

THE ORIGINS AND EVOLUTION OF PIG DOMESTICATION IN PREHISTORIC SPAIN

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Abstract

From the main four domesticates (cattle, sheep, goat, and pig), the pig has only recently attracted scientific interest worthy of its archaeological importance. Synthetic works studying wild or domestic pigs in European regions such as Italy, Sardinia/Corsica and Poland have provided important insights often missed by site-focused zooarchaeological reports. This thesis constitutes the first study focusing on pigs and their interactions with humans in Spain from pre-Neolithic times until the Iron Age. Crucial archaeological issues addressed include, when and how pig domestication occurred, how it was integrated in the neolithisation of Iberia, and how it evolved in post-Neolithic periods. The relationships between humans and wild boar as well as between domestic pigs and their wild counterparts are also explored.

A large volume of biometric data on postcranial and dental elements, combined with age and sex data of pig populations, allow reliable analyses and well-informed interpretations. These data are explored graphically and described to refine the picture of prehistoric pig populations in Spain and generate inferences on their relationship with humans. Biometric data from other countries and ethnoarchaeological data of traditional pig husbandry practices from southwest Iberia and other Mediterranean regions are analysed to enhance the interpretational value of the Spanish zooarchaeological data.

The results support the appearance of domestic pigs from the early 6th millennium cal. BC in most parts of Spain and suggest ample diversity in early pig husbandry practices. By the end of the Neolithic, domestic pigs were present across Spain and more important than hunted wild boar. From the Late/Final Neolithic onwards, domestic pigs were morphologically distinguishable from wild boar on population level. The data also suggest an increase in wild boar hunting in the Bronze Age followed by further intensification of pig management in the Iron Age. Possible explanations and implications of these findings are discussed.

Resumen

Entre las cuatro especies domésticas principales (bovino, ovino, caprino y porcino), el cerdo sólo recientemente ha atraído un interés arqueológico equivalente a su importancia en nuestro pasado. En algunas zonas de Europa como Italia, Cerdeña, Córcega y Polonia obras de síntesis centradas en suidos han generado nuevas aportaciones que normalmente se escapan de estudios zooarqueológicos centrados en yacimientos específicos. Esta tesis constituye el primer estudio que se enfoca hacia el cerdo y sus interacciones con grupos humanos en España desde tiempos pre-Neolíticos hasta la Edad del Hierro. Entre los asuntos arqueológicos tratados en esta tesis se incluyen preguntas como: cuándo y en qué manera ocurrió la domesticación del cerdo, cómo se integró en el proceso de neolitización en la península ibérica, y cuál fue la evolución de este proceso en períodos post-Neolíticos. También se exploran las relaciones entre humanos y jabalí, así como entre jabalí y cerdo.

El gran volumen de datos biométricos postcraiales y dentales combinado con los datos sobre la estructura demográfica (edad y sexo) de poblaciones de cerdos permiten análisis fidedignos e interpretaciones fiables. Estos datos se analizan gráficamente y se describen extensivamente para refinar nuestro conocimiento del cerdo en España durante la prehistoria y generar inferencias sobre su relación con humanos. Datos biométricos de otros países así como datos etnoarqueológicos sobre la cría tradicional de cerdos Ibéricos en el suroeste de la península y otras regiones mediterráneas, se analizan para aumentar el valor interpretativo de los datos zooarqueológicos desde España.

Los resultados apoyan la aparición de cerdos domésticos en el séptimo milenio cal. a.C. en la mayor parte de España y sugieren una amplia diversidad en las prácticas ganaderas relacionadas con cerdos. Antes del final del Neolítico, el cerdo doméstico se encontraba por toda España y desempeñaba un papel más importante que su homólogo salvaje (jabalí). Desde el Neolítico Tardío/Final, cerdos domésticos eran morfológicamente distinguibles del jabalí al nivel de población. Los datos también sugieren un incremento en la caza del jabalí en la Edad de Bronce seguida de una intensificación de la cabaña porcina en la Edad del Hierro. Las posibles explicaciones e implicaciones de estos hallazgos se discuten extensivamente en esta tesis.

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Table of contents

ABSTRACT	I
RESUMEN	II
ACKNOWLEDGEMENTS	III
TABLE OF CONTENTS	VI
LIST OF TABLES	IX
LIST OF FIGURES	XI
LIST OF APPENDICES	XXI
CHAPTER 1. INTRODUCTION	1
1.1 THE ORIGINS OF PIG DOMESTICATION IN SPAIN: CURRENT KNOWLEDGE, ARCHAEOLOGICAL CONTEXT AND RELEVANT ISSUES	1
1.2 PIG DOMESTICATION IN POST-NEOLITHIC PREHISTORIC PERIODS: CURRENT KNOWLEDGE AND ARCHAEOLOGICAL CONTEXT	7
1.2.1 <i>Copper Age</i>	7
1.2.2 <i>Bronze Age</i>	10
1.2.3 <i>Iron Age</i>	13
1.3 EURASIAN WILD BOAR: THE ANCESTOR OF THE DOMESTIC PIG	17
1.4 DETECTION AND STUDY OF PIG DOMESTICATION IN THE EUROPEAN CONTEXT: CURRENT KNOWLEDGE	20
1.5 SUMMARY AND AIMS	24
CHAPTER 2. MATERIALS AND METHODS	27
2.1 ARCHAEOLOGICAL MATERIAL	27
2.1.1 <i>Identification</i>	32
2.1.2 <i>Ageing</i>	34
2.1.2.1 <i>Fusion</i>	34
2.1.2.2 <i>Eruption, wear and dental defects</i>	35
2.1.2.3 <i>Combination of epiphyseal fusion and dental eruption/wear</i>	36
2.1.3 <i>Sexing</i>	37
2.1.4 <i>Biometry</i>	37
2.1.4.1 <i>Measurements: postcranial bones</i>	38
2.1.4.2 <i>Measurements: teeth/mandible</i>	42
2.2 ETHNOARCHAEOLOGY	43
CHAPTER 3. EARLY PREHISTORY (PRE-NEOLITHIC AND NEOLITHIC PERIODS): INVESTIGATING WILD BOAR HUNTING AND THE ONSET OF PIG DOMESTICATION	45
3.1 SEX RATIOS	45
3.1.1 <i>Pre-Neolithic</i>	47
3.1.2 <i>Neolithic</i>	47
3.2 AGEING	50
3.2.1 <i>Pre-Neolithic</i>	50
3.2.2 <i>Neolithic</i>	52
3.3 BIOMETRY	60
3.3.1 <i>Biometry of postcranial elements</i>	60
3.3.2 <i>Tooth biometry</i>	71
3.4 SUMMARY	88
CHAPTER 4. LATE PREHISTORY (COPPER, BRONZE AND IRON AGES): EVOLUTION OF PIG HUSBANDRY AND INTERACTIONS WITH WILD BOAR POPULATIONS	94
4.1 SEX RATIOS	95
4.1.1 <i>Copper Age</i>	96
4.1.2 <i>Bronze Age</i>	99
4.1.3 <i>Iron Age</i>	103

4.2 AGEING	113
4.2.1 Copper Age	113
4.2.2 Bronze Age	118
4.2.3 Iron Age	127
4.3 BIOMETRY	151
4.3.1 <i>Biometry of postcranial elements</i>	151
4.3.1.1 Copper Age	153
4.3.1.1.1 Postcranial bones, age and sex structure-Copper Age	162
4.3.1.2 Bronze Age	163
4.3.1.2.1 Postcranial bones, age and sex structure-Bronze Age	170
4.3.1.3 Iron Age	171
4.3.1.2.1 Postcranial bones, age and sex profile-Iron Age	183
4.3.2 <i>Tooth Biometry</i>	185
4.3.2.1 Copper Age	187
4.3.2.1.1 Dental size, age and sex profile-Copper Age	203
4.3.2.2 Bronze Age	203
4.3.2.2.1 Dental size, age and sex profile-Bronze Age	217
4.3.2.3 Iron Age	218
4.3.2.3.1 Dental size, age and sex profile - Iron Age	233
4.4 LINEAR ENAMEL HYPOPLASIA	234
4.5 SUMMARY	239

CHAPTER 5. COMPARISONS OF SPANISH DATA WITH OTHER EUROPEAN COUNTRIES

244

5.1 BIOMETRY	247
5.1.1 <i>Biometry of postcranial elements</i>	247
5.1.2 <i>Tooth Biometry</i>	261
5.1.3 <i>Postcranial-dental size comparison</i>	277
5.1.3.1 Spain	278
5.1.3.2 Portugal	279
5.1.3.3 Italy	280
5.1.3.4 Britain	281
5.2 SUMMARY	286

CHAPTER 6. TRADITIONAL PIG HUSBANDRY IN SOUTHWEST IBERIA: RESULTS, DISCUSSION AND CONCLUSIONS

290

6.1 ETHNOARCHAEOLOGY OF PIG HUSBANDRY IN SOUTHWEST IBERIA: RESULTS	290
6.1.1 <i>The dehesa</i>	290
6.1.2 <i>The Iberian pig</i>	294
6.1.3 <i>Herd size and composition</i>	299
6.1.4 <i>Wild boar and domestic pig populations</i>	301
6.1.5 <i>Castration</i>	302
6.1.6 <i>Birth season and conditions</i>	303
6.1.7 <i>Purchase/exchange of animals</i>	307
6.1.8 <i>Slaughtering practices and age-at-death</i>	308
6.1.9 <i>Home range, control and movements</i>	309
6.1.10 <i>Capture</i>	311
6.1.11 <i>Diet</i>	312
6.1.12 <i>Weight</i>	314
6.1.13 <i>Damage</i>	316
6.1.14 <i>Products</i>	316
6.2 ETHNOARCHAEOLOGY OF PIG HUSBANDRY IN THE MEDITERRANEAN: ZOOARCHAEOLOGICAL IMPLICATIONS	317
6.2.1 <i>Morphology</i>	318
6.2.2 <i>Age and sex structures</i>	321
6.2.3 <i>Biological status and management</i>	323
6.2.4 <i>Castration</i>	325
6.2.5 <i>Genetic viability of herds and avoidance of inbreeding</i>	326
6.2.6 <i>Seasonality</i>	327
6.3 CONCLUSIONS	328

CHAPTER 7. THE ORIGINS AND EVOLUTION OF PIG HUSBANDRY IN PREHISTORIC SPAIN: DISCUSSION, FUTURE DIRECTIONS AND CONCLUSIONS	331
7.1 PIG DOMESTICATION: THE ORIGINS	332
7.1.1 <i>Spanish wild boar</i>	332
7.1.2 <i>First domestic pigs</i>	335
7.1.3 <i>Integrating zooarchaeology and ethnoarchaeology: the origins of pig domestication</i>	341
7.1.4 <i>The end of the Neolithic period: consolidation of pig domestication</i>	343
7.2 PIG DOMESTICATION: POST-NEOLITHIC EVOLUTION	345
7.2.1 <i>Copper Age</i>	346
7.2.2 <i>Bronze Age</i>	348
7.2.3 <i>Iron Age</i>	352
7.2.4 <i>Integrating zooarchaeology and ethnoarchaeology: the evolution of pig domestication in post-Neolithic periods</i>	354
7.3 WEAKNESSES, STRENGTHS AND FUTURE DIRECTIONS	356
7.3.1 <i>Weaknesses</i>	356
7.3.2 <i>Strengths</i>	358
7.3.3 <i>Future directions</i>	359
7.4 CONCLUSIONS	361
BIBLIOGRAPHY	364
APPENDICES	381
DATABASE CD	INSIDE BACK COVER

List of tables

TABLE 2.1: OVERVIEW OF RECORDED ASSEMBLAGES AND NUMBER OF RECORDED POSTCRANIAL BONES (PC) AND TEETH (T). SITES ARE LISTED IN CHRONOLOGICAL ORDER. _____	29
TABLE 2.2: ROUGH EQUIVALENCES BETWEEN DENTAL ERUPTION AND EPIPHYSEAL FUSION IN PIGS. ____	37
TABLE 2.3: LIST OF POSTCRANIAL MEASUREMENTS TAKEN. _____	39
TABLE 2.4: LIST OF MAXILLARY AND MANDIBULAR MEASUREMENTS TAKEN. _____	42
TABLE 3.1: OVERVIEW OF ANALYSED ASSEMBLAGES CONTAINING PRE-NEOLITHIC AND/OR NEOLITHIC MATERIAL. SITES ARE LISTED IN APPROXIMATE CHRONOLOGICAL ORDER. _____	46
TABLE 3.2: AGE-AT-DEATH DATA FOR ADVANCED MAGDALENIAN-_____	51
TABLE 3.3: AGE-AT-DEATH DATA FOR ADVANCED MAGDALENIAN-EPIPALAEOLITHIC ZATOIA BASED ON TOOTH ERUPTION AND WEAR. _____	52
TABLE 3.4: AGE-AT-DEATH DATA FOR MESOLITHIC AIZPEA _____	52
TABLE 3.5: ESTIMATION OF DAYS AFTER CONCEPTION BASED ON GJESDAL'S 1972 EQUATIONS FOR ALL RECORDED YOUNG AND POROUS TIBIAE, FEMORA, HUMERI AND RADII. _____	55
TABLE 3.6: AGE-AT-DEATH DATA FOR EARLY NEOLITHIC COVA FOSCA BASED ON TOOTH ERUPTION AND WEAR. _____	57
TABLE 3.7: AGE-AT-DEATH DATA FOR EARLY NEOLITHIC CUEVA DE LA VAQUERA BASED ON TOOTH ERUPTION AND WEAR. _____	58
TABLE 3.8: AGE-AT-DEATH DATA FOR LATE NEOLITHIC LA RENKE BASED ON TOOTH ERUPTION AND WEAR _____	60
TABLE 3.9: NUMBER (N), MINIMUM, MAXIMUM, MEAN AND COEFFICIENT OF VARIATION (V) FOR POSTCRANIAL MEASUREMENTS OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. ONLY FULLY FUSED SPECIMENS WERE INCLUDED. _____	62
TABLE 3.10: SIGNIFICANCE (TWO-TAILED) OF SIZE DIFFERENCES IN ASTRAGALUS MEASUREMENTS BETWEEN PERIODS, CALCULATED WITH MANN-WHITNEY TESTS. ONLY SAMPLES WITH A MINIMUM OF FIVE OR MORE MEASUREMENTS WERE SUBJECTED TO TESTING; GREEN: VERY HIGHLY SIGNIFICANT; BLUE: HIGHLY SIGNIFICANT; YELLOW: SIGNIFICANT. _____	63
TABLE 3.11: NUMBER (N), MINIMUM, MAXIMUM, MEAN AND COEFFICIENT OF VARIATION (V) FOR MANDIBULAR MEASUREMENTS OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. _____	72
TABLE 3.12: NUMBER (N), MINIMUM, MAXIMUM, MEAN AND COEFFICIENT OF VARIATION (V) FOR MAXILLARY MEASUREMENTS OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. _____	73
TABLE 3.13 SIGNIFICANCE (TWO-TAILED) OF SIZE DIFFERENCES IN PIG TOOTH MEASUREMENTS BETWEEN PERIODS, CALCULATED WITH MANN-WHITNEY TESTS. ONLY SAMPLES WITH A MINIMUM OF FIVE OR MORE MEASUREMENTS WERE SUBJECTED TO TESTING; GREEN: VERY HIGHLY SIGNIFICANT; BLUE: HIGHLY SIGNIFICANT; YELLOW: SIGNIFICANT. _____	74
TABLE 4.1: OVERVIEW OF ANALYSED ASSEMBLAGES CONTAINING COPPER, BRONZE AND IRON AGE MATERIAL. SITES ARE LISTED IN APPROXIMATE CHRONOLOGICAL ORDER. _____	95
TABLE 4.2: NUMBER (N), MINIMUM, MAXIMUM, MEAN AND COEFFICIENT OF VARIATION (V) FOR POSTCRANIAL MEASUREMENTS OF PRE-NEOLITHIC, NEOLITHIC AND POST-NEOLITHIC CHRONOLOGY. ONLY FULLY FUSED SPECIMENS WERE INCLUDED. _____	152
TABLE 4.3: SIGNIFICANCE (TWO-TAILED) OF SIZE DIFFERENCES IN PIG POSTCRANIAL MEASUREMENTS BETWEEN COPPER AGE AND THE REST OF THE PREHISTORIC PERIODS, CALCULATED WITH MANN-WHITNEY TESTS. ONLY SAMPLES WITH A MINIMUM OF FIVE OR MORE MEASUREMENTS WERE SUBJECTED TO TESTING; GREEN: VERY HIGHLY SIGNIFICANT; BLUE: HIGHLY SIGNIFICANT; YELLOW: SIGNIFICANT. _____	154
TABLE 4.4: SIGNIFICANCE (TWO-TAILED) OF SIZE DIFFERENCES IN PIG POSTCRANIAL MEASUREMENTS BETWEEN BRONZE AGE AND THE REST OF THE PREHISTORIC PERIODS, CALCULATED WITH MANN-WHITNEY TESTS. ONLY SAMPLES WITH A MINIMUM OF FIVE OR MORE MEASUREMENTS WERE SUBJECTED TO TESTING; GREEN: VERY HIGHLY SIGNIFICANT; BLUE: HIGHLY SIGNIFICANT; YELLOW: SIGNIFICANT. _____	164
TABLE 4.5: SIGNIFICANCE (TWO-TAILED) OF SIZE DIFFERENCES IN PIG POSTCRANIAL MEASUREMENTS BETWEEN IRON AGE AND THE REST OF THE PREHISTORIC PERIODS, CALCULATED WITH MANN-WHITNEY TESTS. ONLY SAMPLES WITH A MINIMUM OF FIVE OR MORE MEASUREMENTS WERE SUBJECTED TO TESTING; GREEN: VERY HIGHLY SIGNIFICANT; BLUE: HIGHLY SIGNIFICANT; YELLOW: SIGNIFICANT. _____	172
TABLE 4.6: NUMBER (N), MINIMUM, MAXIMUM, MEAN AND COEFFICIENT OF VARIATION (V) FOR MANDIBULAR MEASUREMENTS OF COPPER, BRONZE AND IRON AGE CHRONOLOGY. _____	185

TABLE 4.7: NUMBER (N), MINIMUM, MAXIMUM, MEAN AND COEFFICIENT OF VARIATION (V) FOR MAXILLARY MEASUREMENTS OF COPPER, BRONZE AND IRON AGE CHRONOLOGY. _____	186
TABLE 4.8: SIGNIFICANCE (TWO-TAILED) OF SIZE DIFFERENCES IN PIG TOOTH MEASUREMENTS BETWEEN COPPER AGE AND THE REST OF THE PREHISTORIC PERIODS, CALCULATED WITH MANN-WHITNEY TESTS. ONLY SAMPLES WITH A MINIMUM OF FIVE OR MORE MEASUREMENTS WERE SUBJECTED TO TESTING; GREEN: VERY HIGHLY SIGNIFICANT; BLUE: HIGHLY SIGNIFICANT; YELLOW: SIGNIFICANT. _	188
TABLE 4.9: SIGNIFICANCE (TWO-TAILED) OF SIZE DIFFERENCES IN PIG TOOTH MEASUREMENTS BETWEEN BRONZE AGE AND THE REST OF THE PREHISTORIC PERIODS, CALCULATED WITH MANN-WHITNEY TESTS. ONLY SAMPLES WITH A MINIMUM OF FIVE OR MORE MEASUREMENTS WERE SUBJECTED TO TESTING; GREEN: VERY HIGHLY SIGNIFICANT; BLUE: HIGHLY SIGNIFICANT; YELLOW: SIGNIFICANT. _	204
TABLE 4.10: SIGNIFICANCE (TWO-TAILED) OF SIZE DIFFERENCES IN PIG TOOTH MEASUREMENTS BETWEEN IRON AGE AND THE REST OF THE PREHISTORIC PERIODS, CALCULATED WITH MANN-WHITNEY TESTS. ONLY SAMPLES WITH A MINIMUM OF FIVE OR MORE MEASUREMENTS WERE SUBJECTED TO TESTING; GREEN: VERY HIGHLY SIGNIFICANT; BLUE: HIGHLY SIGNIFICANT; YELLOW: SIGNIFICANT. _____	219
TABLE 5.1: OVERVIEW OF NON-SPANISH ASSEMBLAGES INCLUDED IN THE ANALYSES PRESENTED IN THIS CHAPTER. SITES ARE LISTED PER COUNTRY AND IN APPROXIMATE CHRONOLOGICAL ORDER. _	246
TABLE 6.1: HERD SIZE PER BREEDER AT THE TIME OF THE INTERVIEWS (MAY 2008). _____	299
TABLE 6.2: NUMBERS OF REPRODUCTIVE MALES AND FEMALES PER HERD (ABOVE). PERCENTAGE OF MALES PER HERD (BELOW), CALCULATED AS A PERCENTAGE OF THE TOTAL OF REPRODUCTIVE PIGS (MALES AND FEMALES). _____	300
TABLE 6.3: PERCENTAGE OF ADULTS PER HERD AT THE TIME OF THE INTERVIEWS (MAY 2008), CALCULATED AS A PERCENTAGE OF THE TOTAL OF EACH HERD. _____	301
TABLE 6.4: FREQUENCY OF PIG PURCHASES TO ENRICH THE GENETIC DIVERSITY OF THE HERD. BREEDER 2 IS NOT INCLUDED BECAUSE HE ONLY BUYS PIGLETS TO RAISE THEM. _____	308
TABLE 6.5: AGE-AT-DEATH OF 'SEMI-FREE-RANGE' (UPPER ROW) AND 'FREE-RANGE' (LOWER ROW) PIGS PER BREEDER. SEE ALSO APPENDICES 3 AND 4 FOR DEFINITIONS OF 'FREE-RANGE' AND 'SEMI-FREE-RANGE' SYSTEMS. _____	309
TABLE 6.6: SUMMARY OF THE DIET OF FREE-RANGE IBERIAN PIGS, DESCRIBED ON A SEASONAL BASIS.	314
TABLE 6.7: WEIGHT OF MALE AND FEMALE REPRODUCTIVE IBERIAN PIGS (UPPER ROW) AND WEIGHT-AT-SLAUGHTER OF NON-REPRODUCTIVE IBERIAN PIGS (LOWER ROW). MANY OF THE MALES ARE GENETICALLY 50% DUROC-JERSEY. _____	315

List of figures

FIGURE 2.1: MAP OF SPAIN INDICATING THE LOCATION OF ALL SITES ANALYSED IN THIS PROJECT. ____	31
FIGURE 2.2: EXAMPLE OF HOW ISOLATED MOLARS RECORDED AS M1/2 ARE SAFELY REASSIGNED INTO M1 OR M2 PRIOR TO THEIR INCLUSION IN BIOMETRIC AND OTHER ANALYSES. _____	34
FIGURE 3.1: MAP OF SPAIN INDICATING THE LOCATION OF ANALYSED ASSEMBLAGES CONTAINING PRE-NEOLITHIC AND/OR NEOLITHIC MATERIAL. _____	46
FIGURE 3.2: SEX RATIOS FOR ADVANCED MAGDALENIAN-EPIPALAEOLITHIC _____	47
FIGURE 3.3: SEX RATIOS FOR EARLY NEOLITHIC CUEVA CHAVES (COMBINED LEVELS IA AND IB) BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT). _____	48
FIGURE 3.4: SEX RATIOS FOR EARLY NEOLITHIC LA DRAGA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT). _____	48
FIGURE 3.5: SEX RATIOS FOR FINAL NEOLITHIC LOS CASTILLEJOS BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT). _____	49
FIGURE 3.6: SEX RATIOS FOR FINAL NEOLITHIC/EARLY COPPER LOS CASTILLEJOS BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT). _____	50
FIGURE 3.7: AGE-AT-DEATH DATA FOR EARLY NEOLITHIC CUEVA CHAVES BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	53
FIGURE 3.8: AGE-AT-DEATH DATA FOR EARLY NEOLITHIC CUEVA CHAVES BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	53
FIGURE 3.9: AGE-AT-DEATH DATA FOR EARLY NEOLITHIC LA DRAGA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	56
FIGURE 3.10: AGE-AT-DEATH DATA FOR EARLY NEOLITHIC LA DRAGA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	56
FIGURE 3.11: AGE-AT-DEATH DATA FOR EARLY NEOLITHIC COVA FOSCA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	57
FIGURE 3.12: AGE-AT-DEATH DATA FOR EARLY NEOLITHIC CUEVA DE LA VAQUERA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	58
FIGURE 3.13: AGE-AT-DEATH DATA FOR MIDDLE-FINAL NEOLITHIC LOS CASTILLEJOS BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	59
FIGURE 3.14: AGE-AT-DEATH DATA FOR MIDDLE-FINAL NEOLITHIC LOS CASTILLEJOS BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	59
FIGURE 3.15: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. LIGHT AND POROUS SPECIMENS ARE EXCLUDED. MEASUREMENTS IN MM. _____	63
FIGURE 3.16: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM ALL THE RECORDED EARLY NEOLITHIC ASSEMBLAGES COMPARED WITH THE COMBINED PRE-NEOLITHIC SAMPLE. LIGHT AND POROUS SPECIMENS ARE EXCLUDED. MEASUREMENTS IN MM. _	64
FIGURE 3.17: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM ALL THE RECORDED FINAL/LATE NEOLITHIC ASSEMBLAGES COMPARED WITH THE COMBINED PRE-NEOLITHIC SAMPLE. LIGHT AND POROUS SPECIMENS ARE EXCLUDED. MEASUREMENTS IN MM. _	65
FIGURE 3.18: SCATTERPLOT OF TIBIA WIDTH X DEPTH OF THE DISTAL END FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM. ____	66
FIGURE 3.19: SCATTERPLOT OF CALCANEUM GREATEST LENGTH X GREATEST DEPTH FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM. _____	66
FIGURE 3.20: SCATTERPLOT OF HUMERUS WIDTH OF TROCHLEA X MINIMUM DIAMETER OF TROCHLEA FROM COMBINED SAMPLES OF EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM. _____	67
FIGURE 3.21: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE. _____	68

FIGURE 3.22: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF SCAPULA NECK) FROM EARLY NEOLITHIC SITES WITH COMBINED SAMPLES OF PRE-NEOLITHIC AND LATE/FINAL NEOLITHIC CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE.	70
FIGURE 3.23: SCATTERPLOT OF CROWN LENGTH X POSTERIOR CUSP WIDTH OF MANDIBULAR FOURTH DECIDUOUS PREMOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM.	75
FIGURE 3.24: SCATTERPLOT OF CROWN LENGTH X POSTERIOR CUSP WIDTH OF MAXILLARY FOURTH DECIDUOUS PREMOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM.	76
FIGURE 3.25: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM.	77
FIGURE 3.26: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MAXILLARY PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM.	77
FIGURE 3.27: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM.	78
FIGURE 3.28: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MAXILLARY PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM.	79
FIGURE 3.29: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM.	80
FIGURE 3.30: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MAXILLARY PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY. MEASUREMENTS IN MM.	80
FIGURE 3.31: RATIO BETWEEN WIDTH AND LENGTH OF PRE-NEOLITHIC, EARLY NEOLITHIC AND LATE/FINAL NEOLITHIC LOWER THIRD MOLARS.	81
FIGURE 3.32: RATIO BETWEEN WIDTH AND LENGTH OF PRE-NEOLITHIC, EARLY NEOLITHIC AND LATE/FINAL NEOLITHIC UPPER THIRD MOLARS.	82
FIGURE 3.33: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY.	83
FIGURE 3.34: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM EARLY NEOLITHIC SITES WITH COMBINED SAMPLES OF PRE-NEOLITHIC AND LATE/FINAL NEOLITHIC CHRONOLOGY.	85
FIGURE 3.35: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM MIDDLE, LATE AND FINAL NEOLITHIC SITES WITH COMBINED SAMPLES OF PRE-NEOLITHIC AND EARLY NEOLITHIC CHRONOLOGY.	87
FIGURE 3.36: GRAPH ILLUSTRATING THE RELATIONSHIP BETWEEN BONE AND TOOTH SIZE THROUGH PRE-NEOLITHIC AND NEOLITHIC PERIODS (CA. 10TH-4TH MILLENNIUM CAL. BC) BASED ON THE MEAN LOG RATIO VALUES OF ALL RECORDED MEASUREMENTS (EXCLUDING THE LENGTH OF SCAPULA NECK FOR POSTCRANIAL).	88
FIGURE 4.1: MAP OF SPAIN INDICATING THE LOCATION OF ANALYSED ASSEMBLAGES CONTAINING COPPER, BRONZE AND IRON AGE MATERIAL.	94
FIGURE 4.2: SEX RATIOS FOR COPPER AGE VALENCINA DE LA CONCEPCIÓN BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	96
FIGURE 4.3: SEX RATIOS FOR COPPER AGE LOS MILLARES BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	97
FIGURE 4.4: SEX RATIOS FOR COPPER AGE LOS CASTILLEJOS BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	97
FIGURE 4.5: SEX RATIOS FOR EARLY COPPER AGE CUEVA RUBIA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	98
FIGURE 4.6: SEX RATIOS FOR CHALCOLITHIC (COPPER AGE) LAS POZAS BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	98
FIGURE 4.7: SEX RATIOS FOR MIDDLE/LATE BRONZE AGE MONTE AGUILAR BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	99
FIGURE 4.8: SEX RATIOS FOR BRONZE AGE MORRA DE QUINTANAR BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	100
FIGURE 4.9: SEX RATIOS FOR BRONZE AGE ACEQUIÓN BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	100
FIGURE 4.10: SEX RATIOS FOR BRONZE AGE (ARGARIC) CERRO DE ENCINA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	101

FIGURE 4.11: SEX RATIOS FOR MIDDLE/FINAL BRONZE AGE LA HOYA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	101
FIGURE 4.12: SEX RATIOS FOR FINAL BRONZE AGE CASTILLO DE HENAYO BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	102
FIGURE 4.13: SEX RATIOS FOR FINAL BRONZE AGE PEÑAS DE ORO BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	102
FIGURE 4.14: SEX RATIOS FOR IRON AGE I LA HOYA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	103
FIGURE 4.15: SEX RATIOS FOR IRON AGE II LA HOYA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	104
FIGURE 4.16: SEX RATIOS FOR IRON AGE I AND II LA HOYA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	104
FIGURE 4.17: SEX RATIOS FOR IRON AGE I CASTROS DE LASTRA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	105
FIGURE 4.18: SEX RATIOS FOR IRON AGE II CASTROS DE LASTRA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	106
FIGURE 4.19: SEX RATIOS FOR IRON AGE I AND II CASTROS DE LASTRA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	106
FIGURE 4.20: SEX RATIOS FOR IRON AGE I CASTILLO DE HENAYO BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	107
FIGURE 4.21: SEX RATIOS FOR IRON AGE PEÑAS DE ORO BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	108
FIGURE 4.22: SEX RATIOS FOR IRON AGE I CASTRO DE BERBEIA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	108
FIGURE 4.23: SEX RATIOS FOR IRON AGE SANTA ANA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	109
FIGURE 4.24: SEX RATIOS FOR IRON AGE I CASTILLAR DE MENDAVIA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	109
FIGURE 4.25: SEX RATIOS FOR IRON AGE II LAS RABAS (OR CELADA MARLANTES) BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	110
FIGURE 4.26: SEX RATIOS FOR IRON AGE (6TH-7TH CENTURY BC) CAMPA TORRES BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	110
FIGURE 4.27: SEX RATIOS FOR IRON AGE I AND II SOTO DE MEDINILLA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	111
FIGURE 4.28: SEX RATIOS FOR IRON AGE (6TH-5TH CENTURY BC) LA MOTA BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	112
FIGURE 4.29: SEX RATIOS FOR TARTESSIAN (IRON AGE) CALLE PUERTO 10 BASED ON JAWS (LEFT) AND LOOSE CANINES (RIGHT).	112
FIGURE 4.30: AGE-AT-DEATH DATA FOR COPPER AGE VALENCINA DE LA CONCEPCIÓN BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	114
FIGURE 4.31: AGE-AT-DEATH DATA FOR COPPER AGE VALENCINA DE LA CONCEPCIÓN BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	114
FIGURE 4.32: AGE-AT-DEATH DATA FOR EARLY COPPER AGE LOS CASTILLEJOS BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	115
FIGURE 4.33: AGE-AT-DEATH DATA FOR MIDDLE/LATE COPPER AGE LOS CASTILLEJOS BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	115
FIGURE 4.34: AGE-AT-DEATH DATA FOR COPPER AGE LOS CASTILLEJOS BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	116
FIGURE 4.35: AGE-AT-DEATH DATA FOR COPPER AGE LOS MILLARES BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	116
FIGURE 4.36: AGE-AT-DEATH DATA FOR COPPER AGE LOS MILLARES BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	117
FIGURE 4.37: AGE-AT-DEATH DATA FOR BRONZE AGE CERRO DE ENCINA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	119

FIGURE 4.38: AGE-AT-DEATH DATA FOR BRONZE AGE CERRO DE ENCINA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	119
FIGURE 4.39: AGE-AT-DEATH DATA FOR BRONZE AGE ACEQUIÓN BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	120
FIGURE 4.40: AGE-AT-DEATH DATA FOR BRONZE AGE ACEQUIÓN BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	121
FIGURE 4.41: AGE-AT-DEATH DATA FOR BRONZE AGE MORRA DE QUINTANAR BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	121
FIGURE 4.42: AGE-AT-DEATH DATA FOR BRONZE AGE MORRA DE QUINTANAR BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	122
FIGURE 4.43: AGE-AT-DEATH DATA FOR BRONZE AGE BASTIDA DE TOTANA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	123
FIGURE 4.44: AGE-AT-DEATH DATA FOR MIDDLE BRONZE AGE MONTE AGUILAR BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	123
FIGURE 4.45: AGE-AT-DEATH DATA FOR LATE BRONZE AGE MONTE AGUILAR BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	124
FIGURE 4.46: AGE-AT-DEATH DATA FOR MIDDLE/LATE BRONZE AGE MONTE AGUILAR BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	124
FIGURE 4.47: AGE-AT-DEATH DATA FOR MIDDLE/LATE BRONZE AGE MONTE AGUILAR BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	125
FIGURE 4.48: AGE-AT-DEATH DATA FOR MIDDLE/FINAL BRONZE AGE LA HOYA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	126
FIGURE 4.49: AGE-AT-DEATH DATA FOR MIDDLE/FINAL BRONZE AGE LA HOYA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	126
FIGURE 4.50: AGE-AT-DEATH DATA FOR IRON AGE I LA HOYA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	128
FIGURE 4.51: AGE-AT-DEATH DATA FOR IRON AGE I LA HOYA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	129
FIGURE 4.52: AGE-AT-DEATH DATA FOR IRON AGE II LA HOYA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	129
FIGURE 4.53: AGE-AT-DEATH DATA FOR IRON AGE II LA HOYA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	130
FIGURE 4.54: AGE-AT-DEATH DATA FOR IRON AGE I+II LA HOYA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	131
FIGURE 4.55: AGE-AT-DEATH DATA FOR IRON AGE I+II LA HOYA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	132
FIGURE 4.56: AGE-AT-DEATH DATA FOR IRON AGE I CASTROS DE LASTRA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	133
FIGURE 4.57: AGE-AT-DEATH DATA FOR IRON AGE I CASTROS DE LASTRA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	133
FIGURE 4.58: AGE-AT-DEATH DATA FOR IRON AGE II CASTROS DE LASTRA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	134

FIGURE 4.59: AGE-AT-DEATH DATA FOR IRON AGE II CASTROS DE LASTRA BASED ON TOOTH ERUPTION AND _____	135
FIGURE 4.60: AGE-AT-DEATH DATA FOR IRON AGE I+II CASTROS DE LASTRA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	136
FIGURE 4.61: AGE-AT-DEATH DATA FOR IRON AGE I+II CASTROS DE LASTRA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	137
FIGURE 4.62: AGE-AT-DEATH DATA FOR IRON AGE I SOTO DE MEDINILLA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	137
FIGURE 4.63: AGE-AT-DEATH DATA FOR IRON AGE I SOTO DE MEDINILLA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	138
FIGURE 4.64: AGE-AT-DEATH DATA FOR IRON AGE II SOTO DE MEDINILLA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	139
FIGURE 4.65: AGE-AT-DEATH DATA FOR IRON AGE II SOTO DE MEDINILLA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	139
FIGURE 4.66: AGE-AT-DEATH DATA FOR IRON AGE I+II SOTO DE MEDINILLA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	140
FIGURE 4.67: AGE-AT-DEATH DATA FOR IRON AGE I+II SOTO DE MEDINILLA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	140
FIGURE 4.68: AGE-AT-DEATH DATA FOR IRON AGE (TRANSITION IRON AGE I-II) LA MOTA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	141
FIGURE 4.69: AGE-AT-DEATH DATA FOR IRON AGE (TRANSITION IRON AGE I-II) LA MOTA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	142
FIGURE 4.70: AGE-AT-DEATH DATA FOR IRON AGE II LAS RABAS BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	142
FIGURE 4.71: AGE-AT-DEATH DATA FOR IRON AGE II LAS RABAS BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	143
FIGURE 4.72: AGE-AT-DEATH DATA FOR IRON AGE (7TH-6TH CENTURY BC) CAMPA TORRES BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	143
FIGURE 4.73: AGE-AT-DEATH DATA FOR IRON AGE (7TH-6TH CENTURY BC) CAMPA TORRES BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	144
FIGURE 4.74: AGE-AT-DEATH DATA FOR IRON AGE II (5TH-3RDTH CENTURIES BC) CASTILLO DE HENAYO BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	145
FIGURE 4.75: AGE-AT-DEATH DATA FOR IRON AGE II (5TH-3RD CENTURIES BC) CASTILLO DE HENAYO BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	145
FIGURE 4.76: AGE-AT-DEATH DATA FOR IRON AGE II (5TH CENTURY BC) CASTRO DE BERBEIA BASED ON EPIPHYSEAL FUSION. DATA ARE PRESENTED PER CATEGORY OF FUSING ELEMENTS (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	146
FIGURE 4.77: AGE-AT-DEATH DATA FOR IRON AGE II (5TH CENTURY BC) CASTRO DE BERBEIA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	146
FIGURE 4.78: AGE-AT-DEATH DATA FOR IRON AGE SANTA ANA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	147
FIGURE 4.79: AGE-AT-DEATH DATA FOR IRON AGE I CASTILLAR DE MENDAVIA BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT). _____	147

FIGURE 4.80: AGE-AT-DEATH DATA FOR IRON AGE (7TH-4TH CENTURIES BC) CALLE PUERTO 10 BASED ON TOOTH ERUPTION AND WEAR. DATA ARE PRESENTED PER AGE CATEGORY (LEFT) AND IN THE FORM OF A MORTALITY BAR (RIGHT).	148
FIGURE 4.81: AGE PROFILES BASED ON POOLED SAMPLES FROM EACH CHRONOLOGICAL PERIOD. THE BLACK COLOUR REPRESENTS EPIPHYSEAL FUSION AND THE GREY COLOUR REPRESENTS TOOTH ERUPTION AND WEAR. BARS SHOW THE MORTALITY PER AGE INTERVAL AND THE LINES SHOW THE SAME DATA IN A CUMULATIVE FORM. THE NUMBERS ON THE X AXIS REPRESENT AGE IN MONTHS.	149
FIGURE 4.82: AGE PROFILES BASED ON POOLED SAMPLES FROM IRON AGE I AND IRON AGE II. THE BLACK COLOUR REPRESENTS EPIPHYSEAL FUSION AND THE GREY COLOUR REPRESENTS TOOTH ERUPTION AND WEAR. BARS SHOW THE MORTALITY PER AGE INTERVAL AND THE LINES SHOW THE SAME DATA IN A CUMULATIVE FORM. THE NUMBERS ON THE X AXIS REPRESENT AGE IN MONTHS.	150
FIGURE 4.83: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. LIGHT AND POROUS SPECIMENS ARE EXCLUDED. MEASUREMENTS IN MM.	155
FIGURE 4.84: SCATTERPLOT OF HUMERUS WIDTH OF TROCHLEA X MINIMUM DIAMETER OF TROCHLEA FROM COMBINED SAMPLES OF EARLY NEOLITHIC, FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM.	156
FIGURE 4.85: SCATTERPLOT OF TIBIA DISTAL WIDTH X DEPTH OF THE DISTAL END FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. ONLY PRE-NEOLITHIC 'FUSING' SPECIMENS ARE INCLUDED. MEASUREMENTS IN MM.	157
FIGURE 4.86: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM ALL THE RECORDED COPPER AGE ASSEMBLAGES. MEASUREMENTS IN MM.	158
FIGURE 4.87: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE.	159
FIGURE 4.88: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) FROM COPPER AGE SITES WITH THE COMBINED COPPER AGE SAMPLE (EXCLUDING VALENCINA). ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE.	161
FIGURE 4.89: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. LIGHT AND POROUS SPECIMENS ARE EXCLUDED. MEASUREMENTS IN MM.	165
FIGURE 4.90: SCATTERPLOT OF HUMERUS WIDTH OF TROCHLEA X MINIMUM DIAMETER OF TROCHLEA FROM COMBINED SAMPLES OF EARLY NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. ONLY FULLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM.	166
FIGURE 4.91: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE.	167
FIGURE 4.92: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) FROM BRONZE AGE SITES WITH THE COMBINED BRONZE AGE SAMPLE. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE.	169
FIGURE 4.93: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. LIGHT AND POROUS SPECIMENS ARE EXCLUDED. MEASUREMENTS IN MM.	173
FIGURE 4.94: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM COMBINED SAMPLES OF THE THREE POST-NEOLITHIC PERIODS (COPPER, BRONZE AND IRON AGE). LIGHT AND POROUS SPECIMENS ARE EXCLUDED. MEASUREMENTS IN MM.	174
FIGURE 4.95: SCATTERPLOT OF HUMERUS WIDTH OF TROCHLEA X MINIMUM DIAMETER OF TROCHLEA FROM COMBINED SAMPLES OF EARLY NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. ONLY FULLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM.	175
FIGURE 4.96: SCATTERPLOT OF TIBIA DISTAL WIDTH X DEPTH OF THE DISTAL END FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. ONLY FULLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM.	176
FIGURE 4.97: SCATTERPLOT OF CALCANEUM GREATEST LENGTH X GREATEST DEPTH FROM COMBINED SAMPLES OF EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM.	176

FIGURE 4.98: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE. _____	178
FIGURE 4.99: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) FROM DIFFERENT IRON AGE SITES. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE. _____	180
FIGURE 4.100: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF SCAPULA NECK) FROM THE COMBINED SAMPLES OF IRON AGE I AND IRON AGE II. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE. ____	181
FIGURE 4.101: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM THE COMBINED SAMPLES OF IRON AGE I AND IRON AGE II. LIGHT AND POROUS SPECIMENS ARE EXCLUDED. MEASUREMENTS IN MM. _____	182
FIGURE 4.102: SCATTERPLOT OF HUMERUS WIDTH OF TROCHLEA X MINIMUM DIAMETER OF TROCHLEA FROM THE COMBINED SAMPLES OF IRON AGE I AND IRON AGE II. ONLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM. _____	182
FIGURE 4.103: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) FROM THREE CHRONOLOGICALLY SUCCESSIVE SAMPLES RECOVERED AT THE SITE OF LA HOYA (MIDDLE/FINAL BRONZE AGE-IRON I-IRON II). ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE. _____	183
FIGURE 4.104: SCATTERPLOT OF CROWN LENGTH X POSTERIOR CUSP WIDTH OF MANDIBULAR FOURTH DECIDUOUS PREMOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	189
FIGURE 4.105: SCATTERPLOT OF CROWN LENGTH X POSTERIOR CUSP WIDTH OF MAXILLARY FOURTH DECIDUOUS PREMOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	190
FIGURE 4.106: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	191
FIGURE 4.107: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MAXILLARY PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	191
FIGURE 4.108: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	192
FIGURE 4.109: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MAXILLARY PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	193
FIGURE 4.110: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	194
FIGURE 4.111: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MAXILLARY PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	194
FIGURE 4.112: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	195
FIGURE 4.113: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MAXILLARY PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	196
FIGURE 4.114: SCATTERPLOT OF ANTERIOR CUSP X CENTRAL CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	197
FIGURE 4.115: SCATTERPLOT OF ANTERIOR CUSP X CENTRAL CUSP WIDTH OF MAXILLARY PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	197
FIGURE 4.116: RATIO BETWEEN WIDTH AND LENGTH OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE LOWER THIRD MOLARS. _____	198
FIGURE 4.117: RATIO BETWEEN WIDTH AND LENGTH OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE UPPER THIRD MOLARS. _____	199
FIGURE 4.118: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND COPPER AGE CHRONOLOGY. _____	200

FIGURE 4.119: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM COPPER AGE SITES WITH THE COMBINED COPPER AGE SAMPLE. _____	202
FIGURE 4.120: SCATTERPLOT OF CROWN LENGTH X POSTERIOR CUSP WIDTH OF MANDIBULAR FOURTH DECIDUOUS PREMOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. ____	205
FIGURE 4.121: SCATTERPLOT OF CROWN LENGTH X POSTERIOR CUSP WIDTH OF MAXILLARY FOURTH DECIDUOUS PREMOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. ____	206
FIGURE 4.122: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. ____	207
FIGURE 4.123: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MAXILLARY PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	207
FIGURE 4.124: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	208
FIGURE 4.125: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MAXILLARY PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	209
FIGURE 4.126: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. ____	210
FIGURE 4.127: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MAXILLARY PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	210
FIGURE 4.128: SCATTERPLOT OF ANTERIOR CUSP X CENTRAL CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	211
FIGURE 4.129: SCATTERPLOT OF ANTERIOR CUSP X CENTRAL CUSP WIDTH OF MAXILLARY PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	212
FIGURE 4.130: RATIO BETWEEN WIDTH AND LENGTH OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE LOWER THIRD MOLARS. _____	213
FIGURE 4.131: RATIO BETWEEN WIDTH AND LENGTH OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE UPPER THIRD MOLARS. _____	213
FIGURE 4.132: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER AND BRONZE AGE CHRONOLOGY. _____	214
FIGURE 4.133: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM BRONZE AGE SITES WITH THE COMBINED BRONZE AGE SAMPLE. _____	216
FIGURE 4.134: SCATTERPLOT OF CROWN LENGTH X POSTERIOR CUSP WIDTH OF MANDIBULAR FOURTH DECIDUOUS PREMOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. MEASUREMENTS IN MM. _	220
FIGURE 4.135: SCATTERPLOT OF CROWN LENGTH X POSTERIOR CUSP WIDTH OF MAXILLARY FOURTH DECIDUOUS PREMOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. MEASUREMENTS IN MM. _	221
FIGURE 4.136: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. MEASUREMENTS IN MM. _	222
FIGURE 4.137: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MAXILLARY PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	222
FIGURE 4.138: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. MEASUREMENTS IN MM. _	223
FIGURE 4.139: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MAXILLARY PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	224

FIGURE 4.140: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	225
FIGURE 4.141: SCATTERPLOT OF CROWN LENGTH X ANTERIOR CUSP WIDTH OF MAXILLARY PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. MEASUREMENTS IN MM. _____	225
FIGURE 4.142: PHOTOGRAPH COMPARING A 'NORMAL'-LOOKING MANDIBULAR THIRD MOLAR WITH A PARTICULARLY SHORTENED SPECIMEN. SEVERAL SUCH SHORTENED THIRD MOLARS WERE RECORDED AND ARE VISIBLE NEAR THE LOWER LEFT CORNER OF THE SCATTERPLOT IN FIGURE 4.140. _____	226
FIGURE 4.143: RATIO BETWEEN WIDTH AND LENGTH OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND IRON AGE LOWER THIRD MOLARS. _____	227
FIGURE 4.144: RATIO BETWEEN WIDTH AND LENGTH OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC AND IRON AGE UPPER THIRD MOLARS. _____	227
FIGURE 4.145: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY NEOLITHIC, LATE/FINAL NEOLITHIC, COPPER, BRONZE AND IRON AGE CHRONOLOGY. _____	228
FIGURE 4.146: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM DIFFERENT IRON AGE I SITES. _____	230
FIGURE 4.147: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM DIFFERENT IRON AGE II SITES. _____	231
FIGURE 4.148: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM THREE CHRONOLOGICALLY SUCCESSIVE SAMPLES RECOVERED AT THE SITE OF LA HOYA (MIDDLE/FINAL BRONZE AGE-IRON I-IRON II). _____	232
FIGURE 4.149: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS FROM THREE CHRONOLOGICALLY SUCCESSIVE SAMPLES RECOVERED AT THE SITE OF CASTROS DE LASTRA (BRONZE AGE-IRON I-IRON II). _____	233
FIGURE 4.150: LEH PRESENCE ON EACH MANDIBULAR MOLAR THROUGH SPANISH PREHISTORY. _____	236
FIGURE 4.151: SINGLE LEH LINE PRESENCE ON EACH MANDIBULAR MOLAR DURING SPANISH PREHISTORY. _____	237
FIGURE 4.152: DOUBLE (OR MORE) LEH LINE PRESENCE ON EACH MANDIBULAR MOLAR DURING SPANISH PREHISTORY. _____	238
FIGURE 4.153: GRAPH ILLUSTRATING THE RELATIONSHIP BETWEEN BONE AND TOOTH SIZE THROUGH SPANISH PREHISTORY (CA. 10TH-1ST MILLENNIUM CAL. BC) BASED ON THE MEAN LOG RATIO VALUES OF ALL RECORDED MEASUREMENTS (EXCLUDING THE LENGTH OF SCAPULA NECK FOR POSTCRANIAL). _____	241
FIGURE 5.1: GEOPHYSICAL MAP OF CENTRAL AND WESTERN EUROPE INDICATING THE LOCATION OF ALL NON-SPANISH SITES INCLUDED IN THE ANALYSES. SEE TABLE 5.1 BELOW FOR A LIST OF THE SITES SHOWN ON THE MAP. _____	245
FIGURE 5.2: SCATTERPLOT OF HUMERUS WIDTH OF TROCHLEA X MINIMUM DIAMETER OF TROCHLEA FROM PRE-NEOLITHIC AND NEOLITHIC SAMPLES FROM SPAIN, PORTUGAL, FRANCE, ITALY AND BRITAIN. ONLY FULLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM. _____	248
FIGURE 5.3: SCATTERPLOT OF HUMERUS WIDTH OF TROCHLEA X MINIMUM DIAMETER OF TROCHLEA FROM POST-NEOLITHIC AND NEOLITHIC SAMPLES FROM SPAIN, PORTUGAL AND ITALY. ONLY FULLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM. _____	249
FIGURE 5.4: SCATTERPLOT OF CALCANEUM GREATEST LENGTH X GREATEST DEPTH FROM PRE-NEOLITHIC, NEOLITHIC AND POST-NEOLITHIC AND SAMPLES FROM SPAIN, PORTUGAL, FRANCE, ITALY AND BRITAIN. ONLY FULLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM. _____	250
FIGURE 5.5: SCATTERPLOT OF TIBIA DISTAL WIDTH X DEPTH OF THE DISTAL END FROM PRE-NEOLITHIC AND NEOLITHIC SAMPLES FROM SPAIN, FRANCE, ITALY AND BRITAIN. ONLY FULLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM. _____	251
FIGURE 5.6: SCATTERPLOT OF TIBIA DISTAL WIDTH X DEPTH OF THE DISTAL END FROM NEOLITHIC AND POST-NEOLITHIC SAMPLES FROM SPAIN, PORTUGAL AND ITALY. ONLY FULLY FUSED SPECIMENS ARE PLOTTED. MEASUREMENTS IN MM. _____	252
FIGURE 5.7: SCATTERPLOT OF ASTRAGALUS GREATEST LATERAL X GREATEST MEDIAL LENGTHS FROM PRE- NEOLITHIC, NEOLITHIC AND POST-NEOLITHIC AND SAMPLES FROM SPAIN AND BRITAIN. MEASUREMENTS IN MM. _____	253
FIGURE 5.8: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) OF SPANISH AND PORTUGUESE SPECIMENS OF PRE-NEOLITHIC, NEOLITHIC AND POST-NEOLITHIC CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE. _____	256

FIGURE 5.9: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) OF SPANISH, ITALIAN AND FRENCH SPECIMENS OF PRE-NEOLITHIC AND NEOLITHIC CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE. _____	257
FIGURE 5.10: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) OF SPANISH AND BRITISH SPECIMENS OF PRE-NEOLITHIC AND NEOLITHIC CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE. _____	260
FIGURE 5.11: LOG RATIO HISTOGRAMS COMPARING PIG POSTCRANIAL MEASUREMENTS (EXCLUDING THE LENGTH OF THE SCAPULA NECK) OF SPANISH, PORTUGUESE, ITALIAN AND BRITISH SPECIMENS OF NEOLITHIC AND POST-NEOLITHIC CHRONOLOGY. ONLY FUSED SPECIMENS ARE PLOTTED. THE DOTTED LINE REPRESENTS THE MEAN VALUE. _____	261
FIGURE 5.12: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. MEASUREMENTS IN MM. _____	263
FIGURE 5.13: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. MEASUREMENTS IN MM. _____	263
FIGURE 5.14: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT FIRST MOLAR FROM COMBINED SAMPLES OF POST-NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. THE EARLY NEOLITHIC SPANISH SAMPLE IS ALSO INCLUDED FOR COMPARATIVE PURPOSES. MEASUREMENTS IN MM. _____	264
FIGURE 5.15: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. MEASUREMENTS IN MM. _____	266
FIGURE 5.16: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. MEASUREMENTS IN MM. _____	266
FIGURE 5.17: SCATTERPLOT OF ANTERIOR X POSTERIOR CUSP WIDTH OF MANDIBULAR PERMANENT SECOND MOLAR FROM COMBINED SAMPLES OF POST-NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. THE EARLY NEOLITHIC SPANISH SAMPLE IS ALSO INCLUDED FOR COMPARATIVE PURPOSES. MEASUREMENTS IN MM. _____	267
FIGURE 5.18: SCATTERPLOT OF ANTERIOR X CENTRAL CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC, EARLY AND LATE/FINAL NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. MEASUREMENTS IN MM. _____	268
FIGURE 5.19: SCATTERPLOT OF ANTERIOR X CENTRAL CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF PRE-NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. MEASUREMENTS IN MM. _____	269
FIGURE 5.20: SCATTERPLOT OF ANTERIOR X CENTRAL CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. MEASUREMENTS IN MM. _____	269
FIGURE 5.21: SCATTERPLOT OF ANTERIOR X CENTRAL CUSP WIDTH OF MANDIBULAR PERMANENT THIRD MOLAR FROM COMBINED SAMPLES OF POST-NEOLITHIC CHRONOLOGY FROM SPAIN, PORTUGAL, ITALY AND BRITAIN. THE EARLY NEOLITHIC SPANISH SAMPLE IS ALSO INCLUDED FOR COMPARATIVE PURPOSES. MEASUREMENTS IN MM. _____	270
FIGURE 5.22: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS OF SPANISH AND PORTUGUESE SPECIMENS OF PRE-NEOLITHIC, NEOLITHIC AND POST-NEOLITHIC CHRONOLOGY. _____	273
FIGURE 5.23: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS OF SPANISH AND ITALIAN SPECIMENS OF PRE-NEOLITHIC AND NEOLITHIC CHRONOLOGY. _____	274
FIGURE 5.24: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS OF SPANISH AND BRITISH SPECIMENS OF PRE-NEOLITHIC AND NEOLITHIC CHRONOLOGY. _____	276
FIGURE 4.25: LOG RATIO HISTOGRAMS COMPARING PIG TOOTH MEASUREMENTS OF SPANISH, PORTUGUESE, ITALIAN AND BRITISH SPECIMENS OF NEOLITHIC AND POST-NEOLITHIC CHRONOLOGY. _____	277
FIGURE 5.26: GRAPH ILLUSTRATING THE RELATIONSHIP BETWEEN BONE AND TOOTH SIZE THROUGH SPANISH PREHISTORY (CA. 10TH-1ST MILLENNIUM CAL. BC) BASED ON THE MEAN LOG RATIO VALUES OF ALL RECORDED MEASUREMENTS (EXCLUDING THE LENGTH OF SCAPULA NECK FOR POSTCRANIAL). _____	279
FIGURE 5.27: GRAPH ILLUSTRATING THE RELATIONSHIP BETWEEN BONE AND TOOTH SIZE FOR THE MESOLITHIC AND THE CHALCOLITHIC PERIODS (CA. 7TH-3RD MILLENNIA CAL. BC) IN PORTUGAL, BASED ON THE MEAN LOG RATIO VALUES OF ALL RECORDED MEASUREMENTS (EXCLUDING THE LENGTH OF SCAPULA NECK FOR POSTCRANIAL). _____	280

FIGURE 5.28: GRAPH ILLUSTRATING THE RELATIONSHIP BETWEEN BONE AND TOOTH SIZE FOR THE PRE-NEOLITHIC, NEOLITHIC AND BRONZE AGE (CA. 10TH-2ND MILLENNIA CAL. BC) IN ITALY, BASED ON THE MEAN LOG RATIO VALUES OF ALL RECORDED MEASUREMENTS (EXCLUDING THE LENGTH OF SCAPULA NECK FOR POSTCRANIAL).	281
FIGURE 5.29: GRAPH ILLUSTRATING THE RELATIONSHIP BETWEEN BONE AND TOOTH SIZE FOR THE MESOLITHIC AND THE NEOLITHIC (CA. 7TH-3RD MILLENNIA CAL. BC) IN BRITAIN, BASED ON THE MEAN LOG RATIO VALUES OF ALL RECORDED MEASUREMENTS (EXCLUDING THE LENGTH OF SCAPULA NECK FOR POSTCRANIAL).	282
FIGURE 5.30: GRAPH COMPARING BONE SIZE IN SPAIN, PORTUGAL, ITALY AND BRITAIN THROUGH PREHISTORY (CA. 10TH-1ST MILLENNIUM CAL. BC) BASED ON THE MEAN LOG RATIO VALUES OF ALL RECORDED MEASUREMENTS (EXCLUDING THE LENGTH OF SCAPULA NECK).	284
FIGURE 5.31: GRAPH COMPARING TOOTH SIZE IN SPAIN, PORTUGAL, ITALY AND BRITAIN THROUGH PREHISTORY (CA. 10TH-1ST MILLENNIUM CAL. BC) BASED ON THE MEAN LOG RATIO VALUES OF ALL RECORDED MEASUREMENTS.	286
FIGURE 6.1: DEHESA WITH HIGH-DENSITY OAK FOREST.	291
FIGURE 6.2: DEHESA WITH OAK FOREST OF MEDIUM-TO-HIGH DENSITY.	292
FIGURE 6.3: DEHESA WITH LOW-DENSITY OAK FOREST	292
FIGURE 6.4: DEHESA ABANDONED FOR TWO YEARS.	294
FIGURE 6.5: A. RETINTO-ENTREPELADO, B. RETINTO-ENTREPELADO, C. LAMPIÑO, D. TORBISCAL, E. 50% IBERIAN/50% DUROC-JERSEY, F. DUROC-JERSEY.	296
FIGURE 6.6: IBERIAN PIGS WITH ALMOST STRAIGHT TAILS.	297
FIGURE 6.7: A-B. PURE IBERIAN, C-D. 50% IBERIAN/50% DUROC-JERSEY.	298
FIGURE 6.8: PURE IBERIAN FREE-RANGE PIGS KEEPING A SAFE DISTANCE AND OBSERVING AN UNFAMILIAR PERSON (AUTHOR) WALKING TOWARDS THEM.	298
FIGURE 6.9: SPECIALISED FACILITIES FOR PIGS TO BREED IN A HIGHLY CONTROLLED AND SAFE ENVIRONMENT. SOME EVEN HAVE HEATING SYSTEMS FOR THE PIGLETS (SEE ARROW IN LOWER LEFT PHOTOGRAPH).	304
FIGURE 6.10: THESE OUTDOOR SHELTERS CALLED 'CAMPING' PROVIDE A SAFE BREEDING ENVIRONMENT FOR PIGS. SOME ARE FENCED IN GROUPS (UPPER TWO PHOTOGRAPHS) AND SOME ARE FENCED INDIVIDUALLY (LOWER TWO PHOTOGRAPHS). SOME ARE EVEN PROVIDED WITH EXTRA INSULATION IN THE FORM OF STRAW (SEE UPPER RIGHT PHOTOGRAPH). IN MOST CASES, THE FLOOR IS COVERED WITH STRAW TO PROVIDE COMFORT AND WARMTH.	305
FIGURE 6.11: SEPARATE FEEDING SPOTS, INTEGRATED IN THE 'CAMPING' SYSTEM, ONLY ACCESSIBLE TO THE PIGLETS TO ACCELERATE WEANING.	306
FIGURE 6.12: PARIDERAS OR SHELTERED BREEDING SPOTS FOR PIGS (LEFT) AND THE RUINS OF THE STONE HUT OF THE PORQUERO OR PIG BREEDER (RIGHT).	306
FIGURE 6.13: STONE-BUILT PARIDERAS OR BREEDING SPOTS, POSSIBLY DATING EARLIER THAN THE 20TH CENTURY. GRANITIC BOULDERS ARE INCORPORATED IN THE STRUCTURE, SAVING USEFUL SMALLER STONES AND LABOUR.	307
FIGURE 6.14: CAMAS (BEDS) ARE PREFERABLE RESTING AND SLEEPING SPOTS FOR PIGS (LEST PHOTOGRAPH). WITH USE OVER TIME THEY BECOME DEVOID OF STONES AND VEGETATION, WITH A LAYER OF SOFT SOIL REMAINING (RIGHT PHOTOGRAPH).	310
FIGURE 6.15: EXAMPLES OF ARTIFICIAL WATER RESERVOIRS AVAILABLE TO PIGS.	311
FIGURE 6.16: NARROW CORRIDORS ARE USED TO RESTRICT THE PIG'S MOBILITY TO ALLOW INSPECTION, VACCINATION, PLACEMENT OF EAR TAGS, ETC.	312
FIGURE 6.17: EXAMPLES OF SNOUT RINGS APPLIED ON IBERIAN PIGS TO RESTRAIN THEM FROM DESTRUCTIVE SOIL LIFTING AND UPROOTING ACTIVITY.	316
FIGURE 6.18: EXAMPLE OF A MODERN LARGE-SCALE FACILITY (CELLAR) FOR HAM DRYING.	317

List of appendices

APPENDIX 1. DATABASE FIELDS AND CODES	381
APPENDIX 2. ETHNOARCHAEOLOGICAL QUESTIONNAIRE	384
APPENDIX 3. SUMMARY TABLE OF ETHNOARCHAEOLOGICAL DATA	387
APPENDIX 4. SUMMARY TABLE OF INTERVIEW WITH AECERIBER VETERINARIAN (ZAFRA, EXTREMADURA, SPAIN)	391

Chapter 1. Introduction

The interaction between pigs and humans in Spain has received insufficient attention from archaeologists and this project constitutes an attempt to shed light on this largely unexplored area. In this chapter an overview of the present knowledge on pig domestication and the evolution of this process in prehistoric Spain are presented. As with the presentation and discussion of results in chapters 3, 4, 5, 6 and 7, this issue is approached chronologically by dividing it into the origins (i.e. pre-Neolithic and Neolithic periods) and evolution (i.e. Copper, Bronze and Iron Ages) of pig domestication in prehistoric Spain. Issues involving the wild boar are also overviewed and the chapter is concluded with a list of the project's aims.

