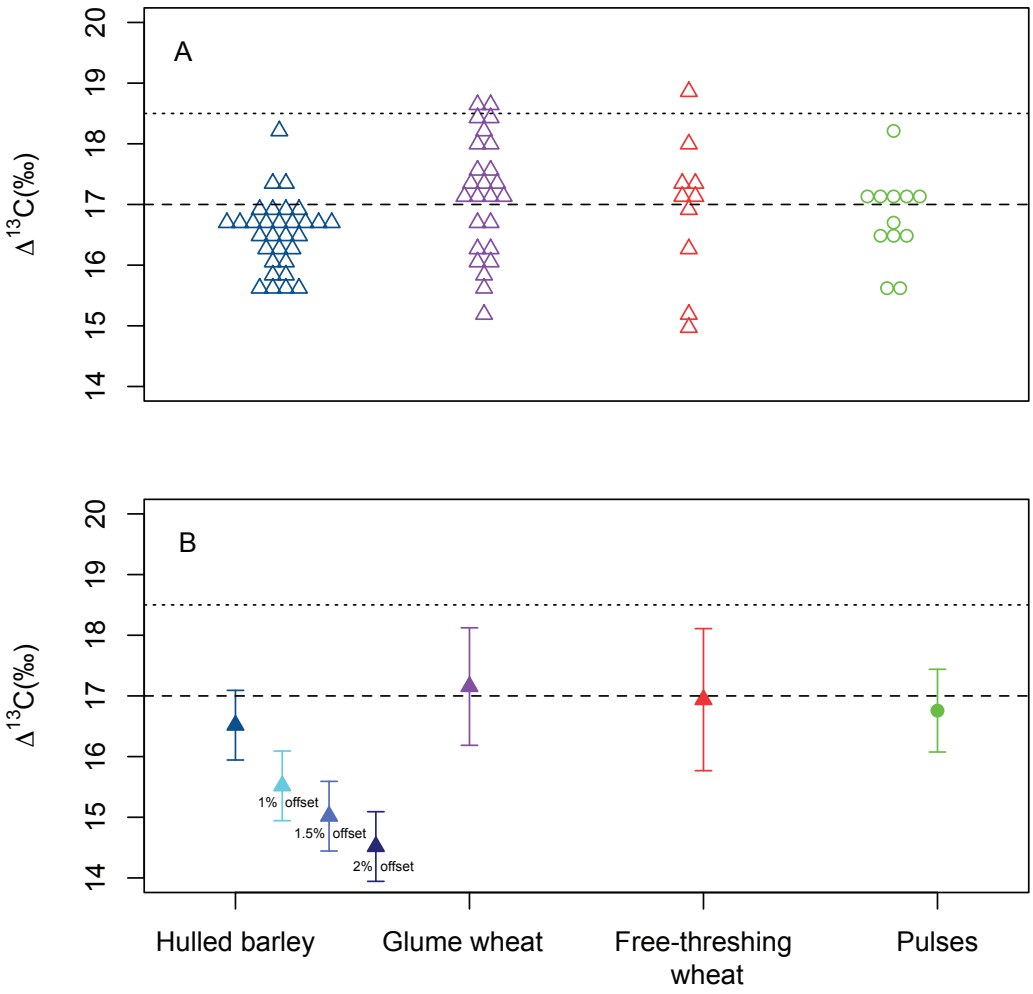


Figure 9.2: The $\Delta^{13}C$ values of general crop categories at Çatalhöyük showing the values (A) and the means and standard deviation (B) of the groups (mean of barley with a 1‰, 1.5‰ and 2‰ offset is included in graph b). The dotted line represents the lower threshold of Wallace et al. (2013)'s well-watered band for barley. The dashed line indicates the lower threshold of Wallace et al. (2013)'s well-watered wheat and pulse band.

Table 9.1: Mean and standard deviation (sd) of the general categories of crops (barley, glume wheat, free-threshing wheat and pulses) for $\delta^{13}C$, $\Delta^{13}C$ and $\delta^{15}N$, for all Çatalhöyük samples (TP area, Trench 1 and Trench 5).

Taxon	Number	$\delta^{13}C$ (‰)		$\delta^{15}N$ (‰)		$\Delta^{13}C$ (‰)	
		Mean	Sd	Mean	Sd	Mean	Sd
Barley	31	-22.8	0.5	10.7	2.6	16.5	0.6
Free-threshing wheat	10	-23.2	1.1	8.2	1.3	16.9	1.2
Glume wheat	25	-23.4	0.9	10.4	2.9	17.1	1.0
Pulses	12	-23.0	0.7	4.1	1.5	16.8	0.7

$\Delta^{13}C$ values differ between the seven species studied (Table 12.11). Examining just the wheats shows that the mean values of emmer (17.4±0.6‰), einkorn

(17±1.2‰), 'new type' wheat (17.4±0.4‰) and free-threshing wheat (16.9±1.2‰) occur within 1‰ of each other. While emmer and 'new type' have relatively high mean $\Delta^{13}C$ values and low variability, these two species are also represented by few samples: five and six respectively, compared to 14 and 10 for einkorn and free-threshing wheat (Table 12.11). ANOVA indicates no significant difference across the wheat species ($p=0.7$), nor is there a difference among the glume wheat species ($p=0.6$).

Of note is the relatively low $\Delta^{13}C$ value of barley, given that modern barley has a *higher* value than free-threshing wheat when grown in similarly watered conditions (Roche et al. 2006; Anyia et al. 2007; Wallace et al. 2013). Archaeobotanical examination of the rachis remains from the Çatalhöyük West samples reveals no evidence of six-row hulled barley (Chapter 5) and thus all barley grains appear to be the two-row variety. Such identification is crucial here as research indicates differences in the discrimination against ^{13}C between wheats and barleys, and between two-row and six-row barley (Wallace et al. 2013) (Chapter 3). Wallace et al. (2013) inferred that there is an offset between barley and wheat but it is smaller in two-row barley (~1‰) than in six-row barley (~2‰). They suggest that if a combination of both were present an ~1.5‰ offset would be applicable.

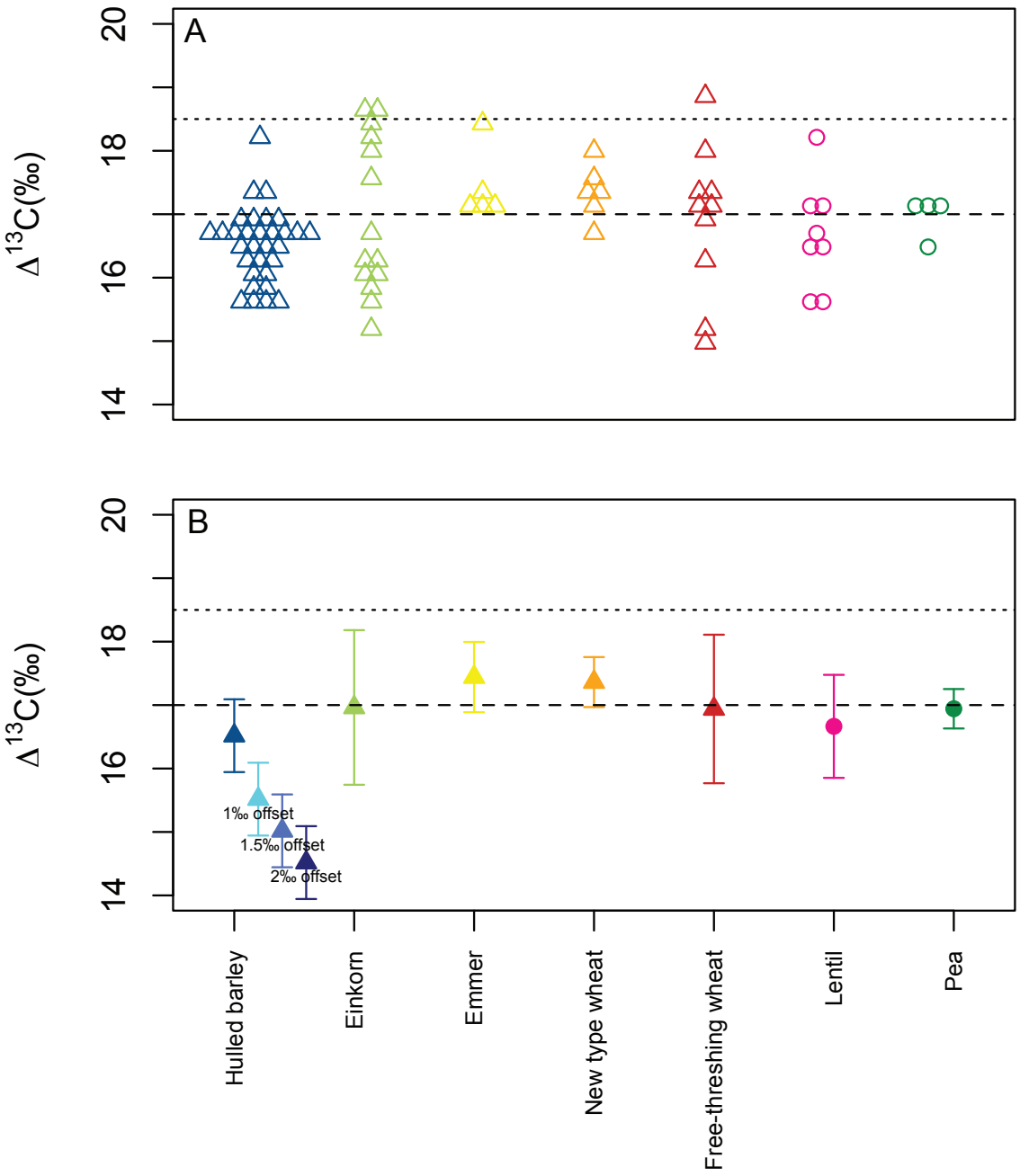


Figure 9.3: Δ¹³C values (A) and mean (B) of Çatalhöyük crop species. Note that the means for barley when a 1, 1.5 and 2‰ offset is applied are represented in Fig. B. The dotted line represents the lower threshold of Wallace et al. (2013)'s well-watered band for barley, while the dashed line indicates that for wheat and pulses.

Application of all the possible barley offsets confirms a difference between barley and other species within the Çatalhöyük dataset (Figure 9.3). Statistically there is no variation between all cereals, or all species, without an offset (Table 9.2). However, barley is significantly different from wheat samples when all wheat

species are grouped together to reduce problems with low sample numbers. Pulses are not significantly different from barley without an offset (Table 9.3). With a 1‰, 1.5‰ or 2‰ offset, barley is significantly different from the other species and categories (Tables 9.2-9.4). As evidence suggests that the barley sampled is only the two-row variety, the ~1‰ offset is the most likely scenario (Wallace et al. 2013).

Table 9.2: Results of analysis of variance (ANOVA) tests on the $\Delta^{13}C$ values for different groups of species when various offsets are applied to barley.

Statistical test	Offset	Taxa included	Results	p-value
ANOVA	0	Cereals	F(4,61)=2.4	p=0.06
ANOVA	1	Cereals	F(4,61)=14.8	p<0.001
ANOVA	1.5	Cereals	F(4,61)=25.3	p<0.001
ANOVA	2	Cereals	F(4,6)=38.7	p<0.001
ANOVA	0	All species	F(6,71)=1.8	p=0.1
ANOVA	1	All species	F(6,71)=10.8	p<0.001
ANOVA	1.5	All species	F(6,71)=18.7	p<0.001
ANOVA	2	All species	F(6,71)= 29	p<0.001
ANOVA	0,1,1.5,2	Wheats, barley, pulses, and barley with a 1, 1.5 and 2‰ offset	F(5,165)=65.2	p<0.001

Table 9.3: Results of a Tukey post hoc test on all wheat, pulse and barley categories, including barley with a 1, 1.5 and 2‰ offset applied.

	Wheat	Pulse	Barley	Barley 1	Barley 1.5
Wheat					
Pulse	0.7				
Barley	0.01	0.91			
Barley 1	<0.001	<0.001	<0.001		
Barley 1.5	<0.001	<0.001	<0.001	0.06	
Barley 2	<0.001	<0.001	<0.001	<0.001	0.06

Table 9.4: Results of a Tukey post hoc test on all species with barley given an 1‰ offset .

	Barley	Einkorn	Emmer	'New type"	Free-threshing	Lentil
Barley						
Einkorn	<0.001					
Emmer	<0.001	0.92				
'New type'	<0.001	0.95	1			
Free threshing	<0.001	0.92	0.92	0.95		
Lentil	<0.001	0.98	0.64	0.67	0.99	
Pea	<0.001	1	0.97	0.98	1	1

Barley exhibits low variability in $\Delta^{13}C$ values, which is in direct contrast to the highly variable einkorn and free-threshing wheat values (Table 12.11, Figure 9.3). The distribution of the einkorn values is abnormal, tending toward a bimodal distribution. Examination of the variety of einkorn, one or two-seeded, shows no correlation with $\Delta^{13}C$ (Figure 9.4). Whether such distribution is due to temporal differences is discussed below. In comparison with Wallace's watering bands the wheats' mean plots just within the well-watered bands, while barley is always considerably below its well-watered band.

There are similarities in the mean $\Delta^{13}C$ values of the pulse taxa but interpretation of their significance is difficult due to the limited numbers of samples (Figure 9.3). Only two pulse taxa were examined: lentil with eight samples and pea with four samples. Both taxa have similar means, 16.9±0.3‰ for pea and 16.7±0.8‰ for lentil, and are not significantly different. Lentil has a much wider range than the pea, possibly due to the higher number of samples. The pulse samples plot on the border of Wallace's well- watered band (Figure 9.3). Comparison with the wheat taxa shows no significant difference: the pulses appear slightly dryer than emmer and 'new-type', but the pulses were grown in a location with higher water availability than that of barley.

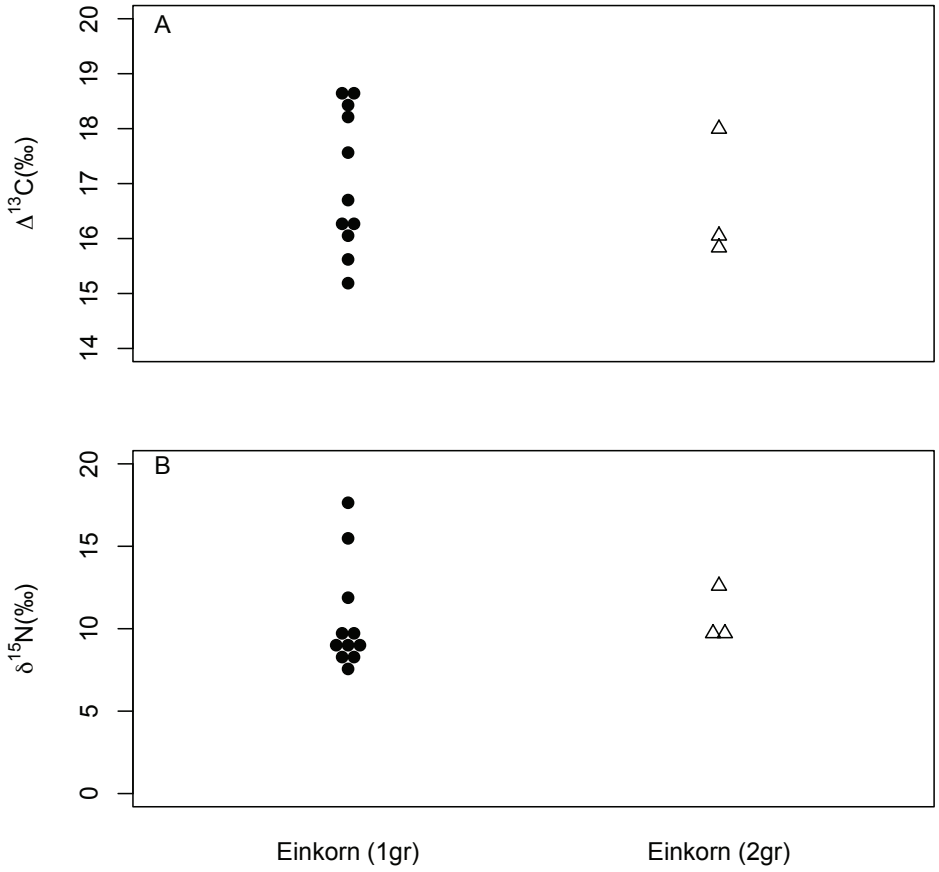


Figure 9.4: The $\Delta^{13}C$ (A) and $\delta^{15}N$ (B) values for the einkorn samples divided on type: one-seeded versus two-seeded.

The results present evidence of variable water availability within and between crops. The highly variable values of einkorn and free-threshing wheat indicate that these taxa were cultivated in a range of conditions. The values cover all three bands developed by Wallace et al. (2013) but the majority, 30 out of 35, of the wheat samples plot above the lower threshold for moderately watered crops (16‰). Emmer and 'new type' are predominantly above 17‰, suggesting cultivation in fields with better water availability.

In contrast to the wheat values, those for barley, especially when its physiological offset is taken into account, are significantly lower, falling within the poorly watered range. Comparison to research conducted on modern wheat and barley

grown under the same conditions supports the hypothesis that barley at Çatalhöyük was grown in fields with lower water availability compared to the wheats, especially those of 'new type' and emmer (Figure 9.3)(Roche et al. 2006).

An investigation into whether the variation seen in the wheats is due to temporal differences is described below (section 9.1.5). The question of whether there was consistent cultivation of barley in a drier niche of the environment across the three phases is also discussed.

9.1.3 Nitrogen

The $\delta^{15}N$ values of Çatalhöyük crops are highly variable, ranging from 2.4‰ to 18.5‰ (Table 12.11). Barley (mean = 10.7±2.6‰) and glume wheats (10.4±2.9‰) have similar means while that of free-threshing wheat (8.2±1.2‰) is lower (Figure 9.5). The variability within the general categories is very high with all group ranges exceeding 4‰: the glume wheats and barley ranges are greater than 10‰. The sizeable ranges of these two groups are due to outlying samples as discussed in Chapter 4. Re-analysis of the outlying samples indicates seven out of the eight samples have a standard deviation less than 1‰ (see Chapter 4).

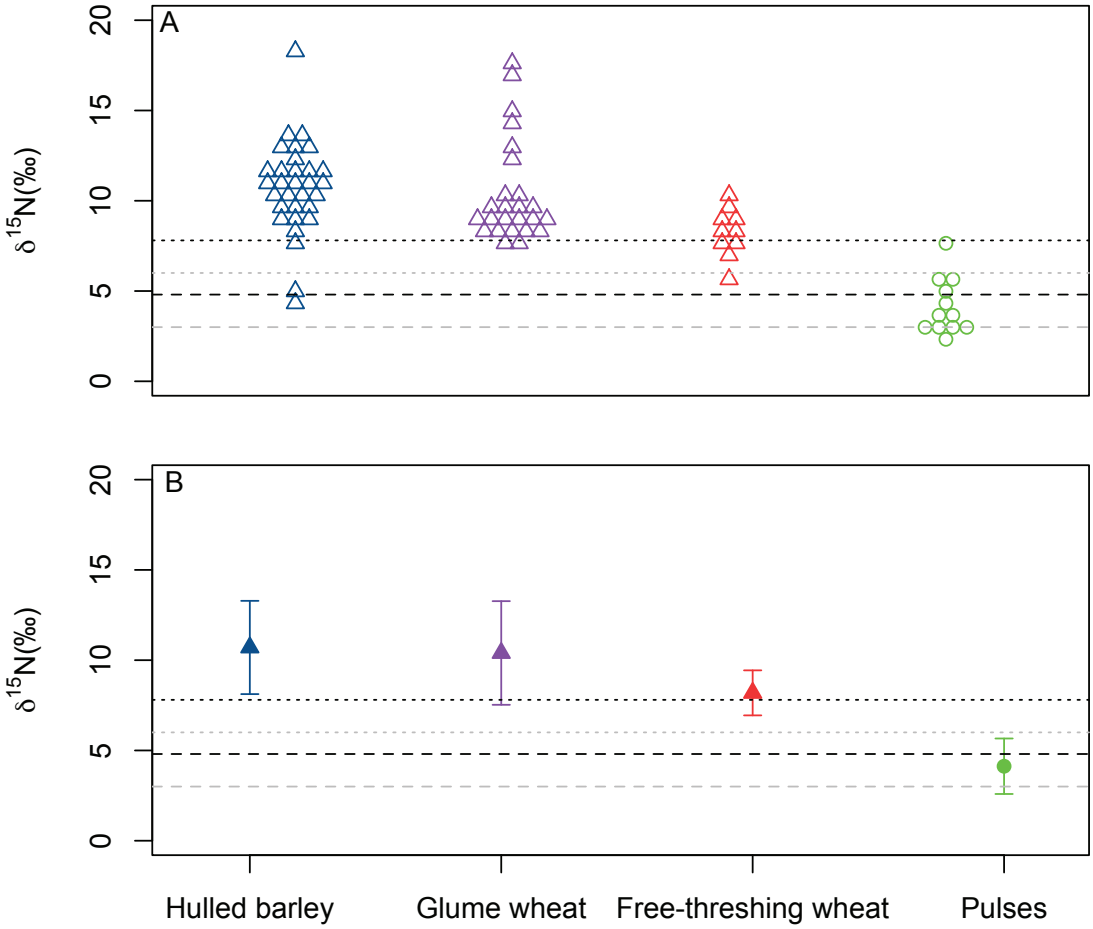


Figure 9.5: $\delta^{15}N$ values (A) and means (B) of the Çatalhöyük general crop categories. The grey lines represent the lower thresholds of the moderate (dashed) and high (dotted) manuring bands for cereals in temperate Europe (Wallace et al. 2013). The black lines represent the Bogaard manuring lines with an offset (2.4‰) added to account for the effect of aridity as per the Hartman and Danin (2013b) regression equation of y= -3.19(log(rainfall))+20.49, where rainfall is 350mm per year (Styring et al. 2016).

Examination of the cereals by species indicates that all exhibit high variability. All glume wheat species are highly variable (Figure 9.6, Table 9.5); emmer (10.4±3.9‰), einkorn (10.6±2.9‰) and 'new type' glume wheat (9.9±2.3‰) are very similar in mean values, with no significant difference between them. Free-threshing wheat (8.2±1.2‰) and barley values (10.7±2.6‰) fall either side of glume wheat, but there is no significant difference between all five cereals (Table 9.6). Free-threshing wheat is significantly different from barley and from einkorn: the other combinations of cereals reveal no significant differences (Table 9.6). This suggests differential growing conditions for the cereals, with taxa such as

barley and einkorn growing in conditions/locations with high but very variable $\delta^{15}N$. Conversely, free-threshing wheat appears to have been growing in conditions which are not as ^{15}N-enriched. The two other glume wheats are too limited in sample numbers for reliable comparison with the other cereals.

Table 9.5. The standard deviation and coefficient of variability of the $\delta^{15}N$ values of the seven taxa examined from Çatalhöyük.

Taxon	Standard Deviation	Coefficient of variability (%)
Barley	2.6	24.1
Emmer	3.9	37.3
Einkorn	2.9	27.3
New type glume wheat	2.3	23.5
Free-threshing wheat	1.2	15.2
Lentil	1.6	37.6
Pea	1.4	38.1

The pulse $\delta^{15}N$ values are lower than the cereals, as expected of atmospheric nitrogen fixers, but the lentil (4.4±1.6‰) and pea (3.7±1.4‰) means are higher than expected if these legumes were sourcing nitrogen only from the atmosphere (Unkovich et al. 1997). Statistically there is no difference between the two pulse species examined (Table 9.6).

Table 9.6: Results of statisical anaylsis of the $\delta^{15}N$ of different crop combinations.

Statistical test	Species examined	Results
ANOVA	Glume wheats	F(2,22)= 0.1, p=0.9
ANOVA	Wheats	F(3,31)=1.8, p=0.2
ANOVA	Cereals	F(4,61)=1.9, p=0.1
Welch two sample T-test	Free-threshing wheat ~ barley	T(32.5)=4.1, p=0.0002*
Welch two sample T-test	Free-threshing wheat ~ einkorn	T(18.8)=-2.8, p=0.01*
Welch two sample T-test	Free-threshing wheat~ emmer	T(4.423)=1.26, p=0.3
Welch two sample T-test	Free-threshing wheat ~ 'new type' wheat	T(6.76)=1.68, p=0.1
Welch two sample T-test	Einkorn ~ emmer	T(5.7)=0.09, p=0.9
Welch two sample T-test	Einkorn ~ barley	T(22.2)=-0.08, p=0.9
Welch two sample T-test	Einkorn~ 'new type' wheat	T(11.8)=0.55, p=0.7
Welch two sample T-test	Emmer ~ barley	T(4.56)=-0.14, p=0.9
Welch two sample T-test	'New type' wheat ~ barley	T(7.4)=-0.7, p = 0.5
Welch two sample T-test	Pea ~ lentil	T(7.1)=-0.78, p=0.5

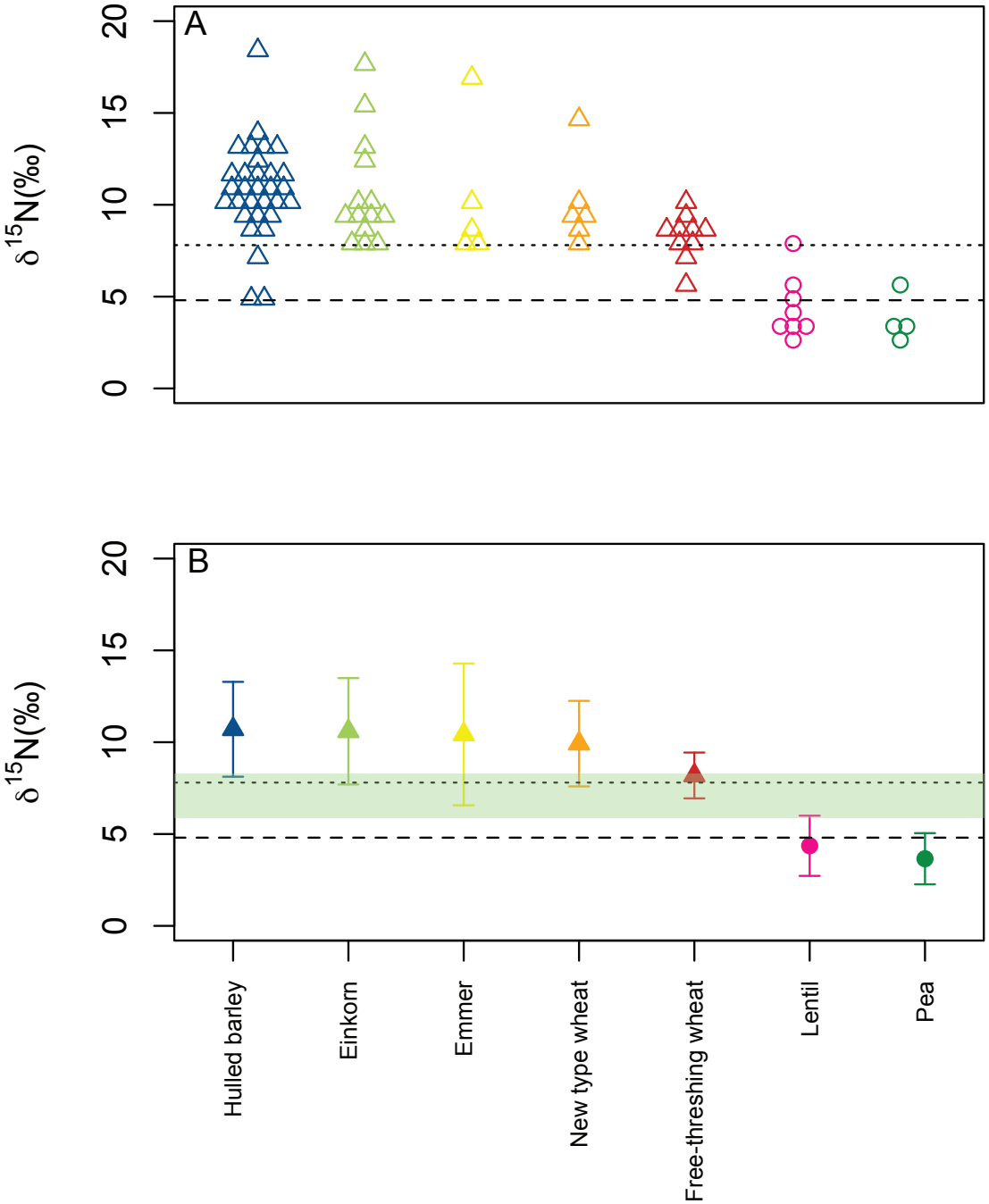


Figure 9.6: $\delta^{15}N$ values of Çatalhöyük (A) and mean and standard deviation (B) of all species examined. Bogaard et al. (2013)'s manuring bands, adjusted for the effect of aridity under 350mm rainfall (Styring et al. 2016), are shown as a dotted line (border between moderate and high manuring) and dashed (lower threshold of the moderate manuring band). The estimated herbivore forage range (green shading on plot B) was calculated by subtracting 4‰ (mean trophic level offset) from the mean herbivore $\delta^{15}N$ value to produce the lower limit, while the upper limit was calculated by the addition of 2.4‰ to account for the difference between grain and leaf consumption.

9.1.4 Question of manuring

The extreme enrichment in ^{15}N of the crops from Çatalhöyük raises the question of causation. As explained in Chapter 3 a range of processes can lead to the enrichment of soil and plants in ^{15}N but the elevated values of the samples occur across all taxa, potentially indicating an ecosystemic cause.

Çatalhöyük was located in a semi-arid environment within a partially wetland landscape, and a potential contributing factor to an ecosystemic enrichment in ^{15}N is aridity (Swap et al. 2004; Hartman and Danin 2010). A regression line postulated by Hartman and Danin (2010) can be used in an attempt to take into account the effect of aridity in enriching ^{15}N following Styring et al. (2016b) (see section 4.2.5.6). The Hartman and Danin (2010) research is highly applicable, as it was conducted in the Eastern Mediterranean, making it geographically and environmentally comparable. The modern-day annual rainfall at Çatalhöyük is ~350mm and such aridity could potentially cause a ~1.8‰ increase in $\delta^{15}N$ values using the Hartman and Danin regression equation adjusted to account for the difference between grain and leaves (1.4‰, Styring et al. 2016b). The application of this offset to the Bogaard et al. (2013) manuring lines (following Styring et al. 2016) indicates that crop enrichment exceeds that expected as a result of aridity alone (Figures 9.5-9.6).

Comparison of the crop values to those of an inferred forage band, where the lower limit is derived from the mean collagen value (9.9‰) of associated herbivores minus a trophic offset (4‰), and the upper limit accounts for the difference between grain and rachis (+2.4‰)(see Chapter 4), demonstrates that

the crops are enriched above the potential values of natural or non-arable vegetation (Figure 9.6). The forage value is based on data from domesticated cattle and sheep/goats from Trenches 1 and 5 of the West Mound (Middleton pers. com 2015, Pearson pers.com 2015) as wild herbivore data were not available. The use of domesticated fauna raises the possibility that these animals consumed, in part, (manured) crop material potentially resulting in an enrichment of the $\delta^{15}N$ value of fauna. The use of the domesticated animal, therefore, if anything limit the possibility of finding a difference between crops and animals that is suggestive of manuring. However there is a significant elevation of the crop values in comparison to the herbivore forage range (Figure 9.6). This could be due to a number of factors such as manuring, but also due to difference in the soil nitrogen of the crop fields compared to the soil on which the animals grazed and so be unrelated to the addition of manure.

While aridity likely explains some of the enrichment in crop ^{15}N, some values for wheats and barleys far exceed this, falling within the highly-manured band and in some cases 10‰ above the inferred forage range, thus suggesting that a proportion of the enrichment was caused by a factor specific to the soil in which the crops were cultivated. The possibility that such enrichment is solely due to manuring is arguably low; the amount of manure required to reach such levels within controlled modern experiments is greater than 35 tons per ha (Bogaard et al. 2013b). Some of the enrichment could, however, be a combined effect of prolonged manuring, middening and effluent from the mound.

It is also possible that areas within the landscape had elevated ^{15}N values because of processes such as wetting and drying or waterlogging (Borken and Matzner 2009; Hartman and Danin 2010). Moreover, research indicates that very high $\delta^{15}N$ values can arise in arid environments when high quantities of water combine with intensive application of manure: oasis fields in arid Morocco have reported $\delta^{15}N$ ratios of ~15‰ (Styring et al. 2016b). The ^{15}N enrichment of the crops from Çatalhöyük significantly above both the adjusted manuring bands and the forage range suggests some sort of human manipulation of the crop growing conditions, either through manuring and/or purposeful selection of locations that were naturally elevated in ^{15}N, potentially areas subjected to more wetting and drying. Whether such manipulation of growing conditions was constant throughout the period examined is discussed below.

9.1.5 Temporal differences

Comparison of the three phases represented by the samples in this study reveals limited differences. There is a possible temporal difference in the values of barley (Figure 9.7), while the other taxa represented either show no statistically significant difference over time or are represented by too few samples for reliable comparison (e.g. one einkorn sample in the Late Neolithic). Barley presents a slightly more robust dataset across two of the three periods and displays differences in mean $\Delta^{13}C$ and $\delta^{15}N$ (Table 12.11).

Late Neolithic barley exhibits lower $\delta^{15}N$ and slightly higher $\Delta^{13}C$ values compared to the West Mound phases of Early Chalcolithic I (ECI) and Early Chalcolithic II (ECII) (Figure 9.7-9.8). The difference between the $\delta^{15}N$ values of

barley dated to the Late Chalcolithic and the Early Chalcolithic barley is significant (Table 9.7) but no statistically significant difference is indicated for the carbon values. Statistical comparison with values from the main occupation phases of the Neolithic East Mound is not yet possible although research is currently underway to make this achievable (Vaiglova in prep). However, the mean value for the ECI is higher than that of the East Mound samples; whether this indicates a change in crop husbandry practice or is the historical effect of prolonged manuring is uncertain. The single data point for the ECII precludes robust interpretation as to whether crop isotope values changed in this period. The context of the TP and ECI barley samples may provide a possible explanation for the difference seen. The ECI samples come from a range of midden contexts, while the samples from TP all derived from the one in situ hearth deposit and this potentially reduces their variability.

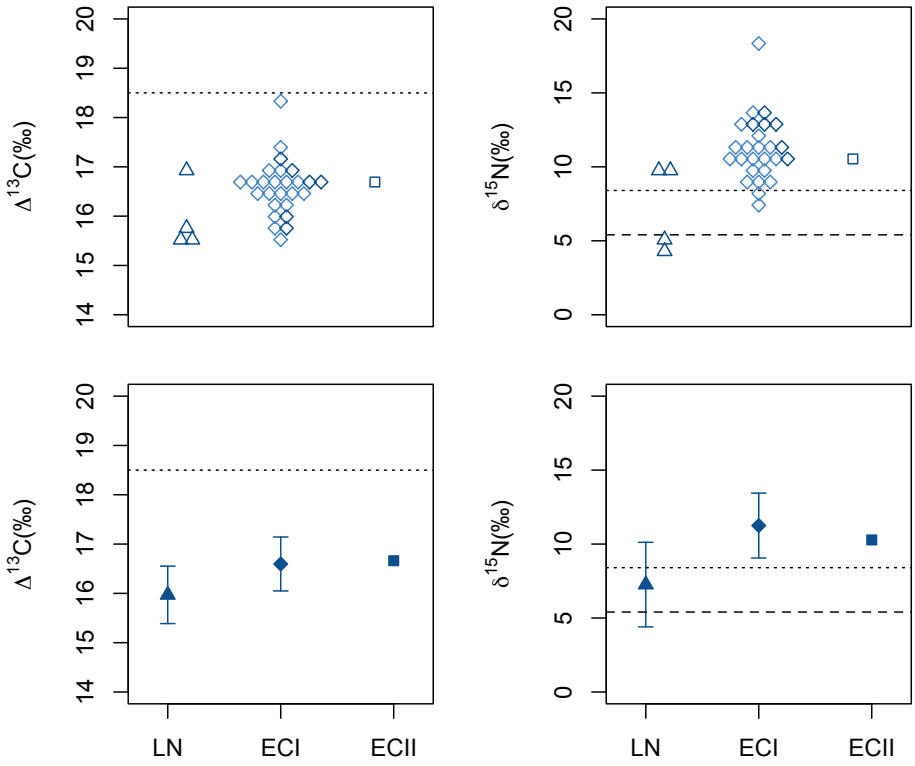


Figure 9.7.: $\Delta^{13}C$ and $\delta^{15}N$ values and means of barley within the three phases of Çatalhöyük: Late Neolithic (LN), Early Chalcolithic I (ECI) and Early Chalcolithic II (ECII). (Trench 5 samples shown in light blue).

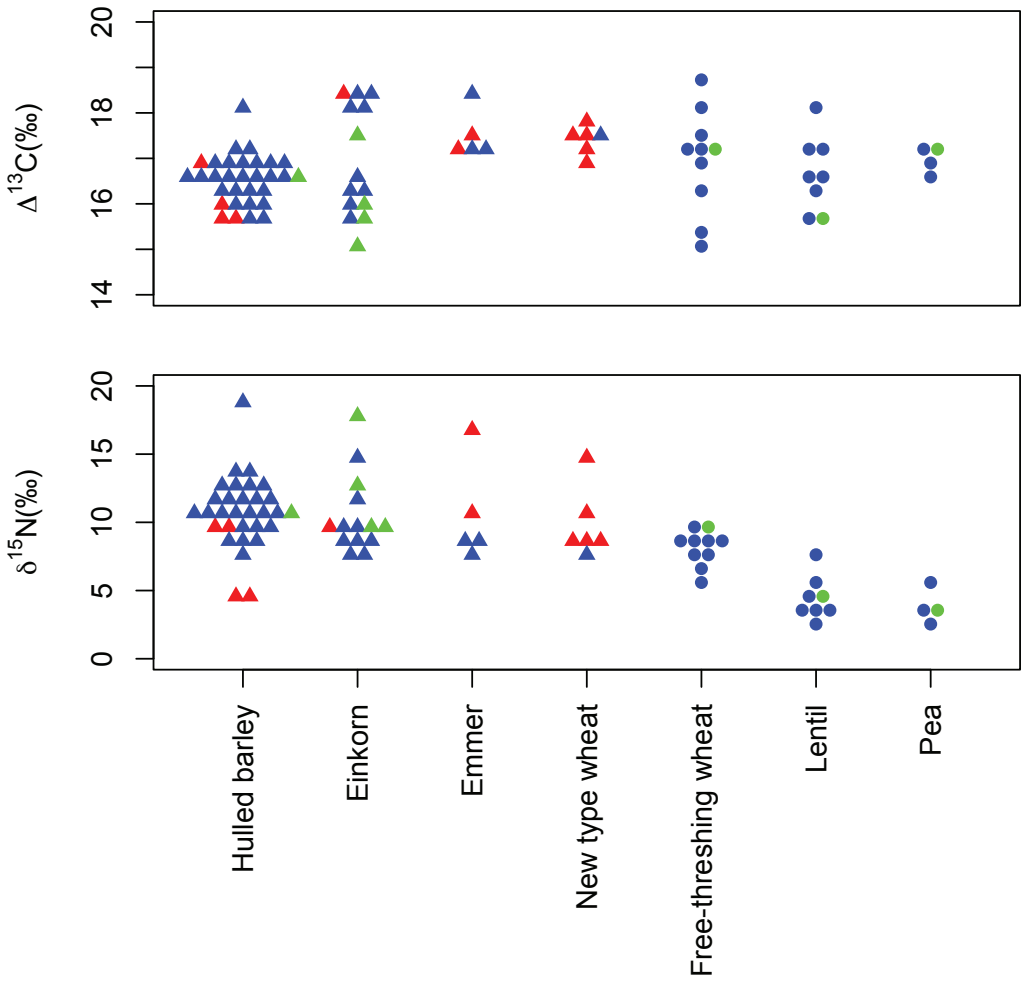


Figure 9.8 $\Delta^{13}C$ and $\delta^{15}N$ values for seven crops through three phases: Late Neolithic (red), Early Chalcolithic I (blue), and Early Chalcolithic II (green).

Table 9.7: Results of statistical tests comparing crop taxa isotope ratios among phases. Only species occurring in three or more samples and in two or more phases were included.

Test	Isotope	Phase	Species	Results
T-test	Nitrogen	LN~ECI	Barley	t(3.56) = -2.8, p= 0.06*
T-test	Carbon	LN~ECI	Barley	t(3.86)=-2, p= 0.12
T-test	Nitrogen	ECI~ECII	Einkorn	t(4.08)=-1.26, p=0.2747
T-test	Carbon	ECI~ECII	Einkorn	t(6.63)=1.55, p=0.17

On the whole the differences between species are the same for each phases as well as for the whole assemblage. There are some exceptions. Barley $\Delta^{13}C$ deviates from the assemblage trend: within the LN period, barley is significantly different from all taxa examined even without an offset applied however caution

is needed when interpreting such results due to the limited sample sizes within the taxa (Table 9.8). Sample size is not a problem in the ECI and with a 1‰ offset all taxa except pea differ significantly in their $\Delta^{13}C$ values from barley (Table 9.8). Pea within the ECI phase is not different statistically unless an 1.5‰ offset is applied, potentially reflecting the consistently low(er) values of pea within the phase (Table 9.8); unfortunately low samples numbers in the ECII period limits investigation in this phase.

Table 9.8: Results of statistical tests on the $\Delta^{13}C$ of species with 1 or more samples, within phase.

Test	Species	Phases	Offset	Results
ANOVA	Barley, emmer, 'new type' wheat	LN	None	f(2,8)=10.4, p=0.006
Tukey	Barley ~ emmer	LN	None	0.03
	Barley ~ 'new type' wheat	LN	None	0.006
	Emmer ~ 'new type' wheat	LN	None	0.98
ANOVA	Barley, einkorn, emmer, 'new type' wheat, free-threshing wheat, lentil, pea	ECI	None	f(5,51)=1.1, p=0.35
ANOVA	Barley, einkorn, emmer, 'new type' wheat, free-threshing wheat, lentil, pea	ECI	1	f(5,51)=8.6, p < 0.0001

Table 9.9: Results of a Tukey *post hoc* test of the taxa (> 1 samples) from the ECI period with a 1‰ offset from barley applied and significant results when a 1.5‰ offset applied (in brackets)

	Einkorn	Emmer	Free-threshing wheat	Barley	Lentil
Emmer	0.97				
Free-threshing wheat	0.99	0.84			
Barley	0.004 (<0.001)	0.005 (<0.001)	0.002 (<0.001)		
Lentil	0.96	0.77	1	0.01 (<0.001)	
Pea	1	0.92	1	0.12 (0.01)	1

Turning to $\delta^{15}N$ values, ECI samples show a difference among the cereals, with barley significantly different to emmer (p=0.08) and free-threshing wheat

(p=0.001). This differs from the LN phases in which the $\delta^{15}N$ values are not statistically different from each other. However, free-threshing wheat was not measured in this phase.

Temporal differences are limited in both $\Delta^{13}C$ and $\delta^{15}N$ values for the species, with the majority of the taxa reflecting the general assemblage-wide patterns. Difficulties arise in the temporal comparison of taxa and phases due to the limited sample sizes, in particular the material deriving from ECII. The older phase (TP) is also under-represented, with the majority of the samples from the ECI phase. Such distribution of the samples limits any firm conclusion on temporal trends, but what can be seen is that the majority of the taxa are not statistically different between phases.

9.1.6 Palaeodietary reconstructions

Palaeodietary reconstructions using the reported Çatalhöyük samples are limited due to the lack of human remains dated to the Chalcolithic. During excavation in Trench 5 only two neonatal skeletons were discovered. Numerous skeletal remains were excavated from the TP area of the East Mound, but as yet no isotopic analysis has been conducted on them (Pearson pers. comm).

Nevertheless, faunal and plant remains can be examined to understand possible combinations of consumed items at the site. Faunal isotopic research, conducted by C. Middleton and J. Pearson, has focused on Trench 1 and Trench 5 of the West Mound. J.Pearson supplied the $\delta^{15}N$ and $\delta^{13}C$ values from sheep and goat remains

from Trench 1 and the maximum and mean of the $\delta^{15}N$ and $\delta^{13}C$ values of cattle and combined sheep and goats from Trench 5 were provided by C.Middleton.

To account for the offset in $\delta^{15}N$ between consumers and their diet, an average of the expected offset is assumed (4‰ from the 3-5‰)(Hedges and Reynard 2007; Lee-Thorp 2008). The faunal values provided by Pearson (pers. comm) and Middleton (pers. comm) allow for the comparison between crops and animals. The $\Delta^{15}N_{crop\ -\ herbivore}$ values (difference between crops and herbivore $\delta^{15}N$) is very low; in the case of cereals, the offset is +0.5‰. Such values indicate that the herbivores at Çatalhöyük could not have been consuming any grains to a significant degree and it is unlikely that they consumed much of the chaff (Figure 9.9). $\Delta^{15}N_{\ pulses\ -\ herbivore}$ offset indicates the possibility that some pulses were consumed by the animals (Table 9.10). The results suggest that animals chiefly consumed wild forage: stubble grazing after harvest may have occurred, supplemented with fodder such as pulses or chaff on the rare occasion the livestock were penned.

Table 9.10: Mean stable isotope values and standard deviation (SD) for fauna and crops and the isotopic offsets (Δ) for $\delta^{15}N$ and $\delta^{13}C$ between them. Note: only the mean value is known for sheep/goat and cattle. Sheep and goat data from Pearson (pers. comm), cattle and sheep/goat from Middleton (pers. comm)

Taxon	Number	$\delta^{13}C$	SD	$\delta^{15}N$	SD	$\Delta^{13}C$‰	$\Delta^{15}N$‰
Sheep	19	-17.9	0.5	9.6	0.9		
Goat	4	-18.2	0.5	10.2	0.9		
Sheep/goat	unknown	-18.1	n/a	10.0	n/a		
Cattle	unknown	-17.9	n/a	10.0	n/a		
Herbivores	25	-18.0	0.9	9.7	1.2		
						Δ crop - herbivore	
Barley	31	-22.8	0.5	10.7	2.6	-4.8	1.0
Wheat	35	-23.4	1.0	9.8	2.7	-5.4	0.1
Pulse	12	-23.0	0.7	4.1	1.5	-5.0	-5.6
Cereals	66	-23.1	0.8	10.2	2.7	-5.1	0.5
All Crop	78	-23.1	0.8	9.3	3.4	-5.1	-0.4

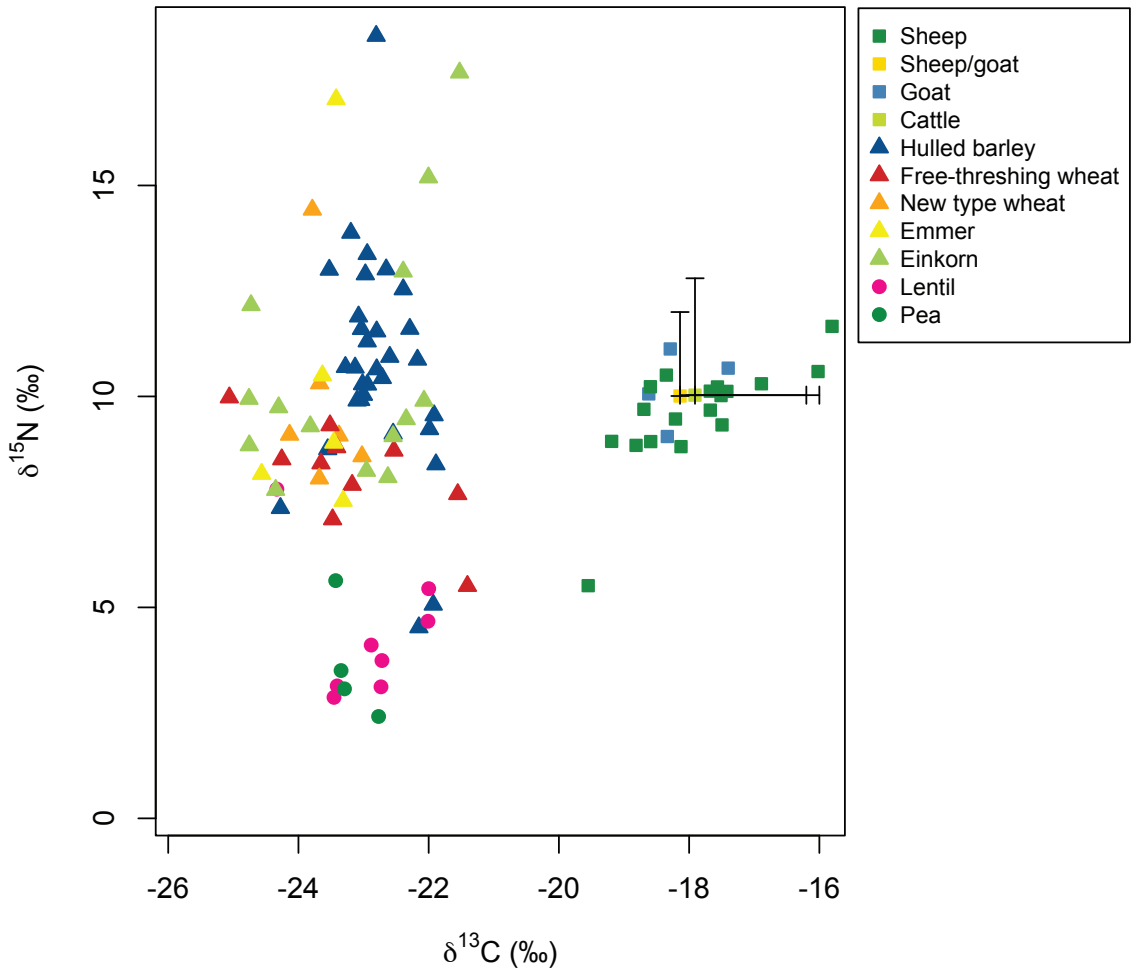


Figure 9.9: The $\delta^{13}C$ and $\delta^{15}N$ results from the examined Çatalhöyük crops, with animal collagen results (Sheep and goat data from Pearson pers. comm. 2015, mean and maximum $\delta^{15}N$ and $\delta^{13}C$ value of sheep/goat and cattle from Middleton pers. comm. 2015).

9.2 Çamlıbel Tarlası

9.2.1 Overall

The stable carbon and nitrogen isotope results from Çamlıbel Tarlası show several distinct patterns (Figure 9.10). As expected, the pulses and cereals differ in their $\delta^{15}N$ values while high variability is observed in $\delta^{13}C$ values within species.

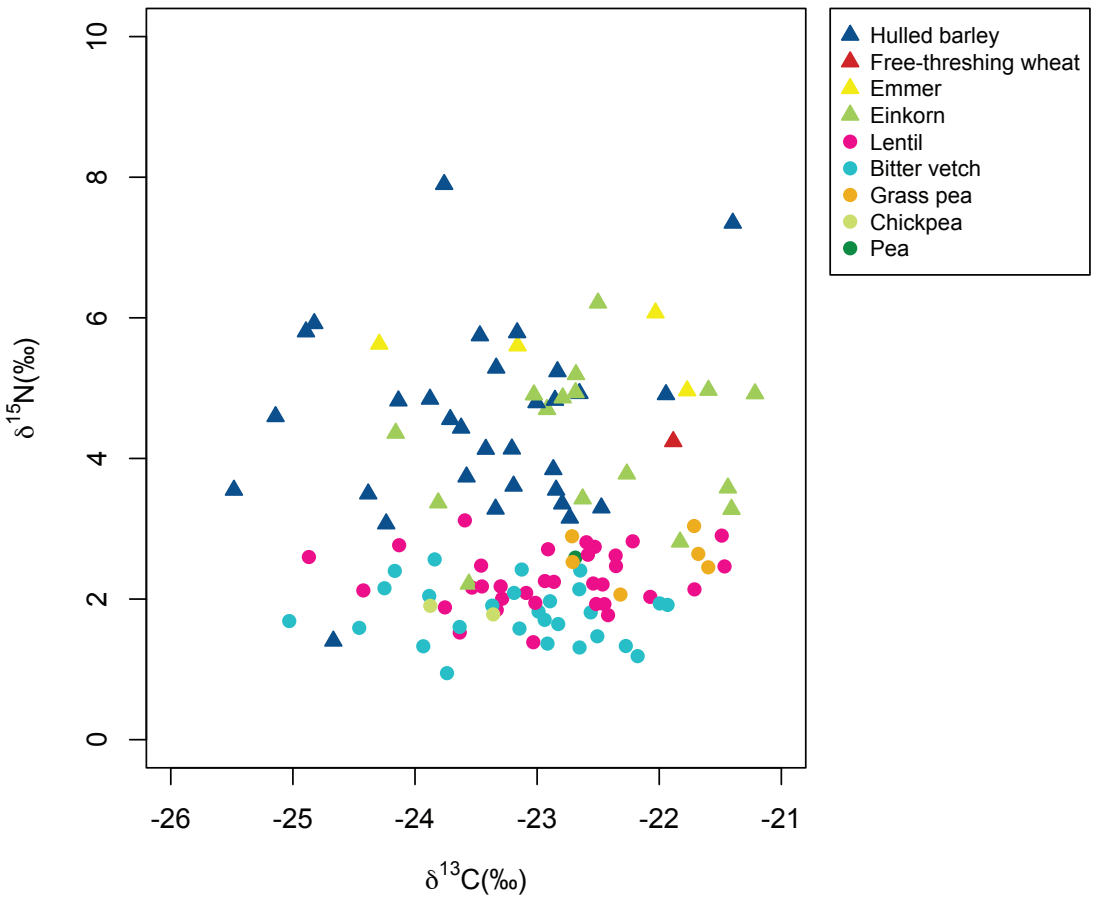


Figure 9.10: $\delta^{15}N$ and $\delta^{13}C$ of all plant samples from Çamlıbel Tarlası.

9.2.2 Carbon

Limited differences can be seen among the crops in their mean $\Delta^{13}C$ values (Table 9.11). The mean $\Delta^{13}C$ barley value (17.5± 1‰) is the highest of the four categories compared to the glume wheats (16.6±0.95‰), free-threshing wheat (15.8‰) and pulses (17±0.8‰) (Table 9.11, Figure 9.11). Barley $\Delta^{13}C$ is expected to be higher, due to the physiological offset (Roche et al. 2006; Anyia et al. 2007: Wallace et al. 2013). The variability within the groups is also similar and this is also reflected in the ranges, especially the minimum values, which are within 0.6‰ of each other (Figure 9.11). Maxima differ, again due to the higher values seen in the barley group at 19.6‰, although some pulses also reach 19‰. Of

note is the high variability within the groups, with values ranging from 3.2‰ in the glume wheat group to 4.3 ‰ among the barley samples (Table 12.12).

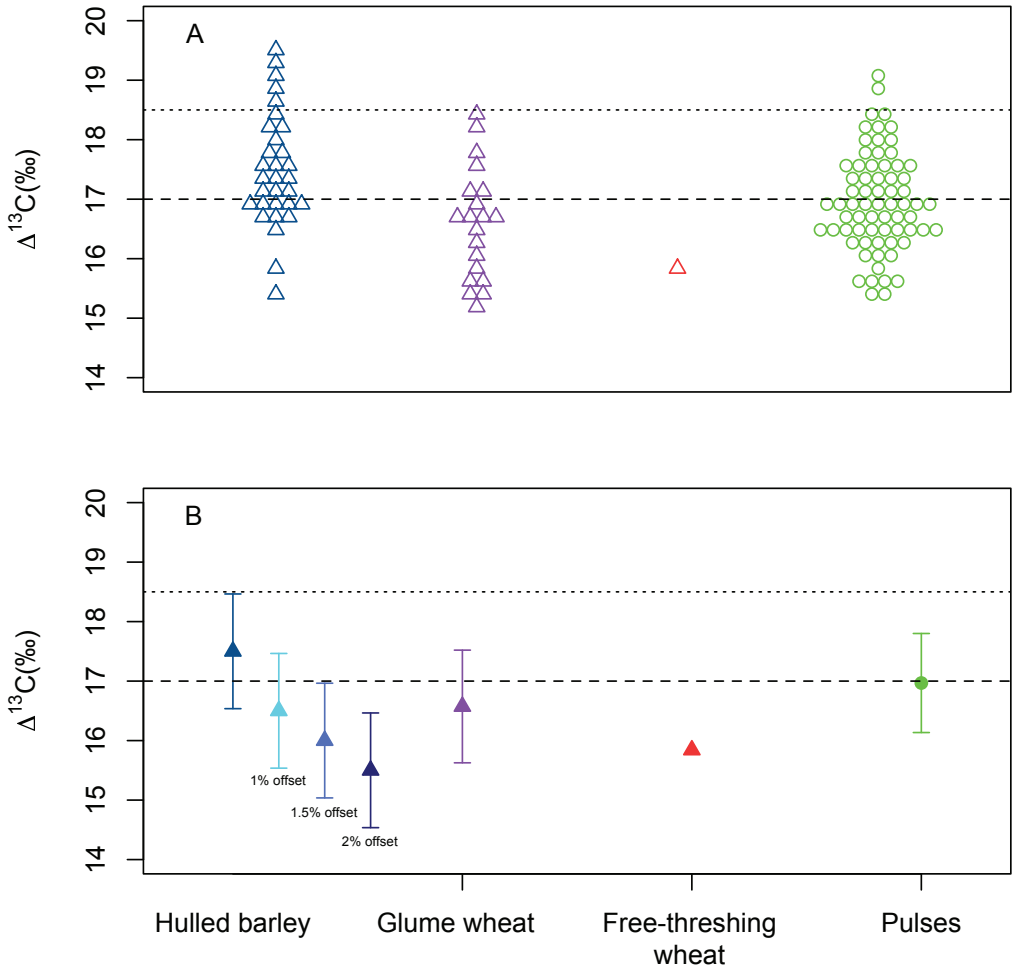


Figure 9.11: $\Delta^{13}C$ values (A) of the four major categories and their means and standard deviations (B). The two lines denote the beginning of the high water input ("well watered" zones) for wheats/pulses (dashed line) and for barley (dotted line). Note that the mean and standard deviation for the three offsets are indicated in graph B.

Table 9.11: Number of samples, mean and standard deviation (1σ) of $\delta^{13}C$, $\delta^{15}N$, and $\Delta^{13}C$ of the general crop categories from Çamlıbel Tarlası.

Taxon	Number	$\delta^{13}C$ (‰)		$\delta^{15}N$ (‰)		$\Delta^{13}C$ (‰)	
		Mean	Sd	Mean	Sd	Mean	Sd
Barley	31	-23.6	1.0	4.5	1.3	17.5	1.0
Free-threshing wheat	1	-21.8	-	4.2	-	15.8	-
Glume wheat	20	-22.6	0.9	4.5	1.0	16.6	0.9
Pulse	69	-23.0	0.8	2.1	0.5	17.0	0.8

A closer examination of the different species reveals the same overall trends as the major categories and indicates that high variability is not due to species-specific differences (Figure 9.12). Within the wheats, einkorn (16.5±0.9‰) and emmer (16.8±1.2‰) sit just below 17‰ and statistically there is no significant difference between them.

Archaeobotanical research indicates that the barley at Çamlıbel Tarlası was either two-row or a combination of two and six-row barley, based on rachis remains. The application of the three offsets (1‰, 1.5‰ and 2‰) lowers the barley $\Delta^{13}C$ values (Figures 9.12-9.13). The six-row offset can be ruled out; preserved remains of two-row barley have been found and Çamlıbel Tarlası barley is either all two-row or a combination of the two types.

Barley is significantly higher in $\Delta^{13}C$ than wheats without an offset applied (Tables 9.11-9.12). The 1‰ and 1.5‰ offset results in no statistically significant difference between barley and the other cereals, or the wheats as a group (Tables 9.11-9.14). This suggests no differentiation between cereal species on the basis of water availability in this more humid zone, a contrast to the differentiation seen at semi-arid Çatalhöyük. There is a statistically significant difference between the pulses and barley with the 1.5‰ and 2‰ offset (Tables 9.12-9.13, 9.15).

Table 9.12: Results of ANOVA conducted on various combinations of crop types when a 1‰, 1.5‰ or 2‰ offset is applied to the barley (* denotes a statistically significant difference).

Test	Group	Results
ANOVA	Cereals no offset	F(2,48)=4.5 p=0.006*
ANOVA	Cereals offset 1‰	F(2,48)=0.2, p=0.8
ANOVA	Cereals offset 1.5‰	F(2,48)=2.3, p=0.1
ANOVA	Cereals offset 2‰	F(2,48)=7.7, p=0.001*
ANOVA	Wheat, pulse, barley, barley 1‰, barley 1.5‰, barley 2‰	F(5,208)=19.7, p<0.001*
ANOVA	Species with >3 samples, no offset	F(5,111)=4.6, p<0.0001*
ANOVA	Species with >3 samples, 1‰	F(5,111)=3, p<0.01*
ANOVA	Species with >3 samples, 1.5‰	F(5,111)=6.7, p<0.001*
ANOVA	Species with >3 samples, 2‰	F(5,111)=13.3, p<0.001*

Table 9.13: Results of a Tukey *post hoc* test on pulse, wheat and raw barley values as well as barley at the three offset levels (* denotes a statistically significant difference).

	Pulse	Wheat	Barley	Barley 1‰	Barley 1.5‰
Pulse					
Wheat	0.42				
Barley	0.08	0.004*			
Barley 1‰	0.18	1	<0.001*		
Barley 1.5‰	<0.001*	0.30	<0.001*	0.27	
Barley 2‰	<0.001*	0.001*	<0.001*	<0.001*	0.2

Table 9.14: Results of a Tukey *post-hoc* testing on taxa with >3 samples from Çamlıbel Tarlası, using a 1‰ offset on barley $\Delta^{13}C$ values. (* denotes a statistically significant difference).

	Barley	Einkorn	Emmer	Bitter vetch	Lentil
Einkorn	1				
Emmer	0.98	0.99			
Bitter vetch	0.04 *	0.14	0.96		
Lentil	0.38	0.63	1	0.84	
Grass Pea	0.26	0.9	0.78	0.06	0.25

Table 9.15: Results of a Tukey *post-hoc* test on all taxa from Çamlıbel Tarlası with more than 3 samples, using a 1.5‰ offset on barley $\Delta^{13}C$ values (* denotes a statistically significant difference).

	Barley	Einkorn	Emmer	Bitter vetch	Lentil
Einkorn	0.38				
Emmer	0.49	0.99			
Bitter vetch	<0.001 *	0.14	0.96		
Lentil	<0.001 *	0.63	1	0.84	
Grass Pea	0.2541	0.90	0.78	0.06	0.25

Analysis of the pulses indicates some trends but interpretation of their significance is difficult due to the vastly different sample numbers (Table 12.12). Chickpea (17.6±0.4‰) and pea (16.7‰) are represented by limited numbers of samples but appear relatively well watered (Figure 9.12, Table 12.12). The grass pea (16.1± 0.5‰) with six samples is more robust and has the lowest of the pulse means. Bitter vetch (17.2±0.8‰) and lentil (16.9±0.8‰), the dominant pulses from the site, have similar means, occurring in the high/moderate water-input band (Figure 9.12). ANOVA indicates that there was statistically significant variation among the three main pulse taxa means ($f(2,63)=4.7$, $p=0.01$), with *post hoc* testing indicating grass pea is statistically significantly lower than bitter vetch ($p=0.008$). As only lentil as been studied in modern watering experiments it is difficult to determine whether such result is a consequence of environmental or physiological differences (Wallace et al. 2013).

Comparison of all the species indicates a significant difference between barley and the two pulse taxa, lentil and bitter vetch (Table 9.12, 9.15). Such a difference is only significant for both pulse taxa when a 1.5‰ offset is applied to the barley, indicating the possibility that barley was grown in slightly drier conditions than relatively wet lentil and bitter vetch (Figure 9.12).

None of the pulse samples are extremely "well watered" compared to either Wallace et al. (2013)'s framework or other research. Published studies of modern and archaeological examples have reported higher means, such as 18.9‰ and 19.1‰ seen at Kouphovouno for peas and lentil (Vaiglova et al. 2014a), and the

high values from modern crops such as fully irrigated lentil in Syria (18.6‰) and watered broad beans in Greece (17.7‰)(Wallace et al. 2013). Only the maximum bitter vetch value at Çamlıbel Tarlası reaches 19‰.

Comparison with the watering bands indicates that while species' means fall within specific bands, the spread of the individual data points covers all watering bands (Figure 9.12A). It has been postulated that high variability within species may be the result of differential hand-watering (Wallace 2011). It is possible, however, given the relatively low mean values, that this variability indicates inter-annual variability in rainfall and/or differential location of fields over the landscape rather than artificial watering, especially as this variability is not species specific and is seen in both cereal and pulse taxa. The topography of the region may also play a role, with recent research by Bogaard et al. (2016) indicating a correlation between slope and $\Delta^{13}C$. As slope increases $\Delta^{13}C$ decreases, a relationship probably due to the increase in runoff with higher slope gradients.

The variability of the samples suggests that the growing conditions within the cultivated areas fluctuated spatially and possibly temporally and that the cereals and some pulses were growing in areas that encompassed a wide range of different water availabilities. The difference between the $\Delta^{13}C$ values of the wheats and barley is limited when the barley offset is taken into account. This indicates that all the cereals were grown under similar conditions at Çamlıbel Tarlası.

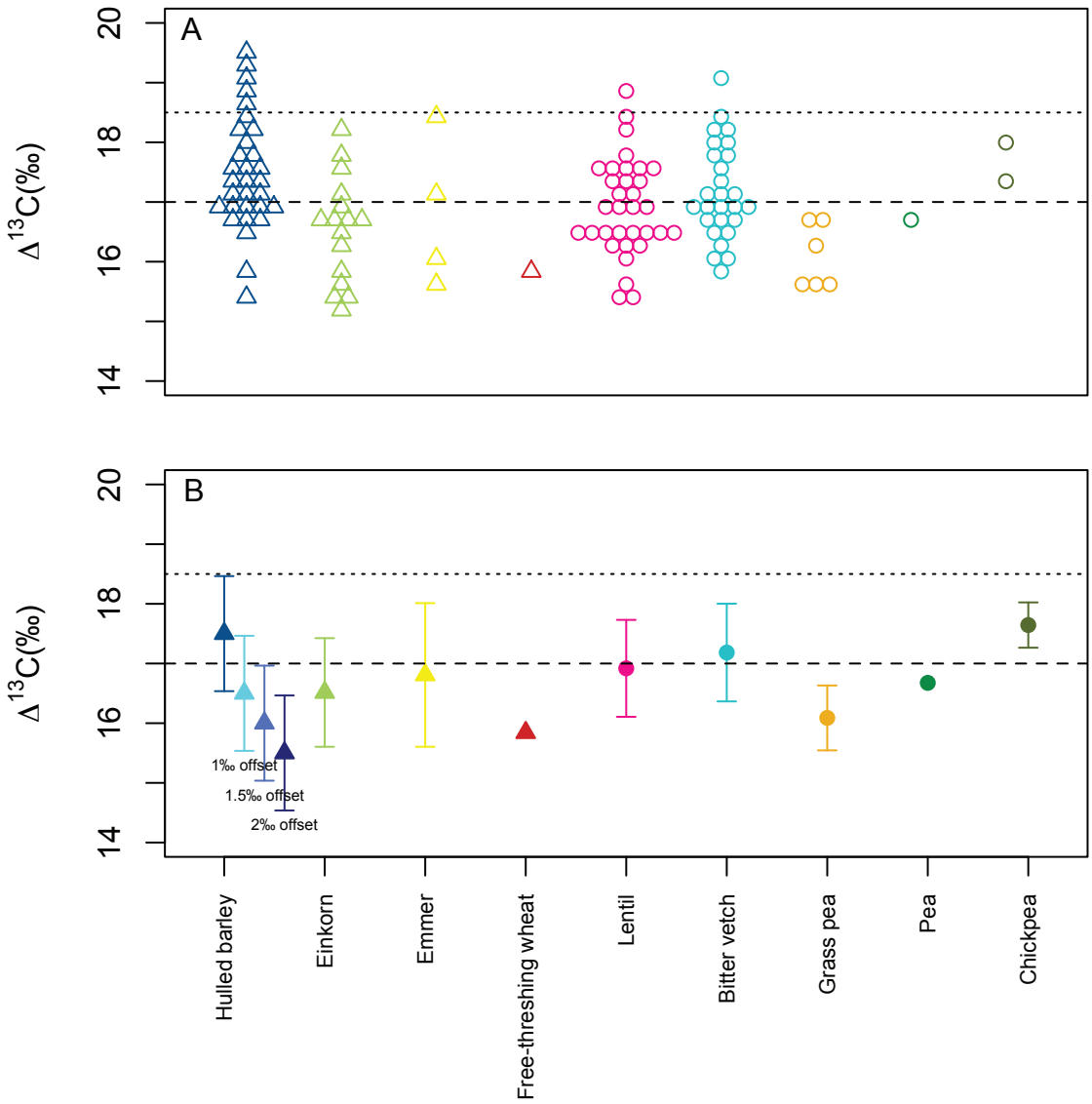


Figure 9.12: Δ¹³C values of each species from Çamlıbel Tarlası are shown in Graph (A) while the means and standard deviation are shown in Graph (B). The dotted lines reflect the beginning of the barley "well- watered" band as per Wallace et al. (2013) and the dashed line that of the wheat and pulses. Four barley means are shown, giving the raw mean and the means when a 1‰, 1.5‰ and 2‰ offset is applied.

9.2.3 Nitrogen

The $\delta^{15}N$ values for the four general crop groups do not show dramatic differences with the exception of the pulses (Table 12.12, Figure 9.13). As expected, the pulse values are lower than the cereals due to atmospheric nitrogen fixation (Marshall et al. 2007). Barley $\delta^{15}N$ values (4.5±1.3‰) show relatively high variability within the taxon. Glume wheats (4.5 ± 1.1‰) and free-threshing

wheat (4.2‰) have similar means, but comparison is limited by sample size with only a single sample of the latter. The pulse $\delta^{15}N$ average (2.1±0.5‰) is elevated above zero, which, given that pulses are atmospheric nitrogen fixers, suggests the plants were gaining nitrogen from the soil as well as the air.

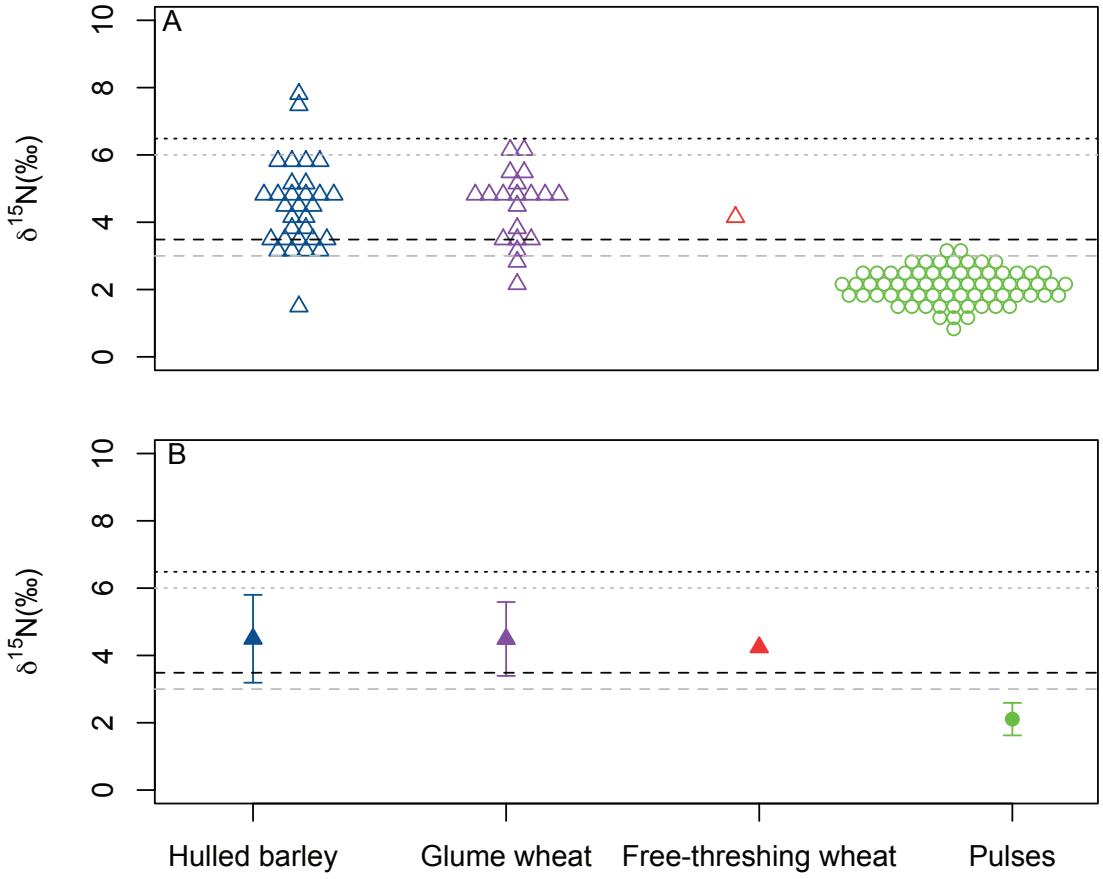


Figure 9.13: $\delta^{15}N$ values (A) and means (B) of the general categories from Çamlıbel Tarlası samples. The grey lines represent the lower thresholds of the moderate (dashed) and high (dotted) manuring bands for cereals in temperate Europe, (Bogaard et al. 2013). The black lines represent the Bogaard manuring lines with an offset (0.48‰) added to account for the effect of aridity as per the Hartman and Danin (2013b) regression equation of y= -3.19(log(rainfall))+20.49, where rainfall is 529mm per year(Styring et al. 2016).

The means of the broad categories fall within the moderate manuring range of Bogaard et al. (2013) when adjusted for aridity (Figure 9.13). The wheat and barley $\delta^{15}N$ values are highly variable, which suggests a variable growing substrate. Overall, the $\delta^{15}N$ values show the possibility of manuring, which is explored further in section 9.2.4.

Barley (4.5±1.3‰) has the highest variability and range of all taxa measured at the site, ranging from 1.4 ‰ to 8‰. Its mean is similar to that of the free-threshing wheat (4.2‰) and einkorn (4.2±1‰). There is high variability within barley and einkorn, with both species having coefficients of variation of 29% and 25%. This indicates several possibilities: differential growing conditions either temporally, spatially or a combination of the two.

There are two outlying barley samples: sample CBT024 (8‰) and sample CBT060 (7.5‰) which have high $\delta^{15}N$ values in comparison to the other data. These samples were re-measured to confirm their values, with the re-runs finding similar values (see Chapter 4). The minimum barley $\delta^{15}N$ value, while not an outlier, is comparable to some of the lowest pulse values. Sample size is not a problem with barley (31 samples) and thus the variability of $\delta^{15}N$ within the taxon appears valid.

Glume wheat comparisons indicate that einkorn and emmer $\delta^{15}N$ values are significantly different (Table 9.16). Emmer (5.6 ±0.5‰) has a more restricted $\delta^{15}N$ range than einkorn (4.2 ±1‰)(Figure 9.14). While they have comparable maximum values, einkorn samples possessing low $\delta^{15}N$ values reduce the einkorn mean in comparison to emmer (Table 12.12). Unfortunately, the difference between emmer (4) and einkorn (16) sample sizes reduces comparability, affecting the robustness of the assumption that emmer values represent the species' true range.

Table 9.16: Results of statistical tests conducted in the $\delta^{15}N$ values of the cereal taxa from Çamlıbel Tarlası (* denotes a statistically significant difference).

Statistical test	Taxa compared	Results
Welch two sample T-test	Barley ~ einkorn	t(36.8)=0.8, p=0.43
Welch two sample T-test	Barley ~ emmer	t(11.7)=-3.3, p=0.007*
Welch two sample T-test	Emmer ~ einkorn	t(12)=3.9, p=0.002*
ANOVA	Barley, einkorn, emmer	f(2,48)=2, p=0.14

Comparison of the cereal species reveals similarities and differences, in turn probably indicating differences/similarities within the soil. There is no difference when glume wheats are compared to barley, but there is a statistically significant difference between emmer and barley, and einkorn and emmer (Welch t-test, Table 9.16). When an ANOVA is conducted on all three cereals there is a statistically significant variation (Table 9.16). The low number of emmer samples hampers the understanding of whether its consistently high values reflect an intentional management difference or not. It is probable that emmer was purposefully and consistently grown in organically rich or manured fields; barley and einkorn were either grown in fields with internal variations of ^{15}N-enrichment or in a number of fields ranging in ^{15}N-enrichment.

Lentil's mean value (2.3±0.4) is higher than that of bitter vetch (1.8±0.4‰) although the difference is less than 1‰. Other pulses with small sample sizes have means similar to lentil and bitter vetch (Figure 9.14). Of note is the grass pea with its more robust sample size; it has a higher mean (2.6±0.3‰) than lentil and bitter vetch (Figure 9.14).

ANOVA indicates statistically significant variation between the three pulses and subsequent *post hoc* testing indicates that lentil and bitter vetch, bitter vetch and

grass pea, but not grass pea and lentil, are statistically different (Table 9.17). The other pulses were not included in the statistical analysis due to their small sample sizes.

The differences in the means of the lentil, bitter vetch and grass pea samples raise the question as to whether they reflect a species or an anthropogenic difference. Research into legume nitrogen usage indicates differential soil nitrogen uptake coupled with atmospheric fixation between species. Different factors influence the use of one source of nitrogen over the other including plant species, environmental conditions such as waterlogging and drought, and the soil available N content (de Molina et al. 2010). Consequently the difference seen in the $\delta^{15}N$ may be due to any one of these factors.

Table 9.17: Results of statistical tests conducted on lentil, bitter vetch and grass pea $\delta^{15}N$ values from Çamlıbel Tarlası samples (* denotes a statistically significant difference).

Statistical test	**Taxa compared**	**Results**
Welch two sample T-test	Bitter vetch ~ lentil	T(55.5)=-4.5, p<0.001*
Welch two sample T-test	Bitter vetch ~ grass pea	T(8.5)=-5, p<0.001*
Welch two sample T-test	Lentil ~ grass pea	T(7.8)=-2.1, p=0.07
ANOVA	Bitter vetch, lentil, grass pea	F(2,63)=15.7, p<0.001*
Tukey *Post-hoc*	Bitter vetch, lentil, grass pea	
	Grass pea ~bitter vetch	p<0.001*
	Lentil ~ bitter vetch	p<0.001*
	Lentil ~ grass pea	p=0.17

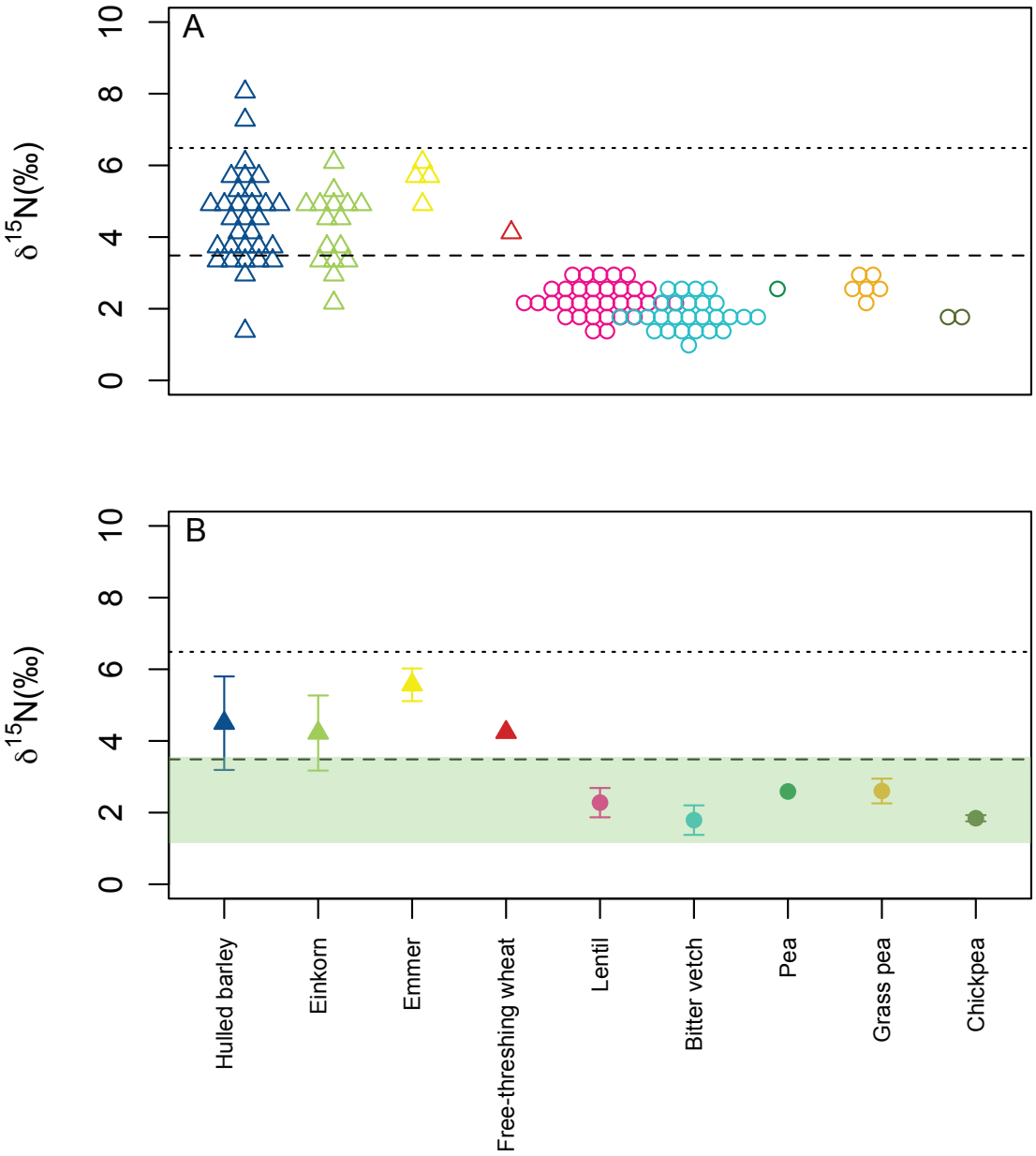


Figure 9.14.: $\delta^{15}N$ values (A) and means (B) of all species examined from Çamlıbel Tarlası. $\delta^{15}N$ values (A) and means (B) of all species examined from Çamlıbel Tarlası. Bogaard et al. (2013) manuring bands, adjusted for the effect of aridity under 529mm rainfall (Styring et al. 2016), are shown as a dotted line (border between moderate and high manuring) and dashed (upper threshold of the low manuring band). The estimated herbivore forage range (green shading on plot B) was calculated by subtracting 4‰ (mean trophic level offset) from the mean herbivore $\delta^{15}N$ value to produce the low limit, while the upper limit was calculated by the addition of 2.4‰ to account for the difference between grains and leaf consumption.

9.2.4 Question of manuring

Aridity would be expected to have a limited effect on the nitrogen in the soil at Çamlıbel Tarlası. As the site is situated in a region which in the present day receives an average of 529 mm of precipitation annually (see Chapter 2), the

offset (y value), calculated using the regression formula postulated by Hartman and Danin (2010), is only 0.48‰. Such an offset moves the Bogaard et al. (2013) manuring bands up by 0.48 ‰, thus reducing the number of samples which fall within the moderate manuring band (Figure 9.13-9.14). Consequently, intensive manuring of the crops at Çamlıbel Tarlası can be ruled out (Fraser et al. 2011). The values fall in both the moderate and low bands, suggesting that some samples come from crops cultivated in areas not previously manured (low band) but other samples in the moderate band are suggestive of manure application (see section 3.2.2.2 for details).

Comparison of the $\delta^{15}N$ values of the crops against an inferred forage range (~1 to 3.5‰) provides an estimation of the baseline for the natural soil nitrogen and gives an indication as to whether the crops are enriched above it. The cereal mean is elevated above the forage range (~ 1‰). This enrichment is not substantial when compared to other sites where enrichment has been seen over 4‰ above an inferred forage line (Bogaard et al. 2013, Vaiglova et al. 2014a). It is possible that manuring of the fields increased the soil $\delta^{15}N$ at Çamlıbel Tarlası, but the variable nature of, and the similarity between, crops indicate no particular differentiation between species. Two possible scenarios are that low-level amounts of manure were applied to the fields, or that the variation is natural and no manure was applied. However the second scenario is not supported by the faunal data, which shows no elevation on par with that of the crops. Thus it is more likely that manure was added to the soil.

9.2.5 Temporal differences

Examination of patterns temporally was in part limited by inconsistent availability of taxa across phases. Thus chickpea, pea and free-threshing wheat are not considered, as they do not cover two or more temporal phases.

The results demonstrate consistently high variability within the taxa in each phase, especially in $\Delta^{13}C$. Statistically there are no significant differences between the phases for each species in either $\Delta^{13}C$ or $\delta^{15}N$ (Figure 9.15). The high variability seen in the overall results was not caused by changes in growing conditions over time and indicates that the variability is more likely due to spatial differences in water availability and soil nitrogen within/between the fields.

Comparison of all taxa within each phase conforms to the overall pattern. When a 1.5‰ offset is applied to the barley there is significant variation within CBTI phases (ANOVA $f(5,54)=5.2$, $p=0.006$). *Post hoc* testing indicates that, as with the overall pattern, barley is significantly lower in $\Delta^{13}C$ than bitter vetch ($p<0.001$) and lentil ($p = 0.002$). Within the other phases there is no significant variation except in $\delta^{15}N$ values due to the difference between pulses and cereals.

The pulse values also reflect the overall assemblage patterns within phases. ANOVA indicated significant variation between pulse $\delta^{15}N$ in CBTI and CBTII (CBTI, $f(2,29)=11.3$ $p=0.0002$, CBTII $f(2,7)=8.5$, $p=0.014$). *Post hoc* testing indicated that in CBTI, bitter vetch is significantly lower than lentil ($p=0.009$) and grass pea ($p<0.001$) but grass pea and lentil are not. In CBTII bitter vetch and lentil are significantly different in $\delta^{15}N$ ($p=0.01$).

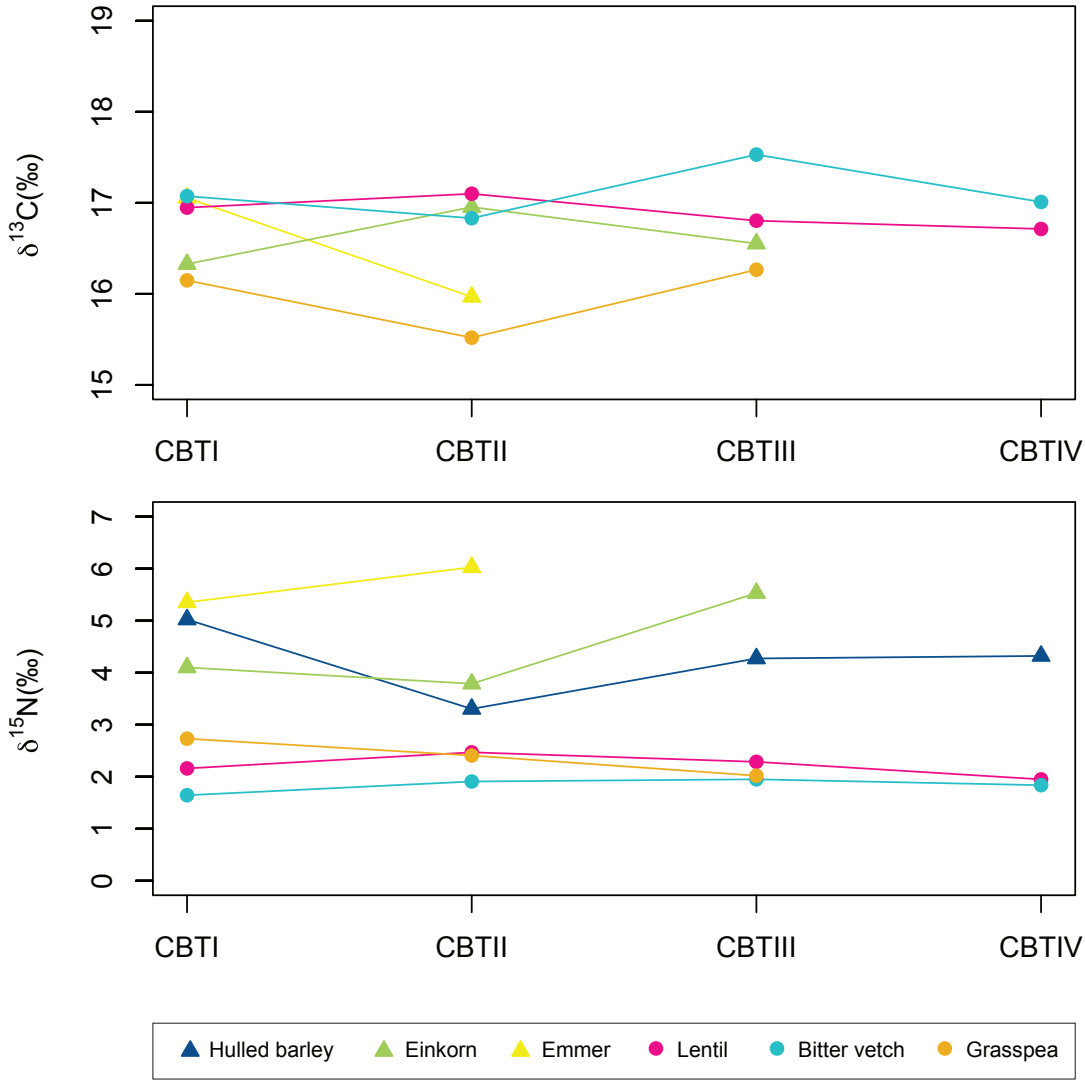


Figure 9.15: $\Delta^{13}C$ and $\delta^{15}N$ mean values from the species with 3 or more samples, examined over the four phases of Çamlıbel Tarlası.

The results indicate continuity in $\Delta^{13}C$ and $\delta^{15}N$ values and therefore the associated causes: water availability and enrichment in soil ^{15}N. Water availability appears variable within species, indicating that such variability is most likely not due to differential treatment of species but rather variability in fields or inter-annual variation in rainfall. The $\delta^{15}N$ is consistently moderate to low throughout the four phases, suggesting no or low enrichment of the soil through the application of manure.

9.2.6 Palaeodietary reconstructions

Examination of the human palaeodiet at Çamlıbel Tarlası is possible thanks to the work on human and faunal remains conducted at the University of Edinburgh by Dr Catriona Prichard. Cattle, pigs and caprine domesticates as well as humans and a number of wild taxa were analysed isotopically (Pickard et al. 2016a, 2016b)(Figure 9.16). These results allow comparison with the crop data and so an attempt can be made to understand both the proportion contributed to human diet by crops and animals, and an understanding of whether crops/foddering played a significant role in the diet of the livestock from the site.

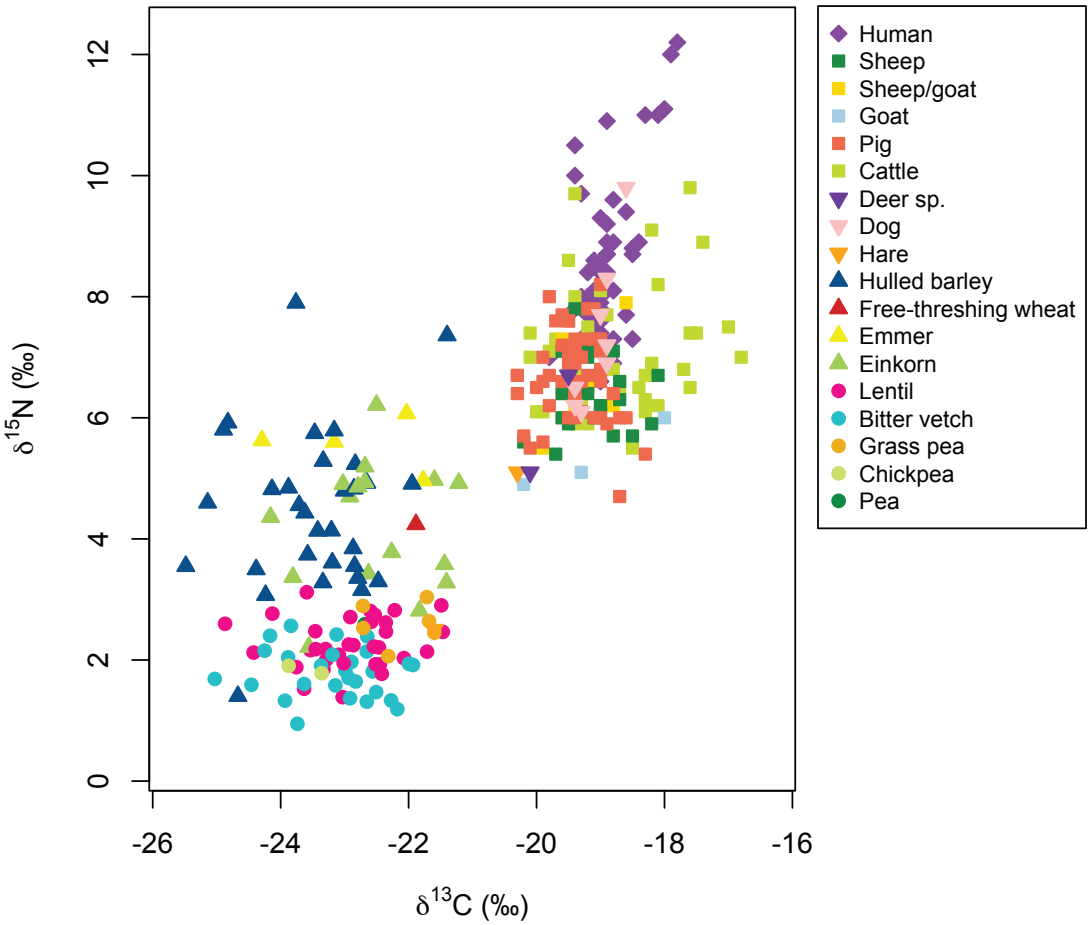


Figure 9.16: Crop $\delta^{15}N$ and $\delta^{13}C$ values together with human and animal results from Çamlıbel Tarlası (Human and faunal data from Vaughan et al. 2013; Pickard et al. 2016a).

The $\Delta^{15}N_{\text{herbivore - human}}$ is very low (-1.8‰), much lower than expected for a full trophic level (4‰) (Table 9.18). The difference between humans and the various animals is also limited, while the $\Delta^{15}N_{\text{crop-human}}$ shows the much larger offset of 5.4‰ (Table 9.18). The results suggest that either a high proportion of human protein was derived from plants rather than animals, or the consumption of pulses lowered the human $\delta^{15}N$ values hiding the consumption of enriched foods such as cereals and in particular animals, a possibility also noted by Pickard et al. (2016a).

Table 9.18: Mean stable isotope values for humans, animals and crops, standard deviation (SD), and the isotopic offsets (Δ) for $\delta^{15}N$ and $\delta^{13}C$ between them.

						Δ fauna - human	
Taxon	**Number**	**$\delta^{13}C$**	**SD**	**$\delta^{15}N$**	**SD**	**$\Delta^{13}C$‰**	**$\Delta^{15}N$‰**
Humans	57	-18.9	0.4	8.5	1.3		
Pig	54	-19.4	0.4	6.7	0.7	-0.5	-1.8
Sheep/goat	39	-19.3	0.4	6.4	0.7	-0.4	-2.1
Cattle	40	-18.7	0.9	7.1	1.1	0.2	-1.4
All fauna	145	-19.2	0.7	6.7	0.97	-0.3	-1.8
Domesticated Herbivores	79	-19	0.8	6.7	1	-0.1	-1.8
						Δ Crop- human	
Barley	31	-23.5	0.9	4.5	1.3	-4.6	-4.0
Wheat	21	-22.6	0.9	4.5	1.1	-3.7	-4.0
Pulse	69	-23	0.8	2.1	0.5	-4.1	-6.4
All crops	121	-23	0.9	3.1	1.5	-4.1	-5.4
						Δ Crop – domesticated herbivore	
Barley						-4.5	-2.2
Wheat						-3.6	-2.2
Pulse						-4	-4.6
All crops						-4	-3.6

Modelling palaeodiets is difficult due to the plethora of possible dietary input combinations. Instead, a simple linear mixing model was used to explore the potential effects of different combinations of food groups and the possible amount of animal and plant protein needed to produce the isotopic values seen at

Çamlıbel Tarlası (Figure 9.17). Different quantities of pulse in the diet have a marked impact on the amount of animal protein consumed. If the plant portion of the diet was composed of 100% cereals, only 1% of the dietary protein could be derived from animals. Such a scenario is doubtful given the ubiquity of pulses within the assemblage, thus consumption of pulses at the site was most likely a common practice, lowering the $\delta^{15}N$ value of the plant component of the diet and consequently higher amounts of animal protein could have been consumed (Figure 9.17). A 100% pulse diet means that 53% of the dietary protein was animal-derived, but such a scenario is as doubtful as the 100% cereal diet, given the prevalence of cereals on the site. The most plausible scenario is a combination of animal, cereal and pulse consumption; a 50:50 ratio of cereals to pulse results in 63% of the dietary protein originating from crop consumption (Figure 9.17). Exploration of different proportions of cereal and pulse in the diet show that plants played an important role in the diet of the people at Çamlıbel Tarlası, with the most likely scenarios of mixed crop types resulting in the conclusion that more than 50% of dietary protein was derived from plants.

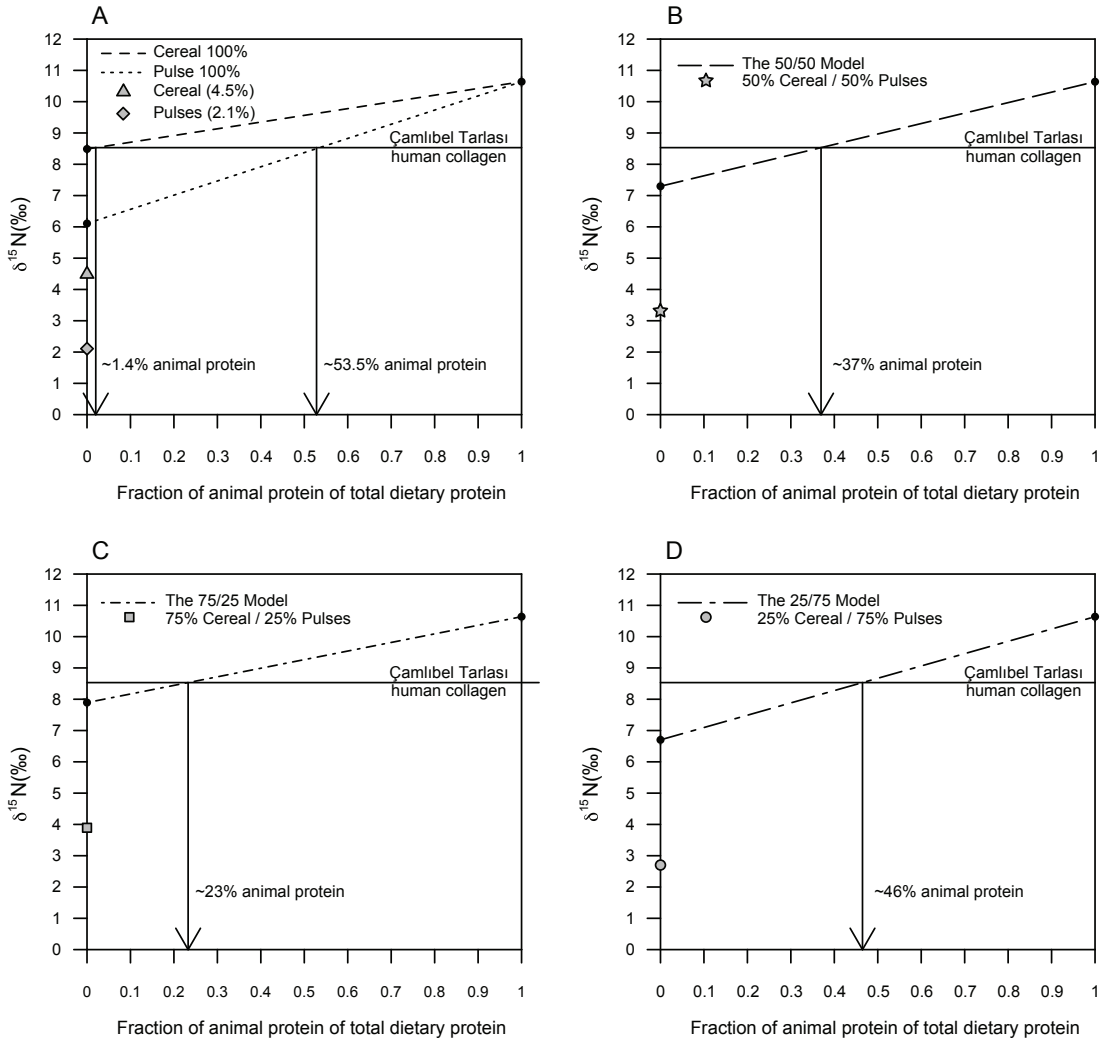


Figure 9.17: Graph (A) shows the proportion of animal protein in the diet of an average human at CBT if all plant protein originated from cereals, (B) if plant protein was a 50:50 mix of cereal and pulses, while (C) and (D) if 75:25 and 25:75 of plant protein comprised of cereals and pulses.

Studies have shown that there is an offset between the grain and the rachis for wheats and barleys: c. -2.4‰ in $\delta^{15}N$ and in $\delta^{13}C$, -1.9‰ for wheat, and -1.7‰ for barley (Fraser et al. 2011, Wallace et al. 2013). Consideration of these offsets informs assessment of the likelihood that crop material contributed a large proportion of the animals' diet. While the animals could have consumed pulse seeds, the cereal *grains* are less likely to have contributed to a significant proportion of dietary intake (Figure 9.18), given the low offset between the two, although the results indicate that livestock could have consumed all cereal by-products (Figure 9.18).

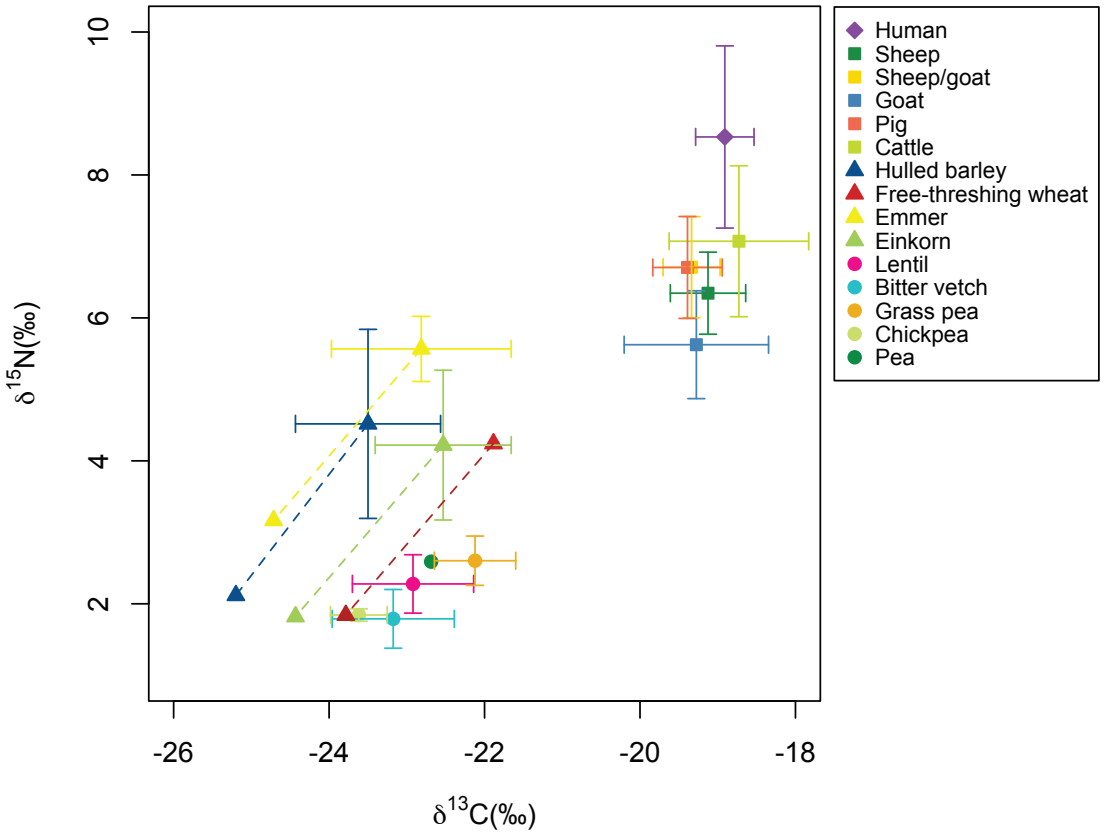


Figure 9.18: Means and standard deviations of the various crops and animals together with human isotopic values, with the projected values for chaff of the four cereal types using a $\delta^{13}C$ offset of -1.9‰ for the wheats and – 1.7‰ for the barley and a $\delta^{15}N$ offset of -2.4 for both categories following Wallace, et al. (2013) and Fraser, et al. (2011).