1.1 The origins of pig domestication in Spain: current knowledge, archaeological context and relevant issues

The origin of pig domestication, its timing and importance in the context of the Spanish Neolithic is the main issue addressed in this section. The results that will be presented in chapters 3, 4, 5 and 6 provide opportunities for important inferences to be drawn about how pig domestication occurred and how it contributed to the process of neolithisation in Spain. This project contributes to the discussion on pig domestication by focusing on a well-defined geographical area (i.e. modern Spain) and the relationships that evolved between humans and pigs in that area. The overall aim is to identify, describe and contribute to the understanding of these relationships.

This section includes an overview of previous relevant studies, the discussion of the role that pigs played in the wider context of neolithisation, and the presentation of a chronological and spatial overview of the pig-human relationship in Neolithic Spain. Before delving into any specific discussion on pigs, it is useful to briefly review current knowledge on the neolithisation of Spain, and the role that animal domestication played in this process.

Research on the emergence of Neolithic innovations in Spain has been characterised in the last couple of decades by the intellectual confrontation

between diffusionists, also known as migrationists, and indigenists, also known as evolutionists (Bernabeu et al 1999). As the names reveal, the former suggest the spread of a 'Neolithic package' including pottery and domesticated animals and plants, through migration (Juan-Cabanilles and Martí 2002; García 1997; Zilhão 2001, in prep.), while the latter favour explanations that involve a gradual evolution of productive economies from the Epipalaeolithic-Mesolithic substrate (Olaria 1998, 2000, 2004-2005). Research based on genetic evidence remains inconclusive and contradictory, and it has been used both to support (Bertranpetit and Cavalli-Sforza 1991) and reject (Arnaiz-Villena 2000) a spread of people with their Neolithic innovations.

The indigenist model has been challenged, on the basis of empirical data, by many researchers (e.g. Fortea and Martí 1984-1985; Zilhão 2001, 2000, 1993; Bernabeu et al 1999) and its influence is currently limited. However, there are many intermediate theories between diffusionism and indigenism (for an overview of these theories in Europe see Richards 2003 and for their impact on the history of Iberian archaeology, see Hernando 1999; Martí and Juan-Cabanilles 1997; Oliveira 2000; Rubio 1997; Zilhão in prep, 2003). For the spread of the Neolithic within the Iberian peninsula, two main models are currently employed, which were developed mainly having in mind the archaeological record of northeast Spain. The first is the 'dual model', which claims the existence of Neolithic sites alongside Mesolithic groups continuing their way of life relatively undisturbed (Bernabeu 1999, 2002; Juan-Cabanilles and Martí 2002). Similar models have also been proposed for other areas in Europe (e.g. for Denmark see Rowley-Conwy 1984). The main alternative model, which can be called 'functional', rejects dualism and suggests the existence of a single cultural tradition, which adapted its material culture and economic activities to the available opportunities in different areas (Barandiarán and Cava 1992, 2000; Molina et al 2003).

Influential researchers such as Andrew Sherratt (2007) expressed the opinion that more than one mechanism must have been responsible for the dispersal of the Neolithic lifestyle in different areas of Europe. In the case of Spain, with its broad variety of climatic, geophysical and environmental conditions, a single mechanism explaining the emergence of Neolithic innovations in all regions is

unlikely (*cf.* Barnett 2000). Undeniably, some – if not most - Neolithic characteristics must have been imported from outside the Iberian peninsula, such as the domestic forms of allochthonous species, but what remains to be resolved is how extensive and widespread the introductions were and how exactly neolithisation evolved as a process in different regions of the peninsula.

Most works focusing on the neolithisation of Spain, and the western Mediterranean in general, inform us of the appearance of Neolithic indicators in the 6th millennium cal. BC (Barnett 2000). Such indicators include domestic animals and plants, Cardial pottery, polished axes and evidence of reduced mobility. In many areas of Iberia such as Valencia and Catalonia (Bernabeu 1989; Bernabeu and Martí 1992; Bosch et al 2000), Andalusia (Acosta 1987; Navarete and Molina 1987; Socas et al 2004), central and south Portugal (Arias 1999; Zilhão 2000), the middle and upper Ebro basin (Alday 2000; Arias 1999; Baldellou 1994; Utrilla 2002) and the northern central *meseta* (Kunst and Rojo 1999; Rojo et al 2006), Neolithic indicators were present already from the early 6th millennium cal. BC. On the other hand, in the Atlantic fringe of Spain, geophysically isolated by the Cantabrian mountains to the south, Neolithic indicators cannot be found before the beginning of the 5th millennium cal. BC (Arias 1999; Zilhão 2000), and their effect on local hunter-gatherers seems to have been gradual and slow (Alday 2005; Arias et al 1999; González et al 1999).

Socioeconomic and technological changes do not seem to have taken place either simultaneously or uniformly in Spain. Based on currently available data, these changes seem to have occurred earlier and were more rapidly established in the Mediterranean area (Ribé et al 1997) than in the Atlantic fringe. The socioeconomic diversity that we encounter in Spain during the 6th and 5th millennia cal. BC points towards a complex neolithisation process, taking place at different speeds in different regions. Sites dating to the 6th and 5th millennia cal. BC show considerable diversity. It is not until the 4th and 3rd millennia cal. BC, during the Middle-Late/Final Neolithic and Copper Age, that agriculture and animal husbandry became the dominant subsistence strategy all over Spain (*cf.* Geddes 1986).

As it has been mentioned earlier, animal domestication is central to the discussion about the origins of the Neolithic (Arias 1999; Barnett 2000; Geddes 1986; Lewthwaite 1986; Price 2000). Although this is also the case in Spain (Altuna 1980; Mariezkurrena 1990; Oliveira 2000; Zilhão 2001), pigs have, so far, received limited attention. This is partly explained by the generally low numbers of pig remains excavated compared to those of other species, as well as the difficulty of morphologically or metrically distinguishing between wild and domestic forms, also due to the relatively small size of the Iberian wild boar (Albarella et al 2005).

In Spain, the appearance of domestic animals has been placed in the 6th millennium cal. BC (e.g. Ribé et al 1997). Although domestic species appear to predominate in some of the earliest Neolithic assemblages in the Iberian peninsula, such as the Cova de l'Or, Cova de les Cendres and others in Valencia and Catalonia, hunting remained an important activity in many areas, sometimes in the vicinity of communities possessing domestic animals. In the Bascocantabrian region (Altuna 1980; González et al 1999; Mariezkurrena 1990), Navarra (Mariezkurrena and Altuna 1989), Andalusia (Morales and Riquelme 2004) and possibly other regions for which we do not have sufficient faunal data, such as central Spain and Galicia, hunting continued to be a major, and in some cases exclusive, source of animal protein for humans. There is a tendency for a decrease of its importance from the 6th to the 4th millennium cal. BC, when productive economies become dominant over most of Spain (Ribé et al 1997). So far, there has been no available thematic work specifically addressing the role of pigs during this process in Spain. However, what we do have available are the published zooarchaeological site reports from across the country and few synthetic zooarchaeological works focusing on specific provinces or autonomous communities (Altuna 1980; Castaños 1986; Mariezkurrena 1990; Morales and Riquelme 2004).

The pig, in its wild form, has been present in Europe and Spain at least since the Upper Pleistocene (Altuna 1990; Ortega et al 2006; Groves 1981). In Spain in particular, there are indications suggesting that the wild boar was becoming progressively more abundant as temperatures and forests were recovering from the last glaciation (Altuna 1972; Arroyo 2004). Domestic pigs have been

identified from various Early Neolithic sites of the 6th and 5th millennia cal. BC, such as La Draga in Catalonia (Saña 2000) and Cueva de la Vaquera on the northern *meseta* (Morales and Martín 1998). Identifications of domestic pigs in pre-Neolithic times are not accepted as valid by most zooarchaeologists and this is also the case for some of the earliest Neolithic cave-sites of southern Spain (Rowley-Conwy 1995b). Some of the domestic species found in Early Neolithic levels in Spain, such as sheep, were certainly imported since their wild progenitors did not exist in the Iberian peninsula. The same cannot be assumed for pigs, since wild boars were relatively abundant immediately before and during the Neolithic period. For this reason, Altuna (1980) stated that since the wild boar was present, local domestication, or at least genetic contribution to the domestic stock, cannot be excluded. In the interpretation of the evidence presented in this project no possible scenario was excluded *a priori*.

According to the existing literature, during the course of the Neolithic the relationship between human and pig shows signs of increasing complexity. Before the Neolithic, hunting was the only regular form of interaction with pigs. In the Basque Country, parts of Navarra, Andalusia and possibly other areas of Iberia, bone assemblages dated to the Early Neolithic generally contain high percentages of wild species (Mariezkurrena 1990; Morales and Riquelme 2004). In Catalonia, a dichotomy has been observed in the reliance on hunting between cave and open-air sites. In cave sites, hunting appears to be a quite significant activity while in open-air sites there is a greater reliance on domestic species, including pigs (Saña 1998). Though later in the Neolithic wild boar hunting declined, while the importance of domestic pigs increased, this was not a sudden phenomenon (Mariezkurrena 1990).

A well-covered area with a long zooarchaeological tradition is represented by Cantabria, the Basque Country and Navarra. Jesus Altuna, who has undertaken zooarchaeological research in that area since the 1960's, studied pig remains from several prehistoric sites. In his doctoral thesis (1972) he compared the size of pre-Neolithic and Neolithic wild boar from the Bascocantabrian region with that of Neolithic central European animals and concluded that Spanish wild boar was of small to medium size. In a later work Altuna (1980), relying on the study of substantial faunal assemblages, reviewed the evolution of animal

domestication from the Neolithic to the Roman period and suggested a late and slow neolithisation of the Basque Country, fully developed only by the 4th millennium cal. BC. The main zooarchaeological argument for this view is that hunting continued to be of great economic significance through the whole Neolithic, even after the appearance of domestic livestock; only during the Eneolithic (roughly equivalent to the Copper Age) and Bronze Age a sharp decrease in hunting is observed. This was accompanied by a size decrease in pigs.

Castañós (1986), in his doctoral thesis dealing with Pleistocene and Holocene faunal assemblages from the Basque province of Vizcaya, discusses the evolution of the relationship between pigs and humans in that area. He considers all pre-Neolithic suid remains as belonging to wild animals and notes an increase in wild boar numbers after the last glaciation, especially during the Mesolithic. Using data from the extensive, multi-period site of Santimamiñe, Castañós (1984) detects the presence of domestic pigs from the Neolithic onwards, based on biometry, age and sex structure of the population. He also notes a general decrease in the size of pigs after the end of the Neolithic, a trend also identified by von den Driesch (1972) and Morales (1976) mainly for southern Spain. As it will also be discussed below, this trend combined with the general decrease in the importance of hunting, reduced mobility and greater expenditure on communal infrastructure and monuments observed after the Neolithic period (Chapman 1990), indicates a more intensive and probably sedentary pig husbandry strategy. Work carried out on pig remains from Italy, dating from Mesolithic to Bronze Age, has revealed similar patterns in the rate of domestication (Albarella et al 2006b).

The hypothesis that domestic pigs were present in Spain at some point in the Neolithic is currently considered as a certainty by the majority of researchers working on Spanish material, though there is some disagreement concerning the exact timing of such appearance (Rowley-Conwy 1995b). However, as more assemblages are studied, we become more confident that domestic pigs were indeed present in Spain since the Early Neolithic. Such occurrence has been suggested for sites dating to the 6th and 5th millennia cal. BC, such as Cueva de la Vaquera (Morales and Martín 1998), La Draga (Saña 2000), Cueva

Chaves (Castaños 2004) and a group of four southern Spanish sites studied by Boessneck and von den Driesch (1980). It does, however, remain to be clarified on what basis such assumptions have been made and how the biometrical and morphological characteristics of these pigs compare with each other. There are also many other questions that still need to be fully addressed: how did pig domestication take place and at what speed? How geographically widespread and uniform was it? Which economic strategies were associated with it and how did this process evolve? What was the role of the local wild boar?

1.2 Pig domestication in post-Neolithic prehistoric periods: current knowledge and archaeological context

The main research questions for post-Neolithic periods do not focus on whether pig domestication occurred in Spain at all – a fact regarded as unquestionable for late prehistory - but rather on how it evolved and articulated with the broader economic, social and environmental changes that occurred during the Copper, Bronze and Iron Ages.

1.2.1 Copper Age

The Copper Age (see section 2.1 for clarification of terminology) roughly spans the 3rd millennium cal. BC in Spain. It has attracted intense archaeological research interest, mainly focusing on the defining technological developments of metallurgy and the erection of megalithic monuments, while animal husbandry has been only superficially discussed. The large sites of south and southeast Spain, such as Valencina de la Concepción, Los Millares and Los Castillejos, have attracted most of the attention, while other areas of the country have been less investigated, partly because they appear to have a more modest – in terms of site size, technological developments and social complexity – archaeological record. Pig-human interactions during the Copper Age have received limited attention and an attempt is made in this section to present the currently available knowledge on this important issue within its wider zooarchaeological and archaeological context.

Despite its considerable variability, Copper Age animal husbandry in Spain exhibits definite dominance over hunting and strong indications of consolidation. This dominance of domestic over wild resources and the establishment of economic systems which integrated a variety of productive activities occurred during the previous millennium (i.e. 4th cal. BC) or even earlier in some areas such as Catalonia. The dominance of husbandry over hunting is easy to demonstrate as in the majority of assemblages the remains of domestic animals are far more abundant than those of wild animals (e.g. Altuna 1980: 27-28; Altuna and Marízkurrena 2001b: 76; Hain 1982: 18-21; Morales 1992; von den Driesch 1972: 10). In a few assemblages the majority of domestic species is only marginal, while even more rarely hunting appears to be predominant (e.g. Castaños 1986: 57-71 for the Eneolithic/Bronze Age level of Santimamiñe). The term 'consolidation' is subjective as it implies a greater degree of reliance on husbandry rather than hunting activities. There is no threshold after which we can call a domestic economy as 'consolidated' but the fact that most assemblages, across Spain, exhibit percentages of domestic remains of 75% or more suggests that animal husbandry represented a core economic activity and its implementation included long-term planning and sound knowledge. Combined with other indicators such as cereal cultivation, large numbers of pottery and communal infrastructure, the term 'economic intensification' – compared with the Early Neolithic situation – acquires a specific content and is based on a variety of lines of archaeological evidence.

Among the domestic animal species, pigs played a very important role in the life of Copper Age human communities. Despite the difficulty in attributing pig remains individually to the domestic or wild form, the fact that the species usually comprises more than 15% and sometimes up to 30-40% of the total assemblage (e.g. Altuna 1980: 27-28; Altuna and Marízkurrena 2001b: 76; Hain 1982: 18-21; Morales 1992; von den Driesch 1972: 10), suggests that domestic pigs were of great economic importance across the country. On the other hand, wild boar percentages were low though – in most cases – underestimated because the common practice has been to classify as wild only exceptionally large specimens. In some other cases, the exact percentages are obscured by the fact that suid remains are combined in the 'pig/wild boar' category.

As in the Neolithic, during the Copper Age considerable social, technological and economic variability is observed in Spain. In addition, the remarkable environmental and climatic variability across the country must also be borne in mind. The terminology employed to describe the 3rd millennium cal. BC in different areas is suggestive of the level of social complexity, technological advance and scale of economy. For example, in the highly advanced south and southeast, the period is called 'Copper Age', in the moderately advanced central Spain it is called 'Chalcolithic', while in the least advanced Atlantic façade and circum-Pyrenean areas it is called 'Eneolithic'. Certainly these terms are not direct indices of the archaeological record but they are nevertheless loosely related - among other factors - to the intensity of animal husbandry and hunting.

At a finer resolution, considerable variability emerges in the reliance on domestic pigs, sometimes even within the same region. In the Bascocantabrian region, there are assemblages of the 3rd millennium cal. BC that exhibit pig percentages below 10% (e.g. Altuna 1986: 622) and others well above 20% (e.g. Castaños 1986: 57-71). In southern Spain, Copper Age assemblages exhibit higher pig percentages (usually well above 20%) – than in the Bascocantabrian region (Hain 1982; Peters and von den Driesch 1990; Ziegler 1990). In central Spain, data are scarce but indicate intermediate percentages (around 10%) for domestic pigs (e.g. Morales 1992; Moreno and Morales 2000). On this basis it can be tentatively suggested that in southern Spain, as well as Portugal (e.g. Zambujal: von den Driesch and Boessneck 1976) there was greater reliance on pig husbandry than in the north, where cattle husbandry was gradually assuming a dominant role and red deer hunting was still contributing important quantities of meat to the human diet. Sheep/goat (mostly sheep) husbandry was also a very important activity all over Spain in the 3rd millennium cal. BC, though in terms of meat output it was rarely dominant.

There are many possible reasons for the variability in reliance on domestic pigs, the most probable of which are environmental and socioeconomic. Strictly speaking, there is no environmental reason to support any differentiation between north and south because the pig is a highly adaptable species and could thrive anywhere in Spain, as it does nowadays. However, cattle are much

more suitable in the humid north than the arid south and it is therefore possible that they were for this reason the most important livestock in the Atlantic fringe. In addition, the existence of dehesa-like oak forests in southern Spain – perhaps actively encouraged by humans - dates back to the 4th millennium cal. BC (López et al 2007) and it would undoubtedly constitute an ideal environment for the exploitation of pig herds, as it would contribute to minimize labour investment. In addition, different socioeconomic systems had been developed in different geographic areas. For instance, in the south larger sites were probably associated with more limited mobility. Though pigs do not necessarily hinder mobility (Moraza 2005), they are more likely to be kept within or around settlements rather than being subjected to extensive movements across the landscape. Moreover, the larger human population and the limited reliance on wild resources in the south may have increased the pressure for fast-growing and fast-breeding species – such as the pig – in order to satisfy the nutritional needs of human communities.

Despite pig husbandry being well established in the Copper Age, the different modalities of its practice make it an interesting subject of study and one that has been unjustifiably neglected, compared to other economic, technological and social features of Copper Age societies. This project is aiming to clarify how pig husbandry evolved in the Copper Age. The collected data will be used to address important issues such as: which were the characteristics of pig husbandry in the Copper Age? What was the relation between wild and domestic pig populations? What do biometric patterns tell us about domestic and wild pigs and their morphology? What do the sex and age structures tell us about the pig husbandry system? How was pig husbandry integrated in the socioeconomic context of the period?

1.2.2 Bronze Age

The Bronze Age (see section 2.1 for a definition) roughly covers the 2nd millennium cal. BC in Spain and is a period of increased cultural diversity which has attracted intense archaeological interest. The Argaric culture of southeast Spain is one of the most studied Bronze Age cultures of Spain and known to many researchers outside Spain. Other Bronze Age cultures include the

Cogotas culture of the *meseta* and the culture of the Motillas of the Levantine region. It is also important to keep in mind that these cultures did not span the entire Bronze Age and were not strictly contemporaneous with each other (e.g. the Argaric culture spans the Early and Middle Bronze Age, while the Cogotas belongs to the Final Bronze Age). Considerable amount of research has also been carried out in connection to the origins and variations of different Bell Beaker groups spanning from the last quarter of the 3rd millennium to the end of the 2nd millennium cal. BC (e.g. Maritime, Ciempozuelos, Salamó, Palmela, etc; for a review of the chronological scheme of Beaker groups in Iberia see Harrison 1977: 97). Despite the cultural diversity, the approach of this project towards Bronze Age pig husbandry has been to study it as a single unit due to the small size of many assemblages and the lack of a balanced representation of different cultural and chronological entities in the collected data (*cf.* Chapman 2003: 178).

Compared to the preceding Copper Age, important social, technological and economic developments occurred in the course of the Bronze Age. In order to fully understand how animal husbandry in general – and pig husbandry specifically – evolved in this period, it is necessary to briefly mention the general characteristics of the period. Among the many developments in the Bronze Age is the widespread use of copper and bronze for an array of symbolic and practical purposes, as well as the increase in the frequency of exotic or ‘expensive’ materials such as gold, silver and ivory, especially in the southeast (e.g. Chapman 1990; Chapman 2003: 139; Díaz-Andreu 1995). Material culture, settlement size and architecture are not uniform across Spain and to a certain extent the patterns of preceding periods (i.e. less complexity and delay in new developments in northern Spain) continue throughout the Bronze Age (e.g. Baldellou 1990: 42, characterises Bronze Age settlements in Aragon and the northeast as ‘semi-urban’, compared to the truly ‘urban civilisations’ that developed in other areas). Many researchers working in Iberia have identified a tendency for increased social stratification in many areas during the Bronze Age, based on indicators such as the increased frequency of individual or dual – rather than communal – burials and the differentiation of individuals within the same community reflected mainly in grave goods and architecture (e.g. Chapman 1990 and Díaz-Andreu 1995 for southeast Spain; Oliveira 2000 for

Portugal; Muñoz 2000 for the Tagus basin in the southern *meseta*; Garrido 1997 for the Madrid area). There is also an increased and widespread preoccupation with warfare, reflected both in the infrastructure (walls, careful selection of strategic locations, etc: e.g. Chapman 2008; Muñoz 2000) and abundance of war-related items such as swords, daggers, warrior-depicting *stelae*, etc (e.g. Chapman 2008; Muñoz 2000; Oliveira 2000).

Bronze Age economy exhibits some particularities, although – to a general degree – it was similar to that of the preceding Copper Age. Productive economies became consolidated all over Spain, even in the Atlantic regions where during the preceding millennium communities were economically less complex than in the south. In the Bronze Age – especially during the first half of the 2nd millennium cal. BC - there was still a tendency for greater socioeconomic complexity in the circum-Mediterranean regions and the southern *meseta*. However, animal husbandry, cereal cultivation, arboriculture and extensive use of animal secondary products were the norm across Spain despite some differences in the intensity and scale of these activities according to the characteristics – mainly environmental and cultural - of each area. Although more work is needed to provide a high-resolution climatic reconstruction of the Iberian peninsula, there are some indications that this period saw increased humidity and more homogeneous intra-annual rainfall (Chapman 1990: 110).

In terms of animal husbandry, the archaeological record of Spain supports a clear dominance of domestic over wild animals in all areas (e.g. Altuna 1980: 35-49; Castaños 1986: 29-143; Chapman 1990: 118; de Miguel et al 1992; Iborra 2004: 379; Manhart et al 2001; Pérez 1987), with very few exceptions of sites where wild animals still played a major – though never dominant – economic role. The importance of pig husbandry in the Bronze Age varied but it very rarely assumed a primary role. Pigs played an important but usually secondary role to that of cattle (in northern Spain and mountainous areas) or sheep/goat (in southern Spain and lowland areas). As for the Copper Age, no zooarchaeological review of the role of pigs in the Spanish Bronze Age is available. Beyond the general importance of pig husbandry in the Bronze Age and the general conclusion – already confirmed by many colleagues – that pig

husbandry played a more important role than wild boar hunting, many issues await to be addressed with the data collected for the current project. What do patterns in the biometry, sex and age structure of Bronze Age pig populations tell us about the style of husbandry? Were there any interactions between humans and wild boar or between wild boar and domestic pigs? Were there any changes in the style of pig husbandry from Copper to Bronze Age? How was pig husbandry integrated in the socioeconomic context of the period? How does the morphology of Bronze Age pigs compare with preceding periods?

1.2.3 Iron Age

The Iron Age or roughly the 1st millennium cal. BC constitutes the last phase of the prehistoric era, and is also known as 'protohistory' in Spain. It ends with the Roman conquest of Hispania that began at the end of the 3rd century BC and was completed within the next two centuries. The Iron Age saw important social, cultural, economic and technological developments and considerable cultural variability all over Spain. It is a relatively well known period because many major sites from across Spain have been extensively excavated. Most discussions on Iron Age Spain have revolved around the different cultural entities or 'tribes', invasions of different peoples (mainly Celtic tribes which eventually became 'Celtiberian'), the establishment of colonies (Greek and Phoenician) in areas on - or near - the Mediterranean coast, as well as the Tartessian culture mainly located in Andalusia and Extremadura. Most of the zooarchaeological data collected for this project derive from the northern regions of the peninsula (northern *meseta*, Cantabria, Basque Country and Navarra) and hence the approach in the study of the data cannot be on the basis of comparing different regions of Iberia. Since Iron Age pig husbandry in Spain has never specifically been studied beyond the analysis of individual sites, the approach adopted in this work is to establish its characteristics on a more general – rather than regional – scale. Before presenting specific aims for this period it would be useful to briefly review its general archaeological context.

General information about Iron Age Spain is available in several publications, such as: Muñoz (2003) for the Tagus basin; Urbina (1997) for the southern *meseta*; Romero and Ramírez (1996) for the northern *meseta*; Alvarez-Sanchís

(1997, 2000) for the western part of the *meseta*; Llanos (1990, 1997), and Olaetxea (1990) for the Basque Country and Navarra; Castiella (1995) for Navarra; Belarte (2008) for Catalonia; Baldellou (1990) for Aragon; Grau (2003) for eastern Iberia.

Towards the end of the Bronze Age major changes are highlighted by many lines of archaeological evidence. As the name of the period implies, the defining characteristic of the Iron Age was the introduction of iron technology in Spain and the profound effects it had on agriculture, trade, warfare and many other aspects of human life. However, the importance of iron metallurgy should not be overstated as it did not occur simultaneously and with the same intensity across Spain. Many more developments took place, which induced significant changes in the social and economic relations within and between human communities.

The widespread introduction of the wheel in important activities such as transportation – through its use on carts (Muñoz 2000: 250) – and the production of ceramics helped increase the scale of agricultural production, encouraged trade and in general played the role of a catalyst for a variety of developments. In many areas there are strong indications that horsemanship was of high social significance (e.g. Almagro-Gorbea and Torres 1999) and this may be taken as an indication for yet another differentiating social factor between individuals, but also of the widespread use of horses as means of transport and an instrument of warfare. There are also direct indications for economic intensification during the Iron Age in the form of: iron tools used in various activities (such as ploughing: Muñoz 2000: 250), introduction of new species of domestic animals (such as the donkey and the chicken: Morales et al 1995), rotation between cereal and legume cultivation (thus reducing even further the need for mobility and promoting land tenure: e.g. Ruiz-Gálvez 1998), grape cultivation and wine production (e.g. Alonso 2008), as well as other indirect indications pointing towards economic intensification. The importance of agriculture and animal husbandry varied from region to region, mainly dictated by the local conditions (soils, altitude, climate and hydrology). Valley bottoms and plains had the most agricultural potential, while highlands (such as most of central Spain) were mostly exploited by herds of domestic animals. It is not the purpose of this project to provide an exhaustive account of the economic and

social context in Iron Age Spain but to present the current knowledge on pig husbandry during that period and what we could aim for in order to improve that knowledge.

As with the previous prehistoric periods, specific knowledge on pig husbandry is limited. The main reason, in my opinion, has been the tacit assumption that after an animal species has been domesticated, the most important change that it can be subjected to is the fluctuation of its economic and perhaps cultural importance in a given society. However, numerous site-focused – and fewer regional - zooarchaeological reports have been produced in Spain, without which this project would not have been possible. In the Basco-cantabrian region, many sites of the 1st millennium cal. BC have been studied by Altuna, Mariezkurrena and Castaños, amongst others. Their work has produced a *corpus* of literature that documents well animal husbandry systems – but also interactions with wild species - in many sites of that region. In general, the economic dominance of domestic over wild animals is overwhelming (e.g. Altuna 1980: 28), though in some sites hunting still played a small role (e.g. La Hoya: Altuna and Mariezkurrena 1990). In most cases, the domestic pig is the second – after cattle - most important species in terms of meat supply in both Iron Age sub-periods (I and II) (Altuna and Mariezkurrena 1990; Mariezkurrena 1990). Castaños (1986: 256) in a comparison between sheep/goat and pig percentages (calculated as a percentage of the total of number of remains belonging to domestic species) from more than 60 Iberian Iron Age assemblages showed quite high percentages for sheep/goat (52% against 12.7% for the pig). In the same comparison, a slight but steady increase in pig percentages is noticeable after the dramatic reduction in its importance after the Neolithic period (i.e. 46% for the Neolithic, 9.8% for the Eneolithic, 11.6% for the Bronze and 12.7% for the Iron Age). These comparisons are crude as they lump together assemblages from different environmental and cultural contexts but they are valid in confirming the diachronically high – though rarely primary - economic importance of domestic pigs across Iberia.

The pattern described above for the Basco-cantabrian region (Altuna and Mariezkurrena 1990) has some similarities to that recorded in some sites of the 'Soto' culture of the northern *meseta* (e.g. Soto de Medinilla: Liesau 1998; Era

Alta: Morales and Liesau 1993; La Mota: Liesau and Morales 1994) but also further north in Asturias (e.g. Campa Tores: Liesau and García 2002). In the Bascocantabrian region, cattle played a pivotal economic role, with sheep/goat and pigs being the second and third most important taxa respectively. Pig generally represented more than 10% of the domestic fauna. Like in the rest of the country, the horse was well represented, contributing to more than 10% of the assemblage at Soto de Medinilla. The data from Soto de Medinilla indicate intensification in animal husbandry and a reduction in the importance of hunting from Iron Age I to Iron Age II.

During this project few Iron Age assemblages from other regions of the Iberian peninsula were accessed and recorded. However, in the literature there are indications that the differences with the patterns described for northern Spain were slight. In Catalonia the situation is similar (e.g. Casellas et al 2002; Valenzuela 2008), while in the Valencian Country there are indications for lower percentages of cattle and higher of pigs and sheep/goat, as well as higher percentages of wild species (Iborra 2004). In southern areas of the peninsula, there are some indications of roughly similar patterns to those in the Atlantic regions and Catalonia, perhaps with lower importance of cattle husbandry (e.g. Morales et al 1994; Moreno 1999).

This project is aiming at addressing, within the dynamic context of Iron Age Iberia, a variety of issues related to pig husbandry, and to a lesser degree wild boar hunting. The Iron Age, being chronologically situated at the end of the prehistoric sequence of this study, automatically assumes additional importance, being somehow similar to the pre-Neolithic assemblages. In the same way that the pre-Neolithic sample has the potential to be used as a baseline by representing a purely wild population, Iron Age assemblages can be employed as a baseline indicating how different aspects (biometry, sex and age structure and other attributes) of domestic pigs evolved under the influence of various human-induced pressures over several millennia. Hence, beyond the questions asked for the Copper and Bronze Age periods, Iron Age data can be used as a baseline of clearly and overwhelmingly domestic populations, in comparison with earlier periods, in which the domestic morphology, sex and age data are less obviously 'domestic'. Specific questions to be addressed by

this project with the use of the recorded Iron Age data are: were there any changes in the importance of pig husbandry and wild boar hunting during this period? Did any changes occur in pig husbandry between subphases of the Iron Age? How does pig husbandry compare with preceding periods? Can the economic intensification suggested by other lines of archaeological evidence, be reflected in the style of Iron Age pig husbandry? How does postcranial and dental size compare diachronically and what do possible changes tell us about the pig-human relationship? Was there an introduction of new morphological types of pigs during the Iron Age migrations to and within Iberia? With the analysis of Iron Age data, what does the origins and evolution of pig husbandry tell us about the domestication process itself? How did domestic and wild pig populations interact diachronically? How was pig husbandry affected by hunting and *vice versa*?

1.3 Eurasian wild boar: the ancestor of the domestic pig

Any study focusing on pig domestication and its evolution in Spain would be incomplete without the inclusion of the wild form of this animal in Europe, i.e. the Eurasian wild boar. It has been repeatedly hinted already in the sections above that pig domestication is interwoven with the relationships between humans and wild boar, as well as between wild boar and domestic pig populations. Even though in biological terms wild boar and domestic pigs belong to the same genetic pool, the nature of their interactions creates opportunities for zooarchaeologists to shed light on human behaviour in the past. Hence, some basic prior knowledge on the wild boar is of high relevance to the aims of this project.

The Eurasian wild boar (*Sus scrofa*) belongs to the order *Artiodactyla* in the family of *Suidae*. Though a certain level of disagreement remains – as it is usually the case with any taxonomic/evolutionary scheme - comprehensive accounts of the evolutionary history of *Suidae* and the current phylogeny of *Sus* sp. and *Sus scrofa* are provided by Kuşatman (1991: 24-31), Porter (1993: 1-9) and Groves (2007).

A multitude of studies on the Eurasian wild boar have been carried out so far. Almost every aspect of a wild boar's existence has been studied by specialists of all kinds (zoologists, taxonomists, veterinarians, geneticists, game specialists, agricultural scientists, epidemiologists, just to name a few). Despite lacking an archaeological perspective, such studies constitute an extensive and valuable *corpus* of information relatively easily available for zooarchaeologists to use. The integration of those disciplines with zooarchaeology unfortunately remains poor. In this study, wherever possible, relevant information is used to improve archaeological interpretations.

There is considerable taxonomical confusion concerning the nomenclature, biogeography and history of wild boar subspecies in the Iberian peninsula. Currently, the most commonly mentioned subspecies in Spain are two. *Sus scrofa castilianus* (ubiquitous over most Spain, larger-sized, with denser coat of lighter colour) and *Sus scrofa baeticus* (distributed in the southern more arid regions of Spain, smaller-sized, with lower density and darker-coloured coat). The previously mentioned 'dual' scheme is mostly used within Spain (e.g. confirmed by the author for the wild boar specimens of the National Museum of Natural Sciences in Madrid). However, based on Groves' scheme on the subspecies of *Sus scrofa* (2007: 22-24), *S. s. castilianus* cannot be considered different from *Sus scrofa scrofa* (i.e. the common wild pig of western and central Europe), while *S. s. baeticus* is similar or same with *Sus scrofa meridionalis*. Pig breeders in southwest Iberia have mentioned that there are currently two populations of wild boar, the local (presumably *S. s. castilianus* or *S. s. scrofa* of Groves' scheme) and animals imported recently from Germany, which are much larger and hence more likely to attract 'customers' for the growing game 'industry' in that area. In the future, studies focusing on the level of interaction and resulting morphology of those wild boar populations would also be of zooarchaeological interest. The resolution we have today on ancient suid populations is too crude to identify wild boar subspecies. This is unlikely to change very soon but ancient phylogeography within Iberia would be an exciting and potentially feasible field of study in the future.

This introduction is not meant to be exhaustive on modern Iberian wild boar populations and hence only examples of studies will be briefly mentioned here.

A wealth of information is available in the literature on many aspects of wild boar in Iberia. Some examples are:

- Population structure and dynamics (e.g. Fernández-Llario and Mateos-Quesada 2003; Fernández-Llario et al 2003; Markina 2002; Markina et al 2004; Rossell 1988; Sáez-Royuela 1987; Sáez-Royuela and Tellería 1985)
- Reproduction and ecology (e.g. Markina 2002; Sáez-Royuela 1987; Santos et al 2006)
- Morphology and physiology (e.g. Markina et al 2004; Monzón and Bento 2004; Rossell 1988; Sáez-Royuela 1987)
- Diet and habitat/economic effects (e.g. Fernández-Llario et al 2003; Herrero et al 2004, 2006; Markina 2002; Rossell 1988; Sáez-Royuela 1987; Santos et al 2006)
- Effects of hunting (e.g. Fernández-Llario and Mateos-Quesada 2003; Fernández-Llario et al 2003; Markina 2002; Monzón and Bento 2004; Rossell 1988)
- Genetics (e.g. Alves et al 2003)

One way or another, all European domestic pigs (including the Iberian breeds) modern or those of the past, derive from the Eurasian wild boar (Zeuner 1963: 256). It has been mentioned in previous sections that the domestic pig in the past has been poorly studied for a variety of reasons. The level of our knowledge on past wild boar populations, especially in Iberia, is even poorer for the same reasons (mainly scarcity of data and difficulty of morphological/metrical distinction). This is a limiting factor in the interpretative potential of new data but at the same time it constitutes a gap in our knowledge that needs to be addressed.

Methodological studies, with an archaeological perspective, focusing on wild boar were published in the last few decades, though their number remains low. Bull and Payne (1982, 1988) conducted pioneering studies on the age, sex and biometry of controlled samples of wild boar in Turkey, which still constitute a cornerstone for the archaeological study of wild boar. Others, such as Kratochvil (1973) on phalanges, Mayer et al (1998) on molar size, and Mainland et al (2007) on cross-sectional geometry and histomorphometry, have added

methodological tools that have been applied to a greater or lesser extent on suid bones to tell wild boar remains apart from those of domestic pigs. Rowley-Conwy et al (in press) and Albarella et al (2006a) provide a comprehensive – though not exhaustive - overview of available methods to the study of suid remains, thus making it unnecessary to expand more and list here each and every study relevant to the topic.

Studies focusing solely - or at least primarily - on the Eurasian wild boar and its study with an archaeological approach are very few. Albarella et al 2009 have recently carried out a study on the wild boar. Mainly through biometric analyses they have reached valuable conclusions such as the detection of size fluctuations through time and the identification of size increase along a south-north and a west-east cline in Europe. Beyond the few specific studies such as that of Albarella et al, every zooarchaeological work on any faunal assemblage in Europe is most likely to contain references to this animal. This constitutes a proof of its diachronic ubiquity and importance for human societies. More relevant to the topic of this thesis are the works of Albarella et al for Portugal (2005) and Italy (2006b). In those studies, based on biometric data a size increase in wild boar size has been suggested for post-Neolithic periods in Portugal (Chalcolithic) and Italy (Bronze Age). It would be interesting to examine this suggestion in the present study with the use of biometric data from Spain. Moreover, this project has the potential to contribute to the completion of some of the many gaps in the history of human-wild boar relationship in Europe.

1.4 Detection and study of pig domestication in the European context: current knowledge

Arguably, of the four main animal species of the 'Neolithic package' (i.e. sheep, goat, cattle, and pig), pigs have attracted the least attention so far. The most common reason is methodological and related to the difficulty of distinguishing the domestic from the wild form of a species that was so abundant across Europe. The wild form of cattle (i.e. aurochs) was also ubiquitous in Europe but the – in most cases - greater biometric difference between the wild and domestic form since the early stages of neolithisation has rendered the distinction of domestic cattle rather easier than for pigs. However, this gap in

our knowledge has started to be addressed in recent years (Albarella et al 2006a; Kuşatman 1991; Rowley-Conwy et al in press). Recently, more regional studies have been conducted and, apart from contributing to our understanding of pig domestication, they are also informative in terms of methodological approaches and research questions.

In Italy, extensive work has been carried out by Albarella and colleagues in order to define the status of Neolithic and later prehistoric pig populations (Albarella et al 2006b). In contrast to many previous studies but in continuation with Payne and Bull (1988), they approached the issue of separating domestic pigs from wild boar at a population level, rather than trying to identify every single specimen. The most significant advantage of this approach is that it allows a shift of attention from size thresholds, which have been frequently employed in earlier studies, to a more dynamic view of pig morphology. Their study was nevertheless still based primarily on biometry. Extensive biometric analyses on dental and postcranial measurements showed that Neolithic pigs in Italy were generally of similar size to their pre-Neolithic counterparts, but there were signs of incipient domestication in the form of gradual and slow size reduction. Only towards the end of the Neolithic period, clearly smaller pigs, which therefore can be more confidently attributed to the domestic form, have been detected in the zooarchaeological record. Local domestication for Italy has also been supported by genetic data (Larson et al 2007). Although the wild or domestic status of pigs at each Italian site and the exact chronology of the appearance of domestic pigs are still debateable, Albarella et al's study has successfully raised our awareness of the complexity of regional issues, which are chronologically and geographically relevant to the subject of this thesis.

Work along the same lines has been carried out in Portugal, focusing on the important Chalcolithic sites of Zambujal and Leceia (Albarella et al 2005). In the abundant suid remains, a clear majority of domestic pigs has been identified at Zambujal by an earlier study (von den Driesch and Boessneck 1976), in which their great importance for the inhabitants of the site was acknowledged. However, subsequent work (Albarella et al 2005) touched upon new issues of the pig-human relationship at Zambujal and Leceia, such as the relative importance of wild boar hunting vs. pig husbandry, differences in the style of

husbandry between sites, the effect of environmental factors, chronological patterns, etc. The biometric exploration proved useful in resolving some of these issues and improved our knowledge on all questions addressed. For example, the biometrical analyses showed that more wild boars were hunted in Zambujal than Leceia. This is also reflected in the older mortality curve of the former site. The majority of domestic pigs in Chalcolithic Portugal were found to be of similar size, but slight differences in the style of husbandry are possible within the same region (e.g. more frequent wild/domestic interbreeding suggested for Zambujal than Leceia). The current project adopts many of those methodological tools and interpretative approaches, as well as the use biometrical data from these two and other Portuguese sites in order to address similar issues in neighbouring Spain.

In another relevant study, Albarella et al (2006c) have applied a biometric-based approach on Sardinian and Corsican suid remains in order to address the complex issue of the origins and history of this species on those islands. Though this issue is further complicated by the insular environment, a flexible approach on an array of biometric measurements and shape indices (e.g. one combining the crown length and width of the third molar) has proved fruitful in supporting the hypothesis that today's populations considered 'wild' on those islands are likely to derive from early domestic animals that turned feral. The effects of island dwarfism were found to be profound and ongoing on both 'wild' and domestic pig populations of the islands. Beyond the plain biometric measurements and shape indices, other approaches from that study are adopted in the analysis of Spanish pigs in the present study, such as the combined analysis of dental and postcranial sizes and comparisons between pig populations from different geographic areas and chronological periods.

Kuşatman's (1991) work focused mainly on the Near East rather than Europe and addressed a variety of issues revolving around the origins and context of pig domestication in that area. Her approach was along the same lines as Payne and Bull (1988) and Albarella et al (2006b, 2006c). Biometrical measurements are not used indiscriminately, but rather in combination with the main factors that affect them, such as age and sex and environment. With this toolset, Kuşatman tentatively identified biometrically distinguishable domestic

pigs in the southeastern Taurus area dating to the end of the 8th millennium, a suggestion that gained further support by later studies (e.g. Ervynck et al 2001; Hongo and Meadow 1998, 2000). Although the geographical, environmental and archaeological context of Kuşatman's study differs from that of the present study, the approach as such was proved productive. Hence many elements of her approach as well as the process of interpretation are adopted in this work on Spanish pigs.

Numerous studies on pigs were carried out also in non-Mediterranean areas. An example that is particularly relevant to the present work is briefly outlined below. The study has been conducted by Rowley-Conwy (1995b) and he investigated the first domestic pigs and cattle in the south Scandinavian and Iberian peninsulas. Rowley-Conwy argues against the presence of domestic animals in late Mesolithic and some early Neolithic contexts in both areas, mainly by using the biometrical patterns of different anatomical elements. His study was successful in raising our awareness concerning how multi-faceted is the issue of detecting domestic pigs. The use of biometry should be carefully applied and each measurement should be interpreted according to its specific qualities. Moreover, despite focusing on biometry, other tools and lines of evidence such as statistical analyses and species composition as well as careful integration in the general archaeological context should be considered. The present work pays attention to all these issues raised by Rowley-Conwy's study.

Beyond the selection of relevant zooarchaeological studies on wild boar and domestic pigs presented above, the implementation of genetic studies has produced useful insights into pig domestication and wild boar phylogeny in Europe in the last decade. One of the most important genetic studies focusing on pigs is that conducted by Larson et al (2007). This study not only provides a useful review of previous genetic studies on pigs but also discusses pig phylogeny in most parts of the world, both in terms of wild suid species as well as the appearance and evolution of domestic pigs. Some of the conclusions include crucial information for zooarchaeologists, such as the finding that wild boar retains a strong phylogenetic signal despite the extensive interactions with humans. This study also confirmed that pigs have been domesticated multiple

times in many areas of the world (as already suggested before, e.g. Giuffra et al 2000). Future genetic and zooarchaeological research is most likely to reveal even more evidence in support of multiple events.

In the Iberian peninsula, genetic studies on pig and wild boar DNA were carried out with interesting outcomes such as the conclusion reached by Alves et al (2003) that the Iberian wild boar and traditional pig breeds are of European origin and no detectable introgression of Asian mtDNA had occurred. Genetic studies still have a lot of ground to cover (such as the exploration of male lineages) but have the potential to help shedding light on crucial zooarchaeological questions. Despite the need for better integration with zooarchaeological evidence in future studies, this new field has already yielded many useful results that not only increase our resolution on the genetic affinities of different ancient pig populations but also raise an array of issues for zooarchaeologists to explore (e.g. the extent of genetic admixture between imported and local animals and the style of husbandry practiced in each region).

This review of studies focusing exclusively – or mainly – on the detection of the origins or evolution of pig domestication was not meant to be exhaustive. It focused on most of the major studies of the last twenty years that are relevant to or influence the present study on Spanish pigs. The methodological and interpretative approaches and knowledge of the above-mentioned studies permeate this work. Their combination with a large volume of original data from Spain and neighbouring countries is expected to help zooarchaeology advance our knowledge on the origins and evolution of pig domestication.

1.5 Summary and aims

In the previous sections of this chapter a brief overview of the current knowledge on pig domestication was presented. Different issues have been reviewed mainly with methodological (see more in chapter 2) and archaeological perspectives. Several facets of the relationships between domestic pig and humans, wild boar and humans, as well as domestic pig and wild boar have been briefly discussed in order to present the available methodological tools and knowledge, but also to expose the gaps in our current

understanding. Since this study is geographically focused on Spain, the archaeological and zooarchaeological context per period was also presented. At the end of each subsection presenting the different chronological periods, several issues that this study is aiming to address were put forward. However, for enhanced clarity and coherence, the aims are mentioned again here in a more structured manner. First the general aims are presented. These are followed by a summary of the more specific aims employed to address the general ones.

General aims:

- 1) Detection of the appearance of domestic pigs in prehistoric Spain
- 2) Assessment of the scale, level of intensity and uniformity of early pig husbandry in Neolithic Spain
- 3) Study of the evolution of pig husbandry in post-Neolithic periods (Copper-Bronze-Iron Ages)
- 4) Evaluation of the importance of wild boar hunting through the entire prehistoric sequence (i.e. pre-Neolithic-Iron Age)
- 5) Comparison of the origins and evolution of pig domestication in Spain with other relevant countries

Specific research aims:

- 1) Reconstruction and study of the biometry of pigs (domestic or wild), from pre-Neolithic periods to the Iron Age
- 2) Reconstruction and study of age/sex structures of pig populations (domestic or wild), from pre-Neolithic periods to the Iron Age
- 3) Correlation between age and sex structures per period and evaluation of their effects on biometry
- 4) Evaluation of the level of physiological stress experienced by pigs in different periods
- 5) Exploration of the biometric relationship between postcranial and dental size and discussion of its fluctuations through time
- 6) Evaluation and integration of the relationship between epiphyseal fusion and tooth eruption and wear
- 7) Detection of possible introductions or local development of new morphological types of pigs
- 8) Biometrical comparison of Spanish pre-Neolithic wild boar with Portuguese, Italian and British counterparts

- 9) Biometrical comparison of Spanish Neolithic pigs with their counterparts from other relevant countries (Portugal, France, Italy, Britain)
- 10) Comparison of post-Neolithic biometric data from Spain and other countries, where available
- 11) Assessment of domestic/wild percentages in assemblages in different chronological periods
- 12) Discussion of the social importance of wild boar hunting
- 13) Integration of pig husbandry and wild boar hunting with other economic activities and environmental processes (natural or anthropogenic)
- 14) Ethnoarchaeological study of modern pig husbandry in southwest Iberia and evaluation of the (zoo)archaeological potential of findings (see chapter 6 for a self-contained study)
- 15) Integration of ethnoarchaeological findings with zooarchaeological data (see chapter 6 for a self-contained study)

Chapter 2. Materials and methods

2.1 Archaeological material

All material analysed for this project derives from archaeological sites in Spain and consists of pig remains accumulated as a consequence of human activity – generally hunting or husbandry with consequent slaughtering, butchering, consumption and finally deposition. The list of recorded assemblages can be viewed in table 2.1. The analysed assemblages derive from different geographic and climatic zones, and a wide range of chronological periods (i.e. from the Palaeolithic to the Iron Age). The availability and accessibility of archaeological materials was, however, such that the geographical and chronological distribution is inevitably uneven. Although this creates a bias in the results, it is not necessarily detrimental to their validity, as biases and gaps in the information can be taken into consideration at interpretation stage. Despite these gaps in the geographic coverage, the three main environmental and climatic regions of Spain are all represented in the dataset. As can be seen in table 2.1 and figure 2.1, sites from southern Spain, the central *meseta*, and the Atlantic coast are all represented in the recorded material. The Canary and Balearic islands were excluded from this project, not only because of practical difficulties but also because islands tend to have their own environmental, climatic, biological and cultural characteristics, which are not easily comparable with continental areas. Portugal has also been excluded, even though in prehistoric times the political separation between the two countries of the Iberian peninsula was meaningless. However, available data collected by colleagues from Portuguese sites – but also Italian, French and British sites - have also been analysed and compared with the Spanish data (see chapter 6 for biometric comparisons between different European countries).

The chronological periods listed in table 2.1 are used throughout this study and are most commonly used in the regions where each site is located. These were also the terms used in the main publications of each site (in table 2.1 priority is given to zooarchaeological publications; the list is by no means exhaustive of the available literature for each site). The terminology employed to describe chronological

periods in different areas of Spain is diverse and this inevitably causes some confusion. In general, this study does not aim to produce a new unified chronological scheme. Such an undertaking is not only outside the scope of the project but it would be of little help in exploring a process such as pig domestication. However, it is still necessary to maintain a general sense of absolute time throughout the presentation and discussion of the results produced by this study. The main classification adopted in this thesis can be summarised as follows:

- **Pre-Neolithic** (includes late Pleistocene periods such as Palaeolithic, Mousterian, Magdalenian, and early Holocene periods such as Epipalaeolithic and Mesolithic): roughly earlier than 6th millennium cal. BC
- **Early Neolithic**: 6th to mid-4th millennium cal. BC
- **Late/Final Neolithic** (Middle Neolithic is a term not so commonly used in Spanish archaeology): mid to end of 4th millennium cal. BC.
- **Copper Age** (also known as 'Chalcolithic' in central Spain and Portugal, and 'Eneolithic' in northern Spain): 3rd millennium cal. BC.
- **Bronze Age** (includes the Argaric sites in southeast Spain which can be attributed to the Early and partly the Middle Bronze Age): 2nd millennium cal. BC.
- **Iron Age** (includes the two sub-periods of 'Iron Age I' and 'Iron Age II', as well as the contemporary 'Tartessian' sites of southwest Spain): 1st millennium cal. BC until the Roman conquest of Hispania.

Table 2.1: Overview of recorded assemblages and number of recorded postcranial bones (pc) and teeth (t). Sites are listed in chronological order.

	Site	Chronology	Location	N of entries	Reference
1	Cueva del Castillo	Mousterian	Cantabria	1(t)	Klein and Cruz-Urbe (1994)
2	Cueva del Mazo	Palaeolithic	Cantabria	1(t)	Limited information in: Azcuénaga (1976)
3	Cueva de Covalanas	Palaeolithic	Cantabria	1(t)	No publication available
4	Cueva del Pendo	Magdalenian	Cantabria	1(t)	Fuentes (1980)
5	Cueva del Otero	Magdalenian	Cantabria	2(pc), 8(t)	Madariaga de la Campa (1966)
6	Cueva de Zatoia	Advanced Magdalenian- Epipalaeolithic	Navarra	47(pc), 65(t)	Mariezkurrena and Altuna (1989) Altuna and Mariezkurrena (2001a)
7	Cueva de Cubío Redondo	Mesolithic	Cantabria	2(pc),3(t)	Castaños (2001)
8	Abrigo de la Peña	Epipalaeolithic and Late Neolithic	Navarra	14(pc), 14(t)	Castaños (1991-1992)
9	Aizpea	Mesolithic	Navarra	36(pc), 2(t)	Castaños (2002)
10	Cueva Chaves	Early Neolithic	Huesca	344(pc), 227(t)	Castaños (2004)
11	Cova Fosca	Early Neolithic	Castellón	54(pc), 31(t)	Llorente (2007)
12	La Draga	Early Neolithic	Catalonia	84(pc), 55(t)	Saña (2000)
13	Sant Pau del Camp	Early Neolithic	Catalonia	12(pc), 20(t)	Colominas et al (2008)
14	Cueva de la Vaquera	Early-Final Neolithic	Segovia	83(pc), 20(t)	Morales and Martín (1998)
15	Cueva del Moro	Neolithic-Bronze Age	Huesca	35(pc), 14(t)	Castaños (1991)
16	Los Castillejos	Neolithic-Copper Age	Granada	164(pc), 109(t)	Ziegler (1990)
17	La Renke	Late Neolithic-Chalcolithic	Álava	9(pc), 20(t)	Altuna and Mariezkurrena (2001b)
18	Los Barruecos	Final Neolithic	Cádiz	3(pc), 9(t)	Morales (2006)
19	Cueva de Abauntz	Chalcolithic	Navarra	25(pc), 20(t)	Altuna and Mariezkurrena (1982) Blasco (1995-1996)
20	Los Husos I	Eneolithic	Álava	15(pc), 36(t)	Altuna (1980) Apellániz (1974)
21	Las Pozas	Chalcolithic	Zamora	23(pc), 19(t)	Morales (1992)
22	Los Millares	Copper Age	Almeria	292 (pc), 71(t)	Peters and von den Driesch (1990)

Table 2.1 continued

	Site	Chronology	Location	N of entries	Reference
23	Valencina de la Concepción	Copper Age (around 2100 cal. BC.)	Sevilla	2117(pc), 473(t)	Hain (1982)
24	Fuente Álamo	Bronze Age 'Argar A' (1850 cal. BC)	Almeria	25(pc), 12(t)	von den Driesch et al (1985)
25	Cerro de la Encina	Bronze Age, including 'Argaric' period	Granada	156(pc), 65(t)	Friesch (1987)
26	Monte Aguilar	Middle-Late Bronze Age	Navarra	105(pc), 63(t)	Sesma (2007) Sesma and García (1994)
27	Acequión	Bronze Age (2000-1500 cal. BC)	Albacete	148(pc), 72(t)	Liesau et al (1995)
28	Morra de Quintanar	Bronze Age	Albacete	88(pc), 43(t)	Morales (1984) and Morales (1991)
29	Cueva Rubia	Copper and Bronze Age	Palencia	7(pc), 15(t)	Morales et al (1992)
30	Bastida de Totana	Bronze Age (1675-1100 cal. BC)	Murcia	37(pc), 18(t)	de Miguel et al (1992)
31	El Castillar de Mendavia	Final Bronze-Iron Age I	Navarra	12(pc), 34(t)	Mariezkurrena (1984, 1986)
32	La Hoya	Middle Bronze-Iron II	Álava	893(pc), 820(t)	Altuna and Mariezkurrena (1990)
33	Castros de Lastra	Middle Bronze-Iron II	Álava	284(pc), 495(t)	Sáenz de Urturi (2000)
34	Las Rabas	Iron Age II	Cantabria	65(pc), 45(t)	García and Rincón (1970) Vega et al (1986)
35	Castro de Berbeia	Iron Age-Roman	Álava	23(pc), 53(t)	Altuna (1978)
36	Cerro de la Cruz	Iron Age	Navarra	17(pc), 157(t)	Bataller (1952, 1953)
37	Castillo de Henayo	Final Bronze-Iron Age I	Álava	70(pc), 147(t)	Altuna (1975)
38	Peñas de Oro	Iron Age-Roman	Álava	127(pc), 146(t)	Altuna (1965)
39	Campa Torres	Iron Age (7th-6th centuries BC)	Asturias	56(pc), 66(t)	Liesau and García (2002, 2005)
40	Soto de Medinilla	Iron Age I-II	Valladolid	163(pc), 160(t)	Liesau and Morales (1993), Liesau (1998) Morales and Liesau (1994)
41	Santa Ana	Iron Age	Logroño	15(pc), 39(t)	de Miguel and Morales (1983, 1986) Morales (1977)
42	Calle Puerto 10	Iron Age ('Tartessian')	Huelva	44(pc), 28(t)	Morales et al (1994)
43	La Mota	Transition Iron Age I-II	Valladolid	68(pc), 95(t)	Liesau and Morales (1994) Morales et al (1993)
				Total: 4908 (pc) 3082 (t)	

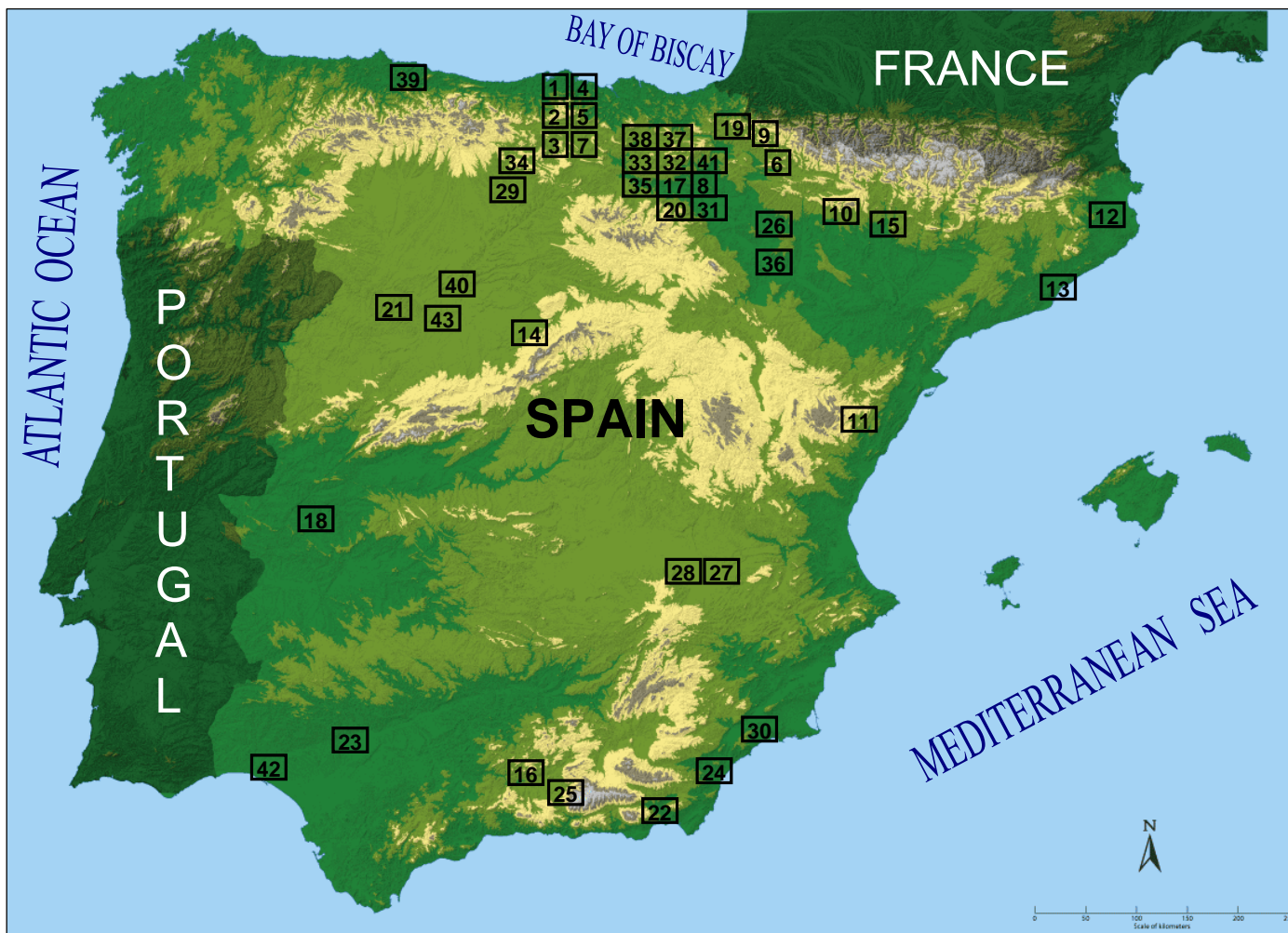


Figure 2.1: Map of Spain indicating the location of all sites analysed in this project.

All assemblages have been studied in museums and universities located mainly in Spain, but also Germany. Assemblages from the southern Spanish provinces of Sevilla, Granada and Almeria were stored at the University of Munich, since they had been studied there in the 80's and 90's. The assemblages recorded in Spain were stored at the provincial archaeological museums of the province where each site belongs (see table 2.1). The vast majority of faunal remains analysed as part of this project had been washed, studied and published by colleagues in the past. However, all material has been re-examined and re-identified and, when appropriate, measured and their age and sex data re-estimated. The aim of this doctoral project is not a full re-analysis of these assemblages but rather the collection of selected metrical, age and sex data. The collection of data by the same researcher and the application of the same recording protocol to different assemblages guarantee a high level of consistency in the recording, and of comparability between sites.

2.1.1 Identification

For this project, 4908 postcranial and 3082 dental pig remains were identified and recorded. The bone atlas of Schmid (1972) has represented a general identification tool. Additionally, wherever possible, modern pig skeletons – domestic and wild - were used as reference. Since this project dealt only with one species (in its wild and domesticated form), identification rarely constituted a problem. The protocol used for recording information from pig bones and teeth follows a system based on that outlined by Davis (1992) and Albarella and Davis (1996) with some modifications relevant to the present project. This system is based on the identification and recording only of specific zones of teeth and bones. These elements and their zones are listed below (see Appendix 1 for codes):

Postcranial bones

- Atlas (at least half)
- Scapula (when neck is measurable)
- Humerus (proximal and distal, at least half of an epiphysis)
- Radius (proximal and distal, at least half of an epiphysis)

- Metacarpal III and IV (at least half of the epiphysis; the proximal end must also be present for the purpose of identification)
- Phalanges 1 and 2 (proximal end, at least half of the epiphysis)
- Pelvis (ischial part of the acetabulum)
- Femur (proximal and distal, at least half of an epiphysis)
- Tibia (proximal and distal, at least half of an epiphysis)
- Metatarsal III and IV (at least half of the epiphysis; the proximal end must also be present for the purpose of identification)
- Astragalus (at least half)
- Calcaneum (sustentaculum present)

For quantification purposes, only the distal ends of long bones are used. However, the proximal ends are also recorded as 'others' in order to be used for ageing and – in the case of the femur - metrical purposes.

Teeth (with at least half of the occlusal surface present):

- Upper and lower permanent molars
- Upper and lower fourth deciduous premolars
- Upper and lower fourth permanent premolars
- Upper and lower canines

The teeth listed above are recorded as either loose or jaws. Jaws are defined by the occurrence of at least one tooth plus at least half adjacent tooth/alveolus or equivalent amount of bone. No attempt is made to separate first and second molars when isolated. Since these teeth are measured, identification is possible at a latter stage, provided that size groups can be identified. Previous work has demonstrated that, although second molars are consistently larger than first molars, overlap may occur and that identification must therefore be undertaken cautiously and it is not recommended when based purely on sight (Albarella et al 2005). The identification of clearly large molars as second and clearly small molars as first would lead to a serious bias in the biometric analysis, with all smaller second molars and larger first molars – presumably assigned to a dubious intermediate group – being excluded. Instead, all isolated first and second molars

were plotted - per assemblage - with known first or second molars and if separation was sufficiently clear the isolated specimens were reassigned as first or second molars (see for example figure 2.2 for the Copper Age assemblage of Valencina de la Concepción). Canines are recorded as female, male, female alveolus or male alveolus, whenever possible.

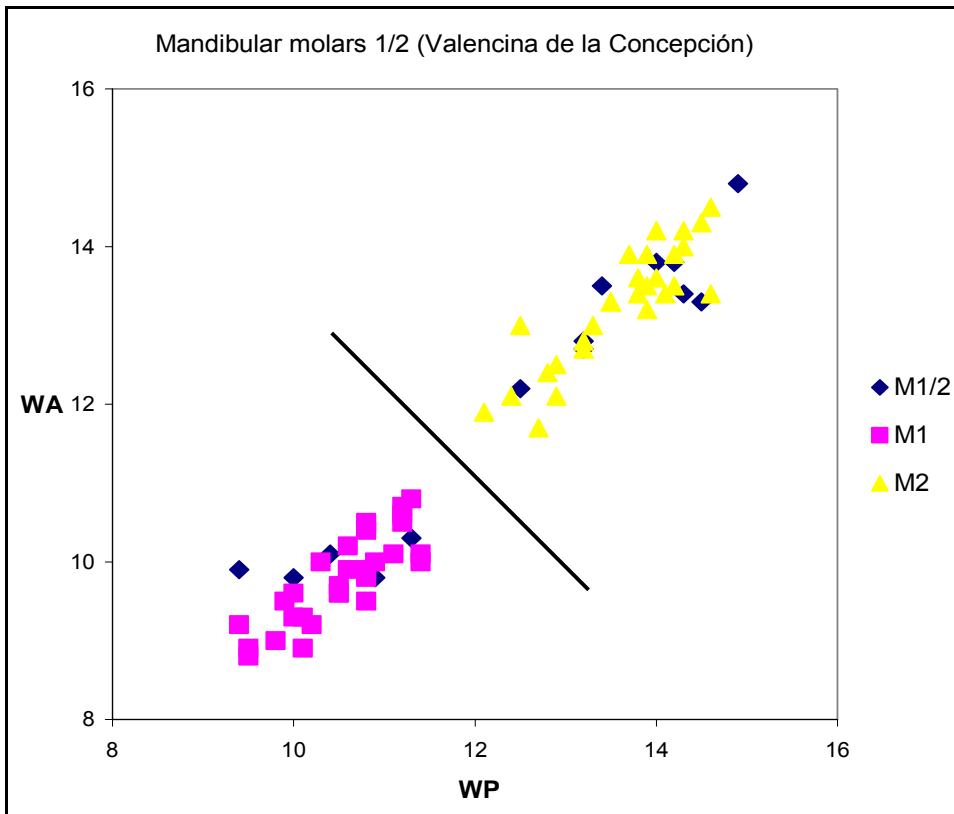


Figure 2.2: Example of how isolated molars recorded as M1/2 are safely reassigned into M1 or M2 prior to their inclusion in biometric and other analyses.

All recorded elements, both postcranial and teeth are inspected for burning marks and pathological conditions, in order to avoid biometrical biases created by these processes.

2.1.2 Ageing

2.1.2.1 Fusion

The state of fusion is recorded for both distal and proximal ends of the recorded elements (see Appendix 1 for codes). Metapodials and scapulae are recorded as

having only a distal end, while phalanges and calcanea are recorded as having only a proximal end. For bones such as atlas and pelvis, for which the proximal/distal definition is not entirely appropriate, the bone fusion is recorded, simply out convenience, as 'distal'. Since no fusion data are possible for astragali, each record includes a characterization of each specimen as 'normal', 'light' or 'porous', based on their overall external appearance and weight. An astragalus is recorded as 'light' when the bone surface has the normal (adult) appearance but it nevertheless feels lighter. 'Porous' are specimens which feel light but also have a porous, due to very young age, bone surface and are obviously underdeveloped. Even though these terms are, to a certain extent, subjective they nevertheless provide a crude, but helpful way to classify the recorded astragali. For example, only 'normal' astragali, likely to belong to adult individuals, are used in comparison to fused bones. Although we cannot rule out that such astragali could have still, to a limited extent, grown further, so is the case for fully fused bones (Payne and Bull 1988).

Epiphyses are considered as 'fused' when no open parts are present along the fusion line and 'fusing' when an opening, however small, along the fusion line is still visible.

2.1.2.2 Eruption, wear and dental defects

Eruption and wear stages are recorded using the system established by Grant (1982) and the age categories 'neonatal', 'juvenile', 'immature', 'subadult', 'adult' and 'elderly' are used *sensu* O'Connor (1988) throughout this study.

The presence of linear enamel hypoplasia (LEH) is recorded on lower permanent molars only, as: **p**=only one line is present, **pp**=more than one line is present, **'blank'**=absent. This method is essentially a simplified version of Dobney's and Ervynck's (1998, 2000) method. Teeth exhibiting wear more advanced than stage 'g' *sensu* Grant (1982) were excluded from the hypoplasia analysis, as hypoplasia lines may have been worn away with the tooth's enamel. Equally, when less than

half of the tooth crown had erupted hypoplasia data were also ignored as in these cases an insufficient part of the enamel surface was visible.

2.1.2.3 Combination of epiphyseal fusion and dental eruption/wear

The two lines of evidence on ageing, i.e. epiphyseal fusion and dental eruption/wear, are not directly comparable because of naturally occurring and environmentally influenced variation in epiphyseal fusion and dental eruption/wear of different pig populations (e.g. Hongo and Meadow 1998: 83-85). However, despite the difficulty of establishing equivalences between epiphyseal fusion and dental eruption/wear, it cannot be ignored that these processes are both related to the passage of time and the ageing of animals. During the presentation of ageing results in subsequent chapters (3 and 4), both lines of evidence are presented independently but rough comparisons and correspondences between them are explored and described. In order to somehow formalise the comparisons, table 2.2 has been produced based on the epiphyseal fusion ages published by Silver (1969, for domestic pigs), Habermehl (1975, for domestic pigs), Lesbire (1897/8, for domestic and wild pigs, cited in Bull and Payne 1982), and the dental eruption ages published by Silver (1969, for domestic pigs), Briedermann (1965, for wild boar) and Matschke (1967, for wild boar). According to Bull and Payne (1982), data based on highly improved modern pig breeds should not be used to interpret archaeological data due to their reduced relevance to the wild boar or ancient domestic breeds.

The purpose of table 2.2 is not to establish a scheme of age correspondence between epiphyseal fusion and dental eruption but rather to establish broad equivalences between the two lines of ageing evidence. Resolution in table 2.2 is inevitably and deliberately low for various reasons: 1) available information on absolute ageing for teeth is based on the eruption of the three permanent molars; 2) there is no reliable way to attribute absolute ages to wear stages; 3) the duration of the 'fusing' stage varies from bone to bone and for this reason only the timing of complete fusion has been taken into account. Despite the low resolution and the

broad character of the equivalences between epiphyseal fusion and tooth eruption, they increase our potential to compare the two lines of evidence.

Table 2.2: Rough equivalences between dental eruption and epiphyseal fusion in pigs.

Eruption time for mandibular molars in months	1-6 (M1)	7-13 (M2)	14-26 (M3)			27-41 (M3 in wear)		42+ (M3 in wear)
Mandibular age stage	Juvenile	Immature	Subadult			Adult		Elderly
Months (until fusion)	1-12		13-18	19-24	25-26	27-30	31-41	42+
Distal Humerus	Unfused			Fused				
Distal Scapula	Unfused		Fused					
Proximal Radius	Unfused		Fused					
Phalanx 2	Unfused		Fused					
Pelvis-acetabulum	Unfused		Fused					
Phalanx 1	Unfused			Fused				
Distal Tibia	Unfused			Fused				
Calcaneum	Unfused					Fused		
Metacarpus	Unfused				Fused			
Metatarsus	Unfused				Fused			
Proximal Humerus	Unfused						Fused	
Distal Radius	Unfused						Fused	
Proximal Femur	Unfused						Fused	
Distal Femur	Unfused						Fused	
Proximal Tibia	Unfused						Fused	

2.1.3 Sexing

Sex determination is exclusively based on the size and morphology of lower and upper canines and their alveoli (see Appendix 1 for codes). However, this can only be reliably determined on individuals old enough to have their permanent canines sufficiently developed and/or erupted, particularly in the case of lower canines which are still embedded in the jaw.

2.1.4 Biometry

All measurements (see tables 2.3 and 2.4; also Appendix 1 for codes) have been taken with a Mitutoyo Digmatic Caliper to the nearest tenth of a millimetre. Due to the practical difficulties of carrying larger callipers or a measuring box to institutions abroad, GL (greatest length) measurements exceeding the maximum length of the

callipers used (i.e. 150 mm) were taken by placing the specimen on a white paper sheet, lock it vertically between two straight surfaces (e.g. a side of a box) and then measure the distance between these two. Due to the crudeness of this method and the higher error associated with larger measurements, all such measurements have been rounded to the nearest millimetre.

In the analyses presented in chapters 3, 4 and 5, the emphasis is in the presentation of the biometric data. Beyond the routinely used scatterplots of different measurements, the log ratio technique has been employed in order to increase sample size and allow comparisons between assemblages (Meadow 1999). The log ratio is a size index scaling technique and it relates our measurements to the measurements of a standard individual or population (Payne and Bull 1988). Essentially it is the decimal logarithm of the ratio between the measurement and its standard. In this case, the measurements of pigs from the Neolithic site of Durrington Walls in England are used as a standard (Albarella and Payne 2005). This method is useful for increasing sample size (different measurements can be plotted on the same scale) and also to allow direct comparison of different measurements, those of teeth and bones for instance.

2.1.4.1 Measurements: postcranial bones

The measurements taken are listed in table 2.3. Measurements were taken regardless of the fusion stage of an epiphysis. Measurements of unfused bones are unsuitable to assess the size of fully grown animals, which is why they are not commonly taken by zooarchaeologists. We have nevertheless measured them because of their potential in highlighting differences in size groups (e.g. males and females; wild and domestic) culled at different age stages (see Zeder 2001). However, when the measurements are much age-related (such as scapula SLC), their size distribution, especially of unfused specimens, can also provide direct information on age structures. Additionally, by measuring elements at different fusion stages, size increase during growth can be assessed and the measurements used accordingly. 'Porous' astragali obviously belonging to very juvenile animals are not measured. The measurements follow the definitions

provided by von den Driesch (1976), Payne and Bull (1988), Albarella and Payne (2005) and Albarella et al (2005).

Table 2.3: List of postcranial measurements taken.

Anatomical Element	Measurement	Description	Reference
Atlas	H	Height	Albarella and Payne (2005)
	BFcr	Width of cranial articular surface	von den Driesch (1976)
Scapula	SLC	Width of collum	von den Driesch (1976)
Humerus	BT	Width of trochlea	Payne and Bull (1988)
	HTC	Minimum diameter of trochlea	Payne and Bull (1988)
Radius	GL	Greatest length	von den Driesch (1976)
MTC III and IV	GL	Greatest length	von den Driesch (1976)
Pelvis	LAR	Diameter of acetabulum	Payne and Bull (1988)
Femur	DCP	Depth of the caput femoris	Payne and Bull (1988)
Tibia	BdP	Distal width	Payne and Bull (1988)
	Dd	Depth of the distal end	von den Driesch (1976)
	GL	Greatest length	von den Driesch (1976)
Astragalus (excluding 'porous' specimens)	GLI	Lateral length	von den Driesch (1976)
	GLm	Medial length	von den Driesch (1976)
Calcaneum	GL	Greatest length	von den Driesch (1976)
	GD	Greatest depth	Albarella and Payne (2005)
MTT III and IV	GL	Greatest length	von den Driesch (1976)

The measurements listed above have been chosen on the basis of three main criteria:

- a)** General availability in archaeological assemblages. The elements selected to be measured, due to their robustness, have been proved to be the most resistant to breakage and loss by pre- and post-depositional processes, and thus abundant in faunal assemblages.

b) Ease with which the measurement can be defined and taken. Whenever possible we have chosen measurements that could be taken rapidly and unambiguously.

c) Adequacy in addressing the specific questions of this project. Some of the measurements are age-related while, others are only slightly, if at all, related to age or sexual dimorphism. Questions relevant to this project include the domestic/wild pig ratio and age and sex groupings in the archaeofaunas under study. Payne and Bull (1988) provide us with an important source of information concerning the behaviour of different measurements, supported by modern data from specimens of known sex and age. Consequently measurements that could ideally address these questions have been chosen.

More details are presented below. Different measurements behave differently according to age and sex and their selection has been thought thoroughly, taking into account mainly Payne and Bull's (1988) work. Below, different individual or groups of measurements are presented, accompanied by a brief comment explaining why they were selected and how their characteristics can be exploited during analysis and interpretation stages.

Scapula SLC. Sexually dimorphic but so highly age-related that this probably over-rides sex differences. It is mainly taken to be used in an attempt to identify age groups (Rowley-Conwy 2001).

Humerus BT and *HTC*. Like other forelimb measurements these are probably fairly highly sexually dimorphic measurements, but not as age-related as the more commonly taken 'Bd' (the largest width of the distal end), which was therefore excluded from our analysis. *HTC* in particular may also be taken on fairly damaged epiphyses. If sex dimorphism can be detected this should be more clearly manifested in these than any other measurements.

Pelvis LAR. Only relatively common due to the frequent erosion of the rim of the acetabulum and also the measuring points are not so obvious. Nonetheless it is a useful measurement due to its relatively low variability. It should complement

the information gained through femur DCP with which it is probably highly correlated.

Femur DCP. Easily taken and defined and only marginally age related. Probably less sex dimorphic than the humerus and consequently a good measurement to compare the size at full growth in different populations. The problem with this measurement is that – since the proximal femur is a late fusing epiphysis – sufficient numbers of measurements from fused bones are rarely available.

Tibia BdP and Dd. Little age and sex dimorphic and also common. There may be some problems in taking Bd unambiguously, particularly in old individuals, but these are some of the best measurements to assess size of the pigs at full growth. The pair also provides the opportunity to make scatter plots.

Astragalus GLI and GLm. They can generally easily and commonly be taken. As long as porous and light specimens are excluded, these measurements are not particularly age-related, despite the fact that astragalus has no epiphysis. Being on the same axis these measurements are highly correlated (Albarella and Payne 2005), but they are both taken to provide the opportunity to create scatterplots.

Calcaneum GD. Very common and very easily taken. Highly age-variable, particularly on unfused specimens, it can, however, be used productively in combination with GL.

All *GLs.* Not commonly available but they provide information about the height of the animals, while all other measurements deal with widths and depths.

Atlas H and BFcr: These measurements usually have variable frequencies in assemblages and constitute the best measurements to take from the axial part of the body. These measurements tend to show little variability and poor correlation with each other (Albarella and Payne 2005).

2.1.4.2 Measurements: teeth/mandible

The following measurements (see table 2.4) are taken for upper and lower teeth as defined in Payne and Bull (1988). M3WC and M3WP – the latter only taken on the lower tooth - are the greatest widths of the central and posterior cusps of the third molar and are taken following the same criteria as the other width measurements defined by Payne and Bull (1988). No measurements are taken if the enamel has been entirely lost. No length measurements are taken on upper and lower teeth when their wear is more advanced than stage 'Wb' (as defined in Albarella and Payne 2005) on both cusps. This level of wear is equivalent to stage 'g' as defined by Grant (1982) for lower teeth.

Table 2.4: List of maxillary and mandibular measurements taken.

Element	Measurement	Description	Reference
dP ⁴ , dP ₄	L	Crown length	Payne and Bull (1988)
	WP	Posterior cusp width	
M ¹ , M ₁	L	Crown length	Payne and Bull (1988)
	WA	Anterior cusp width	
	WP	Posterior cusp width	
M ² , M ₂	L	Crown length	Payne and Bull (1988)
	WA	Anterior cusp width	
	WP	Posterior cusp width	
M ³	L	Crown length	Payne and Bull (1988)
	WA	Anterior cusp width	Albarella et al (2005)
	WC	Central cusp width	
M ₃	L	Crown length	Payne and Bull (1988)
	WA	Anterior cusp width	
	WC	Central cusp width	Albarella et al (2005)
	WP	Posterior cusp width	
Mandible	Height	Height in front of M ₁ on buccal side	von den Driesch (1976)

As with postcranial elements, each tooth is affected, to a different degree, by sexual dimorphism and age (Payne and Bull 1988). The different size and morphology of male and female canines is by far the most reliable means of sexing

pigs. The rest of the recorded teeth (see table 2.4) are not significantly affected by sex. Especially the widths of the upper and lower deciduous premolars and molars, are very little, if at all, affected by sex or age (e.g. Kuşatman 1991; Mayer et al 1998). On the other hand, the lengths of these teeth are known to slightly decrease with the advance of age, which is why the length of very worn teeth has not been taken, as mentioned above. Age does not affect the length of teeth that are not heavily worn as the maximum length occurs near the base of the crown and therefore is not influenced by the earlier stages of wear. It has indeed been demonstrated that there is no significant age-related size decrease of tooth lengths, before wear reaches stage 'j' *sensu* Grant (1982).

2.2 Ethnoarchaeology

The ethnoarchaeological study of surviving practices relevant to the traditional management of the Iberian pig constitutes a secondary but vital component of this project. All the ethnoarchaeological data were collected during a two-week visit in April and March 2008 in southwest Spain (autonomous community of Extremadura) and adjacent Portuguese Alentejo. The methods applied for the collection of ethnoarchaeological data were semi-structured interviews and personal observations (including photographic documentation) of the pigs, the natural environment they are reared in and the infrastructure related to their management. A fixed questionnaire was used, which is a modified version of that designed by Albarella et al (2007) for their ethnoarchaeological study of traditional pig husbandry in Sardinia and Corsica. In this way, consistency in the results is ensured, as well as comparability with those of the similar study conducted in Sardinia and Corsica. Although a fixed questionnaire of 27 questions was used (see Appendix 2), the interviews are characterised as semi-structured because much additional information – beyond the scope of the fixed questionnaire but nevertheless highly relevant to pig management – emerged through casual discussions with the pig breeders or veterinarians working with the Iberian pig. Although the author is proficient in Spanish, to ensure that no information is lost due to local or individual accents, the interviews and some of the casual discussions with pig breeders were recorded - after permission – on a voice

recorder. The recorded interviews were processed at a later stage to extract all the relevant information.

Overall, 11 pig breeders were interviewed - nine in Spain and two in Portugal - with considerable help from two veterinarians working for AECERIBER (Association of Spanish breeders of the Iberian pig breed). One of the veterinarians agreed beforehand to be interviewed with the questionnaire, thus helping in providing a valuable overall view of the traditional pig breeding practices of the area, but also useful feedback on how the questionnaire was formulated and the type of information it was aiming in extracting (see Appendix 2).

The collection of ethnoarchaeological data targeted the recording of specific information on many aspects of pig husbandry, most of which are of relevance to the interpretation of archaeological faunal assemblages. These aspects mainly concern: the physical and behavioural characteristics of the Iberian pig, the practical aspects of traditional pig husbandry, and the natural, cultural and economic environment in which the Iberian pig is managed today. The results of the ethnoarchaeological component are presented and discussed in chapter 6 but are also summarised in a table in Appendix 3.

Chapter 3. Early prehistory (pre-Neolithic and Neolithic periods): investigating wild boar hunting and the onset of pig domestication

The origin of pig domestication, its timing and importance in the context of Neolithic Spain, and the evolution of the pig-human relationship, are the main general issues addressed with the results presented here. The results provide opportunities for important inferences to be made on pig domestication and how this process articulated with the overall neolithisation in Spain.

The material presented in this chapter derives from 18 archaeological sites, the distribution of which covers most of Spain (figure 3.1 and table 3.1), although the chronological coverage is geographically uneven. All assemblages were previously studied by other researchers and are fully published, with the exception of the material from the latest excavations at Cova Fosca, which is still under study at the Archaeozoology Laboratory of the Universidad Autónoma of Madrid. The pre-Neolithic is represented by 94 postcranial and 83 dental remains and the Neolithic by 680 postcranial and 441 dental remains, recorded as part of this project. In Spain Neolithic animal bone assemblages are usually small and contain few pig bones. The situation is even less favourable for the pre-Neolithic record. This makes research on the early stages of pig husbandry challenging and raises the need to investigate it in a wider chronological perspective. For this reason, pre-Neolithic and Neolithic data are also plotted and described in relation to the post-Neolithic data in the following chapter 4.

3.1 Sex Ratios

Sex ratios, estimated on the basis of the morphology of lower and upper canines and their alveoli, are for most of the studied assemblages based on samples that are too small to allow elaborate analyses. Nonetheless, those data that are available can still provide some valuable information on the nature of site occupation, hunting and husbandry strategies and the effects of sex distributions on the biometrical results.

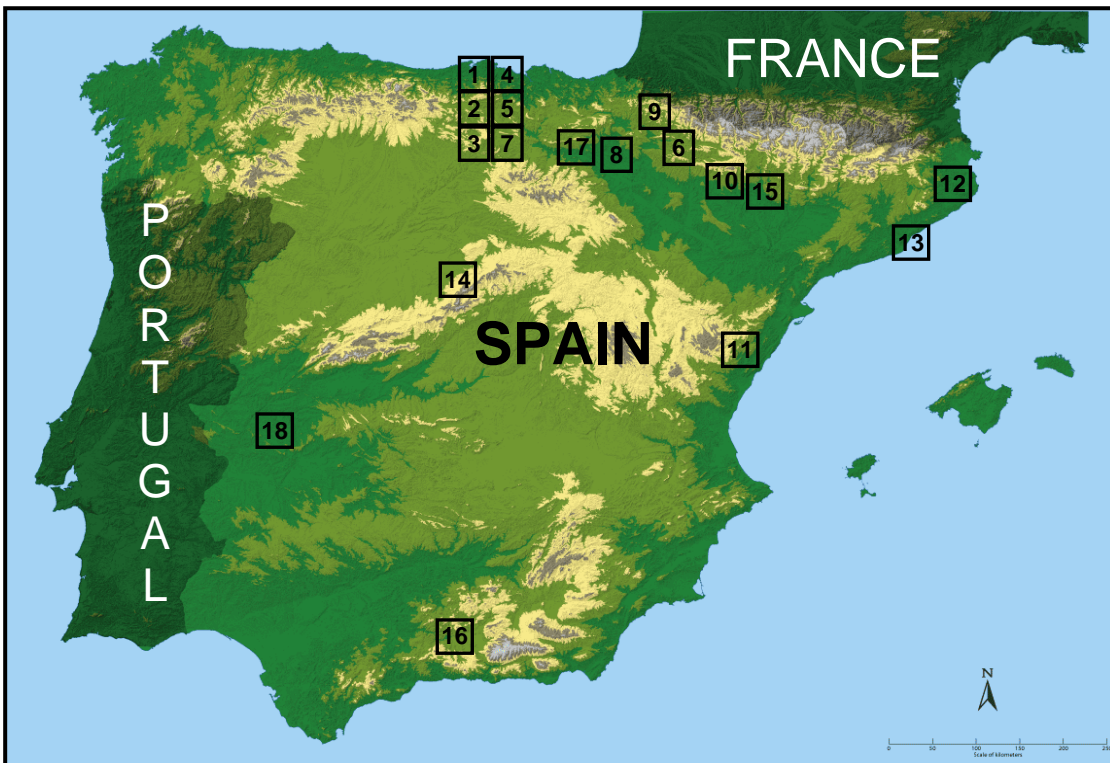


Figure 3.1: Map of Spain indicating the approximate location of analysed assemblages containing pre-Neolithic and/or Neolithic material.

Table 3.1: Overview of analysed assemblages containing pre-Neolithic and/or Neolithic material. Sites are listed in approximate chronological order.

	Site	Chronology
1	Cueva del Castillo	Musterian
2	Cueva del Mazo	Palaeolithic
3	Cueva de Covalanas	Palaeolithic
4	Cueva del Pendo	Magdalenian
5	Cueva del Otero	Magdalenian
6	Cueva de Zatoia	Advanced Magdalenian-Epipalaeolithic
7	Cueva de Cubío Redondo	Mesolithic
8	Abrigo de la Peña	Epipalaeolithic-Late Neolithic
9	Aizpea	Mesolithic
10	Cueva Chaves	Early Neolithic
11	Cova Fosca	Early Neolithic
12	La Draga	Early Neolithic
13	Sant Pau del Camp	Early Neolithic
14	Cueva de la Vaquera	Early-Final Neolithic
15	Cueva del Moro	Neolithic-Bronze Age
16	Los Castillejos	Neolithic-Copper Age
17	La Renke	Late Neolithic-Chalcolithic
18	Los Barruecos	Final Neolithic

3.1.1 Pre-Neolithic

From the pre-Neolithic, the only assemblage which provided some sexing information derives from the Advanced Magdalenian-Epipalaeolithic levels of the cave site of Zatoia. Only a small number of canines was recorded, but nonetheless the combined total of upper and lower loose male (7) and female (7) canines suggests an equal representation of the two sexes in the assemblage (figure 3.2). Since the excavated soil was sieved we can assume that these figures were not seriously affected by a recovery bias.

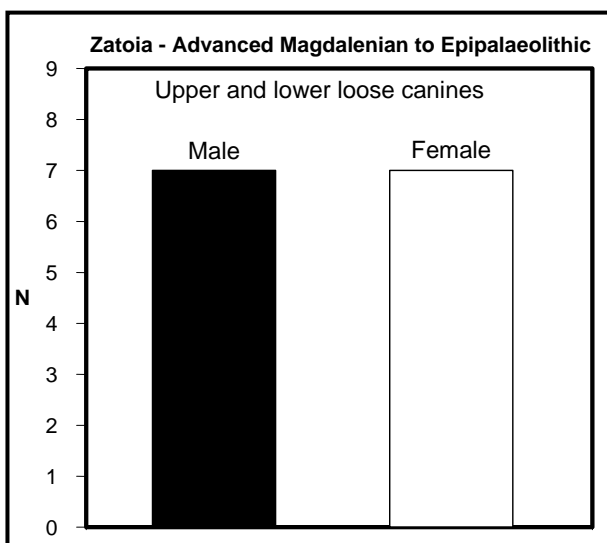


Figure 3.2: Sex ratios for Advanced Magdalenian-Epipalaeolithic Zatoia based on upper and lower loose canines.

3.1.2 Neolithic

From the Neolithic period we have substantial numbers of recorded canines only from the Early Neolithic cave site of Cueva Chaves. In the analysis, the two Early Neolithic levels, Ia and Ib, are combined because they produced almost identical results. According to these results male and female pigs are almost equally represented although a tendency for a predominance of females is apparent. The information provided by loose teeth and jaws is consistent (figure 3.3).

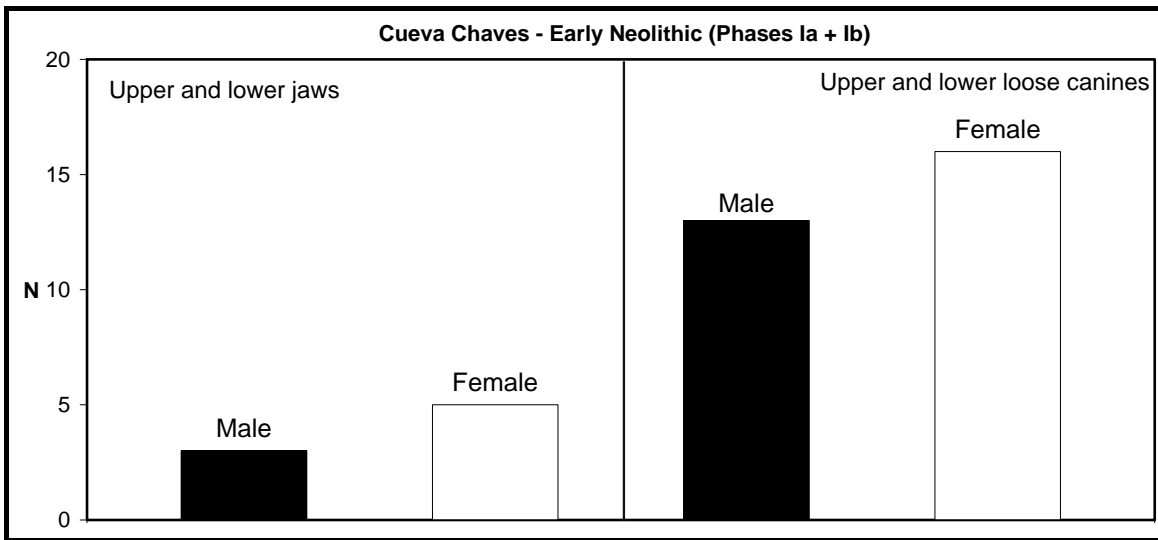


Figure 3.3: Sex ratios for Early Neolithic Cueva Chaves (combined levels Ia and Ib) based on jaws (left) and loose canines (right).

From Early Neolithic La Draga the sample of sexed canines is tiny and hence can only be taken as a crude indication of the sex structure of its pig population. A separate analysis of jaws (4 specimens) and loose teeth (8 specimens) indicates a female majority in jaws and a male majority in loose canines (figure 3.4). In general, results based on jaws are considered more reliable because they are less affected by recovery bias, although the produced results could also be affected by the small sample size. In view of the inconsistent results, the only reliable statement based on the findings is that both male and female pigs are represented at Early Neolithic La Draga.

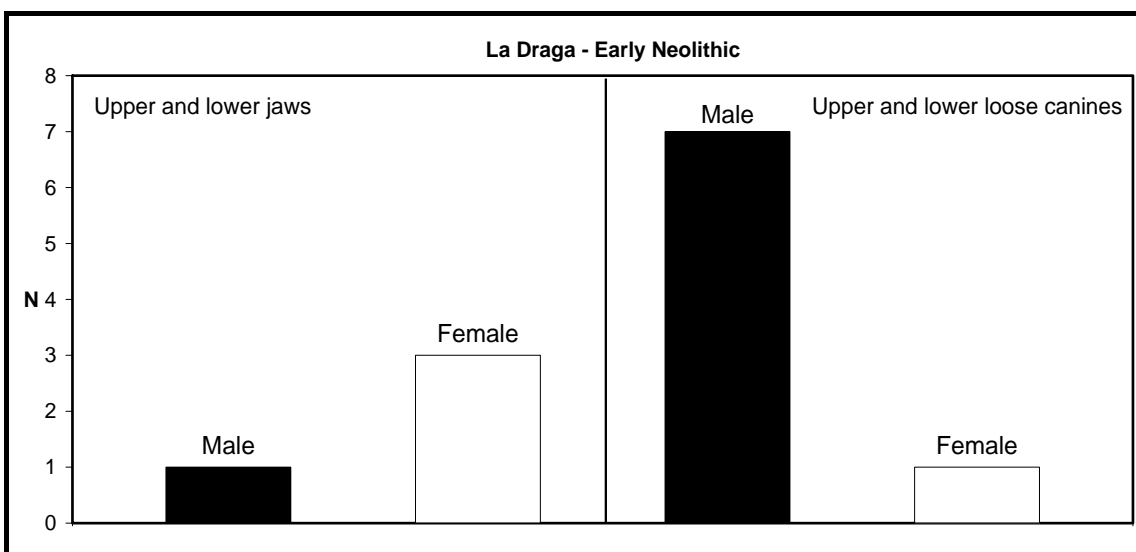


Figure 3.4: Sex ratios for Early Neolithic La Draga based on jaws (left) and loose canines (right).

Samples of sexed pig remains from the rest of the Early Neolithic assemblages are even smaller than that of La Draga. At Cova Fosca three male loose canines and one female jaw were identified, while at Cueva de la Vaquera only two male and one female loose canines and a female jaw. Exactly the same result as for Cueva de la Vaquera has been produced from the analysis of the sample from Sant Pau. Based on the results from Cova Fosca, Cueva de la Vaquera and Sant Pau, the only valid comment allowed is that both male and female individuals are represented in the analysed samples.

Information on the sex structure of pig populations from the later phases of the Neolithic period is even scarcer. The only two samples offering some information are the Late/Final Neolithic Los Castillejos and La Renke. At Los Castillejos (figure 3.5), although the sample is rather small, there is a tendency for a male majority, which appears to be consistent in both jaws and loose canines. However, this can only be taken as a crude indication of the sex structure of the population, especially because sex ratios become equal in jaw counts when the mixed sample of Final Neolithic/Early Copper (indistinguishable) chronology is added to the purely Final Neolithic sample (figure 3.6). The most likely interpretation is therefore an approximately equal number of males and females. The male predominance in Final Neolithic jaws might result from the small sample size, whereas the one in loose canines could be attributed to a recovery bias.

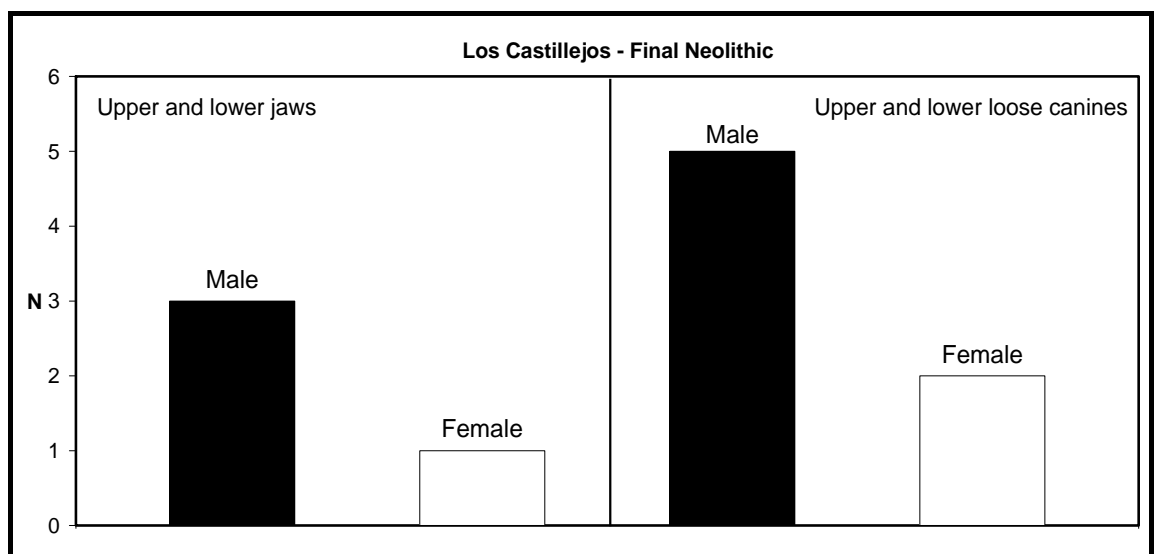


Figure 3.5: Sex ratios for Final Neolithic Los Castillejos based on jaws (left) and loose canines (right).

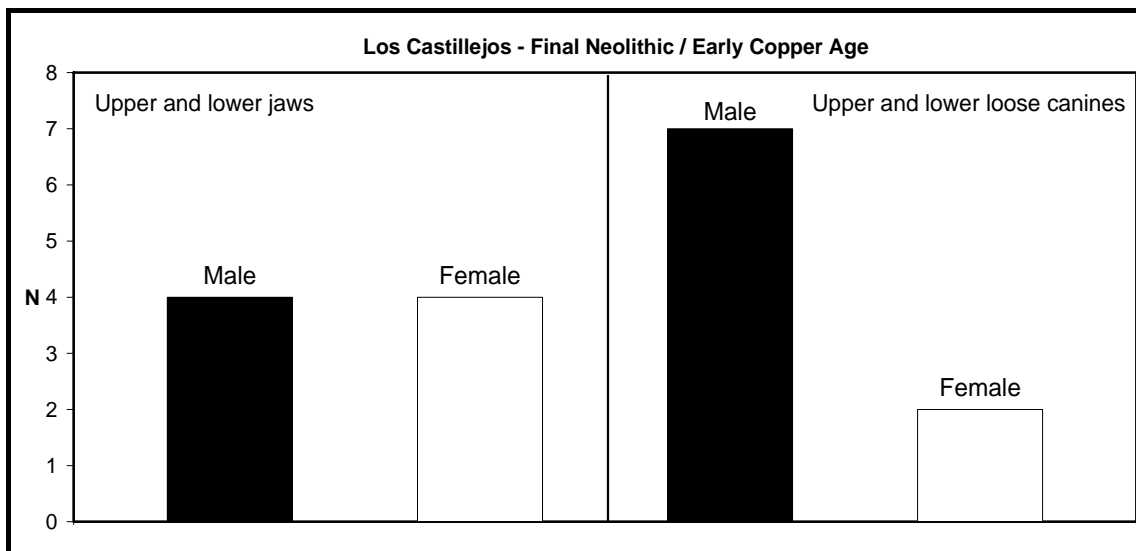


Figure 3.6: Sex ratios for Final Neolithic/Early Copper Los Castillejos based on jaws (left) and loose canines (right).

At Late/Final Neolithic La Renke only a mandibular and a maxillary loose canine were recorded, both female.

3.2 Ageing

Age-at-death data based on bone fusion as well as dental eruption and wear, were recorded for two main reasons. Firstly, to assess kill-off patterns of the pig populations and, secondly to enhance the interpretation of biometrical data as the biometry of many body parts is, to a varying extent, affected by age. In this section, both lines of evidence on ageing are presented independently but approximate comparisons and correspondences between them are also explored and described based on table 2.2 in chapter 2.

As was the case with sexing, not all studied assemblages provided sufficient ageing data for reliable analyses to be carried out. For this reason, only the assemblages which produced more abundant ageing data are presented in this section.

3.2.1 Pre-Neolithic

From the pre-Neolithic material, the Advanced Magdalenian-Epipalaeolithic sample from Zatoia constitutes the largest sample, albeit still quite small (only 31 postcranial elements). Despite the scarcity of material and the low resolution

due to the pooling of three pre-Neolithic levels, this assemblage is one of the very few available in Spain that provides some information about the age structure of pre-Neolithic pig populations.

Of the 17 early fusing elements, 16 (or 94%) are fully fused, as well as 11 (or 85%) of the 13 middle fusing elements (table 3.2). Only one – fully fused - proximal tibia was recorded from the late fusing elements. Thus, despite the sample limitations and the low resolution of this analysis, it seems reasonable to assume that pigs younger than 2 years are scarce in this assemblage.

Unfortunately, data on tooth eruption and wear do not offer much better resolution on the age structure of Zatoia's pre-Neolithic pig population. Only one mandible has been recorded and it belonged to an 'immature' individual. Also 17 loose molars and premolars were assigned to age categories and the results are presented in table 3.3. Compared to epiphyseal fusion data, tooth data reveal a younger population, of which half is culled younger than 12 months of age. This higher number of younger individuals visible in the tooth data points to the possibility that these individuals were under-represented in the postcranial elements. This might be due to a taphonomic bias as unfused bones are rather soft and prone to taphonomic destruction. Moreover, tooth data are suggesting the presence of some individuals in their third or even fourth year which were not revealed by the analysis of epiphyseal fusion, due to the presence of just one late fusing element.

Table 3.2: Age-at-death data for Advanced Magdalenian-Epipalaeolithic Zatoia based on epiphyseal fusion. P=proximal, D=distal.

Zatoia (Advanced Magdalenian – Epipalaeolithic)					
	Fused/Fusing		Unfused		Total
	N	%	N	%	
1 yr					
Atlas	1				
Scapula D			1		
Radius P	1				
2nd Phalanx	14				
Total	16	94%	1	6%	17
2-2¼ yrs					
1st Phalanx	8				
Tibia D	3				
Calcaneum P			2		
Total	11	85%	2	15%	13
3½ yrs					
Tibia P	1				
Total	1	100%	0	0%	1

Table 3.3: Age-at-death data for Advanced Magdalenian-Epipalaeolithic Zatoia based on tooth eruption and wear.

Zatoia (Advanced Magdalenian – Epipalaeolithic)							
	Neonatal	Juvenile	Immature	Subadult	Adult	Elderly	Total
Mandibles			1				1
Loose teeth		4.5	4	5	3.5		17
Total N	0	4.5	5	5	3.5		18
Total %	0%	25%	28%	28%	19%	0%	100.0%

From the remaining pre-Neolithic material, only Mesolithic Aizpea provides some, though limited ageing information. From the 8 early-fusing elements, 4 (or 50%) are fully fused, as well as 8 (or 57%) from the 14 middle fusing elements (table 3.4). Only one – unfused - proximal humerus was recorded from the late fusing elements. This sample is very small, but it hints to the possibility that a fair number of young animals were hunted.

Table 3.4: Age-at-death data for Mesolithic Aizpea based on epiphyseal fusion.

Aizpea (Mesolithic)					
	Fused/Fusing		Unfused		
1 yr	N	%	N	%	Total
Atlas	1		1		
Scapula D			1		
Humerus D	1				
Radius P	1				
2nd phalanx	1		2		
Total	4	50%	4	50%	8
2-2¼ yrs					
1st phalanx	4		4		
Tibia D			1		
Calcaneum P	4		1		
Total	8	57%	6	43%	14
3½ yrs					
Humerus P			1		
Total	0	0%	1	100%	1

3.2.2 Neolithic

With the exception of Cueva Chaves, Neolithic assemblages produced limited ageing information. In view of the current absence of other reliable comparative information, these data are valuable and are therefore fully presented in this section.

The relatively large volume of analysed epiphyseal fusion as well as tooth eruption and wear data from Early Neolithic Cueva Chaves provide us with

reliable information about the age structure of that pig population. Epiphyseal fusion data (figure 3.7) show that almost 60% of the pig population was killed before or near the first year of age. Very few pigs were killed in their second year, while another 31% was killed roughly between 25 and 41 months of age. This pattern is generally corroborated by tooth eruption and wear data (figure 3.8), which reveal two mortality peaks; the first at neonatal age (23%) and the second, most prominent one, at 'immature' age (41%). Both lines of analysis confirm high losses (60-80%) for the first 12 months and a small percentage of survivors (3-5%) beyond the third year of age.

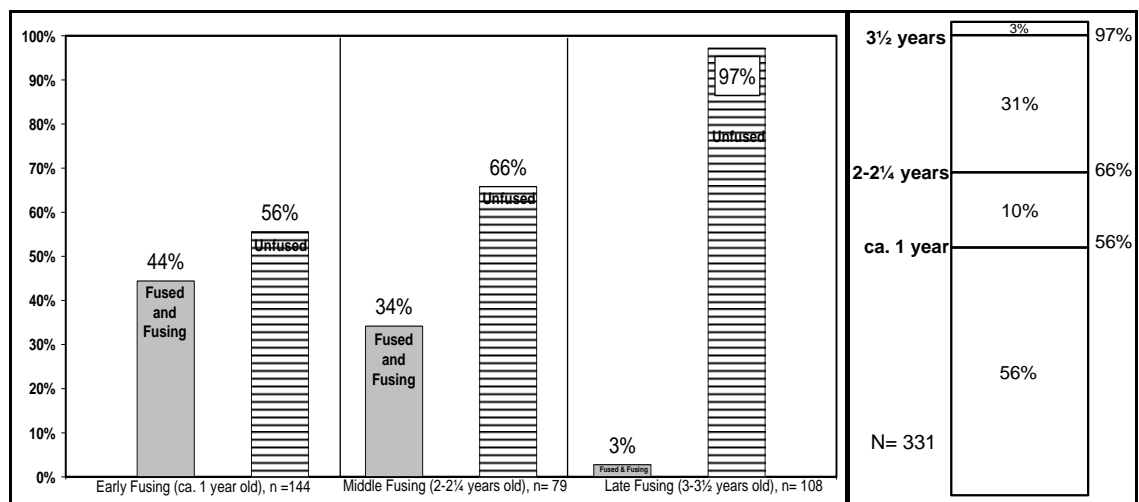


Figure 3.7: Age-at-death data for Early Neolithic Cueva Chaves based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

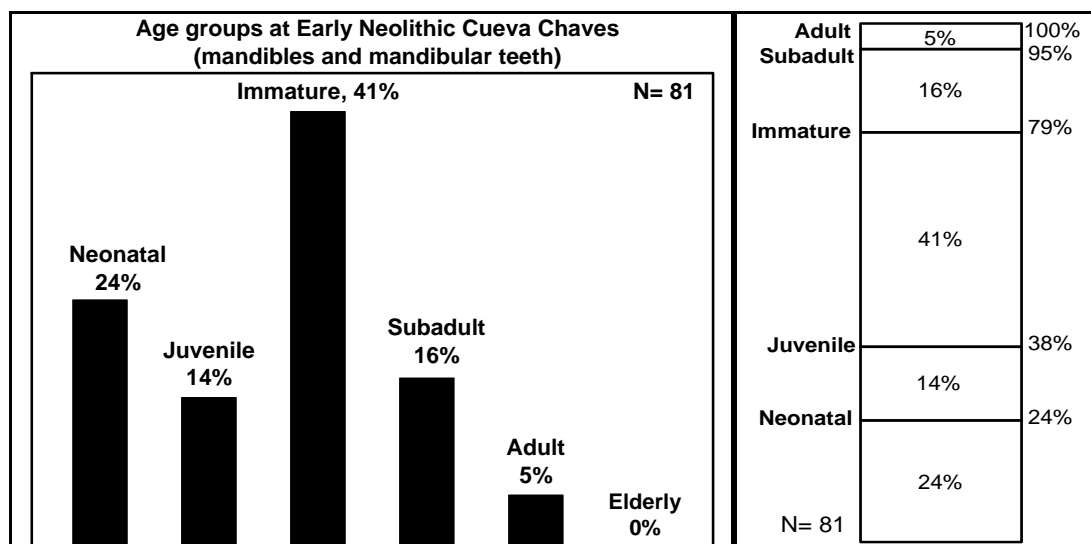


Figure 3.8: Age-at-death data for Early Neolithic Cueva Chaves based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The presence of a high percentage of unworn dP4s and very young porous postcranial bones in the assemblage is intriguing and has been investigated

further. The lengths of all the neonatal-looking, porous postcranial elements were measured and analysed according to Gjesdal's (1972) regression equations to establish whether they were foetal or 'neonatal' (table 3.5). Although Gjesdal's equations are based on hundreds of foetuses of a modern breed (the Norwegian Landrace), they still constitute a useful tool to try to estimate the age of the recorded bones. If we take into account an average gestation period of 115-120 days cited for pigs (e.g. Mauget 1972 and Vericad 1983 reported an average gestation period of 120 days while Rossell 1988 an average of 115 days), then most of the analysed specimens died around the time of birth. Although the vast majority of remains are aged as older than 115 days, there are some that are below this limit. The number of potential foetal specimens increases significantly if we use 120 days as the length of the gestation period. It is also possible that some of the greatest lengths of such young and porous bones are slightly underestimated due to erosion of the particularly porous proximal and distal ends.

Additional information on this issue is provided by the presence of 17 mandibles with dP4 at eruption stages E, H (1/2) and U (according to Ewbank et al 1964). It has been established by observations and experimental work on modern pigs (e.g. Bivin and McClure 1976; Silver 1969; Tucker and Widowski 2009), that the mandibular dP4 erupts after birth. Thus, the scenario that many, if not most, of the analysed specimens are more likely to belong to 'neonatal' piglets rather than foetuses is further supported. A possible pitfall in using zoological or veterinary literature for tooth eruption is that the term 'eruption' is defined as gingival emergence, while in zooarchaeology as emergence through the mandibular bone. Additionally, it is impossible to a) examine whether the time of eruption of a specific tooth has changed from Early Neolithic until today and b) have control over other factors that may affect the eruption of the dP4 (e.g. breed, wild/domestic status, diet, sex, etc). However, based on both the postcranial and dental ageing of these remains it can be concluded that they belong to perinatal, and more probably to 'neonatal' piglets.

Table 3.5: Estimation of days after conception based on Gjesdal's 1972 equations for all recorded young and porous tibiae, femora, humeri and radii.

Element & diaphyseal length in mm	Days after conception according to Gjesdal 1972	
	Based on dissection	Based on x-ray photos
Tibia		
46.2		125
45.4		124
46.7		126
41.6		117
41.4		116
40.4		115
41.8		117
43.3		120
42.3		118
41.9		117
41.2		116
Femur		
44.4	123	119
40	115	111
56.5	145	140
Humerus		
37.1	105	106
28.8	91	91
43.6	115	117
Radius		
31.7		120
34.6		128
29.8		115
30.1		116
29.1		113
28.6		112
31.7		120
29.7		115
34.1		126

No other Early Neolithic assemblage has provided an age dataset as large as that of Cueva Chaves. However, it is still of some value to comment on the available information from the other sites. Even if sample sizes are quite small, the general scarcity of Early Neolithic pig remains in Spain renders the presentation and description of all available data necessary.

From Early Neolithic La Draga, we have information only on early (N=30) and middle fusing (N=22) elements. These show that about 30% of the population was killed before or near the first year of age while by roughly two years of age 45% was killed (figure 3.9). The late fusing elements (N=9) show that a higher percentage survives beyond the third than the second year, an incongruous result that can probably be explained by the low reliability of the small sample size. The pattern observed for epiphyseal fusion is not entirely supported by the few aged mandibles and loose teeth, which suggest that around 90% of the

population was killed earlier than the second year (figure 3.10). Additionally, tooth eruption and wear confirm the presence of some 'neonatal' individuals in the assemblage and low percentages for the 'subadult' and 'adult' categories. The discrepancy between epiphyseal and dental data is likely to be a consequence, at least to a certain extent, of the small sample sizes and the under representation of the fragile young postcranial elements. Contextual differences are also possible, especially because further analyses with new material recovered from La Draga revealed significant differences between contexts in the estimated age structure of the pig population (Maria Saña, personal communication January 2009). If we focus on the dental evidence, kill-off pattern at La Draga is somehow similar to that of Cueva Chaves, excluding the smaller number of 'neonatal' specimens.

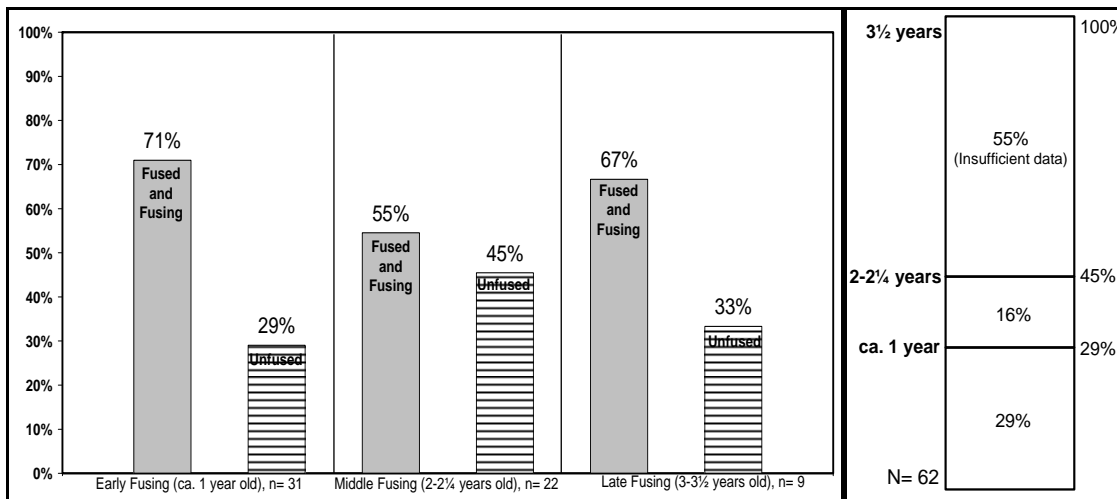


Figure 3.9: Age-at-death data for Early Neolithic La Draga based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

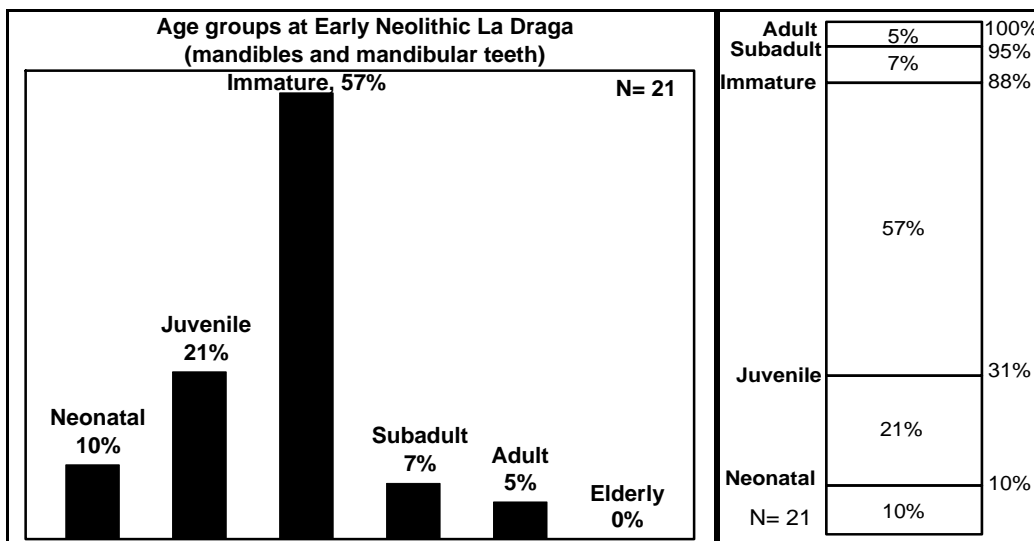


Figure 3.10: Age-at-death data for Early Neolithic La Draga based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

From Cova Fosca, information on the age structure of the Early Neolithic pig population is scarce, with only early (N=15) and middle fusing (N=17) elements offering some information. These show that about 33% of the population was killed before or near the first year of age and about 40% by roughly two years of age (figure 3.11). The few aged mandibles and loose teeth (table 3.6), generally show the presence of some 'juvenile', 'immature' and 'subadult' individuals with a tendency for a majority in the first two age categories. In general, none of the two lines of ageing evidence can be taken at face value due to the small size of the analysed samples. The only reliable observation is that there was high mortality in the first and low mortality in the second year.