The reconstruction of the potential contribution of crops and animals to the human diet indicates two possibilities: that human diet was dominated by crops rather than animal products for protein, or that the human $\delta^{15}N$ values were lowered through the consumption of pulses, thus masking the consumption of other foods. The conclusion may be that cereal grains were predominantly for human consumption, while the chaff and potentially the pulses were used as the fodder for livestock. However some proportion of pulse consumption is required to achieve the $\delta^{15}N$ values measured in the humans.

9.3 Conclusions

Stable isotope analysis of crop material from Çatalhöyük and Çamlıbel Tarlası reflects two different crop husbandry regimes. At Çatalhöyük certain species

exhibit consistent differences in growing conditions. Conversely, at Çamlıbel Tarlası, although crops appear to have been grown in highly variable conditions, there is no clear differentiation among species.

$\Delta^{13}C$ results from Çatalhöyük West indicate species-specific differences, with the water status of barley lower than other species. At Çamlıbel Tarlası there is a slight possibility that specific pulses were grown in fields with higher water availability but there is no difference in the treatment of barley compared to the other cereals, with all having similar but varying $\Delta^{13}C$ values. The rainfall at the two sites probably influenced crop husbandry: at the semi-arid site of Çatalhöyük West barley fulfilled the drought-tolerant crop role, while in the wetter climate of Çamlıbel Tarlası there was no need for such differentiation.

$\delta^{15}N$ results from Çatalhöyük West are highly variable and elevated, suggesting that a number of factors, including aridity and manuring, played a role in elevating the soil ^{15}N content. It is possible that other environmental factors such as seasonal waterlogging also increased the $\delta^{15}N$, given the location of Çatalhöyük in a wet area of an arid region. However the elevation of the crops above both the adjusted manuring bands and the inferred forage value could suggest that in addition to an ecosystem enrichment there is an anthropogenic enrichment in $\delta^{15}N$, most likely a consequence of manuring. Such a scenario assumes that the animals were pastured in part on soils similar to those used to cultivate crops. The high variability of the nitrogen values suggests a high variability of soil nitrogen isotope composition within the landscape, both natural and

anthropogenic, and that farmers utilised such variability within their crop cultivation strategies.

At Çamlıbel Tarlası, again variability of $\delta^{15}N$ is seen within the species, but $\delta^{15}N$ values are not as high as seen at Çatalhöyük. Species-specific differences are noted with emmer elevated above barley and einkorn. The $\delta^{15}N$ values are elevated above the forage range and suggest potential manuring.

Temporally, at Çatalhöyük there is an indication of change in the $\delta^{15}N$ values of barley, with an increase in barley $\delta^{15}N$ values in the ECI. The cause of this is difficult to understand and is limited by the low sample sizes in the Late Neolithic and Early Chalcolithic II phases. Çamlıbel Tarlası, however, reflects stability in growing conditions over time, suggesting a continuation of crop husbandry practices over the duration of the site's occupation of c. 300 years.

The question whether the inhabitants of Çamlıbel Tarlası cultivated their own crops, or were supported by larger communities supplying crops in exchange for other products such as metals, needs to be considered in light of broader discussion of specialisation during the Chalcolithic (See chapter 1). The isotopic results show variable $\Delta^{13}C$ values, something that could either be indicative of cultivation in different places within the landscape and highlighting sloping fields, or crops produced in different environments and thus imported. Manuring at the site contradicts the hypothesis that other sites produced the crops for Çamlıbel Tarlası; the expected model of a site producing large amounts of surplus would be

one of expansive cultivation with low labour input per unit area and thus no manuring (Halstead 2014:351).

Palaeodietary reconstructions at the two sites offer insights into crop consumption by animals and humans. The results suggest that the crops were not consumed in any significant amount by domesticated animals at Çatalhöyük and that the primary use was by humans. At Çamlıbel Tarlası the human stable isotope data contributes to an understanding of the palaeodiet, suggesting that inhabitants of the site subsisted on a large proportion of crop protein rather than animal products, with pulses playing an important role in the diet. The results also indicate that cereal grains were predominantly for human consumption, and chaff possibly for animal consumption.

10 Crop–husbandry: Weed evidence

This chapter examines evidence, available from ecological analysis of arable weed assemblages associated with crop remains, of arable growing conditions and farming practice at Çatalhöyük West, Çamlıbel Tarlası and Kuruçay. Due to the limited identification of weed taxa in the Canhasan I assemblage no attempt was made to identify cultivation techniques. This evidence is complementary to, and independent of, the stable isotope approach reported in Chapter 9 for the sites of Çatalhöyük West and Çamlıbel Tarlası. As set out in Chapter 3 and 4, this project uses a functional ecological approach to compare the archaeobotanical weed datasets with modern weed flora grown under low- and high-intensity husbandry regimes (cf Bogaard et al. 2016b).

10.1 Çatalhöyük West

The preceding chapters have built an understanding of the components and formation processes giving rise to the charred macrobotanical assemblage. Identification of the likely mode by which the taxa entered the assemblage has centred on the burning of fuel and disposal of crop processing waste. Such analyses have allowed the identification of wild taxa likely not derived from crop processing and thus not interpretable as evidence of arable conditions. Table 10.1 summarises the species contributing to the assemblage and their hypothesised derivation.

All taxa classed as dung-derived were removed prior to crop husbandry analysis described below. Some taxa that are dung *and* crop-derived were not removed,

including species of *Descurainia* and *Bolboschoenus* (Table 10.1). *Descurainia*, as previously explained, could be deliberately collected, as well as be an arable weed, while *Bolboschoenus* could derive from basketry/matting, food, or dung material, in addition to being a crop weed. Other species are listed as dung-derived/arable to highlight the possibility of entry into the assemblage from both dung and harvested materials.

Table 10.1: Potential derivation of the Çatalhöyük West taxa, including their ubiquity and percentage of total wild seeds. The lifecycle of the taxa and number of species is provided. P(dis) refers to taxa with perennial lifecycles that can grow in disturbed habitats: p(non dis) refers to perennials growing in undisturbed conditions, a denotes annuals and a/p refers to taxa in which both annual and perennial species may be included within the classification.

Species	% (Ubiquity)	% of seeds	Derivation	Lifecycle (habitat)	No. of species
Sporobolus	77.8	8.0	Dung	/	/
Crypsis aculeata (L.) Aiton type	60.0	4.4	Dung	/	/
Aeluropus Trin.	55.6	4.0	Dung	/	/
Artemisia annua L. type	55.6	4.0	Dung	/	/
Juncus L.	42.2	2.2	Dung	/	/
Chenopodium L.	15.6	0.4	Dung	/	/
Eragrostis	15.6	0.9	Dung	/	/
Alisma L.	13.3	0.6	Dung	/	/
Deschampsia	13.3	0.4	Dung	/	/
Leguminosae , small wild	53.3	1.4	Crop/dung	/	/
Polygonum aviculare	53.3	2.9	Crop/dung	a	15
Atriplex L.	33.3	1.1	Crop/dung	a	20
Chenopodium album L. type	8.9	0.3	Crop/dung	a	1
Anagallis L. type	4.4	0.0	Crop/dung	a	12
Rumex L.	55.6	1.3	Crop/dung	a/p	20
Salsola L.	22.2	0.3	Crop/dung	a/p	20
Polygonum convolvulus L.	8.9	0.2	Crop/dung	a/p	15
Carex L.	22.2	0.5	Crop/dung	p (non dis)	10
Bolboschoenus glaucus (Lam.) S.G. Smith	97.8	18.2	Crop/dung/ collected	p (dis)	1
Descurainia sophia (L.) Webb	84.4	26.2	Crop/ collected	a/p	1
Taeniatherum caput-medusae L.	46.7	0.9	Crop	a	10
Hordeum murinum L. type	28.9	0.3	Crop	a	1
Vaccaria pyramidata Medik.	26.7	0.3	Crop	a	1
Bromus hordeaceus L./*commutatus* Schrad.	17.8	0.2	Crop	a	2
Adonis aestivalis type L.	15.6	0.1	Crop	a	1

Species	% (Ubiquity)	% of seeds	Derivation	Lifecycle (habitat)	No. of species
Adonis microcarpa/annua	4.4	0.0	Crop	a	5
Heliotropium L.	4.4	0.1	Crop	a	10
Bromus L. narrow type	4.4	0.2	Crop	a	5
Valerianella Miller	2.2	0.1	Crop	a	5
Chrysanthemum cf. *segetum* type	2.2	0.0	Crop	a	5
Conringia orientalis L.	2.2	0.1	Crop	a	1
Ranunculus arvensis type	2.2	0.0	Crop	a	1
Lolium temulentum L.	2.2	0.0	Crop	a	1
Galium aparine L. type	51.1	0.4	Crop	a/p	1
Vicia L./Lathyrus L.	20.0	0.2	Crop	a/p	>150
Lavatera L. type	15.6	0.1	Crop	a/p	5
Centaurea sp.	6.7	0.1	Crop	a/p	>150
Eremopyrum (Ledeb.) Jaub. & Spach	6.7	0.0	Crop	a/p	6
Malva L.	4.4	0.2	Crop	a/p	9
Galium verum L. type	4.4	0.1	Crop	a/p	1
Thymelea passerina (L.) Cosson & Germ. type	4.4	0.0	Crop	a/p	5
Euphorbia L.	2.2	0.1	Crop	a/p	90
Silene sp.	2.2	0.1	Crop	a/p	121
Viola L.	2.2	0.1	Crop	a/p	20
Ziziphora capitata L./*persica* Bunge	2.2	0.0	Crop	a/p	5
Sonchus type	4.4	0.2	Crop	a/p	6
Hyoscyanus	2.2	0.1	Crop	a/p	6
Stipa	2.2	0.0	Crop	p (non dis)	15
Hordeum spontaneum C. Koch type	2.2	0.0	Crop	p (dis)	1
Festuca	13.3	0.1	Crop	p (dis)	10
Convolvulus arvensis L. type	11.1	0.1	Crop	p (dis)	1
Sideritis L. type	8.9	0.3	Crop	p (dis)	5
Verbena officinalis L.	2.2	0.1	Crop	p (dis)	10
Ficus sp.	2.2	0.0	Fuel/other		

The results recorded in preceding chapters have allowed an understanding of the crop component of the samples, their likely derivation, and inferences as to the likely association between crop and potential weed material. The Çatalhöyük West assemblage is dominated by glume wheat items, with all samples classified as fine-sieving by-products (see Chapter 8, Table 8.5). While other crop species occur within these samples, they are minor components (less than 30%), either the consequence of cooking or accidents, or mixing from other crop processing

activities. It is therefore most likely that the plausible arable weeds in the assemblage are associated with the cultivation of glume wheats and so this becomes the focus of the examination of crop husbandry techniques via weed ecology for Çatalhöyük West.

10.1.1 Permanence of Cultivation

Permanence of cultivation was investigated through the examination of the lifecycle of the arable weeds. Research in temperate Europe has indicated that newly cleared fields have a high proportion of perennial woodland weeds compared to annuals. The results of the Hambach forest experiment indicated that after clearance, perennials comprised 57-100% of flora recorded in the fields (Bogaard 2002b). While the vegetation and climate at Çatalhöyük was different to temperate Europe, the Hambach forest experiment's broad findings can be used as a framework to assess plot permanence at Çatalhöyük West, as well as Çamlıbel Tarlası and Kuruçay, due to the high likelihood that surrounding vegetation was in part forest/woodland (cf. Filipović 2014, and Chapter 2). Consequently, the proportion of perennials and annuals in the assemblage was investigated together with their habitat requirements. All potential arable weed taxa identified to genus level were included but this in some cases limited identification of lifecycle, as species within a genus can vary as either perennial or annual. Samples were restricted to those that contained at least 10 of the specific measurement unit being used (seeds or taxa). Only potentially arable weeds were used in the analysis, defined in Table 10.1

Figure 10.1a-b shows the proportions of the four groups in the assemblage based on ubiquity and seed abundance: annual, annual/perennial, perennial-disturbed habitats and perennial-undisturbed habitats, with the proportion of *Descurainia* and *Bolboschoenus* indicated; *Descurainia* accounts for a high proportion of annual seed, while the disturbed perennial category is represented principally by *Bolboschoenus*. Table 10.1 also details the taxa and lifecycle information, abundances and ubiquity.

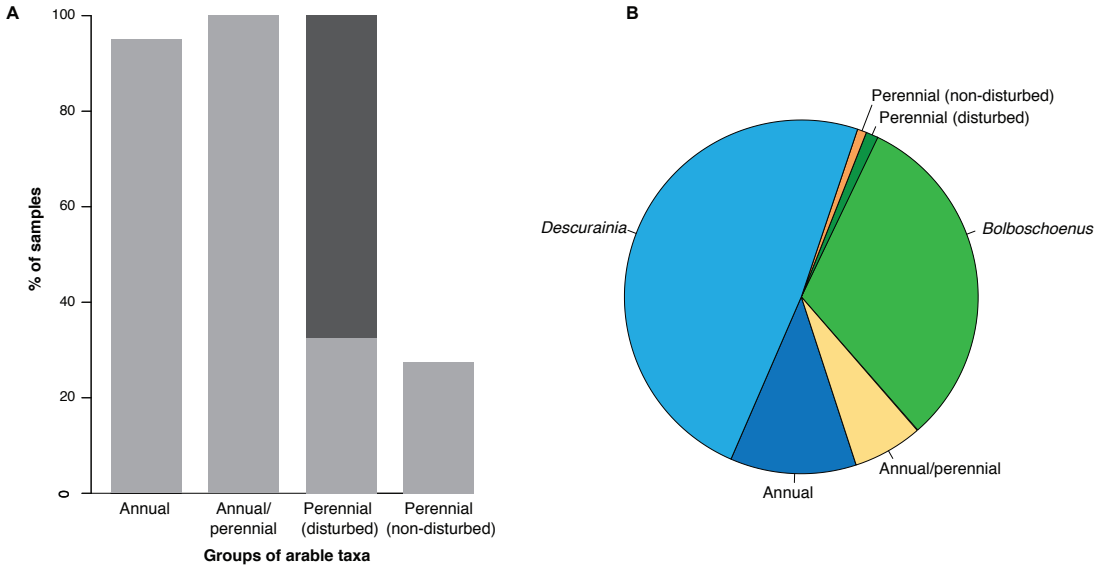


Figure 10.1: (A) shows the percentage of Çatalhöyük West samples containing taxa with annual, perennial lifecycles from disturbed or non-disturbed habitats; black denotes the samples containing *Bolboschoenus* seeds as their only perennial (disturbed) taxa. (B) depicts the proportion seeds of such categories represent. *Descurainia*, an annual, and *Bolboschoenus*, a perennial from disturbed habitats, are shown as lighter blue and green respectively of their corresponding classification.

Classification of *Descurainia* is difficult due to it being described as an annual/biennial in the *Flora of Turkey*. In this present research it has been classed as an annual and has no impact on the recorded presence of annuals' taxa in samples (Figure 10.1a). *Bolboschoenus*, however, has a large impact. While contributing lower numbers of seeds to the assemblage than *Descurainia* (Figure 10.1b), this taxon raises the count from 32.5% to 100 % of the examined 40

samples containing perennial weed taxa from disturbed habitats (Figure 10.1a). Removal of these species from the summary highlights both the impact of the seeds of *Descurainia* on the analysis (Figure 10.1b) and the ubiquity of *Bolboschoenus* (Figure 10.1a). However the multiple pathways by which these species may have entered the assemblage means that their inclusion as potential weeds is always open to question. Therefore, when examining perennial abundance and ubiquity, graphs are shown both including and excluding such species in the calculations.

The assemblage is dominated by the occurrence of the annual/perennial group in all samples examined. This group comprises taxa identified to genus level with a large number of possible perennial and annual species within the genus. There is an exception to this; *Polygonum convolvulus* is identified as a perennial in the *Flora of Turkey* (Davis 1965-1989), but as it is commonly described as an annual it has been classified as an annual/perennial (Filipović 2014).

Six weed taxa within the assemblage have a perennial lifecycle and can grow in disturbed habitats, while only two species, *Carex* and *Stipa*, have perennial lifecycles and grow in the undisturbed habitats of riparian forest and steppe. The inclusion of *Carex* in this analysis could be problematic; other research has related *Carex* to dung burning on the East Mound (Bogaard et al. 2013a; Filipović 2014). However this study found the taxa had a moderate dung-derived score and possibly entered the assemblage via both crop processing and dung burning. *Carex* species inhabit a wide range of environments from the very wet, marsh and bog to dry steppe environments (Davis 1965-1989). *Stipa* occurs as only one seed

in the assemblage, highlighting its and the group's rarity and possibly indicating the lack of undisturbed niches within the crop fields. Based on the Hambach data, this indicates limited evidence for the occurrence of newly cleared fields receiving some degree of tillage or weeding (Bogaard 2002b).

Six perennial weed taxa prefer disturbed habitats, occurring in 33% or 13 samples (47 seeds). Five of these taxa occur in low numbers and infrequently. *Bolboschoenus* as mentioned is ubiquitous and of the other perennials, *Festuca* has the highest ubiquity, occurring in six samples, while *Sideritis* has the highest number of seeds (27) (Table 10.1). Perennials of disturbed habitats have adapted to disturbance and thus can survive clearance of their primary habitat, continuing to survive in highly disturbed plots (Bogaard 2002b).

Figure 10.2a shows the proportions of perennial taxa seeds in the 40 samples analysed, while Figure 10.2b shows the proportions of perennials as a number of taxon counts per unit (as per Bogaard 2002b). In both figures the domination by annuals is obvious; most samples contain no perennials and those that do have a low number of perennial seeds and comprise less than 25% of the samples' arable weed composition.

Examination of the proportions of perennial weed seeds in the assemblage indicates that the inclusion of *Bolboschoenus* seeds has a marked effect, resulting in more than 20% of samples containing greater than 50% perennial seeds. Seven of the eleven samples falling in the 50- 100% histogram bin contain100% *Bolboschoenus* seeds (Figure 10.2a). Removal of *Bolboschoenus* and *Descurainia*

from calculations results in only one sample having greater than 50% perennial seeds indicating small quantities of perennial weed taxa in the assemblage (Figure 10.2c).

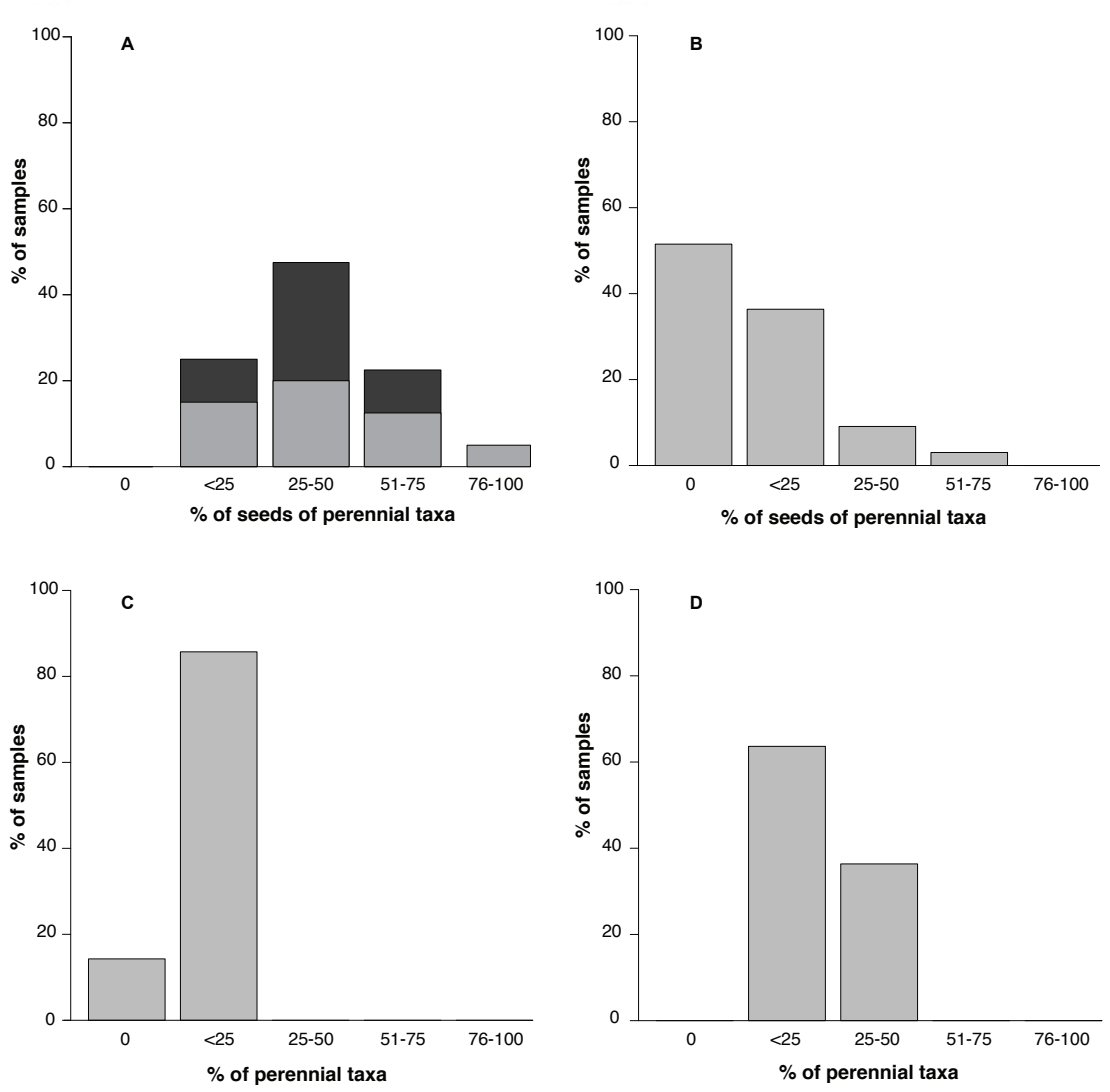


Figure 10.2: Histogram (A) and (B) showing proportion of perennials in the Çatalhöyük West samples based on seed counts, (A) includes all samples with at least 10 weed seeds (n=30), (B) includes all samples containing at least 10 weed seeds after *Bolboschoenus* and *Descurainia* have been removed (n= 33).(C) and (D) show the proportion of perennials in the samples based on taxon counts, with (C) showing all samples with at least 10 weed taxa (n =11), while (D) shows all samples containing 10 or more weed taxa after *Bolboschoenus* and *Descurainia* have been removed (n =7).

Examination of the number of perennial weed taxa shows that the removal of *Descurainia* and *Bolboschoenus* results in an increase in the number of samples containing 25-50% perennial taxa due to the decreased number of taxa upon which this calculation is based. Only eight perennial taxa are present in the assemblage and it is rare for a sample to contain high enough numbers of categorised weed taxa – only eleven samples contain ten or more taxa classed by life cycle and this decreases if *Bolboschoenus* and *Descurainia* are discounted. In either scenario (including or excluding *Bolboschoenus* and *Descurainia*), there are no examined samples that contain more than 50% perennial taxa.

Comparison to the research from Hambach indicates that the Çatalhöyük samples are lacking in perennial weed species, as the Hambach plots contained 57-100% perennial taxa (Bogaard 2002b). This could suggest one of two things: that the fields utilized at Çatalhöyük West had been under cultivation for a long period of time, or that the environment surrounding the site was dominated by annuals before clearance. It is acknowledged that the flood plain vegetation reconstructed around Çatalhöyük would have been dominated by more annuals than the Hambach region in Germany. Anthracological research however indicates wooded areas within the floodplain, potentially a drier, and more suitable location for arable cultivation. Furthermore, the occupation of the East Mound presumably resulted in large cultivated areas of the land surrounding the settlement prior to settlement on the West Mound removing any persistent perennial species that were relics of forest/woodland clearance. Moreover, the stratigraphic location of Trench 5 in the West Mound sequence potentially

reflects 150 plus years of occupation that occurred prior to the deposition of this material (Orton et al. in prep).

10.1.2 Sowing time

Understanding crop sowing times can be attempted using an approach presented by Bogaard et al. (2001), who found that the onset and length of flowering of species were reasonable predictors of germination time and hence the most useful functional attributes to distinguish between autumn and spring sowing. Plants germinating in autumn are unlikely to grow well in spring-sown crops because of the limited time they have to grow and establish before spring ploughing (Bogaard et al. 2001). Plants that germinate in spring/summer will avoid the ploughing disturbance and grow well in spring-sown crops but will be limited in autumn-sown crops: the established autumn germinating crop and weeds will have produced a closed canopy, limiting light and water needed for germination and seedling establishment (Bogaard et al. 2001). In Bogaard et al. (2001)'s German research area species that start their short flowering period between January and June are associated with autumn sowing, while species which are late and of short-medium duration flowering or late flowering and of early-intermediate onset are associated with spring-sown fields (Table 10.2).

Table 10.2: The differing classification for flowering onset and duration used at the sites. The Germany classification refers to Bogaard et al. (2001)'s study on which the technique is based.

Classification	Flowering onset	Duration	Site
Short flowering/ early intermediate onset	January -June	1-3 months	Germany, Çamlıbel West
	January - May	1-3 months	Çatalhöyük West, Kuruçay
Late flowering	July onwards	1-5 months	Germany, Çamlıbel West
	June onwards	1-5 months	Çatalhöyük West, Kuruçay
Long flowering	January- June	>5 months	Germany, Çamlıbel Tarlası
	January - May	>5 months	Çatalhöyük West, Kuruçay

Ethnographic research indicates that the majority of the species under cultivation in the Konya region are commonly autumn/winter sown: the wheats and barley during the autumn, pulses such as lentil and bitter vetch later in the winter (e.g. January)(Hillman 1981; Ertuğ-Yaras 1997; Palmer 1998). This does not rule out spring sowing of such species; some barley varieties not requiring long vernalisation periods can be spring sown, while some pulse species are frost-sensitive, needing spring sowing in regions of heavy frosts, something that has been recorded on the Anatolian plateau (Ertuğ-Yaras 1997). Given the dominance of the samples by glume wheats it is most likely that the weeds will reflect the sowing time of these species in particular.

The study of Bogaard et al. (2001) was conducted in Germany where crops were harvested during August. This method was adjusted for the Çatalhöyük West climate, using the predicted harvest month of June/July. Any taxa that started flowering up to and including May were classed as early-intermediate, while those flowering in or after June as late onset, as per Filipović (2014). Flowering length and flowering onset dates were collated from Davis (1965-1989). Table

10.3 shows the classification of taxa that contain 10 or less species based on flowering onset and length of flowering periods (see Chapter 4 for details). Five species have early-intermediate onset and short duration, one of which, *Descurainia*, is potentially a collected as well as arable weed. *Adonis* and *Lolium* are common modern crop weeds. There are also five species that indicate possible spring sowing conditions, having a late flowering onset or a long duration of flowering. Unfortunately the majority of species could not be classified due to the medium length of their flowering duration.
Spring and autumn sowing indicators are present in the Çatalhöyük West assemblage. However the long-flowering taxa, used as an indicator of spring sowing conditions, could potentially occur in autumn-sown, high-intensity cultivation as the long flowering buffers such species against disturbance, allowing them to regenerate by seed after disturbances such as weeding (Bogaard et al. 2001).

It has been noted that crop processing can bias the results due to the removal of spring-sown taxa during fine sieving (Jones 1992; Bogaard et al. 2005b). As the majority of the Çatalhöyük West samples are classified as fine-sieving by-products, it would be expected that spring-sown taxa would be more prevalent. Thus, given the higher number of autumn indicators, it is more likely that autumn sowing occurred, and the bias towards the preservation of spring-sown weed within fine-sieving by-products produced an over-emphasis of their occurrence.

The results are limited by the un-classifiable nature of taxa not identified to species but do indicate a preference for autumn sowing time indicators in the

assemblages. Overall, the results provide a mixture of autumn and spring sowing indicators: either glume wheats were sown in autumn and spring; glume wheats were sown in autumn and intensively cultivated resulting in spring indicators of high intensity cultivation; or glume wheats were sown in spring but in poorly cultivated plots, allowing the survival of autumn germinating taxa. Given the potential ambiguity of the long-flowering period species and their association with either spring sowing and/or intensive cultivation practices, an autumn sowing time appears to be more strongly supported by both this evidence and the isotopic evidence of probable manuring of the crops. The latter suggests higher fertility and so spring indicators may actually be reflecting fertility and not the season of sowing (Chapter 9). Further investigation of the intensity of cultivation practices is conducted below.

Table 10.3: Flowering onset, duration and resultant classification of sowing time for taxa from Çatalhöyük West samples

Taxa	No. of species	Flowering onset												Total months	Flowering onset class	Duration class	Combined class	Sowing class
		Winter			Spring			Summer			Autumn							
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov					
Adonis aestivalis	1					X								3	Early-intermediate	Short	Early-int/Short	A
Conringia orientalis	1				X									3	Early-intermediate	Short	Early-int/Short	A
Descurainia sophia	1					X								3	Early-intermediate	Short	Early-int/Short	A
Lolium temulentum	1						X							3	Early-intermediate	Short	Early-int/Short	A
Adonis annua/microcarpa	2					X								3	Early-intermediate	Short	Early-int/Short	A
Bolboschoenus glaucus					X									3	Early-intermediate	Short	Early-int/Short	A*
Verbena officinalis	1							X						3	Late	Short	Late	S
Polygonum aviculare	1								X					5	Late	Medium	Late	S
Convolvulus arvensis	1					X								6	Early-intermediate	Long	Long	(S)
Hyoscyamus	5			X	X	X	X							6	Early-intermediate	Long	Indeterminate	
Malva sp.	9					X	X	X	X					6	Early-inter/late	Long	Indeterminate	
Chenopodium album	5						X	X						4	Early-inter/late	Medium	Indeterminate	
Chrysanthemum cf. segetum	2				X	X								4	Early-intermediate	Medium	Indeterminate	
Eremopyrum	4				X	X	X							4	Early-intermediate	Medium	Indeterminate	
Hordeum murinum	1					X								4	Early-intermediate	Medium	Indeterminate	
Hordeum spontaneum	1						X							5	Early-intermediate	Medium	Indeterminate	
Lavatera	5					X	X							5	Early-intermediate	Medium	Indeterminate	
Polygonum convolvulus	1						X							5	Early-intermediate	Medium	Indeterminate	
Ranunculus arvensis	2				X									4	Early-intermediate	Medium	Indeterminate	
Taeniatherum caput-medusae	1						X							4	Early-intermediate	Medium	Indeterminate	
Thymelaea passerina	7			X		X			X		X			5	Early-inter/late	Medium	Indeterminate	
Vaccaria pyramidata	1					X								4	Early-intermediate	Medium	Indeterminate	
Ziziphora sp	5					X	X		X					5	Early-inter/late	Medium	Indeterminate	

10.1.3 Intensity of cultivation

The samples from Çatalhöyük West were examined to investigate the likely intensity of arable cultivation (i.e. labour inputs per unit area as gauged through soil fertility and mechanical disturbance). Only included were arable weed taxa that were identified to species, or, if identified to genus, had less than five potential species in that genera (Table 10.4). Only samples that contained 10 or more seeds of such taxa were included.

Table 10.4: The 24 taxa used to investigate the intensity of cultivation at Çatalhöyük West. In the cases where taxa were not identified to species, the species available with functional data were used, producing an average value for that taxon.

Species/taxa present in assemblage	Alternative species used for analysis
Adonis aestivalis L. Type	
Adonis microcarpa/annua	
Anagallis L.	*Anagallis arvensis*
Bolboschoenus glaucus (Lam.) S.G. Smith	
Bromus hordeaceus L./commutatus Schrad.	
Chenopodium album L. type	
Chrysanthemum cf. segetum type	
Conringia orientalis L.	
Convolvulus arvensis L. type	
Descurainia sophia (L.) Webb	
Eremopyrum (Ledeb.) Jaub. & Spach	*E. bonaepartis, E. distans, E. orientale*
Polygonum convolvulus L.	
Galium L., large type	*Galium aparine/tricornutum*
Galium verum type	
Hordeum murinum L. type	
Hordeum spontaneum C. Koch type	
Hyoscyanus type	*Hyoscyanus niger*
Polygonum aviculare	
Ranunculus cf. *arvensis* L. type	
Taeniatherum caput-medusae L.	
Thymelea cf. *passerina* (L.) Cosson & Germ.	
Vaccaria pyramidata Medik.	
Verbena officinalis L.	
Ziziphora capitata L. Bunge	

Data on the functional attributes of the arable taxa from field studies conducted in Morocco, Spain, France and Greece (Charles et al. 1997; Jones et al. 2000a: Jones et al. 2005; Bogaard et al. 2016a; Bogaard et al. 2016b) were used to discriminate between low and high intensity regimes (see Chapter 4 for details). The

discriminant function used to distinguish between these two regimes was in turn used to classify the archaeological samples as reflecting either high or low intensity regimes.

Figure 10.3a portrays the discriminant scores from the weed associations in modern field studies for low and high intensity regimes while (Figure 10.3b) shows results of the classification of the archaeological samples from Çatalhöyük West. Due to the uncertainty of the role of *Bolboschoenus* and *Descurainia* as an arable weeds, the analyses were also conducted excluding just *Bolboschoenus* (Figure 10.3c), as well as excluding *Bolboschoenus* and *Descurainia* (Figure 10.3d). The number of classifiable samples containing 10 seeds of the weed species used was therefore reduced, upon the exclusion of *Bolboschoenus,* from 40 to 37 samples and then to 20 when both *Bolboschoenus* and *Descurainia* were excluded. The classification of the samples is shown in Table 10.5. Examination of the number of seeds and number of taxa included in the individual samples indicates that there is no trend in classification regarding seed numbers nor number of species classified (Table 10.5).

The results indicate a wide spread of discriminant function scores for the Çatalhöyük West assemblage. The impact of including *Bolboschoenus* is significant, resulting in some samples returning very low discriminant function scores. Inclusion or exclusion of *Descurainia* has limited impact on the analysis and the samples' classification but does reduce significantly the number of samples that can be analysed.

Overall the analysis indicates that a wide range of "intensities" of crop husbandry practice is represented in the assemblage, varying in levels of fertility and mechanical disturbance. The nature of the samples, deriving as they do from midden deposits, means that mixing may have resulted from different events. Different growing conditions could therefore have been conflated into one sample: thus the results are not as clear as they could be if the samples were from storage deposits where one activity and potentially one harvest/field is represented. Generally the samples are highly variable but fall more towards the low-intensity side of the spectrum.

10.1.4 Combined results of weed-based and stable isotope analysis

The nitrogen stable isotope results indicate manuring in addition to an ecosystem-wide enrichment in ^{15}N at Çatalhöyük (Chapter 9), while the weed results indicate that the cultivation "intensities" at the site cover the spectrum from low to high. Such results are not contradictory; research in Morocco indicates that relatively low intensity regimes can include manuring (Bogaard et al. 2016b).

Direct comparability between the stable carbon and nitrogen isotope results and the weed results from the same individual samples is limited; modern research has indicated correlation only occurs when comparing across different agrosystems, not within them, and that a relationship between the weed and isotope values at the field level does not necessarily occur (Bogaard et al. 2016a; Bogaard et al. 2016b). In light of the limited connection between the isotope signatures and the weed flora within a given sample, it is better to view the weed

results on an assemblage-wide basis highlighting the wide variability in fertility and disturbances. This is in agreement with the stable carbon and nitrogen isotope results, which highlight high variability in both water availability and ^{15}N enrichment (Chapter 9).

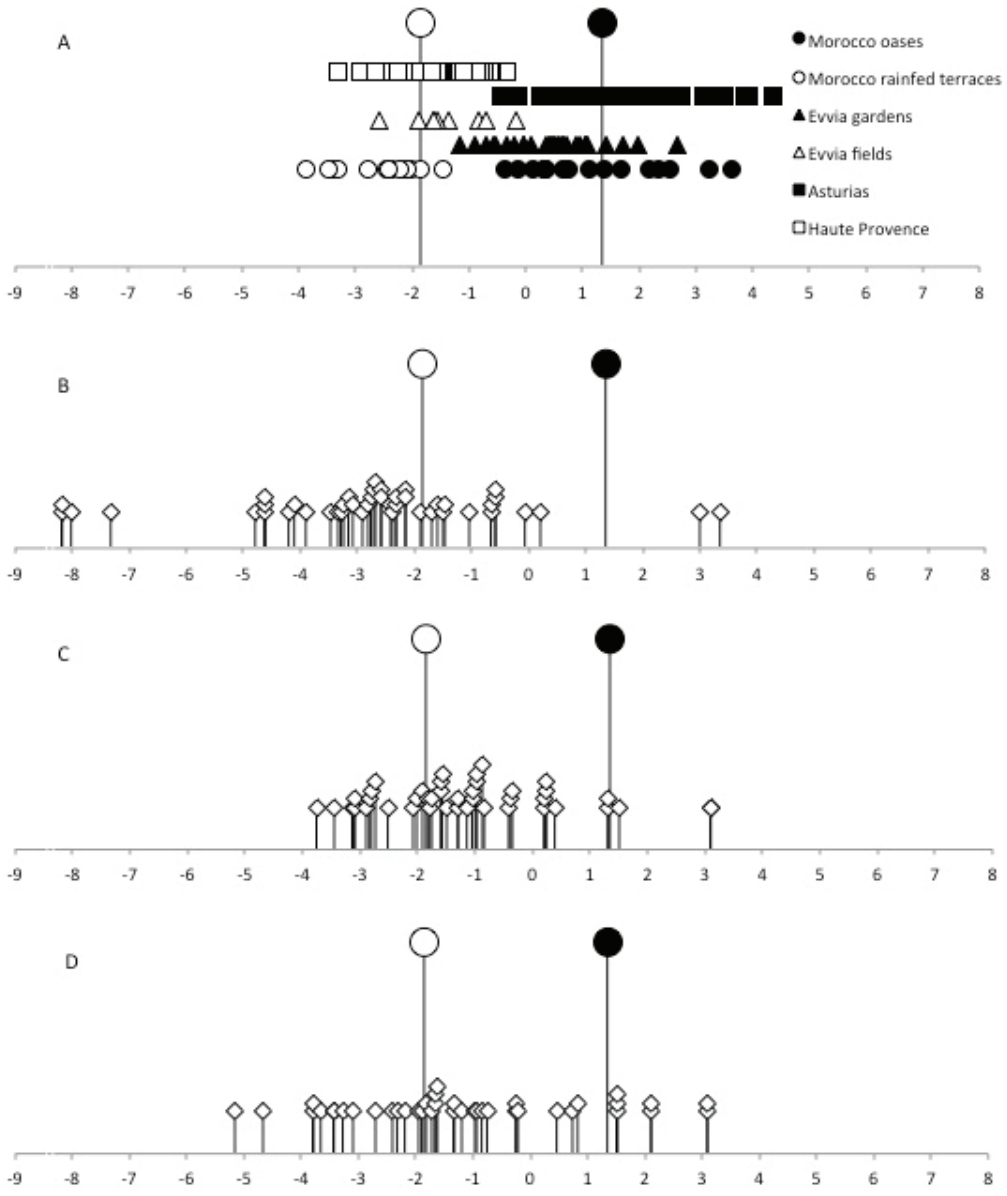


Figure 10.3: (A) shows the distribution of the different modern field surveys in relation to the discriminant function extracted to distinguish between the high (black) and low (white) intensity crop husbandry regimes. The large circles represent the group centroids. Graph (B) depicts the relationship of the Çatalhöyük West samples to the discriminant function used to separate the high and low modern regimes as shown in (A). (C) displays the relationship of the Çatalhöyük West samples to the discriminant function of the modern fields, with *Bolboschoenus* removed from the analysis, while (D) shows the relationship of the samples to the discriminant function when *Descurainia* and *Bolboschoenus* are both removed from the analysis.

Table 10.5. The number of taxa and items of taxa used in the discriminant analysis as well as the results of the discriminant analysis of the Çatalhöyük West samples, showing their classification as high- or low-intensity cultivation, with high or low probability. The results for the three different analyses, including and excluding *Bolboschoenus* and *Descurainia,* are shown.

	All taxa					Without *Bolboschoenus*					Without *Bolboschoenus* and *Descurainia*				
Sample	No. of items	No. of taxa	Intensity class	Probability		No. of items	No. of taxa	Intensity class	Probability		No. of items	No. of taxa	Intensity class	Probability	
				Level	%				Level	%				Level	%
9341	103	6	High	High	1.000	44	6	High	Low	0.816	20	5	High	High	0.908
9603	76	5	High	Low	0.813	42	5	Low	High	1	10	4	Low	High	1
Floor16777	251	10	High	Low	0.645	179	10	Low	High	0.991	26	9	Low	High	0.993
11100	27	4	High	High	1.000	23	4	Low	Low	0.862					
11087	128	3	Low	High	0.999	97	2	High	Low	0.826	16	1	High	High	0.997
11088	39	3	Low	Low	0.787	12	2	High	High	1	12	2	High	High	1
11093	64	4	Low	High	0.995	53	3	High	Low	0.812	13	2	High	High	0.97
9358	55	6	Low	High	0.925	29	5	High	Low	0.886					
9471	59	5	Low	Low	0.738	37	4	High	High	0.994					
10265	35	5	Low	Low	0.738	14	4	High	High	0.994					
11094	138	3	Low	High	0.999	107	2	High	Low	0.826					
11092	81	7	Low	High	0.982	53	6	Low	Low	0.604	13	5	High	Low	0.5
8911	161	8	Low	High	0.998	95	7	Low	High	0.965	30	6	Low	High	0.969
8953	148	10	Low	High	1.000	69	9	Low	High	0.999	29	8	Low	High	1
9519	137	5	Low	High	1.000	66	4	Low	High	1	10	3	Low	High	1
9619	128	4	Low	High	1.000	99	3	Low	High	1	11	2	Low	High	1
10100	313	5	Low	High	1.000	306	4	Low	High	0.996	10	3	Low	High	0.999
10110	107	6	Low	High	1.000	45	4	Low	High	1	11	3	Low	Low	0.894
11041	143	11	Low	High	0.999	107	10	Low	High	0.993	27	9	Low	High	0.995
11053	158	9	Low	High	0.999	124	8	Low	High	0.986	12	7	Low	High	0.989
11089	112	9	Low	High	0.999	75	8	Low	High	0.986	19	7	Low	High	0.989
11096	139	8	Low	High	1.000	109	7	Low	High	1	25	6	Low	High	1
u18341	212	8	Low	High	0.998	88	7	Low	High	0.966	40	6	Low	High	0.97

	All taxa					Without *Bolboschoenus*					Without *Bolboschoenus* and *Descurainia*				
Sample	**No. of items**	**No. of taxa**	**Intensity class**	**Probability**		**No. of items**	**No. of taxa**	**Intensity class**	**Probability**		**No. of items**	**No. of taxa**	**Intensity class**	**Probability**	
				Level	**%**				**Level**	**%**				**Level**	**%**
u31114	211	7	Low	High	1.000	141	6	Low	High	0.993	34	5	Low	High	0.995
u31210	324	10	Low	High	0.987	230	9	Low	Low	0.878	46	8	Low	Low	0.87
8360	20	5	Low	High	1.000	13	4	Low	High	0.98					
8461	39	5	Low	High	1.000	19	4	Low	High	0.995					
9524	21	3	Low	High	1.000	17	2	Low	High	1					
9562	38	5	Low	High	1.000	18	4	Low	High	1					
9564	105	5	Low	High	1.000	22	4	Low	High	0.997					
9591	56	6	Low	High	1.000	37	4	Low	High	1					
9600	63	5	Low	High	0.999	11	4	Low	High	0.911					
9613	56	6	Low	High	1.000	36	5	Low	High	0.986					
10099	46	6	Low	High	0.990	28	5	Low	Low	0.615					
10111	54	4	Low	High	1.000	35	3	Low	High	0.906					
11097	98	4	Low	High	1.000	75	3	Low	High	0.945					
Floor18376	73	7	Low	High	0.980	33	6	Low	Low	0.574					
9495	14	3	Low	Low	0.787										
9563	17	4	Low	High	1.000										
9602	13	2	Low	High	1.000										

10.2 Çamlıbel Tarlası

Chapters 5, 6 and 7 investigate the major components of the Çamlıbel Tarlası samples and their modes of entry into the charred plant assemblage. Through the results of the analyses in Chapters 7 and 8, wild taxa potentially not derived from crop processing were removed prior to ecological analysis of the potential weed assemblage. Table 10.6 summarises the species contributing to the assemblage, and their hypothesised derivation.

Table 10.6: The wild species found in the Çamlıbel Tarlası assemblage, providing the number of potential species the taxa could represent, its ubiquity and proportion of total wild seeds, as well as its lifecycle, annual (a), perennial (p), and the habitat preferences of the perennial species (disturbed (dis) or non-disturbed (non-dis)) or the taxa classed as deriving from arable fields.

Species	Ubiquity (%)	% of wild seeds	Class	Lifecycle (Habitat)	No. of species
Sporobolus R. Br. (*S. virginicus* (L.) Kunth type)	16.4	0.9	Dung		
Eragrostis N.M. Wolf	6.0	0.3	Dung		
Artemisia annua L. type	1.5	0.1	Dung		
Crypsis aculeata (L.) Aiton type	1.5	0.0	Dung		
Phalaris cf minor Retz.	79.1	8.4	Crop/dung	a	1
Polygonum aviculare	61.2	4.2	Crop/dung	a	1
Anagallis L. type	28.4	2.2	Crop/dung	a	1
Silene, small	13.4	0.7	Crop/dung	a/p	2
Silene, type 2	10.4	0.4	Crop/dung	a/p	2
Ranunculus sceleratus	9.0	0.3	Crop/dung	a	1
Chenopodium L.	3.0	0.1	Crop/dung	a	11
Salsola L.	1.5	0.0	Crop/dung	a/p	2
Bolboschoenus glaucus (Lam.) S.G. Smith	1.5	0.0	Crop/dung	p (dis)	1
Lolium L., small type	97.0	51.0	Crop - flax	a	2
Silene, type1	47.8	2.8	Crop - flax	a/p	2
Galium aparine/tricornutum types	88.1	3.3	Crop	a/p	2
Vicia L./*Lathyrus* L.	68.7	2.3	Crop	a/p	2
Bifora radians Bieb.	68.7	1.3	Crop	a	1
Thymelea cf. passerina (L.) Cosson & Germ. type	61.2	1.4	Crop	a/p	2
Asperula arvensis L.	62.7	1.8	Crop	p (dis)	3
Bromus arvensis L.	56.7	1.9	Crop	a/p	2
Polygonum convolvulus L.	50.7	1.4	Crop	a/p	2
Ranunculus arvensis L. type	52.2	0.8	Crop	a	1
Vaccaria pyramidata Medik.	50.7	1.3	Crop	a	1
Stipa L.	49.3	1.2	Crop	p(non-dis)	4
Lolium temulentum L.	40.3	0.9	Crop	a	1

Species	Ubiquity (%)	% of wild seeds	Class	Lifecycle (Habitat)	No. of species
Rumex L.	25.4	0.3	Crop	a/p	2
Heliotropium L.	16.4	0.4	Crop	a	1
Cruciata Millier, cf.	16.4	0.1	Crop	a/p	2
Leguminosae , small wild	35.8	1.0	Crop	a/p	>150
Sideritis L. type	13.4	0.4	Crop	p (dis)	3
Ajuga/Teucrium type	11.9	0.1	Crop	p (dis)	3
Ziziphora capitata L./persica Bunge	11.9	0.5	Crop	a/p	2
Hordeum murinum L. type	11.9	0.1	Crop	a	1
Lallemantia, cf.	10.4	0.1	Crop	a/p	3
Lavatera L. type	10.4	0.1	Crop	a/p	2
Taeniatherum caput-medusae L.	10.4	0.1	Crop	a	1
Bromus rigidus/diandrus	10.4	0.2	Crop	a/p	2
Carex L.	9.0	0.1	Crop	p(non-dis)	4
Trigonella astroites type	7.5	0.2	Crop	a	1
Atriplex L.	7.5	0.1	Crop	a	1
Chrysanthemum cf. segetum type	6.0	0.0	Crop	a	1
Convolvulus arvensis L. type	6.0	0.1	Crop	p (dis)	3
Verbascum type 1	6.0	0.2	Crop	a/p	2
Verbascum type 2	6.0	0.3	Crop	a/p	2
Centaurea sp.	4.5	0.0	Crop	a/p	2
Valerianella Mill.	4.5	0.0	Crop	a	1
Alyssum type	4.5	0.0	Crop	a/p	2
Hordeum spontaneum C. Koch type	4.5	0.1	Crop	a	1
Chenopodium album L. type	3.0	0.1	Crop	a	1
Conringia orientalis L.	3.0	0.1	Crop	a	1
Medicago sp.	3.0	0.1	Crop	a/p	2
Avena sp	4.5	0.0	Crop	a	1
Poa type	3.0	0.0	Crop	a/p	2
Primulaceae, large type	3.0	0.3	Crop	a/p	16
Hyoscyanus type	3.0	0.1	Crop	a/p	6
Onopardum type	1.5	0.0	Crop	a	17
Geranium L.	1.5	0.0	Crop	a/p	2
Malva L.	1.5	0.1	Crop	a/p	9
Fumaria L.	1.5	0.0	Crop	a	1
Adonis sp.	1.5	0.0	Crop	a	1
Galium L., small cf. *verum*	1.5	0.0	Crop	a/p	2
Sherardia arvensis L., cf.	1.5	0.0	Crop	a	1

All taxa classed as dung-derived were removed from further crop husbandry analysis below. Some taxa that are potentially dung *and* crop-derived were still included, as they may have entered the assemblage from both dung burning and harvested crop materials. Given the overall limited contribution of dung taxa to the assemblage their impact is minimal.

The preceding chapters' research on the samples from Çamlıbel Tarlası provides an understanding of the crop component of the samples, their likely derivation and inferences as to the likely association between crops and weeds. Glume wheat items dominate Çamlıbel Tarlası's samples with no other crop group dominating (>70%) a sample. Given the dominance of glume wheats it is likely that at least some of the weed material is associated with them. However, flax weeds also demonstrably occur in the samples and form a significant proportion of the weed assemblage (Table 10.6). As seen in Chapter 8, they have a significant impact on the classification of the samples: only when flax weed seeds are removed are the majority of samples likely to be classified as fine-sieving by-products (section 8.2). Thus some samples contain a combination of glume wheat and flax processing waste and it is possible that the weed seeds reflect a mixture of flax and glume wheat growing conditions and husbandry practices, even if the dominant flax weed, small-seeded *Lolium*, is removed. The mixed nature of the samples therefore offers a generalised agroecological signal, contrasting with crop-specific practices that can be inferred from in situ storage deposits, such as at Kuruçay (section 10.3).

10.2.1 Permanence of cultivation

Figure 10.4 shows the high proportion of annual and annual/perennial seeds in the Çamlıbel Tarlası assemblage, comprised primarily of small-seeded *Lolium* (Figure 10.4a). All 63 samples contain seeds from annual species, with perennials from un-disturbed or disturbed habitats found in 82% of samples (52 samples)(Figure 10.4b). The presence of annuals in 100% of the examined

samples is not explained simply by the ubiquitous occurrence of *Lolium*; all samples contain seeds from other annual taxa. Overall there is a notable presence of annual seeds and annual taxa within the Çamlıbel Tarlası assemblage.

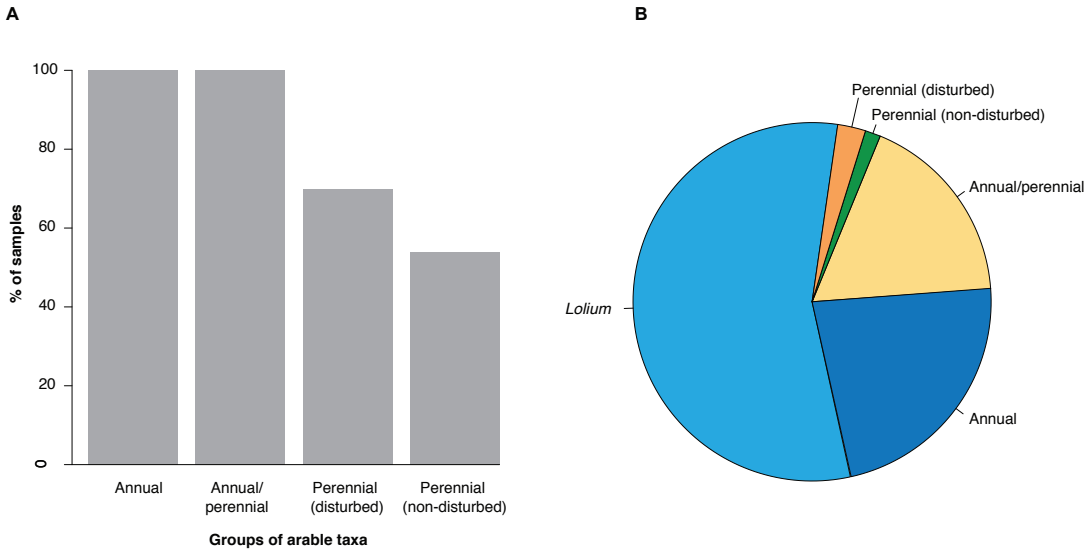


Figure 10.4: Bar chart (A) displays the percentage of Çamlıbel Tarlası samples that contain taxa with annual, perennial lifecycles from disturbed or non-disturbed habitats. Graph (B) presents the proportion that the seeds of such categories represent. Small-seeded *Lolium* (an annual) is shown as a lighter shade of its corresponding classification.

Six taxa were classed as perennials, two from undisturbed habitats, *Carex* and *Stipa. Stipa*, with 153 items, occurs in 45% of samples, while *Carex* occurs in 8% of samples (Table 10.6). These two taxa have very different habitats; *Stipa* is principally a steppe genus, while *Carex* species have habitat preferences ranging from wet/marsh environments to dry forests (Davis 1965-1989). Four other perennials were identified, deriving principally from disturbed habitats, and ranging in abundance. The main contributor to the assemblage is *Asperula* cf. *arvensis*, which occurs in 59% of samples (Table 10.6). Generally there are limited perennial species indicative of undisturbed environments.

Examination of the number of seeds of perennial taxa in the samples indicates that while occurring in 82% of samples, perennial seeds make up only 25% or less of the total seed assemblage (Figure 10.5a). A similar trend is detected when the proportion of occurrence of perennial taxa in the assemblage is graphed (Figure 10.5b).

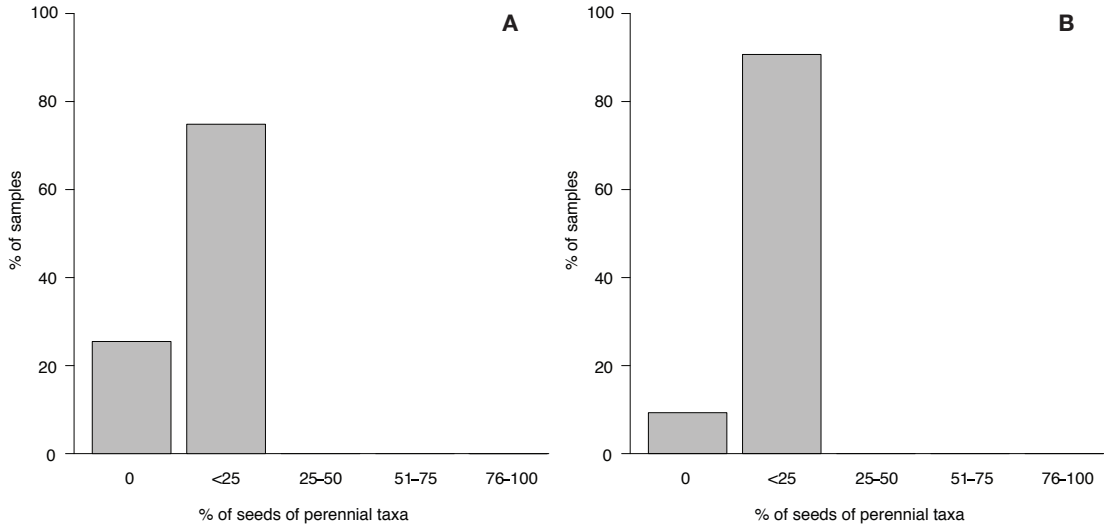


Figure 10.5: Histogram (A) displays the proportion of perennials based on seed counts in the Çamlıbel Tarlası samples containing at least 10 weed seeds (n= 63), (B) shows the proportion of perennials in the samples based on taxon counts including only samples containing 10 or more weed taxa (n =43).

Examination of the proportion of perennial taxa in the assemblage across the four occupation phases indicates limited variation (graphs not shown). CBTI, the phase spanning the foundation of the settlement, would be expected to have higher proportions of perennials if agriculture, requiring the clearance of areas for fields, commenced upon site settlement. It is also possible that the fields from the phases after the two periods of ephemeral site use (CBTIII and CBTIV), if abandoned and reforestation commenced, would have high quantities of perennials. However there is no evidence of the 57-100% perennial species recorded in the Hambach plots (Bogaard 2002b). Based on present identification

levels there is limited evidence of newly cleared plots, with all phases containing relatively low proportions of perennial seeds and taxa. This suggests two possibilities. Firstly, the samples may date from at least six years after the commencement of cultivation. The Hambach study was conducted over six years with no decline in perennials, leading to the conclusion that perennials must start to decline after a specific length of cultivation longer than six years. Secondly, the fields were possibly intensively managed from the commencement of agriculture, providing limited survival opportunity for perennials with a habitat preference for un-disturbed environments, thus promoting the survival of annuals and perennials adapted to disturbed conditions (Bogaard 2002b). Overall, the results indicate the use of well-established arable plots throughout the duration of site settlement.

10.2.2 Sowing time

The crop sowing times for Çamlıbel Tarlası were investigated through identification of the flowering duration and onset of arable weed species in the samples (see section 10.1.2 for details). In addition to the cereals and pulses in the assemblage, flax presents as an additional taxon, which, similar to the others, could be sown either in autumn or spring. Ethnographic accounts indicate that sowing time may depend on the use of flax; spring-sown flax produces long fibres ideal for textile making, while autumn-sown flax is more suitable for oil production due to its high oil content (Ertuğ 2010).

Harvest time in the Çamlıbel Tarlası regions is predicted as July/August (see Chapter 2). This harvest time correlates with the German harvest time used in the Bogaard et al. (2001) study, and so the categories for the different flowering onsets remained unchanged, with the early-intermediate category referring to onset between January and June, and the late category including anything flowering from July onwards (Table 10.2). Long-flowering onset, as in the Çatalhöyük West analysis, refers to species that flower for more than 5 months (Table 10.2).

Examination of the species' flowering time in the Çamlıbel Tarlası assemblage highlights the limitations imposed by imprecise identification coupled with the limited regional detail of specific flowering times cited in the *Flora of Turkey* (Davis 1965-1989). The majority of species/taxa could not be classified based on flowering onset and length, due to either different potential onset dates for species within the genus or a moderate length of flowering period falling between the two classes (4-5 months) (Table 10.7).

The only late-flowering species is *Polygonum aviculare*. Five taxa are classed as long flowering with durations over five months: *Anagallis* occurs in 19 samples (26%) with the other four occurring in less than five samples (Table 10.7). Two of these species, *Avena* and *Hyoscyamus,* have long flowering periods, but classification of flowering onset is difficult due to the multiplicity of possible species. Only one species in each of these groups has a flowering length longer than five months, *Avena sterilis* and *Hyoscyamus aureus*. It is therefore possible that their identification as spring indicators is erroneous and they are therefore

discounted. There are three autumn-classified taxa: *Adonis*, *Lallemantia* and *Lolium temulentum*.

Both spring and autumn sowing-classed taxa occur in the assemblage (Table 10.7). However, as previously noted, the long-flowering-duration taxa, used as an indicator of spring sowing conditions, could also potentially occur in autumn-sown, high-intensity cultivation, as the long flowering period buffers such species against disturbance. It has been noted that crop processing can bias the results due to the removal of spring-sown taxa during fine sieving (Bogaard et al. 2005b). Most of the Çamlıbel Tarlası samples were classified as fine-sieving by-products, with limited samples classed as product. It would be expected then that spring-sown taxa would be more prevalent due to the higher frequency of fine-sieving by-product. Thus the results could indicate a mixture of autumn and spring sowing times at the site, or they may indicate that the majority of crops were sown during the autumn and the occurrence of some spring species is the result of over-emphasis due to crop processing. Alternatively, crops may have been sown in spring but poorly managed, or grown in autumn using intensive crop husbandry practices.

Table 10.7: The flowering onset, length of flowering and resultant classification of the species from Çamlıbel Tarlası.

Taxa	No. of species	Flowering onset												Total months	Onset classification	Duration classification	Combined classification	Sowing class
		Winter			Spring			Summer			Autumn							
		Dec	Jan	Feb	Ma	Apr	Ma	Jun	Jul	Au	Sep	Oct	No					
Adonis aestivalis	1					X								3	Early-intermediate	Short	Early-int/Short	A
Lallemantia	3					X	X	X						3	Early-intermediate	Short	Early-int/Short	A
Lolium temulentum	1						X							3	Early-intermediate	Short	Early-int/Short	A
Polygonum aviculare	1								X					5	Late	Medium	Late	S
Anagallis sp	2					X	X	X						6	Early-intermediate	Long	Long	(S)
Convolvulus arvensis	1					X								6	Early-intermediate	Long	Long	(S)
Sherardia arvensis	1					X								6	Early-intermediate	Long	Long	(S)
Hyoscyamus	5			X	X	X	X							6	Early-intermediate	Long	Indeterminate	
Avena sp.	6				X	X		X						6	Early-intermediate	Long	Indeterminate	
Hordeum spontaneum	1						X							5	Early-intermediate	Medium	Indeterminate	
Bifora radians	1					X								5	Early-intermediate	Medium	Indeterminate	
Chenopodium album	5						X	X						4	Early-intermediate	Medium	Indeterminate	
Chrysanthemum cf. segetum	2				X	X								4	Early-intermediate	Medium	Indeterminate	
Cruciata sp	5				X	X	X							4	Early-intermediate	Medium	Indeterminate	
Hordeum murinum	1					X								4	Early-intermediate	Medium	Indeterminate	
Lavatera	5					X	X							5	Early-intermediate	Medium	Indeterminate	
Phalaris cf *minor*	8					X								4	Early-intermediate	Medium	Indeterminate	
Polygonum convolvulus	1						X							5	Early-intermediate	Medium	Indeterminate	
Ranunculus arvensis	2				X									4	Early-intermediate	Medium	Indeterminate	
Taeniatherum caput-medusae	1						X							4	Early-intermediate	Medium	Indeterminate	
Atriplex	7						X	X						4	Early-intermediate	Medium	Indeterminate	
Vaccaria pyramidata	1					X								4	Early-intermediate	Medium	Indeterminate	
Small-seeded *Lolium*	4					X								4	Early-intermediate	Medium	Indeterminate	
Ziziphora sp	5					X	X		X					5	Early-inter/late	Medium	Indeterminate	
Thymelaea passerina	7			X		X			X		X			5	Early-inter/late	Medium	Indeterminate	

10.2.3 Intensity of cultivation

The intensity of arable cultivation was assessed for the Çamlıbel Tarlası samples using the same protocol used for the Çatalhöyük West samples as outlined in Chapter 4. Only taxa that had been identified to species were used, or if identified to genus, had less than five potential species within that genus (Table 10.8). Only samples that had 10 or more seeds of such taxa were included in the analysis.

Table 10.8: The 30 taxa used to investigate the intensity of cultivation at Çamlıbel Tarlası. In the cases where taxa were not identified to species, the species available with functional data were used, producing an average value for that taxon.

Species/taxa present in assemblage	Alternative species used for analysis
Adonis sp.	*Adonis aestivalis*
Anagallis L. type	*Anagallis arvensis*
Asperula arvensis L.	
Avena sp.	*A. fatua, A. sativa, A. sterilis*
Bifora radians Bieb.	
Bolboschoenus glaucus (Lam.) S.G. Smith	
Bromus rigidus Roth/ *diandrus* Roth.	
Bromus arvensis L.	
Chenopodium album L. type	
Chrysanthemum cf. segetum type	
Conringia orientalis L.	
Convolvulus arvensis L. type	
Cruciata Millier, cf.	*C. laevipes , C. taurica*
Galium L. cf. *aparine*	
Galium L. cf. *tricontum*	
Galium L., cf. *verum*	
Hordeum murinum L. type	
Hyoscyamus L. type	*Hyoscyamus niger*
Lolium L., small type	*L. remotum*
Lolium temulentum L.	
Medicago radiata	
Phalaris cf. *minor* Retz.	
Polygonum aviculare	
Polygonum convolvulus L.	
*Ranunculus arvensi*s L. type	
Sherardia arvensis L., cf.	
Taeniatherum caput-medusae L.	
Thymelea cf. *passerina* (L.) Cosson & Germ. type	
Vaccaria pyramidata Medik.	
Ziziphora capitata L.	

Figure 10.6a shows the discriminant analysis scores from the weed associations in modern field studies for low and high intensity regimes. Figure 10.6b shows the results of the classification of the archaeological samples from Çamlıbel Tarlası against the discriminant score from the modern studies. The results indicate a concentrated range of scores centring on a discriminant function score of -1; the majority of the samples are classified as coming from low-intensity regimes but fall within the overlapping zone between low- and high-intensity regimes (Table 10.9). There are some high intensity samples, and while the samples are generally classed as low-intensity it is toward the higher intensity end of this group. Examination of the probability of the classifications reflects the intermediate position of most samples, with only 29 of the 67 sample classifications having a probability of over 90% (Table 10.9).

Given the high proportion of flax weeds in the samples, investigation without small-seeded *Lolium* was conducted to understand its impact. Removal of this species had limited impact on the overall results (Figure 10.6c).

Examination of the different occupation phases from which the samples came indicates limited chronological variation (figure not shown).

The analysis shows that the samples have a restricted range of intensities concentrating around the midpoint of the two regime types measured in the modern field studies. Overall the samples indicate that the crop husbandry practices used on different fields for primarily glume wheat at Çamlıbel Tarlası

were consistent, the exceptions being the six samples possessing a more lower-intensity signature.

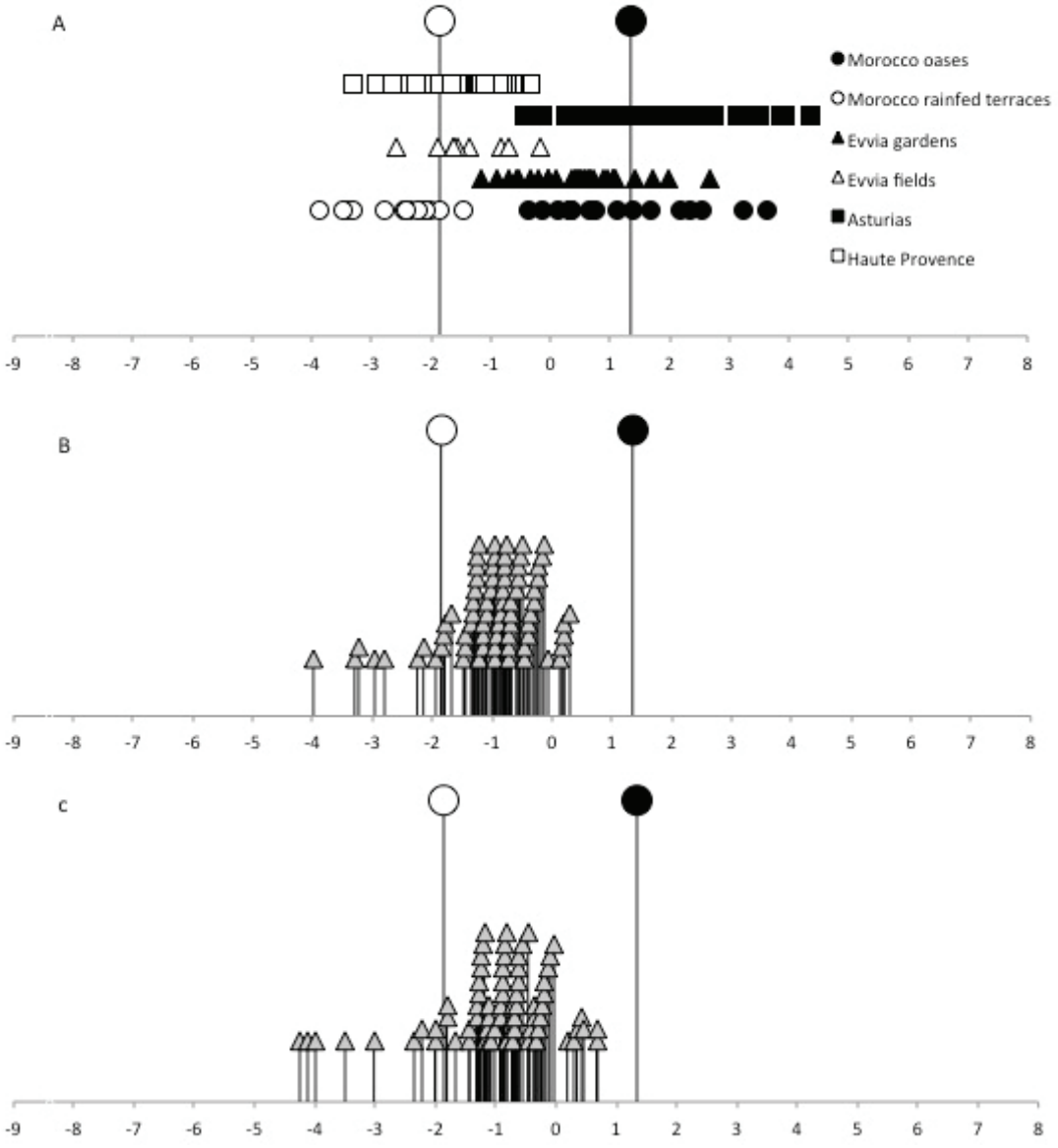


Figure 10.6: (A) Distribution of the modern field surveys in relation to the discriminant function extracted to distinguish between the high (black) and low (white) intensity crop husbandry regimes. The large circles represent the group centroids. Graph (B) shows the relationship of the Çamlıbel Tarlası samples to the discriminant function used to separate the high and low modern regimes shown in (A). (C) depicts the relationship of the samples to the discriminant function when small-seeded *Lolium* is removed from the analysis.

Table 10.9: The number of taxa and items of taxa used in the discriminant analysis as well as the results of the discriminant analysis of the Çamlibel Tarlası samples, shorted by intensity classification of high- or low-intensity cultivation, with high or low probability shown. The results are shown of two different analyses, including and excluding small-seeded *Lolium*.

Sample	Phase	All eligible arable weeds					No flax weed included				
		No. of seeds	No. of taxa	Intensity class	Probability		No. of seeds	No. of taxa	Intensity class	Probability	
					%	Level				%	Level
337	CBT I	37	12	High	0.57	Low	22	11	High	0.672	Low
406	CBT I	53	11	High	0.792	Low	21	10	High	0.872	Low
17	CBT I	260	12	High	0.782	Low	16	11	High	0.858	Low
396	CBT II	25	5	High	0.814	Low	11	4	High	0.951	High
132	CBT II	58	6	High	0.604	Low	22	5	High	0.804	Low
419	CBT II	143	11	High	0.523	Low	32	10	High	0.634	Low
366	CBT III	18	4	High	0.651	Low					
m440	CBT III	99	13	High	0.515	Low	38	12	High	0.609	Low
48	CBT IV	41	6	High	0.856	Low					
306	CBT IV	89	9	High	0.81	Low	18	8	High	0.9	High
19	CBT I	114	8	Low	0.96	High	22	7	Low	0.952	High
425	CBT I	114	8	Low	0.661	Low	50	7	Low	0.53	Low
90	CBT I	127	11	Low	0.851	Low	38	10	Low	0.813	Low
209	CBT I	137	17	Low	0.876	Low	97	16	Low	0.858	Low
421	CBT I	141	10	Low	0.96	High	109	9	Low	0.954	High
226	CBT I	146	14	Low	0.851	Low	93	13	Low	0.822	Low
54	CBT I	184	12	Low	0.71	Low	80	11	Low	0.639	Low
357	CBT I	219	17	Low	0.793	Low	114	16	Low	0.759	Low
361	CBT I	276	12	Low	0.855	Low	58	11	Low	0.822	Low
358	CBT I	363	17	Low	0.818	Low	175	16	Low	0.788	Low
79	CBT I	515	11	Low	0.608	Low	130	10	Low	0.508	Low
49	CBT I	666	17	Low	0.966	High	206	16	Low	0.964	High
392	CBT I	734	18	Low	0.89	Low	232	17	Low	0.875	Low
m877	CBT I	1003	20	Low	0.945	High	805	19	Low	0.94	High
186/202	CBT II	17	2	Low	0.994	High					

Sample	Phase	All eligible arable weeds					No flax weed included				
		No. of seeds	No. of taxa	Intensity class	Probability		No. of seeds	No. of taxa	Intensity class	Probability	
					%	Level				%	Level
76/12	CBT II	21	6	Low	0.716	Low					
78/116	CBT II	26	8	Low	0.864	Low					
213	CBT II	27	6	Low	1	High					
422	CBT II	35	9	Low	0.97	High					
113/6	CBT II	37	10	Low	0.818	Low					
74/3	CBT II	38	11	Low	0.886	Low	19	10	Low	0.859	Low
200	CBT II	41	3	Low	0.968	High	41	3	Low	0.968	High
321	CBT II	52	8	Low	0.998	High	19	7	Low	0.998	High
210	CBT II	66	9	Low	0.905	High	37	8	Low	0.879	Low
427	CBT II	96	10	Low	0.947	High	38	9	Low	0.937	High
400	CBT II	128	13	Low	0.91	High	85	12	Low	0.893	Low
365	CBT II	133	13	Low	0.661	Low	42	12	Low	0.586	Low
180	CBT II	175	12	Low	0.955	High	22	11	Low	0.95	High
405	CBT II	217	10	Low	0.679	Low	153	9	Low	0.582	Low
411	CBT II	260	13	Low	0.979	High	48	12	Low	0.977	High
423	CBT II	294	11	Low	0.901	High	55	10	Low	0.878	Low
428	CBT II	397	10	Low	0.839	Low	68	9	Low	0.791	Low
415	CBT II	589	10	Low	0.845	Low	56	9	Low	0.799	Low
m466	CBT III	53	13	Low	0.993	High	25	12	Low	0.993	High
370	CBT III	20	4	Low	0.901	High	10	3	Low	0.809	Low
35/38	CBT III	47	7	Low	1	High	31	6	Low	1	High
m439	CBT III	53	9	Low	0.75	Low	18	8	Low	0.662	Low
45	CBT III	62	9	Low	0.793	Low	16	8	Low	0.721	Low
46	CBT III	88	14	Low	0.571	Low	51	13	High	0.509	Low
377/365	CBT III	89	11	Low	0.727	Low	29	10	Low	0.651	Low
311	CBT III	114	14	Low	0.526	Low	34	13	High	0.558	Low
88	CBT III	117	12	Low	0.947	High	68	11	Low	0.939	High
42	CBT III	123	16	Low	0.938	High	61	15	Low	0.93	High

Sample	Phase	All eligible arable weeds					No flax weed included				
		No. of seeds	No. of taxa	Intensity class	Probability		No. of seeds	No. of taxa	Intensity class	Probability	
					%	Level				%	Level
223	CBT III	151	14	Low	0.901	High	50	13	Low	0.885	Low
75	CBT III	165	16	Low	0.815	Low	77	15	Low	0.782	Low
m887	CBT III	270	14	Low	0.8	Low	146	13	Low	0.759	Low
139	CBT IV	199	8	Low	0.989	High	23	7	Low	0.989	High
324	CBT IV	49	7	Low	0.993	High	16	7	Low	0.993	High
m632	CBT IV	54	10	Low	0.917	High	24	9	Low	0.897	Low
310	CBT IV	76	11	Low	0.954	High	40	10	Low	0.947	High
50	CBT IV	82	9	Low	0.966	High	24	8	Low	0.96	High
325	CBT IV	89	16	Low	0.617	Low	42	15	Low	0.552	Low
238	CBT IV	138	11	Low	0.932	High	15	10	Low	0.92	High
224	CBT IV	181	7	Low	0.91	High					
204	CBTII/CBTII	223	14	Low	0.533	Low	38	13	High	0.551	Low
424	CBTIII/IV	111	8	Low	0.979	High	35	7	Low	0.978	High
60	CBTIII/IV	114	7	Low	0.998	High	72	6	Low	0.999	High

10.2.4 Combined results of weed-based and stable isotope analysis

The overall intermediate results (i.e. falling between the two extremes of the modern high- and low-intensity regimes) of the weed ecology reflects the partial trend seen in the isotopes research where some samples show evidence of moderate manuring but others are suggestive of only a low manuring signature (Chapter 9). Given the lack of correlation of isotope and weed scores on a field by field basis in modern studies, a generalised assemblage-wide understanding of growing conditions in the crop fields can instead be constructed. The low to moderate nitrogen enrichment corresponds to the limited range of "intensities" seen in the weed data, presenting a picture of a cohesive set of crop husbandry practices at the site.

The notion that the inhabitants of Çamlıbel Tarlası were supported by larger communities seems unlikely given the crop husbandry results. The highly consistent findings on the intensity of cultivation for the samples suggest a community producing crops using similar methods. In a large-scale surplus-producing system, which could be hypothesised, excess crops for trade would be produced at the extensive, low input end of the cultivation spectrum (Halstead 2014:351, and this is not the case at Çamlıbel Tarlası.

10.3 Kuruçay

Identification of sowing time and permanence of plots and examination of the intensity of the plots was attempted for Kuruçay. Due to the storage nature of the Kuruçay material a direct association of weed seeds with particular crops

provides the opportunity to investigate the crop husbandry of different crop species.

10.3.1 Permanence of cultivation

Examination of the lifecycle of weeds in the Kuruçay assemblage revealed the occurrence of only three perennial species: *Stipa*, *Festuca* and *Asperula* cf. *arvensis*. As mentioned, *Stipa* prefers undisturbed steppe environments while *Festuca* and *Asperula* prefer disturbed habitats. Due to limited numbers of weed items, only nine samples met the eligibility criteria for inclusion in any graphical representation.

The assemblage comprises a high proportion of annual and annual/perennial seeds, the main contributor being the flax samples containing high proportions of *Lolium* and *Silene* seeds (Figure 10.7). All nine samples contain annual/perennial seeds, but perennial seeds only occur in limited samples; four samples contain perennials of disturbed habitats, two samples contain *Stipa*, indicating non-disturbed niches, and four samples contain perennials from disturbed habitats. Overall they contribute less than 25% of the total seed for all nine samples (Figure 10.7).

Examination of the proportions of perennial seeds per sample reveals low levels, with perennials contributing less than 25 % of the seed totals for all nine samples (Figure 10.8). No single sample contained ten or more weed taxa and so the proportion that perennial taxa contributed to sample taxon numbers was not graphed.

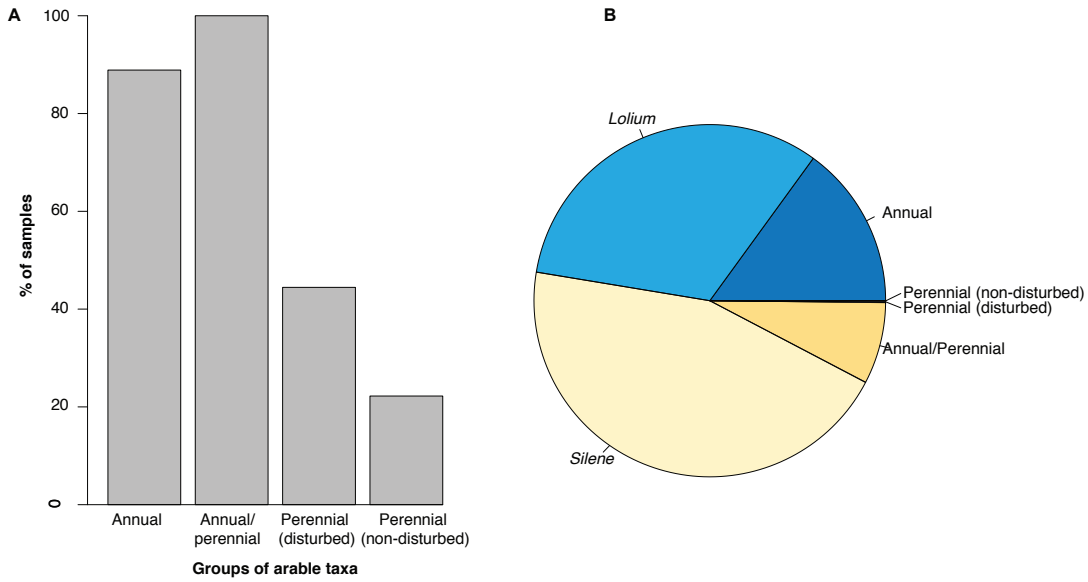


Figure 10.7 Bar chart (A) displays the percentage of Kuruçay samples containing taxa with annual, perennial lifecycles from disturbed or non-disturbed habitats. Graph (B) presents the proportion represented by seeds of such categories. Small seeded *Lolium* (an annual) and *Silene* (either an annual or perennial) are shown as a lighter shade of their corresponding classification.

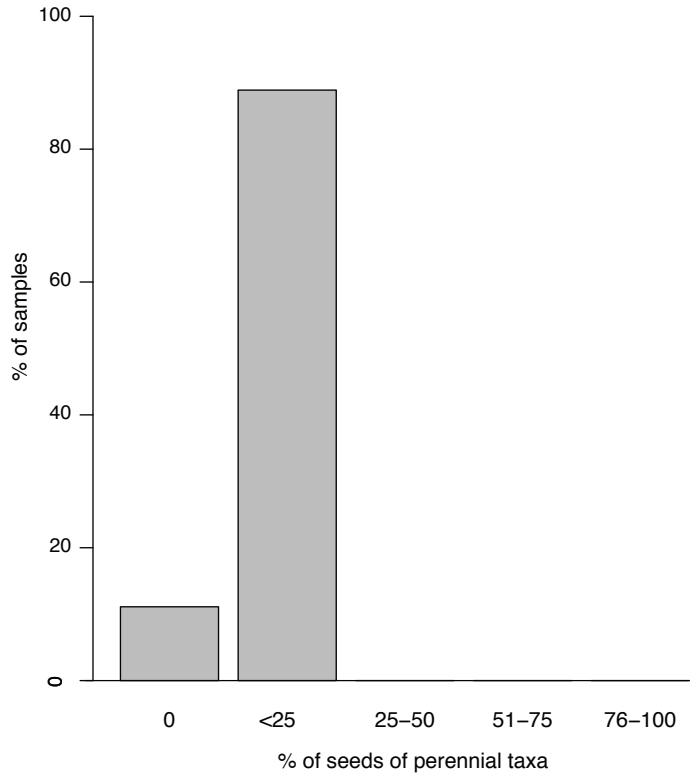


Figure 10.8: Histogram showing the proportion of perennials based on seed counts in the Kuruçay samples containing at least 10 weed seeds (n=9).

The Kuruçay material shows little evidence of recently cleared fields. The only perennial with a preference for undisturbed environments is that of *Stipa*, possibly indicating the location of fields near steppe environments. Overall the assemblage is dominated by annuals and there is no evidence of ephemeral field use or recent clearance.

10.3.2 Sowing time

Only ten of the taxa from the Kuruçay assemblage fulfilled the requirements needed for inclusion in analysis of sowing time (less than ten potential species of a taxa). Harvest time for Kuruçay was predicted as around June/July, similar to that of Çatalhöyük West and so the same divisions were used to classify the species based on flowering onset and duration (Table 10.2).

Only one taxa was classed as a potential indicator of spring sowing: *Avena.* As previously mentioned, the validity of including *Avena* as a long-flowering species is questionable. It is also possible that long-flowering species could be present due to intensive cultivation of autumn-sown crops. Four species are indicators of autumn sowing, having a short flowering duration and early onset flowering time: *Conringa, Triticum boeoticum* and two *Camelina* species (Table 10.10).

As all except the flax samples from Kuruçay are fine-sieving products, there is a possibility that spring-sown indicators have been removed during crop processing (Bogaard et al. 2005b). Unfortunately the only analysed samples from Kuruçay are storage samples and so assessment has to rely solely on product samples.

Table 10.10: The flowering onset, length of flowering and resultant classification of sowing time for the species from Kuruçay.

	No. of species	Flowering period												Total months	Onset class	Duration class	Combined class	Sowing class
		Winter			Spring			Summer			Autumn							
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov					
Camelina microcarpa	2				X									3	Early-intermediate	Short	Early-int/short	A
Camelina sativa	1				X									3	Early-intermediate	Short	Early-int/short	A
Conringia orientalis	1				X									3	Early-intermediate	Short	Early-int/short	A
Triticum boeoticum	1						X							3	Early-intermediate	Short	Early-int/short	A
Avena sp.	6				X	X		X						6	Early-inter/late	Long	Indeterminate	
Cruciata sp	5				X	X	X							4	Early-intermediate	Medium	Indeterminate	
Hordeum murinum	1					X								4	Early-intermediate	Medium	Indeterminate	
Small-seeded *Lolium*	4					X	X							4	Early-intermediate	Medium	Indeterminate	
Taeniatherum caput-medusae	1						X							4	Early-intermediate	Medium	Indeterminate	
Vaccaria pyramidata	1					X								4	Early-intermediate	Medium	Indeterminate	

It is likely that the crops at Kuruçay were autumn-sown but there is the possibility that crop processing may have removed any spring indicators; the crops at the site may have been sown in both spring and autumn. Given the storage nature of these crops, direct association of weed species with crop species can be made. There is however limited indication of difference between the crops. Overall the crop husbandry investigations of the Kuruçay material indicates established plots, which were most likely sown in autumn.

10.3.3 Intensity of cultivation

The intensity of arable cultivation was assessed for the Kuruçay samples using the same protocol as for samples from Çatalhöyük West and Çamlıbel Tarlası. Only eight samples contained 10 or more seeds of well-identified weed species (Table 10.11).

Table 10.11: The 12 taxa used to investigate the intensity of cultivation at Kuruçay. Where taxa were not identified to species, the species with available functional data were used, producing an average value for that taxa.

Species/taxa present in assemblage	Alternative species used for analysis
Conringia orientalis L.	
Camelina sativa L.	
Vaccaria pyramidata L.	
Galium, large	*G. aparine/tricornutum*
Asperula arvensis L.	
Lolium remotum	
Taeniatherum caput-medusae L.	
Bromus rigidus Roth	
Cruciata sp.	*Cruciata laevipes* Opiz
Hordeum murinum L.	
Lolium temulentum L.	
Triticum boeoticum L.	*Triticum monococcum* L.

Figure 10.9a displays the discriminant analysis scores from the weed associations in modern field studies for low and high intensity regimes. Figure 10.9a shows

the results of the classification of the archaeological samples from Kuruçay. The results are very similar to those of Çamlıbel Tarlası, concentrated around a discriminant function score of -1; all of the samples are classified as a low-intensity regime but fall within the overlapping zone between low- and high-intensity regimes and so are more intermediate (Table 10.12).

The storage nature of the samples allows the points to be coded to reflect the crop from which they were derived. It can be seen that the lower-intensity samples are glume wheat samples, while the flax, barley and lentil samples are concentrated towards the higher-intensity end.

The analysis reveals a restricted range of intensities in the samples that concentrate around the midpoint of the two regime types and reflects a high similarity to the Çamlıbel Tarlası results. While there are limited samples within the Kuruçay analysis there is a suggestion that glume wheats were cultivated under slightly lower-intensity conditions than the other species. The similarity in cultivation intensities seen at Kuruçay and Çamlıbel Tarlası, the two Late Chalcolithic sites, may point to a trend in cultivation practices during this period. Such possibilities are explored in Chapter 11.

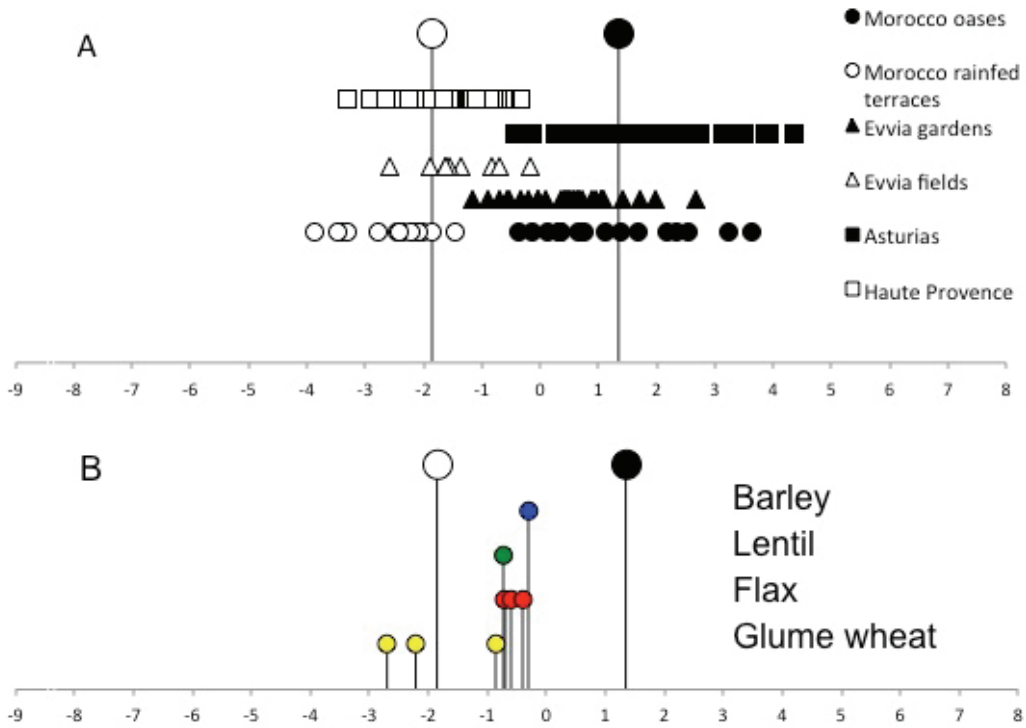


Figure 10.9(A) shows the distribution of the modern field surveys in relation to the discriminant function extracted to distinguish between the high (white) and low (black) crop husbandry regimes. The large circles represent the group centroids. Graph (B) shows the relationship of the Kuruçay samples to the discriminant function used to separate the high and low modern regimes as shown in (A). The crop taxon that dominates each sample is shown in blue (barley), green (lentil), red (flax) and yellow (glume wheats).

Table 10.12: The sample, dominant crop taxa, number of weed taxa and seeds of such taxa used in the discriminant analysis as well as the results of the discriminant analysis of the Kuruçay samples, showing their classification as high- or low-intensity cultivation, with high or low probability.

Sample	Dominant taxa	No. of seeds	No. of taxa	Intensity class	Probability	
					%	Level
15	Glume wheat	18	4	Low	1	High
12	Glume wheat	11	5	Low	0.998	High
10	Glume wheat	25	5	Low	0.872	Low
8	Lentil	137	3	Low	0.82	Low
21	Flax	1625	3	Low	0.806	Low
20	Flax	2973	4	Low	0.749	Low
19	Flax	355	4	Low	0.611	Low
47	Barley	42	5	Low	0.537	Low

11 Discussion and conclusions

This study aimed to identify and understand the implications of plant-related activities during the Chalcolithic in central Anatolia, based on comparative analysis of archaeobotanical assemblages from four sites: Çatalhöyük West, Çamlıbel Tarlası, Canhasan I and Kuraçay. The key aims of the research were to identity the plant species used; assess the impact of major formation processes (dung burning as fuel, crop processing) on the assemblages; and, lastly, reconstruct crop growing conditions and husbandry techniques using a combination of stable isotope analysis of crop remains and functional ecological analysis of weed flora. The crops cultivated and agricultural methods used reflect the environmental and social constraints of the sites, providing insight into agroecological change at varying social scales during the Chalcolithic.

This final chapter is organised according to the research questions set out in Chapter 1. Synthesised discussion of each of these key areas and final conclusions places them in the broader context of past and current research on Chalcolithic central Anatolia.

11.1 What plants were cultivated or collected and were there differences between the sites?

Fifteen domesticated species were identified; Table 11.1 presents the summarised abundances and relative ubiquities of crop taxa across all four sites. Emmer and ‘new type’, as well as hulled barley, free-threshing wheat, pea and

lentil, occur at all sites. The six pulse species identified vary in occurrence across the sites, with lentil the most common. Bitter vetch, pea, grass pea, chickpea and Cyprus vetch were found in varying quantities and not at all sites; while domesticated, some may not have been purposefully cultivated. Flax, an oil and/or textile crop, occurs only at the later Chalcolithic sites of Çamlıbel Tarlası and Kuruçay, while the Early Chalcolithic site of Çatalhöyük West may have utilised the wild species *Descurainia* for oil. Other wild, though potentially managed, species also occur at the sites; pistachio was found at all four, while *Prunus* species appear only at the Konya plain sites of Çatalhöyük West and Canhasan I. The presence of hackberry, grape, caper and acorn varies from site to site.

Detailed comparison of the four sites in order to detect trends is difficult due to differences in retrieval methods, particularly at Canhasan I, where high numbers of large items could be the consequence of dry sieving sizeable quantities of sediment, and the lack of small items the result of the large gauge of the sieve used. At Kuruçay the unique nature of the storage samples means that gauging routine use through ubiquity is not possible. However, examination and comparison of Çamlıbel Tarlası and Çatalhöyük West is possible because of similar retrieval methods and common refuse contexts.

Conducting a new correspondence analysis of both the Çatalhöyük West and Çamlıbel Tarlası samples shows the separation between the two assemblages (Figure 11.1). Çatalhöyük West samples are characterised by collected wild items, free-threshing wheat, naked barley and pea. Çamlıbel Tarlası samples, on the

other hand, are characterised by flax and four pulses: lentil, grass pea, bitter vetch and chickpea.

Table 11.1: Summary of the major components of the four examined sites providing the total number of items and their ubiquity in the samples containing 30+ items. * denotes a mixture of emmer and 'new type'.

Taxa	Çamlıbel Tarlası		Çatalhöyük West		Canhasan I		Kuruçay	
	(67 samples)		(43 samples)		(37 samples)		(25 samples)	
Cereal	Total	%	Total	%	Total	%	Total	%
Einkorn	1408	73	442	67			514	16
Emmer	335	30	215	38	1023*	81*	12940*	24*
'New Type'	60	6	82	19				
Bread wheat	59	15	172	48	409	86	2448	20
Naked barley			32	21	210	16		
Hulled barley	1266	93	510	86	13110	100	30130	52
Emmer glume base	6768	85	3359	93	393*	8*	7088*	24*
Einkorn glume base	1319	66	58	24			437	24
'New Type' glume base	625	39	3589	95				
Hulled barley rachis	44	21	74	31	266	5	21	16
Naked barley rachis			105	48			14	12
Bread wheat rachis	3	4	106	40	5	3	7	12
Pulses								
Lentil	649	91	122	55	39	19	36207	56
Bitter vetch	408	78	13	14	4	11		
Grass Pea	54	30	2	2			9238	32
Chick pea	29	21					3	8
Pea	21	16	42	29	5850	63	7164	32
Cyprus vetch	3	4						
Other								
Flax/linseed	232	75					40964	32

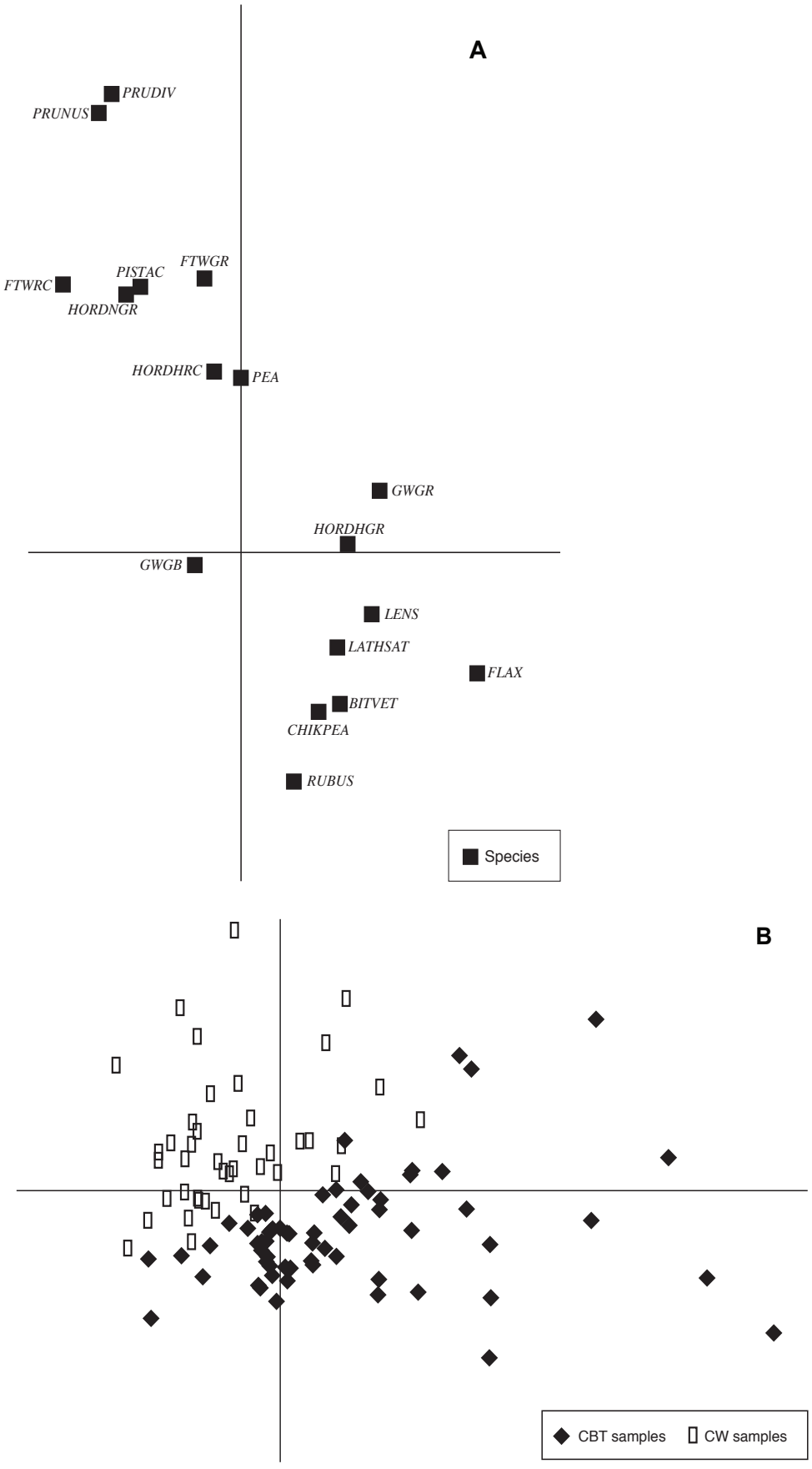


Figure 11.1: Results of correspondence analysis of the assemblage from Çatalhöyük West and Çamlıbel Tarlası. (A) shows the taxon plot (n =17), and (B) the sample plot (n =104), coded by site.

11.1.1 Glume wheat species

Three glume wheat species were identified at all sites except Canhasan I, where einkorn was absent. Identification of 'new type' glume wheat at Kuruçay and Canhasan I is based purely on type specimens examined during this research. Emmer glume bases are recorded at all sites, and while at Canhasan I and Kuruçay some emmer glume bases are in fact 'new type', emmer appears to be a primary crop at all four examined sites.

Differences can be noted in the overall proportion of emmer to 'new type' and to einkorn glume bases at Çatalhöyük West and Çamlıbel Tarlası. The limited einkorn glume bases could be questioned as an artefact of charring bias. However research on the chronological changes of crops on the East Mound provides evidence of the waxing and waning of glume wheat choices through time (Bogaard et al. 2013a; Bogaard et a. in prep). Emmer was dominant in the early phases of the East Mound while einkorn never featured heavily in the East Mound crop suite (Bogaard et al. in prep). This new research on the Trench 5 archaeobotanical assemblage, together with archaeobotanical data from Last/Gibson's excavation of Trench 1, shows an increase in emmer that contrasts with the mid-later Neolithic sequence on the East Mound, where 'new type' was the dominant glume wheat (see Bogaard et al. 2013a; Bogaard et al. in prep).

Çamlıbel Tarlası's glume wheat suite is dominated by emmer glume bases (77%), with einkorn (15%) and 'new type' glume wheat (7%) comparatively limited in numbers unlike at Çatalhöyük West (Table 11.1). Çamlıbel Tarlası highlights the notion that the proportions of glume wheats species are community specific.

Whether the difference in the comparative proportions of 'new type' glume bases compared to einkorn and emmer in the Çamlıbel Tarlası assemblage is a temporal or regional trend cannot be assessed on the basis of the data currently available. Additional research on material from surrounding sites such as Çadir Höyük is needed before an assessment can be made.

Investigation of 'new type' glume wheat as a Chalcolithic crop at other sites is difficult as the majority of archaeobotanical assemblages were published before the recognition of 'new type' glume wheat as a separate species (Jones et al. 2000b; Kohler-Schneider 2003). Photographs suggest that 'new type' was present at Hacılar (Helbaek 1970) and this, together with the identification of 'new type' in the assemblages of Kuruçay, Canhasan I, Çamlıbel Tarlası, and Çatalhöyük West alongside the Neolithic Çatalhöyük East (Bogaard et al. 2013a), indicate a widespread distribution in central Anatolia. It is more difficult to ascertain the presence of this crop in other regions. 'New type' is known to occur in the Eastern Fertile Crescent with reports of it at Neolithic Jeitun in Turkmenistan, Sang-e Chaqmaq and Khaleseh in Iran (Charles and Bogaard 2011; Fuller 2014; Whitlam 2014). There are limited reports of it in Anatolia, with reports of it at Caferhöyük one of the few (cited in Jones et al. 2000b:135). This is probably due to the historical lack of recognition of 'new type' as a separate species. What can be said, given the limited sites and the Çamlıbel Tarlası evidence, is that usage of this wheat was clearly variable within central Anatolia.