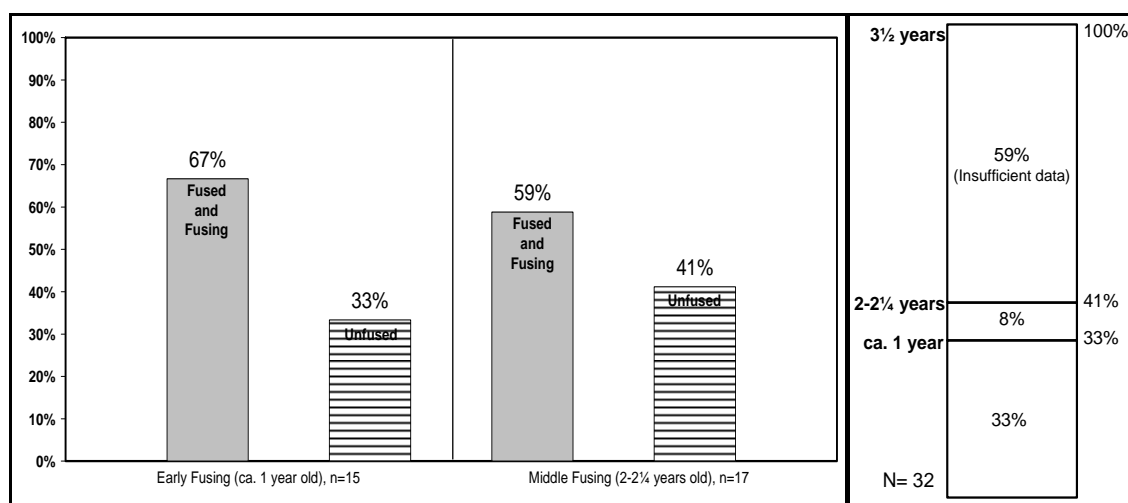


Figure 3.11: Age-at-death data for Early Neolithic Cova Fosca based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Table 3.6: Age-at-death data for Early Neolithic Cova Fosca based on tooth eruption and wear.

Cova Fosca (Early Neolithic)							
	Neonatal	Juvenile	Immature	Subadult	Adult	Elderly	Total
Mandibles			0.5	0.5			1
Loose teeth		3	2.5	0.5			6
Total N	0	3	3	1	0	0	7
Total %	0%	43%	43%	14%	0%	0%	100%

Early Neolithic Cueva de la Vaquera yielded a small amount of epiphyseal fusion data and even fewer dental eruption and wear data. Epiphyseal fusion data (figure 3.12) suggest that a high percentage (42%) was killed around or before the first year of age, while 88% of the population was killed by the beginning of the third year. Although ageing information on late fusing elements is even less reliable due to a small sample size (N=7), all such elements are unfused, thus being in line with the general tendency for high mortality rates in

the first two years of life. In contrast to the epiphyseal fusion, the few ageable mandibles and teeth (table 3.7) indicate the presence of some 'adult' and 'subadult' individuals. Despite this discrepancy, both lines of evidence agree on high mortality during the second and possibly third year, as well as 25-45% mortality in the first year.

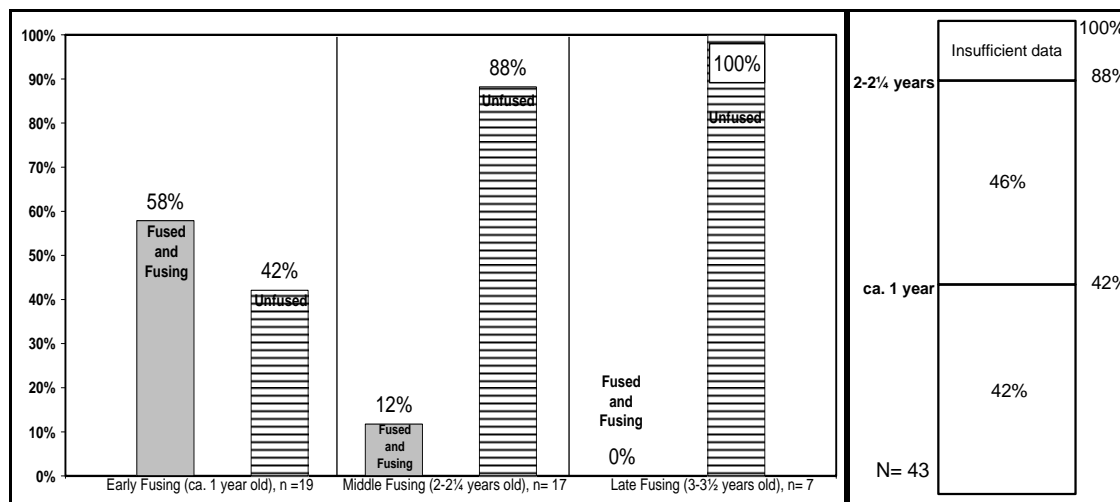


Figure 3.12: Age-at-death data for Early Neolithic Cueva de la Vaquera based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Table 3.7: Age-at-death data for Early Neolithic Cueva de la Vaquera based on tooth eruption and wear.

Cueva de la Vaquera (Early Neolithic)							
	Neonatal	Juvenile	Immature	Subadult	Adult	Elderly	Total
Mandibles		1		0.5	2.5		4
Loose teeth			1	1.5	1.5		4
Total N	0	1	1	2	4		8
Total %	0%	13%	13%	25%	50%	0%	100%

Very little material dating to the later phases of the Neolithic has been recorded and thus information on the age structure of pig populations in this period is rather limited. The largest, combined, sample available is that of Middle-Final Neolithic Los Castillejos. Epiphyseal fusion data (figure 3.13) indicate a particularly high (55%) mortality rate during the first year, which is drastically reduced (6%) in the second year. Too few late fusing elements are available to provide reliable information about the next age group, but some individuals older than 3.5 years are present. Tooth data (figure 3.14) suggest high mortality (64%) during the first year of life, another significant peak during the second year and a striking absence of 'adults'. The two lines of ageing evidence combined, despite the small size of the samples, generally agree on high mortality during the first 1-1.5 year of age (including some 'neonatal')

individuals), another slaughtering peak prior to adulthood, and possibly low percentages of ‘adults’. This pattern is similar to that identified for some Early Neolithic assemblages, such as Cueva Chaves and La Draga, especially because of the presence of neonates and mortality above 60% during the first year.

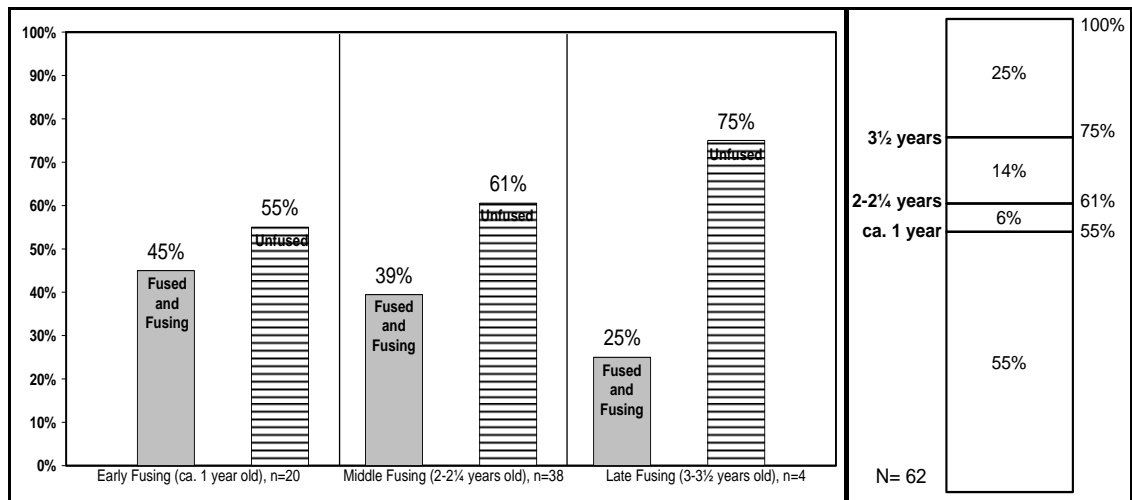


Figure 3.13: Age-at-death data for Middle-Final Neolithic Los Castillejos based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

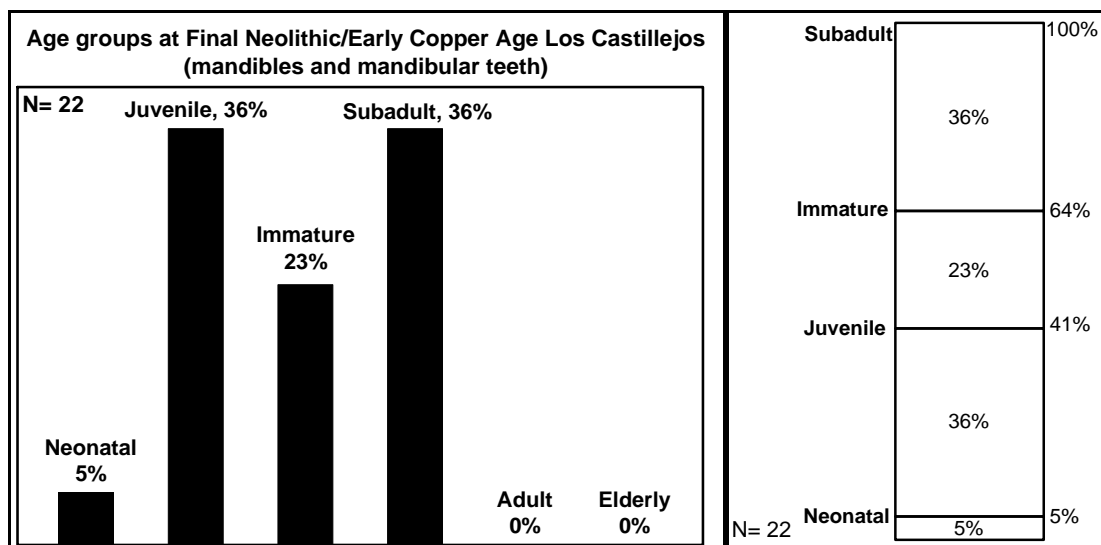


Figure 3.14: Age-at-death data for Middle-Final Neolithic Los Castillejos based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The Late Neolithic assemblage of La Renke has produced only six ageable postcranial elements, three of which are early fusing (all fused or fusing) and three middle fusing (1 fusing and 2 unfused). Eruption and wear data are also limited, with most ageable mandibles and loose teeth belonging to ‘adult’ and ‘subadult’ animals (table 3.8). The only provisional comment that can be made is that a considerable percentage of animals survived their first year.

Table 3.8: Age-at-death data for Late Neolithic La Renke based on tooth eruption and wear.

La Renke (Late/Final Neolithic)							
	Neonatal	Juvenile	Immature	Subadult	Adult	Elderly	Total
Mandibles			1	3	3		7
Loose teeth				1	1		2
Total N	0	0	1	4	4		9
Total %	0%	0%	11%	44%	44%	0%	100.0%

3.3 Biometry

In this section, the biometric analyses on pre-Neolithic and Neolithic dental and postcranial pig remains are presented. The aim is to examine the size and, to some extent, the shape of pigs in order to detect any changes or fluctuations that may have occurred in these periods. Though more data are available for post-Neolithic assemblages, a careful biometric assessment for pre-Neolithic and Neolithic periods is important in order to assess the effect of the domestication process on pig morphology. In the following chapter, comparisons with the more abundant later prehistoric data will allow further insights into this key period of transition.

3.3.1 Biometry of postcranial elements

In this section the analyses conducted on postcranial bones of pre-Neolithic and Neolithic chronology are presented and described. The analyses are mainly in the form of scatterplots and log ratio histograms. Both periods are presented in the same section. Scatterplots are presented first followed by log ratio histograms. Samples are rather small but nevertheless presented because of the potential of measurements from these periods to contribute to our understanding of the origins of pig domestication.

Table 3.9 provides summary statistics for all postcranial elements of pre-Neolithic and Neolithic chronology. Beyond the straightforward statistical indices such as number of measurements, maximum, minimum and mean, the coefficient of variation (V) has also been calculated (standard deviation as a percentage of the mean) to enable an evaluation of the variability of different measurements. The coefficient of variation is considered to be a relatively reliable and size-independent index of variability in different measurements (Payne and Bull 1988).

For measurements that can be compared across periods (i.e. those of the astragalus), a trend towards smaller size can be observed from the pre-Neolithic to the Early Neolithic and from the Early to the Late/Final Neolithic. It is also interesting to note that the minimum measurements of pre-Neolithic astragali are larger than the maximum measurements of Late/Final Neolithic astragali.

Pre-Neolithic and Neolithic data are very scarce (measurements with $N < 5$ were excluded) and thus, their interpretation should remain on a general level. Only the astragalus measurements can be compared across the three periods considered here. They show higher - approximately double - variability in the Early Neolithic than the pre-Neolithic and Late/Final Neolithic. Although the small sample size of the pre-Neolithic and Late/Final Neolithic invites caution, this variability is confirmed in further biometric analyses – visible in both histograms and scatterplots. It is important to note that the rest of Early Neolithic measurements also suggest high variability in the Early Neolithic. Strictly speaking, the coefficient of variation values for the Early Neolithic are higher than that supposed to represent a single population. One could argue that this might have been expected as the sample represents a combination of different sites, but so do the pre-Neolithic and Late/Final Neolithic samples. Thus, it still provides useful information for the interpretation of the period.

The most abundant element by far is the astragalus and in figure 3.15 the greatest lateral and the greatest medial lengths of all pre-Neolithic, Early Neolithic and Late/Final Neolithic specimens are plotted. Pre-Neolithic specimens tend to plot in the central and upper right parts of the distribution, the Late/Final Neolithic plot in the lower left part, while the more numerous Early Neolithic specimens cover all parts of the distribution. The observed overlap would probably be even more extensive had the pre-Neolithic and Late/Final Neolithic samples been larger. With such extensive overlap the aim must shift from discerning clear patterns to detecting tendencies. Beyond the general tendency for smaller size during the Late/Final Neolithic and larger during the pre-Neolithic, a good part of the Early Neolithic specimens (roughly a third of them) is of similar size to the smaller-sized Late/Final specimens. On the other hand, there are some particularly large Early Neolithic specimens, larger than

the largest recorded pre-Neolithic material. Overall, the Early Neolithic specimens show great variability in size (also see table 3.9), with most specimens plotting near the central part of the distribution.

Table 3.9: Number (N), minimum, maximum, mean and coefficient of variation (V) for postcranial measurements of pre-Neolithic, Early and Late/Final Neolithic chronology. Only fully fused specimens were included.

Pre-Neolithic					
	N	Minimum	Maximum	Mean	V
Astragalus GLI	8	44.3	50.2	47.7	4.4
Astragalus GLm	6	39.5	46.1	42.8	5.9
Early Neolithic					
	N	Minimum	Maximum	Mean	V
Astragalus GLI	30	37.6	53.4	45.9	8.7
Astragalus GLm	33	34.7	47.4	41.2	8.0
Humerus BT	8	31.9	41.5	36.7	8.2
Humerus HTC	9	20.1	24.9	22.7	8.0
Tibia BdP	7	30.9	43.1	38.2	11.2
Tibia Dd	7	25.4	34.5	31.1	10.3
Calcaneum GL	5	84.6	101.9	94.3	6.9
Calcaneum GD	5	29.5	37.4	34.4	8.6
Late/Final Neolithic					
	N	Minimum	Maximum	Mean	V
Astragalus GLI	7	37.5	43.5	40.7	4.5
Astragalus GLm	7	35.3	38.7	37.1	3.1

In addition to the graphical exploration, size changes between pre-, Early and Late/Final Neolithic astragali were further analysed by using Kruskal-Wallis followed by Mann-Whitney tests. Due to the small pre-Neolithic and Late/Final Neolithic samples, only the astragalus (greatest lateral and greatest medial lengths) was qualified (i.e. >than five measurements) for presentation. Statistically significant size differences between the periods in general could be found for both astragalus measurements (all Kruskal-Wallis tests $p < 0.001$). The subsequently applied Mann-Whitney test showed that pre-Neolithic and Early Neolithic specimens were significantly larger than Late/Final Neolithic. However, no statistically significant differences between pre-Neolithic and Early Neolithic samples could be established (table 3.10).

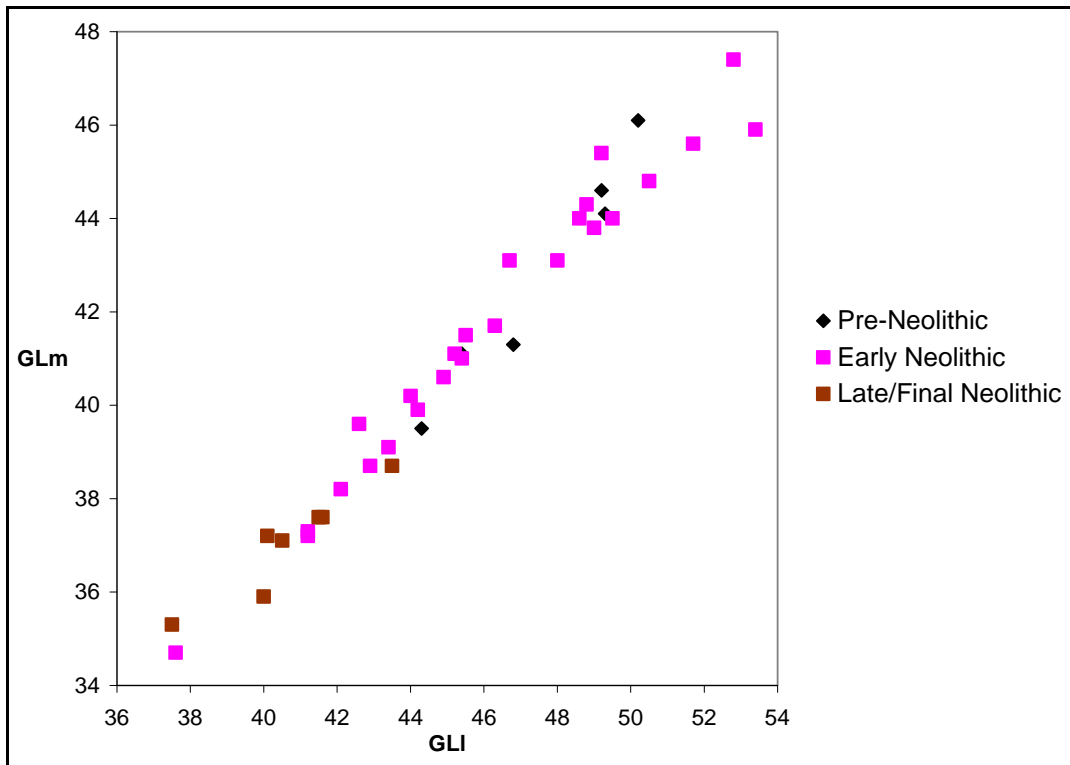


Figure 3.15: Scatterplot of astragalus greatest lateral x greatest medial lengths from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Light and porous specimens are excluded. Measurements in mm.

Table 3.10: Significance (two-tailed) of size differences in astragalus measurements between periods, calculated with Mann-Whitney tests. Only samples with a minimum of five or more measurements were subjected to testing; green: very highly significant; blue: highly significant; yellow: significant.

	GLI	GLm
Pre-Neolithic / Early Neolithic	0.128	0.206
Pre-Neolithic / Late-Final Neolithic	0.001	0.003
Early Neolithic / Late-Final Neolithic	0.001	0.001

Since the Neolithic sample of astragali is relatively large, it would be interesting to examine possible variations between sites. Although none of the sites produced a great number of measurements, some trends in the distribution suggest important differences in size between and within Neolithic pig populations. In figure 3.16 below, the greatest lateral and greatest medial lengths of pre-Neolithic and Early Neolithic astragali are plotted. In general there is considerable overlap in size between pre-Neolithic and Early Neolithic samples but also a definite tendency towards smaller size in the Early Neolithic, especially at La Draga and Cueva de la Vaquera. The largest Early Neolithic sample of Cueva Chaves, unsurprisingly exhibits the broadest size range with most measurements overlapping with the pre-Neolithic ones. There are also measurements that are either considerably smaller or larger than the pre-

Neolithic ones. Interesting is also the pattern of the specimens from Cova Fosca, which are of similar size to that of their pre-Neolithic counterparts. The only two specimens available from Early Neolithic Sant Pau are worth commenting because one is very small and the other is very large, thus providing an indication of the large variability of pig size in this period. The presence of some particularly large-sized pigs during the Early Neolithic is further supported by the two very large specimens from Cueva Chaves. Early Neolithic specimens exhibit considerable size differences, which, to some extent, seem to be site specific. Astragali from some Early Neolithic sites, such as Cueva de La Vaquera and La Draga, clearly have a smaller size than those from Cueva Chaves and Cova Fosca, which in turn are more similar in size to the pre-Neolithic than to the Late/Final Neolithic specimens.

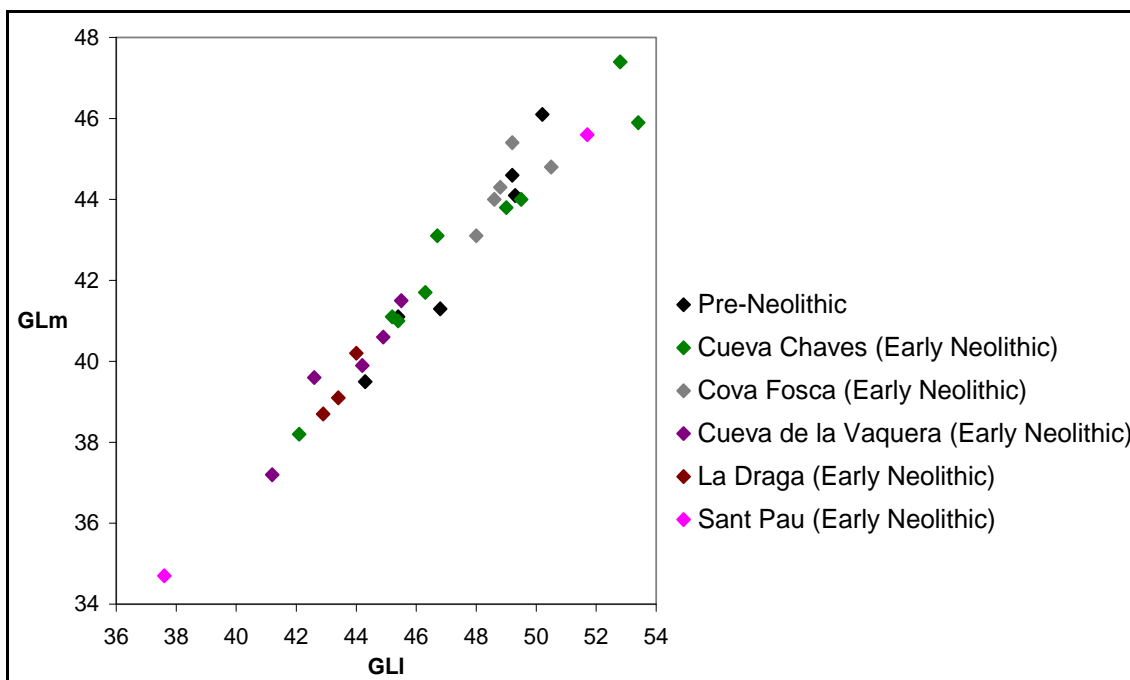


Figure 3.16: Scatterplot of astragalus greatest lateral x greatest medial lengths from all the recorded Early Neolithic assemblages compared with the combined pre-Neolithic sample. Light and porous specimens are excluded. Measurements in mm.

As shown in figure 3.15 there is a clear trend for smaller size in Late/Final Neolithic specimens and this is confirmed in figure 3.17 in which the greatest lateral and the greatest medial lengths of all pre-Neolithic and Late/Final Neolithic astragali are plotted. Late/Final Neolithic specimens from Los Castillejos, Los Barruecos and Abrigo de la Peña are all of similar size and clearly smaller than pre-Neolithic specimens.

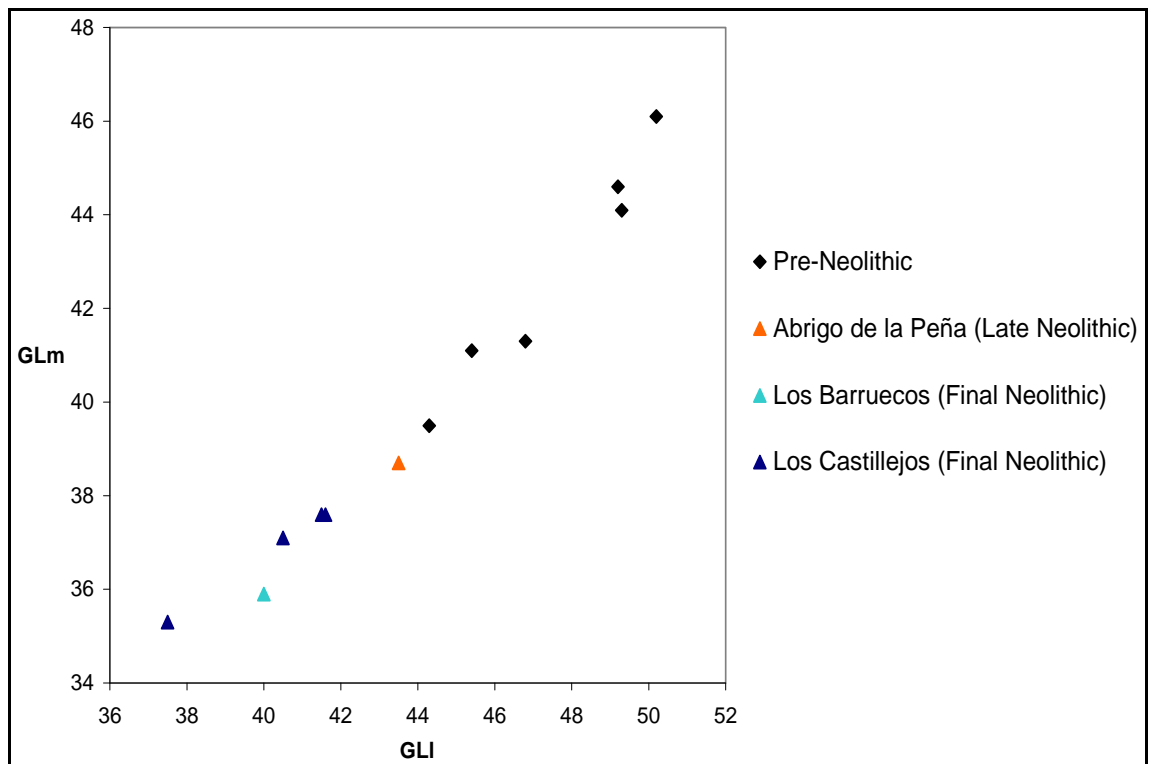


Figure 3.17: Scatterplot of astragalus greatest lateral x greatest medial lengths from all the recorded Final/Late Neolithic assemblages compared with the combined pre-Neolithic sample. Light and porous specimens are excluded. Measurements in mm.

The rest of the postcranial elements provided fewer measurements and are, therefore, only briefly discussed. In figure 3.18 the measurements of distal tibia are presented, including fusing elements in order to increase sample size - bearing in mind that post-fusion size increase in distal tibia is negligible (Albarella and Payne 2005). In general, there are some parallels with the picture obtained from the astragalus. Some Early Neolithic measurements are larger and some smaller than pre-Neolithic measurements. The coefficient of variation (see table 3.9 above) confirms that tibia measurements are the most variable of the period. The only Final Neolithic specimen is small, which is consistent with the information provided by the astragalus.

Although calcaneum measurements from fully fused specimens are few, they are in line with the trends highlighted above (figure 3.19). Early Neolithic specimens are very variable, plotting above and below the pre-Neolithic distribution, and the only Final Neolithic specimen is very small.

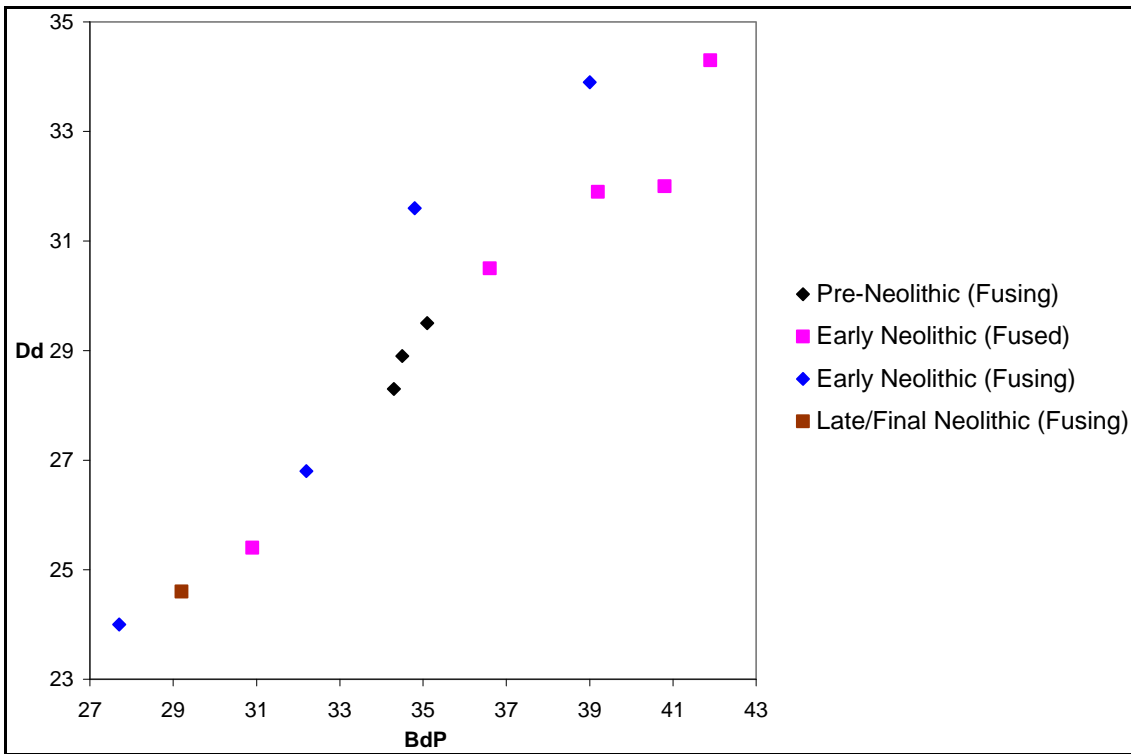


Figure 3.18: Scatterplot of tibia width x depth of the distal end from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Measurements in mm.

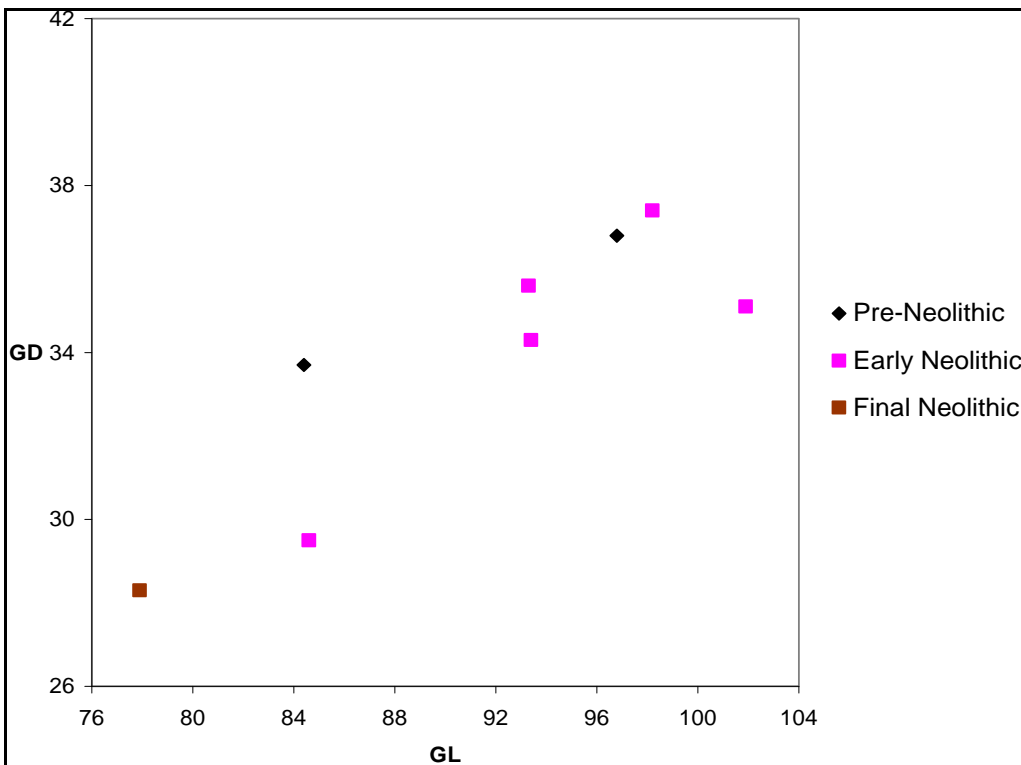


Figure 3.19: Scatterplot of calcaneum greatest length x greatest depth from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Only fused specimens are plotted. Measurements in mm.

No measurements from distal humeri are available from pre-Neolithic periods. For this reason only the Early Neolithic (fused and fusing) and one Final Neolithic (fused) specimens are presented in figure 3.20. To evaluate the Early

Neolithic material better, fusing and fused/fusing humeri are also plotted despite the obvious tendency for larger size in fused rather than fusing specimens. The Final Neolithic fused specimen plots with a group of fusing Early Neolithic specimens in the lower left part of the distribution. The observed small size of most Early Neolithic fusing specimens is likely to be due to their young age. The upper right part of the distribution is occupied by the majority of fused Early Neolithic specimens, but one fusing specimen is large as well. In general this plot confirms the wide spread of Early Neolithic size, with the largest specimens being a good third larger than the smallest, even if we ignore fusing specimens.

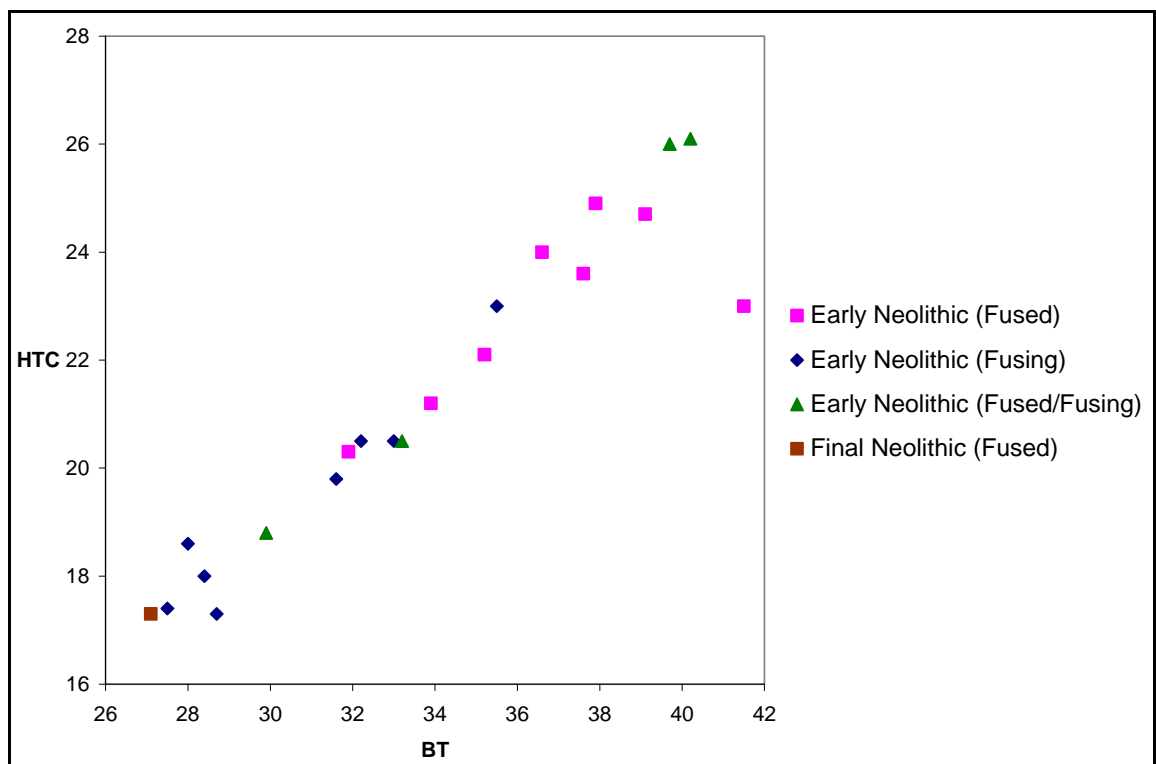


Figure 3.20: Scatterplot of humerus width of trochlea x minimum diameter of trochlea from combined samples of Early and Late/Final Neolithic chronology. Measurements in mm.

Additional to scatterplots, log ratio histograms with pre-Neolithic and Neolithic specimens have been produced. Although the specimens included in scatterplots are also included in the histograms, they provide useful additional information because all recorded postcranial measurements, excluding the heavily age-dependent length of the scapula neck (Payne and Bull 1988; Rowley-Conwy 2001), are included in the analysis. As a result, more individuals are represented in the histograms than in scatterplots and hence, a more general picture becomes available, though at a lower resolution.

The histograms in figure 3.21 offer an overview of the postcranial size of pre-Neolithic, Early Neolithic and Late/Final Neolithic pigs. Overall, the histograms are, as expected, consistent with the scatterplot results and also the summary statistics at the beginning of the section (table 3.9). As shown in the scatterplots before, Early Neolithic size was on average smaller than the pre-Neolithic size, though not statistically significant in astragalus measurements (table 3.10). At the bottom of the histogram stack, the small Late/Final Neolithic sample, compared with all preceding periods, reveals a considerably – and statistically significant - smaller postcranial size. Furthermore, in accordance with the scatterplots and coefficient of variation, the Early Neolithic presents the greatest size diversity. It is noteworthy that some Early Neolithic specimens are as small as the smallest Final/Late Neolithic while others exceed in size the largest pre-Neolithic specimens. This greater range is likely to be, to some extent, a consequence of the larger sample size.

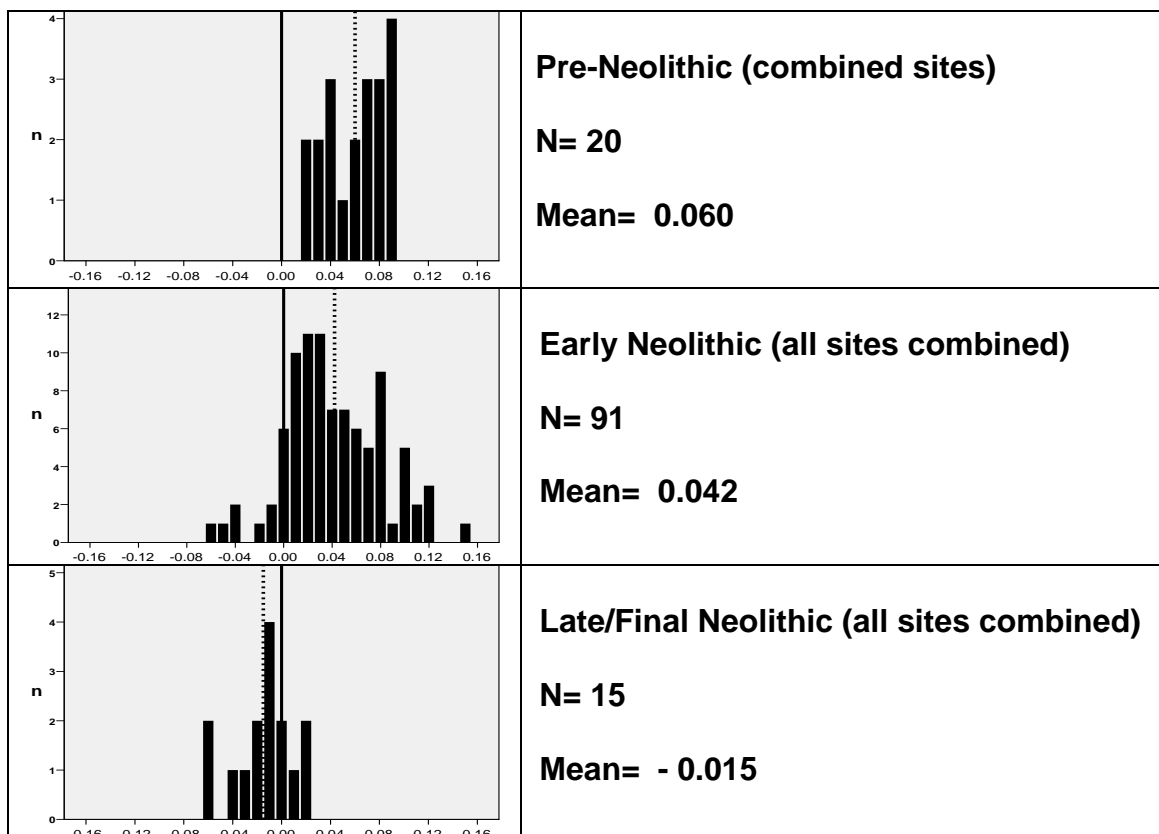


Figure 3.21: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Only fused specimens are plotted. The dotted line represents the mean value.

In addition to the general comparison of combined measurements of different chronology (figure 3.21), possible size differences between sites (or grouped

sites of similar chronology) are also explored. In figure 3.22, the postcranial size of pre-Neolithic pigs (divided in Magdalenian and Epipalaeolithic/Mesolithic samples) is compared with different Early Neolithic populations and the combined sample of Late/Final Neolithic sites. Although none of the sites produced a large number of measurements, some trends in the histograms suggest important size differences between pig populations of both different and similar chronologies. No significant difference is noticeable between the two pre-Neolithic samples, but an interesting diversity emerges in the four Early Neolithic pig populations. Despite being on average slightly smaller than their pre-Neolithic counterparts, the pigs from Cueva Chaves and Cova Fosca seem to be noticeably larger than those from La Draga and Cueva de la Vaquera. The latter are intermediate in size between Cova Fosca and Cueva Chaves on the one hand, and the Late/Final Neolithic sample on the other, which may prove to be significant. It is unfortunate that these log ratio values are not amenable to standard statistical testing, due to the potential interdependence of the measurements and the inherent characteristics of ratio values (Atchley et al 1976).

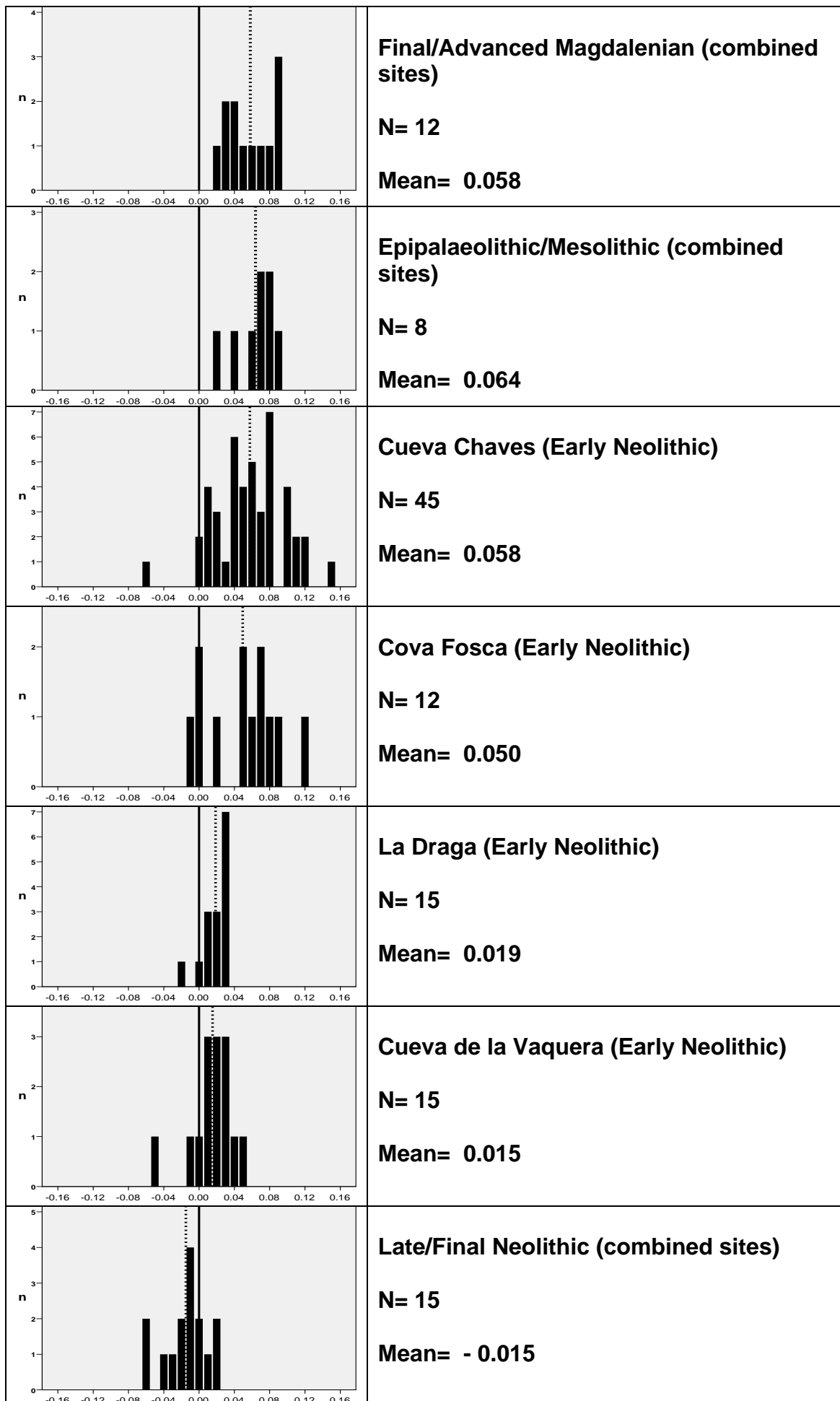


Figure 3.22: Log ratio histograms comparing pig postcranial measurements (excluding the length of scapula neck) from Early Neolithic sites with combined samples of pre-Neolithic and Late/Final Neolithic chronology. Only fused specimens are plotted. The dotted line represents the mean value.

3.3.2 Tooth biometry

In this section the analyses conducted on pig teeth of pre-Neolithic and Neolithic chronology are presented and described. The data are presented in the form of scatterplots and log ratio histograms.

As for the analysis of the postcranial data, the analysis of pre-Neolithic and Neolithic tooth data is of particular interest in order to assess the level of size variation in these crucial periods for the domestication process. Furthermore, the comparison between tooth and postcranial measurements has the potential to offer additional information on the morphology of pre-Neolithic and Neolithic pigs.

The following two tables provide summary statistics for all mandibular (3.11) and maxillary (3.12) teeth of pre-Neolithic and Neolithic chronology. As expected due to later eruption time, third molar measurements usually comprise the smallest samples. The general pattern that emerges from the statistics of both the mandibular and maxillary teeth is a decrease in most measurements from the pre-Neolithic to the Early Neolithic. This is apparent in the means, maxima and minima of most measurements. An even sharper size decrease is prominent from the Early Neolithic to the Late/Final Neolithic – visible in all (except one) means and all minima and maxima (except one). Another general pattern, with few exceptions, is the tendency for sharper size decrease in the second and third molar measurements compared to the first molar or fourth deciduous premolar. This observation is important because it can be related to a possible shortening of the snout, a process which would have affected more the distal than the mesial end of jaws.

Unlike the postcranial measurements (table 3.9), the coefficient of variation (V) does not present any particular pattern or pronounced change between periods, except perhaps a tendency towards increased variation in Late/Final Neolithic (mandibular teeth) compared to the Early or pre-Neolithic periods. When we compare variation in different teeth within a period some interesting patterns emerge. Maxillary Early Neolithic measurements show a progressive trend for increased variation the more distally a tooth is situated in the jaw.

Unexpectedly, the same trend is not discernible in mandibular Early Neolithic measurements.

Table 3.11: Number (N), minimum, maximum, mean and coefficient of variation (V) for mandibular measurements of pre-Neolithic, Early and Late/Final Neolithic chronology.

Pre-Neolithic					
	N	Minimum	Maximum	Mean	V
dP4L	8	16.5	18.8	17.7	4.1
dP4WP	9	8.2	11.3	9.3	12.8
M1L	9	14.1	17.1	15.5	5.5
M1WA	10	9.4	11.3	10.1	7.2
M1WP	9	10.4	11.8	11.0	5.2
M2WP	5	13.9	14.9	14.5	2.8
M3WC	5	15.8	17.4	16.6	3.4
Early Neolithic					
	N	Minimum	Maximum	Mean	V
dP4L	24	17.0	19.7	17.9	3.6
dP4WP	28	8.3	10.9	8.9	6.3
M1L	38	14.5	17.1	15.6	3.8
M1WA	47	9.6	11.6	10.5	4.3
M1WP	47	10.2	12.2	11.0	4.8
M2L	22	18.0	21.3	19.9	4.4
M2WA	27	12.8	14.9	13.8	4.5
M2WP	23	12.8	15.1	13.9	5.3
M3L	6	32.6	37.8	34.8	5.0
M3WA	7	14.8	16.9	15.8	4.6
M3WC	7	13.8	16.0	14.9	5.5
M3WP	5	11.3	12.4	11.9	4.2
Late/Final Neolithic					
	N	Minimum	Maximum	Mean	V
dP4L	7	16.7	18.7	17.4	4.0
dP4WP	9	7.7	9.8	8.8	7.0
M1L	11	13.7	15.8	14.8	4.8
M1WA	15	8.9	10.8	10.2	5.6
M1WP	15	9.8	11.6	10.9	5.7
M2L	15	13.7	20.7	18.1	12.4
M2WA	15	11.5	14.8	12.9	9.2
M2WP	15	11.0	14.9	12.8	9.4
M3L	2	29.7	31.8	30.8	4.8
M3WA	15	13.3	17.1	14.5	6.7
M3WC	15	12.7	14.8	13.8	3.6
M3WP	15	8.9	12.2	10.2	7.3

Table 3.12: Number (N), minimum, maximum, mean and coefficient of variation (V) for maxillary measurements of pre-Neolithic, Early and Late/Final Neolithic chronology.

Pre-Neolithic					
	N	Minimum	Maximum	Mean	V
dP4L	6	12.0	13.5	13.1	4.3
dP4WP	8	10.0	10.9	10.5	2.8
M1WA	6	12.5	13.9	13.3	4.1
M1WP	6	12.5	13.9	13.3	4.1
M2L	8	18.2	23.0	20.2	7.7
M2WA	5	15.8	17.4	16.8	4.8
M2WP	6	14.6	18.3	16.2	7.7
M3WA	7	16.8	21.4	19.4	9.2
M3WC	5	15.7	18.1	16.8	5.7
Early Neolithic					
	N	Minimum	Maximum	Mean	V
dP4L	22	12.3	13.7	13.0	2.9
dP4WP	26	10.2	11.3	10.8	2.9
M1L	30	14.0	16.3	15.0	4.5
M1WA	57	11.8	14.8	13.5	4.4
M1WP	56	11.8	14.7	13.4	4.6
M2L	29	16.4	20.6	19.0	5.3
M2WA	42	13.9	19.0	16.6	5.8
M2WP	34	14.2	17.7	15.9	5.2
M3L	6	31.1	41.7	35.6	9.8
M3WA	16	15.0	23.0	19.3	10.9
M3WC	10	12.3	18.5	15.8	12.6
M3WP	7	9.2	15.2	11.4	17.4
Late/Final Neolithic					
	N	Minimum	Maximum	Mean	V
M1L	10	14.2	16.9	15.0	6.1
M1WA	16	11.7	14.7	13.2	5.9
M1WP	13	12.3	14.9	13.2	5.4
M2L	8	17.2	20.4	18.4	5.8
M2WA	9	15.4	17.1	16.3	3.8
M2WP	8	14.5	17.3	16.0	6.0
M3WA	6	17.0	18.8	18.0	3.4

In addition to the graphical exploration of size differences between pre-, Early and Late/Final Neolithic pig teeth, presented below, those were further analysed by using Kruskal-Wallis followed by Mann-Whitney tests. Statistically significant size differences between periods could be found for all – mandibular and maxillary - tooth measurements (all Kruskal-Wallis tests $p < 0.009$). Mann-Whitney tests were used to follow up this finding, excluding samples containing less than five specimens. Results are presented in table 3.13 but are commented separately for each tooth in combination with the scatterplots.

Table 3.13 Significance (two-tailed) of size differences in pig tooth measurements between periods, calculated with Mann-Whitney tests. Only samples with a minimum of five or more measurements were subjected to testing; green: very highly significant; blue: highly significant; yellow: significant.

MANDIBULAR												
	dP4L	dP4WP	M1L	M1WA	M1WP	M2L	M2WA	M2WP	M3L	M3WA	M3WC	M3WP
Pre-Neolithic / Early Neolithic	0.419	0.749	0.946	0.060	0.982	N/A	N/A	0.111	N/A	N/A	0.007	N/A
Pre-Neolithic / Late-Final Neolithic	0.520	0.825	0.052	0.578	0.471	N/A	N/A	0.016	N/A	N/A	0.001	N/A
Early Neolithic / Late-Final Neolithic	0.118	0.790	0.004	0.171	0.680	0.011	0.020	0.004	N/A	0.004	0.009	0.003
MAXILLARY												
	dP4L	dP4WP	M1L	M1WA	M1WP	M2L	M2WA	M2WP	M3L	M3WA	M3WC	M3WP
Pre-Neolithic / Early Neolithic	0.415	0.026	N/A	0.318	0.642	0.089	0.691	0.608	N/A	0.947	0.500	N/A
Pre-Neolithic / Late-Final Neolithic	0.435	0.797	N/A	0.739	0.660	0.021	0.177	0.795	N/A	0.153	0.121	N/A
Early Neolithic / Late-Final Neolithic	N/A	N/A	0.754	0.091	0.228	0.073	0.220	0.822	N/A	0.032	N/A	N/A

In figures 3.23 and 3.24 the mandibular and maxillary measurements (crown length x posterior cusp width) of fourth deciduous premolars from pre-Neolithic, Early Neolithic and Late/Final Neolithic sites are presented. Both the mandibular and maxillary measurements show extensive size overlap (especially in mandibular dP4) in all analysed datasets. However, a tendency for some Late/Final Neolithic specimens to be particularly small is evident, though an extremely large maxillary and two rather large mandibular dP4s also occur. As for bones, the Early Neolithic data overlap with the whole of pre-Neolithic distribution, and even spread beyond this range (i.e. specimens both smaller and larger than the entire pre-Neolithic distribution). A similar picture is reflected also in the results of the Mann-Whitney test, which showed no significant difference between the three periods in any measurement of the fourth deciduous premolar (table 3.13). An exception to this is the maxillary posterior cusp width that indicates that Early Neolithic specimens were significantly larger than Late/Final Neolithic.

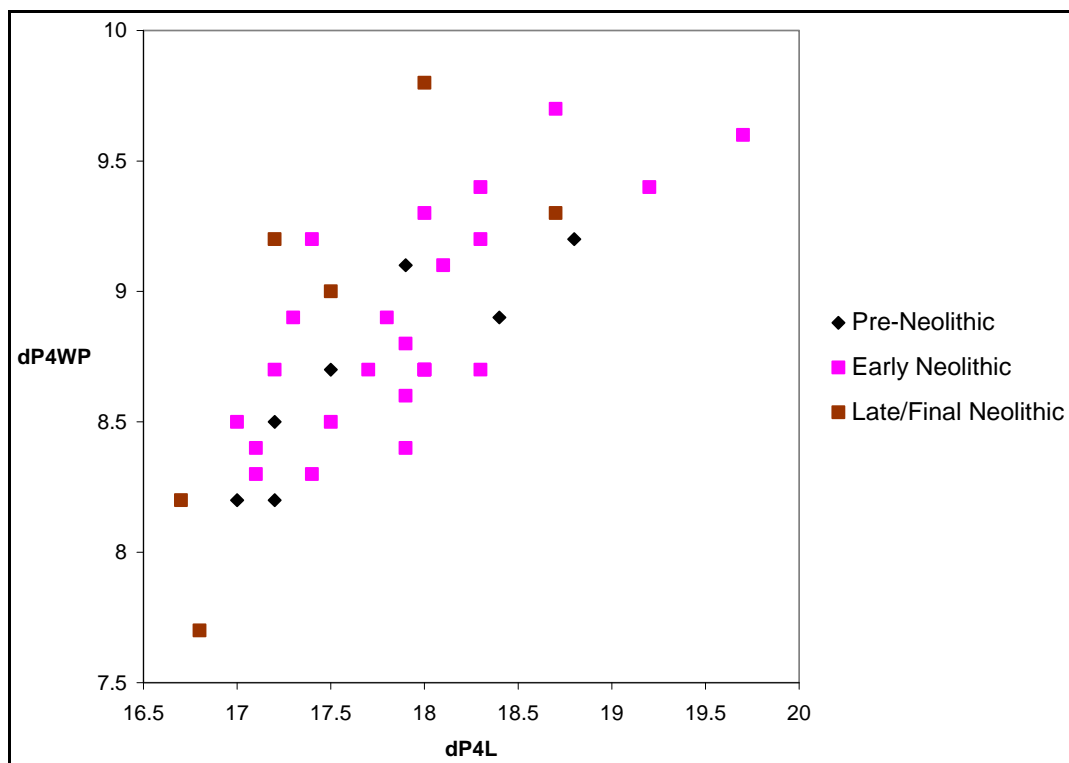


Figure 3.23: Scatterplot of crown length x posterior cusp width of mandibular fourth deciduous premolar from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Measurements in mm.

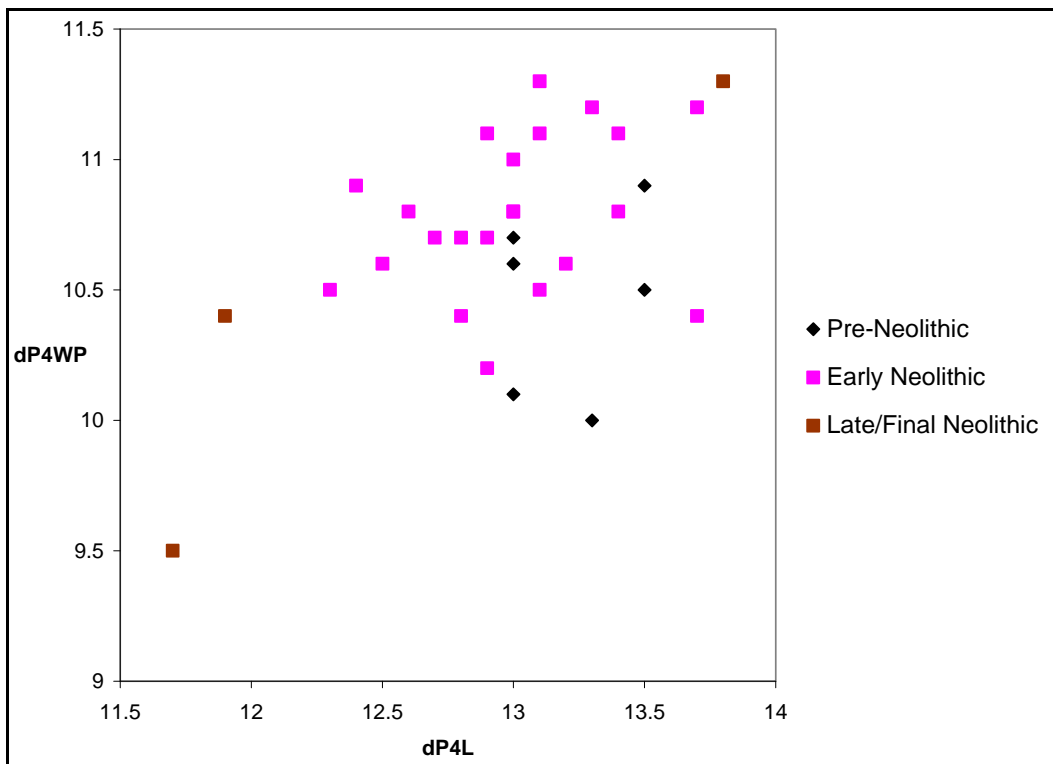


Figure 3.24: Scatterplot of crown length x posterior cusp width of maxillary fourth deciduous premolar from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Measurements in mm.

The following two scatterplots show the crown length x anterior cusp width of mandibular (figure 3.25) and maxillary (figure 3.26) first molars from pre-Neolithic, Early Neolithic and Late/Final Neolithic sites. The pattern that emerges is the same as that observed for the dP4 (i.e. extensive overlap between the three chronological periods). This is supported by the results of Mann-Whitney tests, which showed a significant difference only between the larger Early and smaller Late/Final Neolithic mandibular crown lengths (table 3.13). Once again, the Late/Final Neolithic specimens tend to plot towards the bottom of the distribution (especially in mandibular first molars), but some large outliers are present (especially in maxillary first molars). Early Neolithic specimens span the whole of the distribution, with some being smaller than the smallest Late/Final Neolithic specimens, and others larger than the largest pre-Neolithic specimens. Different plots of the same tooth (e.g. crown length x posterior width and anterior x posterior width) have also been analysed and produced similar results.

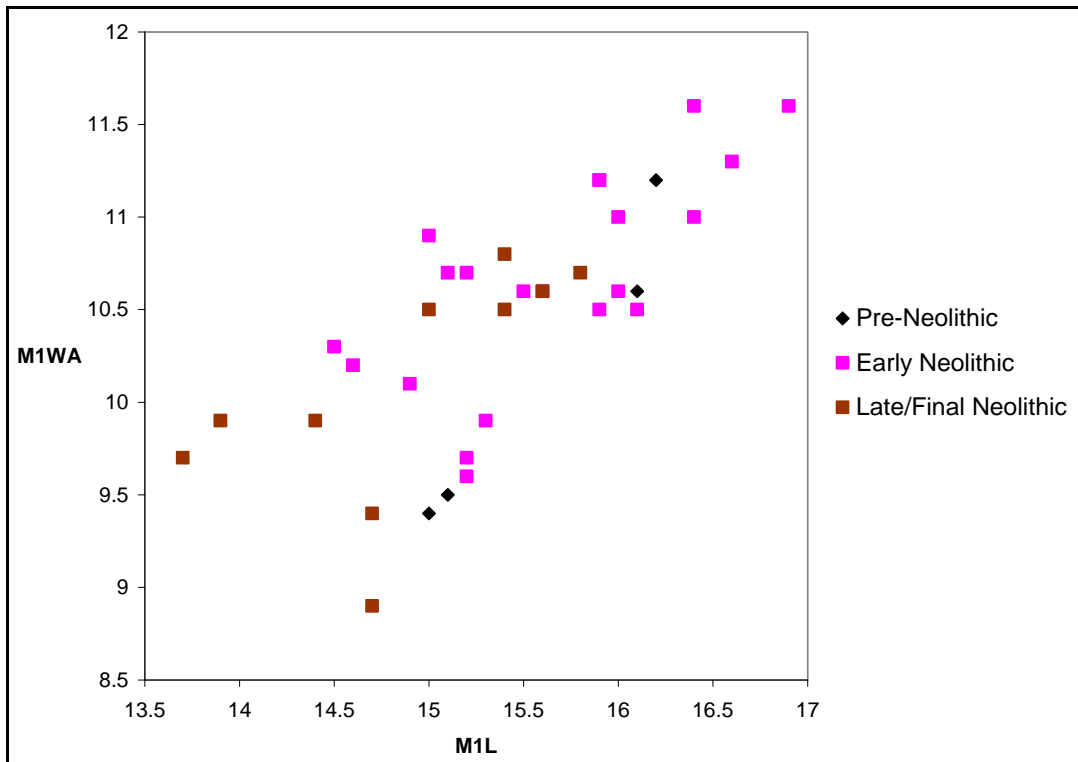


Figure 3.25: Scatterplot of crown length x anterior cusp width of mandibular permanent first molar from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Measurements in mm.

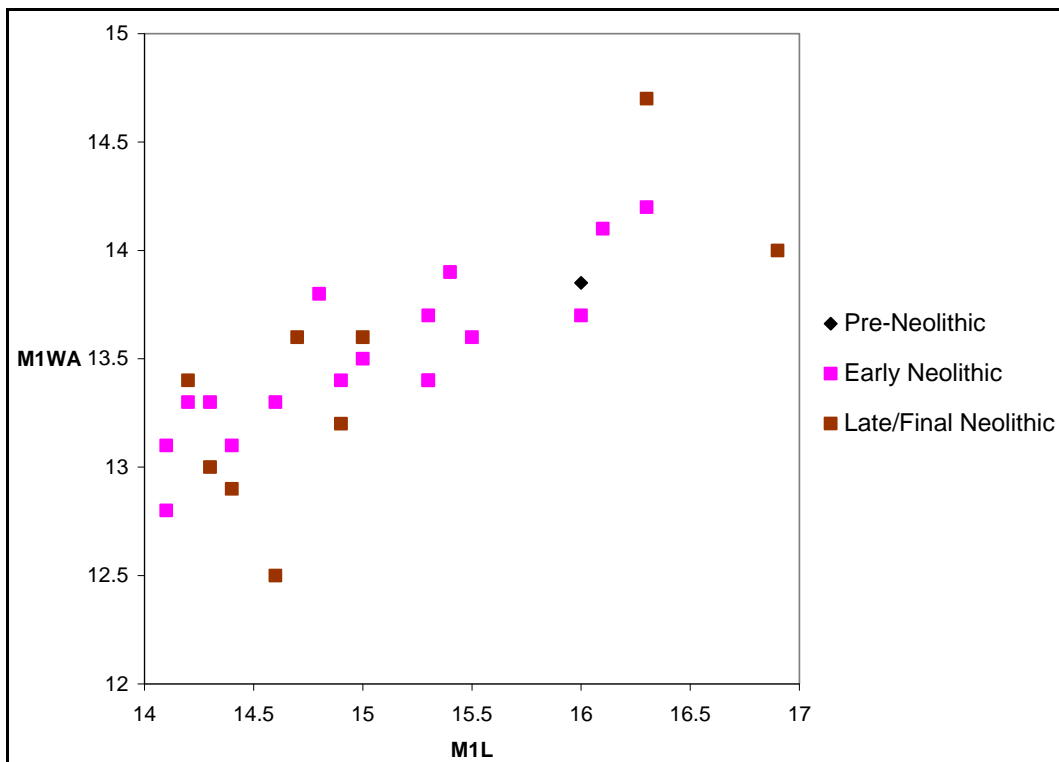


Figure 3.26: Scatterplot of crown length x anterior cusp width of maxillary permanent first molar from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Measurements in mm.

In the two figures below the anterior x posterior width measurements of mandibular (figure 3.27) and maxillary (figure 3.28) second molars from pre-Neolithic, Early Neolithic and Late/Final Neolithic sites are presented. In general, these results are similar to those produced by the other teeth. The Late/Final Neolithic specimens plot towards the bottom of the distribution, the pre-Neolithic towards the top, and the Early Neolithic specimens overlap with both other datasets. Plots including the length of the second molar provided similar results. Mann-Whitney tests showed that Late/Final Neolithic mandibular second molars were significantly smaller than both the pre- and Early Neolithic specimens (table 3.13). However, no significant difference could be established for maxillary measurements, with the exception of pre-Neolithic versus Late/Final Neolithic maxillary crown lengths. As for the dP4 and the M1, pre-Neolithic and Early Neolithic specimens did not differ significantly.

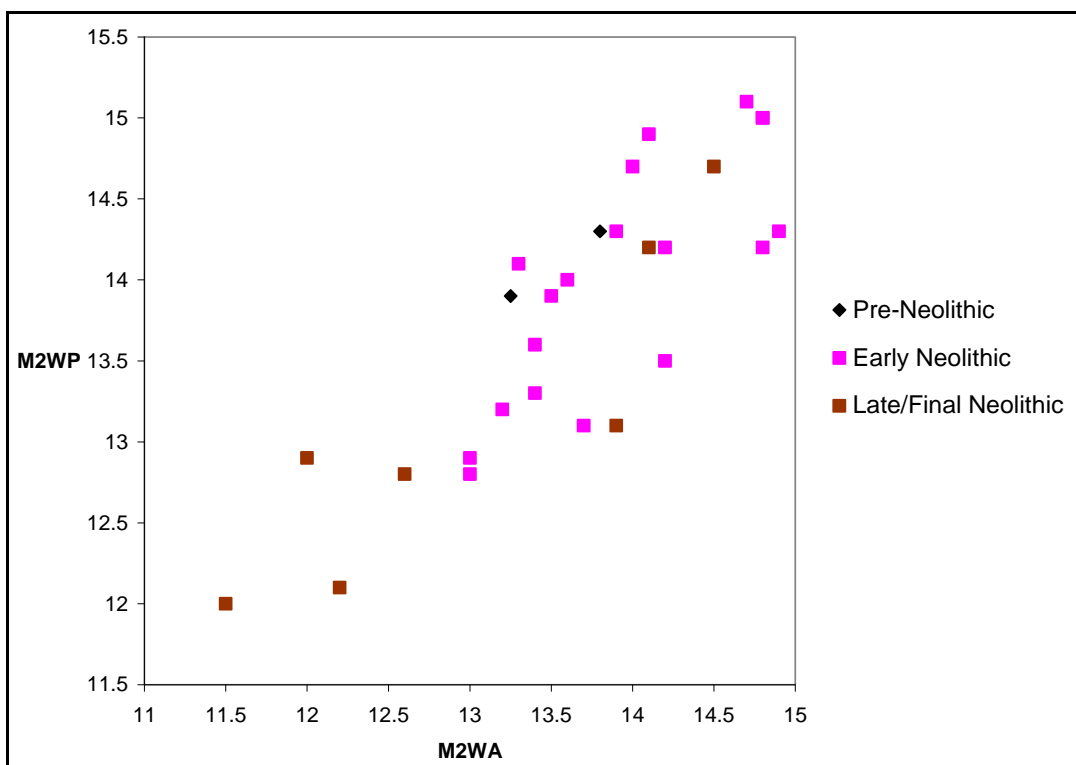


Figure 3.27: Scatterplot of anterior x posterior cusp width of mandibular permanent second molar from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Measurements in mm.

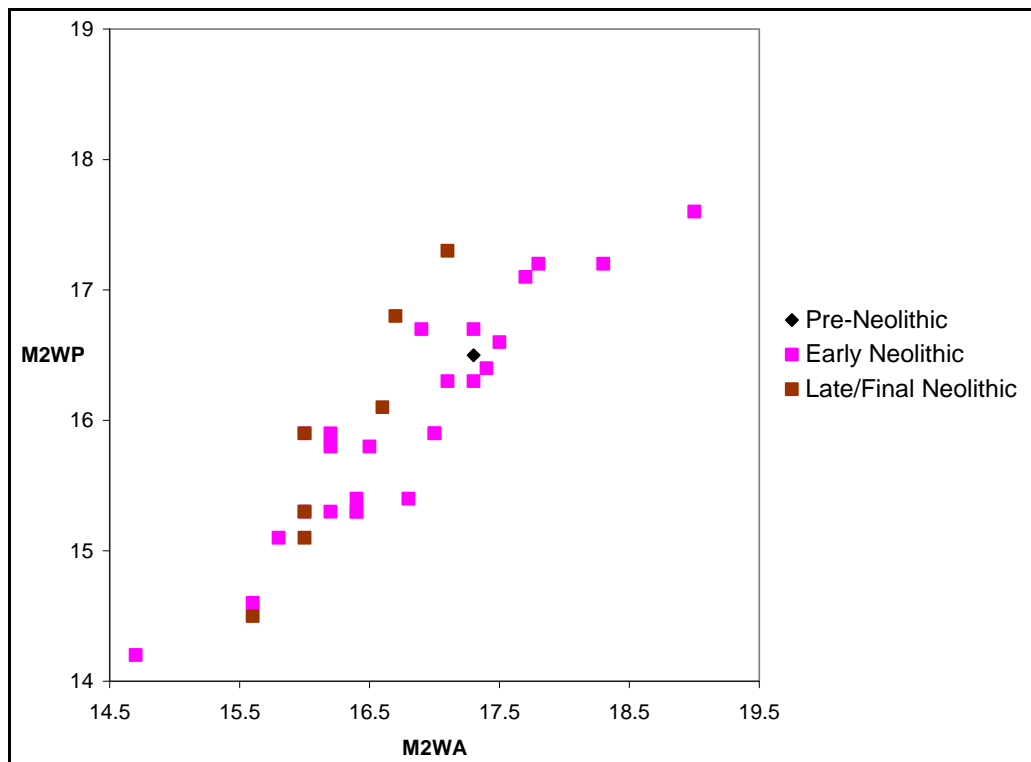


Figure 3.28: Scatterplot of anterior x posterior cusp width of maxillary permanent second molar from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Measurements in mm.

The lengths and anterior widths of mandibular (figure 3.29) and maxillary (figure 3.30) third molars from pre-Neolithic, Early Neolithic and Late/Final Neolithic assemblages are plotted in the following two scatterplots. Samples are quite small and hence, caution is required. Late/Final Neolithic specimens occupy the lower left part of the distribution, Early Neolithic specimens the central part, while the upper right part is occupied with considerable size difference by the few available pre-Neolithic specimens and the occasional Early Neolithic outlier. One large Late/Final Neolithic specimen has a distinctively odd shape and may represent a recording mistake. The groups appear to be clear-cut but this could partly be an artefact of small sample size, as larger samples would have certainly produced wider ranges and therefore greater overlap. However, statistics showed significant differences between all three periods in all mandibular measurements that could be tested with Mann-Whitney tests (table 3.13). It is noteworthy that the significance of size differences between periods tends to increase progressively from the fourth deciduous premolar to the third molar. In scatterplots and statistical tests alike, differences appear more pronounced in second and third molars than in fourth deciduous premolar and first molar, especially in mandibular than maxillary specimens.

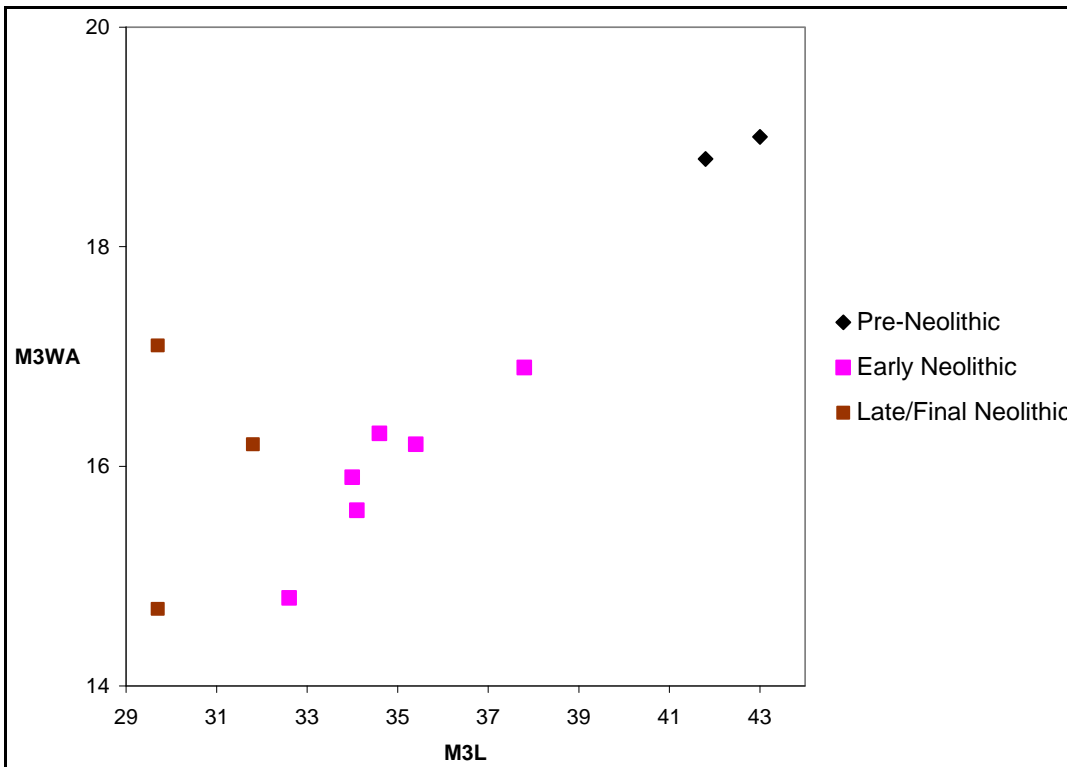


Figure 3.29: Scatterplot of crown length x anterior cusp width of mandibular permanent third molar from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Measurements in mm.

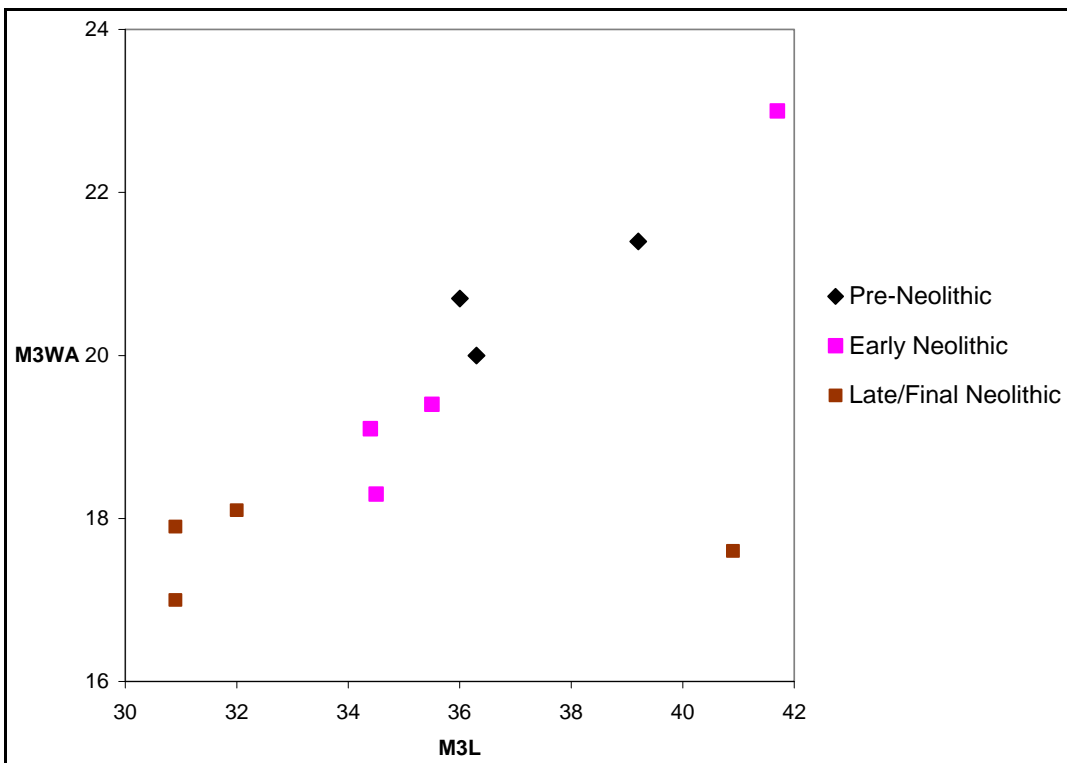


Figure 3.30: Scatterplot of crown length x anterior cusp width of maxillary permanent third molar from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology. Measurements in mm.

In addition to the analyses assessing size (figures 3.29 and 3.30), the shape of pre-Neolithic and Neolithic third molars is also examined with the use of a shape index (the ratio between length and anterior and central widths). The mandibular third molar shows that Early Neolithic third molars had a shape approaching that of their pre-Neolithic counterparts, while Late/Final Neolithic specimens appear to have had a distinct shape (figure 3.31). Relatively speaking, Late/Final Neolithic third molars tended to be broader and shorter than Early and pre-Neolithic specimens. The same picture, though based on an even smaller sample is provided by the maxillary specimens (figure 3.32).

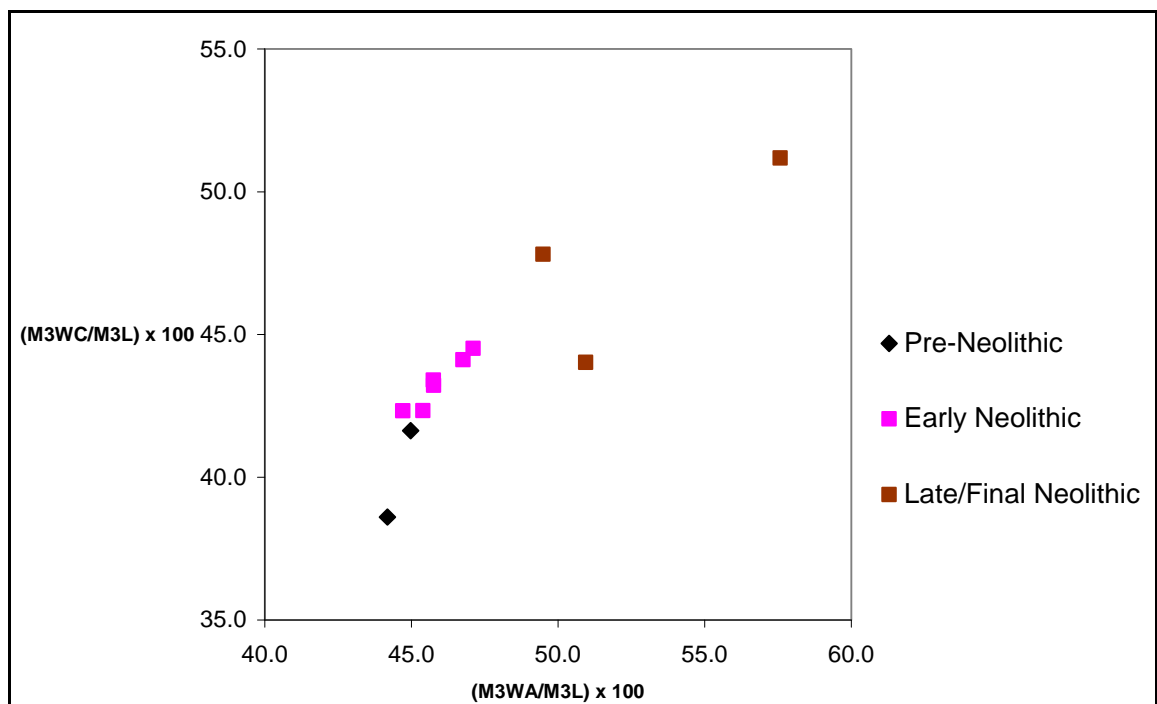


Figure 3.31: Ratio between width and length of pre-Neolithic, Early Neolithic and Late/Final Neolithic lower third molars.

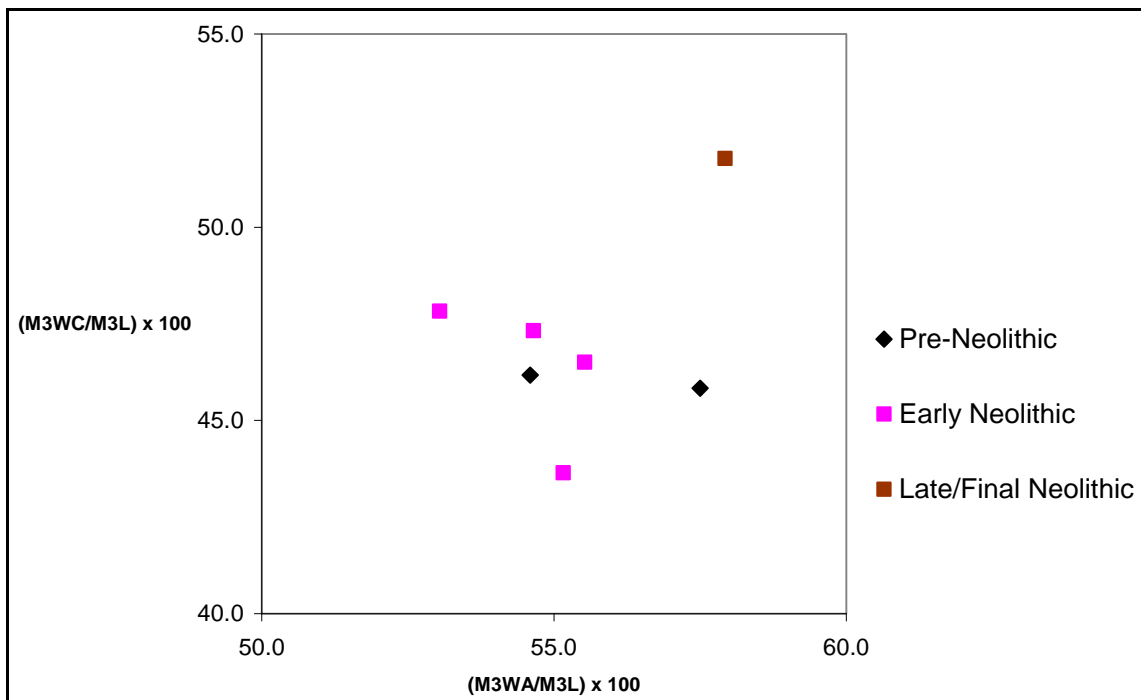


Figure 3.32: Ratio between width and length of pre-Neolithic, Early Neolithic and Late/Final Neolithic upper third molars.

Additionally to the scatterplots, log ratio histograms showing all pre-Neolithic and Neolithic tooth measurements have been produced. These histograms do not include tooth crown length measurements as these were taken differently from the measurements of the standard population (Late Neolithic Durrington Walls, England). Although it has been found not to significantly affect the third molar crown length, this measurement has also been excluded to ensure consistency.

More assemblages and measurements are represented in the histograms than in scatterplots and thus a more general picture, though at lower resolution, becomes available. Figure 3.33 compares general tooth size between pre-Neolithic, Early Neolithic and Late/Final Neolithic combined samples. As expected, histograms are consistent with the results presented in the scatterplots. Pre-Neolithic pigs are on average the largest. Early Neolithic pigs are slightly smaller than their pre-Neolithic counterparts, while during the Final/Late Neolithic tooth size appears significantly reduced (also proven statistically for at least the second and third mandibular molars; see table 3.13). Compared to postcranial measurements (figure 3.21), there is more size overlap indicating that size reduction occurred more slowly in teeth, although the general evolutionary trend is the same. The sharpest size decrease in teeth,

as well as in postcranial bones, occurs between the earlier (6th millennium cal. BC) and later (4th millennium/beginning of 3rd millennium cal. BC) phases of the Neolithic period.

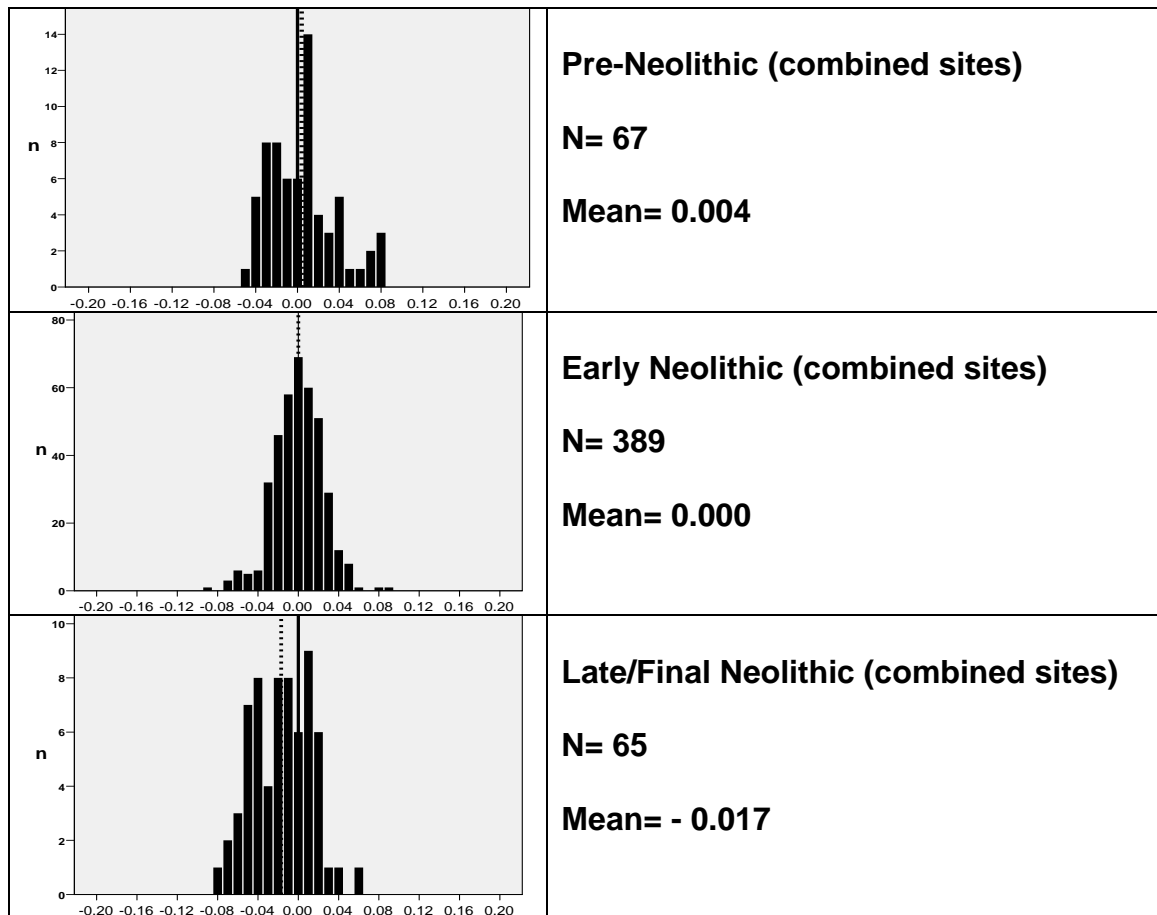


Figure 3.33: Log ratio histograms comparing pig tooth measurements from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology.

In addition to the comparison of combined measurements from different periods (figure 3.33), possible size differences between sites (or grouped sites of similar chronology) are explored. Figure 3.34 depicts pre-Neolithic tooth measurements divided into a purely Magdalenian sample from Zatoia and a sample combining the rest of Palaeolithic-Mesolithic measurements; Early Neolithic samples are presented per site and the Late/Final Neolithic measurements as a combined sample at the bottom of the stack. The size difference between the two pre-Neolithic samples can be attributed partly to the small size of the sample without the measurements from Zatoia and partly to the presence of some large Mesolithic specimens in that sample (i.e. those that plot at the right of the distribution). From the Early Neolithic assemblages, the largest tooth size is observed at Cova Fosca and the smallest at Sant Pau, while at Cueva Chaves,

Cueva de la Vaquera and La Draga tooth size is approximately similar to that of the pre-Neolithic Zatoia sample. Compared to the Late/Final Neolithic, all pre-Neolithic and Early Neolithic teeth (except Sant Pau) are larger on average. In general, the small tooth size observed at Sant Pau (i.e. smaller than the general Late/Final Neolithic size) and the large size observed at Cova Fosca highlight a picture of diversity in the size of Early Neolithic populations. Moreover, an important consideration is that the two smallest-sized populations (Sant Pau and La Draga) and the largest-sized population (Cova Fosca) all derive from the Catalanian-Valencian region. Also noteworthy is the fact that the three largest-sized Early Neolithic populations derive from cave sites (Cova Fosca, Cueva Chaves and Cueva de la Vaquera), while the remaining two smallest-sized populations are from open air sites (Sant Pau and La Draga).

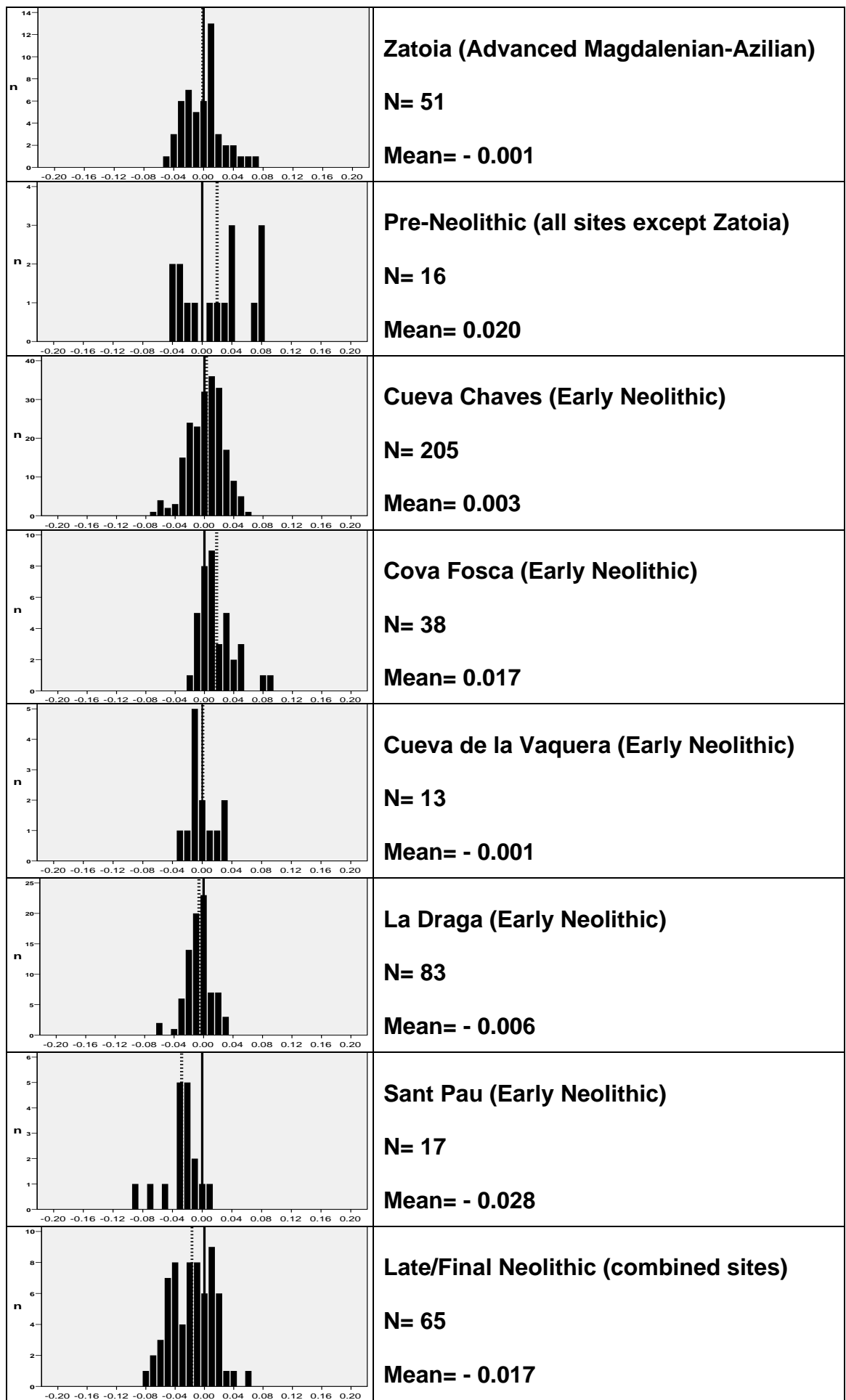


Figure 3.34: Log ratio histograms comparing pig tooth measurements from Early Neolithic sites with combined samples of pre-Neolithic and Late/Final Neolithic chronology.

A similar analysis to the one presented in figure 3.34 has been carried out on the Late/Final Neolithic material, although the samples are in most cases small (figure 3.35). The Late Neolithic population of La Renke presents a size similar to that of La Draga. The same is true for the Middle/Late Neolithic sample from Los Castillejos. On the other hand, the Final Neolithic specimens from Los Castillejos show significantly smaller size, similar to that of the smallest Early Neolithic specimens observed at Sant Pau. Based on the sequence of two samples from Los Castillejos, tooth size reduction seems to have been still in progress in the later stages Neolithic. Excluding the small sample of Los Barruecos, all Late/Final Neolithic populations had, on average, smaller teeth than the Early Neolithic and pre-Neolithic populations presented at the base of the stack.

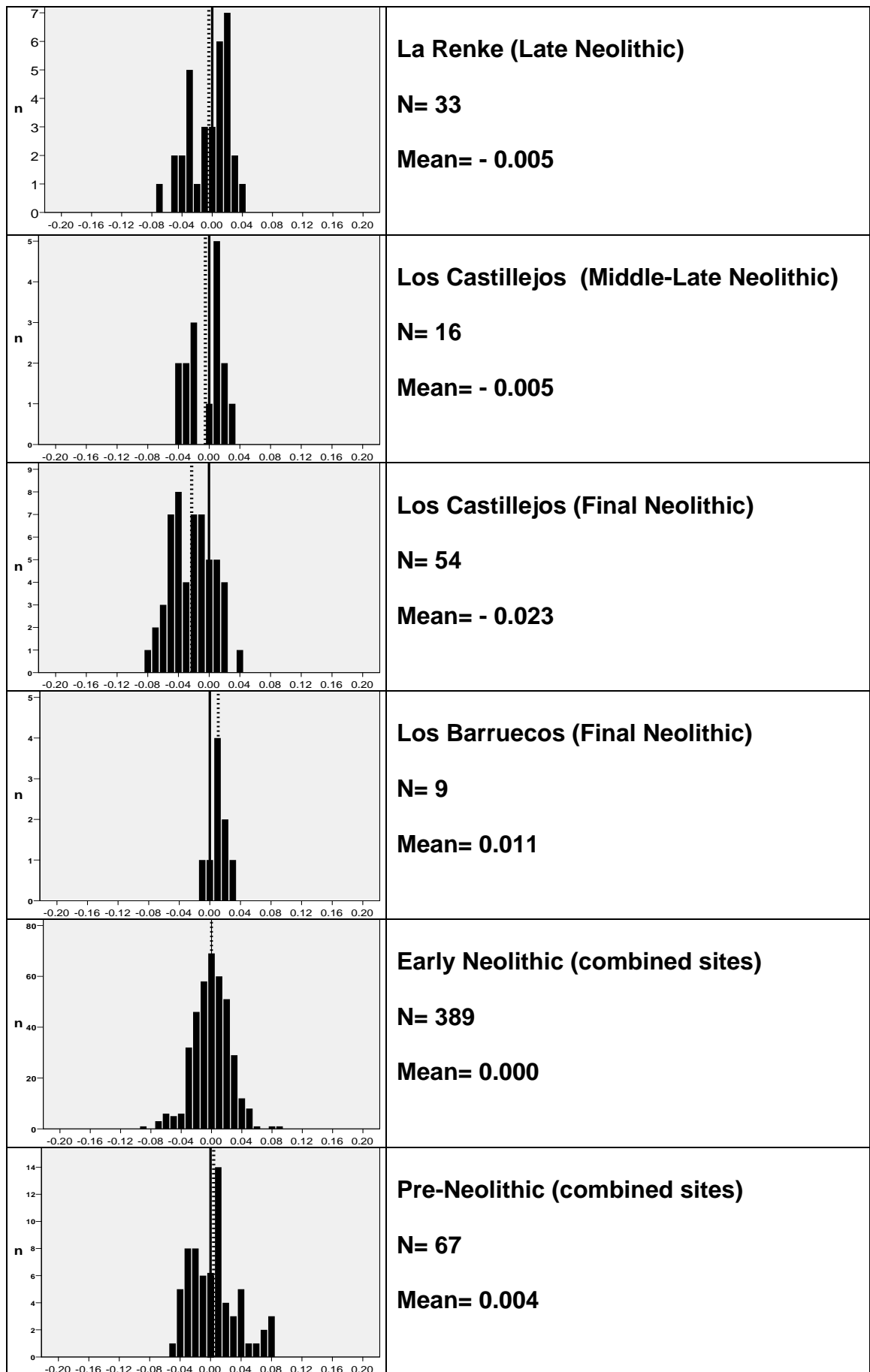


Figure 3.35: Log ratio histograms comparing pig tooth measurements from Middle, Late and Final Neolithic sites with combined samples of pre-Neolithic and Early Neolithic chronology.

3.4 Summary

In order to obtain an overview and compare size fluctuations in bones and teeth occurring before and during the Neolithic, a graph based on the log ratio mean values of all recorded measurements (figure 3.36) has been produced. The relationship between postcranial and dental elements has sporadically been discussed earlier in this chapter, but figure 3.36 allows examining this relationship in a synthesised way. According to the diagram, during the pre-Neolithic and Early Neolithic periods, pigs in Spain had larger bones than teeth. A reduction in both bone and tooth size is clear in the Early Neolithic but the most prominent size reduction occurred between the 6th and the 4th/beginning of 3rd millennium cal. BC (i.e. during the entire Neolithic period). The described size reductions affected both postcranial and dental elements, though not to the same degree. The reduction was clearly more pronounced in postcranial than dental size. It was only by the 4th millennium that bone and tooth sizes became proportionate to those of the standard British Late Neolithic population.

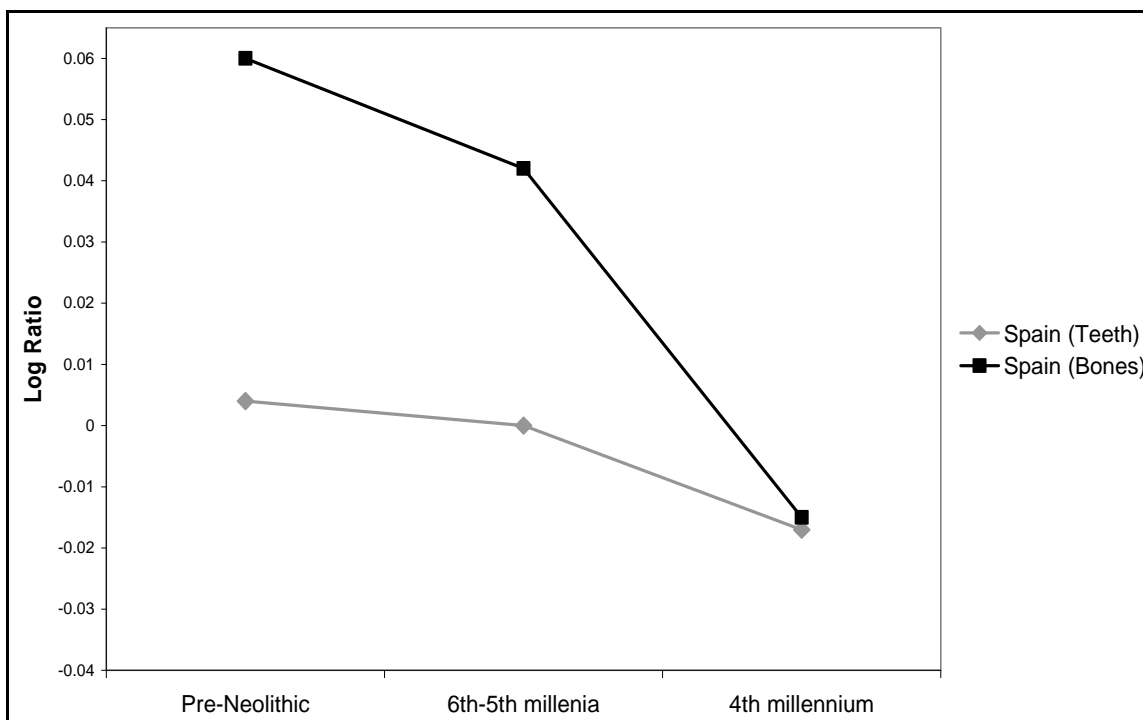


Figure 3.36: Graph illustrating the relationship between bone and tooth size through pre-Neolithic and Neolithic periods (ca. 10th-4th millennium cal. BC) based on the mean log ratio values of all recorded measurements (excluding the length of scapula neck for postcranial).

Measurements of pre-Neolithic specimens which presumably belong to the wild form are scarce but valuable as a comparison with Neolithic specimens. However, it is important to consider that wild boar size should not be regarded

as a fixed baseline since data from this and other studies (e.g. Albarella et al 2006b) show that this was not the case. Hence, any comparisons with supposedly domestic pigs must be made bearing in mind that the size of their wild counterparts varied through time (and presumably space).

The most reliable information about the sex and age structure of pre-Neolithic pig populations derives from Zatoia and suggests an equal representation of males and females and high mortality after the first year of life.

In biometry, the available data do not allow a detailed examination of changes in wild boar size over time but they exhibit a tendency towards a size increase in postcranial bones from the Neolithic onwards. This suggestion is based on a handful of postcranial measurements from Early Neolithic Cueva Chaves and Cova Fosca which are larger than those of any pre-Neolithic animal. Similar tendencies, though less pronounced, can be traced in tooth measurements. We must also consider that the vast majority of the pre-Neolithic specimens come from the northernmost part of Spain and are of Palaeolithic (rather than Mesolithic) date, thus probably lived under colder climatic conditions, which are known to increase animal body size (Bergmann 1847). Their reduced size in comparison to the Neolithic therefore assumes even greater significance and an increase in size during the Neolithic seems to represent a likely scenario.

An important site that contributes to our understanding of the situation in the Early Neolithic is Cova Fosca, where pig postcranial size was similar to that of pre-Neolithic wild boar. This raises the possibility of the whole pig population of Early Neolithic Cova Fosca being wild. This possibility becomes even more probable if we consider that in the latest excavations at Cova Fosca and preliminary analysis of the assemblage only wild species have been identified in the Early Neolithic levels (Llorente 2007). In the Middle Neolithic levels sheep/goat become dominant, while pigs were very scarce. The fact that Cardial pottery was present in the Early Neolithic levels highlights the dynamism of this transitional period. Given that the evidence for pottery is not the result of disturbed contexts (Zilhão 2001), this suggests that the site belongs to what we could define as a pre-husbandry Neolithic. The existence of sites such as Cova Fosca provides evidence against the hypothesis that the Neolithic traits (mainly

pottery, domesticates, polished axes and restricted mobility) were adopted as a package everywhere.

Cueva Chaves, with the largest Early Neolithic assemblage in Spain, has generated interesting results. At this site the pigs were of similar size to Cova Fosca, both in teeth and bones, but their interpretation is aided by more lines of evidence than biometry. Unlike Cova Fosca, more than half of the Early Neolithic assemblage at Cueva Chaves was comprised of the bones of domestic species (Castaños 2004). Moreover, according to the stratigraphy of the site, there is a stalagmitic level separating the Palaeolithic and the Neolithic levels. While during the Palaeolithic levels just a single pig remain has been reported from a total of more than 1100 identified remains (Castaños 1993), in the Neolithic levels more than 1371 pig remains were identified from a total 12754. Additionally, the age structure of the pig population, especially the particularly high percentage of 'neonatal' remains, suggests the rearing of pigs within the cave. This is in contrast to the available pre-Neolithic data, which show increased mortality after the first year. Lastly, the slight predominance of female pig jaws may be the result of strategies which allowed more reproducing females than males to reach adulthood. Again this contrasts with the pre-Neolithic data from Zatoia that show an equal representation of males and females.

Overall, it seems likely that the pig remains from Cueva Chaves are the combined result of slaughtered domestic pigs and hunted wild boar. The proportions are difficult to estimate because, although the age structure and species composition suggest a domestic economy, the size was generally similar to that of pre-Neolithic and Cova Fosca wild boar. This is likely to be the case of a population that was domesticated but had not yet developed the morphological traits that are characteristic of domestic animals.

The evidence from Early Neolithic La Draga reveals a biometrically different and generally smaller-sized pig population. The level of size reduction between pre-Neolithic sites and La Draga is, however, much more pronounced in bones than teeth. As is well known from previous studies (Payne and Bull 1988), teeth are less plastic than bones and react to environmental stimuli more conservatively.

Consequently, as it has been demonstrated for other European areas (e.g. Albarella et al 2006b: 221), bones decrease more rapidly than teeth during the domestication process, as long as there is some level of genetic separation between wild and domestic populations. Though scarce, age and sex data reveal a slight female majority in jaw counts, high mortality in the first year and a presence of neonates. These results support the hypothesis that the Early Neolithic pig population of La Draga – dating to as early as the end of the 7th or early 6th millennium cal. BC - was predominately domestic. It is interesting to note that the three largest Early Neolithic assemblages available to this study - Cueva Chaves, Cova Fosca and La Draga – offered support to three different scenarios, demonstrating the complexity and diversity of the process of neolithisation.

The remaining two Early Neolithic sites of Cueva de la Vaquera and Sant Pau provided limited but important data. The postcranial size at La Vaquera is similar to that of La Draga and, considering that La Vaquera revealed a predominately domestic economy (Morales and Garcia 1998), the presence of domestic pigs, as at La Draga, can be considered as the most probable scenario. The available tooth measurements from Sant Pau, a site of later chronology within the Early Neolithic and with an almost exclusively domestic economy (Colominas et al 2008), add another perspective to the interpretation of Early Neolithic data. Despite the small sample, it is clear that the pigs of Sant Pau had smaller teeth than all other, chronologically earlier, Early Neolithic populations. This suggests that by the end of the 5th millennium cal. BC some domestic pig populations, such as that of Sant Pau, had either been already transformed by husbandry strategies or represent the introduction of morphologically distinct animals.

Despite the scarcity of assemblages from the later phases of the Neolithic, the presented results in both bones and teeth suggest that a significant reduction in size occurred in this period. This can also be statistically proved for most measurements, both postcranial and dental. Size reduction was general, though more pronounced in postcranial than dental elements. Another interesting observation about the Late/Final Neolithic is the presence of few particularly large individuals which are usually as large as or even larger than their largest

pre-Neolithic and Early Neolithic counterparts. It seems that by the end of the Neolithic, the size overlap between the domestic and wild form was reduced to a degree which makes the two forms biometrically distinct. It is important to keep in mind that this process that rendered the domestic and wild form biometrically distinguishable works in both ways. Not only the domestic pigs reduced in size but also possibly the wild boar increased in size.

To conclude, the pre-Neolithic and Early Neolithic data have the potential to shed new light on the process of pig domestication in Spain. Unfortunately the resolution of the presented results remains low for most sites. However important inferences can be drawn from them. A synthesis of results over broad chronological and geographical spans, never attempted before with a focus on pig domestication, has the potential to set up a framework and put forward possible scenarios, which will hopefully provoke and facilitate future research on this topic.

The results and their interpretation presented in this chapter, revealed age, sex and biometric differences between pre-Neolithic and Neolithic pigs, which are probably related to the process of domestication. The tendency of younger culling age and slight predominance of females during the Early Neolithic contrasts with the older culling age and equal representation of males and females in pre-Neolithic material. In addition to this, the indication of some size reduction at certain sites, especially those of the Mediterranean coast, may be another indication of pig management. However, there are some Early Neolithic sites (e.g. Cova Fosca) that show no indication of animal domestication, while in other sites (e.g. Cueva Chaves) biometric similarity with the local wild boar raises the possibility of an involvement of local wild stock in the domestication process. This hypothesis is supported by the fact that, in the Neolithic as a whole, the size of the teeth was reduced much less and with delay compared to the bones. Moreover, recent genetic evidence for Europe strengthens the hypothesis that both local and introduced stock took part in the process of pig domestication in Europe (Larson et al 2005).

In general, the Early Neolithic results draw a picture of diversity in the interactions between humans and pigs with all scenarios (i.e. entirely wild

populations, mixed populations, and predominately domestic populations) finding some support in the presented data. This diversity can be explained partly chronologically, as some of the analysed assemblages being of earlier or later chronology in the Early Neolithic; but also partly geographically, as lowland open-air sites provide stronger evidence for the presence of domestic pigs – and domestic animals in general - than montane cave sites (*cf.* Altuna and Mariezkurrena 2009: 155-156). Despite the paucity of Late/Final Neolithic data, the results provide sound evidence for a completed morphological change which renders the domestic form biometrically distinguishable from the wild form, at least on a population level. In the following two chapters, the process of pig domestication is investigated in post-Neolithic chronology, as well as in a broader chronological framework with comparisons with relevant European regions such as Portugal, France, Italy and Britain.

Chapter 4. Late prehistory (Copper, Bronze and Iron Ages): evolution of pig husbandry and interactions with wild boar populations

The material presented in this chapter derives from 27 archaeological sites distributed over most of Spain. The chronological coverage by geographic area is uneven but sites of all main periods are available for the country as a whole. The Copper Age is represented by 2499 postcranial and 619 dental remains, the Bronze Age by 721 postcranial and 522 dental remains and the Iron Age by 1531 postcranial and 1933 dental remains. Additionally, 98 postcranial and 70 dental remains are dated to the transition from Bronze to Iron Age. Although it has already been presented in the 'Materials and methods' (chapter 2), the geographical and chronological distribution of the late prehistoric material is repeated in figure 4.1 and table 4.1 for ease of reference.



Figure 4.1: Map of Spain indicating the approximate location of analysed assemblages containing Copper, Bronze and Iron Age material.

Table 4.1: Overview of analysed assemblages containing Copper, Bronze and Iron Age material. Sites are listed in approximate chronological order.

	Site	Chronology
15	Cueva del Moro	Neolithic-Bronze Age
16	Los Castillejos	Neolithic-Copper Age
17	La Renke	Neolithic (2700-3300 cal. BC)-Chalcolithic
19	Cueva de Abauntz	Chalcolithic
20	Los Husos I	Eneolithic
21	Las Pozas	Chalcolithic
22	Los Millares	Copper Age
23	Valencina de la Concepción	Copper Age (around 2100 cal. BC)
24	Fuente Álamo	Bronze Age 'Argar A' (1850 cal. BC)
25	Cerro de la Encina	Bronze Age, including 'Argaric' period
26	Monte Aguilar	Middle-Late Bronze Age
27	Acequión	Bronze Age (2000-1500 cal. BC)
28	Morra de Quintanar	Bronze Age
29	Cueva Rubia	Copper and Bronze Age (14th -16th c. cal. BC)
30	Bastida de Totana	Bronze Age (1675-1100 cal. BC)
31	El Castillar de Mendavia	Final Bronze-Iron Age I
32	La Hoya	Middle Bronze-Iron II
33	Castros de Lastra (Carranca)	Middle Bronze-Iron II
34	Las Rabas (Celada Marlantes)	Iron Age II
35	Castro de Berbeia	Iron Age-Roman
36	Cerro de la Cruz (Cortes de Navarra)	Iron Age
37	Castillo de Henayo	Final Bronze Age-Iron Age I
38	Peñas de Oro	Iron Age-Roman
39	Campa Torres	Iron Age (7th-6th centuries BC)
40	Soto de Medinilla	Iron Age I-II
41	Santa Ana 2	Iron Age
42	Calle Puerto 10	Iron Age ('Tartessian')
43	La Mota	Transition Iron Age I-II

4.1 Sex Ratios

Sex ratios are estimated on the basis of the morphology of lower and upper canines and their alveoli. In most cases, the samples are large enough to produce reliable results but there are a few assemblages which offer limited or no information about the sex structure of the pig population they represent.

4.1.1 Copper Age

We have a good volume of sexing data for this period, particularly due to the large sample from Valencina de la Concepción (Sevilla province, Andalusia). At this site recovery was exclusively by hand and this should be taken into account in the interpretation of the results in order to identify possible biases against the smaller - when isolated - female canines. When the combined total of upper and lower jaws is considered (left half of figure 4.2), females are more abundant (31) than males (15). Regarding loose canines (right half of figure 4.2) the ratio is inverted in favour of the males - 42 males as opposed to 20 females. This could be, at least partly, attributed to a recovery bias in favour of the larger male canines. A predominance of females therefore represents a more realistic scenario at Valencina de la Concepción. This is an interesting pattern that seems to deviate from the, admittedly scarce, indications of a more even sex representation noted in Neolithic and pre-Neolithic assemblages (chapter 3).

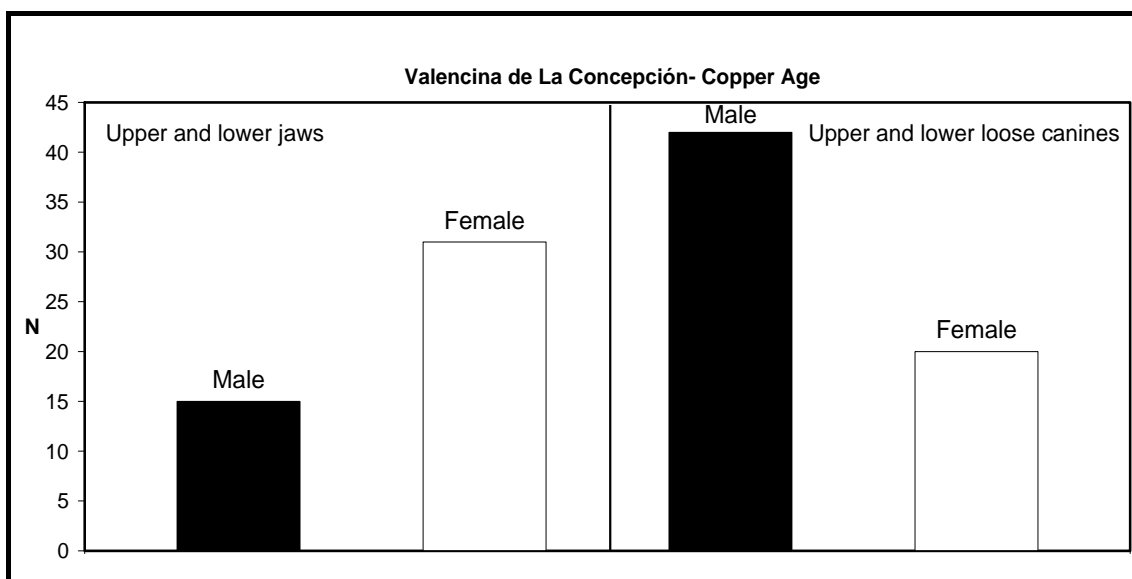


Figure 4.2: Sex ratios for Copper Age Valencina de la Concepción based on jaws (left) and loose canines (right).

Although the rest of the Copper Age assemblages yielded small samples, their sex structures seem to generally corroborate the pattern identified at Valencina de la Concepción. At Los Millares (Almeria province, Andalusia, figure 4.3), Los Castillejos (Granada province, Andalusia, figure 4.4), Cueva Rubia (Palencia province, northwest Spain, figure 4.5) and Las Pozas (Madrid area, central Spain, figure 4.6) there are also indications that more female than male pigs reached maturity, or at least an age in which canines can be reliably sexed. Of

particular interest is the observation that at the Early Copper Age sites of Cueva Rubia and Las Pozas there is already a clear trend of a female predominance. This may be in continuity with the trend noticed in some Neolithic assemblages.

The exact male:female ratios cannot be inferred from such small samples. Nevertheless, the overall trend towards an adult female predominance is apparent. Taking the ratio produced by the data from Valencina de la Concepción (jaw count) as the most reliable Copper Age example, adult females were about twice as common as adult males in this period.

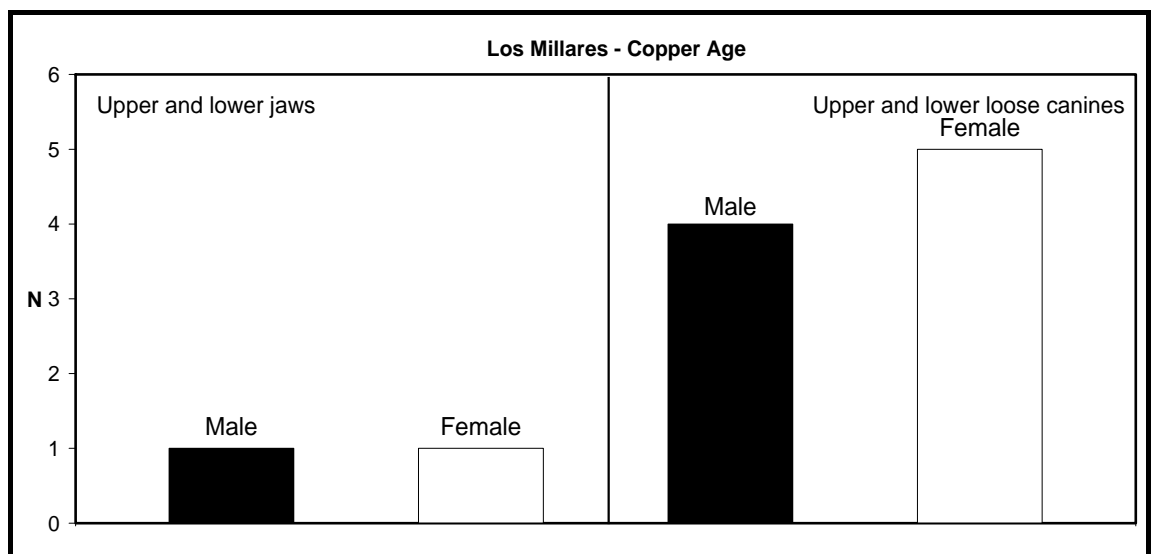


Figure 4.3: Sex ratios for Copper Age Los Millares based on jaws (left) and loose canines (right).