Examination of crop trends can be conducted through collation of published data of Chalcolithic sites from the whole of Turkey and Table 11.2 presents the

summary of all sites with quantitative or semi-quantitative archaeobotanical data. Emmer and einkorn had different roles during the Chalcolithic; emmer is normally the dominant taxon although this could include unrecognised 'new type'. Einkorn has a comparatively limited presence and is absent at some sites (Table 11.2). The evident changes in glume wheat usage through time on the East Mound of Çatalhöyük (Bogaard et al. in prep) hint that either subtle ecological and/or culinary differences played a role in the usage of these crops. More research into stable carbon isotope ratios of archaeological examples of the three glume wheats may potentially shed light on differences in drought tolerance and whether particular species were grown in drier conditions. Presently there is no such evidence, suggesting that social choice may have been the driving factor in the selection of glume wheat species.

Table 11.2: Turkish Chalcolithic sites with quantitative data published on species present, as well as the new quantities data from Çatalhöyük West, Canhasan I, Çamlıbel Tarlası and Kuruçay, detailing the proportion of the species from the total crop assemblage. X = <25%, xx 25-49%, xxx= 50-74%, xxxx = 75-100%. Regions refers to the areas highlighted in Figure 1.1, Chapter 1, dates refer only to Chalcolithic phases. Data collected from: (Helbaek 1970; van Zeist and Bakker-Heeres 1975a; Van Zeist 1979; van Zeist and Waterbolk- van Rooyen 1995; Chernoff and Harnischfeger 1996; Miller 1996, 1998; Cappers 2001; Riehl and Kümmel 2005; Longford et al. 2009; Graham 2011).

	Time period (cal. BC)	Region	Barley				Free-threshing wheat		Glume wheat							Pulse					Oil
			Hulled grain	Naked grain	Indeterminate grain	Indeterminate rachis	Grain	Rachis	Emmer grain	Emmer glume bases	Einkorn grain	Einkorn glume bases	New type grain	New type glume bases	Glume bases indeterminate	Bitter vetch	Lentil	Pea	Chickpea	Grass pea	Flax
Canhasan I	6000-5000	South central	XXX	X			X	X	X	X						X	X	XX			
Çatalhöyük West	6000-5000	South central	X	X		X	X	X	X	XX	X	X	X	XX		X	X	X			
Ilıpınar	6400-4200	North west	X	X	XX	X	X		X	X	X					XX	X	X	X	X	X
Tell Kurdu	6000-5100	Euphrates			X						X						X		XXX		X
Girikihaciyan	~5100	Euphrates	X				X		X		X				XXX	X	XX		X		X
Kumtepe	5200-3000	North west	X	X		X			XX	X	X	X				X	X			X	X
Oylum Höyük	5200-3000	Euphrates	X		XX				XX	X	X	X				X	X				X
Tilbeshar	5200-3000	Euphrates			X	X	X		XX								X				X
Tepecik	~4000	Euphrates	XX				X		XX		X					X		X			
Yarim Höyük	~4000	Euphrates			X				XXX						XX						
Cayboyu	4800-3800	Euphrates	X	X		X	X	X	X		X					X	XX	X			
Hacınebi tepe	4800-3800	Euphrates	XX				X	X	X		X				XXX		X			X	X
Korucutepe	4500-3000	Euphrates	X				X		XX		X					X	X	X			X
Kuruçay	4000-3000	South central	X			X	X	X	X	X	X	X					X	X	X	X	XX
Ikiztepe	3500-3000	Black sea														XXXX					
Yarim Höyük	3500-3100	Euphrates							X						XXX		X				
Çamlıbel Tarlası	3500-3000	North central	X			X	X	X	X	XXX	X	X	X	X	X	X	X	X	X	X	X
Çadir Höyük	3000-2800	North central					X		XXX		X										
Sos Höyük	3500-3000	Euphrates	XX				XXX	X													

11.1.2 The importance of hulled barley

Hulled barley occurs at the four examined sites and is by far the most common free-threshing cereal. Naked barley does occur but at low levels and reflects a trend noted on the East Mound and in Trench 1 of the West Mound – a change from hulled to naked barley (Bogaard et al. 2013a). Trench 5 data confirms the switch and provides evidence that hulled barley supersedes naked barley in numbers and ubiquity during the Chalcolithic occupation. Hulled and naked barley also occur together at Canhasan I; hulled barley dominates with limited naked barley remains found throughout the phases. Kuruçay barley samples comprise pure hulled barley grains although the barley rachis found in some samples also includes naked barley items. Çamlıbel Tarlası's assemblage completes the picture of hulled barley's replacement of naked barley, with no remains of the naked variety found on the site.

Examination of other Turkish Chalcolithic sites (Table 11.2) shows that barley, the majority identified to the hulled variety, occurs at the same number of sites as emmer, emphasising the importance of hulled barley in the Chalcolithic crop suite. Furthermore there is a limited occurrence of naked barley, with only five sites, two of which are Canhasan I and Çatalhöyük West, having records of naked barley grains. These five sites all have hulled barley in the same or higher proportions than naked barley (Table 11.2).

Others have noted the change from naked to hulled barley in south-west Asia and the Mediterranean, beginning in south-west Asia during the Neolithic and

Chalcolithic, and changing in the Mediterranean by the Bronze Age/ Iron Age/Roman period (Lister and Jones 2013). Causal factors that have been hypothesised include the pressures of drought, yield reduction of naked barley, pest prevention or lastly, replacement of naked barley by other crops best suited to the role naked barley was fulfilling (Hillman 1985; Nesbitt 1996; Buxó i Capdevila et al. 1997; Lister and Jones 2013). Of course it is possible that a combination of the above could be the reason for the change from naked to hulled barley.

The hypothesis that the change to hulled barley was caused by drought, or the requirement for a more drought-tolerant species has limited support archaeologically. At Çatalhöyük there is no stable carbon isotopic evidence for a change in water availability for hulled barley cultivation from the East Mound to the West Mound, with the isotopic signature ($\Delta^{13}C$) showing no significant difference (Chapter 9). In addition, comparison with $\Delta^{13}C$ values from naked barley grains on the East Mound reveals no significant difference, suggesting continuity in the cultivation of barley in dry conditions, regardless of the variety (Wallace et al. 2015). However no studies could be identified where research on differences in $\Delta^{13}C$ between hulled and naked barley have been conducted to confirm similar reactions to water-limiting conditions. What can be noted is that, in comparison to the other cereals, both hulled and naked barley at Çatalhöyük, are associated with the drier niche. Thus barley, regardless of variety, was cultivated due to its drought tolerance.

Nesbitt (1996:136) cited production decline as the cause of naked barley being replaced by hulled barley. Agronomic literature reveals differing views about the yield of naked barley compared to hulled; some studies suggest a comparable yield between the two (Ingledew et al. 1995), others find differences (McGuire and Hockett 1981). Pest resistance is also suggested as a cause of the change in barleys, the lemma and palea of the hulled barley protecting the grains from insect and bird predation (Hillman 1985).

The change could be a social preference where hulled barley was required for a specific use, or naked barley no long fulfilled its culinary purpose. The decline in Mediterranean Spain of naked barley correlated with an increase in free-threshing wheat as a bread ingredient (Buxó i Capdevila et al. 1997). Another possibility is that the barley changed from use as a human food to one for animals – hulled barley is a common modern animal feed (Zohary et al. 2012:52). The Anatolian evidence does not support either scenario. Sites appears to show either similar or a decreased use of free-threshing wheat alongside high use of glume wheat and hulled barley. In particular, Çamlıbel Tarlası has high numbers and ubiquity of hulled barley but no naked barley and limited free-threshing wheat remains (see Table 11.1). There is also evidence of human consumption of hulled barley at Çamlıbel Tarlası: cracked grains fused into lumps suggesting coarse grinding of hulled barley prior to human consumption. The analysis of stable isotopes of carbon and nitrogen supports the idea of human consumption of hulled barley at Çamlıbel Tarlası (Chapter 9), as the trophic level offset between herbivores and barley grains is too small to suggest the consumption of hulled barley grain by livestock.

Beer production could be another possibility, hulled barley being more useful as its lemma and palea protected the embryo of the malted grain from damage (Dickson 1968; Stika 1996; Zohary et al. 2012). There is no evidence of malting structures in the archaeological record at the sites, nor have any germinated grains been identified and while the lack of malting evidence does not mean grain was not being fermented, it does limit its usefulness as the possible reason for the switch from naked to hulled barley: if grains were not being malted before fermentation, then there is no need for the protective lemma and palea, thus no need to switch barley variety.

A change in cooking method occurred in the late stages of the East Mound, with the increased use of ceramic vessels, evidence of direct heating of ceramics over flames, a decline in and then the abandonment of cooking with clay balls upon settlement of the West Mound, and the introduction of the pot stand on the West Mound (Atalay 2005; Last 2005; Atalay and Hastorf 2006:308; Hodder 2016). Ceramic vessels, as well as pot stands, present the opportunity for cooking/boiling liquids over direct heat (Atalay and Hastorf 2006:308). Such changes in cooking methods started in the late occupation phases of the East Mound, and by the occupation of the West Mound were dominant with a significant increase in ceramics, and a lack of excavated cooking clay balls evident. Thus another reason for the change from naked to hulled barley could have been the suitability of hulled barley for a different form of cooking/food, such as lengthy boiling, or malting (cf. Atalay and Hastorf 2006:309).

The multiple theories that have been proposed to explain the shift from hulled to naked barley are not mutually exclusive. What is evident is that both types of barley were grown for drought tolerance at Çatalhöyük, with the change from naked to hulled not affecting the use of barley as the crop to cultivate in the drier areas of the landscape. Further research is needed on the grain lumps from Çamlıbel Tarlası to clarify what kind of preparation they represent, e.g. soaking, grinding (cf. Valamoti 2002; Valamoti et al. 2008). Furthermore comparison of the $\Delta^{13}C$ of naked and hulled barley in modern traits would help clarify any differences in drought tolerance between the two varieties, while the analysis/excavation of more sites that reflect a transition from naked to hulled barley would provide additional information regarding the social situation surrounding this shift. Together such information may provide an insight into the factors that caused the change from naked to hulled barley.

11.1.3 The importance of pulses

There is a high diversity and abundance of pulses at the four sites, some species occurring more commonly than others (Table 11.1) and some appearing to increase temporally or differ spatially. The Çatalhöyük West assemblage contains two main species, lentil and pea, differing from Çamlıbel Tarlası's lentil and bitter vetch dominance. Bitter vetch is absent in the storage samples of Kuruçay, while grass pea is more common in the later sites of Kuruçay and Çamlıbel Tarlası. The occurrence in high numbers and the ubiquity of such species at Çamlıbel Tarlası highlights the importance of pulses in this Chalcolithic community. The limited number of sites means that site differences cannot be extrapolated into regional

differences but it can be said that there were differences between the Chalcolithic communities examined in this study.

As discussed in section 5.1.3 and 6.2 certain rarely attested pulse species may be crop contaminants rather than purposefully cultivated crops. For example, chickpea is not a stored crop in the Kuruçay assemblage but occurs in low numbers in other pulse stores. This does not necessarily mean it was not a crop – it could be a function of chance that no chickpea storage deposits were charred, and there is evidence that the stored crop species do occur in each other as contaminants. However chickpea's low quantity and ubiquity is a trend across the sites examined: none were found in the Çatalhöyük West Trench 5 samples but Bogaard et al. (2013a) report the occurrence of two chickpeas in the West Mound Trench 1 assemblage. The occurrence of this species at Çamlıbel Tarlası is also minimal. Thus it seems that chickpea at these three sites, grass pea at Çatalhöyük West and Cyprus vetch at Çamlıbel Tarlası could represent crop contaminants rather than deliberately cultivated crops.

Examination of the use of pulses on a wider scale can be conducted using Table 11.2. Lentil, bitter vetch and pea occur widely at all sites listed and the other species are more variable in occurrence (Table 11.2). Although chickpea is negligible at the sites analysed for this research, other Chalcolithic sites, principally those located in the Euphrates region, do report more frequent finds of chickpea (Table 11.2). Chickpea is also reported at sites more relevant in distance to the examined sites, such as Hacılar (~ 10 km from Kuruçay) and Ilıpınar. Helbaek's report of chickpea in the Hacılar assemblages is brief,

mentioned only in the species list and not discussed as a crop (Helbaek 1970). Ilıpınar has finds of chickpea in "reasonably large concentrations" (Cappers 2001:128). Of relevance is also the site of Höyücek, which while Late Neolithic in date contains one of the few examples of large quantities of chickpea from a single sample in central Anatolia (Nesbitt and Martinoli 2003). This site, in close proximity to Kuruçay and Hacılar (~ 40 Km), highlights the fact that chickpea was at least intermittently grown as a crop and stored in this region.

The storage numbers and concentrations of chickpea found on the Euphrates sites may highlight a crop boundary between the use of chickpea and its occurrence as a crop contaminant (Table 11.2). Chickpea movement from the south - the region of its domestication- into central Anatolia most likely occurred as a weed, with a few sites utilizing this crop contaminant as a cultivated crop when cultural or environmental conditions allowed it. Similarly, grass pea is limited in its occurrence but is present more on central/north west Anatolian sites rather than the Euphrates. This may reflect an Aegean influence, an area where large quantities of grass pea have been recorded (Zohary et al. 2012); it has been hypothesised that grass pea was domesticated in the Balkans or Greece (Kislev 1989). Thus its occurrence on sites in Turkey could reflect its dispersal from these regions (Nesbitt 1996).

11.1.4 The use of flax

Flax seeds occur only at the two Late Chalcolithic sites, with no evidence of flax at Canhasan I and Çatalhöyük West. Investigation into the specific use of flax is difficult; the seeds could have been cultivated for oil, the plant stems cultivated

for fibre or a combination of both. Examination of the dimension of the seeds from both Çamlıbel Tarlası and Kuruçay cannot clarify its use (see Chapter 5).

The Kuruçay flax samples' weed seeds provided an understanding of the flax-specific weed flora that emerged with cultivation of this crop. A small-seeded *Lolium*, possibly a precursor to the modern flax weed *Lolium remotum*, was found in high numbers in these samples, together with a *Silene* species and two crucifer species, *Camelina* and *Lepidium* (Nesbitt 1996). The tight linkage of such species with flax seeds was also identified in the Çamlıbel Tarlası assemblage (Chapter 6) and presents a convincing picture of the development of a flax weed flora within Late Chalcolithic flax cultivation, something which resembles later flax weed assemblages found in Europe (Leuzinger and Rast-Eicher 2011; Valamoti 2011). *Lolium remotum* occurs only in flax fields in present times, with its place of origin unknown (Davis 1965-1989). *Camelina sativa* and specific *Silene* species are also closely associated with flax cultivation in Europe (Lataowa 1998; Valamoti 2011). It has been hypothesised by Nesbitt (1996) that the occurrence of such weeds in the flax samples of Kuruçay indicates the development of a flax weed flora that could be the precursor of European flax weeds. The evidence from Çamlıbel Tarlası of the same weeds in association with flax seeds highlights the fact that the occurrence at Kuruçay is not isolated and this specific flax weed flora occurred at other sites during the Chalcolithic.

Flax has been found at other Chalcolithic sites outside central Anatolia, principally in the Euphrates region, potentially signifying the movement and adoption of this crop from further south (Table 11.2). Flax appears to be a Late

Chalcolithic adoption in central Anatolia, compared to the Euphrates region where finds of flax occur at Early Chalcolithic sites.

The late adoption of flax in this region may indicate its use as an oil or textile crop. Schoop (2014) and Arbuckle (2011) hypothesised that wool during the Late Chalcolithic became the more important textile in Anatolia, with an increase in production. The availability of wool-bearing sheep and the lower labour requirements for the production of woollen textiles compared to linen (McCorriston 1997) may indicate that the adoption of flax for specialised production of textiles in the Late Chalcolithic is unlikely. The alternative hypothesis is that this crop was grown for oil, not fibre. As there is currently no conclusive method for determining the role of the flax at the sites, the question of the reason for its adoption and consequent social impact remains unanswerable.

11.1.5 Wild species use

The utilisation of wild taxa is notable at the two early sites. Çatalhöyük West and Canhasan I assemblages contain nuts from a variety of species, in addition to the probable collection of wild mustard at Çatalhöyük West. *Pistacia*, *Prunus* species and hackberry contribute to the assemblage at Çatalhöyük, with high numbers of *Pistacia* and almond/plum in samples at Canhasan I. However, as mentioned previously, this could be due to the retrieval method.

The storage sample of *Pistacia* at Kuruçay indicates collection and storage during the later periods but there are limited nut/fruit items in the Çamlıbel Tarlası assemblage. This should not be due to lack of access to such species given the

reconstruction of a forested landscape surrounding the site (Dörfler et al. 2000). Consequently it is possible that the lack of wild taxa in the Çamlıbel Tarlası assemblage is due to a social situation, where there is a limited need to utilise such wild taxa or a social preference against its use.

Tuber fragments, principally identified as club rush (*Bolboschoenus glaucus*), were found at both Çatalhöyük West and Canhasan I while the seeds of *Bolboschoenus glaucus* were also found at Çatalhöyük West. As noted in Chapter 5 there are multiple uses and pathways by which such items could enter the archaeological record. No storage deposits of *Bolboschoenus* seeds or tubers have been identified on either of the Chalcolithic sites, or at Çatalhöyük East, where the same high ubiquity of the seeds and tubers occurs (Bogaard et al. 2013a). Seeds and tubers could have been used for food, fodder, fuel as well as the stems for mud brick and basketry/mat construction (Fairbairn et al. 2005; Ryan 2009; Wollstonecroft et al. 2008; Wollstonecroft et al. 2011; Bogaard et al. 2013a; Filipović 2014) Disentangling the use of such items is extremely difficult and there is a high probability that it is a combination of them all.

11.2 Fuel use and its implications

Examination of the assemblages for the possible use of dung for fuel indicates differences between the sites. Çatalhöyük West presents a robust signature of dung burning, with small-seeded grasses, for example, likely dung-derived. The detection of dung burning highlights a continuum between glume base-dominated samples and weed-dominated samples in the Çatalhöyük West assemblage. The crop processing by-product material in the assemblage is not

dung derived; the excellent preservation of the chaff remains indicates no signs of digestive activity and research has also indicated the limited survivability of glume wheat chaff through digestion (Wallace and Charles 2013). It is possible that chaff remains could have been fed to animals, however due to its limited survivability this would not be present on site. Stable isotope analysis of carbon and nitrogen also indicates that while the chaff remains of cereals could have been fodder for domesticated animals, it would have been on a limited scale (Chapter 9).

The identification of dung burning in the Çatalhöyük West assemblage, while identifying a biasing process, also provides information about plant-related activities. It highlights the use of different fuels within the settlement and displays continuity with the fuel-use pattern detected on the East Mound of Çatalhöyük (Bogaard et al. 2013a; Bogaard et al. 2014; Filipović 2014). The lack of in situ samples limits any detection of contextual variation such as the interior and exterior fuel use patterns detected on the East Mound, where dung appears to be used predominantly outside (Bogaard et al. 2014). However the identification of dung burning does provide an indication of a continued pattern from East Mound to West Mound of grazing and foddering of wetland plants (Bogaard et al. 2013a; Filipović 2014). There appears to be no discontinuity in such practices during the shifts in occupation between the two Mounds.

The dung burning results from the Çamlıbel Tarlası assemblage are ambiguous: limited taxa could be identified as non-arable, while the overwhelming dominance of *Lolium* seeds in the assemblage, likely derived from flax processing,

possibly obscures trends. This, together with the examination of crop processing stages, indicate that the Çamlıbel Tarlası assemblage may represent the combination of by-products of the processing of different crops, in particular glume wheat and flax. If dung was routinely burnt on the site, and there is evidence of potential charred dung matter, then it was on a limited scale. This suggests alternative fuel sources. One source could be wood but given the notable presence of flax weed seeds (small-seeded *Lolium*) in contexts such as ovens, it is plausible that flax/linseed by-products were used as fuel on the site.

Such results support the hypothesis framed at the beginning of the research, that sites in more arid environments may have needed to supplement their fuel with alternative sources, while sites situated in more temperate locations may have had plentiful wood fuel available. Çatalhöyük West and Çamlıbel seem to fit such an hypothesis, with higher dung use seen at the more arid Çatalhöyük West.

11.3 The implications of crop processing and storage practices

Crop processing analysis highlights similarities between the sites. Free-threshing crops in the Çatalhöyük West, Çamlıbel Tarlası and Canhasan I assemblages predominantly return ratios of fine-sieving by-products. However in the majority of samples from the sites, these are contained in mixed samples or in samples dominated by glume wheat. It cannot be ruled out that the amount of free-threshing cereal grain and chaff in a sample is due to admixture of such components from various activities.

Stored free-threshing crops at Kuruçay and Canhasan I are represented as clean fine-sieving products: that is, concentrations of the crop seed with low levels of

weed seeds that mimic the size and shape of the grain. The occurrence of fine-sieving by-products of free-threshing crops at Çatalhöyük West, Canhasan I and Çamlıbel Tarlası indicates a number of possibilities by which such remains became charred: the crops may not have been stored completely processed; the by-products of fine sieving may have been used; rachis fragments were removed during hand cleaning; or as a contaminant of glume wheat crops mixed with the clean grain from cooking accidents. Any of these possibilities could have produced ratios similar to those of fine-sieving by-products.

The dominance of glume wheat dehusking waste is the common trend at Çamlıbel Tarlası and Çatalhöyük West assemblages, with Kuruçay samples providing complementary insight into the form in which crops were stored. Kuruçay provides a useful comparison to Çatalhöyük West and Çamlıbel Tarlası when examining the processing of glume wheats: this site has stores of glume wheats in spikelets, something that is only hypothesised through by-products at the other sites. Glume wheat spikelets were apparently stored after fine sieving at Kuruçay, with limited weed seeds.

Comparison of weeds contained in the spikelet stores at Kuruçay with the fine-sieving by-products from Çatalhöyük West and Çamlıbel Tarlası, however, emphasises one contradictory finding: the large quantity of weed seed the later sites' samples contain. If the assumption is that the glume wheats were stored as clean spikelets, as at Kuruçay, and the free-threshing cereals as fine-sieving product, again as at Kuruçay and Canhasan I, then the high proportion of weeds in the samples does not correlate with the processing of such stores before

consumption. There is a high proportion of small heavy weeds compared to glume bases in the samples but a high proportion of these should have been removed prior to storage, via the sieving of spikelets.

It is possible that the fine-sieving by-products of crops, both glume wheats before dehusking as well as free-threshing cereals, were utilised in an alternative way, such as for kindling. Another explanation for the high weed content is that it is a combination of the fine-sieving remains before and after glume wheat dehusking and fine sieving of the free-threshing cereals, as such an assemblage would be rich in small heavy seeds as well as glume wheat chaff. Thus it is possible that the samples were stored without being initially fine-sieved and/or they were stored fine-sieved, but the by-products of the initial fine sieving were collected and stored for later use.

The dehusking of glume wheat is apparent due to the high proportion of glume wheat glume bases in the Çatalhöyük West and Çamlıbel Tarlasi samples. The recurrence of glume bases in the samples indicates that dehusking was a daily or at least regular activity resulting in the continual disposal of dehusking waste in fires. Such a scenario is commonly hypothesised for South West Asian/Mediterranean/Central European sites, where it appears that it was a common practice to store glume wheat in spikelets and process them further when needed (see for example Jones et al. 1986; Bogaard 2011; Bogaard et al. 2013a; Graham and Smith 2013).

Storage in spikelet form could be due to a number of factors, and it was hypothesised at the commencement of this research that glume wheats would have been stored as spikelets to protect against fungal spoilage in regions of wet summers (Hillman 1981, 1984b). Alternatively it has been suggested that storage in spikelets is a means of spreading labour requirements throughout the year (Jones et al. 1986). Full processing of a harvested crop would require significant amounts of labour or time during a period of the year when labour may have been limited. Storage of partially processed glume wheat limits the amount of processing required at harvest and consequently spreads the rest of the processing labour requirements over the year. Finally, pest mitigation is another potential reason to store in spikelets (Hillman 1984b).

The climatic reconstructions for the four sites indicate wet months during winter but not summers, as is the case in of Hillman's (1984b) ethnographic account. Although climate cannot be completely eliminated as a reason, it is limited in its validity. Insect or pest attack cannot be ruled out. Evidence of charred rodent dung in the West Mound assemblage indicates the presence of these commensal species but no charred insects were identified. This is in contrast to the beetles identified in the Kuruçay storage samples but it is possible that insect preservation is limited to in situ storages samples.

A purposeful choice based on specific social trends or history of practice cannot be excluded as a social factor governing the storage of glume wheats in spikelets. The repeated occurrences of dehusking waste reflects repeated activities and highlights the fact that different social units are doing the same thing: glume

wheats were stored in spikelets, with households processing them when needed. Such activities indicate that the pressures or choices involved in the storage of these crops are community-based and not social unit specific. Past generations may have been under particular pressures, promoting storage of glume wheat crops as spikelets. Future generations may have continued such a trend, even though the pressure may have no longer been active. Conversely, if limited labour within the agricultural landscape was the motivating factor, this in itself indicates a need to spread labour over a particular time, something highly likely in small-scale household/village societies.

11.4 Consumption of plants

The dehusking waste of glume wheats has been cited as evidence of the preparation of crops for human consumption, given that it is time-consuming and unnecessary if the grains are for animal consumption (Nesbitt et al. 1996:242; Pena-Chocarro 1999). Thus presence of glume wheat dehusking waste could indicate its preparation for human food, which, given the regularity of the occurrence of the by-products, was potentially consumed on a daily basis. The stable carbon and nitrogen isotope analysis conducted on the crop seeds, and the complementary stable carbon and nitrogen isotope analysis of faunal and human material conducted by researchers for both Çatalhöyük West (fauna only) and Çamlıbel Tarlası, provides the opportunity to explore consumption of the agricultural products by animals as well as humans (Pickard et al. 2016a; 2016b; Middleton, pers. comm.; Pearson, pers. comm.). The Çatalhöyük West and Çamlıbel Tarlası results indicate that regular *grain* consumption by animals was unlikely although they may have been foddered strategically on chaff remains and

pulses. The inference is that the cereal grains were primarily for human consumption, the routine dehusking of the grains indicating that grain was a dietary cornerstone for the people of Çatalhöyük West and Çamlıbel Tarlası. The other crop items, free-threshing cereals and pulses, were most likely also largely for human consumption.

Çamlıbel Tarlası provides the opportunity to explore directly the human consumption of pulse species as the high ubiquity of pulses suggests an important role in the diet of Chalcolithic peoples. Pickard et al. (2016a) noted the limited trophic level offset between humans and animals at Çamlıbel Tarlası, highlighting that a low $\delta^{15}N$ value food must have played a significant role in people's diet. Pulses most likely fulfilled this role.

The use of pulses, in particular some of the toxic pulses such as bitter vetch, is indicative of a social preference for a food requiring labour-intensive preparation. Bitter vetch, grass pea and Cyprus vetch are toxic and without specific processing steps can, in the case of grass pea and Cyprus vetch, cause lathyrism, a neurological disease which causes paralysis, while a different protein in bitter vetch can lead to fatigue and illness (Enneking et al. 1995; Zohary et al. 2012). Ethnobotanical research indicates that these legumes are made palatable through specific preparations, in particular soaking or boiling of the seeds (Miller 2002). Such preparations add additional labour requirements to the consumption of these species, and suggest, similar to glume wheats, that their cultivation was not due to the ease of use but for a particular purpose. Many of the crops listed require complex processing or preparations steps to make them fit for

consumption, while the more simple to prepare taxa such as free-threshing wheats and peas only feature in a minor way in the assemblage at some sites such as Çamlıbel Tarlası. Hulled barley, as mentioned before, requires an additional step to make it fit for consumption but there is evidence of its potential consumption at Çamlıbel Tarlası in the form of cracked grain within a food-like substructure (cf Valamoti 2002).

The consumption of plant species is not always tied to ease of cultivation or use, but is a socially mediated exchange relating to social perceptions of value, taste and repeated rituals and traditions (Robb 2007:120-158). Food and its preparation can empower or facilitate the gaining of social power/status (Dietler and Hayden 2001; Twiss 2012). Just as in the specific ways in which food is prepared, or recipes used, food can be linked to social or geographic identities. The use of specific plants to make specific foods is intertwined with the geographic and social group to which the food-preparer belongs, reinforcing collective identity (Caplan 1997; Atalay and Hastorf 2006:284; Shuman 2008).

Thus the examination of the production and consumption of food cannot be explained solely on the basis of environmental or economic factors. The social sphere plays a pivotal role in shaping choices made regarding the crops grown, how they are grown and how they are processed and stored.

11.5 Crop husbandry

The crop husbandry techniques used at Çatalhöyük West, Çamlıbel Tarlası and Kuruçay are summarised in Table 11.3. There are overall similarities between the sites, for instance the predominance of autumn sowing, while other methods are

used in site-specific ways such as the growing of certain crops in drier conditions than others.

Table 11.3: Summary of the different crop husbandry techniques practised at Çatalhöyük West, Çamlıbel Tarlası and Kurucay.

Technique	Crop husbandry practice	Çatalhöyük West	Çamlıbel Tarlası	Kuruçay
Weeds (ecology)	***Sowing time***	Autumn	Autumn	Autumn
	Field permanence	Long term	Long term	Long term
Isotopes	***Manuring***	Moderate	Low to moderate	n/a
	Water availability	Species specific	Highly variable within species	n/a
Weeds (FIBS)	***Intensity (fertility and disturbance) – variability***	Highly variable	Cohesive, similar intensity	Cohesive, similar intensity
	Intensity (fertility and disturbance)- overall input	Moderate high – to moderate low	Intermediate	Intermediate

The reasons for the use of particular crop husbandry methods may reflect a number of environmental and social influences. The environmental conditions of the site's location play a role in dictating cultivation practices in order to overcome or exploit specific environmental conditions. This manifests in multiple ways: the utilisation of specific crops adapted to the environment, the use of specific crop husbandry techniques to allow the cultivation of crops not adapted to the environment and use of methods to both increase productivity of the soil and prevent crop competition from weeds.

While the environmental conditions play a large role in determining which crops are cultivated and the crop husbandry techniques used to do so, the choice to either work with or against the site's environmental conditions is a decision determined by a multitude of factors encompassing traditions, identity, population/site size, site organisation, perceived value and labour costs.

The inhabitants of Çatalhöyük West appear to have carefully located crops within the landscape exploiting the available water resources in a semi-arid region. They used available environmental conditions, growing crops with higher water requirements in areas of the mosaic landscape that retained water over the growing period, and cultivated the more drought-tolerant barley in drier areas. The inhabitants of Çamlıbel Tarlası, less constrained by water availability due to higher annual precipitation, did not select locations in the landscape for cultivation of particular species. Rather, the high variability *within* species detected in the stable carbon isotope analysis is most likely a consequence of the hilly topography surrounding the settlement (cf. Bogaard et al. 2016a). Such interpretations highlight the consequences of the environmental conditions surrounding sites.

The addition of manure to the soil improves soil conditions and consequently plant production. This improvement of arable conditions is seen at the sites, with evidence of anthropogenic enrichment in ^{15}N within the crop fields (Chapter 9). The weed ecology indicates variable fertility and consequently variable mechanical disturbance, as fertile fields may require weeding to prevent weed competition with glume wheat (Chapter 10). Variable fertility represented by the weeds is most likely the consequence of human action.

The addition of manure to the fields is principally the result of two mechanisms – the availability of manure and the availability of labour to move and spread it. Both sites have domesticated animals so manure would have been available

(Bartosiewicz and Gillis 2011; Best et al. 2012). As discussed in Chapter 7, however, dung was also used for fuel at Çatalhöyük West, resulting in the division of this resource between two uses (Anderson and Ertuğ-Yaras 1998), something that does not appear to have been significant at Çamlıbel Tarlası. Furthermore the manure had to be collected, a difficult activity depending on how the animals were kept. The diet of the animals at Çatalhöyük West suggests grazing over wetland vegetation; such an environment would make collecting manure difficult. It is more likely that the manure was collected from areas in which animals congregated. It is also possible that midden material was used to increase fertility of the fields.

The reconstruction of the location of Çatalhöyük fields on raised hummocks surrounded by anastomosing streams indicates how difficult cultivation in such an environment would have been, particularly the transport across or through water to the fields of manure or midden material from either the site or animal penning areas. These actions required labour at specific times of the year and the amount required would be dependent on the ease of accessibility of the fields/the fertilizer's location. Organisation of the movement as well as ownership of this resource would require mediation within the community, leading to questions as to whether all households had access to manure (i.e. kept enough animals), and the consequences of inaccessibility to manure/fields on productivity and labour management.

The size of a site or its distance from cultivatable land plays a significant role in the intensity of cultivation - the amount of labour input per area- with

intensive/high input cultivation of crops facilitated by the close proximity of the settlement (Jones et al. 1999; Bogaard 2005; Jones 2005). Intensity/labour input decreases the further away from the settlement the plots are located (Halstead and Jones 1989; Bogaard 2005; Jones 2005). Çatalhöyük West's large size would have shaped the intensity of cultivation practised by its inhabitants. Areas of land closer to the site or easier to access were most likely cultivated more intensively, while areas further away and consequently more labour/time intensive to get to, receive less input, thus explaining the variability seen in the weed ecology. Different social groups may also have had less access to manure/midden material, cultivation areas may have been more inaccessible, or less labour may have been available to cultivate the fields in a more intensive way. Thus the mixture of high and low input cultivation seen at Çatalhöyük West through the weed ecology could reflect a pattern of different crop husbandry techniques employed to cope with the differing access to labour on a temporal and spatial scale. The lack of storage samples hampers a nuanced view of cultivation at the site, due to the absence of the relationship between crop seeds, their weeds and the social unit from which they are derived. However the results do show that people in the settlement were not following one particular method for cultivating the crops, in particular glume wheats, but were cultivating at different intensities, with fields reflecting a wide range of fertility and mechanical disturbance. Such variability most likely reflects the location of the fields, access to them and the labour required to cultivate them. Thus labour availability and field access is in part dictated by the size of the site.

The Late Chalcolithic site of Çamlıbel Tarlası is different to the Early Chalcolithic site of Çatalhöyük West. The small size of Çamlıbel Tarlası plus its metal working activities raises the question as to whether this site was agriculturally self-sufficient or relied on other sites for crops in exchange for the metal produced at the site. This question needs to be addressed before any discussion on crop husbandry can be conducted.

The plausibility of trade/movement of crops is very difficult to gauge given the paucity of archaeological knowledge of the region around Çamlıbel Tarlası. If Çamlıbel Tarlası received crops in exchange for goods, such actions would suggest that the other site/s practiced a form of agriculture that resulted in a large surplus available for trade. The cohesive set of crop husbandry methods seen in the weed ecology, however, does not support this assumption: the expected signature of crop husbandry from a large surplus-producing site is extensive, low input crop husbandry. Moreover, finds at the site support the idea of local cultivation, with finds of sickle blades with silica gloss (Schoop pers.com). The gloss indicates the harvesting of silica-rich plants such as grasses and sedges (Fullagar 1991; Maeda et al. 2016:228). At the site of Çamlıbel Tarlası the grass would most likely be cereals. There is also no indication of the complex social structures needed to support the movement of agricultural products within the region (Schoop pers.com). However given the limited archaeological investigation, conclusive determination of local versus regional crop production is difficult to reach for this period.

There is currently no evidence that suggests crops were imported on a large scale to Çamlıbel Tarlası, allowing inferences to be made on the local mode of crop husbandry. In contrast to Çatalhöyük West , Çamlıbel Tarlası's weed ecology indicates that there was a more cohesive set of crop husbandry practices followed by all. Manuring/middening occurred on a low scale, but occurred none the less. Domestic animals were plentiful at Çamlıbel Tarlası as evident in the zooarchaeological material excavated, in particular mature cattle which would have provided large quantities of manure over their lifetime (Bartosiewicz and Gillis 2011) and so manure was available for use. The hilly slopes around the site would make it potentially difficult or labour costly to distribute manure and the slight variation in enrichment of ^{15}N in the examined crops could be a consequence of this accessibility of the fields, with fields that were easier to access receiving higher amounts of manure than ones on steeper gradients. In addition, the availability of labour required to move the manure has to be considered. Çamlıbel Tarlası is a small site, potentially housing just one extended family during certain phases of occupation. In addition to farming, other industries were practised at the site with metal extraction and smelting a large component (Schoop 2011b; Pickard and Schoop 2013), resulting in limited labour for farming. Again the size of the site will impact on the labour input per area. The very small size of Çamlıbel Tarlası is most likely reflected in the cohesive set of crop husbandry intensity seen in the weed ecology results. Crop fields would have been in close proximity to the settlement, allowing consistent access to labour. Overall the results suggests that the plots were farmed using a method that allowed crop cultivation in small areas, but did not require high labour input possibly because labour was needed elsewhere. What sharply contrasts with the

results from Çatalhöyük West is that all the Çamlıbel Tarlası fields received the same intensity of input, most likely reflecting the consequence of the size of the site.

Kuruçay provides interesting results, presenting a weed ecology picture of crop husbandry intensity very similar to that of Çamlıbel Tarlası, although a significantly larger site. The Late Chalcolithic occupation of the site covered about 1.5 ha, six times larger than the 0.25ha of Çamlıbel Tarlası, but five times smaller than Çatalhöyük West. However its weed ecology looks very similar to that of Çamlıbel Tarlası. The lack of isotope results limits examination of manuring or water availability and the effect of the semi-arid environment on cultivation techniques.

The weed ecology suggests that, as at Çamlıbel Tarlası, the people of Kuruçay cultivated their crops at similar levels of intensity/labour input. This suggests equal access to the same level of labour inputs for the cultivation of at least barley, flax and lentil, with glume wheats potentially receiving less. Caution should be taken when interpreting the Kuruçay results, as the samples' size (8 samples), is low and some species are represented by just one sample. Such results tentatively suggest that the inhabitants all had the same access to their fields/labour.

The limited contrast between Çamlıbel Tarlası and Kuruçay highlights an interesting fact. If the hypothesis that site size affects the input of labour in cultivation – that smaller sites, given the ease of access/close proximity of their

fields have the opportunity to cultivate on a high intensity scale, while large sites due to the friction of scale are forced to cultivate further away from the settlement at a lower input rate- why does the very small site of Çamlıbel Tarlası not show a high input signature? The results appear to be suggesting that while site size can have a significant impact of the accessibility of fields, high input cultivation requires labour and a need or reason to cultivate at a high input level. Çamlıbel Tarlası, due to its tiny size, was most likely labour limited, as mentioned above, while the smallness of the site meant that sufficient food could be cultivated using the scale practised – there was no need to cultivate at a high input level and the labour which would have been require to do so could instead be used for alternate activities.

The social organisation of the examined sites as reflected in the archaeobotany differs. Çatalhöyük West, with its large population of many social units, while processing and consuming similar crops, principally glume wheat, utilised different techniques for cultivation. This was most likely a function of the wide cultivation area surrounding this large community. The variations may also reflect the site's organisation with social units having wider access to different resources, different access to fields in close proximity to the settlement or access to cultivatable land at a range of different distances from the site. Kuruçay presents a moderately sized settlement where there appears to be consistent access to labour or fields for the cultivation of crops across the different social units. The size of the site did not overly affect access to the fields, nor was labour too restricted between households. Çamlıbel Tarlası, however, was much smaller in size, with different social dynamics dictating access to resources and an

environmental setting less constricting than that of Çatalhöyük West and Kuruçay. Consequently, Çamlıbel Tarlası's crop cultivation represents the actions of a small community whose inhabitants use similar cultivation methods that were able to sustain the small population.

11.6 Future directions

This study has provided two new and two reassessed archaeobotanical datasets for the Chalcolithic in central Anatolia, increasing the number of quantitative archaeobotanical datasets for a time period seriously lacking in such information. They have provided a framework for understanding crop-based agriculture in a period leading up to the development of highly stratified societies. This study has been able to address the specific research questions set at its commencement, although a number of key areas have been noted that would benefit from further investigation.

Methodologically this research has highlighted the need for a quantitative study of the resultant product and by-products of 'traditional' glume wheat crop processing. Moreover it has highlighted the lack of detailed research into the processing of flax and/or linseed, the methods used and the by-products produced. Additional research, through stable carbon and nitrogen isotope analysis, into the cultivation of flax at sites would provide a greater understanding of this crop's cultivation but for this research to be undertaken, foundation work on the reaction of flax crops to both dry and wet conditions as well as the application of manure is first required.

This study has indicated the value of the reassessment of old assemblages as traditionally, preliminary assessments of site assemblages were either in the form of presence/absence data, or focused primarily on crop items. Kuruçay and Canhasan I highlight the usefulness of full quantitative data, allowing comparison of proportions of crop types. Such information from other sites, for example Hacılar, would be valuable for research.

The assemblages of Kuruçay and Canhasan I could not be completely reassessed, particularly with regards to weed flora, or chaff remains which are currently housed in Turkey. Reassessment of old assemblages for 'new type' glume wheat would be highly valuable, allowing an assessment of the role of this and the other glume wheat species in Chalcolithic central Anatolia. As indicated in Section 11.1.1 the proportion of glume wheat species differ between Çatalhöyük West and Çamlıbel Tarlası and the lack of other comparative sites with this information limits any conclusion that can be drawn about the reasons for this difference.

Additional detailed weed identifications are required to allow for a wider interpretation of crop processing and crop husbandry methods. Full identification of weed species from Canhasan I and other sites such as Hacılar would provide further datasets from which an understanding of the crop husbandry methods employed at these sites could be gained. The current framework constructed in this research is an excellent starting point for understanding Chalcolithic crop husbandry, and the addition of more comparative sites would allow conclusions as to whether the crop husbandry techniques employed are site, region or time period specific. Such information would allow a wider range of site types/sizes to

be included: as highlighted by the tiny site of Çamlıbel Tarlası, site size potentially affects the method used for cultivation – the addition of more small sites would provide a robust answer to this question.

This research has highlighted the value of stable carbon and nitrogen isotope analysis of crop seeds for the interpretation of crop husbandry methods used in the past, with this method complementing and enhancing weed ecology research. Investigation of the growing condition of crops through stable carbon and nitrogen isotope analysis from Canhasan I and Kuruçay was outside the scope of this project but such research is a vital next step, and would provide supporting information about the cultivation of different crop species, especially at Kuruçay given its storage samples. Carbon and nitrogen stable isotopes analysis on material from Canhasan I would be advantageous, allowing a comparison with Çatalhöyük West and providing the opportunity to explore whether the Canhasan region of the Konya plain also has an ecosystem wide enrichment in $\delta^{15}N$. Furthermore, Canhasan I provides an excellent opportunity to explore in more detail the change from naked to hulled barley, with both varieties present in the samples. Such isotopic investigation may allow the understanding of whether the Çatalhöyük approach of cultivating barley within the drier niche is purely site specific or whether other sites in semi-arid regions adopted such practices.

This research has indicated the need for further investigation of Chalcolithic sites within central Anatolia, especially the apparently elusive Middle Chalcolithic sites, which are sadly lacking. The excavation of Çamlıbel Tarlası by Ulf Schoop has underscored the lack of knowledge about small-scale communities within the

Chalcolithic; this research has highlighted the site-specific cultivation of such sites and the valuable information that can be gained from the analysis of these small settlements.

11.1 Final remarks

This study has provided significant new archaeobotanical data about Chalcolithic central Anatolia, revealing a pattern of crop use, focusing on hulled barley, glume wheats and key pulse species and showing that flax cultivation commenced in the Late Chalcolithic and had flax-specific weed flora. Furthermore, this research discovered that plant use was specific to each Chalcolithic community: the different proportions of glume wheat and relative importance of pulse species were community specific as was the exploitation of wild plant foods. In contrast, the processing and storage of glume wheats as spikelets is a common theme throughout the sites. Differences in the use of dung as fuel and crop husbandry techniques used highlight both the impact of the environment and the size, scale and organization of the communities themselves. Ultimately, this research has furthered the understanding of plant use in, and social organisation of, Chalcolithic central Anatolia, as well as highlighting the need for further research into this under-studied time period, a period that could play an important role in the understanding of the later social organisational changes of the Bronze Age.

12 Appendix

12.1 Appendix - Calculation of discrimination during photosynthesis

Discrepancies and the use of different equations to derive $\Delta^{13}C$ have been noted during this research. Two different expressions have been used in archaeological literature to obtain Δ and provide different results. As noted in section 3.22, the common equation used has been adopted from plant science (Equation 1, Section 3.2.2.1) due to its ease of application to archaeological material; it does not require any measurement that cannot be obtained from archaeological material. McCarroll and Loader (2004), in their review of the application of stable carbon isotope analysis to archaeology provide an alternative equation. This appendix compares in detail the derivation, and ultimate values produced, by these two equations.

McCarroll and Loader (2004) used the expression:

$$\Delta‰ = a+(b-a)(Ci/Ca)$$

Equation 3

Equation 3 is a formula constructed by Farquhar et al. (1982:124, formula 10), to calculate discrimination. In this formula (a) represents fractionation due to diffusion, (b) is the net fractionation due to carboxylation, while Ci/Ca is the ratio of internal over external concentrations of carbon dioxide. This formula relies on the assumption of values for (a) and (b), however both are not constant. 4.4 is the common value used for fractionation due to diffusion (a) however this can vary

depending on stomatal size (McCarroll and Loader 2004). A divergence between the value for (*a*) given by Farquhar et al. (1982) and McCarroll and Loader (2004) is that McCarroll and Loader report it as a negative value, while Farquhar et al. (1982) report it as positive. The value for the net fractionation due to carboxylation (*b*) is again not a constant. Farquhar et al. (1989) report a range between 27 and 30 and 27 is the commonly used value in many studies. Again, differences in whether this value is positive or a negative is evident, with Farquhar's value positive while McCaroll and Loader report it as negative. Ci/Ca, the ratio of internal over external concentrations of carbon dioxide, is unknown.

The use of for archaeological material is difficult, as it does not relate to a measurement of $\delta^{13}C$ nor can Ci/Ca for the plants from which the archaeological material came be determined. Values for Ci/Ca can range from 0.48 to 0.76 for crop plants (Constable and Rawson 1980). Thus the choice is to assume a value for Ci/Ca or try to derive it from measured $\delta^{13}C$.

To derive it, a formula describing the relationship of Ci/Ca to measured $\delta^{13}C$ is required. Two published formulas can be used to do this. The first is from Farquhar et al. 1982 (formula 11):

$$\delta_{Product} = \delta_{Source} - a - (b-a) * (Ci/Ca)$$

Equation 4

As $\delta_{Product}$ and δ_{Source} are known and values for a and b can be assumed Ci/Ca can be derived:

$$Ci/Ca = (\delta_{Source} - \delta_{Product} - a)/(b-a)$$

Equation 5

Once put into equation 3 the result is

$$\Delta‰ = a+(b-a)*((\delta_{Source} - \delta_{Product} -a)/(b-a))$$

Consequently (b-a) and a cancel out and the final equation is just:

$$\Delta‰ = \delta_{Source} - \delta_{Product}$$

Equation 6

Comparison of to Equation 1 (Section 3.2.2.1) reveals limited difference. If $\delta_{product}$= -23 and δ_{Source} is -6.4 then the difference between the two formulas is 0.10‰. McCarroll and Loader (2004) however published a different formula to derive *Ci/Ca.*

$$Ci/Ca=(\delta_{Product-} - \delta_{Source} +a)/(b-a)$$

Equation 7

Substituted into the formula for Δ‰ this produces

$$\Delta‰=a+(b-a)* (\delta_{Product-} - \delta_{Source} +a)/(b-a)$$

and ultimately

$$\Delta‰= 2a + (\delta_{Product-} - \delta_{Source})$$

Equation 3 is described by McCarroll and Loader (2004) and its derivation is not referenced. This formula produces a higher value for *Ci/Ca* and the values given for (*a)* and (*b)* are negative not positive. If a negative (*a)* and (*b)* is used then the *Ci/Ca* ratio is large, close to one, and this results in a negative value for Δ‰. If positive values of (*a)* and (*b)* are used then the *Ci/Ca* ratio is negative, resulting again in a negative Δ‰. These results suggest that there is something wrong with the formula McCarroll and Loader (2004) used to derive *Ci/Ca*.

It is confusing that there seems to be differences between Farquhar et al. (1982) and McCarroll and Loader (2004) as McCarroll and Loader (2004) reference Farquhar as the source of their equation. It is possible the discrepancy is purely due to the inversion of positives and negative in their paper. As they provide no

information to support the derivation of their formula, the Farquhar et al. (1982) formulas seems to have higher validity.

12.2 Chapter 4 tables

Table 12.1: Unit number and flot number of samples, the merged samples and the name by which they are referred to in the text, their context, phase or building details.