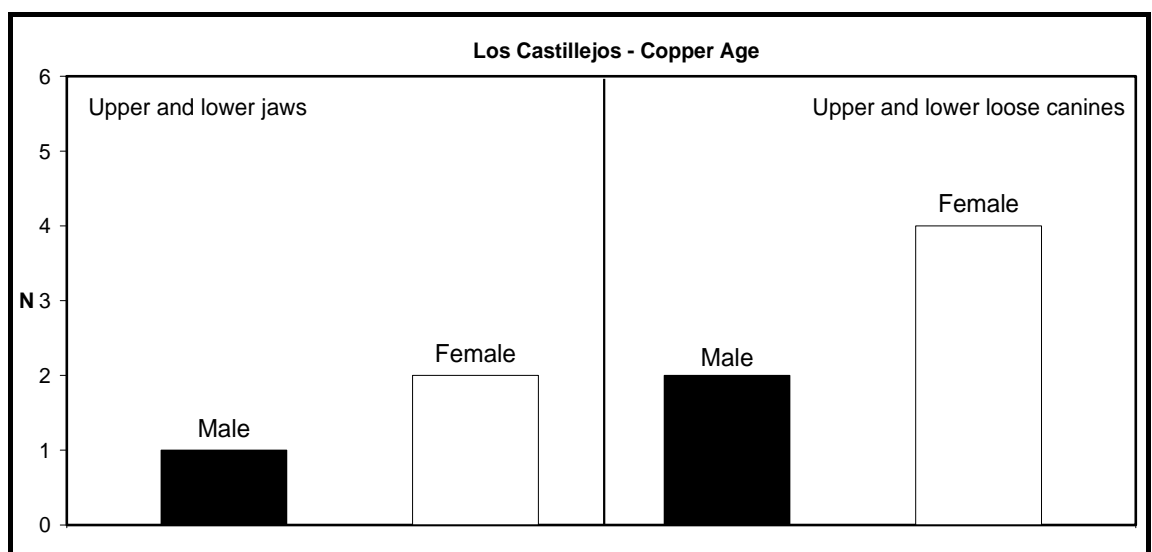


Figure 4.4: Sex ratios for Copper Age Los Castillejos based on jaws (left) and loose canines (right).

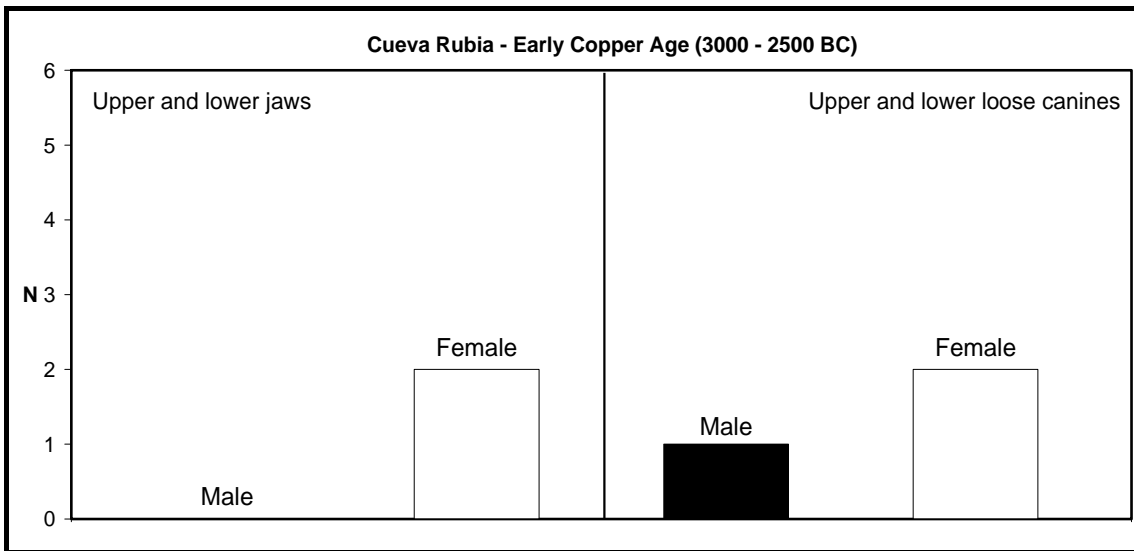


Figure 4.5: Sex ratios for Early Copper Age Cueva Rubia based on jaws (left) and loose canines (right).

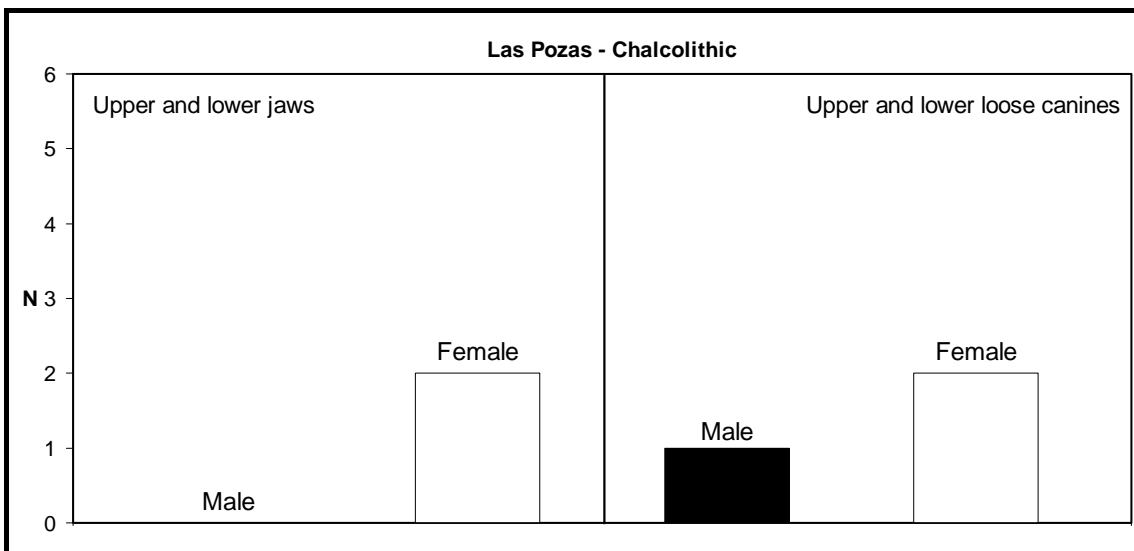


Figure 4.6: Sex ratios for Chalcolithic (Copper Age) Las Pozas based on jaws (left) and loose canines (right).

Despite the scarcity of sexed pig remains, the analysis of the Neolithic material produced a male:female ratio around 1:1, with only a slight trend towards an overall female majority in some assemblages (e.g. Cueva Chaves). The results based on the Copper Age assemblages indicate a definite trend towards a predominance of female animals.

4.1.2 Bronze Age

Although the Bronze Age assemblages produced interesting results as well, these should be regarded as tentative, particularly in view of the absence of large samples.

The largest sample is that of Middle/Late Bronze Age Monte Aguilar (Navarra), the results of which indicate a predominance of males (figure 4.7). This is a notable contrast in comparison to the trend for a female majority in the Copper and some Neolithic assemblages. Thus, it has to be evaluated with the rest of the data during interpretation.

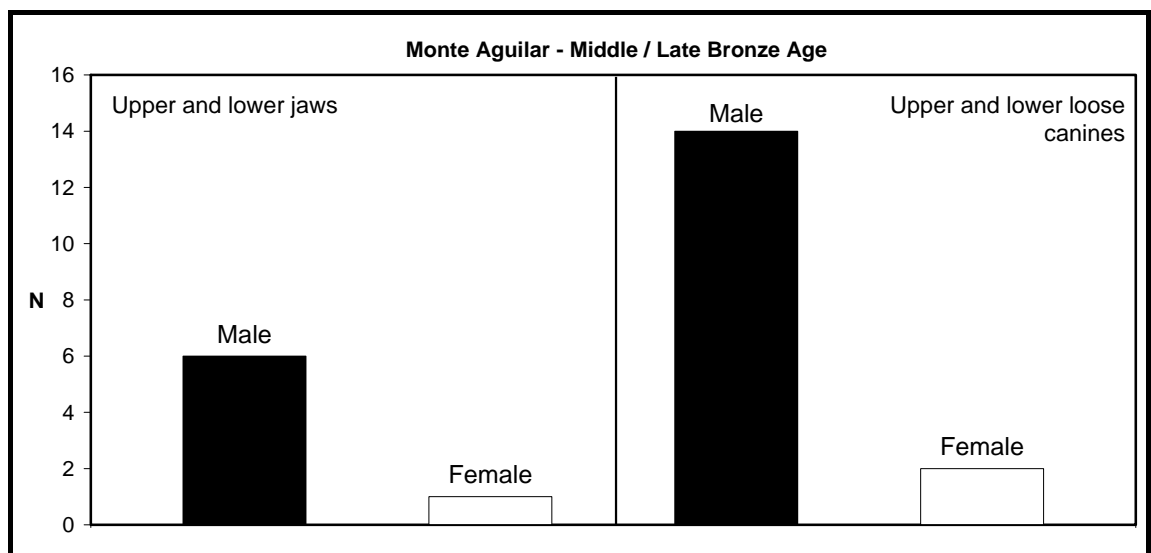


Figure 4.7: Sex ratios for Middle/Late Bronze Age Monte Aguilar based on jaws (left) and loose canines (right).

Morra de Quintanar (Albacete province, southeast Spain) displays a similar trend to that observed for Monte Aguilar (figure 4.8), but the sample of jaws is very small (only 2 males and 1 female). The more numerous loose canines exhibit a much clearer male predominance, but this may be affected by a recovery bias. Considering that in Copper Age sites (excluding Valencina de la Concepción) females were predominant even in the loose teeth count the result may, at least to some extent, be nevertheless genuine. Both sites, therefore, seem to divert from the overall tendency of a female majority identified in previous periods.

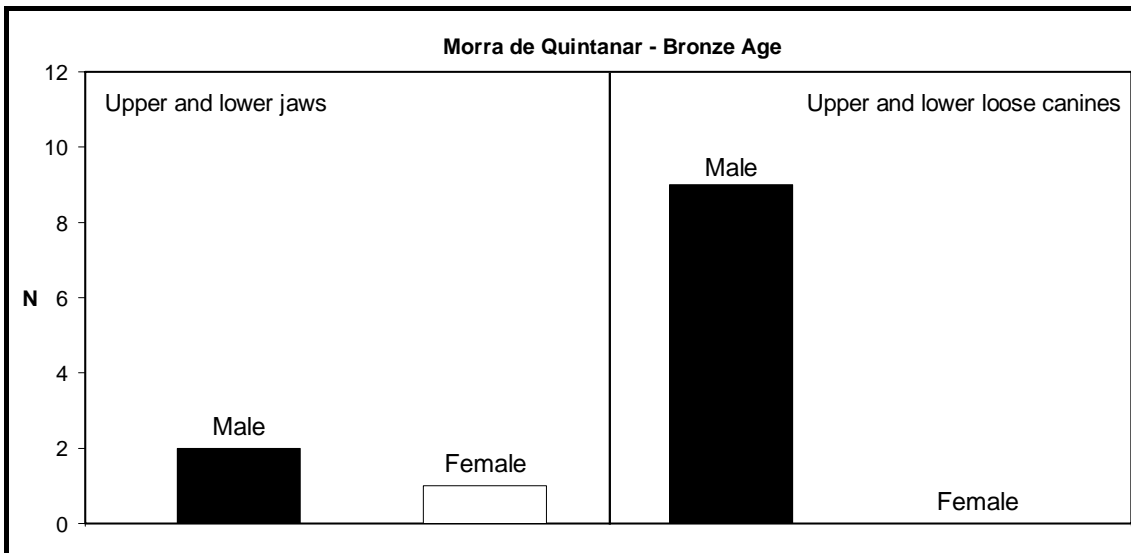


Figure 4.8: Sex ratios for Bronze Age Morra de Quintanar based on jaws (left) and loose canines (right).

At Acequión, another Bronze Age site from Albacete female pigs appear to be more abundant if only jaws are taken into account, (figure 4.9). Based only on loose canines, male are more abundant than female pigs. It is possible that at this site a recovery bias played a particularly important role, and therefore the results from jaws are more reliable.

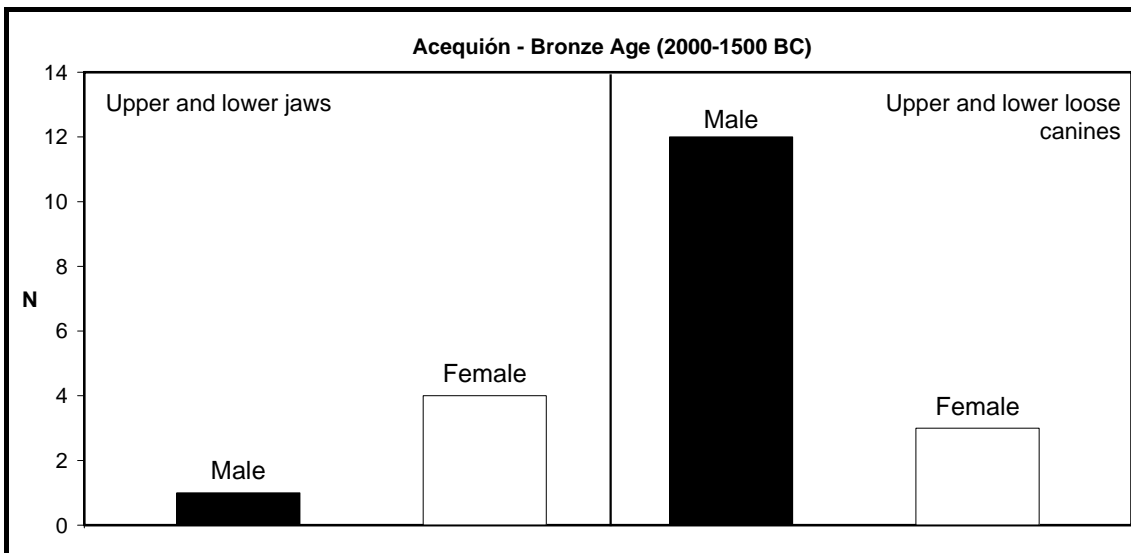


Figure 4.9: Sex ratios for Bronze Age Acequión based on jaws (left) and loose canines (right).

At Cerro de Encina (Granada province, Andalusia), when only jaws are taken into account, female pigs appear to be slightly more abundant, but, based only on loose canines, males and females are equally represented (figure 4.10). Thus, a slight female majority seems to be the most likely scenario at this site.

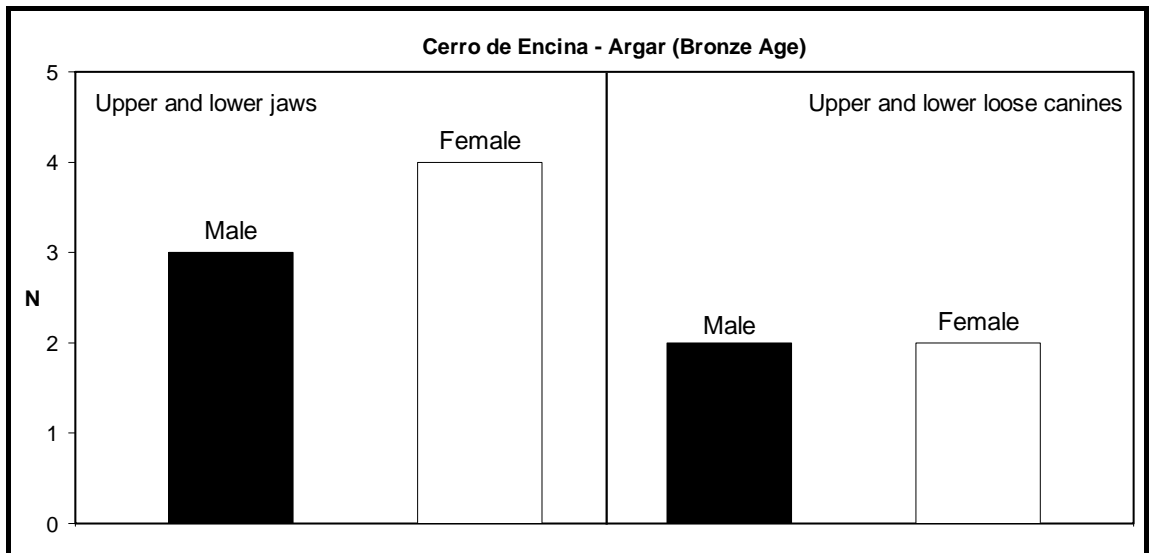


Figure 4.10: Sex ratios for Bronze Age (Argaric) Cerro de Encina based on jaws (left) and loose canines (right).

The assemblage of La Hoya (Álava province, Basque Country) mainly belongs to the Iron Age but also has Middle and Final Bronze Age levels. These levels yielded a relatively good-sized sample of pig jaws and loose canines. All 10 sexed jaws belonged to female pigs, and females are also predominant in the loose canine count though to a much lesser extent (figure 4.11). The pattern identified at this site seems to be similar to the Copper Age strategy of retaining a greater number of adult females.

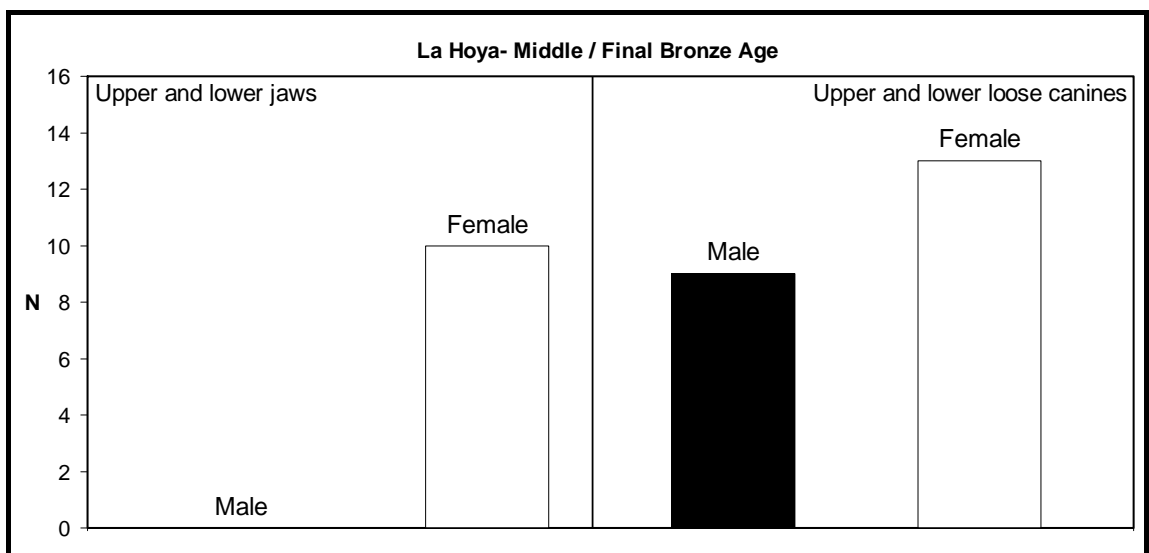


Figure 4.11: Sex ratios for Middle/Final Bronze Age La Hoya based on jaws (left) and loose canines (right).

The remaining two Bronze Age assemblages of Castillo de Henayo (figure 4.12) and Peñas de Oro (figure 4.13) are both of Final Bronze Age chronology and

derive from the same area as La Hoya, the Basque province of Álava. Both populations exhibit a strikingly similar sex structure with an absence of male jaws and a slight male majority in loose canines.

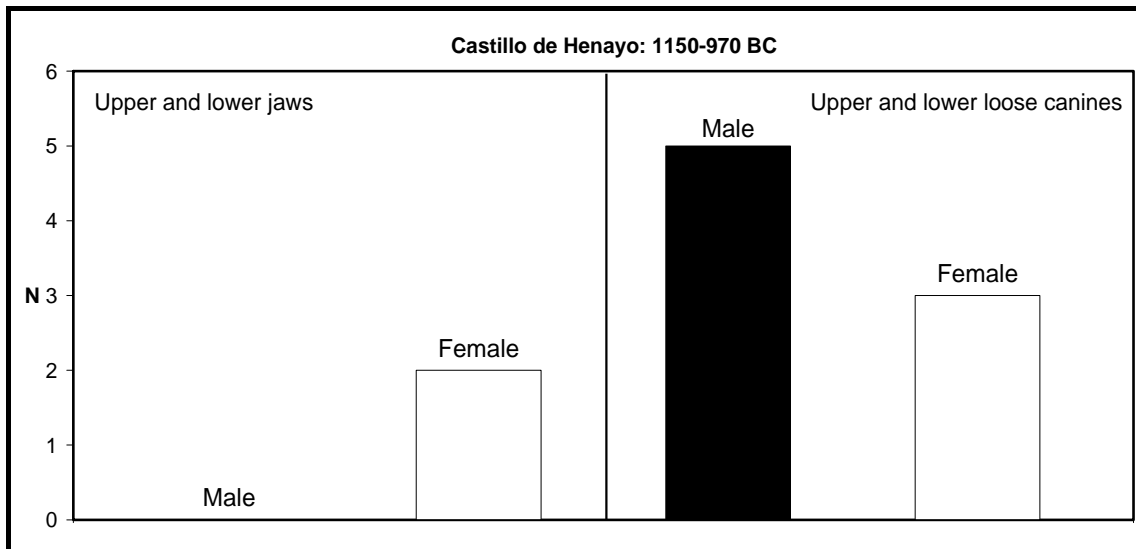


Figure 4.12: Sex ratios for Final Bronze Age Castillo de Henayo based on jaws (left) and loose canines (right).

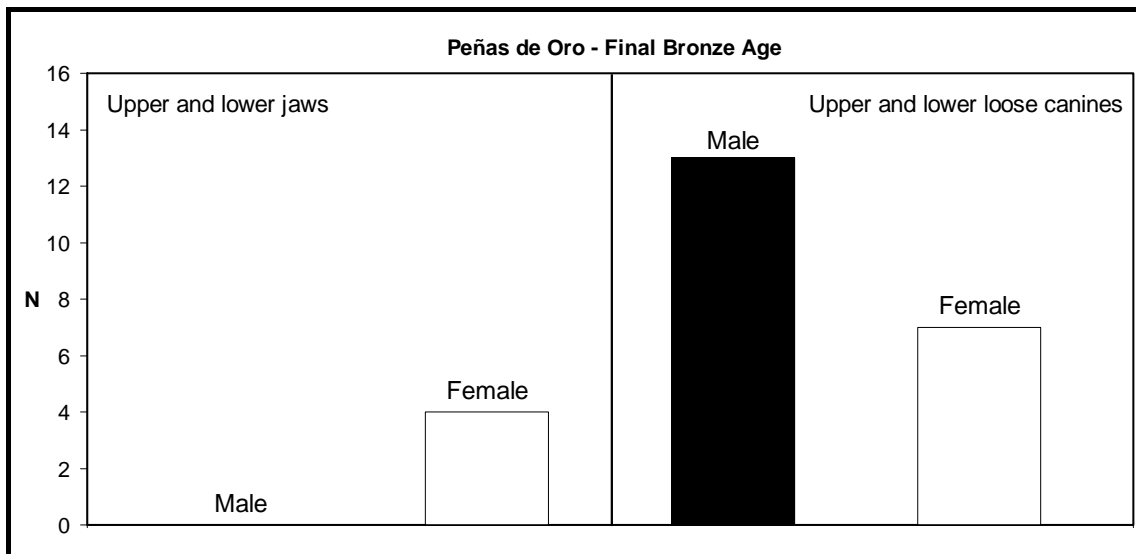


Figure 4.13: Sex ratios for Final Bronze Age Peñas de Oro based on jaws (left) and loose canines (right).

Overall, the results for the Bronze Age revealed that only some assemblages show a predominance of males but the majority points towards a greater number of females. Compared to the preceding periods, the sex structure of pig populations in this period appears more variable. The factors affecting the observed patterns are unarguably many (preservation, age-at-death,

domestic/wild status of specimens, etc). Furthermore, the small sample size makes any interpretation inevitably tentative.

4.1.3 Iron Age

The Iron Age is well represented in the recorded assemblages and this allows the drawing of a reliable picture of the sex structure of Iron Age pig populations. Data from 12 Iron Age assemblages which offer sexing information were recorded and are presented in this section.

Starting with the largest Iron Age sample of sexed pig remains, La Hoya (Álava, Basque Country), a female predominance is apparent in both Iron Age phases (I and II; figures 4.14 and 4.15). In both jaw and loose canine counts, female remains are more abundant. In Iron Age II, this trend is even more pronounced when only the, generally more reliable, jaw counts are taken into account.

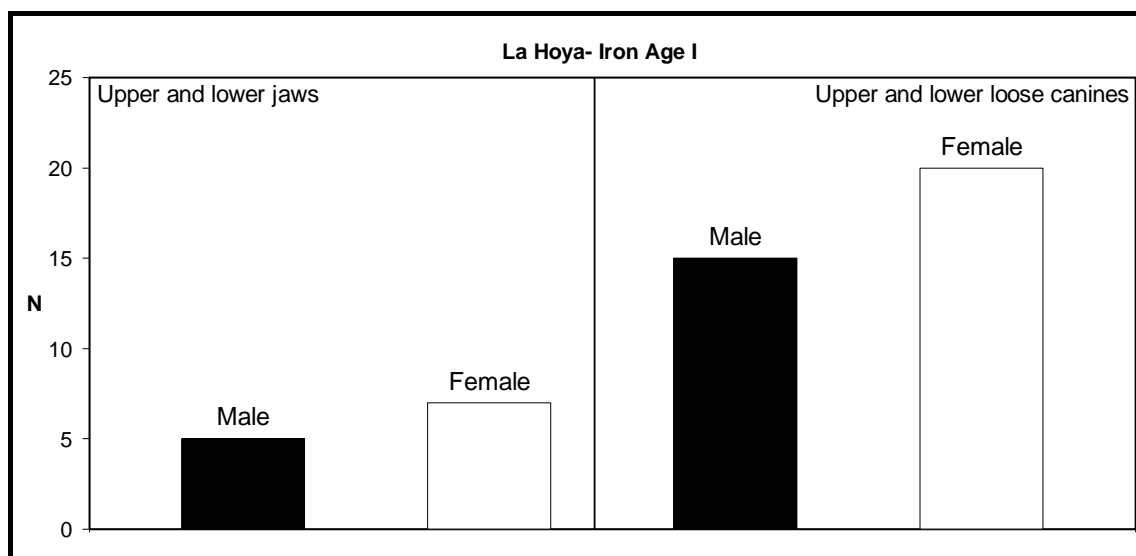


Figure 4.14: Sex ratios for Iron Age I La Hoya based on jaws (left) and loose canines (right).

As far as the differences between the different chronological phases of the site are concerned, these do not seem to be dramatic. However, in Iron Age II the ratio of female to male jaws increased to almost 5:1 (from approximately 1.5:1 in the Iron Age I). The female predominance in the Middle/Final Bronze Age levels of the same site (figure 4.11) is even more pronounced, but the results of the Iron Age are more reliable due to their much larger sample size.

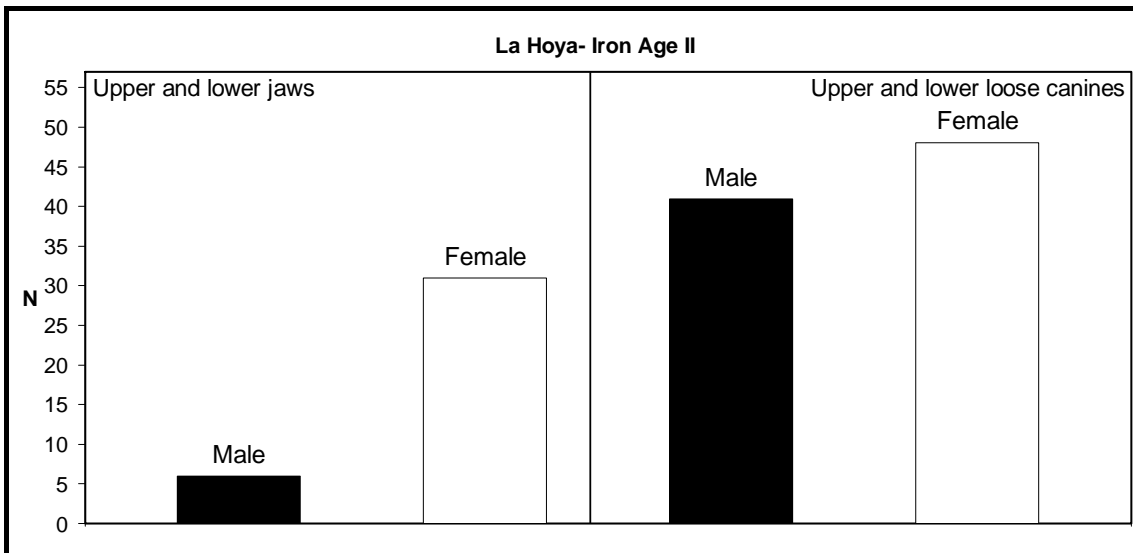


Figure 4.15: Sex ratios for Iron Age II La Hoya based on jaws (left) and loose canines (right).

When all Iron Age material (I and II) is combined (figure 4.16), the general picture is similar to the Iron Age II sample, with a comfortable female majority of almost 3.5:1 of sexed jaws. This was expected as the Iron Age II sample is larger than the Iron Age I. As in most sites presented so far, the difference between the sexes is not so pronounced in the loose canine count, but the female majority is nevertheless comfortably maintained.

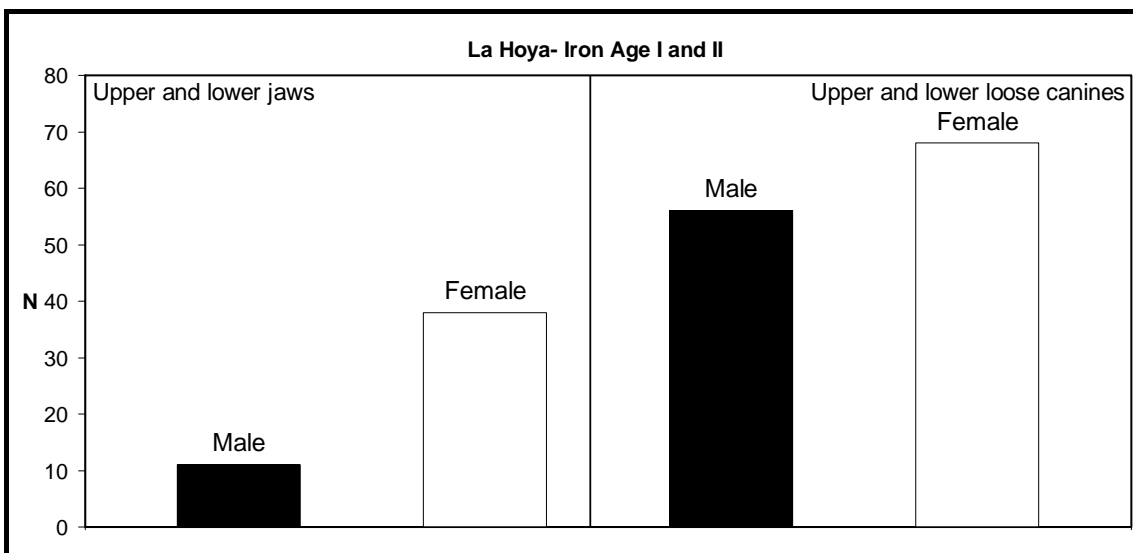


Figure 4.16: Sex ratios for Iron Age I and II La Hoya based on jaws (left) and loose canines (right).

La Hoya constitutes a useful assemblage for the analysis of diachronic changes in sex structure of pig populations, not only due to the large available samples but also because it offers a long stratigraphic sequence from the Middle Bronze

to the end of the Iron Age. In essence it provides useful insights into the exploitation of pigs throughout late prehistoric Spain.

Another assemblage from the Basque province of Álava in northern Spain is Castros de Lastra. As La Hoya, it is divided into Iron Age phases I and II. The Iron Age I sample is small (figure 4.17), with only four jaws and 19 loose teeth recorded, but, as far as its reliability goes, points towards a female predominance.

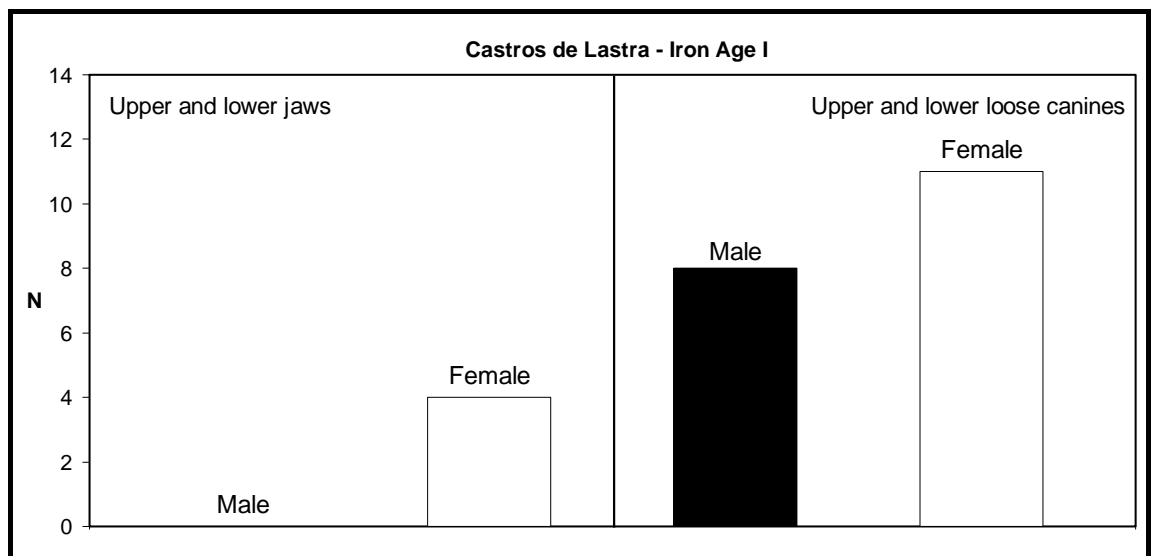


Figure 4.17: Sex ratios for Iron Age I Castros de Lastra based on jaws (left) and loose canines (right).

The Iron Age II sample (figure 4.18) is only slightly larger, with only seven jaws and 57 loose canines recorded. The picture is different from the Iron Age I sample, with a more balanced representation of the two sexes.

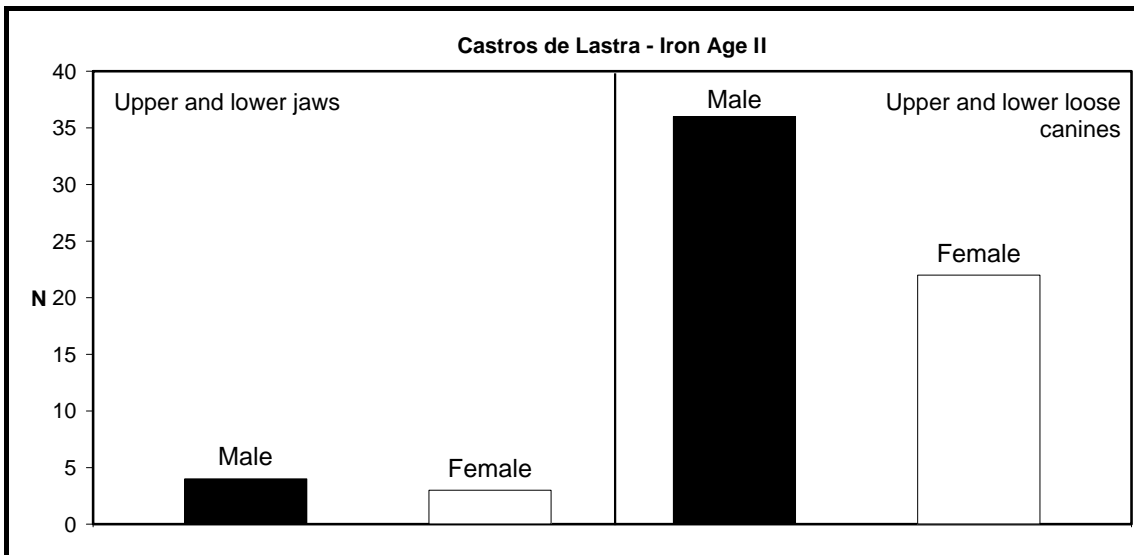


Figure 4.18: Sex ratios for Iron Age II Castros de Lastra based on jaws (left) and loose canines (right).

When the two phases are considered together (figure 4.19), the results show a slight predominance of females in the jaw count and of males in the loose canine count. Unlike La Hoya, at Castros de Lastra the two sexes seem to be roughly equally represented.

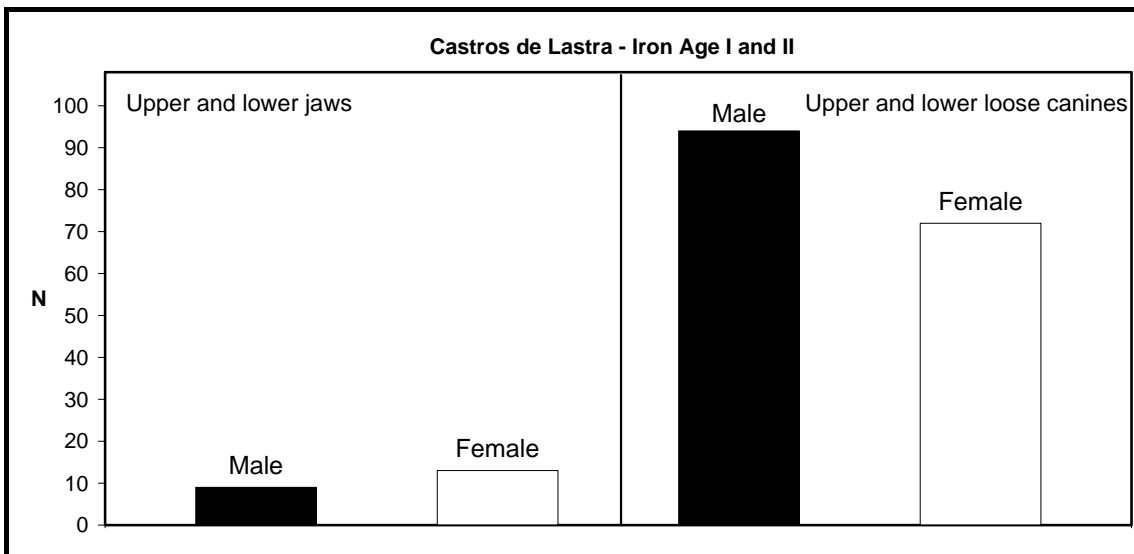


Figure 4.19: Sex ratios for Iron Age I and II Castros de Lastra based on jaws (left) and loose canines (right).

The Iron Age sites of Castillo de Henayo (Iron Age I), Peñas de Oro (generic Iron Age) and Castro de Berbeia (Iron Age I) are also in Álava and they are worth examining in comparison to the large samples of La Hoya and Castros de Lastra.

Overall, all three sites (figures 4.20, 4.21 and 4.22) show a female majority that tends to exceed the ratio of 2:1, especially in the more reliable jaw counts. This pattern is more similar to the pattern exhibited by the assemblage of La Hoya but also not very different from the combined Iron Age samples of Castros de Lastra.

The picture concerning sex ratios of Iron Age pig populations in Álava can be summed up by stating that a female majority is apparent throughout the Iron Age and in many sites it exceeds the ratio of 2:1. For some sites such as La Hoya, Peñas de Oro and Castillo de Henayo with Bronze and Iron Age levels, sex ratios are consistent in both periods, perhaps suggesting continuity in pig husbandry practices. There is a slight tendency towards an increase in female predominance later in the Iron Age, roughly from the 5th century BC onwards. Excluding Iron Age II Castros de Lastra, with its unusually high male percentage, all sites dating to the second half of the 1st millennium cal. BC have a clear female majority. Iron Age II La Hoya is the most characteristic example of this pattern.

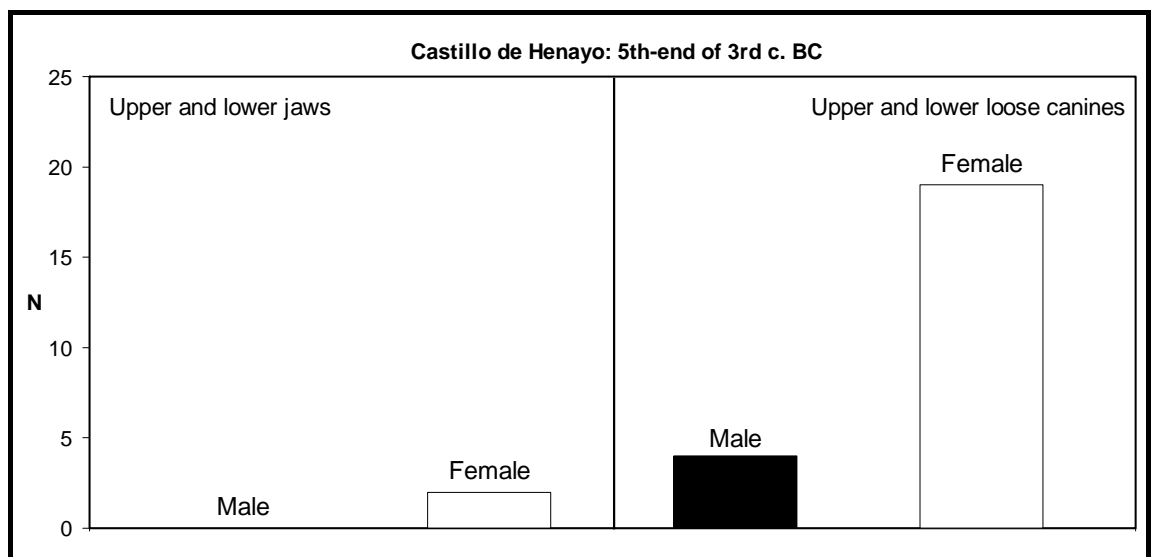


Figure 4.20: Sex ratios for Iron Age I Castillo de Henayo based on jaws (left) and loose canines (right).

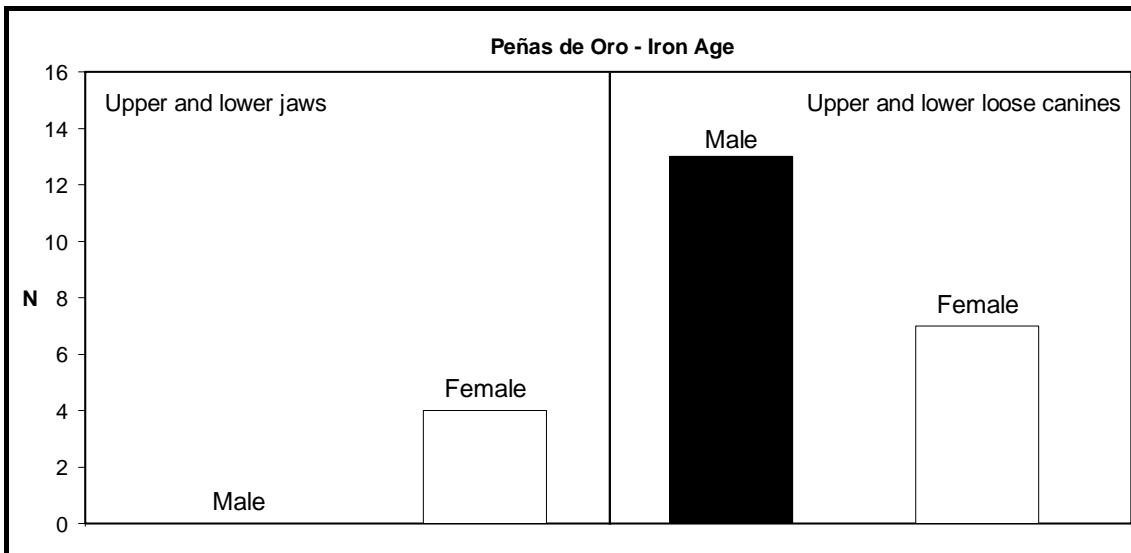


Figure 4.21: Sex ratios for Iron Age Peñas de Oro based on jaws (left) and loose canines (right).

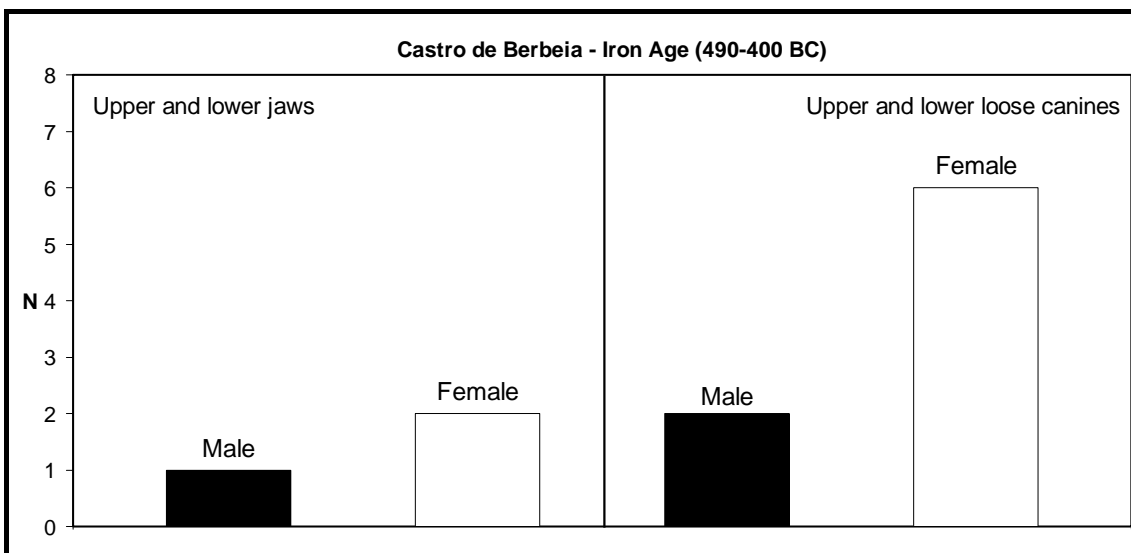


Figure 4.22: Sex ratios for Iron Age I Castro de Berbeia based on jaws (left) and loose canines (right).

Beyond the large group of Iron Age sites from Álava, more Iron Age assemblages from other areas of Spain were analysed to obtain information on the sex structure of pig populations.

From the adjacent area of Rioja to the south of Álava, the Iron Age assemblage from the site of Santa Ana exhibits the same pattern as in the sites from Álava (figure 4.23). The female majority in the more reliable jaw count is absolute. At the same time, males are the majority in the loose canine count; the same pattern has been observed in most previously presented Iron Age assemblages. As before, a recovery bias represents the most likely explanation for the apparent inconsistency between jaw and loose canine counts.

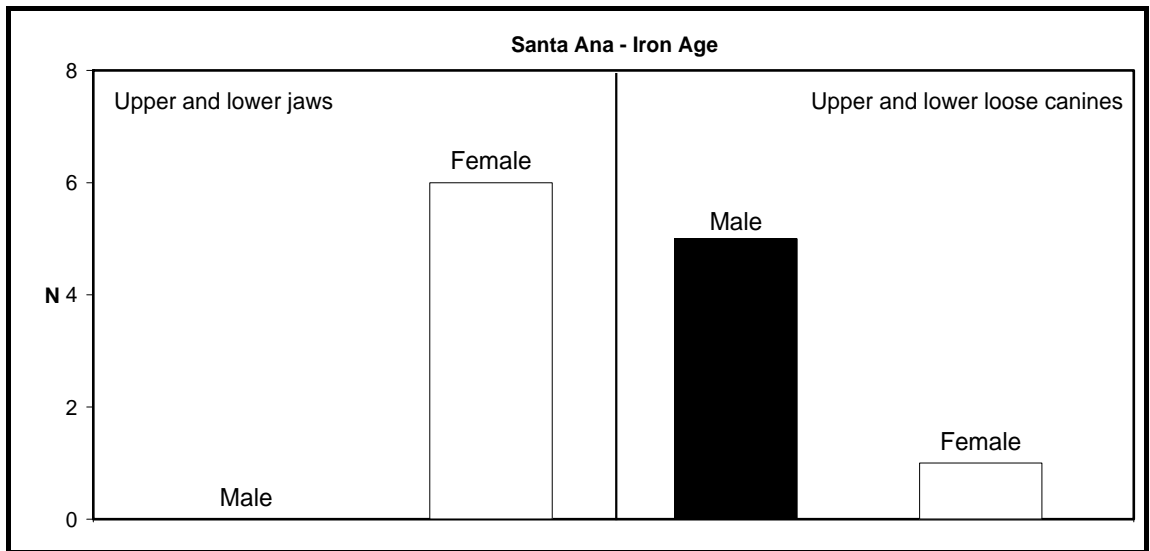


Figure 4.23: Sex ratios for Iron Age Santa Ana based on jaws (left) and loose canines (right).

The Iron Age I assemblage of Castillar de Mendavia (Navarra, also an area adjacent to Álava) suggests a narrow female majority in the jaw counts and exactly the opposite in the loose canine count (figure 4.24). Considering the small size of this assemblage it does not seem worth elaborating on this result in great detail, apart from noticing that it follows the same overall pattern identified in other Iron Age assemblages.

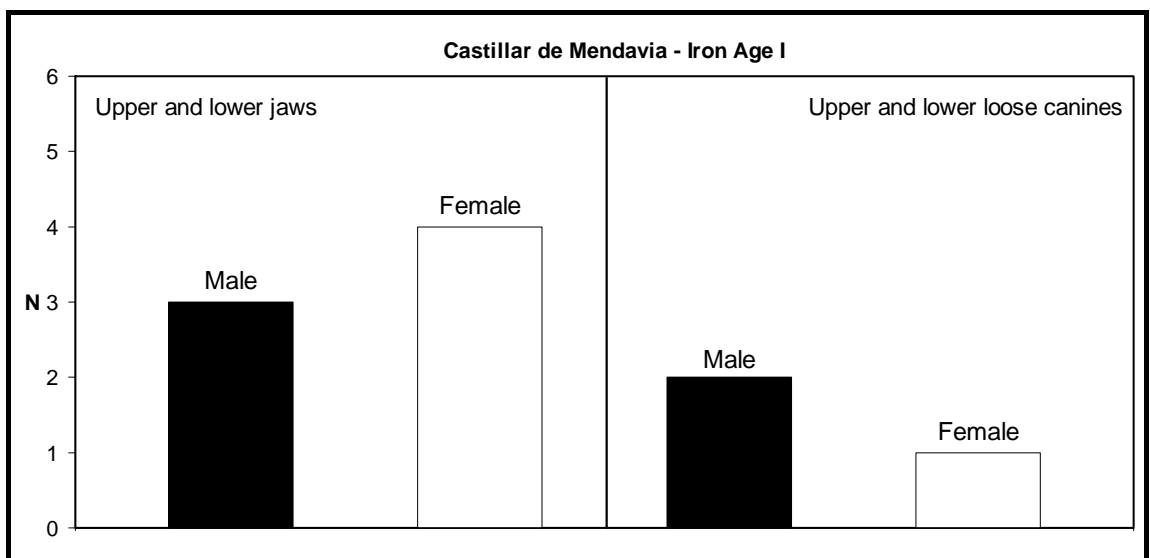


Figure 4.24: Sex ratios for Iron Age I Castillar de Mendavia based on jaws (left) and loose canines (right).

The Iron Age II assemblage from the site of Las Rabas (also known as Celada Marlantes) derives from northern Spain as well, and specifically from Cantabria. This sample confirms the general Iron Age tendency observed so far revealing a clear female predominance in the jaw counts (figure 4.25). Similarly to other

assemblages, the pattern is reversed when loose canines are taken into account, which is again a likely consequence of a recovery bias.

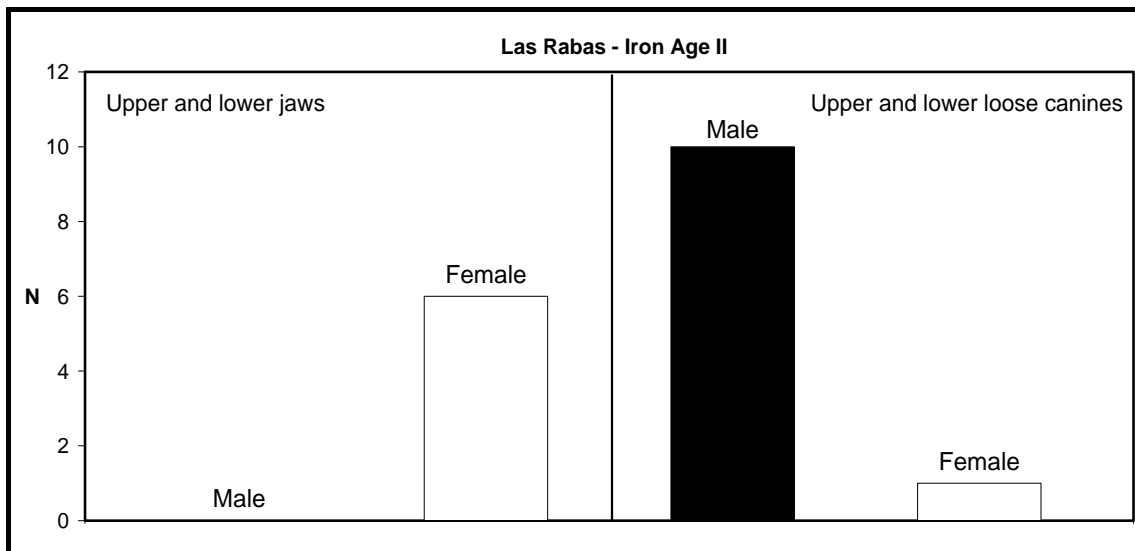


Figure 4.25: Sex ratios for Iron Age II Las Rabas (or Celada Marlantes) based on jaws (left) and loose canines (right).

Not far from the site of Las Rabas in the Cantabrian region, the Asturian hillfort of Campa Torres (6th-7th century BC onwards) offers a small sample of sexed pig canines (figure 4.25). Only one (female) jaw has been recorded but the female majority is confirmed by the loose canine count.

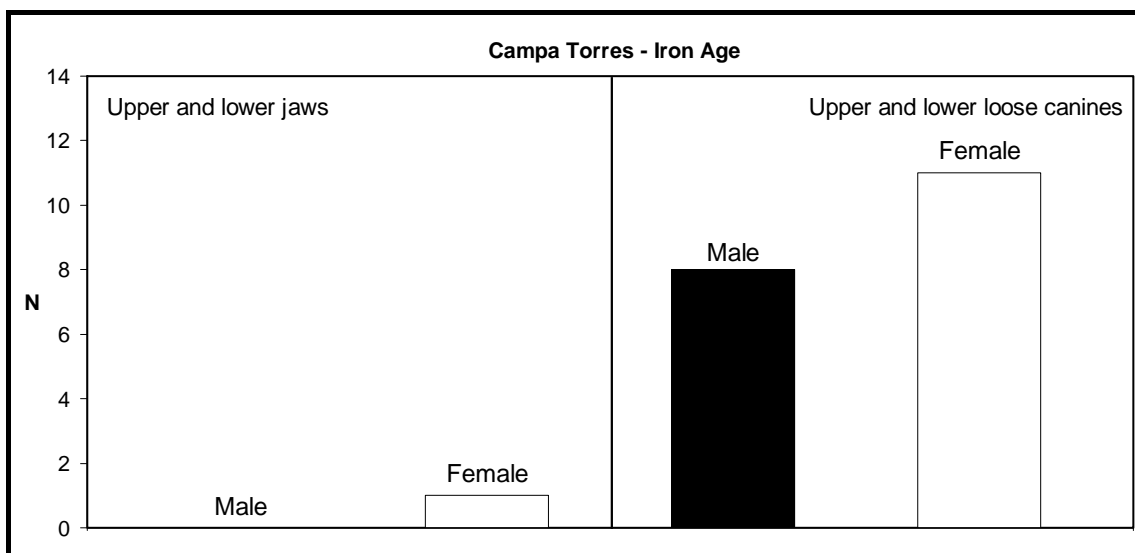


Figure 4.26: Sex ratios for Iron Age (6th-7th century BC) Campa Torres based on jaws (left) and loose canines (right).

Soto de Medinilla and La Mota, two assemblages from the northern central plateau (province of Valladolid) yielded viable samples of sexed pig remains (figures 4.27 and 4.28).

The relatively large sample from Soto de Medinilla offers useful insights in the sex structure of that pig population. Similarly to La Hoya and most other Iron Age assemblages, the sample from Soto de Medinilla reveals a clear female majority, exceeding 6:1 in jaw counts from Iron Age I and II samples combined (figure 4.27). The Iron Age I and Iron Age II samples produced almost identical results and hence are not presented separately here.

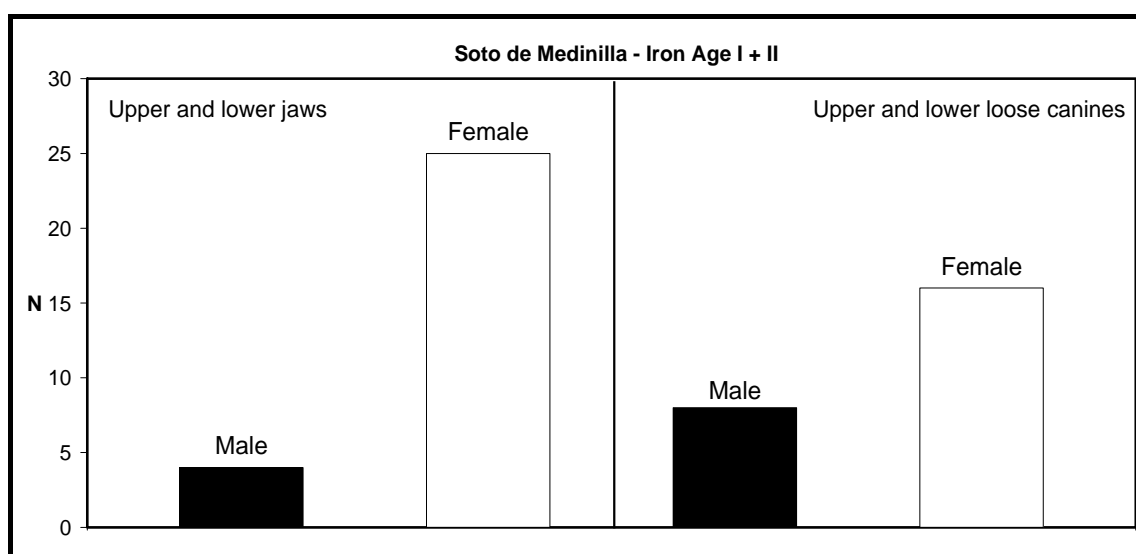


Figure 4.27: Sex ratios for Iron Age I and II Soto de Medinilla based on jaws (left) and loose canines (right).

The second assemblage from Valladolid, the Iron Age (transition Iron I-II or 6th-5th century BC) site of La Mota, has produced a ratio of more than 2:1 in favour of female pigs (figure 4.28). This confirms once more the tendency for an overall female majority in the Iron Age.

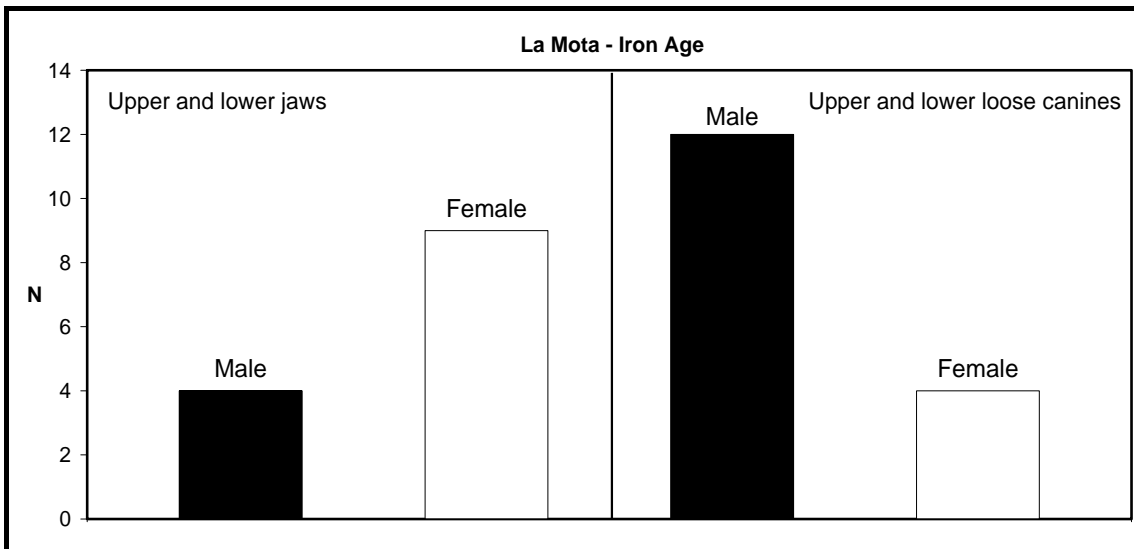


Figure 4.28: Sex ratios for Iron Age (6th-5th century BC) La Mota based on jaws (left) and loose canines (right).

Finally we have an assemblage from the Tartessian - contemporary to the Iron Age in the rest of Spain - site of Calle Puerto 10 (Huelva, southwest Spain). The pattern for a broad female majority we have seen in the northern Spanish assemblages is repeated in the southwest too (figure 4.29). Female pigs are more abundant based on the jaw count, while males are the majority if loose canines only are taken into account. Given that the assemblage of Calle Puerto 10 is corroborating the results obtained from sites further to the north, it appears reasonable to suggest that we are dealing with a geographically widespread pattern that seems to be the norm for Spanish Iron Age sites.

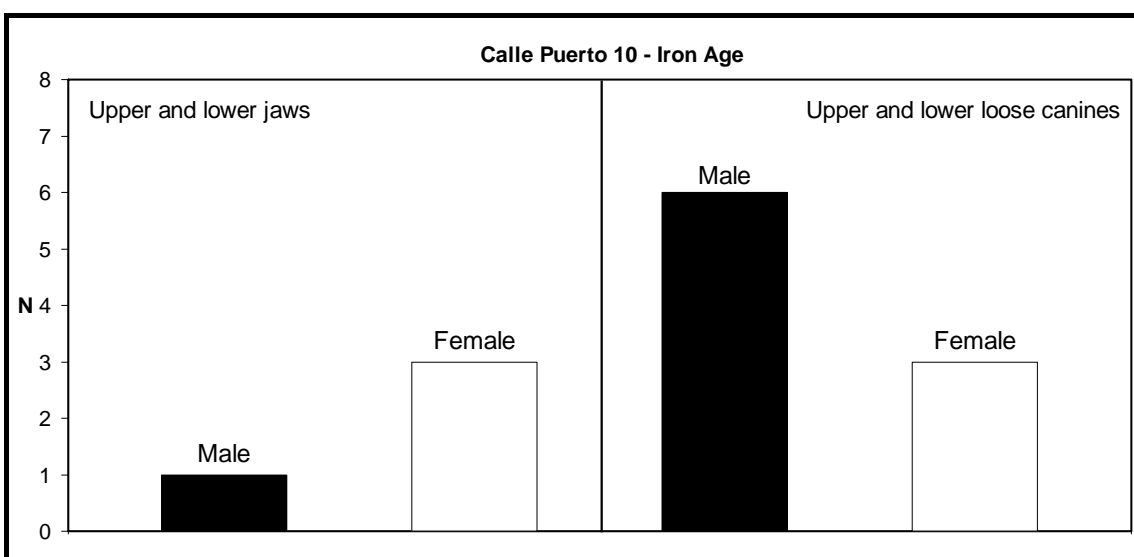


Figure 4.29: Sex ratios for Tartessian (Iron Age) Calle Puerto 10 based on jaws (left) and loose canines (right).

Overall, the sex structure of Spanish Iron Age pig populations is fairly uniform. This uniformity is defined by a clear, except in Iron Age II Castros de Lastra, female majority. In some assemblages, such as La Hoya and Soto de Medinilla, the female predominance reaches a ratio of 5-6:1, which is the highest observed in all the assemblages analysed as part of this project.

4.2 Ageing

Age-at-death data, based on bone fusion and dental eruption and wear, were recorded to assess kill-off patterns of pig populations. This also enhances the interpretation of biometrical data as the biometry of many body parts is, to a varying extent, affected by age. In this section the two main lines of evidence on ageing are presented independently but approximate correspondences are outlined in chapter 2 (table 2.2).

As was the case for sexing, not all studied assemblages provided sufficient ageing data. For this reason, only the assemblages which produced more abundant data are presented in this section.

4.2.1 Copper Age

All Copper Age sites with large and reliable ageing data sets derive from the south (Valencina de la Concepción, Los Millares and Los Castillejos) and this creates a geographic bias that should be taken into account in the interpretation.

The analysed epiphyseal fusion and tooth eruption and wear data from Copper Age Valencina de la Concepción provide us with consistent results. Epiphyseal fusion (figure 4.30) shows a major slaughtering peak (38%) between 13 and 26 months. A smaller, but still substantial percentage of animals (26%) was slaughtered in the 27-41 months interval. About 20% of the population reached adulthood (older than 42 months in absolute age) while a similar percentage (16%) was killed during its first year of age. This pattern is supported by tooth eruption and wear data (figure 4.31), which show a slaughtering peak of about 40% in the 14-26 months interval. The remaining pigs were slaughtered in equal

proportions (23%) in the 7-13 and 1-6 months intervals, while a smaller number (13%) exceeded 26 months of age.

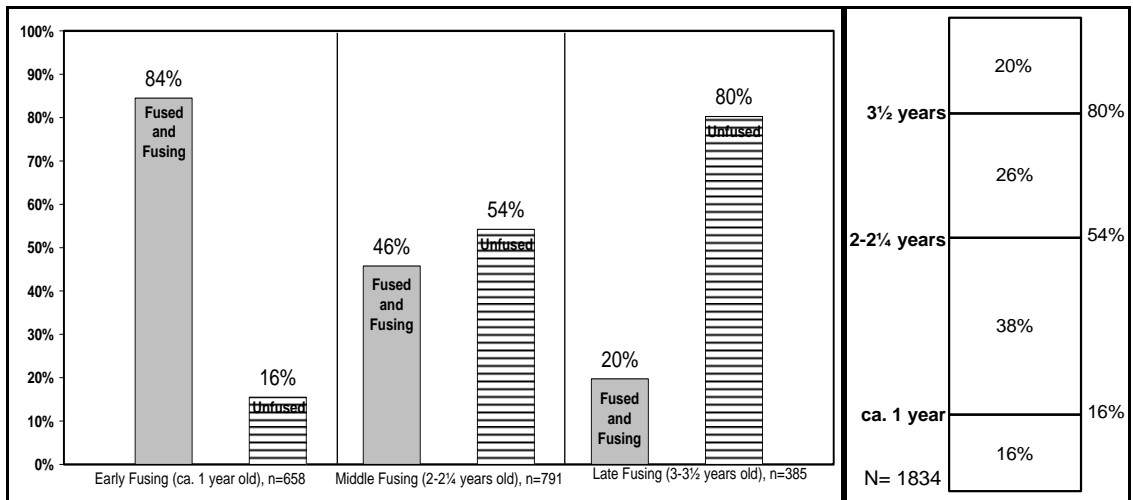


Figure 4.30: Age-at-death data for Copper Age Valencina de la Concepción based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

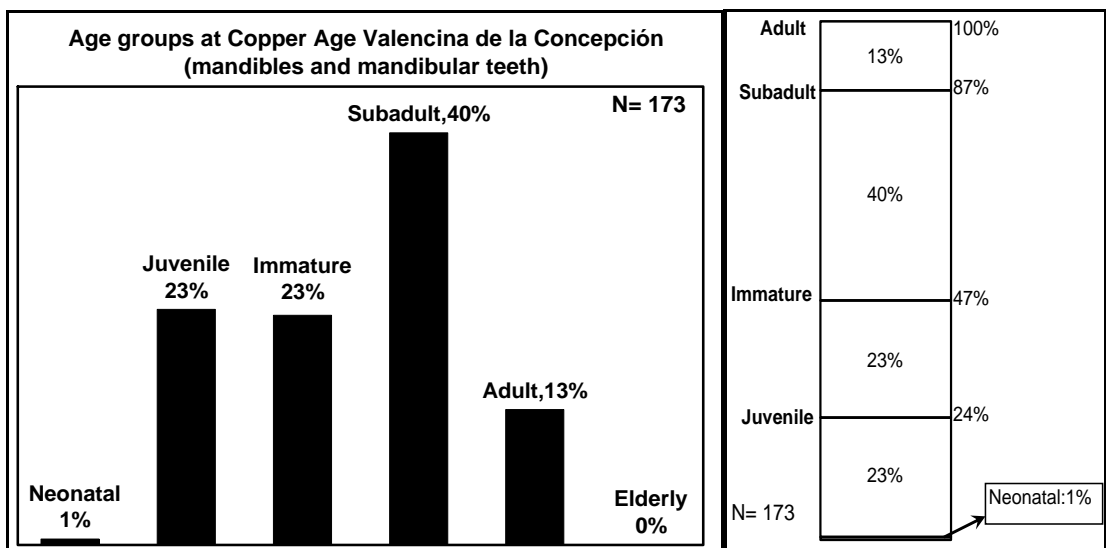


Figure 4.31: Age-at-death data for Copper Age Valencina de la Concepción based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

At Los Castillejos, abundant data on age structure come from the Early Copper Age sample of postcranial bones (figure 4.32). They reveal that roughly a third (36%) of the pigs was slaughtered in the first year. By the beginning of the third year, 50% of the population was already culled. Of the remaining 50%, 25% was slaughtered in the 27-41 months interval, while 25% reached full adulthood beyond the 42 months of age. Data from the Middle/Late Copper Age (figure 4.33) present a similar pattern, though there are slightly fewer losses during the first 12 months and a slightly higher survival rate beyond 42 months of age.

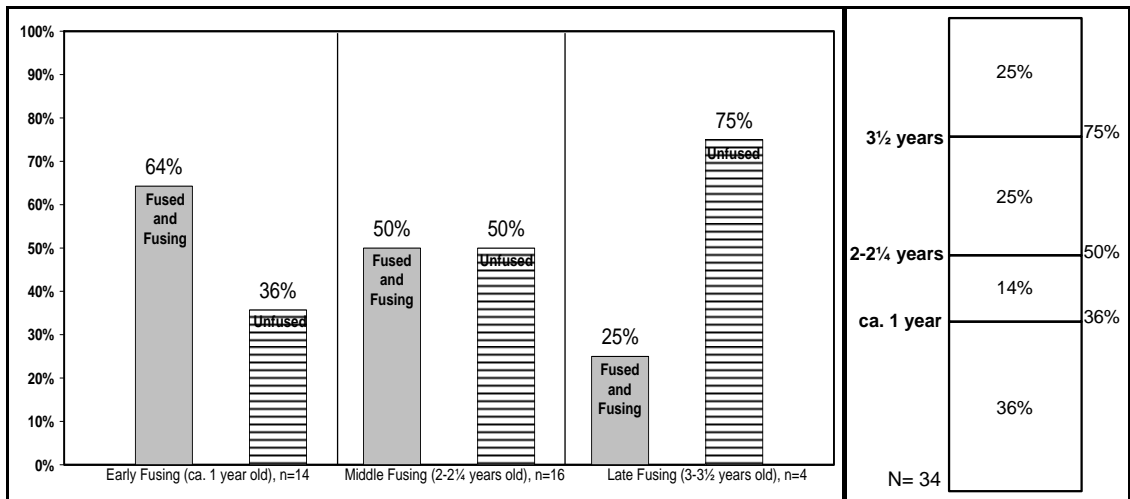


Figure 4.32: Age-at-death data for Early Copper Age Los Castillejos based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

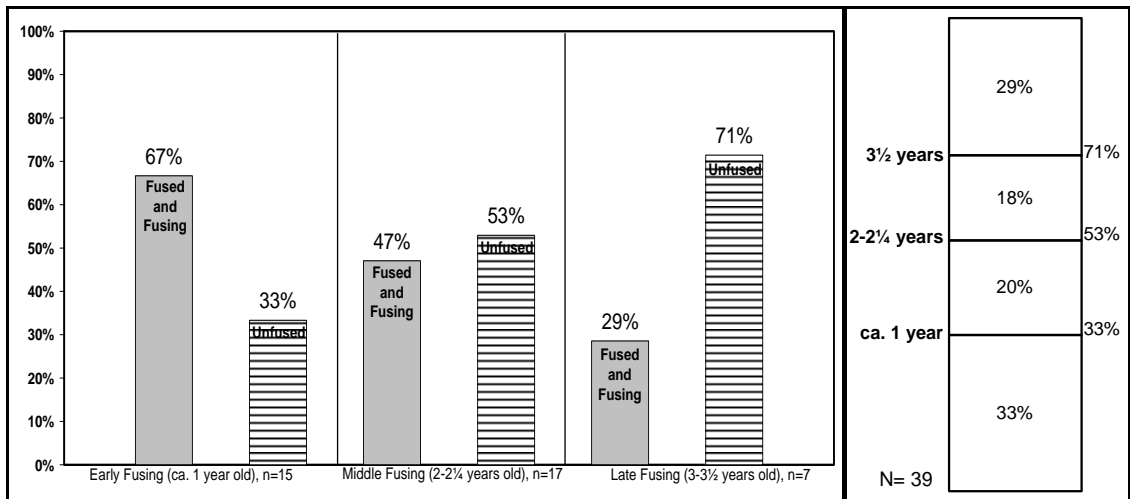


Figure 4.33: Age-at-death data for Middle/Late Copper Age Los Castillejos based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

A small set of mandibles and loose teeth provide additional ageing information for Copper Age Los Castillejos (figure 4.34). Tooth eruption and wear is in general agreement with the epiphyseal fusion data, recording high losses (almost 100%) during the first 26 months. However, there seems to be a complete lack of animals older than 26 months. Although this is probably a product of the small sample size, it confirms the results obtained from postcranial bones showing that most pigs were killed young. A preservation bias against unfused postcranial elements may have also contributed to the generally older profile based on epiphyseal fusion.

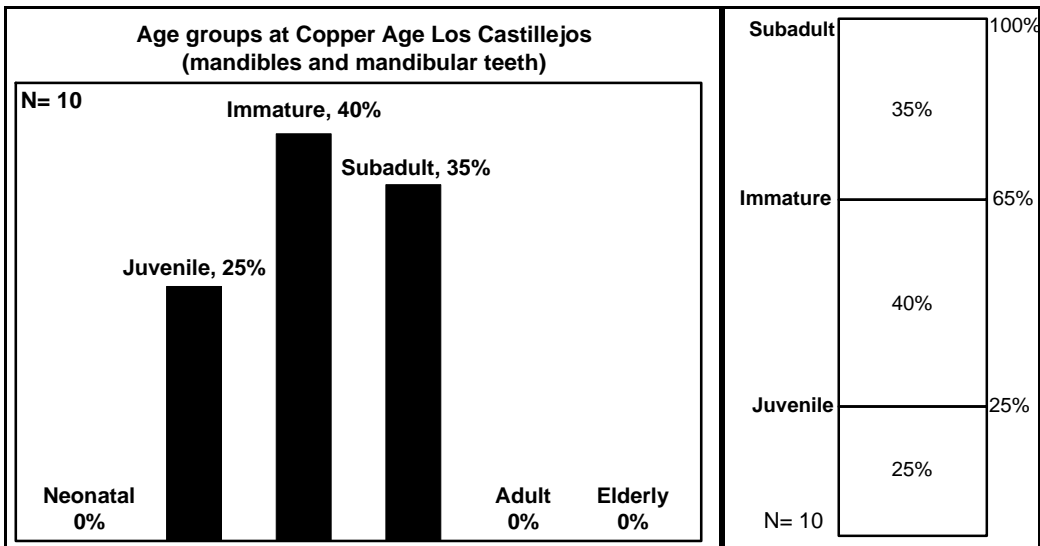


Figure 4.34: Age-at-death data for Copper Age Los Castillejos based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The important Copper Age site of Los Millares has produced a substantial sample of fusion data but, unfortunately, late-fusing elements were rare. According to the results (figure 4.35), losses during the first year were relatively low (20%), while almost half the pig population (41%) was culled between 13 and 26 months of age. Unfortunately, only few data beyond this stage are available; therefore to reconstruct the full population's age structure we need to turn our attention to the dental data.

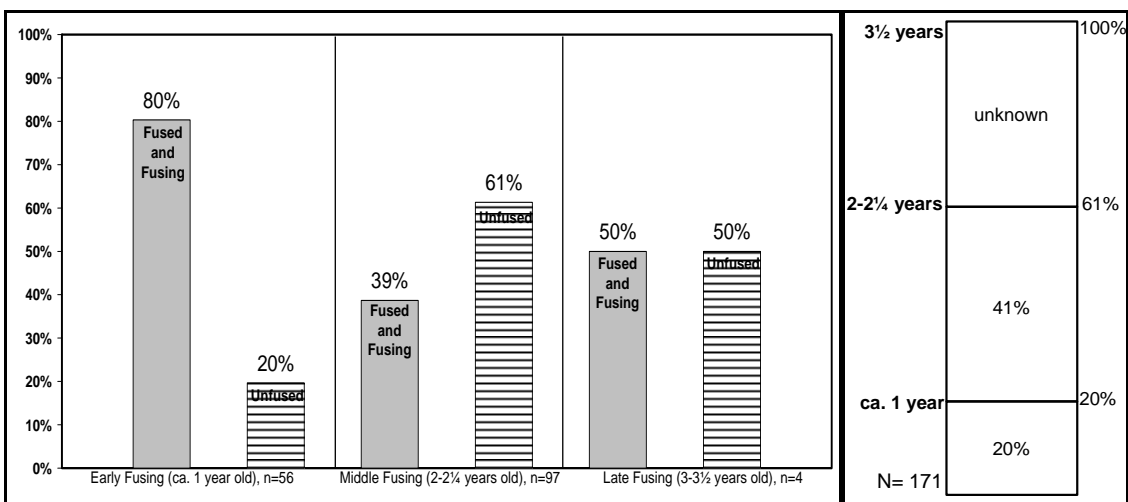


Figure 4.35: Age-at-death data for Copper Age Los Millares based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Eruption and wear data are limited (23 specimens in all) but still worth analysing in combination with the fusion data. Based on eruption and wear (figure 4.36), the pig population of Copper Age Los Millares presents minimal losses (only

6%) during the first 6 months. The 7-13, 14-26 and 27-41 intervals share about 30% each (28%, 33% and 33% respectively). If we exclude the stage without reliable information on epiphyseal fusion, the age profiles are in general agreement. The main points of similarity are a mortality of 20-35% during the first year and a sharply increased mortality beyond the first year of age. Eruption and wear indicate a significant percentage of survival (33%) into the 27-41 months interval, which is broadly compatible with fusion data. The small size of the sample is acknowledged but it nevertheless, constitutes an indication that a significant number of individuals reached their third and even fourth year of life.

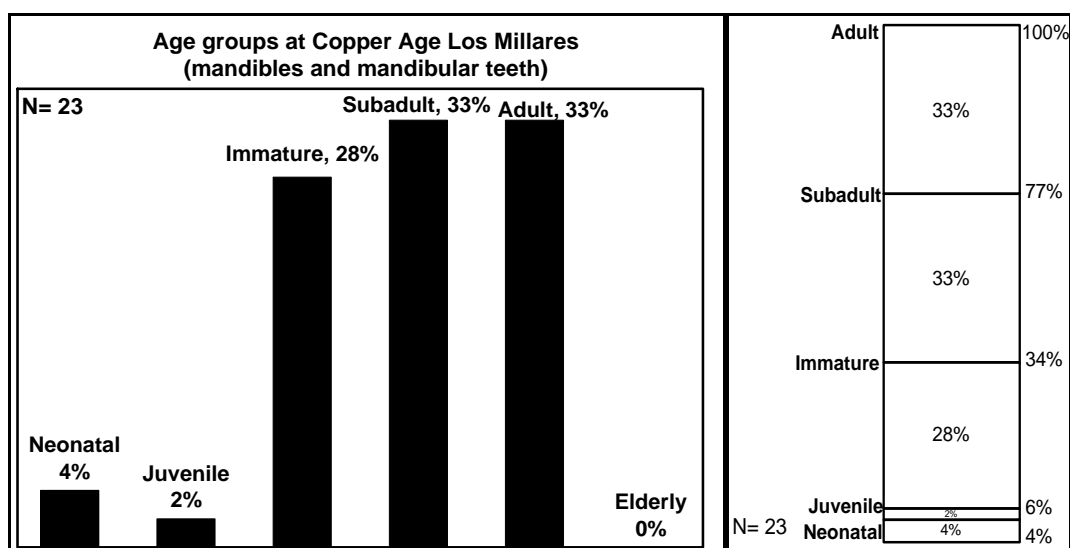


Figure 4.36: Age-at-death data for Copper Age Los Millares based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The age profiles of the three Copper Age assemblages presented overall similarities but also a few differences. Compared to the Neolithic (chapter 3), there is a shift towards an older age-at-death in the Copper Age. During the Neolithic and especially the Early Neolithic, a tendency for high mortality percentages in the early stages – younger than one year based on epiphyseal fusion, and 0-6 months (including neonatal remains) based on tooth eruption and wear - could be observed. The earliest Copper Age sample (Early Copper Age Los Castillejos) produced an age structure closer to that observed for the Neolithic data, while the samples from Los Millares and Valencina de la Concepción – both, generally of later chronology within the Copper Age – produced age structures that differ from Early Copper Age Los Castillejos and most of the Neolithic assemblages. At Valencina de la Concepción and Los

Millares the tendency towards an older age-at-death is clear, with increased mortality in the 13-26, 27-41 and 42+ intervals. At the same time, mortality in the younger age stages decreased compared to the Neolithic. It will be interesting to examine how these trends evolve in the subsequent Bronze Age.

4.2.2 Bronze Age

There are seven assemblages from this period with reasonably large samples. Unlike the Copper Age sites, these are geographically widespread (figure 4.1) and therefore more likely to reflect culling strategies in several different regions of Spain.

The largest Bronze Age sample of ageing data is represented by the site of Cerro de Encina (Granada province, Andalusia), for which early- and middle-fusing elements yielded similar culling percentages (40% and 42% respectively, figure 4.37). This is surprising, as – taken at face value - this should mean that there were heavy losses (40%) during the first year, but almost none (2%) between 13 and 26 months. A likely explanation for this rather odd pattern is provided by the fact that more than half (17/33) of the middle-fusing elements are ‘fusing’ rather than fully fused, meaning that the percentage of killings in the 13-26 months period is probably underestimated. The high proportion of fusing bones in this age range is probably an indication that quite a few animals were slaughtered at the beginning of their third year. According to the data almost a third of the population was culled between 27 and 41 months, while 28% of the population survived beyond 42 months of age into full adulthood. If we, however, take into account the underestimation of the culling in the middle-fusing age range, both percentages for the later life stages are likely to be slightly overestimated.

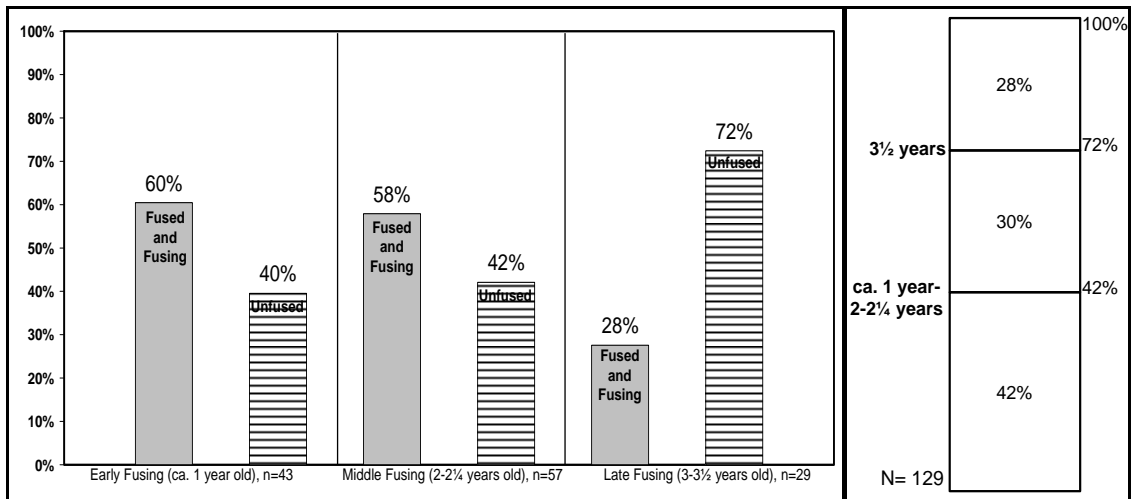


Figure 4.37: Age-at-death data for Bronze Age Cerro de Encina based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Similarly to the epiphyseal fusion results, eruption and wear reveal a high percentage (43%) of losses in the first 13 months (figure 4.38), with a notable presence of neonates (8%). However, unlike epiphyseal fusion data, eruption and wear show more culling (33%) in the 14-26 months interval. As mentioned above, this discrepancy may be explained by the unusually high percentage of ‘fusing’ middle-fusing elements. Finally, the percentage of survival beyond the 26th month of age (24%) is somewhat lower. This might be due to a preservation bias acting against unfused postcranial elements, though it is broadly compatible with the 28% that survived beyond 42 months based on epiphyseal fusion.

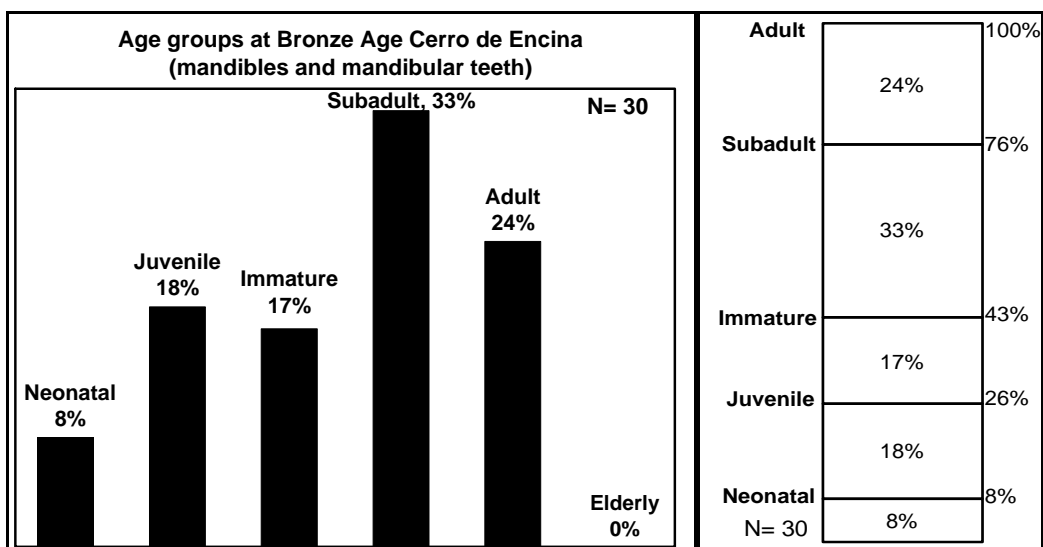


Figure 4.38: Age-at-death data for Bronze Age Cerro de Encina based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The second largest Bronze Age sample used for ageing is that from the site of Acequión (Albacete province, south-central Spain). According to epiphyseal fusion (figure 4.39), mortality (35%) in the first year was high and a similar percentage (36%) is observed for the 13-26 months interval. The remaining 29% was culled within the 27-41 months interval, as no fused late-fusing epiphyses were recorded.

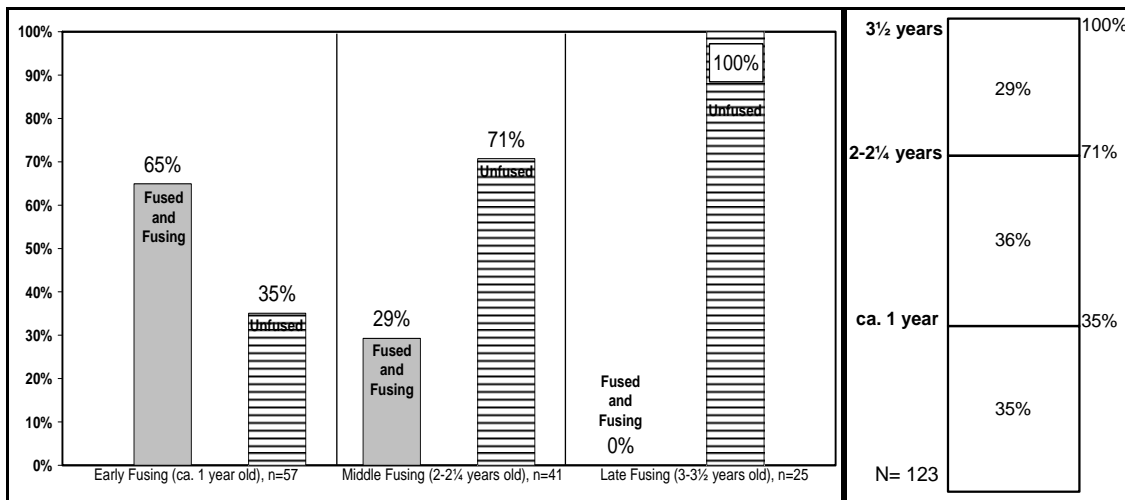


Figure 4.39: Age-at-death data for Bronze Age Acequión based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

The age structure based on tooth eruption and wear (figure 4.40) has mainly similarities but also some differences in comparison to epiphyseal fusion. Eruption and wear data confirm the high mortality within the first year (54%), especially in individuals 7-13 months old (30%), and similar mortality in the 13-26 months range (30%). The most significant difference is the presence of a few individuals (4%) older than 42 months of age.

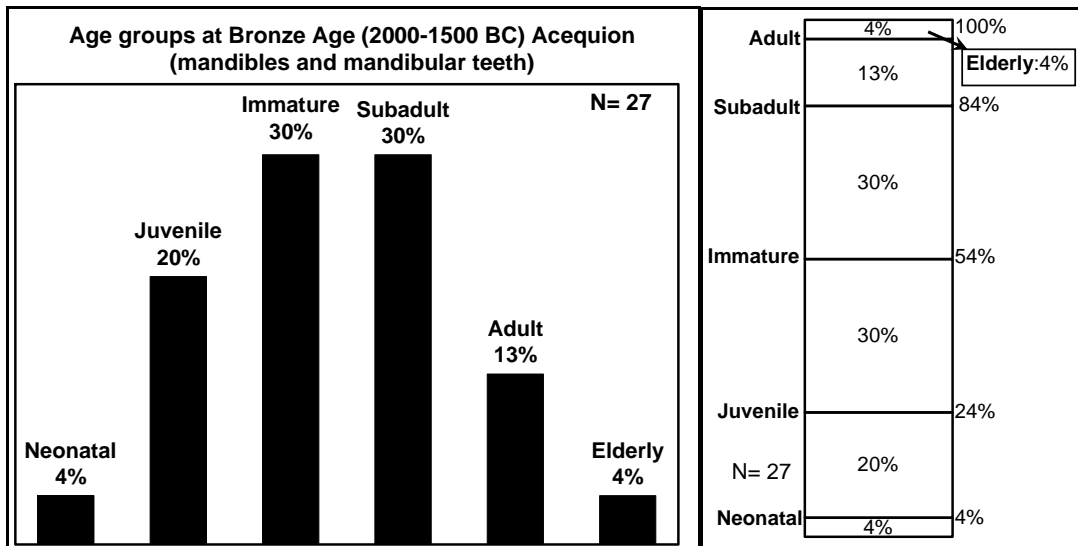


Figure 4.40: Age-at-death data for Bronze Age Acequión based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

Like Acequión, Bronze Age Morra de Quintanar is a site from the province of Albacete. Epiphyseal fusion (figure 4.41) reveals a rather low 22% culling in the first year and a further 26% between 13 and 26 months. The most prominent peak is registered in the 27-41 interval (40%), while 12% of the population survived beyond 3.5 years of age into full adulthood.

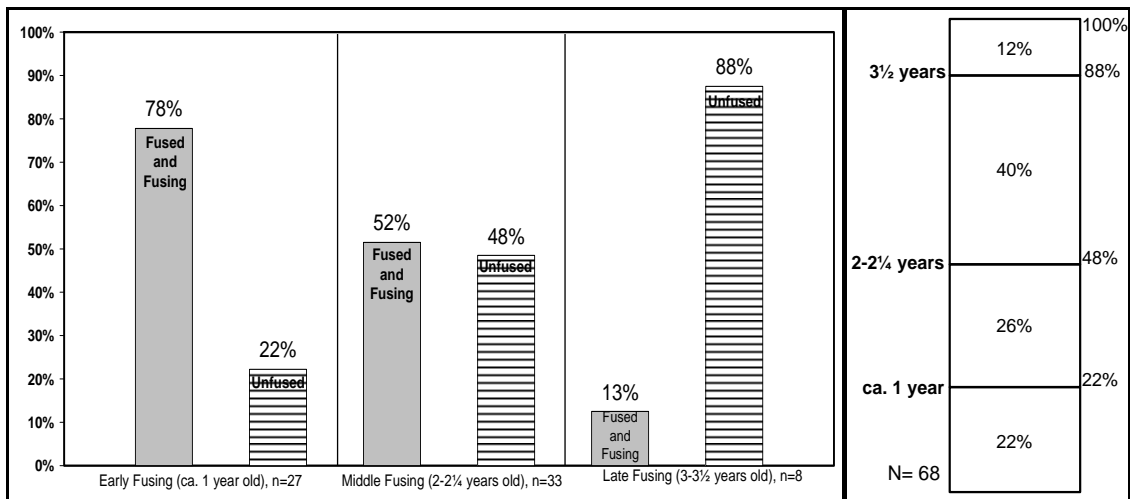


Figure 4.41: Age-at-death data for Bronze Age Morra de Quintanar based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Eruption and wear results from Morra de Quintanar (figure 4.42) are broadly in line with epiphyseal fusion, though, again some differences are also present. As in epiphyseal fusion, relatively low mortality is observed for the first year (23%). However, eruption and wear data reveal a younger age profile, with only 29% of the population surviving beyond the 26th month of age. This contrasts the 52%

observed for epiphyseal fusion data. The most likely explanation for this discrepancy is the better preservation of unfused postcranial elements. Taking also into account the small sample sizes – especially of eruption and wear data – then the patterns exhibited by the two lines of ageing evidence are broadly compatible.

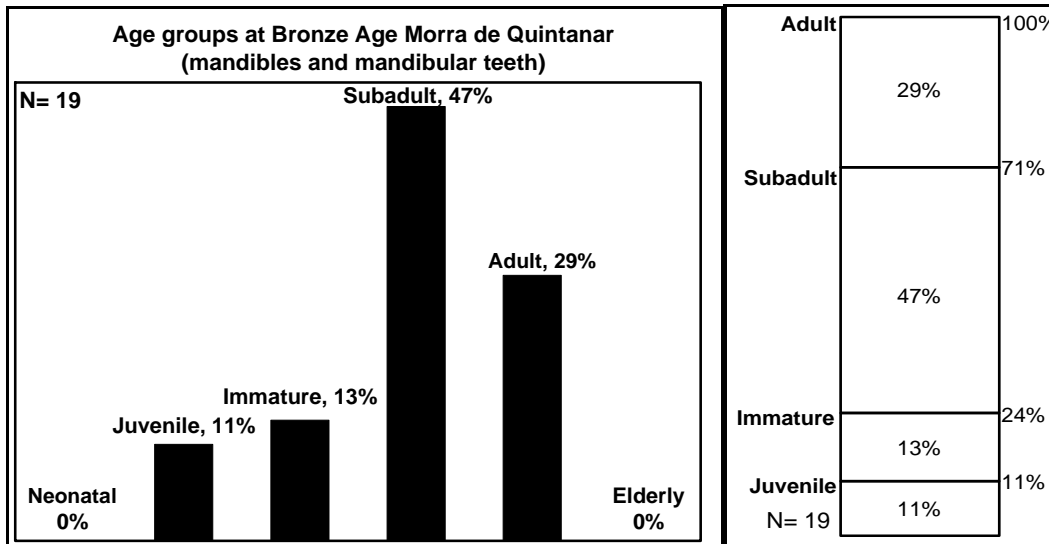


Figure 4.42: Age-at-death data for Bronze Age Morra de Quintanar based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

Bastida de Totana (Murcia province, on the Spanish Mediterranean coast), a site not far from Cerro de Encina, Acequión and Morra de Quintanar, provided sufficient data only for epiphyseal fusion. Due to the small sample (N=31) of ageable postcranial remains, the results (figure 4.43) should be interpreted with caution, especially for the late-fusing group, which includes only five specimens. Perhaps the most reliable information from the age profile of the Bastida de Totana pig population is the high mortality (38%) among individuals younger than a year old and the low mortality (8%) in the next stage (13-26 months).

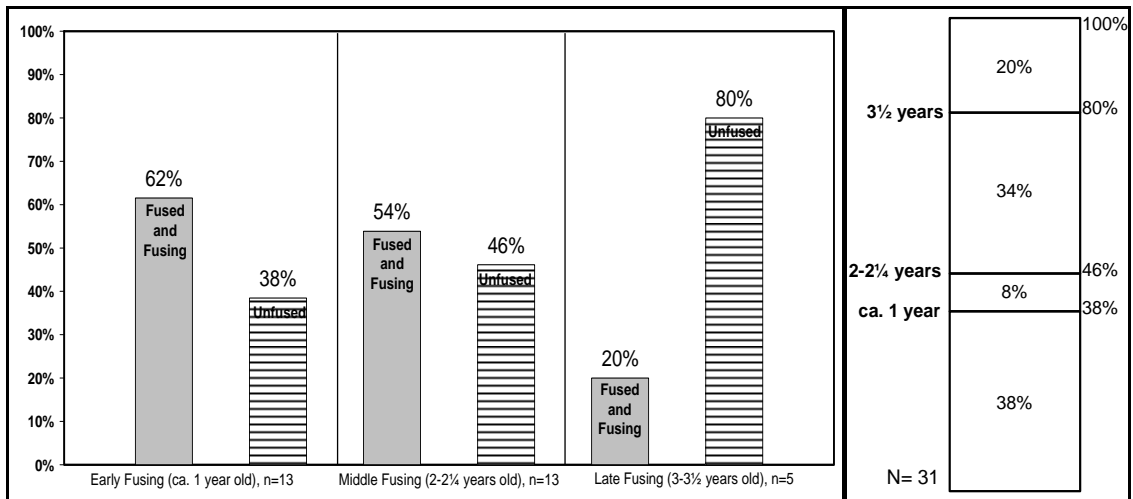


Figure 4.43: Age-at-death data for Bronze Age Bastida de Totana based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

From northeast Spain the assemblage of Monte Aguilar (Navarra) yielded several age profiles for its Middle, Late and combined Middle-Late Bronze samples of postcranial bones. For tooth eruption and wear the Middle and Late Bronze Age phases were combined to increase sample size.

The Middle Bronze Age sample produced reliable results only for the first two age stages (figure 4.44). Low mortality is observed for the first year (14%), while a significant slaughtering peak (48%) is evident for the 13-26 interval. A quite similar result has been obtained from the Late Bronze Age sample (figure 4.45). As a logical consequence, the results of the two samples combined (figure 4.46) are also almost identical to the results of the separate samples.

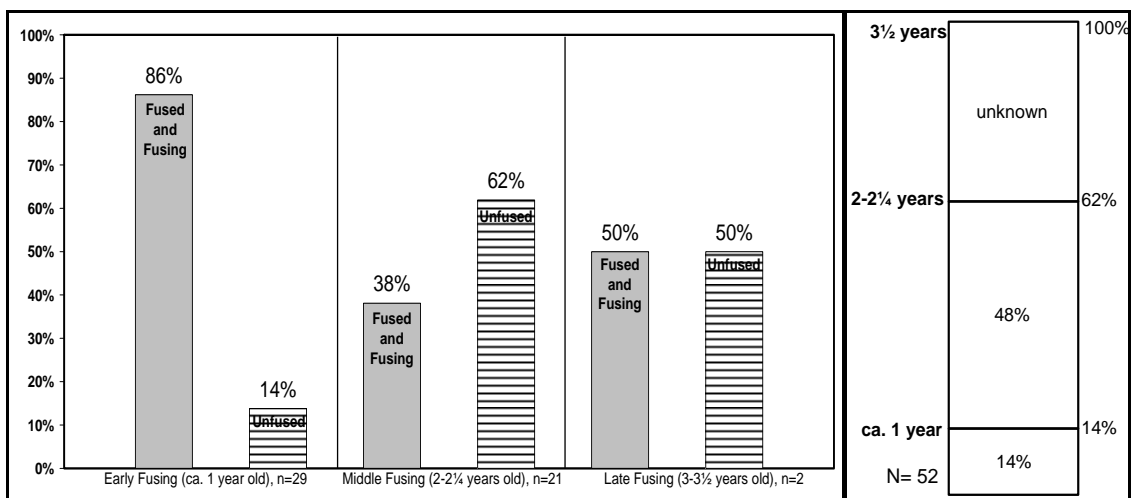


Figure 4.44: Age-at-death data for Middle Bronze Age Monte Aguilar based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

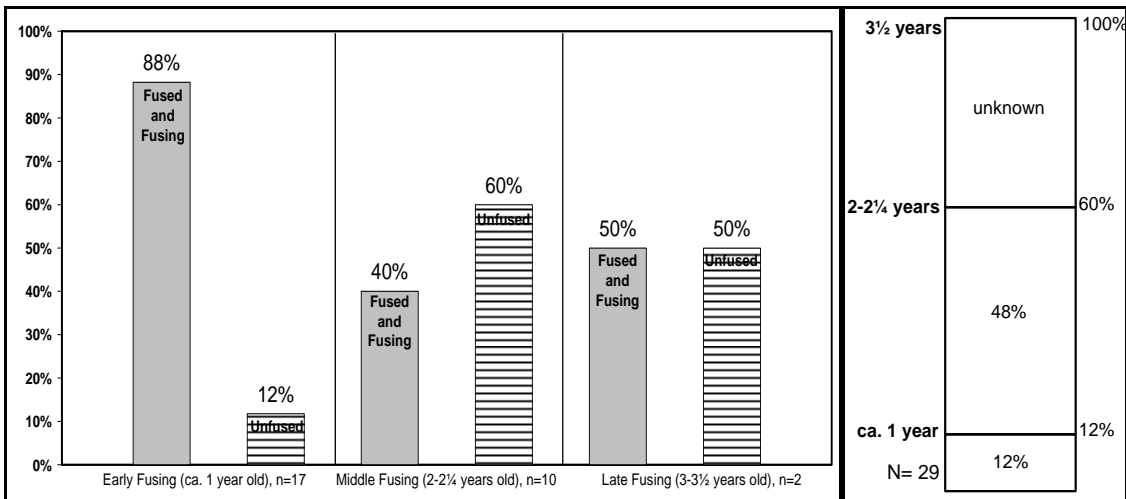


Figure 4.45: Age-at-death data for Late Bronze Age Monte Aguilar based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

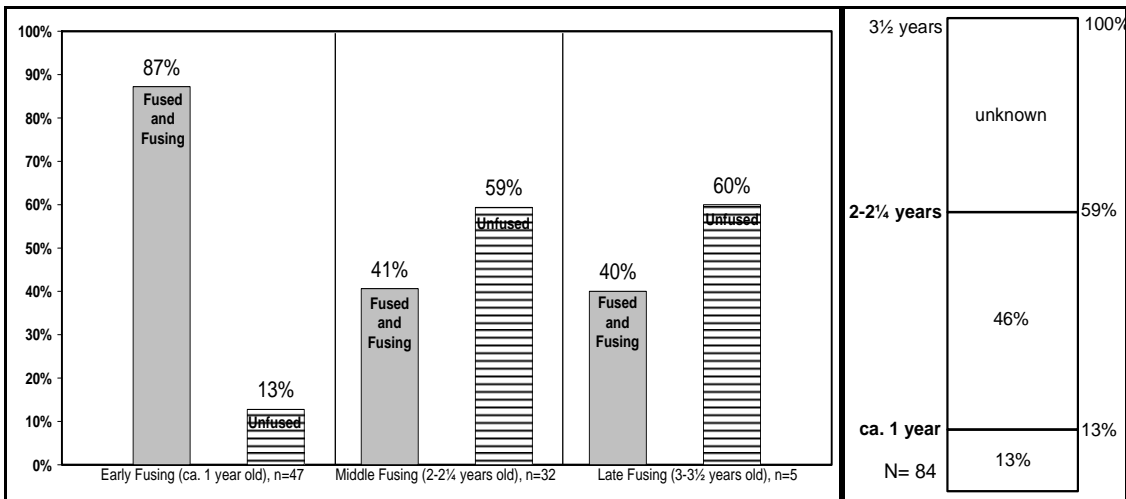


Figure 4.46: Age-at-death data for Middle/Late Bronze Age Monte Aguilar based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Eruption and wear data from Middle/Late Bronze Age Monte Aguilar (figure 4.47) indicate that a substantial number of pigs were slaughtered in the 7-13 (28%) and 14-26 (30%) months intervals. This confirms high mortality during the second year as indicated by the epiphyseal fusion results. Tooth data also suggest that a significant proportion of pigs reached an age between 27 and 41 months old, which cannot be compared with the fusion data due to the small sample size of late-fusing epiphyses.

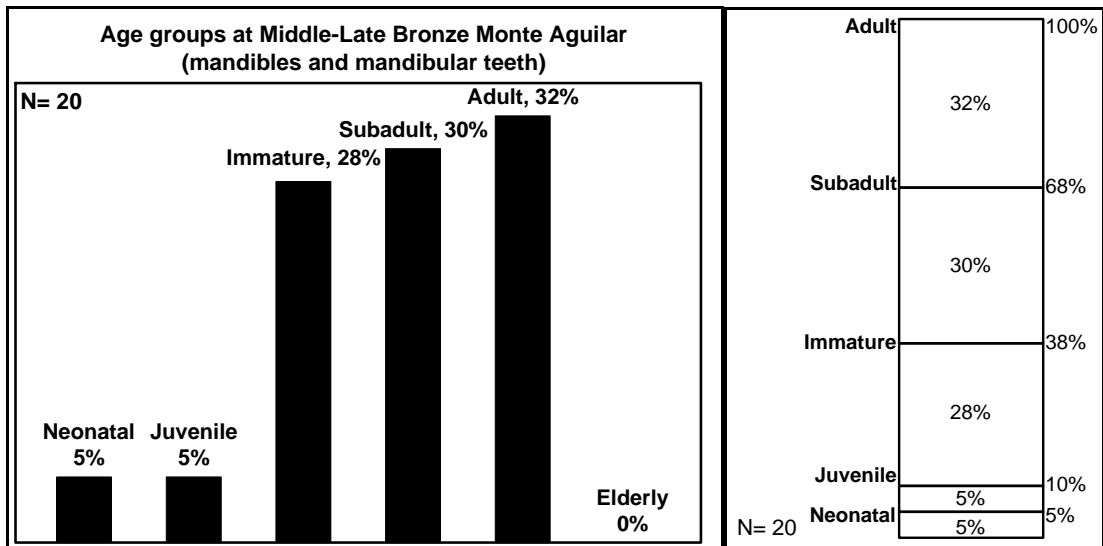


Figure 4.47: Age-at-death data for Middle/Late Bronze Age Monte Aguilar based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

Two assemblages from further north in Spain (Basque province of Álava), Middle/Final Bronze Age La Hoya and Final Bronze Age Castillo de Henayo, produced useful ageing data.

The age profile of Middle/Final Bronze Age La Hoya (figure 4.48) based on epiphyseal fusion data has two main characteristics. The first characteristic is the low mortality during the first (9%) and second years (5%). The second characteristic is the dominant mortality peak (74%) between 27 and 41 months. The unusually high mortality in the 27-41 months interval can be better understood by considering that most middle-fusing specimens (14/18) are 'fusing', which suggests that most of them were culled around the two years of age. Finally, 12% of the population reached an age older than 42 months. As in the vast majority of assemblages included in this study, late-fusing elements are generally scarce. Although this limits the resolution of the produced results, they are still useful for observing general trends.

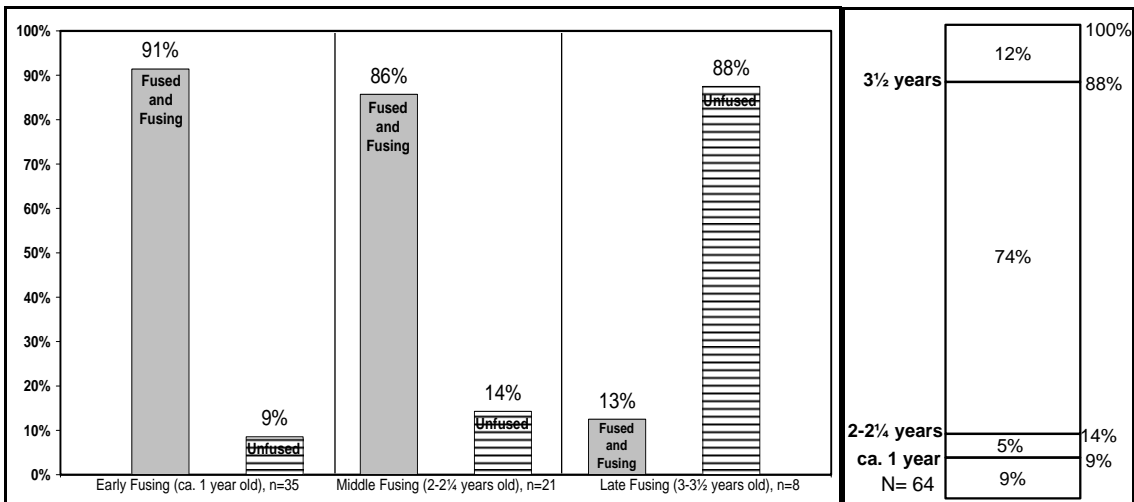


Figure 4.48: Age-at-death data for Middle/Final Bronze Age La Hoya based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Tooth eruption and wear data from Middle/Final Bronze Age La Hoya (figure 4.49) present a rather different picture from the epiphyseal fusion. Noteworthy is the presence (8%) of neonatal remains and the generally high mortality (71%) during the first year, most of which (40%) occurred in the 7-13 months interval. In contrast to epiphyseal fusion which indicated high mortality at the end of the second and during the third year, tooth eruption and wear suggest losses of around 21% for the 14-26 and 8% for the 27-41 months intervals. As in other similar cases, the most likely reason for this inconsistency is the preservation bias against unfused postcranial elements.

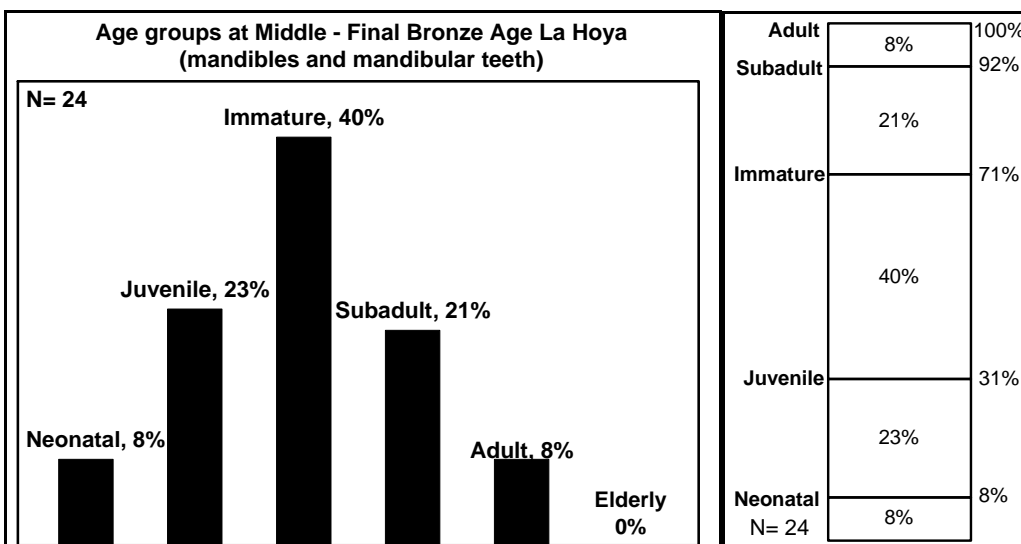


Figure 4.49: Age-at-death data for Middle/Final Bronze Age La Hoya based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

Overall, Bronze Age pig populations exhibit similar characteristics in their age profiles compared to those of the Copper Age. The main characteristics of Bronze Age populations are the consolidation of high mortality during the second year (almost always more than 30%) and a slight increase of individuals exceeding the age of two years compared to the Copper Age. The strong trend for culling around the age of two years is also supported by the numerous 'fusing' middle-fusing postcranial elements.

So far, the evolution of age profiles of pig populations has been followed from the Neolithic to the Bronze Age. A tendency towards an older age-at-death that appeared sporadically in some Neolithic assemblages is more pronounced in the Copper Age, and consolidated in the Bronze Age. The results of the last period of the prehistoric era, the Iron Age, remain to be explored in order to reveal how the age profile of pig populations evolved in the last millennium BC in Spain.

4.2.3 Iron Age

The Iron Age material provides a wealth of ageing data. In this subsection, ageing analysis on material from 12 Iron Age sites is presented. The geographical distribution of the sites is broad, though with better coverage for the northern than the southern half of Spain. This wide distribution improves the possibility of detecting regional differences and allows comparisons between sites. Furthermore, the relative abundance of Iron Age samples has the potential to highlight possible chronological intra- and inter-site differences in the age profiles of pig populations.

The largest analysed Iron Age assemblage is that of La Hoya (Álava province, Basque Country). Since the Bronze Age material from this site has already been presented in a previous section, here only the analysis of the Iron Age I and II material is presented, both separately and combined.

The age profile during Iron Age I relies on a substantial sample of more than 140 postcranial specimens (figure 4.50). Compared to the Middle/Final Bronze Age sample from the same site, it shows an older age profile with low mortality

(17%) for the first year, followed by the highest mortality (34%) in the second year. A similar percentage (31%) is observed for the next age interval (27-41 months), while almost a fifth (18%) of the pig populations survived beyond 42 months.

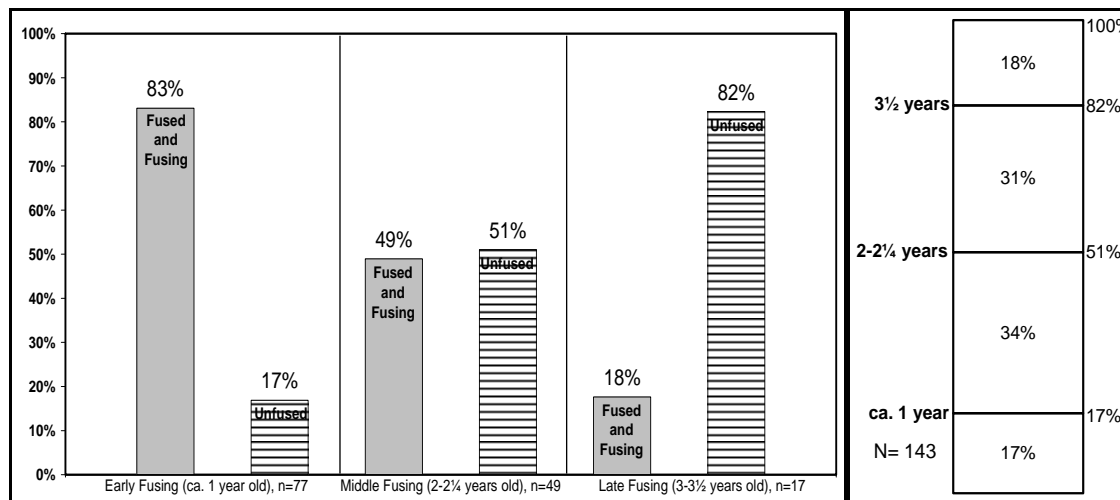


Figure 4.50: Age-at-death data for Iron Age I La Hoya based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Tooth eruption and wear data from Iron Age I La Hoya, (figure 4.51) are only broadly compatible with the epiphyseal fusion data. There is an absence of neonatal remains and for the rest of the first year there is 16% mortality in the 1-6 and 22% in the 7-13 months interval. This amounts to 38% mortality in the first year, which is twice the one indicated by epiphyseal fusion for roughly the same age interval. Similar mortality levels (34%) are recorded for the next age interval (14-26 months), which is identical to the result of the epiphyseal fusion for the same age interval. The remaining 28% of the population was culled between 27 and 41 months of age. Overall, tooth eruption and wear show higher mortality in the first year and lower in the third and fourth, compared to the pattern of the epiphyseal fusion data. This is most likely due a preservation bias against unfused bones. Despite some minor discrepancies, both lines of ageing evidence agree that a slaughtering peak in the 13-26 months interval is the defining feature of the age profile of Iron Age I La Hoya. Furthermore, it is likely that many pigs were culled around two years of age, if we consider that many 'fusing' middle-fusing specimens (19/49) were recorded.

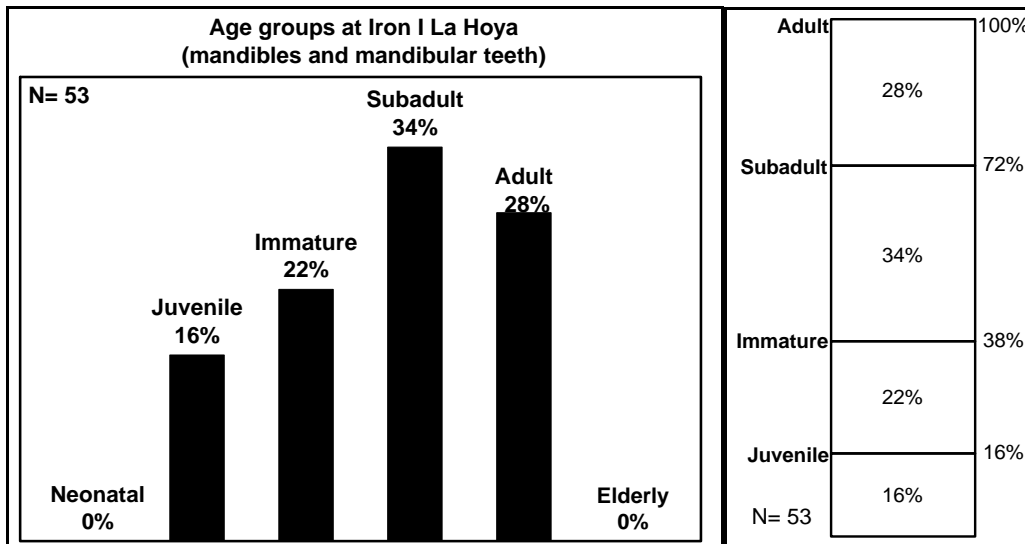


Figure 4.51: Age-at-death data for Iron Age I La Hoya based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

Figure 4.52 presents the epiphyseal fusion data of Iron Age II La Hoya, which is the largest Iron Age sample analysed for this project. The picture is different, but not substantially so, from the one obtained from the Iron Age I sample of the same site. In general, the representation of each age interval is more even. In the Iron Age II there is a slightly higher percentage (21%) of individuals younger than one year old, a much lower percentage (21%) of 13-26 month-olds, and a slightly lower percentage (27%) of 27-41 month-olds. Mainly as a consequence of the lower frequency of killings in the 13-26 months interval, almost a third (31%) of the represented population reached full adulthood beyond the age of 42 months. This is a substantially higher proportion than in the previous period. Thus, apart from a few more juvenile killings, the Iron Age II age profile is therefore distinctively older that of Iron Age I.