Site	Unit	Flot No (/merged flot no.)	Text name	Phase/ Building	Context
Çamlıbel Tarlası	50	60	60	CBTIV/III	Fill
Çamlıbel Tarlası	66	35/38	35/38	CBTIII	Ext. floor
Çamlıbel Tarlası	66	40	40	CBTIII	Ext. floor
Çamlıbel Tarlası	66	29	29	CBTIII	Ext. floor
Çamlıbel Tarlası	68	88	88	CBTIII	Floor
Çamlıbel Tarlası	97	204	204	CBTI/II	Fill
Çamlıbel Tarlası	109	110	110	CBTIV	Fill
Çamlıbel Tarlası	133	139	139	CBTIV	Floor
Çamlıbel Tarlası	146	224	224	CBTIV	Floor
Çamlıbel Tarlası	147	50	50	CBTIV	Floor
Çamlıbel Tarlası	151	48	48	CBTIV	Floor
Çamlıbel Tarlası	152	238	238	CBT IV	Floor
Çamlıbel Tarlası	203	74/3	74/3	CBTII	Floor
Çamlıbel Tarlası	203	78/116	78/116	CBTII	Floor
Çamlıbel Tarlası	203	113/6	113/6	CBTII	Floor
Çamlıbel Tarlası	208	76/12	76/12	CBTII	Floor
Çamlıbel Tarlası	243	17	17	CBTI	Ash layer
Çamlıbel Tarlası	246	79	79	CBTI	Ash layer
Çamlıbel Tarlası	251	19	19	CBTI	Ash layer
Çamlıbel Tarlası	254	49	49	CBTI	Ash layer
Çamlıbel Tarlası	257	90	90	CBTI	Ash layer
Çamlıbel Tarlası	259	180/26	180/26	CBTII	Floor
Çamlıbel Tarlası	264	200	200	CBTII	Floor
Çamlıbel Tarlası	264	186/202	186/202	CBTII	Floor
Çamlıbel Tarlası	300	75	75	CBTIII	Floor
Çamlıbel Tarlası	301	42	42	CBTIII	Ext. floor
Çamlıbel Tarlası	302	45	45	CBTIII	Ext. floor
Çamlıbel Tarlası	304	209	209	CBTI	Ash layer
Çamlıbel Tarlası	306	54	54	CBTI	Ash layer
Çamlıbel Tarlası	310	223	223	CBTIII	Ext. floor
Çamlıbel Tarlası	313	226	226	CBTI	Ash layer
Çamlıbel Tarlası	314	46	46	CBTIII	Ext. Floor
Çamlıbel Tarlası	315	210	210	CBTII	Floor
Çamlıbel Tarlası	315	132	132	CBTII	Floor
Çamlıbel Tarlası	315	213	213	CBTII	Floor
Çamlıbel Tarlası	430	250	250	CBTIII	Fill (ext. floor)
Çamlıbel Tarlası	439	253/222/255/261	m439	CBTIII	Floor
Çamlıbel Tarlası	439	260	260	CBTIII	Floor
Çamlıbel Tarlası	440	270/220/268/265 /266/263/262	m440	CBTIII	Floor
Çamlıbel Tarlası	455	306	306	CBTIV	Ext. floor
Çamlıbel Tarlası	460	325	325	CBTIV	Ext. floor
Çamlıbel Tarlası	463	324	324	CBTIV	Floor
Çamlıbel Tarlası	465	311	311	CBTIII	Ext. floor

Site	Unit	Flot No (/merged flot no.)	Text name	Phase/ Building	Context
Çamlıbel Tarlası	466	295/294/293/291/303	m466	CBTIII	Floor
Çamlıbel Tarlası	468	276	276	CBTIII	Floor
Çamlıbel Tarlası	632	322/308/333	m632	CBTIV	Fill (ext. floor)
Çamlıbel Tarlası	647	310	310	CBTIV	Pit
Çamlıbel Tarlası	706	321	321	CBTIII	Fill (floor)
Çamlıbel Tarlası	823	337	337	CBTI	Ash layer
Çamlıbel Tarlası	843	358	358	CBTI	Ash layer
Çamlıbel Tarlası	848	357	357	CBTI	Ash layer
Çamlıbel Tarlası	850	361	361	CBTI	Ash layer
Çamlıbel Tarlası	868	365	365	CBTII	Floor
Çamlıbel Tarlası	869	377/365	377/365	CBTIII	Floor
Çamlıbel Tarlası	869	370	370	CBTIII	Floor
Çamlıbel Tarlası	869	366	366	CBTIII	Floor
Çamlıbel Tarlası	877	390/387/417	m877	CBTI	Ash layer
Çamlıbel Tarlası	887	414/418	m887	CBTIII	Ext. floor
Çamlıbel Tarlası	325	163			
Çamlıbel Tarlası	895	424	424	CBTII post-ab	Fill
Çamlıbel Tarlası	900	405	405	CBTII	Fill (Ext. floor)
Çamlıbel Tarlası	902	411	411	CBTII	Floor
Çamlıbel Tarlası	907	425	425	CBTI	Fill
Çamlıbel Tarlası	911	415	415	CBTII	Oven
Çamlıbel Tarlası	921	428	428	CBTII	Oven
Çamlıbel Tarlası	939	422	422	CBTII	Fill (floor)
Çamlıbel Tarlası	942	427	427	CBTII	"Silo"
Çamlıbel Tarlası	956	419	419	CBTII	"Silo"
Çamlıbel Tarlası	958	423	423	CBTII	"Silo"
Çamlıbel Tarlası	980	406	406	CBTI	Ash layer
Çamlıbel Tarlası	1006	396	396	CBTII	Floor
Çamlıbel Tarlası	1007	392	392	CBTI	Ash layer
Çamlıbel Tarlası	1008	400	400	CBTII	Floor
Çamlıbel Tarlası	1009	421	421	CBTI	Ash layer
Çatalhöyük W	15160	9341	9341	98	Cluster
Çatalhöyük W	15180	9358	9358	98	Fill
Çatalhöyük W	15362	9495	9495	98	Fill
Çatalhöyük W	15380	9524	9524	98	Fill
Çatalhöyük W	16950	9562	9562	98	Fill
Çatalhöyük W	16964	9563	9563	98	Fill
Çatalhöyük W	16951	9573	9573	98	Lens
Çatalhöyük W	15389	9591	9591	98	Cluster
Çatalhöyük W	16969	9602	9602	98	Lens
Çatalhöyük W	16973	10099	10099	98	Fill
Çatalhöyük W	16980	10100	10100	98	Fill
Çatalhöyük W	16981	10111	10111	98	Fill
Çatalhöyük W	18376	10279	10279	98	Floor
Çatalhöyük W	31200	11092	11092	98	Fill
Çatalhöyük W	31222	11093	11093	98	Fill
Çatalhöyük W	31122	11015	Floor 16977	98	Floor
Çatalhöyük W	31120	11016			
Çatalhöyük W	31107	11017			
Çatalhöyük W	31105	11018			
Çatalhöyük W	31106	11019			
Çatalhöyük W	31104	11021			

Site	Unit	Flot No (/merged flot no.)	Text name	Phase/ Building	Context
Çatalhöyük W	31103	11022			
Çatalhöyük W	31119	11023			
Çatalhöyük W	31118	11026			
Çatalhöyük W	31117	11027			
Çatalhöyük W	31121	11028			
Çatalhöyük W	31102	11029			
Çatalhöyük W	31135	11037	Floor18376	98	Floor
Çatalhöyük W	31136	11045			
Çatalhöyük W	31137	11051			
Çatalhöyük W	31138	11062			
Çatalhöyük W	31139	11067			
Çatalhöyük W	31140	11078			
Çatalhöyük W	31143	11046	11046	98	Fill
Çatalhöyük W	16899	8360	8360	105	Cluster
Çatalhöyük W	18311	8911	8911	105	Fill
Çatalhöyük W	18328	8953	8953	105	Fill
Çatalhöyük W	15360	9519	9519	105	Lens
Çatalhöyük W	16958	9564	9564	105	Lens
Çatalhöyük W	16938	9600	9600	105	Lens
Çatalhöyük W	16966	9603	9603	105	Lens
Çatalhöyük W	16959	9613	9613	105	Lens
Çatalhöyük W	16939	9619	9619	105	Lens
Çatalhöyük W	17274	10110	10110	105	Fill
Çatalhöyük W	31141	11053	11053	105	Fill
Çatalhöyük W	31224	11087	11087	105	Fill
Çatalhöyük W	31239	11097	11097	105	Fill
Çatalhöyük W	18341	10289/9033	u18341	105	Fill
Çatalhöyük W	31210	11091/11090	u31210	105	Fill
Çatalhöyük W	17231	8461	8461	106	Cluster
Çatalhöyük W	15365	9471	9471	106	Cluster
Çatalhöyük W	31232	11096	11096	106	Fill
Çatalhöyük W	31114	11007/11008	u31114	107	Fill
Çatalhöyük W	18377	11041	11041	125	Fill
Çatalhöyük W	31196	11088	11088	125	Fill
Çatalhöyük W	31214	11089	11089	125	Fill
Çatalhöyük W	31227	11094	11094	125	Fill
Çatalhöyük W	31245	11100	11100	125	Lens
Çatalhöyük W	31217	11086	11086	125	Lens
Çatalhöyük W	17294	10265	10265	126	Floor
Çatalhöyük W	17277	10271	10271	126	Fill

Table 12.2: The sites, lab code, sample name referred to in text, it unit and flot number species and phases of the 199 samples used for isotopic analysis.

Site	Lab code	Name in text	Unit	Flot number	Species	Phase
East Mound (TP)	TP009	u13508	13508		New type'	LN
East Mound (TP)	TP010	u13508	13508		Emmer	LN
East Mound (TP)	TP002	u13521	13521		New type'	LN
East Mound (TP)	TP003	u15269	15269		New type'	LN
East Mound (TP)	TP004	u15278	15278		New type'	LN
East Mound (TP)	TP011	u15278	15278		Emmer	LN
East Mound (TP)	TP012	u15278	15278		Einkorn	LN
East Mound (TP)	TP001	u15827	15827		'New type'	LN
East Mound (TP)	TP008	u15829	15829		Barley	LN
East Mound (TP)	TP007	u15829s2	15829	sample 2	Barley	LN
East Mound (TP)	TP006	u15829s6	15829	sample 6	Barley	LN
East Mound (TP)	TP005	u15829s8	15829	sample 8	Barley	LN
West Mound (trench1)	CW1T013	1483	2944	1483	Barley	ECII
West Mound (trench1)	CW1T015	1490	2910	1490	Free-threshing wheat	ECII
West Mound (trench1)	CW1T016	1490	2910	1490	Einkorn (1gr)	ECII
West Mound (trench1)	CW1T019	1490	2910	1490	Einkorn (2gr)	ECII
West Mound (trench1)	CW1T021	1514	2959	1514	Einkorn (1gr)	ECII
West Mound (trench1)	CW1T017	1517	2911	1517	Pea	ECII
West Mound (trench1)	CW1T023	1517	2911	1517	Lentil	ECII
West Mound (trench1)	CW1T024	1517	2911	1517	Einkorn (2gr)	ECII
West Mound (trench1)	CW1T014	4109	3488	4109	Barley	ECI
West Mound (trench1)	CW1T002	4232	6525	4232	Free-threshing wheat	ECI
West Mound (trench1)	CW1T018	4232	6525	4232	Pea	ECI
West Mound (trench1)	CW1T001	4243	6514	4243	emmer	ECI
West Mound (trench1)	CW1T004	4243	6514	4243	Lentil	ECI
West Mound (trench1)	CW1T005	4382	6559	4382	Einkorn (1gr)	ECI
West Mound (trench1)	CW1T022	4444	6586	4444	Free-threshing wheat	ECI
West Mound (trench1)	CW1T011	5540	7729	5540	Free-threshing wheat	ECI
West Mound (trench1)	CW1T025	5596	7754	5596	Barley	ECI
West Mound (trench1)	CW1T026	5596	7754	5596	Free-threshing wheat	ECI

Site	Lab code	Name in text	Unit	Flot number	Species	Phase
West Mound (trench1)	CW1T007	5598	7759	5598	Lentil	ECI
West Mound (trench1)	CW1T003	5655	7790	5655	Barley	ECI
West Mound (trench1)	CW1T012	5701	9019	5701	Barley	ECI
West Mound (trench1)	CW1T020	5740	9028	5740	Emmer	ECI
West Mound (trench1)	CW1T009	5767	9033	5767	Einkorn (1gr)	ECI
West Mound (trench1)	CW1T010	5767	9033	5767	Einkorn (2gr)	ECI
West Mound (trench1)	CW1T008	5778	9049	5778	Barley	ECI
West Mound (trench1)	CW1T006	5779	9052	5779	Barley	ECI
West Mound (trench 5)	CW021	8911	18311	8911	Barley	ECI
West Mound (trench 5)	CW022	8911	18311	8911	New type'	ECI
West Mound (trench 5)	CW023	9341	15160	9341	Barley	ECI
West Mound (trench 5)	CW024	9358	15180	9358	Barley	ECI
West Mound (trench 5)	CW025	9495	15362	9495	Barley	ECI
West Mound (trench 5)	CW026	9562	16950	9562	Barley	ECI
West Mound (trench 5)	CW027	9563	16964	9563	Barley	ECI
West Mound (trench 5)	CW028	9564	16958	9564	Barley	ECI
West Mound (trench 5)	CW029	9564	16958	9564	Pea	ECI
West Mound (trench 5)	CW030	9573	16951	9573	Free-threshing wheat	ECI
West Mound (trench 5)	CW031	9591	15389	9591	Barley	ECI
West Mound (trench 5)	CW032	9602	16969	9602	Emmer	ECI
West Mound (trench 5)	CW033	9602	16969	9602	Free-threshing wheat	ECI
West Mound (trench 5)	CW034	9602	16969	9602	Lentil	ECI
West Mound (trench 5)	CW001	10110	17274	10110	Barley	ECI
West Mound (trench 5)	CW002	10111	16981	10111	Barley	ECI
West Mound (trench 5)	CW035	10265	17294	10265	Barley	ECI
West Mound (trench 5)	CW009	11041	18377	11041	Barley	ECI
West Mound (trench 5)	CW010	11041	18377	11041	Lentil	ECI
West Mound (trench 5)	CW011	11088	31196	11088	Barley	ECI
West Mound (trench 5)	CW037	11088	31196	11088	Lentil	ECI
West Mound (trench 5)	CW038	11089	31214	11089	Einkorn	ECI
West Mound (trench 5)	CW016	11093	31222	11093	Barley	ECI
West Mound (trench 5)	CW017	11094	31227	11094	Barley	ECI

Site	Lab code	Name in text	Unit	Flot number	Species	Phase
West Mound (trench 5)	CW018	11096	31232	11096	Barley	ECI
West Mound (trench 5)	CW039	11096	31232	11096	Einkorn	ECI
West Mound (trench 5)	CW019	11097	31239	11097	Barley	ECI
West Mound (trench 5)	CW020	11097	31239	11097	Free-threshing wheat	ECI
West Mound (trench 5)	CW040	11097	31239	11097	Einkorn	ECI
West Mound (trench 5)	CW003	18341	18341	10289/9033	Barley	ECI
West Mound (trench 5)	CW004	18341	18341	10289/9033	Free-threshing wheat	ECI
West Mound (trench 5)	CW005	18341	18341	10289/9033	Einkorn	ECI
West Mound (trench 5)	CW006	31114	31114	11007/11008	Barley	ECI
West Mound (trench 5)	CW007	31114	31114	11007/11008	Pea	ECI
West Mound (trench 5)	CW008	31114	31114	11007/11008	Lentil	ECI
West Mound (trench 5)	CW036	31114	31114	11007/11008	Einkorn	ECI
West Mound (trench 5)	CW012	31210	31210	11091/11090	Barley	ECI
West Mound (trench 5)	CW013	31210	31210	11090/11091	Einkorn	ECI
West Mound (trench 5)	CW014	31210	31210	11090/11091	Lentil	ECI
West Mound (trench 5)	CW015	31210	31210	11090/11091	Free-threshing wheat	ECI
Çamlıbel Tarlası	CBT001	939	939	422	Lentil	CBTII
Çamlıbel Tarlası	CBT002	133	133	100/218/140/143/146/196	Bitter vetch	CBTIV
Çamlıbel Tarlası	CBT003	980	980	406	Lentil	CBTI
Çamlıbel Tarlası	CBT004	980	980	406	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT005	900	900	405	Bitter vetch	CBTII
Çamlıbel Tarlası	CBT006	902	902	411	Barley	CBTII
Çamlıbel Tarlası	CBT007	1009	1009	421	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT008	465	465	311	Barley	CBTIII
Çamlıbel Tarlası	CBT009	465	465	311	Lentil	CBTIII
Çamlıbel Tarlası	CBT010	152	152	144/205/238/237	Barley	CBTIV
Çamlıbel Tarlası	CBT011	152	152	144/238/237	Lentil	CBTIV
Çamlıbel Tarlası	CBT012	152	152	59/151238/237	Bitter vetch	CBTIV
Çamlıbel Tarlası	CBT013	97	97	204/207	Lentil	CBTI/II
Çamlıbel Tarlası	CBT014	97	97	204/207	Bitter vetch	CBTI/II
Çamlıbel Tarlası	CBT015	907	907	425	Barley	CBTI
Çamlıbel Tarlası	CBT016	907	907	425	Einkorn	CBTI

Site	Lab code	Name in text	Unit	Flot number	Species	Phase
Çamlıbel Tarlası	CBT017	907	907	425	Lentil	CBTI
Çamlıbel Tarlası	CBT018	843	843	356	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT019	843	843	356/358	Barley	CBTI
Çamlıbel Tarlası	CBT020	843	843	356	Einkorn	CBTI
Çamlıbel Tarlası	CBT021	304	304	209	Barley	CBTI
Çamlıbel Tarlası	CBT022	304	304	209	Emmer	CBTI
Çamlıbel Tarlası	CBT023	304	304	209	Lentil	CBTI
Çamlıbel Tarlası	CBT024	257	257	90	Barley	CBTI
Çamlıbel Tarlası	CBT025	257	257	90	Lentil	CBTI
Çamlıbel Tarlası	CBT026	325	325	161/159/163	Einkorn	CBTIII
Çamlıbel Tarlası	CBT027	325	325	124/122/130/134/161/154	Bitter vetch	CBTIII
Çamlıbel Tarlası	CBT028	1008	1008	400	Bitter vetch	CBTII
Çamlıbel Tarlası	CBT029	1008	1008	400	Barley	CBTII
Çamlıbel Tarlası	CBT030	1008	1008	400	Lentil	CBTII
Çamlıbel Tarlası	CBT031	146	146	85/224/72	Bitter vetch	CBTIV
Çamlıbel Tarlası	CBT032	146	146	85/224/72/71	Lentil	CBTIV
Çamlıbel Tarlası	CBT033	254	254	49	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT034	254	254	49	Lentil	CBTI
Çamlıbel Tarlası	CBT035	887	887	389/414/420/412/418	Lentil	CBTIII
Çamlıbel Tarlası	CBT036	887	887	412/289/420/414/418/388	Bitter vetch	CBTIII
Çamlıbel Tarlası	CBT037	958	958	423	Lentil	CBTII
Çamlıbel Tarlası	CBT038	1006	1006	396	Lentil	CBTII
Çamlıbel Tarlası	CBT039	895	895	424	Bitter vetch	CBTII post-ab
Çamlıbel Tarlası	CBT040	895	895	424	Lentil	CBTII post-ab
Çamlıbel Tarlası	CBT041	895	895	424	Einkorn	CBTII post-ab
Çamlıbel Tarlası	CBT042	254	254	49	Einkorn	CBTI
Çamlıbel Tarlası	CBT043	254	254	49	Barley	CBTI
Çamlıbel Tarlası	CBT044	887	887	418/420/388/414	Barley	CBTIII
Çamlıbel Tarlası	CBT045	133	133	140/141/138/218/142/100	Barley	CBTIV
Çamlıbel Tarlası	CBT046	315	315	213/217/210/206/231	Barley	CBTII
Çamlıbel Tarlası	CBT047	97	97	204/208	Barley	CBTI/II
Çamlıbel Tarlası	CBT048	68	68	88/70/69/89/65/67	Lentil	CBTIII

Site	Lab code	Name in text	Unit	Flot number	Species	Phase
Çamlıbel Tarlası	CBT049	911	911	415	Einkorn	CBTII
Çamlıbel Tarlası	CBT050	325	325	130/163/134	Barley	CBTIII
Çamlıbel Tarlası	CBT051	907	907	425	Triticum aestivum	CBTI
Çamlıbel Tarlası	CBT052	68	68	67/88/70/65/88/68	Bitter vetch	CBTIII
Çamlıbel Tarlası	CBT053	1009	1009	421	Barley	CBTI
Çamlıbel Tarlası	CBT054	313	313	226	Emmer	CBTI
Çamlıbel Tarlası	CBT055	68	68	88/70/69/89/65/67	Barley	CBTIII
Çamlıbel Tarlası	CBT056	440	440	262/272/264/219/263	Bitter vetch	CBTIII
Çamlıbel Tarlası	CBT057	300	300	75/182/82	Barley	CBTIII
Çamlıbel Tarlası	CBT058	958	958	423	Barley	CBTII
Çamlıbel Tarlası	CBT059	F394	1007	394	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT060	54	54	?54	Barley	CBTI
Çamlıbel Tarlası	CBT061	911	911	415	Lentil	CBTII
Çamlıbel Tarlası	CBT062	315	315	213/217/231/160/179/234/132	Lentil	CBTII
Çamlıbel Tarlası	CBT063	843	843	356/358	Lentil	CBTI
Çamlıbel Tarlası	CBT064	911	911	415	Barley	CBTII
Çamlıbel Tarlası	CBT065	313	313	226	Barley	CBTI
Çamlıbel Tarlası	CBT066	315	315	232/160/157/234/132/	Bitter vetch	CBTII
Çamlıbel Tarlası	CBT067	1006	1006	396	Barley	CBTII
Çamlıbel Tarlası	CBT068	147	147	50	Lentil	CBTIV
Çamlıbel Tarlası	CBT069	848	848	357	Lentil	CBTI
Çamlıbel Tarlası	CBT070	848	848	357	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT071	315	315	213/160/132	Einkorn	CBTII
Çamlıbel Tarlası	CBT072	921	921	428	Einkorn	CBTII
Çamlıbel Tarlası	CBT073	850	850	361	Barley	CBTI
Çamlıbel Tarlası	CBT074	251	251	19	Einkorn	CBTI
Çamlıbel Tarlası	CBT075	246	246	79	Lentil	CBTI
Çamlıbel Tarlası	CBT076	246	246	79	Barley	CBTI
Çamlıbel Tarlası	CBT077	306	306	54	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT078	208	208	11/186	Barley	CBTI
Çamlıbel Tarlası	CBT079	F390	877	390	Einkorn	CBTI
Çamlıbel Tarlası	CBT080	F390	877	390	Lentil	CBTI

Site	Lab code	Name in text	Unit	Flot number	Species	Phase
Çamlıbel Tarlası	CBT081	F392	1007	392	Lentil	CBTI
Çamlıbel Tarlası	CBT082	F394	1007	393	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT083	F395	1007	395	Lentil	CBTI
Çamlıbel Tarlası	CBT084	F395	1007	395	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT085	877	877	417/387	Barley	CBTI
Çamlıbel Tarlası	CBT086	F390	877	390	Einkorn	CBTI
Çamlıbel Tarlası	CBT087	F390	877	390	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT088	251	251	19	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT089	F395	1007	395	Emmer	CBTI
Çamlıbel Tarlası	CBT090	243	243	17	Barley	CBTI
Çamlıbel Tarlası	CBT091	251	251	19	Barley	CBTI
Çamlıbel Tarlası	CBT092	F390	877	390	Barley	CBTI
Çamlıbel Tarlası	CBT093	310	310	223/194/225/215/230/235	Barley	CBTIII
Çamlıbel Tarlası	CBT094	F393	1007	393	Einkorn	CBTI
Çamlıbel Tarlası	CBT095	850	850	361	Einkorn	CBTI
Çamlıbel Tarlası	CBT096	325	325	154/161/134/163/172/159/124/122	Lentil	CBTIII
Çamlıbel Tarlası	CBT097	313	313	226	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT098	877	877	387	Bitter vetch	CBTI
Çamlıbel Tarlası	CBT099	302	302	45	Bitter vetch	CBTIII
Çamlıbel Tarlası	CBT100	304	304	209	pisum	CBTI
Çamlıbel Tarlası	CBT101	877	877	417/387	Grass pea	CBTI
Çamlıbel Tarlası	CBT102	310	310	135/223/215/216/211/225	Bitter vetch	CBTIII
Çamlıbel Tarlası	CBT103	F390	877	390	chickpea	CBTI
Çamlıbel Tarlası	CBT104	310	310	212/194/215/166/225/223	Lentil	CBTIII
Çamlıbel Tarlası	CBT105	1006	1006	396	Grass pea	CBTII
Çamlıbel Tarlası	CBT106	877	877	387	Lentil	CBTI
Çamlıbel Tarlası	CBT107	325	325	161/163/159	Grass pea	CBTIII
Çamlıbel Tarlası	CBT108	304	304	209	Grass pea	CBTI
Çamlıbel Tarlası	CBT109	F390	877	390	Grass pea	CBTI
Çamlıbel Tarlası	CBT110	251	251	19	Lentil	CBTI
Çamlıbel Tarlası	CBT111	243	243	17	Lentil	CBTI
Çamlıbel Tarlası	CBT112	325	325	163/154/122	Emmer	CBTII

Site	Lab code	Name in text	Unit	Flot number	Species	Phase
Çamlıbel Tarlası	CBT113	F393	1007	393	Barley	CBTI
Çamlıbel Tarlası	CBT114	68	68	70/88	Einkorn	CBTIII
Çamlıbel Tarlası	CBT115	243	243	17	Einkorn	CBTI
Çamlıbel Tarlası	CBT116	466	466	291/303/295/293	Lentil	CBTIII
Çamlıbel Tarlası	CBT117	300	300	182/61/84/75	Lentil	CBTIII
Çamlıbel Tarlası	CBT118	313	313	226	Lentil	CBTI
Çamlıbel Tarlası	CBT119	313	313	226	Einkorn	CBTI
Çamlıbel Tarlası	CBT120	877	877	417/387	Chickpea	CBTI
Çamlıbel Tarlası	CBT121	843	843	356/358	Grass pea	CBTI

Table 12.3: Raw data table for Çatalhöyük West showing the items found.

Çatalhöyük West	Sample number in text		11100	Floor 18376	10100	10271	11086	8911	Floor 16977	11093	11046	11096	9603	11087	u31210	11053	9519	9341	10279	9619	11089	9358
	Building		125	98	98	126	125	105	98	98	98	106	105	105	105	105	105	98	98	105	125	98
	Context		Lens	Floor	Fill	Fill	Lens	Fill	Floor	Fill	Fill	Fill	Lens	Fill	Fill	Fill	Lens	Cluster	Floor	Lens	Fill	Fill
	Non-seed/fruit/chaff material																					
	>2 mm wood charcoal (ml)	**misc.**	0.75	3.1			3.7		9.85	2.5	0.55	2.75	4.5	3.5	7	4		4.5	0.75	4.5	2	
	>2 mm tuber (ml)	**misc.**	0.25	0.8					2.5	0.25	0.5	1.4	1	1	4.75	1		0.25	0.75	0.5	1	
	>2 mm fruit/bread (ml)	**misc.**											0.25	0.2	0.75	0.75		0.25		0.25	0.5	
	>2 mm oily burnt mass (ml)	**misc.**		0.2																		
	Mouse pellets	**misc.**		1																1		
Latin name	**Common name**	**Plant part**																				
	Crops																					
Hordeum vulgare var. *nudum*	**Naked barley**	**Grain**													1		1					
Hordeum vulgare var. *vulgare*	**Hulled barley**	**Grain**			3			6	2	4	1	6	5	3	4	1	3	5		3	3	4
Hordeum vulgare	**Barley indeterminate**	**Grain**	4	2	3			7	5		1	6		7	19	7	1	5	2	4	5	4
Triticum aestivum	**Free-threshing wheat**	**Grain**		1				1						2	4	2		1			1	
Triticum monococcum	**Einkorn, one-seeded type**	**Grain**		1					3	1		3	1	1	10	3					4	
Triticum monococcum	**Einkorn, one-seeded/wild type**	**Grain**																		2		
Triticum monococcum	**Einkorn, two-seeded type**	**Grain**													1		1					
Triticum monococcum	**Einkorn, two-seeded/Emmer**	**Grain**																				
Triticum dicoccum	**Emmer**	**Grain**		1				1	1	0.5		1		1				2			1	
Triticum sp.	**"New Type" glume wheat**	**Grain**						4					1							1		
Triticum dicoccum/Triticum sp.	**Emmer/ "New Type" glume wheat**	**Grain**																				
Triticum sp.	**Glume wheat indeterminate**	**Grain**			2				3	0.5			1		10	2	4					3
Triticum sp.	**Glume wheat indet. 1 seeded**	**Grain**																				
Triticum sp.	**Glume wheat indet. 2 seeded**	**Grain**		1				3	2			2		6	6			8			2	
Triticum sp.	**Wheat indeterminate**	**Grain**	8	8	4	1		9	26	4.5	3	8	6	2	35	13	5	10	1	3	12	10
Hordeum/Triticum	**Cereal indeterminate**	**Grain**	4	8	7	1	1	14	30	4.5	2	16	15	12	73	27	11	18	3	9	9	5
Triticum aestivum	**Bread wheat**	**Rachis**			1			1								4		1				2
Hordeum vulgare var. *nudum*	**Naked 6-row barley**	**Rachis**		1	2				1				1		1		8					

Sample number in text		u31114	11097	9591	8953	11041	10111	8360	9471	9524	11094	9613	10110	u18341	10265	11092	11088	8461	9600	9563	9564	10099	9495	9562	9573	9602
Building		107	105	98	105	125	98	105	106	98	125	105	105	105	126	98	125	106	105	98	105	98	98	98	98	98
Context		Fill	Fill	Cluster	Fill	Fill	Fill	Cluster	Cluster	Fill	Fill	Lens	Fill	Fill	Floor	Fill	Fill	Cluster	Lens	Fill	Lens	Fill	Fill	Fill	Lens	Lens
Non-seed/fruit/chaff material																										
>2 mm wood charcoal (ml)	**misc.**	12	2.5			6.5					2	2	7	5.5		1.75	5.5		19			2.5			3.5	
>2 mm tuber (ml)	**misc.**	0.75	0.5			0.75					0.6	0.75	0.75	1.8		0.75	0.75		0.25			0.5				
>2 mm fruit/bread (ml)	**misc.**	0.2									0.25		0.5			0.5	0.25									
>2 mm oily burnt mass (ml)	**misc.**											0.1														
Mouse pellets	**misc.**																									
Common name	**Plant part**																									
Crops																										
Naked barley	**Grain**					2	1						1	2						1				1		1
Hulled barley	**Grain**	13	4	5	3	5	7	1	2	4	7		5	15.5	3	6	3	3	3	4	5		11	6		1
Barley indeterminate	**Grain**	3	4	9	7	4				3	2	1	6	16	1	10	4	4	1	2	5	6	3	3	5	
Free-threshing wheat	**Grain**	1	4		2	1						1	2	15	2		1			1		1			3	2
Einkorn, one-seeded type	**Grain**	3	3	1							3			8		2							1			
Einkorn, one-seeded/wild type	**Grain**			1	1				1			1		1				1			1			1		
Einkorn, two-seeded type	**Grain**				2		1						1				2									3
Einkorn, two-seeded/Emmer	**Grain**									1																
Emmer	**Grain**	1			1									1			1		1		1		1			3
"New Type" glume wheat	**Grain**			1		1		1		2	1															
Emmer/ "New Type" glume wheat	**Grain**																									
Glume wheat indeterminate	**Grain**	2	1		3	5			4		2			11	1						1		4	1		4
Glume wheat indet. 1 seeded	**Grain**																									
Glume wheat indet. 2 seeded	**Grain**	3					2			1	2	2	1	3		3	4	3	3			2		3		3
Wheat indeterminate	**Grain**	17	9	7	12	7	3	2		3	7	7	15	33.5	7	10	7	7	5	6	7	7	4	11	2	10
Cereal indeterminate	**Grain**	23	5	12	17	21	10	2	8	5	10	9	12	45.5	6	27	8	16	20	11	9	12	6	11	11	7
Bread wheat	**Rachis**	9	1		4	18		1			1			42		3					2			5	5	5
Naked 6-row barley	**Rachis**	1			1	3		1					1	19	1				2						1	

Çatalhöyük West	Sample number in text		11100	Floor 18376	10100	10271	11086	8911	Floor 16977	11093	11046	11096	9603	11087	u31210	11053	9519	9341	10279	9619	11089	9358
Hordeum vulgare var. *nudum*	**Naked 2-row barley**	**Rachis**							2					1			1			1		1
Hordeum vulgare var. *nudum*	**Naked barley indet**	**Rachis**																				
Hordeum vulgare var. *vulgare*	**Hulled 2-row barley**	**Rachis**			1								1				1	9				
Hordeum vulgare	**Barley indet. cf. 2 row**	**Rachis**											1									
Hordeum vulgare	**Barley cf. hulled**	**Rachis**						16														
Hordeum vulgare	**Barley indet.**	**Rachis**						8	2				2				2					
Triticum monococcum	**Einkorn**	**Glume base**										2			2	3						
Triticum dicoccum	**Emmer**	**Glume base**	22	4	5			27	13	18	1	6	8	11	24	8		9	9	5	29	19
Triticum dicoccum/Triticum sp.	**Emmer/'New Type'**	**Glume base**	16		2			30	10	5.5		14	17	15	16	15	26	30	4	14	11	13
Triticum sp.	**'New Type'**	**Glume base**			4			36	29	6.5		3	13	9	64	15	9	17	4	6	14	7
Triticum dicoccum/Triticum sp.	**Terminal glume bases**	**Glume base**			26			10	3	2		2	4		4	6				7	4	
Triticum sp.	**Wheat indet**	**Rachis**						1													1	
Triticum sp.	**Indeterminate glume base**	**Glume base**	28	19	19			65	41	50.5		39	49	50	124	72	48	121	21	110	31	68
Vicia ervilia	**Bitter vetch**	**Seed**													1			1				
Lens culinaris	**Lentil**	**Seed**	2	1				1	1				2		5	1	1				10	
Pisum saitvum	**Pea**	**Seed**						1	1						2	2					1	
Lathyrus sativus	**Lathyrus stativus**	**Seed**																				
Leguminosae	**Pulse indet.**	**Seed**	7		1			6	4.8	0.5		2	2	4	7	4	1	1	1	2	1	
	Collected																					
Cruciferae	***Descurainia sophia***	**Seed**	16	24	296			65	153	40	1	84	32	81	184	112	56	24		88	56	24
Pistacia terebinthus type	**Pistachio**	**Nutshell**	1				3	1	1			1			8	2	2			1		
Quercus	**Acorn**	**Nutshell**																				
Quercus	**Acorn/culm centre**														1			2				1
Prunus/Amygdalus	**Almond/plum**	**Fruitstone**	0.6				0.05	0.55	1.9			0.15	0.15		2.7	11	1.25	0.65		1.2	1.7	0.45
Prunus divaricata	***Prunus divocata* type (ridged)**	**Fruitstone**						0.1				0.05			1	2	0.1					0.1

Sample number in text		u31114	11097	9591	8953	11041	10111	8360	9471	9524	11094	9613	10110	u18341	10265	11092	11088	8461	9600	9563	9564	10099	9495	9562	9573	9602
Naked 2-row barley	Rachis	3			1									3					1							
Naked barley indet	Rachis																								2	
Hulled 2-row barley	Rachis				9		1											1			2				1	
Barley indet. cf. 2 row	Rachis																		2							
Barley cf. hulled	Rachis													8												
Barley indet.	Rachis	1										8	8	8					1			8			18	
Einkorn	Glume base	1			1	6							1				1				3					2
Emmer	Glume base	48	18	4	33	24	5	5	8		22	5	16	83	5	5	5	12	9	7	25	6	4	20		175
Emmer/'New Type'	Glume base	31		4	51	15	17	2	18	8	15	20	38	51	8	28	5	29	25	27	41	17	3	22	11	90
'New Type'	Glume base	48	18	2	25	39	12	4	7	7	25	10	16	70	5	16	11	22	16	7	32	12	14	9	2	53
Terminal glume bases	Glume base	18	2	2	16	36					22	4	12	18	2	2	2	13		6	8	2		6	2	16
Wheat indet	Rachis													8												
Indeterminate glume base	Glume base	201	71	47	181	234	52	16	70	59	212	111	105	258	70	67	7	124	156	125	265	174	93	237	106	426
Bitter vetch	Seed										2							1		1		1				
Lentil	Seed	7	1		3	9				1			1	5	1		4	3			1		2	2		1
Pea	Seed	3				3								1		2		1			3	1				
Lathyrus stativus	Seed													1												
Pulse indet.	Seed	15	2	2	2	3	2	1	1	2	2		2	8	1	2	3	2	2	2	3			2	1	1
Collected																										
Descurainia sophia	Seed	107	72	32	40	80	24	11	32	16	104	32	40	48	8	40		16	8		16	24		16		8
Pistachio	Nutshell		3		1	1	1		1		2	1	1	1				4	1		1	1	1	1	1	
Acorn	Nutshell								1															1		0.5
Acorn/culm centre						1							1											1		
Almond/plum	Fruitstone	0.05	0.1		2.35				0.2	0.1		0.2	0.2	0.55				23	0.65	0.4	1.9	2.1	0.6	0.45		
Prunus divocata type (ridged)	Fruitstone		0.15		0.8						0.2		0.05	0.1				2			0.4	0.15		0.05		

Çatalhöyük West	Sample number in text		11100	Floor 18376	10100	10271	11086	8911	Floor 16977	11093	11046	11096	9603	11087	u31210	11053	9519	9341	10279	9619	11089	9358
Celtis	**Hackberry, white**	**Nutlet, silicified**	1.2	7.5	14		0.8	4	26	0.75	1.7	5.4	2.5	3.6	84.1		3.8		2	6.3	2.4	1
Celtis	**Hackberry, black**	**Nutlet, silicified**		0.6				1	2.1				2		9.1	2	0.6		1.3		2.6	
	Fruitstone/nutshell	**shell**							1									1				
	Nutshell indet.	**Nutshell**	0.4						0.7												0.8	
	Nut kernel indet	**kernel**		1											0.5							1
	Culm																					
Cereal indeterminate	**Culm nodes cereal**	**culm nodes**		2	1			2									2	1	1	2	1	2
Gramineae indet.	**Culm bases indeterminate**	**culm base**			1								3			1						
Gramineae indet.	**Culm nodes indeterminate**	**culm nodes**						2							3							
Gramineae, reed type	**Reed culm - centre**	**culm centre**																				
Gramineae	**Gramineae, reed type**	**rhizome**						2				2	2		2	1					1	
Gramineae, reed type	**Reed culm nodes**	**culm nodes**		1	1			2	3		1	4	2	1	6	3	1	3	1	1	1	2
	Wild																					
Family	**Genus/species/type**																					
Alismataceae	***Alisma***	**Seed**							5		1				8							
Boraginaceae	***Heliotropium***	**Seed**																				
Caprifoliaceae	**cf. *Valerianella***	**Seed**																				
Caryophyllaceae	**Caryophyllaceae**	**Seed**							1											8		
Caryophyllaceae	***Silene* sp.**	**Seed**																				
Caryophyllaceae	***Vaccaria pyramidata***	**Seed**						3	5			1					8	1		1	1	
Caryophyllaceae/ Chenopodiaceae	**Caryophyllaceae/ Chenopodiaceae**	**Seed**			1																	
Chenopodiaceae	***Atriplex sp.***	**Seed**		4					8	8			8	8	8	9	1			1	8	
Chenopodiaceae	**Chenopodiaceae**	**Seed**	1	2					11	0.5	1	16		1	117	17	9	1		8	2	
Chenopodiaceae	***Chenopodium album* type**	**Seed**	2						3				8			1						
Chenopodiaceae	***Chenopodium* sp.**	**Seed**						8	8				9									
Chenopodiaceae	***Salsola sp.***	**Seed**												1	1	8		1			1	
Compositae	***Artemisia annua* type**	**Seed**	1	5		1		8	10			4			48	16	16	8		8	16	72
Compositae	***Centaurea* sp.**	**Seed**						1								1						

Sample number in text		u31114	11097	9591	8953	11041	10111	8360	9471	9524	11094	9613	10110	u18341	10265	11092	11088	8461	9600	9563	9564	10099	9495	9562	9573	9602
Hackberry, white	Nutlet, silicified	1.5	3.5	4	3	15.7	17		1		1.5	15.9	2	9		2.1	3.6	1	6.4	5.2	4	5		1		0.5
Hackberry, black	Nutlet, silicified	1.2			1						0.5	0.6		2	1		0.6	2				1				
Fruitstone/nutshell	shell							2				1							1		1	1				
Nutshell indet.	Nutshell																						1			
Nut kernel indet	kernel			1			1				1															
Culm																										
Culm nodes cereal	culm nodes			3	4	2			2	1	1		1	29					3					1	1	
Culm bases indeterminate	culm base				4	1					1		1	4					1		4					
Culm nodes indeterminate	culm nodes	8								1		1			2	1				1						
Reed culm - centre	culm centre					1													1			1				
Gramineae, reed type	rhizome												2	1	1	1				2						
Reed culm nodes	culm nodes	2	1	2	4	2	4	1	1	1		2	2	4	1	5	2	1	3	1	3	3	3	1	2	1
Wild																										
Genus/species/type																										
Alisma	Seed				16							8													8	
Heliotropium	Seed											1									8					
cf. *Valerianella*	Seed																	8								
Caryophyllaceae	Seed																									
Silene sp.	Seed	8																								
Vaccaria pyramidata	Seed	3	1		1											1				1						
Caryophyllaceae/ Chenopodiaceae	Seed																	8								
Atriplex sp.	Seed	1			3	8							3	9												
Chenopodiaceae	Seed	16	8		24	8	17	2			8	8	9	11		1	3	9		8	8	16	8			
Chenopodium album type	Seed			1		8							2													
Chenopodium sp.	Seed														8											
Salsola sp.	Seed					1							1				1		2		8					
Artemisia annua type	Seed			4	8	16		2	8	16					8	16			8			8		8		8
Centaurea sp.	Seed									8																

Çatalhöyük West	Sample number in text		11100	Floor 18376	10100	10271	11086	8911	Floor 16977	11093	11046	11096	9603	11087	u31210	11053	9519	9341	10279	9619	11089	9358
Compositae	**cf. *Centaurea* sp.**	**Seed**																				
Compositae	***Chrysanthemum* cf. *segetum***	**Seed**											2									
Compositae	**Compositae Type 1**	**Seed**																				
Compositae	***Sonchus*, medium Type**	**Seed**		1		1			4											8		
Compositae	***Sonchus,* small Type**	**Seed**																				
Convolvulaceae	***Convolvulus arvensis* type**	**Seed**						1										1				
Convolvulaceae	**cf. *Convolvulus arvensis* type**	**Seed**													1						1	
Cruciferae	***Conringia orientalis***	**Seed**			8																	
Cruciferae	**Crucifer, round type**	**Seed**																				
Cruciferae	**Cruciferae, cf.**	**Seed**												1								
Cruciferae	**Cruciferae, large type**	**Seed**							5			2	1		1	1					2	
Cruciferae	**Cruciferae, medium type**	**Seed**							3			4			17							
Cruciferae	**Cruciferae, small flat**	**Seed**																				
Cyperaceae	***Bolboschoenus glaucus***	**Seed**	4	40	7	1		66	72	11	3	30	34	31	94	34	71	59	8	29	37	26
Cyperaceae	***Carex* sp.**	**Seed**		1	1							8	2		8							
Cyperaceae	**Cyperaceae**	**Seed**	1	6	24			16	5	16					32	24			8	16	24	16
Cyperaceae	**Cyperaceae, small type**	**Seed**																				
Dipsacaceae	**Dipsacaceae**	**Seed**																				
Euphorbiaceae	***Euphorbia* sp.**	**Seed**																				
Gramineae	**Gramineae, awn indeterminate**	**awn**						3												1		
Gramineae	**Gramineae indet, rachis**	**rachis**																				
Gramineae	***Taeniatherum caput-medusae***	**rachis**		1				8	2				1									
Gramineae	***Aeluropus* sp.**	**Seed**		6		1		40	32	8		12	8	8	8	16	8	16		8		32
Gramineae	***Bromus* sp. (pointed apex)**	**Seed**																				
Gramineae	***Bromus hordeaceus* /*commutatus***	**Seed**		1																	1	
Gramineae	**Bromus indet.**	**Seed**							1							1						
Gramineae	**cf. *Sporobolus/Crypsis***	**Seed**																16			8	
Gramineae	***Crypsis aculeata***	**Seed**		3	8	1		24	24	8		8			8		8	24				
Gramineae	***Deschampsia***	**Seed**			8	2							8				8	8				
Gramineae	***Eragrostis* type**	**Seed**	1											16							8	
Gramineae	***Eremopyrum***	**Seed**															1					
Gramineae	***Festuca***	**Seed**								0.5		1										1
Gramineae	**Gramineae indet.**	**Seed**																8				
Gramineae	**Gramineae indet., large**	**Seed**							1				1		8		1			1		

Sample number in text		u31114	11097	9591	8953	11041	10111	8360	9471	9524	11094	9613	10110	u18341	10265	11092	11088	8461	9600	9563	9564	10099	9495	9562	9573	9602
cf. *Centaurea* sp.	Seed																	8								
Chrysanthemum cf. *segetum*	Seed																									
Compositae Type 1	Seed							1																		
Sonchus, medium Type	Seed				8													8								
Sonchus, small Type	Seed								8						8											
Convolvulus arvensis type	Seed																									
cf. *Convolvulus arvensis* type	Seed							1																		
Conringia orientalis	Seed																									
Crucifer, round type	Seed																			1						
Cruciferae, cf.	Seed																									
Cruciferae, large type	Seed	1			1																	2		1		
Cruciferae, medium type	Seed	1												8							16					
Cruciferae, small flat	Seed					16													8							
Bolboschoenus glaucus	Seed	70	23	19	79	36	19	7	22	4	31	20	62	124	21	28	27	20	52	15	83	18	5	20	2	5
Carex sp.	Seed	1		4										2					8							8
Cyperaceae	Seed	9		2	24				8			16	8	8	8	8			40	1			24		8	
Cyperaceae, small type	Seed					8																				
Dipsacaceae	Seed				1								1													
Euphorbia sp.	Seed										8															
Gramineae, awn indeterminate	awn			1					1																	
Gramineae indet, rachis	rachis													8												
Taeniatherum caput-medusae	rachis	16		1	8			1												1						
Aeluropus sp.	Seed	8	8						8		16		8			8		16		24	8	8				8
Bromus sp. (pointed apex)	Seed			4									8													
Bromus hordeaceus /commutatus	Seed			4	1	1								2				1			2					
Bromus indet.	Seed	1																	8							
cf. *Sporobolus/Crypsis*	Seed																									
Crypsis aculeata	Seed	16		8	8	16				8	48	16	24	16		8		16		8	8	8	8	8		8
Deschampsia	Seed							2																		
Eragrostis type	Seed										16		8									8		16		
Eremopyrum	Seed																	1		1						
Festuca	Seed		1											1				1								
Gramineae indet.	Seed																									24
Gramineae indet., large	Seed			2								1	3	2								1				

Çatalhöyük West	Sample number in text		11100	Floor 18376	10100	10271	11086	8911	Floor 16977	11093	11046	11096	9603	11087	u31210	11053	9519	9341	10279	9619	11089	9358
Gramineae	**Gramineae indet., small**	**Seed**																				
Gramineae	**Gramineae, large indeterminate**	**Seed**							2	8		13				16						
Gramineae	**Gramineae, medium laterally flattened type**	**Seed**												8	8							
Gramineae	**Gramineae, small dorsally flattened type**	**Seed**								16												
Gramineae	**Gramineae, small elongated type**	**Seed**						8	8	8		8	8		8	8		24	8	8	8	
Gramineae	**Gramineae, small laterally flattened type**	**Seed**																				
Gramineae	**Gramineae/Cereal indet.**	**Seed**																				
Gramineae	***Hordeum* indet.**	**Seed**											1									
Gramineae	***Hordeum/Lolium* indet.**	**Seed**									1										1	
Gramineae	***Hordeum murinum* type**	**Seed**		1					2						1	2						1
Gramineae	***Hordeum spontaneum***	**Seed**																				
Gramineae	***Hordeum*, crop/wild**	**Seed**							2								1					
Gramineae	***Lolium/Taeniatherum***	**Seed**																				
Gramineae	***Sporobolus virginicus* type**	**Seed**	2	10	32	2		16	37	40	2	16	8	16	32	24	8	32		16	8	16
Gramineae	***Stipa* sp.**	**Seed**						1														
Gramineae	***Taeniatherum caput-medusae***	**Seed**		1	1				1			2			9	3	1			10	1	1
Juncuaceae	***Juncus* sp.**	**Seed**		2					17	8		8		8			8	16		8		
Labiatae	**Labiatae**	**Seed**																				
Labiatae	**Labiatae, small**	**Seed**																				
Labiatae	***Sideritis* type**	**Seed**							3						8	8						
Labiatae	***Ziziphora capitata /persica***	**Seed**										1										
Leguminosae	**Leguminosae , small wild**	**Seed**		1				19	9						9	7	8	9		1		1
Leguminosae	***Vicia /Lathyrus***	**Seed**	7									1			1	1						
Malvaceae	***Lavatera* type**	**Seed**							1					1				1				1
Malvaceae	***Malva*, cf.**	**Seed**													8							
Malvaceae	**Malvaceae**	**Seed**												1								
Moraceae	***Ficus* sp.**	**Seed**							1													
Polygonaceae	**Polygonaceae**	**Seed**						1	1	8										8		
Polygonaceae	***Polygonum aviculare***	**Seed**		3				3	2	1.5		6		8	9	4		1			3	1
Polygonaceae	***Polygonum convolvulus***	**Seed**	2																			

Sample number in text		u31114	11097	9591	8953	11041	10111	8360	9471	9524	11094	9613	10110	u18341	10265	11092	11088	8461	9600	9563	9564	10099	9495	9562	9573	9602
Gramineae indet., small	**Seed**				8																					
Gramineae, large indeterminate	**Seed**					2					2			16												
Gramineae, medium laterally flattened type	**Seed**													2	8											
Gramineae, small dorsally flattened type	**Seed**																									
Gramineae, small elongated type	**Seed**	8		8			8						16								8	8		8		
Gramineae, small laterally flattened type	**Seed**										32															
Gramineae/Cereal indet.	**Seed**								2	1																
***Hordeum* indet.**	**Seed**								1		8	1														
***Hordeum/Lolium* indet.**	**Seed**																									
***Hordeum murinum* type**	**Seed**					2			1						1	1	2		1			2	8			
Hordeum spontaneum	**Seed**					1																				
***Hordeum*, crop/wild**	**Seed**									1				1												
Lolium/Taeniatherum	**Seed**		1.6							1																
***Sporobolus virginicus* type**	**Seed**	40	16	12	32	24	8	3	16	8			8	24		16		24		24		8		24		24
***Stipa* sp.**	**Seed**																									
Taeniatherum caput-medusae	**Seed**	1			10	8	1					1	1	12		1			1		1			1		
***Juncus* sp.**	**Seed**	8	16			8		1		8	8				8				8	8	8			24		
Labiatae	**Seed**																		1							
Labiatae, small	**Seed**																	8	8		8					
***Sideritis* type**	**Seed**		8																							
Ziziphora capitata /persica	**Seed**																									
Leguminosae , small wild	**Seed**	2	8				9	3			1			1	1	1	1	1		11	2		1	2		2
Vicia /Lathyrus	**Seed**	1	1								1			1									1			
***Lavatera* type**	**Seed**	1									1							1								
***Malva*, cf.**	**Seed**													8												
Malvaceae	**Seed**																									
***Ficus* sp.**	**Seed**																	1								
Polygonaceae	**Seed**					8																				
Polygonum aviculare	**Seed**	7			1	4	1		1		1	1		5	1	1	9						1		2	
Polygonum convolvulus	**Seed**		1			1								2												

Çatalhöyük West	Sample number in text		11100	Floor 18376	10100	10271	11086	8911	Floor 16977	11093	11046	11096	9603	11087	u31210	11053	9519	9341	10279	9619	11089	9358
Polygonaceae	***Polygonum* indet.**	**Seed**	2	2				20	1	10.5		13		8	22			8	1		11	1
Polygonaceae	***Rumex* sp.**	**Seed**		3				1		0.5		4	10	9	17		2		1			
Primulaceae	***Anagallis* sp.**	**Seed**	1						2													
Ranunculaceae	***Adonis aestivalis* type**	**Seed**						2							1	1						
Ranunculaceae	***Adonis microcarpa/annua***	**Seed**																				
Ranunculaceae	***Ranunculus cf. arvensis* type**	**Seed**																				
Rubiaceae	***Galium*, small (*G. verum* type)**	**Seed**																				
Rubiaceae	***Galium*, large type**	**Seed**		1	1			1	1.4	0.5		2			2	1		1			1	1
Solanaceae	***Hyoscyamus* type**	**Seed**																8				
Thymelaeaceae	***Thymelaea* cf. *passerina***	**Seed**													1							
Umbelliferae	**Umbelliferae, large**	**Seed**													1							
Verbenaceae	***Verbena officinalis***	**Seed**							8													
Violeae	***cf. Viola* sp.**	**Seed**										4										
	Pods																					
Cruciferae	**Cruciferae pod indeterminate**	**pod**													1							
Cruciferae	**Cruciferae pod Type 1**	**pod**																				
Cruciferae	***Euclidium***	**pod**							3						3					1		
Cruciferae	***Myagrum perfoliatum* type**	**pod**		1				1				1			7	3						
Leguminosae	**Leguminosae**	**pod**												1								
	Mineralised																					
Cyperaceae	***Carex* sp.**	**min. seed**																				
Cyperaceae	**Cyperaceae**	**min. seed**																				
Labiatae	**Labiatae**	**min. seed**																				
Lemneae	***Lemna* sp.**	**min. seed**	1	103				400	43	56	8			80	32	16		152	40	24	8	
Papaveraceae	***Fumaria* sp.**	**min. seed**																				
Boraginaceae	**Boraginaceae indet.**	**min. seed**																				
Boraginaceae	**Boraginaceae, type 1**	**min. seed**										1			1							
Boraginaceae	***Buglossioides arvensis*, white**	**min. seed**	2120	15	1	1	1	2	3		1	10	158	7	14	2	6	3	6	2		
Boraginaceae	***Buglossoides arvensis*, black**	**min. seed**	1		2			3				2	1		13	8	2	2	3	1	1	1
Boraginaceae	***Echuim***	**min. seed**																				
	Potentially identifiable pod							1					1			1				1		
	Potentially identifiable seed							8		0.5		2				2		8	8	8		
	Potentially identifiable chaff																					
	Indeterminate		7	8					24		2	20				24						

Sample number in text		u31114	11097	9591	8953	11041	10111	8360	9471	9524	11094	9613	10110	u18341	10265	11092	11088	8461	9600	9563	9564	10099	9495	9562	9573	9602
Polygonum indet.	Seed	21	1	1	3		9	2	1	1	3		2	13	3	8	1	6			8			3		1
Rumex sp.	Seed	3		1	11	8	1		3	1		2	1	13	1			1	9	2	2			1		
Anagallis sp.	Seed																									
Adonis aestivalis type	Seed				2									1					1					1		
Adonis microcarpa/annua	Seed									1		1														
Ranunculus cf. arvensis type	Seed																					1				
Galium, small (*G. verum* type)	Seed				8			1																		
Galium, large type	Seed	2			3	1			1			1	2	5	1	1		1			3	1				
Hyoscyamus type	Seed																									
Thymelaea cf. *passerina*	Seed					1																				
Umbelliferae, large	Seed												1								8					
Verbena officinalis	Seed																									
cf. Viola sp.	Seed																									
Pods																										
Cruciferae pod indeterminate	pod										8									1						
Cruciferae pod Type 1	pod													1										1		
Euclidium	pod				8																1					
Myagrum perfoliatum type	pod	1			2									2		1						3		1		
Leguminosae	pod																									
Mineralised																										
Carex sp.	min. seed	1																								
Cyperaceae	min. seed																							8		
Labiatae	min. seed										1															
Lemna sp.	min. seed	280	16		120	240						16		264												
Fumaria sp.	min. seed													1												
Boraginaceae indet.	min. seed			12																	1					
Boraginaceae, type 1	min. seed																									
Buglossioides arvensis, white	min. seed	6	6	5	6	10			4	3	6	12	4	3	4	3		1	5	2		2	6			
Buglossoides arvensis, black	min. seed	2	3	1	2	1	1				9		1	3			5			3						1
Echuim	min. seed									11																
Potentially identifiable pod			1					2				8		1						1	1					
Potentially identifiable seed								1	8	8	8	1	1	1					9		18					1
Potentially identifiable chaff				1																						
Indeterminate		16				26					2			32												

Table 12.4: Raw data table for Çamlıbel Tarlası showing the items found.

Çamlıbel Tarlası	Sample number in text		17	19	29	40	42	45	46	48	49	50	54	60	75	79	88	90	110	132	139	180
	Phase		CBTI	CBTI	CBTIII	CBTIII	CBTIII	CBTIII	CBTIII	CBTIV	CBTI	CBTIV	CBTI	CBTIII /IV	CBTIII	CBTI	CBTIII	CBTI	CBTIV	CBTII	CBTIV	CBTII
	Context		Ash layer	Ash layer	Ext. floor	Ext. floor	Ext. floor	Ext. floor	Ext. Floor	Floor	Ash layer	Floor	Ash layer	Fill	Floor	Ash layer	Floor	Ash layer	Fill	Floor	Floor	Floor
	Non-seed/fruit/chaff material																					
	> 2 mm Wood charcoal (ml)	**misc.**						0.5	2.25	2.5	6					9.5	4		0.5			
	> 2 mm Animal dung (ml)	**misc.**																1				
	Mouse pellets	**misc.**																			1	
	> 2 mm Amalgamated grain/matter (ml)	**misc.**	0.03				0.5		1	0.5		0.5			0.3	1.6	0.85	1.5			0.25	1.5
Latin name	**Common name**	**Plant part**																				
	Crops																					
Triticum monococcum	**Einkorn**	**grain**																				1
Triticum cf. monococcum	**cf. Einkorn**	**grain**																				
Triticum monococcum	**Einkorn, two-seeded type**	**grain**									1											
Triticum cf. monococcum	**cf. Einkorn, two-seeded type**	**grain**																				
Triticum monococcum	**Einkorn, one-seeded type**	**grain**		2			1		2		4		4			8	5	2				
Triticum cf. monococcum	**cf. Einkorn, one-seeded type**	**grain**					1	2	2		2	2			1						1	
Triticum monococcum/boeoticum	**Einkorn, one-seeded type/wild**	**grain**							2		6				3							1
Triticum cf. monococcum/boeoticum	**cf. Einkorn, one-seeded type/wild**	**grain**																				
Triticum dicoccum	**Emmer**	**grain**														8						
Triticum cf. dicoccum	**cf. Emmer**	**grain**					1								1		1					
Triticum sp.	**"New Type" glume wheat**	**grain**																				
Triticum sp. cf.	**cf. "New Type" glume wheat**	**grain**														8						

Sample number in text	200	204	209	210	213	223	224	226	238	250	260	276	306	310	311	321	324	325	337	357	358	361	365	377/365	366	370
Phase	CBTII	CBTI/II	CBTI	CBTII	CBTII	CBTIII	CBTIV	CBTI	CBTIV	CBTIII	CBTIII	CBTIII	CBTIV	CBTIV	CBTIII	CBTIII	CBTIV	CBTIV	CBTI	CBTI	CBTI	CBTI	CBTII	CBTIII	CBTIII	CBTIII
Context	Floor	Fill	Ash layer	Floor	Floor	Ext. floor	Floor	Ash layer	Floor	Fill (ext. floor)	Floor	Floor	Ext. floor	Pit	Ext. floor	Fill -floor	Floor	Ext. floor	Ash layer	Ash layer	Ash layer	Ash layer	Floor	Floor	Floor	Floor
Non-seed/fruit/chaff material																										
> 2 mm Wood charcoal (ml)	2									0.5	1	0.5					1.5			3					0.75	1.75
> 2 mm Animal dung (ml)								0.5																		0.25
Mouse pellets																										
> 2 mm Amalgamated grain/matter (ml)	0.6		0.625		0.1		0.25	2.75	1.1		0.2		0.35		0.25		1.25			3.25	0.75			3.5		0.1
Common name																										
Crops																										
Einkorn																					14					
cf. Einkorn								2																		
Einkorn, two-seeded type																								1		
cf. Einkorn, two-seeded type																										1
Einkorn, one-seeded type	5		0.25		3			1						3							1	5			1	
cf. Einkorn, one-seeded type		1				1			2	1					3				1		1			1	1	
Einkorn, one-seeded type/wild	1		2.25					2																		
cf. Einkorn, one-seeded type/wild																										
Emmer			0.75					4														1				
cf. Emmer		1	0.25			2									1											
"New Type" glume wheat								2																1		
cf. "New Type" glume wheat																										

Sample number in text	m877	392	396	400	405	406	411	m887	415	419	421	422	423	424	425	427	428	113/6	186/202	m439	35/38	74/3	76/12	78/116	m440	m466	m632
Phase	CBTI	CBTI	CBTII	CBTII	CBTII	CBTI	CBTII	CBTIII	CBTII	CBTII	CBTI	CBTII	CBTII	CBTIII post-ab	CBTI	CBTII	CBTII	CBTII	CBTII	CBTIII	CBTIII	CBTII	CBTII	CBTII	CBTIII	CBTIII	CBTIV
Context	Ash layer	Ash layer	Floor	Floor	Fill (Ext. floor)	Ash layer	Floor	Ext. floor	Oven	Silo	Ash layer	Fill-floor	Silo	Fill	Fill	Silo	Oven	Floor	Floor	Floor	Ext. floor	Floor	Floor	Floor	Floor	Floor	Fill (ext. floor)
Non-seed/fruit/chaff material																											
> 2 mm Wood charcoal (ml)		38			6.5		1			2.75			2.75	5	8		0.5	0.1	0.5	2.25			0.1		29.3	4.5	0.2
> 2 mm Animal dung (ml)	0.75	0.5											0.25			0.25									2.25	0.1	
Mouse pellets				1				1																			
> 2 mm Amalgamated grain/matter (ml)	1.25	6.35	0.625	1	1.75	0.75		2.2			0.38		0.25	2	1.25	0.25		1	0.1	2.5		0.5			3.5	0.85	
Common name																											
Crops																											
Einkorn	13			3			2		1				3		8	1											
cf. Einkorn	1										1				3											1	
Einkorn, two-seeded type																											
cf. Einkorn, two-seeded type	1					1																					
Einkorn, one-seeded type	3	21	1			5		6	5	2				1	4		5				1						2
cf. Einkorn, one-seeded type	2			2	2	1	1	1					1		8	1		1	1								
Einkorn, one-seeded type/wild	16.5				4						1		1	2	1		1								4		
cf. Einkorn, one-seeded type/wild													1														
Emmer			0.5					8		2																	
cf. Emmer	1.5	10				2		2			0.5		1		4											8	
"New Type" glume wheat																											
cf. "New Type" glume wheat																1											

Çamlıbel Tarlası	Sample number in text		17	19	29	40	42	45	46	48	49	50	54	60	75	79	88	90	110	132	139	180
Triticum dioccum/Triticum sp.	"New type"/ Emmer grain	grain																				
Triticum sp.	Two seeded glume wheat	grain								1	3		4			2						
Triticum sp.	One seeded glume wheat	grain																				
Triticum sp.	Glume wheat	grain		2		1	1				6	2			2	56		1			2	1
Triticum aestivum	Bread wheat	grain	1		1																	
Triticum cf. aestivum	cf. Bread wheat	grain													1							
Triticum sp.	Wheat indeterminate	grain	6	2			7	2		4	11	11	4	5	7	16	12	2		1	8	8
Hordeum vulgare	Hulled barley	grain	12	12.13			11	4	12	3	16	10	12		18	40	8	10		2	19	4
Triticum/Hordeum	Cereal indeterminate	grain	1	8.125			10	6	14	3	22	9	4	8	24	65	6	15	2	3	8	11
Triticum monococcum	Einkorn	glume base					3	8	2		40	5	12	8	7		2	17		4	2	18
T. cf. *monococcum*	cf. Einkorn	glume base																				
Triticum dicoccum	Emmer	glume base	6	4	2	8	12		14		121	27	40		46	104	35	25		20	73	33
Triticum sp.	New type glume wheat	glume base								5	6		16	16		24					8	
Triticum dioccum/Triticum sp.	New type glume wheat/emmer	glume base					3		17	11	24		32	16	5	48	8			24	1	4
Triticum dioccum/Triticum monococcum/Triticum sp.	New type glume wheat/einkorn/emmer	glume base	4	16			17	6	23	4	138	108	44	12	94	73	63	49	8	4	101	85
Triticum dioccum/Triticum sp.	Terminal glume base	glume base							16		20	4	8		2		18			8	10	
Triticum sp.	Glume wheat rachis	glume base rachis																6				
Triticum sp.	Basal glume base	basal glume bases																				
Triticum aestivum	Bread wheat	rachis																				
Triticum sp.	Wheat indeterminate	rachis																				
Hordeum vulgare, hulled 2 row	Hulled barley 2-rowed	rachis																				
Hordeum vulgare, hulled cf. 2 row	Hulled barley cf. 2-rowed	rachis																				
Hordeum vulgare, hulled cf. 6 row	Hulled cf. 6-rowed	rachis																				
Hordeum vulgare, hulled	Hulled barley	rachis																				
Hordeum vulgare, cf. hulled	cf. Hulled barley	rachis																				
Hordeum vulgare indet.	Barley indeterminate	rachis																				

Sample number in text	200	204	209	210	213	223	224	226	238	250	260	276	306	310	311	321	324	325	337	357	358	361	365	377/365	366	370
"New type"/ Emmer grain																										
Two seeded glume wheat			0.25											1							2					
One seeded glume wheat																										
Glume wheat	1		1.75		1			8						1	1		1	1		4	2	1				3
Bread wheat																								1		
cf. Bread wheat																					1					
Wheat indeterminate	5	5	7.75	1	3		3	18	5					15	6	5	2	5	10	20	14	3	5	10		5
Hulled barley	10	13	7.75	5	8	7	5	17	9				3	4	13	8	7	2	9	26	22	4	9	11	2	7
Cereal indeterminate	5	7	9	26	3	6	11	24	7	1			3	22	14	5	7	6	15	29	42	4	13	18	5	11
Einkorn	8	18	8			23		13	4						4	2	2	1	1	2	10		2	14		2
cf. Einkorn																										
Emmer	16	42	27	28	1	73	46	72	36		16		10	37	56	14		14	24	49	161	40	18	55		
New type glume wheat				2		5							2	6	9	2	17				24	1	6			
New type glume wheat/emmer	28	7				38	7	17	4				14	11		2	19	4	2	10	53	5	16	7		
New type glume wheat/einkorn/emmer	8	72	46.25	54	1	134	39	67	76	1	9		15	159	87	72	35	23	17	89	279	63	17	86		2
Terminal glume base		5	10			6	1	6	2				2	4	20		1	2	4		10	3	4	2		
Glume wheat rachis																										
Basal glume base																							2			
Bread wheat																										
Wheat indeterminate								1																		
Hulled barley 2-rowed																										
Hulled barley cf. 2-rowed																					2					
Hulled cf. 6-rowed						1																				
Hulled barley																										
cf. Hulled barley																										
Barley indeterminate		1					8	1														1				

Sample number in text	m877	392	396	400	405	406	411	m887	415	419	421	422	423	424	425	427	428	113/6	186/202	m439	35/38	74/3	76/12	78/116	m440	m466	m632
"New type"/ Emmer grain											0.5																
Two seeded glume wheat	3.5	9		2	2		1	1		3	1		1		12	1									1		
One seeded glume wheat		1																									
Glume wheat	11.5	17	4	1	1		2	4	2	4	1.5			2	26								1		1		
Bread wheat	2	1								3					4										1		
cf. Bread wheat		2						1							1										1		
Wheat indeterminate	21	108	5.5	17	9	14		17	3	3	14	7	12	7	98	6			3	7				2	5	9	2
Hulled barley	49.5	129	7.5	17	17	9	9	32	18	7	21.5	5	16	9	56	10	4	3	4	4	5				5	5	5
Cereal indeterminate	22	137	6.5	25	21	15	7	45	9	5	20	12	13	18	116	11	8	6	4	13	5	4	4	2	23	6	12
Einkorn	52	136		38	10	20	62	6			7		4	3	8					16	4	18			24		
cf. Einkorn	12																										
Emmer	235.5	74	1	62	94	22	37	92	1	22	41	7	45	54	24	3		4	7	24	17	20	3		61	28	14
New type glume wheat	16	12		3			8	4									2			8					2	2	7
New type glume wheat/emmer	56	94	2	19	10		16	6	8	1	24	4	3	27						9					22	19	3
New type glume wheat/einkorn/emmer	468	374	12	170	66	40	95	139	5	51	123	7	76	60	44	37	2		16	40	31	47			89	51	18
Terminal glume base	34	40		26	20		6	6			25		2	14					1		2	3			2	4	
Glume wheat rachis																											
Basal glume base							1				1																
Bread wheat											1		1			1											
Wheat indeterminate		4																									
Hulled barley 2-rowed															4												
Hulled barley cf. 2-rowed																											
Hulled cf. 6-rowed																											
Hulled barley								1																			
cf. Hulled barley																					1						
Barley indeterminate			8			8					4					1											

Çamlıbel Tarlası	Sample number in text		17	19	29	40	42	45	46	48	49	50	54	60	75	79	88	90	110	132	139	180
Hordeum vulgare indet.	**Barley indeterminate**	**basal rachis**																				
Triticum/Hordeum	**Cereal indeterminate**	**basal rachis**																				
Lens culinaris	**Lentil**	**seed**	1	4	1		2	4	3	1	8	7	4		2	8	5	6			9	6
Lens cf. *culinaris*	**cf. Lentil**	**seed**	1	2														2		1		
Lens/Vicia	**Lentil/Bitter vetch**	**seed**																				
Lathyrus sativus	**Grass Pea**	**seed**					2													1	1	
Lathyrus cf. sativus	**cf. Grass Pea**	**seed**																				
Lathyrus sativus/Vicia ervilia	**Grass pea/Bitter vetch**	**seed**	1																			
Vicia ervilia	**Bitter vetch**	**seed**	1	6	1			8	6		7	2	16				3	3			7	2
cf. Vicia ervilia	**cf. Bitter vetch**	**seed**		0.125		1					1											1
Lathyrus ochrus	**Cyprus vetch**	**seed**																				
Pisum sativum	**Pea**	**seed**									1											
cf. Pisum sativum	**cf. Pea**	**seed**								1	1											
Cicer arietinum	**Chick pea**	**seed**														2						
cf. Cicer arietinum	**cf. Chick pea**	**seed**									1											
Pisum saitvum/Lathyrus ochrus/Lathyrus sativus	**Pea/Cyprus vetch/Grass pea**	**seed**																				
Pisum saitvum/Lathyrus sativus	**Pea/Grass pea**	**seed**																				
Leguminosae	**Large-seeded legume indeterminate**	**seed**			2	4	3		4	1	14	4	4	8	26		14	4		1	7	7
Linum usitatissimum	**Flax/linseed**	**seed**	4.125		2		4		2		12	2			3	32	4				3	1
cf. Linum usitatissimum	**cf. Flax/linseed**	**seed**					1		2						1			1				
	Culm																					
Gramineae, reed type	**Reed culm nodes**	**culm nodes**																				
Gramineae, cf. reed type	**cf. Reed culm nodes**	**culm nodes**										1										
Gramineae, indeterminate	**Culm nodes indet**	**culm nodes**						4							1							
Gramineae, reed type	**Reed rhizome**	**rhizome**					2															
Gramineae, cf. reed type	**cf. Reed rhizome**	**rhizome**					4										2					
Cereal indeterminate	**Cereal culm nodes**	**culm nodes**					5	4		2	5	4			3	8	1	2				
cf. Cereal indeterminate	**cf. Cereal culm nodes**	**culm nodes**					2					1			1	8					1	1
Gramineae, small type	**Culm nodes, small type**	**culm nodes**																				8
Gramineae, ridged type	**Culm nodes, ridged type**	**culm nodes**													2		1					

Sample number in text	200	204	209	210	213	223	224	226	238	250	260	276	306	310	311	321	324	325	337	357	358	361	365	377/365	366	370
Barley indeterminate			3																							
Cereal indeterminate								1																		
Lentil	1	2	2.25		17	4	3	6	4	1			1	3	5	7	2	3	6	23	16	1	1	1	1	
cf. Lentil			1																	1				1		
Lentil/Bitter vetch																										
Grass Pea			1.25														1			1	2					
cf. Grass Pea		1				1																				
Grass pea/Bitter vetch																			1	4						
Bitter vetch		3	0.75			1	3	18	3					3		1	2	2	1	8	4	1	2	2	1	1
cf. Bitter vetch				1					2				1										1			
Cyprus vetch																					1					
Pea			1																		1					
cf. Pea																					1					
Chick pea						4														1	1					
cf. Chick pea			0.25				1							1				1								
Pea/Cyprus vetch/Grass pea																										
Pea/Grass pea																					1					
Large-seeded legume indeterminate	13	2	3.75	4	2	5	3	37	4		1		3	11	9	10	3	2	2	13	6	2	2	21	1	1
Flax/linseed		6	4		4	7		3	2				2	3	2		3	2	1	14	8	5	3	2		2
cf. Flax/linseed							1			2			1		1					1	1					2
Culm																										
Reed culm nodes								4																		
cf. Reed culm nodes																										
Culm nodes indet		1						2	1																	
Reed rhizome		1						1																		
cf. Reed rhizome						1		4													2					
Cereal culm nodes	4	9	0.25			5	1	4	1						7	2			1	2	4		8	3		
cf. Cereal culm nodes		1		2				1						1	1	1				2	2					2
Culm nodes, small type								8																		
Culm nodes, ridged type			0.25					1							1	1					4					

Sample number in text	m877	392	396	400	405	406	411	m887	415	419	421	422	423	424	425	427	428	113/6	186/202	m439	35/38	74/3	76/12	78/116	m440	m466	m632
Barley indeterminate																											
Cereal indeterminate																1											
Lentil	31	20.5	3	5	7	12	4	9	8	4	2	12	6	10	20	3	1		2	4	3			1	2	6	1
cf. Lentil	1	6		1		1		1		1			1										2				
Lentil/Bitter vetch	0.5			1										1													
Grass Pea	9		2	1				1	1					1	1										1	1	
cf. Grass Pea	1	1	0.5																	1							
Grass pea/Bitter vetch	1								1														2		1		
Bitter vetch	27.5	26	0.5	9	11	4.5		3	2	2	2	2	2	6				1			1				3		1
cf. Bitter vetch		1	1		1						0.5				1		1							1	2	1	
Cyprus vetch	0.5	1																									
Pea				1					1																1		
cf. Pea			0.5			1									1												1
Chick pea	3																1										
cf. Chick pea	1	1				1															1						
Pea/Cyprus vetch/Grass pea																					1						
Pea/Grass pea																											
Large-seeded legume indeterminate	13.5	23	2.5	16	16	10	3	20	9	5	7.5	5	4	11	15	1	2	1	4	15	4	3		1	11	9	5
Flax/linseed	4				2	2	5	6	3	3		2	10	3	4	4	17				1	1	2	2	2	2	1
cf. Flax/linseed	2	2																		1		1			1		1
Culm																											
Reed culm nodes																											
cf. Reed culm nodes		2											3												1		
Culm nodes indet																											
Reed rhizome	1										1																
cf. Reed rhizome	1	1											1														
Cereal culm nodes		18		5		12	2	8		2	1.5	1	2	4	4					1							
cf. Cereal culm nodes				1	2		1				1				9											2	
Culm nodes, small type				8																							
Culm nodes, ridged type	3									1	0.5																

Çamlıbel Tarlası	Sample number in text		17	19	29	40	42	45	46	48	49	50	54	60	75	79	88	90	110	132	139	180
Gramineae, ridged type	**Culm base, cf. ridged**	**culm base**					3					1			1							
Gramineae, cf. ridged type	**Culm base, ridged**	**culm base**																				
Gramineae, indeterminate	**cf. Cereal culm bases**	**culm base**					1			1	3	1				8	1					
cf. Gramineae, indeterminate	**Cereal culm bases**	**culm base**					1				1							1				
	Collected																					
Fruit stone/nut shell	**fruit stone/nut shell**	**stone/shell**																				
cf. *Prunus*	**Plum/Almond**	**Nut shell**																				
cf. *Pistacia* sp.	**Pistachio**	**Nut shell**																				
Nutshell indeterminate	**Nutshell indeterminate**	**Nut shell**		2																		
Quercus	**Acorn shell**	**Nut shell**																				
cf. *Rubus*	**cf. blackberry**	**seed**							2													
Rubus cf.. fruitcous	**Blackberry**	**seed**							2					4							1	
	Wild																					
Family	**Genus/Species/Type**																					
Boraginaceae	***Heliotropium sp.***	**seed**															9					1
Caprifoliaceae	***Valerianella sp.***	**seed**				1																
Caryophyllaceae	***Vaccaria pyramidata***	**seed**									34	2				8	2	2			2	9
Caryophyllaceae	***Vaccaria cf.***	**seed**																				
Caryophyllaceae/ Chenopodiaceae	**Caryophyllaceae/ Chenopodiaceae**	**seed**																				
Caryophyllaceae	**Caryophyllaceae**	**seed**																				
Caryophyllaceae	**cf. Caryophyllaceae**	**seed**																				
Caryophyllaceae	***cf. Silene,* small**	**seed**					8															
Caryophyllaceae	***Silene,* small**	**seed**				8																
Caryophyllaceae	***Silene,* cf. Type 1**	**seed**										8										
Caryophyllaceae	***Silene*, Type 1**	**seed**	6.125	2			8			2	26	1			1			7		4		7
Caryophyllaceae	***Silene,* Type 2**	**seed**					8					8						1				
Chenopodiaceae	**Chenopodiaceae sp.**	**seed**				1					4	8				8		16				
Chenopodiaceae	**cf. Chenopodiaceae**	**seed**																				
Chenopodiaceae	***Chenopodium sp.***	**seed**									8											
Chenopodiaceae	***Chenopodium album***	**seed**																				
Chenopodiaceae	***Chenopodium cf. album***	**seed**																				
Chenopodiaceae	***Atriplex sp.***	**seed**	2	0.125																		
Chenopodiaceae	***cf. Atriplex***	**seed**																				

Sample number in text	200	204	209	210	213	223	224	226	238	250	260	276	306	310	311	321	324	325	337	357	358	361	365	377/365	366	370
Culm base, cf. ridged				1												1					1		1			
Culm base, ridged								1																		
cf. Cereal culm bases		7				1									2	1			1	1	4					
Cereal culm bases								1															1			
Collected																										
fruit stone/nut shell		1	0.25																1			1		1		
Plum/Almond													1													
Pistachio			0.25																							
Nutshell indeterminate																										
Acorn shell								1																		
cf. blackberry																										
Blackberry				1		3		4								1			3	4	4	1				
Wild																										
Genus/Species/Type																										
Heliotropium sp.	4					1		2													2					
Valerianella sp.									1																	
Vaccaria pyramidata		1	1			4	1						1	10	1			5	1	2	10					
Vaccaria cf.																										
Caryophyllaceae/ Chenopodiaceae																8										
Caryophyllaceae																										
cf. Caryophyllaceae																										
cf. Silene, small					8																					
Silene, small																							4			
Silene, cf. Type 1							0.8																			
Silene, Type 1		10				16	13	1	2								1				2	12	5			
Silene, Type 2					8																					
Chenopodiaceae sp.				16													1									
cf. Chenopodiaceae																										
Chenopodium sp.																										
Chenopodium album													4	8	1										1	
Chenopodium cf. album																			8							
Atriplex sp.					1																					
cf. Atriplex																										

Sample number in text	m877	392	396	400	405	406	411	m887	415	419	421	422	423	424	425	427	428	113/6	186/202	m439	35/38	74/3	76/12	78/116	m440	m466	m632
Culm base, cf. ridged	1	2		2																					1		
Culm base, ridged								1																			
cf. Cereal culm bases	4	6		5		2					1.5			2	16												
Cereal culm bases																1			1								
Collected																											
fruit stone/nut shell					2											1		1					1				
Plum/Almond																											
Pistachio																											
Nutshell indeterminate																											
Acorn shell																											
cf. blackberry																											
Blackberry	1			1	2			1			1			1										1		
Wild																											
Genus/Species/Type																											
Heliotropium sp.				3				2		17		1	6														
Valerianella sp.								1																			
Vaccaria pyramidata	29.5	8		1	4		2	1	4	3	1		3	3			3				1				1	3	3
Vaccaria cf.	2								1		1														1		1
Caryophyllaceae/ Chenopodiaceae																											
Caryophyllaceae		4																									
cf. Caryophyllaceae																			8								
cf. Silene, small																											
Silene, small	4							16					24		8	8											
Silene, cf. Type 1																											
Silene, Type 1	14	112		4	2	6	57		2	1			10			1	25		2				8				
Silene, Type 2		8		1							24																
Chenopodiaceae sp.										8						8											1
cf. Chenopodiaceae									1																		
Chenopodium sp.																											
Chenopodium album		16					1						32														
Chenopodium cf. album					8																						
Atriplex sp.	4																										
cf. Atriplex																			1								

Çamlıbel Tarlası	Sample number in text		17	19	29	40	42	45	46	48	49	50	54	60	75	79	88	90	110	132	139	180
Chenopodiaceae	***cf. Salsola***	**seed**																				
Compositae	***Chrysanthemum type***	**seed**																				
Compositae	***Onopardum type***	**seed**																				
Compositae	**Compositae, Type 1**	**seed**																				
Compositae	**Compositae, Type 2**	**seed**									2											
Compositae	**Compositae, Type 3**	**seed**																				2
Compositae	**Compositae, Type 4**	**seed**																1				
Compositae	**Compositae, Type 5**	**seed**																				
Compositae	**Compositae, Type 6**	**seed**																				
Compositae	**Compositae, Type 7**	**seed**																				
Compositae	**Compositae, Type 8**	**seed**					2															
Compositae	***Artemisia, cf.***	**seed**																				
Compositae	***Sonchus type***	**seed**					1															
Compositae	***cf. Centaurea type***	**seed**																				
Compositae	***Centaurea* type**	**seed**													1							
Compositae /Dipsacaceae	***Compositae/Dipsacaceae***	**seed**																				
Convolvulaceae	***Convolvulus sp.***	**seed**						2														
Convolvulaceae	***cf. Convulvulus***	**seed**									2											
Cruciferae	***Alyssum type***	**seed**																				
Cruciferae	***cf. Alyssum***	**seed**																				
Cruciferae	***Conringia orientalis***	**seed**									8											
Cruciferae	***cf. Conringia orientalis***	**seed**																				
Cruciferae	**Round crucifer**	**seed**																				
Cruciferae	**cf. Round crucifer**	**seed**									4											
Cruciferae	**Cruciferae, medium type**	**seed**									4	1										1
Cruciferae	**Crucif. cf. medium type**	**seed**					1				8											
Cruciferae	**Cruciferae, small type**	**seed**										1										
Cruciferae	**Crucifer, small with cells**	**seed**																				
Cruciferae	**Indeterminate crucifer**	**seed**	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyperaceae	**Cyperaceae**	**seed**											4									
Cyperaceae	**cf. Cyperaceae**	**seed**																				
Cyperaceae	***Carex sp.***	**seed**					1															
Cyperaceae	***cf. Carex***	**seed**																				
Cyperaceae	***Bolboschoenus sp.***	**seed**																				

Sample number in text	200	204	209	210	213	223	224	226	238	250	260	276	306	310	311	321	324	325	337	357	358	361	365	377/365	366	370
cf. Salsola																	1									
Chrysanthemum type																2	1									
Onopardum type																										
Compositae, Type 1																										
Compositae, Type 2																										
Compositae, Type 3																										
Compositae, Type 4																										
Compositae, Type 5																										
Compositae, Type 6																										
Compositae, Type 7																										
Compositae, Type 8																										
Artemisia, cf.																										
Sonchus type													4					1								
cf. Centaurea type			0.25																							
Centaurea type																										
Compositae/Dipsacaceae																				1						
Convolvulus sp.																										
cf. Convulvulus																				2						
Alyssum type								1	1																	
cf. Alyssum																								1		
Conringia orientalis																										
cf. Conringia orientalis																										
Round crucifer																										
cf. Round crucifer																								8		
Cruciferae, medium type					1	3		1											1			1				
Crucif. cf. medium type																										
Cruciferae, small type					1	8																				
Crucifer, small with cells											8										24	8				
Indeterminate crucifer	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
Cyperaceae																										
cf. Cyperaceae																										
Carex sp.			1																				1			
cf. Carex																				8						
Bolboschoenus sp.																	1									

Sample number in text	m877	392	396	400	405	406	411	m887	415	419	421	422	423	424	425	427	428	113/6	186/202	m439	35/38	74/3	76/12	78/116	m440	m466	m632
cf. Salsola																											
Chrysanthemum type	2			1																							
Onopardum type																	3										
Compositae, Type 1																1											
Compositae, Type 2																											
Compositae, Type 3																											
Compositae, Type 4																											
Compositae, Type 5	2																										
Compositae, Type 6																	2										
Compositae, Type 7																					8						
Compositae, Type 8								1																			
Artemisia, cf.											8																
Sonchus type																											
cf. Centaurea type														1													
Centaurea type																											
Compositae/Dipsacaceae																											
Convolvulus sp.																											
cf. Convulvulus	6																										
Alyssum type																											
cf. Alyssum																											
Conringia orientalis																											
cf. Conringia orientalis	2																										
Round crucifer					2																				2		
cf. Round crucifer																											
Cruciferae, medium type				1	2		1	1	1				8			8											
Crucif. cf. medium type																											
Cruciferae, small type	8															8											
Crucifer, small with cells								8		8											8						
Indeterminate crucifer	8	0	0	1	0	0	0	0	1	0	0	0	0	0	0	2	16	0	0	0	0	0	0	0	0	0	0
Cyperaceae	8																										
cf. Cyperaceae								1																			
Carex sp.	2																										
cf. Carex								1																			
Bolboschoenus sp.																											

Çamlıbel Tarlası	Sample number in text		17	19	29	40	42	45	46	48	49	50	54	60	75	79	88	90	110	132	139	180
Gramineae	*Avena sp.*	seed					1															
Gramineae	*cf. Avena*	seed																				
Gramineae	*Hordeum spontaneum*	seed					1														6	
Gramineae	*Stipa* type	seed					1			1	5	9			3							3
Gramineae	*Lolium,* small type	seed	244	91.5	6		62	46	35	33	460	58	104	42	88	385	49	89		36	176	153
Gramineae	*cf. Lolium,* small type	seed							2													
Gramineae	*Lolium temulentum*	seed							2	1	1		4			16	3					
Gramineae	*cf. Lolium temulentum*	seed																				
Gramineae	*Phalaris cf. minor*	seed		8		1	21		12	5	11	11	20	24	42	16	26	1		8	2	1
Gramineae	*cf. Phalaris*	seed															1					
Gramineae	Gramineae indet, large	seed					3						4		11		8	2				
Gramineae	*Taeniatherum caput-medusae*	seed													1						1	
Gramineae	*Lolium/Taeniatherum*	seed																				
Gramineae	*Hordeum/Lolium*	seed																				
Gramineae	*Hordeum murinum type*	seed											4					2				1
Gramineae	*cf. Hordeum,* wild	seed									2											
Gramineae	*Bromus* indeterminate	seed		0.125					2								1				1	
Gramineae	*Bromus rigidus/diandrus*	seed										1										
Gramineae	*Bromus arvensis*	seed	2			1	5		10		16	2			1			1		6		2
Gramineae	*cf. Bromus sp.*	seed																				
Gramineae	*cf. Crypsis aculeata*	seed																				
Gramineae	Gramineae indet., small	seed															8					
Gramineae	Gramineae, Mlat type	seed																				
Gramineae	*Poa* type	seed																				
Gramineae	*Sporobolus* sp.	seed																				
Gramineae	*cf. Sporobolus*	seed													8							
Gramineae	*Eragrostis* type	seed																				
Gramineae	Gram., cf. small round type	seed																				
Gramineae	Gram., small round type	seed																				
Gramineae	*Aegilops sp.*	rachis															4				2	
Gramineae	*cf. Aegilops sp.*	rachis																8				
Gramineae	Gramineae	rachis													8							
Gramineae	Gramineae, indet.	seed																				
Gramineae	cf. Gramineae, indet.	seed																				

Sample number in text	200	204	209	210	213	223	224	226	238	250	260	276	306	310	311	321	324	325	337	357	358	361	365	377/365	366	370
Avena sp.					1																					
cf. Avena																										
Hordeum spontaneum																										
Stipa type		1		8				8	2						2	1	8			10	2	10	4			
Lolium, small type		185	40.5	29	21	101	172	53	123	8	1	3	69	36	80	33	33	47	15	105	188	218	91	59	10	10
cf. Lolium, small type													2											1		
Lolium temulentum	36		2					2						1	1			1						1		
cf. Lolium temulentum						1								2			1									
Phalaris cf. minor		2	9.5	1		4		35	1		1			8	5	8	2	1	3	24	22		8	14	4	8
cf. Phalaris			4														2									
Gramineae indet, large						1		4	1				1										4	1		
Taeniatherum caput-medusae						1												3				1	1			
Lolium/Taeniatherum						1																				
Hordeum/Lolium																										
Hordeum murinum type			0.25											1	2											
cf. Hordeum, wild													1													
Bromus indeterminate			1					1						2	1							8		1		
Bromus rigidus/diandrus		1	1													1				2						
Bromus arvensis		1	0.25	4		2	2	1			1				2	3		1	1	3	12	3	14	2		
cf. Bromus sp.																			8							
cf. Crypsis aculeata																		4								
Gramineae indet., small																1										
Gramineae, Mlat type																	2									
Poa type																					2					
Sporobolus sp.		8													16		4				8					
cf. Sporobolus																										
Eragrostis type				8																8	8					
Gram., cf. small round type																										
Gram., small round type									8																	
Aegilops sp.	4					3	1	2													2	1				
cf. Aegilops sp.																										
Gramineae					1																					
Gramineae, indet.								1																		
cf. Gramineae, indet.																										

Sample number in text	m877	392	396	400	405	406	411	m887	415	419	421	422	423	424	425	427	428	113/6	186/202	m439	35/38	74/3	76/12	78/116	m440	m466	m632
Avena sp.																											
cf. Avena		2																									
Hordeum spontaneum	5																										
Stipa type	10	6	0.5	3			1	2	1	3	6		8	1	21	1	9								2		1
Lolium, small type	198	502	14	43	64	32	212	106	533	111	32	27	239	76	64	58	329	21	16	35	16	19	19	20	61	28	30
cf. Lolium, small type								18										8									
Lolium temulentum	14			4				7	1		2		2							1					3		1
cf. Lolium temulentum	4	6	0.5														1										
Phalaris cf. minor	188	100		49	130		2	97	20		75	2	5	14		14	5	1		2	17				1	1	2
cf. Phalaris	8				1												8				1	8					
Gramineae indet, large	1	4						1	4	1			2				1			3					1	1	2
Taeniatherum caput-medusae	1																										
Lolium/Taeniatherum																											
Hordeum/Lolium																		1									
Hordeum murinum type			0.5											1													
cf. Hordeum, wild					2																						1
Bromus indeterminate	0.5	8				2	8												1								
Bromus rigidus/diandrus												1			16												
Bromus arvensis	73.5	2		3	4			6		10	7		2	4	12			1							9	1	
cf. Bromus sp.																											
cf. Crypsis aculeata																											
Gramineae indet., small					16								8						4							1	
Gramineae, Mlat type																											
Poa type				2																							
Sporobolus sp.								8	24	8					8		8				16						
cf. Sporobolus																											
Eragrostis type																				16							
Gram., cf. small round type							4																				
Gram., small round type																									8		
Aegilops sp.				1							2		1	1											1		
cf. Aegilops sp.																											
Gramineae																											
Gramineae, indet.	8	2									1								1								
cf. Gramineae, indet.																									8		

Çamlıbel Tarlası	Sample number in text		17	19	29	40	42	45	46	48	49	50	54	60	75	79	88	90	110	132	139	180
Labiatae	***Ajuga/Teucrium***	**seed**	0.125				1														1	
Labiatae	***Ziziphora cf. capitata /persica***	**seed**																				
Labiatae	**cf. *Ziziphora sp.***	**seed**																				
Labiatae	**cf. *Lallementia sp.***	**seed**																				
Labiatae	***Sideritis sp.***	**seed**	2			8	8															
Labiatae	**cf. *Sideritis sp.***	**seed**																				
Labiatae	**cf. Labiatae, small**	**seed**													1							
Labiatae	**Labiatae, small**	**seed**																				
Labiatae	**Labiatae**	**seed**				8												8				
Leguminosae	***Medicago* sp.**	**seed**																				
Leguminosae	**cf. *Medicago radiata***	**seed**																				
Leguminosae	**Leguminosae, small**	**seed**	1						2												1	
Leguminosae	***Trigonella astroites* type**	**seed**													16							
Leguminosae	***Lathyrus/Vicia* type**	**seed**		4			7	2			22	5		28	2		10	4		4		1
Malvaceae	***Lavatera sp.***	**seed**																1				
Malvaceae	**cf. *Lavatera***	**seed**	1				1															
Malvaceae	***Malva sp.***	**seed**																				
Papaveraceae	***Fumaria sp.***	**seed**																				
Polygonaceae	**Polygonaceae**	**seed**					1															
Polygonaceae	***Polygonum aviculare***	**seed**	2.125	2			4	6	11	1	20	2	8		6	9	5	4				
Polygonaceae	***Polygonum convolvulus***	**seed**	2			2	3					1	4		2	8		1		4	1	
Polygonaceae	***Polygonum sp.***	**seed**			1	2	1		2		26	2	4		4	16	15	2			3	6
Polygonaceae	***Rumex sp.***	**seed**				1	1				4	1			1							
Polygonaceae	**cf. *Rumex sp.***	**seed**																				
Primulaceae	***Anagalis type***	**seed**													8			8				
Primulaceae	**cf. *Anagalis***	**seed**																				
Primulaceae	**Primulaceae core**	**seed**																8				
Primulaceae	**Primulaceae, large type**	**seed**																				
Ranunculaceae	**Ranunculaceae**	**seed**																				
Ranunculaceae	***Ranunculus arvensis type***	**seed**	2.125				4	2	2		8			4	1	8	1	4				1
Ranunculaceae	**cf. *Ranunculus arvensis***	**seed**																				
Ranunculaceae	**cf. *Adonis sp.***	**seed**																				
Ranunculaceae	***Ranunculus sceleratus* type**	**seed**																				8

Sample number in text	200	204	209	210	213	223	224	226	238	250	260	276	306	310	311	321	324	325	337	357	358	361	365	377/365	366	370
Ajuga/Teucrium																										
Ziziphora cf. capitata /persica			4																	24	2					
cf. *Ziziphora sp.*																										
cf. *Lallementia sp.*		1															1			4	4					
Sideritis sp.			8			1																				
cf. *Sideritis sp.*						1																	4			
cf. Labiatae, small																										
Labiatae, small						1																				
Labiatae						2																				
Medicago sp.																										
cf. *Medicago radiata*							8																			
Leguminosae, small				1		17	1	19							2			1			1		1	11		
Trigonella astroites type																	4	1			2					
Lathyrus/Vicia type		9	16	4	1		2	13	6			1		3		3			5	10	23	3		6		1
Lavatera sp.								1																		
cf. *Lavatera*																										
Malva sp.																										
Fumaria sp.																										
Polygonaceae								1	1													8				
Polygonum aviculare		3	1	2		9	1	11	1						3		1		1	6	20	12	1			
Polygonum convolvulus		1	4			1		1					4				1	1	1	3	6		2		2	2
Polygonum sp.	1.6	5	1.25	4	1	7	2	13	5	2				4	9	7	2	1	4		8	7	1	5		
Rumex sp.			1						2						2					2	2					
cf. *Rumex sp.*																										
Anagalis type		9	0.5	16									4				4	8	8	8	1		8			
cf. *Anagalis*															1						8		4			
Primulaceae core				8																						
Primulaceae, large type																					2					
Ranunculaceae																										
Ranunculus arvensis type		1	4			3		2					2		2					2	9	3		2		
cf. *Ranunculus arvensis*																										
cf. *Adonis sp.*					1																					
Ranunculus sceleratus type						8	8														8					

Sample number in text	m877	392	396	400	405	406	411	m887	415	419	421	422	423	424	425	427	428	113/6	186/202	m439	35/38	74/3	76/12	78/116	m440	m466	m632
Ajuga/Teucrium	4			1						1						1											1
Ziziphora cf. capitata /persica	16	2					8														8						
cf. *Ziziphora sp.*																										1	
cf. *Lallementia sp.*								1	1	2																	
Sideritis sp.	8															8											
cf. *Sideritis sp.*																											4
cf. Labiatae, small																											1
Labiatae, small																											
Labiatae								1											1								
Medicago sp.				1																							
cf. *Medicago radiata*																											
Leguminosae, small	31	11		8		1	8			2			1						1	9		1			5	1	
Trigonella astroites type										8																	
Lathyrus/Vicia type	21.5	10		11	2	8	1	13	6	4	1		6	6	5	5	1			2	1	1		2		1	
Lavatera sp.	2	2														1											
cf. *Lavatera*																											
Malva sp.														8													
Fumaria sp.													1														
Polygonaceae	1						8															1			1		
Polygonum aviculare	83	11			2	2	3		1	3	4		6	1		2	1					1			1		
Polygonum convolvulus	42	8		1		4	2	1		1						1		1		3					1		3
Polygonum sp.	50	12		1	4		12	2	19	8	4	1	8	5	4	4	24	1		2		2	1	1	1	2	1
Rumex sp.	7	4		9				1			2		1														
cf. *Rumex sp.*			0.5																								
Anagalis type	128.5							8			8		16			8											
cf. *Anagalis*																											
Primulaceae core																	16										
Primulaceae, large type	38.5																										
Ranunculaceae		12																									
Ranunculus arvensis type	15	2		1		2		4			0.5						4			2		1	1		3		1
cf. *Ranunculus arvensis*																			1							1	
cf. *Adonis sp.*																											
Ranunculus sceleratus type																											1

Çamlıbel Tarlası	Sample number in text		17	19	29	40	42	45	46	48	49	50	54	60	75	79	88	90	110	132	139	180
Ranunculaceae	cf. *Ranunculus sceleratus* type	seed																				
Rosaceae	*Rosa* sp.	seed										1										
Rosaceae	cf. *Rosa* sp.	seed																				
Rubiaceae	*Sherardia cf. arvensis*	seed					1															
Rubiaceae	cf. *Cruciata* sp.	seed													1							
Rubiaceae	*Galium*, large	seed	2	6.125		2	4		2		35	2	8	8	1		3	4			3	1
Rubiaceae	*Galium* cf. *aparine*	seed		2				2	2				12			24				4		
Rubiaceae	cf. *Galium*	seed																				
Rubiaceae	*Galium*, small	seed																				
Rubiaceae	*Asperula arvenus*	seed	2	2			12	2	2		12		8	24	2		2	1				3
Rubiaceae	cf. *Galium/Asperula*	seed																				
Rubiaceae	*Galium/Asperula*	seed									8				3						1	
Rubiaceae	*Geranium type*	seed																				
Schophulariaceae	*Verbascum*, Type 1	seed					8				8											
Schophulariaceae	*Verbascum*, Type 2	seed																				
Solanaceae	*Hyoscyanus* type	seed																			8	
Thymelaeaceae	*Thymelaea* sp.	seed	2	2	3		3	2	2		2	1	4	12	3	16	5		7		2	3
Thymelaeaceae	cf. *Thymelaea*	seed																				
Thymelaeaceae	Thymelaeaceae	seed																				
Umbelliferae	Umbelliferae, short type	seed				8									8		8					
Umbelliferae	Umbelliferae, long type	seed																				
Umbelliferae	Umbelliferae, large	seed					1				4	1						1				
Umbelliferae	*Bifora radians*	seed	2				2		2	1	15		4		2	9	3					1
	Potentially identifiable	seed																2				
	Pods	Pod																				
Linaceae	*Linum usitatissimum*	Pod																				
	Pod, Type 1	Pod									2											
Caryophyllaceae	*Silene*, Type 2 with cells	Pod									10											
Caryophyllaceae	*Silene*, Type 2 no cells	Pod													2		2	1				
Caryophyllaceae	*cf. Silene*, Type 2	Pod																				
	Pod, Type 3	Pod																				
Leguminosae	Legume pod	Pod																				
Leguminosae	cf. legume pod	Pod									2											
	Pod, Type 5	Pod					1															

Sample number in text	200	204	209	210	213	223	224	226	238	250	260	276	306	310	311	321	324	325	337	357	358	361	365	377/365	366	370
cf. *Ranunculus sceleratus* type								8																		
Rosa sp.														1												1
cf. *Rosa* sp.																										
Sherardia cf. arvensis																										
cf. *Cruciata* sp.							1													2	2					
Galium, large	4	11	20.25	1		8	2	7	1		1		1	3	2	1		3		6	33	17	1	6		
Galium cf. *aparine*	1		1															1						2	2	
cf. *Galium*					1										2		2									
Galium, small																		4								
Asperula arvenus		1	22.25	1	4	2		2	1		1		1	4	1	1		1		11	25	3				
cf. *Galium/Asperula*			4																							
Galium/Asperula									2				4		1	1			1			1		2		
Geranium type			4																							
Verbascum, Type 1																										
Verbascum, Type 2																					8					
Hyoscyanus type														1												
Thymelaea sp.			11			1		15	1		2				1	2		2	1	9	12		1			
cf. *Thymelaea*																	1									
Thymelaeaceae																										
Umbelliferae, short type																				2		8				
Umbelliferae, long type			4																8	16						
Umbelliferae, large					1	1		2							1							1				
Bifora radians		2	4.75			3		3	2				3	2	2			10	1	10	5	3	1	1		
Potentially identifiable			0.5			4		2	1									5				1				
Pods																										
Linum usitatissimum																										
Pod, Type 1		1																	1							
Silene, Type 2 with cells							1							1			1						1			
Silene, Type 2 no cells		1		1	1	2	1	1					1	1		1		1	1	2			1	1		
cf. Silene, Type 2																										
Pod, Type 3																										
Legume pod						1		1							1	1							1	1		
cf. legume pod																				2						
Pod, Type 5																										

Sample number in text	m877	392	396	400	405	406	411	m887	415	419	421	422	423	424	425	427	428	113/6	186/202	m439	35/38	74/3	76/12	78/116	m440	m466	m632
cf. *Ranunculus sceleratus* type																											
Rosa sp.																										1	
cf. *Rosa* sp.																										1	
Sherardia cf. arvensis																											
cf. *Cruciata* sp.	4			1	2			1	2					1			1										
Galium, large	49.5	13	0.5	2	2	6	13	2	5	2	4.5	1	8	1	1	3	3	1			2	4		2	3	6	4
Galium cf. *aparine*		7											1														
cf. *Galium*																								1	1		
Galium, small																											
Asperula arvenus	44	4		1			1	1	2	4		1	3	4		5					1	1		1		2	
cf. *Galium/Asperula*																											
Galium/Asperula			8	5	2		2	2						1	4		1						1			8	
Geranium type																											
Verbascum, Type 1	8															16											
Verbascum, Type 2														8		16										1	
Hyoscyanus type																											
Thymelaea sp.	20	2		13		2	2	11			2	2	1			1		1			1				10	1	8
cf. *Thymelaea*																											
Thymelaeaceae								1																			
Umbelliferae, short type																					8						
Umbelliferae, long type										8																	
Umbelliferae, large										1					4				1							1	
Bifora radians	20	4	1	3	2	5	1	2	1	1		1			18		1	2		8		2	1	3	3	1	1
Potentially identifiable	4												1				1				1				1	1	
Pods																											
Linum usitatissimum								1																			
Pod, Type 1											1					2											
Silene, Type 2 with cells							9																				
Silene, Type 2 no cells	2.5			2				2		8	1.5	1	1							1							
cf. Silene, Type 2				1																							
Pod, Type 3	2													2													
Legume pod	10			1				1												1							
cf. legume pod																											
Pod, Type 5																											

Çamlıbel Tarlası	**Sample number in text**		**17**	**19**	**29**	**40**	**42**	**45**	**46**	**48**	**49**	**50**	**54**	**60**	**75**	**79**	**88**	**90**	**110**	**132**	**139**	**180**
	Pod, Type 6	**Pod**									2											
Cruciferae	***Myagrum perfoliatum* type**	**Pod**					1								1							
Cruciferae	**Pod, round crucifer**	**Pod**											4									
	Pod, potentially identifiable	**Pod**																				
	Mineralised																					
	Celtis	**min. seed**																				
	Indet	**min. seed**									2				1							
Ranunculaceae	***Ranunculus arvensis* type**	**min. seed**																				
Polygonaceae	***Polygonum* sp.**	**min. seed**									2											
Cyperaceae	***Carex* sp.**	**min. seed**																				
	Indet. Type 1	**min. seed**									2											
	Indet. Type 2	**min. seed**																				
	Indet. Type 3	**min. seed**													2							
Labiatae	**Labiatae**	**min. seed**																				
Labiatae	**Labiatae, large**	**min. seed**																				
Boraginaceae	***Buglossoides*, black**	**min. seed**	10.25	16	1		21	18	22	1	43	6	145	218	14	24	20	14	2		34	6
Boraginaceae	***Buglossoides*, white**	**min. seed**	11	12.13			10		2		19		12	5	27	24	31	24		17	3	5
Boraginaceae	***Lithospermum officinale***	**min. seed**																				
Boraginaceae	***Onosma orientale***	**min. seed**		30.5	1											8	2	5	4			
Boraginaceae	***Echium* type**	**min. seed**																				
Boraginaceae	***Anchusa officinalis* type**	**min. seed**		66.13																		
	Indeterminate	**seed**	4				24		2						8		4	8			1	4

Sample number in text	200	204	209	210	213	223	224	226	238	250	260	276	306	310	311	321	324	325	337	357	358	361	365	377/365	366	370
Pod, Type 6																										
***Myagrum perfoliatum* type**															1											
Pod, round crucifer																										
Pod, potentially identifiable				8		2											1							1		
Mineralised																										
Celtis																										
Indet						1																				
***Ranunculus arvensis* type**						1																				
***Polygonum* sp.**																										
***Carex* sp.**				1																						
Indet. Type 1																				8						
Indet. Type 2																										
Indet. Type 3																										
Labiatae																										
Labiatae, large																										
***Buglossoides*, black**	10	7	127.25	2		14	3	45	12	4			13	14	26	9	3	13	27	138	104	7	19	8		5
***Buglossoides*, white**	8	6	7.75	2	1	11	3	8	1					2	11	6	1	6	10	18	22	1	7	37		
Lithospermum officinale		1																		2						
Onosma orientale	1	43														1					1					
***Echium* type**		1																		5						
***Anchusa officinalis* type**																				1						
Indeterminate		16	0.5	4	8	24		4	1	2	1		2	3	3	1	3		10	32		18				

Sample number in text	m877	392	396	400	405	406	411	m887	415	419	421	422	423	424	425	427	428	113/6	186/202	m439	35/38	74/3	76/12	78/116	m440	m466	m632
Pod, Type 6																											
***Myagrum perfoliatum* type**	2		0.5				1				0.5																
Pod, round crucifer																											
Pod, potentially identifiable			0.5	1			1			1	8											1			1		
Mineralised																											
Celtis																									1		
Indet	1							1		1																	
***Ranunculus arvensis* type**			0.5																								
***Polygonum* sp.**						4																					
***Carex* sp.**																											
Indet. Type 1	8			1		2		1		17	8																
Indet. Type 2										24			16														
Indet. Type 3										8																	
Labiatae						8																					
Labiatae, large											1																
***Buglossoides*, black**	154.5	228	3	30	9	20	2	9		13	46.5	10	5	7	23	20	3	4	5	4	2		1	5	13	4	5
***Buglossoides*, white**	29.5	51		4	12	22	1	51		8	25	9	9	11	5	6		7	12	4	4	2			13	7	1
Lithospermum officinale														2													
Onosma orientale	0.5					3	162		2								4			6					1	1	4
***Echium* type**						1																				2	
***Anchusa officinalis* type**																											
Indeterminate	28			1	2						16		4			32		9	8	2		1				33	13

Table 12.5: Raw data table for Kuruçay showing the items found.

Kuruçay	Sample number in text		1	2	3	4	5	6	7	8	9	10	11
	% sorted		100	100	100	100	100	100	12.5	100	100	100	100
	Phase		6A	3	3	-	3	6a	-	-	6c	3	3
	Context		Shrine 1	Shrine 2	Shrine 2		Shrine2	Room 16			Room 27	House 57	House 57
Latin name	Common name	Plant part											
	Crops												
Hordeum vulgare var. nudum	**Naked barely**	twisted grain											
Hordeum vulgare	**Hulled barley**	straight grain						1		9		5	
Hordeum vulgare	**Hulled barley**	twisted grain		1				5		6		8	3
Hordeum vulgare	**Hulled barley**	indet grain						2		5		2	2
Triticum aestivum/durum	**Bread wheat**	grain		2				3					1
Triticum dicoccum	**Emmer, two-seeded**	grain						5		4		658	452
Triticum dicoccum	**Emmer, one-seeded**	grain										342	75
Triticum dicoccum/Triticum aestivum	**Emmer/Bread wheat**	grain						2				6	
Triticum dicoccum	**Emmer indet.**	grain											12
Triticum dicoccum/Triticum monococcum	**Emmer/Einkorn**	grain						1					
Hordeum vulgare var. nudum	**Naked 2-row barley**	rachis											1
Hordeum vulgare var. nudum	**Naked 6-row barley**	rachis											
Hordeum vulgare var. nudum	**Naked barely indet.**	rachis											
Hordeum vulgare indet	**Barley indet. 6-row**	rachis											
Hordeum vulgare	**Hulled 2-row barley**	rachis											
Hordeum vulgare	**Hulled 6-row barley**	rachis											
Hordeum vulgare	**Hulled barley indet.**	rachis										1	
Hordeum vulgare	**Hulled barley**	sub-/basal rachis											
Triticum aestivum/durum	**Bread wheat**	rachis											
Triticum aestivum/durum	**Bread/macaroni wheat**	rachis											
Triticum dicoccum	**Emmer, two-seeded**	glume bases						12				1640	798
Triticum dicoccum	**Emmer, one-seeded**	glume bases						2				124	46
Triticum dicoccum/Triticum monococcum	**Emmer/Einkorn**	glume bases				1		10				1068	376
Triticum dicoccum/Triticum monococcum/Triticum sp.	**Emmer/Einkorn**	basal glume base										16	2
Triticum dicoccum/Triticum monococcum/Triticum sp.	**Emmer/Einkorn**	sub-basal/basal rachis										87	5
Triticum monococcum	**Einkorn, one-seeded**	grain										84	2

Sample number in text		12	14	15	16	17	18	19	20	21	22	23	25	46	47
% sorted		50	100	25	100	100	100	100	100	100	100	100	100	100	19
Phase		6a	-	-	6A	-	6A	6/6A	3	-	6/6A	3	-	-	-
Context		House 18			Room 24		Room 24		House 57			House 57			
Common name	Plant part														
Crops															
Naked barely	twisted grain				1										
Hulled barley	straight grain	107		154	25	61							97	48	2352
Hulled barley	twisted grain	252	1	196	66	92							151	76	5600
Hulled barley	indet grain	143		205	2	15							43	51	1344
Bread wheat	grain	5			558										
Emmer, two-seeded	grain		1068	565											
Emmer, one-seeded	grain		903	133											
Emmer/Bread wheat	grain														
Emmer indet.	grain														
Emmer/Einkorn	grain														
Naked 2-row barley	rachis														
Naked 6-row barley	rachis	8		1											
Naked barely indet.	rachis	2													
Barley indet. 6-row	rachis	2													
Hulled 2-row barley	rachis														1
Hulled 6-row barley	rachis				1										16
Hulled barley indet.	rachis							1							1
Hulled barley	sub-/basal rachis							1	1						
Bread wheat	rachis				1										
Bread/macaroni wheat	rachis				3										2
Emmer, two-seeded	glume bases		1128	700	2										
Emmer, one-seeded	glume bases		80	24	2										
Emmer/Einkorn	glume bases		793	219	9										
Emmer/Einkorn	basal glume base														
Emmer/Einkorn	sub-basal/basal rachis		5	2	2										
Einkorn, one-seeded	grain		65	1											

Kuruçay	Sample number in text		1	2	3	4	5	6	7	8	9	10	11
Triticum monococcum	**Einkorn, one-seeded**	glume bases			2							72	2
Triticum monococcum/boeoticum	**Einkorn, one-seeded type/wild**	grain										20	
Triticum/Hordeum sp.	**Cereal indet.**	Grain						51		60		1796	1463
Gramineae	**Cereal indet.**	Culm node										1	
Lens culinaris	**Lentil**	seed	2	8	17	18097	935	9193		22	7921	1	
Pisum sativum	**Pea**	seed		4004	11			29	2	3105			
Lathyrus sativus	**Grass Pea**	seed	1736		2935	1		5	4518	1			
Cicer arietinum	**Chick pea**	seed	2			1							
Leguminosae	**Pulse indet.**	seed			3								
Linum usitatissimum	**Flax/Linseed**	seed			1								
	Collected												
Anacardiaceae	***Pistacia* sp.**	nut kernel/shell						1					
	Wild												
Boraginaceae	**Boraginaceae**	seed											
Caprifoliaceae	***Valerianella* sp.**	seed											
Caryophyllaceae	***Vaccaria pyramidata***	seed											
Caryophyllaceae	**cf. *Vaccaria***	seed											
Caryophyllaceae	***Silene,* Type 1**	seed										2	
Caryophyllaceae	***Silene,* Type 2**	seed											
Compositae	**cf. *Lapsana/Sonchus***	seed											
Compositae	***Antermis* type**	seed											
Cruciferae	***Conringia orientalis***	seed											
Cruciferae	***Camelina sativa***	seed											
Cruciferae	***Camelina* cf. *sativa***	seed											
Cruciferae	***Lepidum* type**	seed											
Cruciferae	**cf. *Lepidum* type**	seed											
Cruciferae	***Camelina microcarpa***	seed											
Cyperaceae	**Cyperaceae**	seed											
Gramineae	***Lolium,* small type (*Lolium* cf. *remotum*)**	seed		1								1	
Gramineae	**Gramineae, indet**	seed		1				6				4	
Gramineae	***Taeniatherum caput-medusae***	seed										4	
Gramineae	***Hordeum murinum***	seed										1	
Gramineae	***Hordeum* indet.**	seed											
Gramineae	***Lolium temulentum***	seed											

Sample number in text		12	14	15	16	17	18	19	20	21	22	23	25	46	47
Einkorn, one-seeded	glume bases		192	2	2										
Einkorn, one-seeded type/wild	grain		3	1											
Cereal indet.	Grain	2530	4036	3155	2157	1252							5785	1027	6618
Cereal indet.	Culm node			1	2			1							1
Lentil	seed			1		1	1	1							7
Pea	seed	1							6						6
Grass Pea	seed				36										3
Chick pea	seed														
Pulse indet.	seed														
Flax/Linseed	seed						15218	7756	7018	10824		145	1		1
Collected															
***Pistacia* sp.**	nut kernel/shell				1						**298**				
Wild															
Boraginaceae	seed														25
***Valerianella* sp.**	seed														1
Vaccaria pyramidata	seed	1		2					40	337.5					
cf. *Vaccaria*	seed								24	50					
***Silene*, Type 1**	seed						20	26	1008	3687.5					
***Silene*, Type 2**	seed			1											
cf. *Lapsana/Sonchus*	seed														2
***Antermis* type**	seed														1
Conringia orientalis	seed		1	1											
Camelina sativa	seed						3	86	760	212.5					
Camelina* cf. *sativa	seed		3						3						1
***Lepidum* type**	seed								408	137.5					
cf. *Lepidum* type	seed							5							
Camelina microcarpa	seed														4
Cyperaceae	seed														1
***Lolium*, small type (*Lolium* cf. *remotum*)**	seed							267	2128	1025					
Gramineae, indet	seed	1	4												7
Taeniatherum caput-medusae	seed	1		1											33
Hordeum murinum	seed														
***Hordeum* indet.**	seed														2
Lolium temulentum	seed	1													

Kuruçay	Sample number in text		1	2	3	4	5	6	7	8	9	10	11
Gramineae	***Lolium/Hordeum***	seed											
Gramineae	***Stipa* type**	seed										3	
Gramineae	**cf. *Stipa* type**	seed											
Gramineae	***Festuca* sp.**	seed										8	
Gramineae	***Bromus* indet.**	seed		1									
Gramineae	***Bromus rigidus/diandrus***	seed											
Gramineae	**cf. *Avena***	seed											
Gramineae	***Poa* sp.**	Bulblet											
Gramineae	**cf. *Poa***	Bulblet											
Gramineae	***Triticum boeoticum***	seed						1				11	
Gramineae	***Aegilops rachis***	rachis										1	
Gramineae	**Gramineae culm node**	Culm node											
Leguminosae	***Lathyrus/Vicia type***	seed								3			
Leguminosae	**cf. *Medicago* sp.**	seed		3									
Leguminosae	**Leguminosae indet.**	seed			3								
Rosaceae	***Rosa***	seed											
Rubiaceae	***Galium*, large**	seed			1				8	124		8	
Rubiaceae	***Asperula arvenus***	seed				3		1		3			
Rubiaceae	***Galium/Asperula***	seed				1				8			
Rubiaceae	***Galium*, small trigonous**	seed											
Rubiaceae	**cf. *Cruciata***	seed								2			
Scrophulariaceae	***Scrophulariaceae***	seed											
Umbelliferae	***Cheaerophullum* type**	seed										3	
Vicieae	**Vicieae**	seed	3	12	4								
	Beetles											2	
	Unindent.		1	15	11					13		3	

Sample number in text		12	14	15	16	17	18	19	20	21	22	23	25	46	47
Lolium/Hordeum	seed			1											
***Stipa* type**	seed														
cf. *Stipa* type	seed		2					1							
***Festuca* sp.**	seed				1										
***Bromus* indet.**	seed														
Bromus rigidus/diandrus	seed							1							1
cf. *Avena*	seed			1											
***Poa* sp.**	Bulblet														52
cf. *Poa*	Bulblet			1											
Triticum boeoticum	seed														
Aegilops rachis	rachis														
Gramineae culm node	Culm node							2							2
Lathyrus/Vicia type	seed														
cf. *Medicago* sp.	seed												1		
Leguminosae indet.	seed														
Rosa	seed	1													
***Galium,* large**	seed	6		12					16					5	3
Asperula arvenus	seed	1			1			1							
Galium/Asperula	seed	1		2	1				2	8					
***Galium,* small trigonous**	seed							3							
cf. *Cruciata*	seed														
Scrophulariaceae	seed							8							
***Cheaerophullum* type**	seed														
Vicieae	seed														17
Beetles		1													12
Unindent.		3		6	3		1	49	216	56			1		164

Table 12.6: Raw data table for Canhasan I showing the items found.

Canhasan I	Sample number in text		2200	2203	1855	2202	2170	624	1984	1972	1979	1771	1980	1950	1953	1817	1942
	Year		67	67	67	67	67	64	67	67	67	66	67	67	67	66	67
	Trench		R21b	R21b	R21b	R21b	R24c	Q21c	Q22a	Q22A	Q22a	Q21 c/d	Q22a	Q22a	Q22a	Q21c	Q22a
	Level		5	5	5	5	[?2b}	2A	2A 2	2A 2	2A 2	2A 2/4	2A 3	2A 3	2A 3	2A 3	2A 3
Latin name	**Common name**	**Plant part**															
	Crops																
Hordeum vulgare	**Hulled barley, straight**	grain		809	610	9	2	11	15	7	6	6	101	24	21	16	9
Hordeum vulgare	**Hulled barley, twisted**	grain		151	47	4	1	10	3		1	1	30	4	2		
Hordeum vulgare	**Hulled barley**	grain	3	4060	1000	49	1	22	24	20	14		86	27	18	6	1
Hordeum vulgare	**Hulled barley**	rachis						18									
Hordeum vulgare var. *nudum*	**Naked Barley, straight**	grain		18	9												
Hordeum vulgare var. *nudum*	**Naked barley, twisted**	grain		59	9								2				
Hordeum vulgare var. *nudum*	**Naked barley**	grain		95	7								1				
Hordeum vulgare	**Barley indet., straight**	grain			1												
Hordeum vulgare	**Barley indet., twisted**	grain															
Hordeum vulgare	**Barley indet.**	grain															
Triticum aestivum	**Free-threshing wheat**	grain			2	3	35	4	3	3	2		39	2	4	2	1
Triticum aestivum	**Free-threshing wheat, fragmented**	grain					13										
Triticum aestivum	**Free-threshing wheat**	Rachis															
Triticum dicoccum	**Emmer, 2 seeded**	grain	10		5	2			1	9	5	2	64	3	3	4	1
Triticum dicoccum	**Emmer, 1 seeded**	grain							2	2	1	1		2			1
Triticum dicoccum	**Emmer**	grain							5	4				1	2		2
Triticum dicoccum	**Emmer**	glume bases															
Triticum dicoccum	**Emmer**	sub-/basal glume bases															
Triticum dicoccum	**Emmer**	terminal glume bases															
Triticum dicoccum/aestivum	**Free-threshing wheat/Emmer**	grain		7	1		8		1	4			35	5	1		
Cereal indet.	**Cereal indeterminate**	grain			1			7				2	20			1	

Sample number in text		1966	1949	1951	1952	1958	1963	1815	1779	1768	1960	1134	1798	1961	1774	137	55	1308	1997
Year		67	67	67	67	67	67	66	66	66	67	65	66	67	66	61	61	65	67
Trench		Q22a	Q22a	Q22a	Q22a	Q22a	Q22a	Q21c	Q21c	Q21 c/d	Q22a	R21b	q21C	Q22a	Q21d	R23b	R23B	R21b	q22a
Level		2A 3	2A 3	2A 3	2A 3	2A 3	2A 3	2A 3	2A 3	2a 4	2A 4	2A/2B	2A2	2A3	2A3	2b	2B	2b	2b(?)
Common name	Plant part																		
Crops																			
Hulled barley, straight	grain	9	3	5	4	3	2	6	2	7	3	51	4	19		7		40	8
Hulled barley, twisted	grain		2		4	1	1		1			2	1	1		2	2	5	5
Hulled barley	grain	6	7	4	6	4	6	3	1	8	6	93	6	16	1	1909	1152	13	3
Hulled barley	rachis																		
Naked Barley, straight	grain																		
Naked barley, twisted	grain											1							
Naked barley	grain							3											
Barley indet., straight	grain																		
Barley indet., twisted	grain																		
Barley indet.	grain																		1
Free-threshing wheat	grain	2	2	1	1	1	1			6	3	23	1	2	1	1		12	1
Free-threshing wheat, fragmented	grain											4						1	
Free-threshing wheat	Rachis																		
Emmer, 2 seeded	grain	1	2	1					1	5	3	16	1	12					3
Emmer, 1 seeded	grain	3				1		1	1			5	1	3					2
Emmer	grain	1			2							3							
Emmer	glume bases															303	60		
Emmer	sub-/basal glume bases															2			
Emmer	terminal glume bases															20	6		
Free-threshing wheat/Emmer	grain		3	3					2		4			10				11	
Cereal indeterminate	grain									2				4					

Sample number in text		2046	2039	2008	2018	2023	2007	2006	1236	1235	1206	2017/ 2018	2008/ 2015	2027	2014	922	768	814b	921
Year		67	67	67	67	67	67	67	65	65	65	67	67	67	67	64		64	64
Trench		S24c	S24c	S24c	S24c	S24c	S24c	S24c	R21b	R21b	R21b	S24c	S24c	S24c	S24c	S26c	Q21c	s26c	s26b/c
Level		2B 1	2b 1	2B 2	2B 2	2B 2	2B 2	2B 2	2b 3	2b 3	2b 3/2	2B2	2B2	2B2	2B2	1	2A	1	1
Common name	**Plant part**																		
Crops																			
Hulled barley, straight	grain	188	4	64	49	14	18	11	16	4	17	83	21	4	9			113	12
Hulled barley, twisted	grain	37	1	9	10	3	3	2		1	2	9	5	1				139	
Hulled barley	grain	455	1	128	126	33	37	19	6	4	13	139	74	2	8			336	4
Hulled barley	rachis	248																	
Naked Barley, straight	grain	1																	
Naked barley, twisted	grain	3																1	
Naked barley	grain	2																	
Barley indet., straight	grain																		
Barley indet., twisted	grain				1														
Barley indet.	grain							1											
Free-threshing wheat	grain	2	9	15	1	3			2	3	5	14	3		1			58	4
Free-threshing wheat, fragmented	grain	4	1				5		2	1									1
Free-threshing wheat	Rachis	5																	
Emmer, 2 seeded	grain	38	3	85	70	26	16	12	1	2	8		21	7	9			23	
Emmer, 1 seeded	grain	2			9	6		5		1	2		9	1	3			1	
Emmer	grain	79					7	19			4	67							
Emmer	glume bases																		
Emmer	sub-/basal glume bases												2						
Emmer	terminal glume bases																		
Free-threshing wheat/Emmer	grain	6		47	32		2	1	1	4	2	101	15		3			45	2
Cereal indeterminate	grain	160	1	46	22	17	3					21	7	3				67	

Canhasan I	**Sample number in text**		**2200**	**2203**	**1855**	**2202**	**2170**	**624**	**1984**	**1972**	**1979**	**1771**	**1980**	**1950**	**1953**	**1817**	**1942**
Secale/Triticum	**Rye/wheat**	grain															
Cereal indet.	**Cereal indeterminate**	culm						10					1				
Pisum sativum	**Pea**	seed	5691		1	17			1		2	3	11	25	6	3	3
Vicia ervilia	**Bitter vetch**	seed											1	1		1	
Lens culinaris	**Lentil**	seed												4			
Leguminosae	**Indet pulse**	seed															
	Collected																
Cyperaceae	***Bolboschoenus***	tuber															
Anacardiaceae	***Pistacia* sp.**	kernel/shell		1	2				2	1	3	2	516	28	2	1	15
Vitaceae	***Vitis* sp.**	seed															
Rosaceae	***Prunus divaricata***	fruitstone													2		
Cappareaceae	**Capparis sp.**	seed	763														
Family	**Weeds**																
Rubiaceae	***Galium* sp.**	seed		8				17									
Caryophyllaceae	***Vaccaria***	seed		20				13									
Leguminosae	**small weed vetches**	seed															
Leguminosae	**Large weed vetches**	seed											3				
Leguminosae	**Grass vetchling**	seed											2				
Leguminosae	**Clover group**	seed						84									
Gramineae	**Weed grass**	grain		1				39									
Gramineae	**Weed grass**	spikelet base						9									
Gramineae	***Aegilops* sp.**	grain															
Gramineae	***Aegilops* sp.**	rachis															
Gramineae	***Triticum boeoticum***	grain															
	Misc. Weed	seed		1	4	16		95						1			
	Grubs	insects											3				

Sample number in text		1966	1949	1951	1952	1958	1963	1815	1779	1768	1960	1134	1798	1961	1774	137	55	1308	1997
Rye/wheat	grain																		
Cereal indeterminate	culm																		
Pea	seed	3	4		8		5	3		8	6		3	3	7				3
Bitter vetch	seed														1				
Lentil	seed	1		2					1	2		3				8	2		
Indet pulse	seed			7												13	4		
Collected																			
Bolboschoenus	tuber																		
***Pistacia* sp.**	kernel/shell	2	4	2	1	14	2		1		8	4		2	2	1			5
***Vitis* sp.**	seed									1									
Prunus divaricata	fruitstone			1												1			
Capparis sp.	seed																		
Weeds																			
***Galium* sp.**	seed															280			1
Vaccaria	seed															49	17		
small weed vetches	seed															14	5		
Large weed vetches	seed								1						1	6			
Grass vetchling	seed									1									
Clover group	seed																		
Weed grass	grain																		
Weed grass	spikelet base																		
***Aegilops* sp.**	grain											1							
***Aegilops* sp.**	rachis													2					
Triticum boeoticum	grain																		
Misc. Weed	seed										1					21	3		
Grubs	insects																		

Sample number in text		2046	2039	2008	2018	2023	2007	2006	1236	1235	1206	2017/ 2018	2008/ 2015	2027	2014	922	768	814b	921
Rye/wheat	grain																	1	
Cereal indeterminate	culm																		
Pea	seed	28	1		4	3	4	5				16			3				
Bitter vetch	seed	1																	
Lentil	seed	1																	1
Indet pulse	seed	3		8					1					1					1
Collected																			
Bolboschoenus	tuber															14	1	8	1
***Pistacia* sp.**	kernel/shell		1						1	1	4						20		
***Vitis* sp.**	seed															7			20
Prunus divaricata	fruitstone																	1	
Capparis sp.	seed																		
Weeds																			
***Galium* sp.**	seed																		
Vaccaria	seed																		
small weed vetches	seed																		
Large weed vetches	seed									1								14	
Grass vetchling	seed																		
Clover group	seed																		
Weed grass	grain																	1	
Weed grass	spikelet base																		
***Aegilops* sp.**	grain																		
***Aegilops* sp.**	rachis																		
Triticum boeoticum	grain	1																1	
Misc. Weed	seed																		
Grubs	insects								1										

12.4 Chapter 6 tables

Table 12.7: The 63 taxa included in the Çatalhöyük West correspondence analysis with the codes used in the graphical representation shown.

Taxon	Code
Glume wheats grain	GLUMEGR
Glume wheats, glume base	GBASE
Naked barley grain	HORDNGR
Naked barley rachis	RACHISN
Hulled barley grain	HORDHGR
Hulled barley rachis	HOR2HRC
Free-threshing wheat grain	FTWGR
Free-threshing wheat rachis	BWHRC
Bitter vetch	BITVET
Lentil	LENS
Pea	PEA
Adonis aestivalis L. type	ADOAES
Aeluropus Trin.	AELURO
Alisma L.	ALISMA
Artemisia annua L. type	ARTEM
Atriplex L.	ATRIPX
Bolboschoenus glaucus (Lam.) S.G. Smith	BOLBGLA
Bromus hordeaceus L./*commutatus* Schrad.	BROMWI
Carex L.	CAREX
Cruciferae pod type 1	CATALP
Chenopodium album L. type	CHENOA
Chenopodiaceae	CHENOCE
Chenopodium L.	CHENOP
Small compositae indeterminate	COMPTTO
Convolvulus arvensis L. type	CONVOL
Crypsis aculeata (L.) Aiton type	CRPSIS
Crucifereae , large	CRUILRG
Crucifereae, medium	CRUMED
Gramineae	CULMBS
Gramineae	CULMCE
Gramineae	CULMCEN
Cyperaceae	CYPERA
Deschampsia P. Beauv.	DESCHAM
Descurainia sophia (L.) Webb	DESCUR
Eragrostis N.M. Wolf	ERAGRO
Euclidium	EUCLID
Festuca L.	FESLOL
indeterminate nutshell/fruitstone	FRUNUT
Galium L., large type	GALILR
Gramineae, large indeterminate	GRAMLR
Hordeum murinum L. type	HORDMUR
Juncus L.	JUNCUS
Lavatera L. type	MALVA
Indeterminate nut shell	NUTTOT
Pistacia terebinthus L. type	PISTA

Taxon	Code
Polygonaceae	PLOYAE
Polygonum aviculare	POLYAVI
Polygonum convolvulus L.	POLYCON
Amygdalus L./*Prunus* L.	PRUAMYG
Prunus divaricata Ledeb. type	PRUDIV
Phragmites australis (Cav.) Trin.	REED
Rumex L.	RUMEX
Salsola L.	SALSOL
Gramineae, small elongated type	SEGRAS
Sideritis L. type	SIDERIT
Leguminosae, small wild	SLEG
Sporobolus R. Br. (S. virginicus (L.) Kunth type)	SPOROB
Taeniatherum caput-medusae L., grain	TAENGR
Taeniatherum caput-medusae L., rachis	TAENRC
Vaccaria pyramidata Medik.	VACCA
Vicia L./*Lathyrus* L.	VICLAT

Table 12.8: The taxa included in the Çamlıbel Tarlası correspondence analysis and the codes used to represent them.

Taxon	**Code**
Glume wheat glume bases	GWBG
Glume wheat grain	GWGR
Hulled barley grain	HORDHGR
Hulled barley rachis	HORDHRC
Free-threshing wheat grain	FTGR
Lentil	LENS
Bitter vetch	VICIER
Grass pea	LATHSAT
Chick pea	CHIPEA
Pea	PEA
Flax	FLAX
Lolium L., small type	LOLISML
Phalaris cf *minor* Retz.	PHALARIS
Vicia L./Lathyrus L.	LATHVICA
Bifora radians Bieb.	BIFORA
Asperula arvensis L.	ASPERU
Thymelea cf. passerina (L.) Cosson & Germ. type	THYMEL
Polygonum aviculare	POLYAVI
Bromus arvensis L.	BROMW
Ranunculus arvensis L. type	RANARV
Polygonum convolvulus L.	POLYCON
Vaccaria pyramidata Medik.	VACCA
Stipa L.	STIPA
Silene, type1	SILENERI
Lolium temulentum L.	LOLILRG
Leguminosae, small wild	SLEG
Anagallis L. type	ANAGLIS
Rumex L.	RUMEX
Umbelliferae, large	UMBELCEP

Taxon	Code
Heliotropium L.	HEliOT
Cruciata Millier, cf.	CRUCIA
Sporobolus R. Br. (S. virginicus (L.) Kunth type)	SPORO
Chenopodaceae	CHENACE
Silene, small	SILENESM
Sideritis L. type	SIDERIT
Ajuga/Teucrium	AJUG
Ziziphora capitata L./*persica* Bunge	ZIZI
Hordeum murinum L. type	HORDMUR
Silene, type 2	SILSPIK
Lallemantia, cf.	LALLEME
Lavatera L. type	MALVA
Taeniatherum caput-medusae L.	TAENCAP
Cruciferae, medium type	MEDCRU
Cruciferae, small celled type	SMCRUCEL
Ranunculus sceleratus L.	RANSCEL
Umbelliferae, long narrow type	UMBELNG
Trigonella astroites type	TRIGONEL
Atriplex L.	ATRIPLEX
Galium, large types	GALLRG
Cereal culm base	CEREALB
Cereal culm node	CEREALN
Culm node type 1	RIDGEN
Culm node base type 1	RIDGEB
Reed culm nodes	REEDN
Reed rhizome	REEDRZ
Nodes indeterminate	NODE
Aegilops rachis	AEGILRC
Legume pod.	LEGPOD
Pod 2	POD2
Pod 4	POD4
Silene pod	POD1A
Pod, potentially identifiable	PODPI
Carex L.	CAREX
Rubus cf *fruitcous* L.	RUBUS
Fruit stone/nut shell	FRUITST
Gramineae, indeterminate	GASSIND
Gramineae, Large indeterminate	LRGRASS
Gramineae, Small indeterminate	SMGRASIN

Table 12.9: The taxa included in the Canhasan I correspondence analysis and the codes used to represent them.

Taxon	Code
Hulled barley rachis	HORDHRC
Hulled barley grains	HORDHGR
Naked barley grains	HORDNGR
Free-threshing grains	FTWHGR
Emmer grains	EMMGR
Emmer glume bases	EMMGB

Taxon	Code
Pea	PEA
Bitter vetch	BITVET
Lentil	LENS
Indet Pulse	PULSE
Tuber	TUBER
Pistacia	PISTAC
Grape	GRAPE
Prunus	PRUNUS
Misc. Weed	MISCWEED
Galium	GALIUM
Vaccaria	VACCA
Small weed vetches	SLEGSM
Large weed vetches	SLEGLR
Grass vetchling	GRASSVET
Weed grass grain	GRASSGR
Aegilops grain and rachis	AEGRCGR
Triticum boeoticum	WEINKGR

Table 12.10: The taxa included in the Kuruçay correspondence analysis and the codes used to represent them.

Taxon	Code
Glume wheat glume bases	GWGB
Free-threshing wheat rachis	FTWRC
Hulled barley rachis	HORDHRC
Naked barley rachis	HORDNRC
Glume wheat grain	GWGR
Free-threshing wheat grain	FTWGR
Hulled barley grain	HORDHGR
Lentil	LENS
Pea	PEA
Grass pea	LATHSAT
Chick pea	CHIKPEA
Flax	FLAX
Culm node	CEREALN
Pistacia sp.	PISTA
Conringia orientalis L.	CONRING
Camelina sativa (L.) Crantz	CAMSAT
Lepidium L. type	LEPIDU
Vaccaria pyramidata Medik.	VACCA
Silene, type 1	SILENERI
Silene type 2	SILSPIK
Galium L., large type	GALLRG
Asperula arvensis L.	ASPERU
Vicieae	VITIS
Lolium L.,small (Lolium remotum type)	LOLISML
Gramineae indeterminate	GRASSIN
Taeniatherum caput-medusae L.	TAENCAP
Stipa L.	STIPA

Taxon	Code
Festuca L.	LOLFEST
Bromus L., narrow type	BROMN
Poa	POABUL
Medicago, cf.	MEDICAG
Gramineae, culm node	NODE
Lathyrus L./Vicia L.	
Galium/Asperula	GALASP
Gramineae, large seeded species	LRGRASS

12.5 Chapter 9 tables

Table 12.11: $\delta^{13}C$, $\delta^{15}N$, and $\Delta^{13}C$ values for all samples from Çatalhöyük, showing the mean and standard deviation (1σ) of each species in the four phases of Late Neolithic (LN), Early Chalcolithic I (ECI), Trench 5 (T5) and Early Chalcolithic II (ECII). (Values shown have been adjusted for charring)

Taxon	Lab code	English name	Phase	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\Delta^{13}C$ (‰)
Hordeum vulgare						
	TP005	Barley	LN	-21.9	5.1.	15.6
	TP006	Barley	LN	-21.9	9.6	15.6
	TP007	Barley	LN	-23.1	9.9	16.8
	TP008	Barley	LN	-22.2	4.5	15.8
	CW1T003	Barley	ECI	-23.5	13.0	17.3
	CW1T006	Barley	ECI	-22.2	10.9	15.8
	CW1T008	Barley	ECI	-23.0	12.9	16.7
	CW1T012	Barley	ECI	-23.2	13.9	16.9
	CW1T014	Barley	ECI	-22.4	12.5	16.1
	CW1T025	Barley	ECI	-22.9	11.3	16.7
	CW001	Barley	T5	-23.0	10.0	16.7
	CW002	Barley	T5	-23.0	11.6	16.7
	CW003	Barley	T5	-22.8	10.6	16.5
	CW006	Barley	T5	-22.0	9.2	15.7
	CW009	Barley	T5	-21.9	8.4	15.6
	CW011	Barley	T5	-24.3	7.4	18.2
	CW012	Barley	T5	-22.7	10.4	16.4
	CW016	Barley	T5	-23.0	9.9	16.8
	CW017	Barley	T5	-23.0	10.3	16.7
	CW018	Barley	T5	-22.6	10.9	16.3
	CW019	Barley	T5	-23.5	8.7	17.3
	CW021	Barley	T5	-23.3	10.7	17.0
	CW023	Barley	T5	-22.8	11.5	16.5
	CW024	Barley	T5	-22.8	18.5	16.5
	CW025	Barley	T5	-23.1	10.7	16.8
	CW026	Barley	T5	-23.1	11.9	16.8
	CW027	Barley	T5	-22.5	9.1	16.2
	CW028	Barley	T5	-22.3	11.6	16.0
	CW031	Barley	T5	-22.9	13.4	16.7
	CW035	Barley	T5	-22.7	13.0	16.3
	CW1T013	Barley	ECII	-22.9	10.3	16.6
			No. of samples			
	Average all barley		31	-22.8	10.7	16.5

Taxon	Lab code	English name	Phase	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\Delta^{13}C$ (‰)
	Standard deviation			0.5	2.6	0.6
	Average LN		4	-22.3	7.3	16.0
	Standard deviation			0.6	2.9	0.6
	Average ECI		6	-22.9	12.4	16.6
	Standard deviation			0.5	1.1	0.5
	Average T5		20	-22.9	10.9	16.6
	Standard deviation			0.5	2.3	0.6
	Average ECII		1	-22.9	10.3	16.6
	Standard deviation			-	-	-
Lens culinaris						
	CW1T004	Lentil	ECI	-22.9	4.1	16.6
	CW1T007	Lentil	ECI	-23.4	3.1	17.1
	CW008	Lentil	T5	-22.7	3.1	16.4
	CW010	Lentil	T5	-23.5	2.9	17.2
	CW014	Lentil	T5	-22.7	3.7	16.4
	CW034	Lentil	T5	-22.0	5.4	15.7
	CW037	Lentil	T5	-24.3	7.8	18.1
	CW1T023	Lentil	ECII	-22.0	4.7	15.7
			No. of samples			
	Average all lentils		8	-22.9	4.4	16.6
	Standard deviation			0.8	1.6	0.8
	Average ECI		2	-23.1	3.6	16.9
	Standard deviation			0.4	0.7	0.4
	Average T5		5	-23.0	4.6	16.8
	Standard deviation			0.9	2.1	0.9
	Average ECII		1	-22.0	4.7	15.7
	Standard deviation			-	-	-
' New type' wheat						
	TP009	'New type'	LN	-24.1	9.1	17.9
	TP004	'New type'	LN	-23.7	10.3	17.4
	TP003	'New type'	LN	-23.4	9.1	17.1
	TP002	'New type'	LN	-23.8	14.4	17.5
	TP001	'New type'	LN	-23.0	8.6	16.7
	CW022	'New type'	T5	-23.7	8.1	17.4
			No. of samples			
	Average all 'New type'		6	-23.6	9.9	17.4
	Standard deviation			0.4	2.3	0.4
	Average LN		5	-23.6	10.6	17.3
	Standard deviation			0.4	2.7	0.4
	Average T5		1	-23.7	8.1	17.4
	Standard deviation			-	-	-
Pisum sativum						
	CW1T018	Pea	ECI	-23.3	3.1	17.0
	CW007	Pea	T5	-22.8	2.4	16.5
	CW029	Pea	T5	-23.4	5.6	17.2
	CW1T017	Pea	ECII	-23.3	3.5	17.1
			No. of samples			
	Average all peas		4	-23.2	3.7	16.9
	Standard deviation			0.3	1.4	0.3
	Average ECI		1	-23.3	3.1	17.0
	Standard deviation			-	-	-
	Average T5		2	-23.1	4.0	16.8
	Standard deviation			0.5	2.3	0.5

Taxon	Lab code	English name	Phase	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\Delta^{13}C$ (‰)
	Average ECII		1	-23.3	3.5	17.1
	Standard deviation			-	-	-
Triticum aestivum						
	CW1T002	Free-threshing wheat	ECI	-23.5	7.1	17.2
	CW1T011	Free-threshing wheat	ECI	-21.6	7.7	15.2
	CW1T022	Free-threshing wheat	ECI	-25.1	10.0	18.9
	CW1T026	Free-threshing wheat	ECI	-21.4	5.5	15.1
	CW033	Free-threshing wheat	T5	-22.5	8.7	16.2
	CW030	Free-threshing wheat	T5	-24.3	8.5	18.0
	CW020	Free-threshing wheat	T5	-23.7	8.4	17.4
	CW015	Free-threshing wheat	T5	-23.2	7.9	16.9
	CW004	Free-threshing wheat	T5	-23.4	8.8	17.1
	CW1T015	Free-threshing wheat	ECII	-23.5	9.3	17.2
			No. of samples			
	Average all free-threshing wheat		10	-23.2	8.2	16.9
	Standard deviation			1.1	1.2	1.2
	Average ECI		4	-22.9	7.6	16.6
	Standard deviation			1.7	1.9	1.8
	Average T5		5	-23.4	8.5	17.1
	Standard deviation			0.6	0.4	0.7
	Average ECII		1	-23.5	9.3	17.2
	Standard deviation					
Triticum dicoccom						
	TP011	Emmer	LN	-23.4	17	17.2
	TP010	Emmer	LN	-23.6	10.5	17.4
	CW1T001	Emmer	ECI	-24.6	8.2	18.4
	CW1T020	Emmer	ECI	-23.3	7.5	17.0
	CW032	Emmer	T5	-23.5	8.9	17.2
			No. of samples			
	Average all emmer		5	-23.7	10.4	17.4
	Standard deviation			0.5	3.8	0.6
	Average LN		2	-23.5	13.8	17.3
	Standard deviation			0.1	4.6	0.1
	Average ECI		2	-23.9	7.8	17.7
	Standard deviation			0.9	0.5	1
	Average T5		1	-23.5	8.9	17.2
	Standard deviation					
Triticum monococcum						
	TP012	Einkorn	LN	-24.8	9.9	18.5
	CW1T010	Einkorn (2 gr)	ECI	-24.3	9.7	18.1
	CW1T009	Einkorn	ECI	-22.6	8.1	16.3
	CW1T005	Einkorn	ECI	-22.3	9.5	16.0
	CW005	Einkorn	T5	-24.3	7.8	18.1
	CW013	Einkorn	T5	-23.0	8.2	16.7
	CW036	Einkorn	T5	-24.7	12.2	18.5
	CW038	Einkorn	T5	-22.5	9.1	16.2
	CW039	Einkorn	T5	-22.0	15.2	15.7
	CW040	Einkorn	T5	-24.8	8.8	18.5
	CW1T024	Einkorn (2 gr)	ECII	-22.1	9.9	15.7
	CW1T021	Einkorn	ECII	-23.8	9.3	17.6
	CW1T019	Einkorn (2 gr)	ECII	-22.4	13.0	16.1
	CW1T016	Einkorn	ECII	-21.5	18	15.2
			No. of			

Taxon	Lab code	English name	Phase	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\Delta^{13}C$ (‰)
			samples			
	Average all Einkorn		14	-23.2	10.6	17
	Standard deviation			1.2	2.9	1.2
	Average LN		1	-24.8	9.9	18.5
	Standard deviation			-	-	-
	Average ECI		3	-23.1	9.1	16.8
	Standard deviation			1.1	0.9	1.1
	Average T5		6	-23.6	10.2	17.3
	Standard deviation			1.2	2.9	1.3
	Average ECII		4	-22.5	12.6	16.1
	Standard deviation			1.0	4	1.0

Table 12.12. Number of samples, mean, standard deviation and range of $\delta^{13}C$, $\delta^{15}N$ and $\Delta^{13}C$ for the crop species examined at Çamlıbel Tarlası.

	Lab code	English	Phase	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\Delta^{13}C$ (‰)
Hordeum vulgare						
	CBT015	Barley	CBTI	-23.5	4.0	17.5
	CBT019	Barley	CBTI	-23.2	5.6	17.3
	CBT021	Barley	CBTI	-23.8	5.2	17.8
	CBT024	Barley	CBTI	-23.7	8.3	17.7
	CBT043	Barley	CBTI	-23.1	4.4	17.1
	CBT053	Barley	CBTI	-22.9	5.1	16.9
	CBT060	Barley	CBTI	-21.3	7.8	15.2
	CBT065	Barley	CBTI	-24.8	6.1	18.9
	CBT073	Barley	CBTI	-22.7	3.7	16.7
	CBT076	Barley	CBTI	-23.5	4.7	17.6
	CBT085	Barley	CBTI	-23.1	6.1	17.1
	CBT090	Barley	CBTI	-23.6	4.9	17.6
	CBT091	Barley	CBTI	-23.1	3.9	17.1
	CBT092	Barley	CBTI	-21.8	5.2	15.8
	CBT113	Barley	CBTI	-22.7	5.1	16.8
	CBT047	Barley	CBTI/CBTII	-22.7	3.9	16.7
	CBT006	Barley	CBTII	-23.3	4.4	17.3
	CBT029	Barley	CBTII	-24.0	5.1	18.1
	CBT046	Barley	CBTII	-22.4	3.6	16.4
	CBT058	Barley	CBTII	-22.6	3.5	16.6
	CBT064	Barley	CBTII	-24.6	1.7	18.6
	CBT067	Barley	CBTII	-23.2	3.6	17.3
	CBT078	Barley	CBTII	-23.4	6.1	17.4
	CBT008	Barley	CBTIII	-22.5	5.2	16.5
	CBT044	Barley	CBTIII	-24.1	3.4	18.2
	CBT050	Barley	CBTIII	-25.0	4.9	19.1
	CBT055	Barley	CBTIII	-24.7	6.2	18.8
	CBT057	Barley	CBTIII	-22.8	4.2	16.8
	CBT093	Barley	CBTIII	-25.4	3.9	19.5
	CBT010	Barley	CBTIV	-22.7	5.5	16.7
	CBT045	Barley	CBTIV	-24.3	3.8	18.3
			No. of samples			
	Average all		31	-23.4	4.8	17.4
	Standard deviation			0.9	1.3	1.0
	Average CBTI		15	-23.1	5.3	17.1
	Standard deviation			0.8	1.3	0.9
	Average CBTII		7	-23.4	4.0	17.4
	Standard deviation			0.8	1.4	0.8

	Lab code	English	Phase	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\Delta^{13}C$ (‰)
	Average CBTIII		6	-24.1	4.6	18.2
	Standard deviation			1.2	1.0	1.2
	Average CBTIV		2	-23.5	4.7	17.5
	Standard deviation			1.1	1.2	1.1
Triticum monococcum						
	CBT016	Einkorn	CBTI	-22.8	5.0	16.8
	CBT020	Einkorn	CBTI	-21.5	5.3	15.4
	CBT042	Einkorn	CBTI	-21.7	3.1	15.7
	CBT074	Einkorn	CBTI	-21.3	3.6	15.3
	CBT079	Einkorn	CBTI	-22.9	5.2	16.9
	CBT086	Einkorn	CBTI	-22.6	5.5	16.6
	CBT094	Einkorn	CBTI	-21.3	3.9	15.3
	CBT095	Einkorn	CBTI	-23.7	3.7	17.8
	CBT115	Einkorn	CBTI	-22.2	4.1	16.1
	CBT119	Einkorn	CBTI	-22.7	5.2	16.7
	CBT049	Einkorn	CBTII	-23.4		17.5
	CBT071	Einkorn	CBTII	-21.1	5.2	15.1
	CBT072	Einkorn	CBTII	-24.0	4.7	18.1
	CBT041	Einkorn	FPEU	-22.5	3.7	16.5
	CBT026	Einkorn	CBTIII	-22.6	5.2	16.6
	CBT114	Einkorn	CBTIII	-22.4	6.5	16.4
			No. of samples			
	Average all einkorn		16	-22.4	4.7	16.4
	Standard deviation			0.9	0.9	0.9
	Average CBTI		10	-22.3	4.5	16.3
	Standard deviation			0.8	0.9	0.8
	Average CBTII		3	-22.9	5.0	16.9
	Standard deviation			1.6	0.4	1.6
	Average CBTIII		2	-22.5	5.9	16.5
	Standard deviation			0.1	0.9	0.1
Triticum dicoccum						
	CBT022	Emmer	CBTI	-23.1	5.9	17.1
	CBT054	Emmer	CBTI	-24.2	5.9	18.3
	CBT089	Emmer	CBTI	-21.7	5.3	15.6
	CBT112	Emmer	CBTIII	-21.9	6.4	15.9
			No. of samples			
	Average all Emmer		4	-22.7	5.9	16.7
	Standard deviation			1.2	0.5	1.2
	Average CBTI		3	-23.0	5.7	17.0
	Standard deviation			1.3	0.4	1.3
Triticum aestivum						
	CBT051	Free-threshing wheat	CBTI	-21.8	4.6	15.7
Vicia ervilia						
	CBT004	Bitter vetch	CBTI	-22.4	1.8	16.4
	CBT007	Bitter vetch	CBTI	-22.5	3.5	16.5
	CBT018	Bitter vetch	CBTI	-21.8	2.2	15.8
	CBT033	Bitter vetch	CBTI	-22.8	1.7	16.8
	CBT059	Bitter vetch	CBTI	-22.8	2.0	16.8
	CBT070	Bitter vetch	CBTI	-22.1	1.5	16.1
	CBT077	Bitter vetch	CBTI	-23.1	2.4	17.1
	CBT082	Bitter vetch	CBTI	-23.8	1.6	17.9
	CBT084	Bitter vetch	CBTI	-22.5	1.6	16.5
	CBT087	Bitter vetch	CBTI	-22.9	2.1	16.9
	CBT088	Bitter vetch	CBTI	-23.5	1.9	17.6
	CBT097	Bitter vetch	CBTI	-24.1	2.5	18.2

	Lab code	English	Phase	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\Delta^{13}C$ (‰)
	CBT098	Bitter vetch	CBTI	-24.3	1.9	18.4
	CBT014	Bitter vetch	CBTI/CBTII	-23.6	1.3	17.7
	CBT005	Bitter vetch	CBTII	-22.5	2.4	16.5
	CBT028	Bitter vetch	CBTII	-22.5	2.1	16.5
	CBT066	Bitter vetch	CBTII	-23.3	2.2	17.3
	CBT039	Bitter vetch	FPEU	-22.8	2.3	16.8
	CBT027	Bitter vetch	CBTIII	-21.9	2.2	15.9
	CBT036	Bitter vetch	CBTIII	-23.8	2.4	17.8
	CBT052	Bitter vetch	CBTIII	-22.2	1.6	16.2
	CBT056	Bitter vetch	CBTIII	-24.9	2.0	19.0
	CBT099	Bitter vetch	CBTIII	-23.7	2.9	17.8
	CBT102	Bitter vetch	CBTIII	-24.1	2.7	18.1
	CBT002	Bitter vetch	CBTIV	-22.7	2.0	16.7
	CBT012	Bitter vetch	CBTIV	-23.0	2.7	17.0
	CBT031	Bitter vetch	CBTIV	-23.0	1.9	17.1
			No. of samples			
	Average all Bitter vetch		27	-23.1	2.1	17.1
	Standard deviation			0.8	0.5	0.8
	Average CBTI		13	-23.0	2.1	17.0
	Standard deviation			0.8	0.5	0.8
	Average CBTII		3	-22.8	2.3	16.8
	Standard deviation			0.4	0.2	0.5
	Average CBTIII		6	-23.4	2.3	17.5
	Standard deviation			1.2	0.5	1.2
	Average CBTIV		3	-22.9	2.2	16.9
	Standard deviation			0.2	0.5	0.2
Pisum sativum						
	CBT100	Pea	CBTI	-22.6	2.9	16.6
Cicer arietium						
	CBT103	Chickpea	CBTI	-23.2	2.1	17.3
	CBT120	Chickpea	CBTI	-23.8	2.2	17.8
			No. of samples			
	Average all Chickpea		2	-23.5	2.2	17.6
	Standard deviation			0.4	0.1	0.4
Lathyrus sativus						
	CBT101	CBT877	CBTI	-22.6	3.2	16.6
	CBT108	CBT304	CBTI	-21.6	3.0	15.5
	CBT109	CBTF390	CBTI	-21.6	3.3	15.6
	CBT121	CBT843	CBTI	-22.6	2.8	16.6
	CBT105	CBT1006	CBTII	-21.5	2.8	15.5
	CBT107	CBT325	CBTIII	-22.2	2.4	16.2
			No. of samples			
	Average Grass pea		6	-22.0	2.9	16.0
	Standard deviation			0.5	0.3	0.5
	Average CBTI		4	-22.1	3.1	16.1
	Standard deviation			0.6	0.2	0.6
Lens culinaris						
	CBT003	Lentil	CBTI	-22.8	2.6	16.8
	CBT017	Lentil	CBTI	-23.5	1.8	17.6
	CBT023	Lentil	CBTI	-21.4	3.2	15.3
	CBT025	Lentil	CBTI	-22.9	1.7	16.9
	CBT034	Lentil	CBTI	-23.0	2.4	17.0
	CBT063	Lentil	CBTI	-24.3	2.4	18.4
	CBT069	Lentil	CBTI	-22.4	3.1	16.4
	CBT075	Lentil	CBTI	-23.2	2.5	17.2
	CBT080	Lentil	CBTI	-23.5	3.4	17.5

	Lab code	English	Phase	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\Delta^{13}C$ (‰)
	CBT081	Lentil	CBTI	-23.6	2.2	17.7
	CBT083	Lentil	CBTI	-22.3	2.1	16.3
	CBT106	Lentil	CBTI	-23.3	2.5	17.4
	CBT110	Lentil	CBTI	-22.1	3.1	16.1
	CBT111	Lentil	CBTI	-21.6	2.4	15.6
	CBT118	Lentil	CBTI	-22.9	2.3	16.9
	CBT013	Lentil	CBTI/CBTII	-22.0	2.3	15.9
	CBT001	Lentil	CBTII	-22.2	2.8	16.2
	CBT030	Lentil	CBTII	-24.8	2.9	18.9
	CBT037	Lentil	CBTII	-21.4	2.8	15.3
	CBT038	Lentil	CBTII	-23.4	2.5	17.5
	CBT061	Lentil	CBTII	-22.2	2.9	16.2
	CBT062	Lentil	CBTII	-24.0	3.1	18.1
	CBT040	Lentil	FPEU	-22.8	3.0	16.8
	CBT009	Lentil	CBTIII	-22.5	3.1	16.5
	CBT035	Lentil	CBTIII	-23.2	2.3	17.2
	CBT048	Lentil	CBTIII	-22.8	2.6	16.8
	CBT096	Lentil	CBTIII	-23.3	2.8	17.4
	CBT104	Lentil	CBTIII	-22.5	2.9	16.5
	CBT116	Lentil	CBTIII	-22.4	2.2	16.4
	CBT117	Lentil	CBTIII	-22.4	2.5	16.4
	CBT011	Lentil	CBTIV	-22.3	2.2	16.3
	CBT032	Lentil	CBTIV	-23.2	2.2	17.3
	CBT068	Lentil	CBTIV	-22.4	2.5	16.3
			No. of sample			
	Average all Lentil		33	-22.8	2.6	16.8
	Standard deviation			0.8	0.4	0.8
	Average CBTI		15	-22.9	2.5	16.9
	Standard deviation			0.8	0.5	0.8
	Average CBTII		6	-23.0	2.8	17.0
	Standard deviation			1.3	0.2	1.3
	Average CBTIII		7	-22.7	2.6	16.7
	Standard deviation			0.4	0.3	0.4
	Average CBTIV		3	-22.6	2.3	16.6
	Standard deviation			0.5	0.2	0.5

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