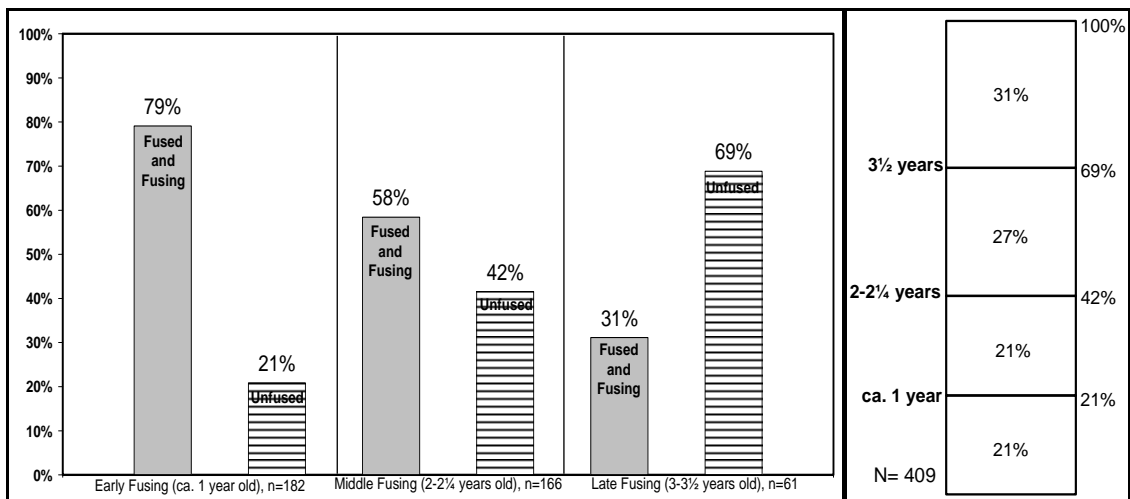


Figure 4.52: Age-at-death data for Iron Age II La Hoya based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Tooth eruption and wear provide data that are broadly compatible with those of the epiphyseal fusion, though by and large they indicate slightly younger age (figure 4.53). Beyond the presence of a few (4%) neonatal remains, 18% of the population was culled in the 1-6 and 20% in the 7-13 months intervals. The total of 42% mortality in the first 13 months is significantly higher than the 21% indicated by epiphyseal fusion. Considering that the same pattern was observed for the Iron Age I sample and that these two samples are among the largest and most reliable, it provides support to the approach that the two lines of ageing evidence should be compared only in a general way.

For the 13-26 months interval there is good correlation between eruption and wear (23%) and epiphyseal fusion (21%). As for the Iron Age I sample, tooth eruption and wear show less survival beyond the age of 26 months (35%), while epiphyseal fusion shows more (58%). It is also plausible that tooth eruption and wear indicate lower survival than epiphyseal fusion in the third and fourth years of age due to a preservation bias acting primarily against the survival of unfused bones and to a much lesser degree against heavily worn teeth. Compared to the Iron Age I, both lines of evidence show a consistently higher survival into the third and fourth years of age and therefore an overall older kill-off pattern in the Iron Age II.

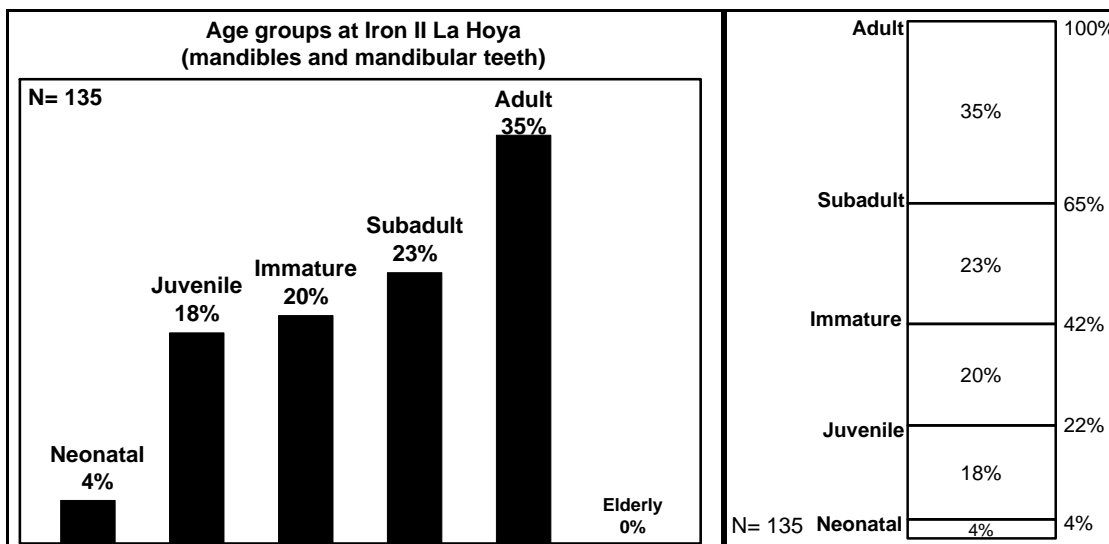


Figure 4.53: Age-at-death data for Iron Age II La Hoya based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The two Iron Age samples from La Hoya were also combined to produce an overall picture for the Iron Age. Since the Iron Age II sample is more than

double the size of the Iron Age I sample and the two age profiles are broadly similar, it is not surprising that the combined age profile based on epiphyseal fusion (figure 4.54) is intermediate between the Iron Age I and II samples, but nearer to the Iron Age II sample. The general pattern is that the first two age categories (0-12 and 13-26 months) exhibit percentages near 20%, while the older two age categories (27-41 and 42+ months) exhibit percentages near 30%.

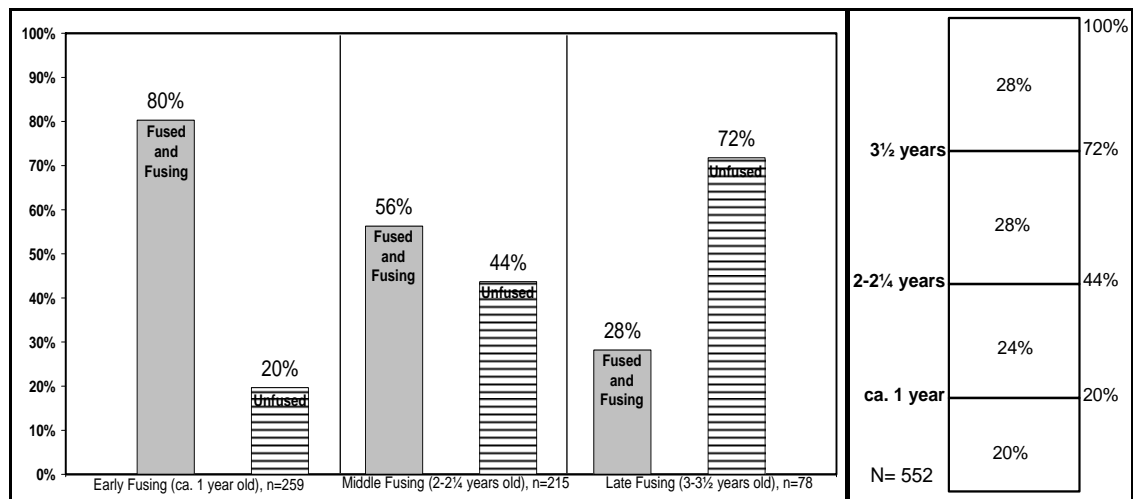


Figure 4.54: Age-at-death data for Iron Age I+II La Hoya based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

The same general comments, as for the epiphyseal fusion data, are valid for the Iron Age I+II sample of eruption and wear data. However, as noted for the separate samples before, there is higher mortality in the first year and lower in the third and fourth. The results (figure 4.55) show very few neonatal individuals (3%), 18% in the 1-6 months interval and 20% in the 7-13 months interval. Beyond the first year, 26% of the La Hoya Iron Age pig population was culled in the second year and 33% between 27 and 41 months old.

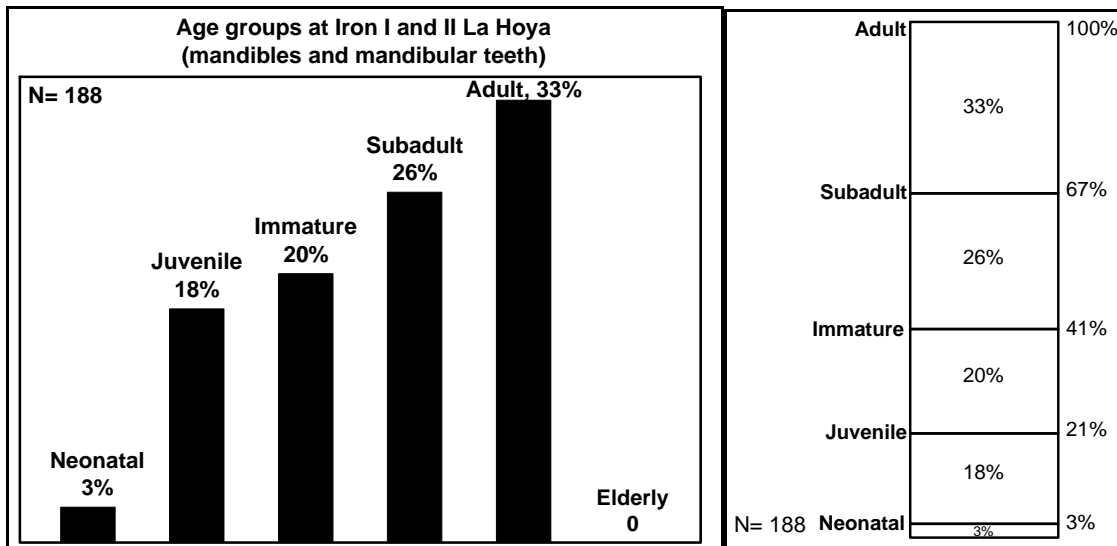


Figure 4.55: Age-at-death data for Iron Age I+II La Hoya based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

La Hoya, as a multi-phase site with large samples assigned to successive chronological periods, offers an opportunity to study possible changes in the age profile that may have occurred from one period to the next. Such data may in turn provide useful insights into the evolution of pig husbandry. In all three phases of La Hoya (Middle/Final Bronze Age, Iron Age I and Iron Age II) a tendency towards an increase in the percentage of adults is clearly observable. The most pronounced change towards an older profile occurs between the Middle/Final Bronze Age sample and the Iron Age I sample, while the trend as such continued from the Iron Age I to the Iron Age II.

The second largest Iron Age sample is from the site of Castros de Lastra (also known as Carranca). As La Hoya, Castros de Lastra is situated in the province of Álava in the south of the Basque Country and yielded large samples of pig remains from its Iron Age I and II levels, which will be presented here first separately and then combined.

The results of the epiphyseal fusion data from Iron Age I Castros de Lastra are presented in figure 4.56. Unfortunately, the sample is quite small (with only 22 specimens available) and hence, observations remain inevitably tentative. According to this small sample, few pigs died in their first year of life and only slightly more in their second year of life. Further observations are not possible due to the absence of late-fusing elements in the sample.

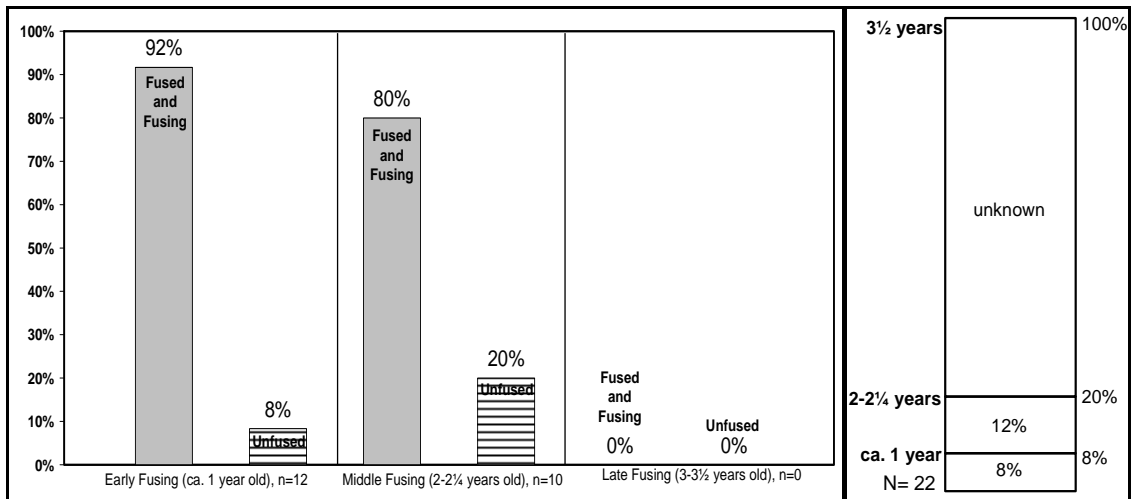


Figure 4.56: Age-at-death data for Iron Age I Castros de Lastra based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

The sample of mandibles and mandibular teeth from Iron Age I Castros de Lastra is relatively large (N=33) and offers more reliable evidence (figure 4.57). Neonatal individuals are absent from the profile and 22% of the population was culled relatively evenly during the first 13 months (11% in the 1-6 and 11% more in the 7-13 months intervals). The highest mortality occurred during the 14-26 months interval and 37% survived into the third and fourth years. The general characteristic of this age profile is the relatively low mortality in the first year and the high mortality in the second, third and fourth years. The results are therefore consistent with the admittedly scanty evidence from bone fusion in highlighting the low culling proportion in the early stages of life.

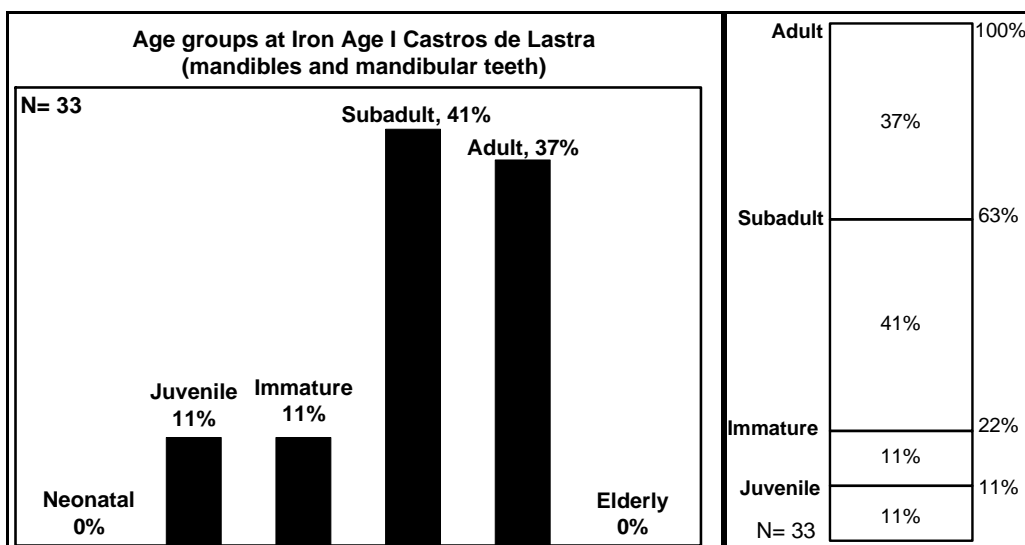


Figure 4.57: Age-at-death data for Iron Age I Castros de Lastra based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

To follow the evolution of the age structure of the pig population at Castros de Lastra the Iron Age II sample has also been analysed. The postcranial bone sample is considerably larger (N=89) than that of Iron Age I (N=22) and therefore offers more reliable information (figure 4.58). As in the Iron Age I sample, few (9%) individuals were culled within their first year of life, although in this case there is higher mortality (from 12% to 28%) in the 13-26 months interval. Only eight late-fusing elements were recorded - all unfused - and hence, the remaining 63% of the population was aged within the 27-41 months interval.

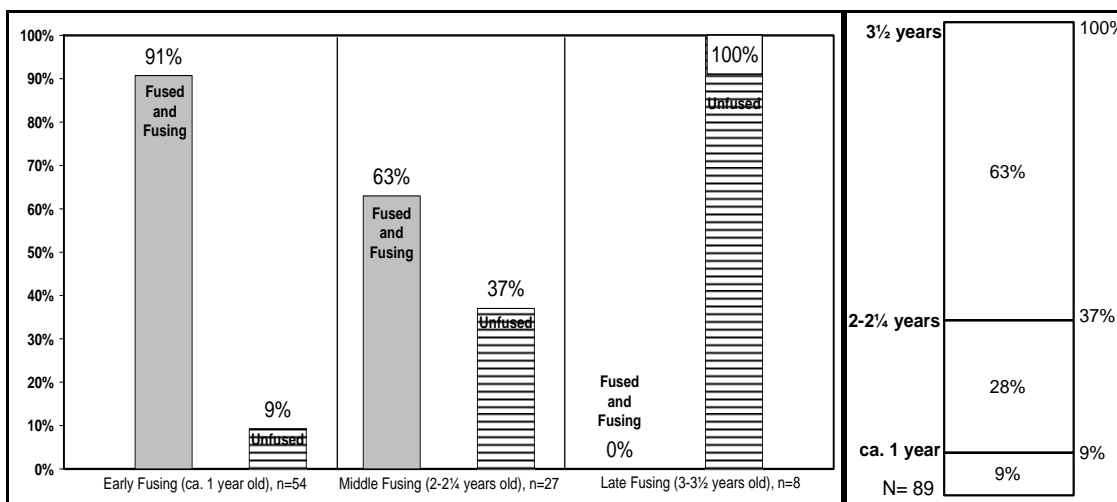


Figure 4.58: Age-at-death data for Iron Age II Castros de Lastra based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

The age profile based on tooth eruption and wear is similar but also offers some clarity to the blurry picture obtained from fusion data, especially for the older age intervals (figure 4.59). No neonatal remains were present. 13% of the population was culled between 1 and 6 months, and another 13% in the 7-13 months interval. In the 14-26 month interval, mortality was relatively low (18%), while more than half of the population (56%) was culled in the 27-41 months interval. Unlike bones, teeth therefore suggest an older age profile in the later Iron Age phases, which is likely to be more reliable as bone fusion is more easily subjected to preservation bias.

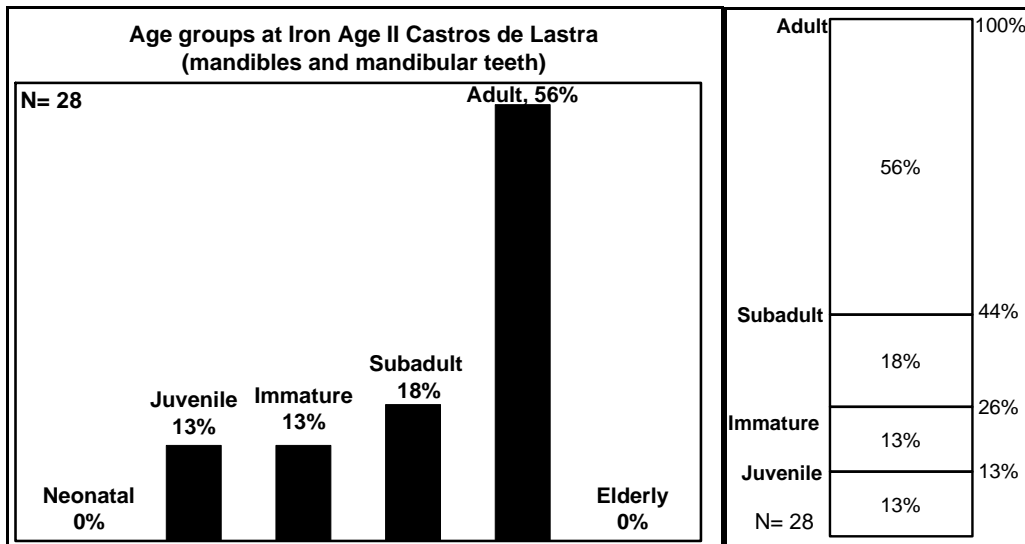


Figure 4.59: Age-at-death data for Iron Age II Castros de Lastra based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The most reliable ageing analysis from Castros de Lastra, at least in terms of sample size, was produced by combining the Iron Age I and II samples. Furthermore, all specimens that could not be assigned to Iron Age I or II, but generically belonged to the Iron Age, were added in the analyses. In this way, the sample of combined epiphyseal fusion data is much larger (N=228) than the separate datasets. The resulting graph (figure 4.60) is nevertheless fairly consistent with the separately presented Iron Age I and II samples. The low mortality observed for the first year of life is confirmed in this case too (6%), while almost a third (29%) of the population was culled during the 13-26 months interval. As in the Iron Age II profile based on epiphyseal fusion (figure 4.58), a quite high mortality is observed (65%) in the third age interval (27-41 months), and no recorded specimen could be aged beyond the 3.5 years threshold. However, it can be added that almost half (34/79) of the middle-fusing elements are 'fusing' and hence reveal that much of the 65% was culled around the age of two years.

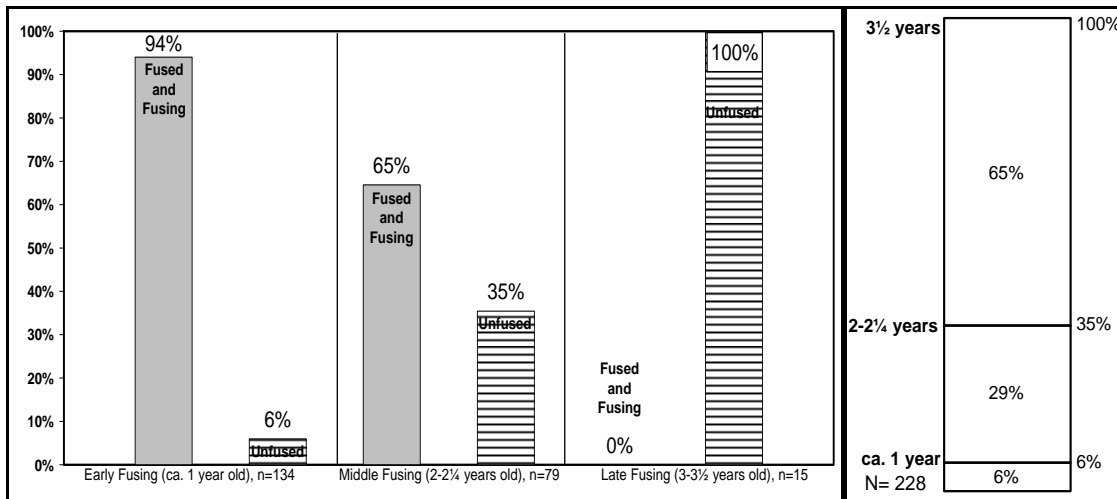


Figure 4.60: Age-at-death data for Iron Age I+II Castros de Lastra based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Tooth eruption and wear data reveal an age profile (figure 4.61) characterised by no neonatal remains and 28% mortality until the end of the first year. Almost a third of the population (32%) was slaughtered in the 14-26 months interval. In the 27-41 months interval the remaining 40% of the population appears to have been culled. As it was the case with the two lines of ageing evidence from La Hoya, and also from chronologically earlier sites (Neolithic, Copper and Bronze Age), at Castros de Lastra epiphyseal fusion shows an older age profile, compared to that based on tooth eruption and wear. This observation is validated by the large Iron Age samples, which reduce the influence of factors that may slightly skew age profiles, such as chance, chronological and geographical differences. Among the possible causes of this discrepancy is the preservation bias that consistently acts against unfused elements and perhaps to some extent against heavily worn teeth.

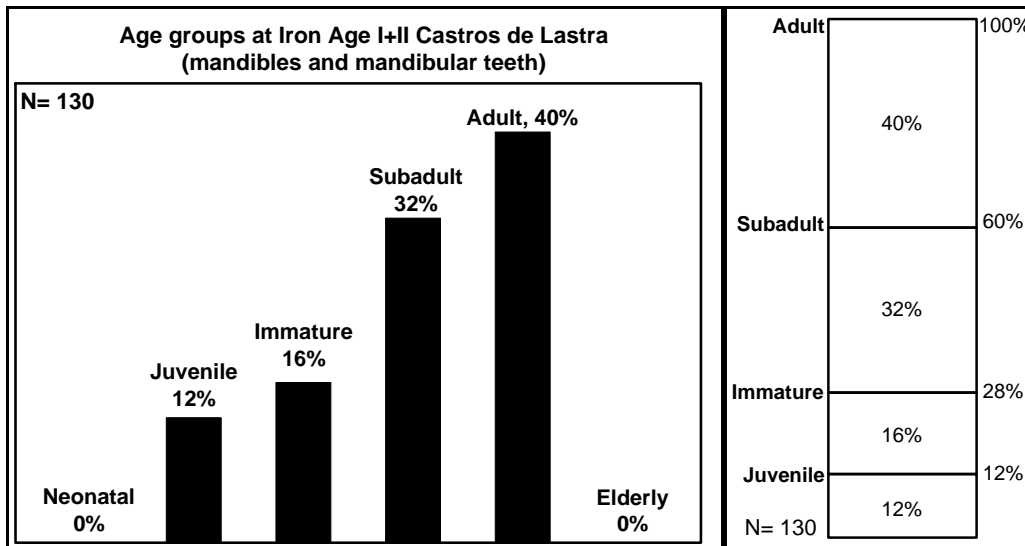


Figure 4.61: Age-at-death data for Iron Age I+II Castros de Lastra based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The third largest Iron Age assemblage is that of Soto de Medinilla, a site from the province of Valladolid in the Duero valley on the northern central plateau. As in the cases of La Hoya and Castros de Lastra, there are separate samples for the Iron Age I and Iron Age II levels available. The two samples are considered separately and in combination to provide a more comprehensive picture.

Figure 4.62 illustrates the age profile of the pig population at Soto de Medinilla during the Iron Age I, based on a sample of 41 aged postcranial specimens. According to the graph, the pig population was reduced by 12% during the first year and by further 38% during the 13-26 months interval. The scarce (N=2) late-fusing elements are here reported here merely for the sake of completeness as such a small sample prevents a reliable analysis.

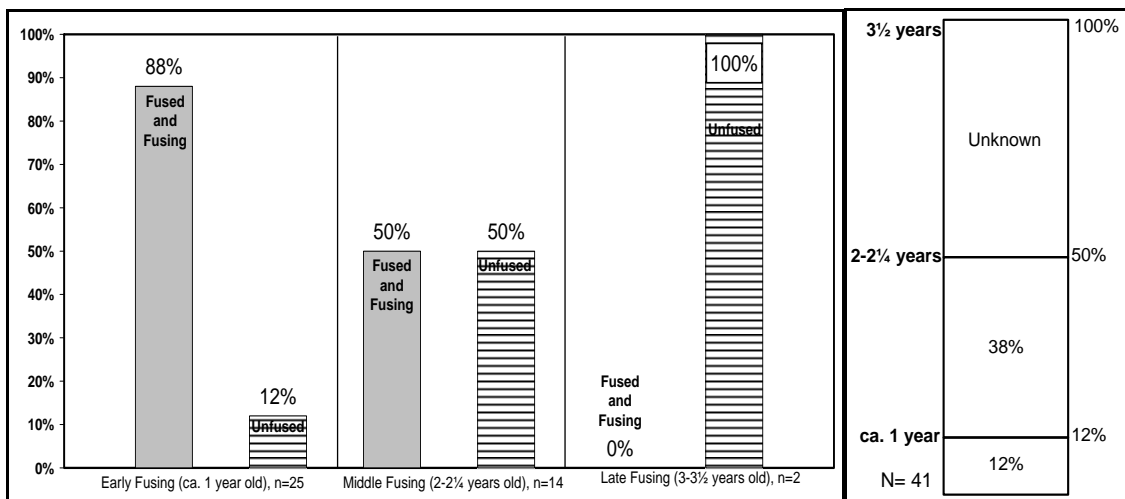


Figure 4.62: Age-at-death data for Iron Age I Soto de Medinilla based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Tooth eruption and wear informs us of a small loss of 3% during the neonatal stage and of 12% in the 1-6 months interval. The mortality peak (59%) during the 7-13 months interval is the dominant feature of the age profile in this phase. Following this main slaughtering peak, the culling of 10% in the 14-26 and of 16% in the 27-41 months interval is recorded. As it has been observed in other assemblages, tooth eruption and wear produce a younger age profile.

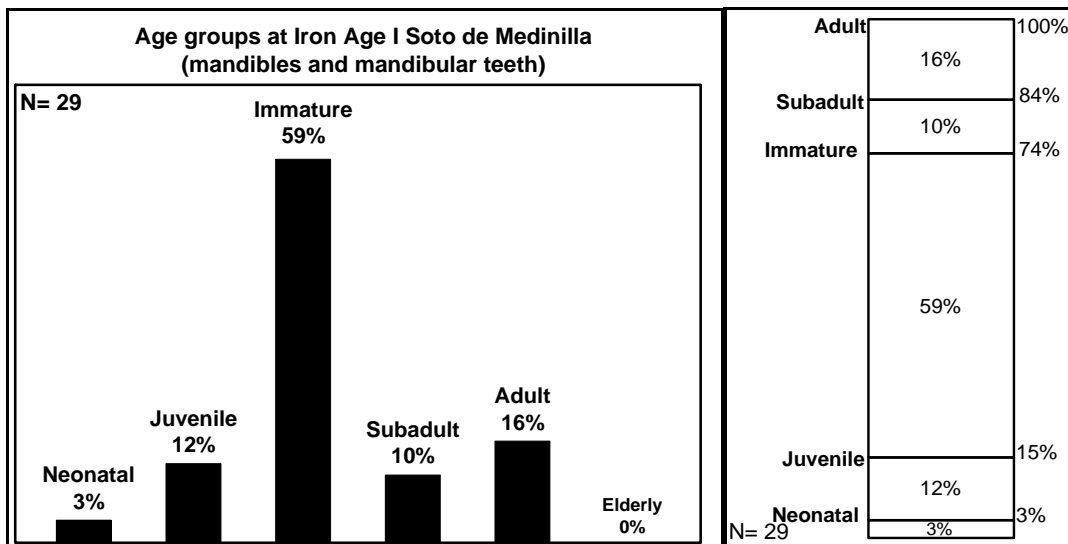


Figure 4.63: Age-at-death data for Iron Age I Soto de Medinilla based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

In the Iron Age II at Soto de Medinilla (figure 4.64), an increase in mortality during the first year (from 12% in Iron Age I to 21%) can be observed, while losses during the second year are almost the same as in the Iron Age I (50% and 49%). The larger Iron Age II sample also provides some evidence for late-fusing bones, which was almost completely lacking in the earlier period. This indicates that *ca.*25% of the Iron Age II population was culled when older than 3.5 years. Overall, the pattern for the two periods can be considered as relatively similar.

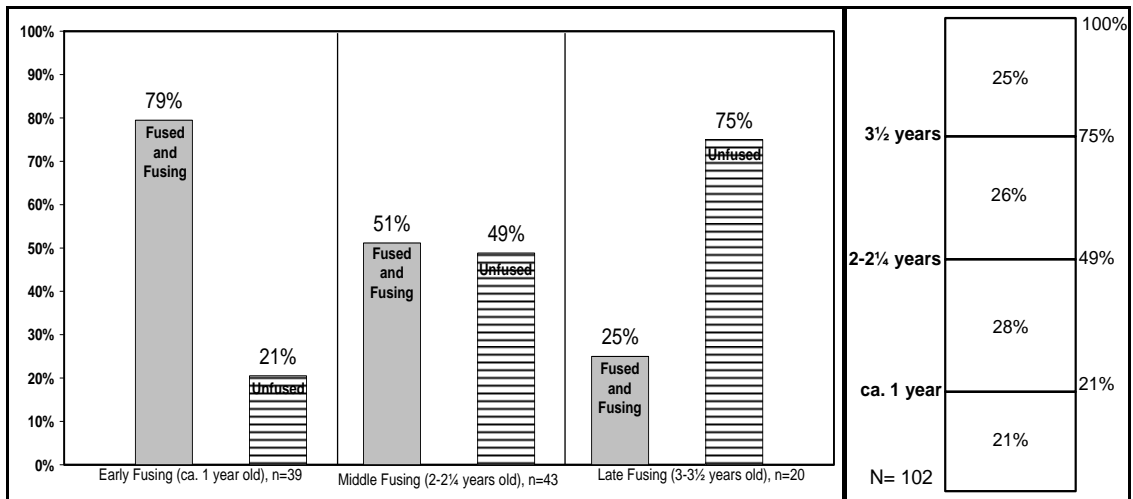


Figure 4.64: Age-at-death data for Iron Age II Soto de Medinilla based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Tooth eruption and wear for Iron Age II Soto de Medinilla (figure 4.65) indicate high mortality in the first year (62% with 31% in the 1-6 and 7-13 months respectively). Mortality in the 14-26 and 27-41 months is rather low (19% each). Compared to the profile of the previous phase (Iron Age I, figure 4.63), Iron Age II presents slightly higher percentages of survival into the 14-26 (19% vs. 10%) and 27-41 (19% vs. 16%) months intervals. The dominant mortality peak, which was at the 7-13 months interval in Iron Age I (59%), is evenly distributed between the 1-6 (31%) and 7-13 (31%) month intervals in Iron Age II.

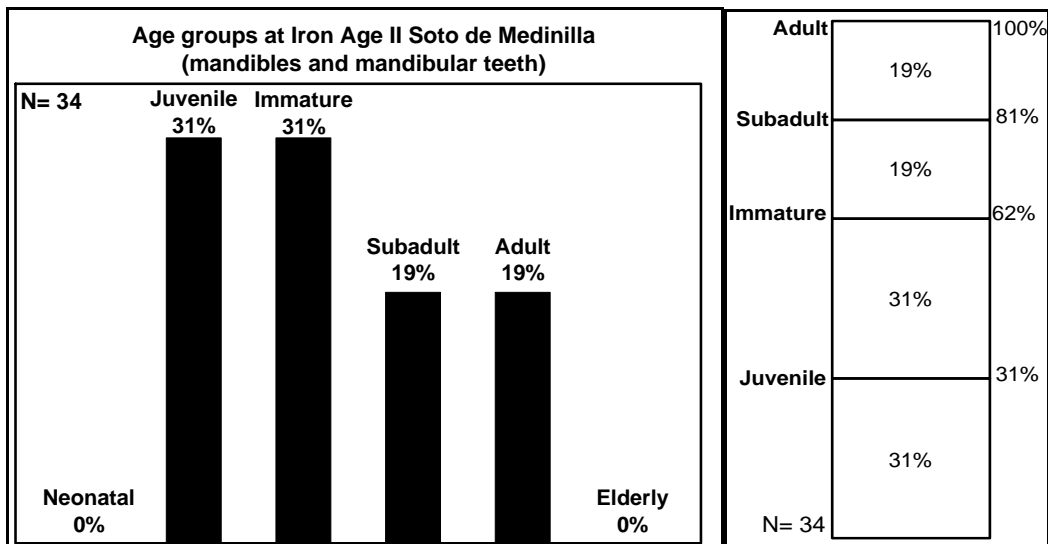


Figure 4.65: Age-at-death data for Iron Age II Soto de Medinilla based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

An overall picture of the age profile of the pig population during the Iron Age at Soto de Medinilla is provided in figure 4.66, which combines the epiphyseal fusion data from both Iron Age phases. Since the data have been pooled and

the largest sample is that of Iron Age II (102 vs. 41 specimens), the results are expectedly more similar to those of the later period. The age profile shows 17% culling in the first year, 32% in the 13-26 months interval, 28% in the 27-41 interval and 23% survives beyond 3.5 years of age.

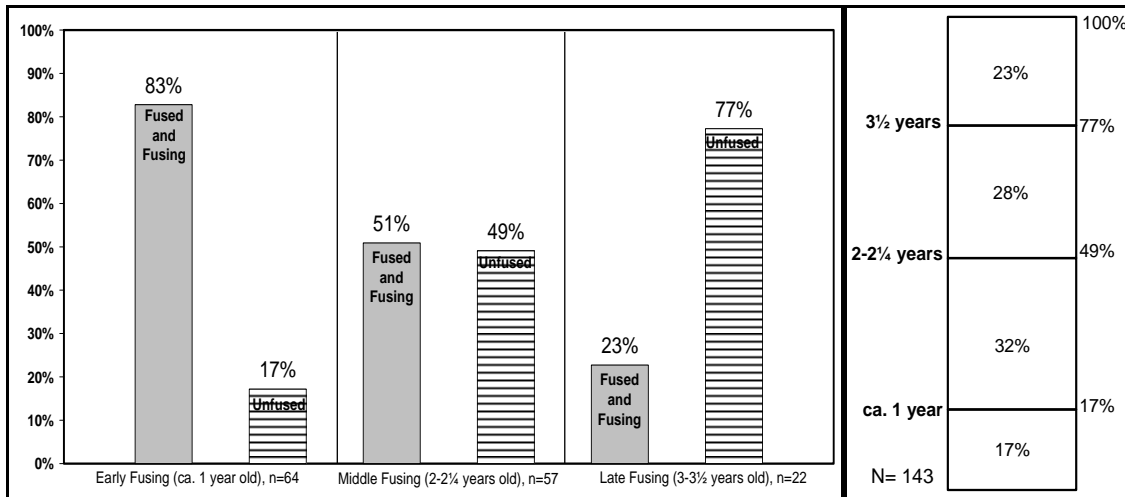


Figure 4.66: Age-at-death data for Iron Age I+II Soto de Medinilla based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Due to the almost equal amount of available specimens - 29 for Iron Age I vs. 34 for Iron Age II – tooth eruption and wear data produced a more balanced age structure for the Iron Age pig population of Soto de Medinilla (figure 4.67). A minimal (2%) loss of neonatal individuals is followed by a further reduction of the pig population by 22% in the first six months. As in Iron Age I, the dominant slaughtering peak is in the 7-13 months interval. The remaining 31% is almost equally divided between the 14-26 (15%) and 27-41 (17%) month intervals.

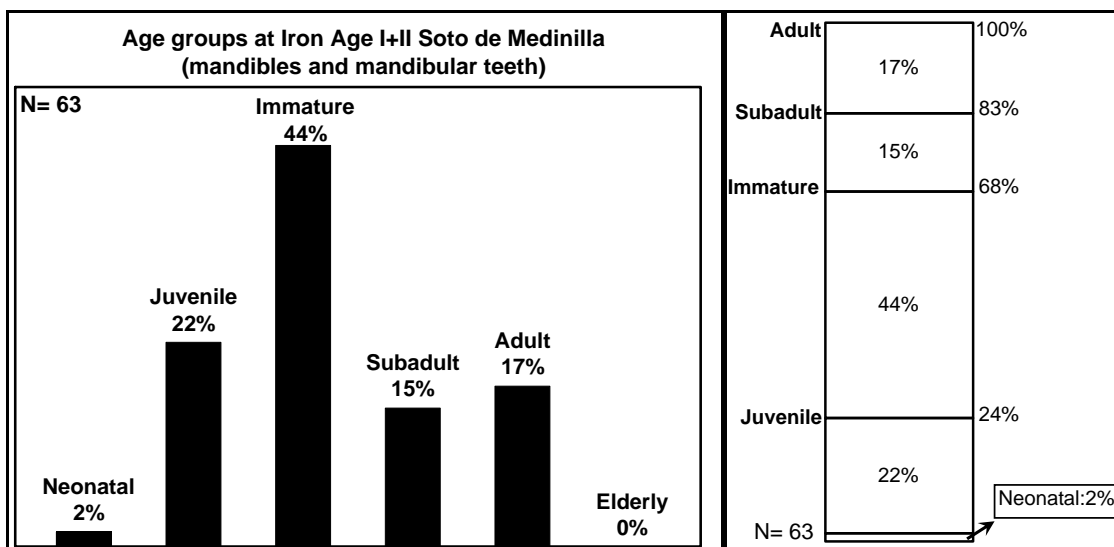


Figure 4.67: Age-at-death data for Iron Age I+II Soto de Medinilla based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The fourth largest assemblage from the Iron Age is that of La Mota, which, like Soto de Medinilla, is located in the province of Valladolid on the northern central plateau. This site dates to the Iron Age I-II transition (6th-5th centuries BC).

The sample of ageable postcranial elements is rather small (N=50) and the late-fusing category in particular is hardly represented (N=1). According to the produced age profile, almost a third of the pig population was culled in the first year, and 12% more in the 13-26 months interval (figure 4.68). It therefore seems that the majority of pigs were slaughtered when older than 26 months of age. Due to the lack of information regarding late-fusing bones, it is not possible to reconstruct the age profile completely.

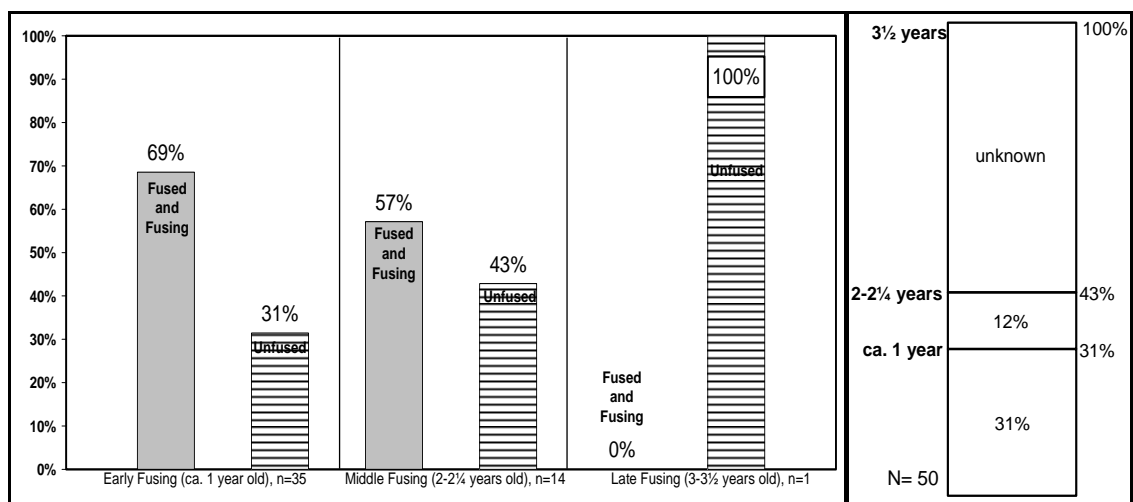


Figure 4.68: Age-at-death data for Iron Age (transition Iron Age I-II) La Mota based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Tooth eruption and wear data from La Mota show 6% mortality among neonates, no mortality in the 1-6 months interval and 30% in the 7-13 months interval (figure 4.69). In the 14-26 months interval 28% of the population was culled. A similar percentage (30%) was culled in the 27-41 months interval. Finally, the presence of individuals (6%) older than 3.5 years is confirmed at La Mota, which is a finding only rarely encountered in dental ageing data so far.

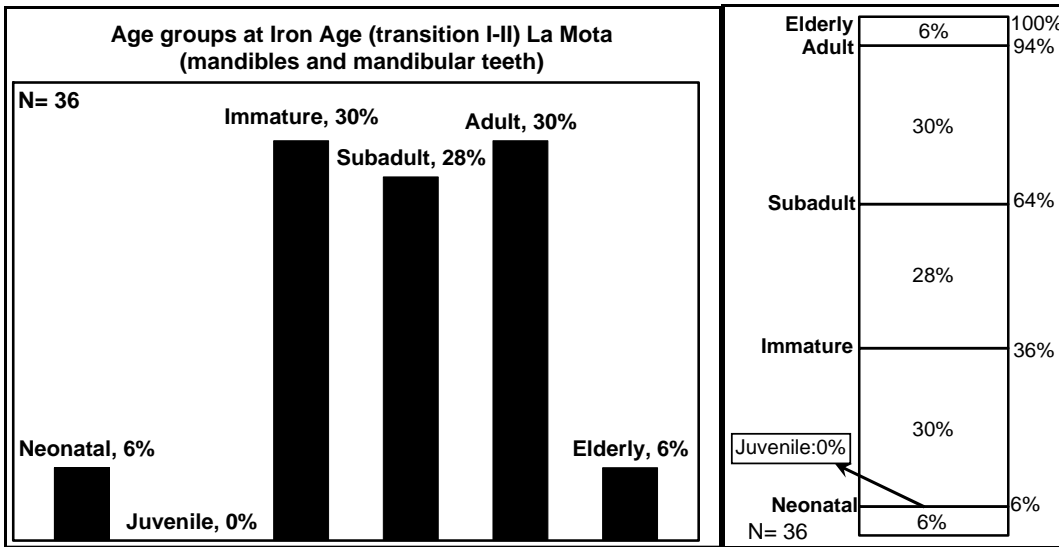


Figure 4.69: Age-at-death data for Iron Age (transition Iron Age I-II) La Mota based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

A relatively good-sized sample of postcranial bones is available from the Iron Age II site of Las Rabas in Cantabria. The age profile based on epiphyseal fusion (figure 4.70) exhibits fairly low mortality in the 0-12 (10%) and 13-26 (14%) months intervals, but the dominant feature is the slaughtering peak (51%) in the 27-41 months interval. Moreover, a significant proportion of the population (25%) survived beyond the age of 3.5 years.

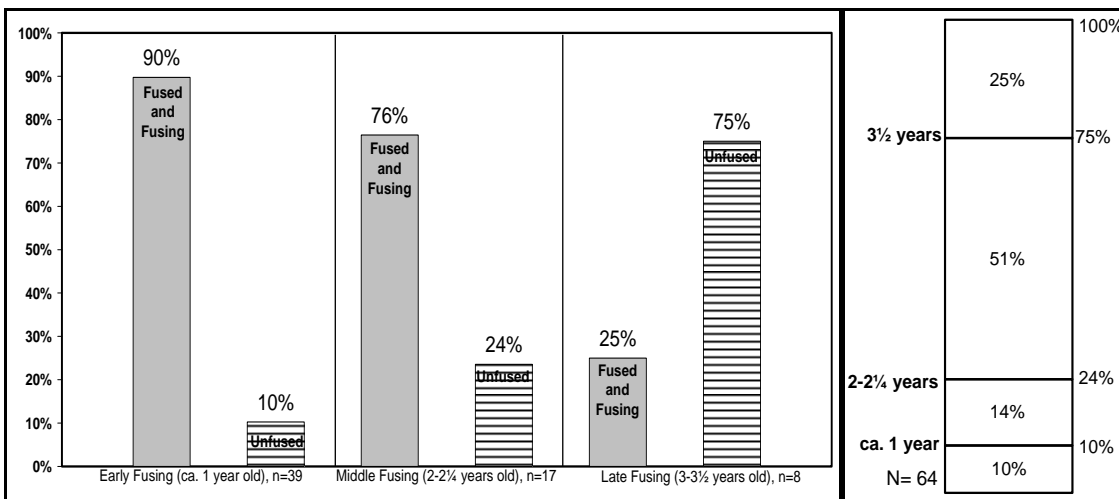


Figure 4.70: Age-at-death data for Iron Age II Las Rabas based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Tooth eruption and wear data from Las Rabas are rather scarce (N=15, figure 4.71) but they are nonetheless of interest in comparison with the fusion data. Approximately a quarter of the population (27%) was culled in the first year and 23% in the 14-26 months interval. The dominant peak (50%) is recorded in the 27-41 months interval. As has been noted for other assemblages, the age

structure based on dental eruption and wear appears to be somewhat younger than the one based on epiphyseal fusion, probably due to the common preservation bias against unfused bones.

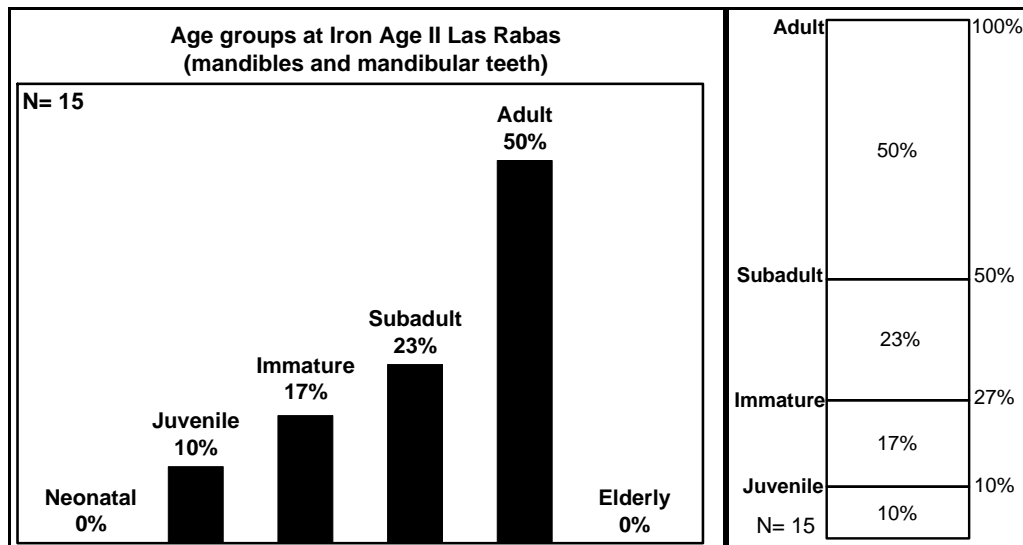


Figure 4.71: Age-at-death data for Iron Age II Las Rabas based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

Not far from Las Rabas, the Iron Age (7th-6th century BC) site of Campa Torres in Asturias on the Atlantic coast of Spain yielded a relatively small sample of postcranial bones and teeth. Like Las Rabas, the profile based on epiphyseal fusion (figure 4.72) exhibits low mortality in the 0-12 (7%) and 13-26 (7%) months intervals, and a significant peak (53%) in the 27-41 interval. A significant percentage of the population (33%) reached an age older than 3.5 years.

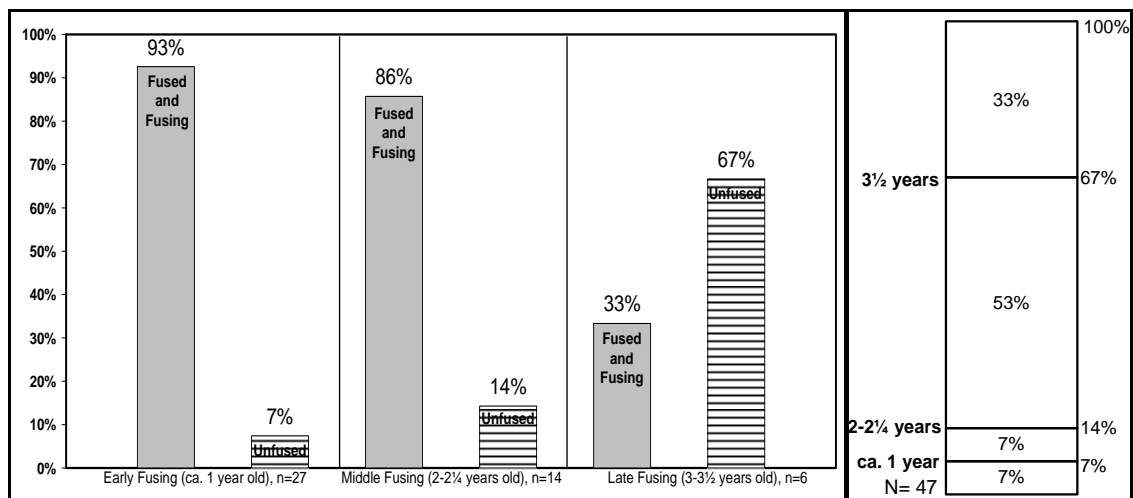


Figure 4.72: Age-at-death data for Iron Age (7th-6th century BC) Campa Torres based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

Tooth eruption and wear data also produced an age profile similar to that of Las Rabas. The results (figure 4.73) show relatively few losses in the first year (18%), which are almost doubled (34%) in the 14-26 months interval. Finally, almost half the population (48%) was culled in the 27-41 months interval. It is worth noticing that the two lines of ageing evidence are broadly compatible for this assemblage, despite a tendency towards an older age profile based on epiphyseal fusion.

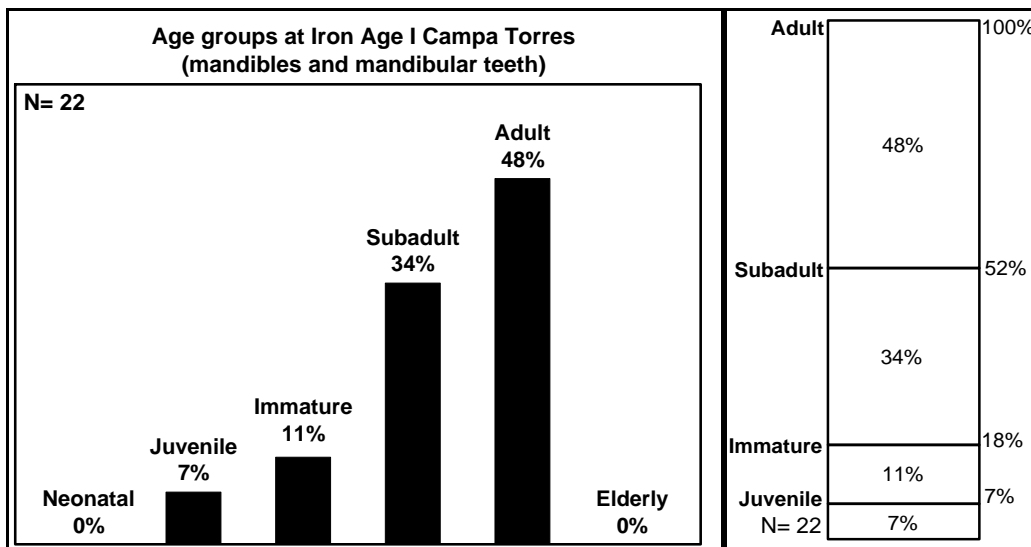


Figure 4.73: Age-at-death data for Iron Age (7th-6th century BC) Campa Torres based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

Castillo de Henayo (Álava, Basque Country) yielded a small (N=31) sample of ageable postcranial bones dating to the Iron Age II (5th-3rd centuries BC). Due to the small sample size, the findings (figure 4.74) should be interpreted with caution. However scanty, the data suggest a low percentage of culling in the first year, and that most pigs were culled in the 13-26 months interval.

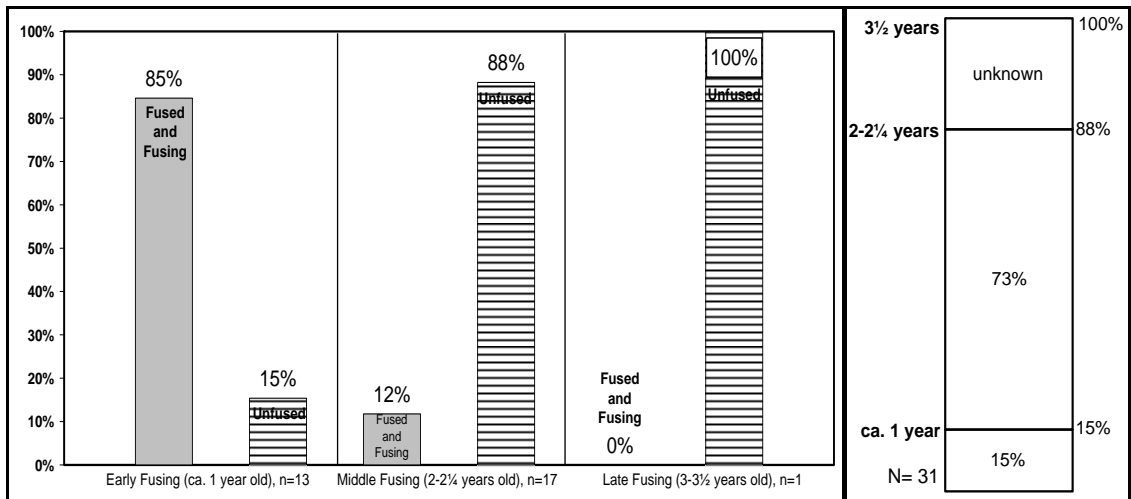


Figure 4.74: Age-at-death data for Iron Age II (5th-3rd centuries BC) Castillo de Henayo based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

The assemblage of Castillo de Henayo also produced a small sample (N=21) of mandibles and mandibular teeth. On the basis of eruption and wear (figure 4.75) the age profile of this pig population exhibits some losses in the neonatal stage (5%), low mortality (7%) in the 1-6 and high mortality (31%) in the 7-13 months intervals. A further 24% was culled in the 14-26 months interval and 33% survived into the third and fourth year of age.

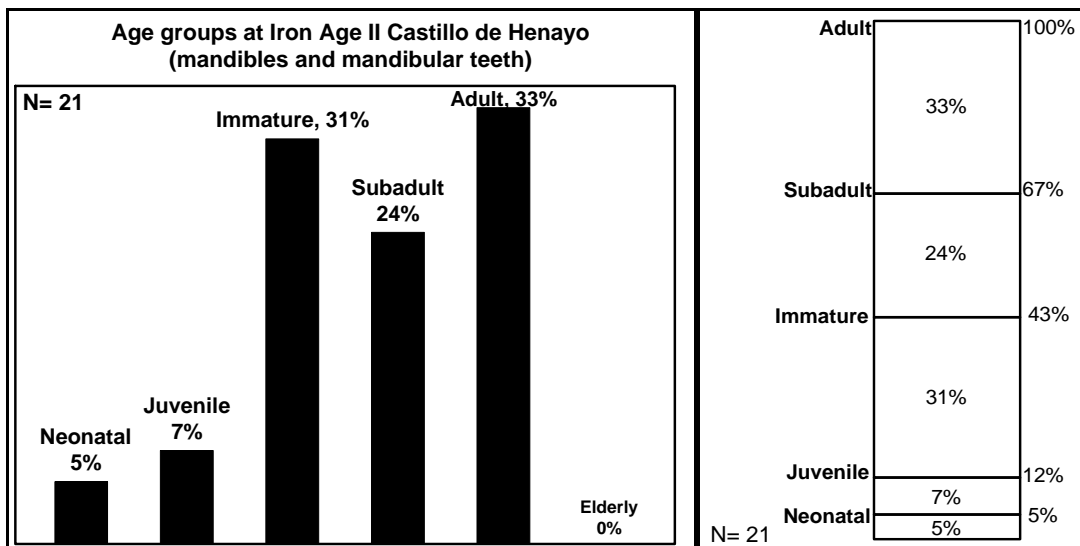


Figure 4.75: Age-at-death data for Iron Age II (5th-3rd centuries BC) Castillo de Henayo based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The Iron Age II (5th century BC) assemblage of Castro de Berbeia (Álava, Basque Country) yielded a quite small sample of postcranial elements (N=15), which offers limited information on the age profile of the population. Considering

the small sample size, the only valid comment is that the mortality is low in the first year of life, but increases in the second (figure 4.76).

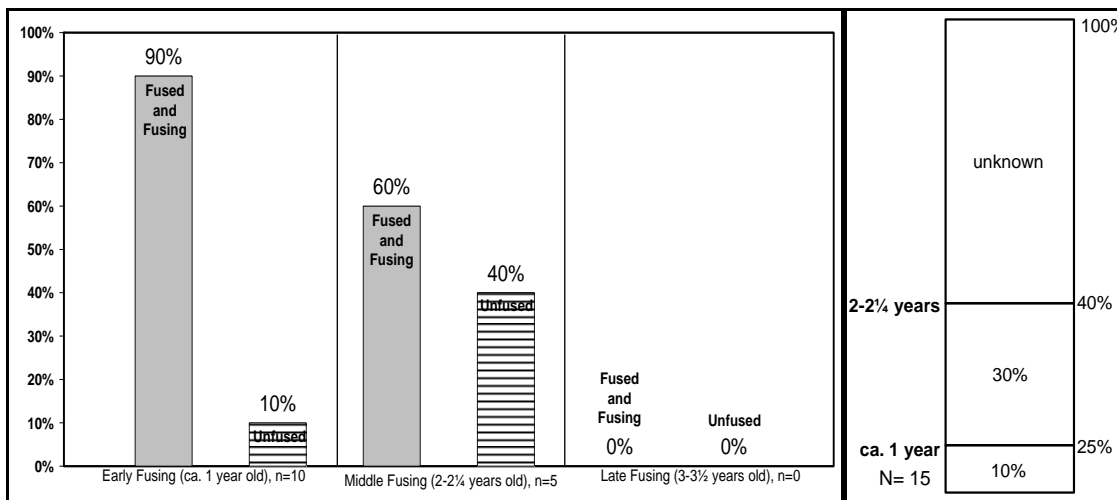


Figure 4.76: Age-at-death data for Iron Age II (5th century BC) Castro de Berbeia based on epiphyseal fusion. Data are presented per category of fusing elements (left) and in the form of a mortality bar (right).

The sample of mandibles and loose mandibular teeth from Castro de Berbeia is also too small (N=10) for detailed and reliable analysis. However, these data can offer insights missed by the small postcranial sample, such as the survival of important parts of this population into the third and fourth years of age (figure 4.77).

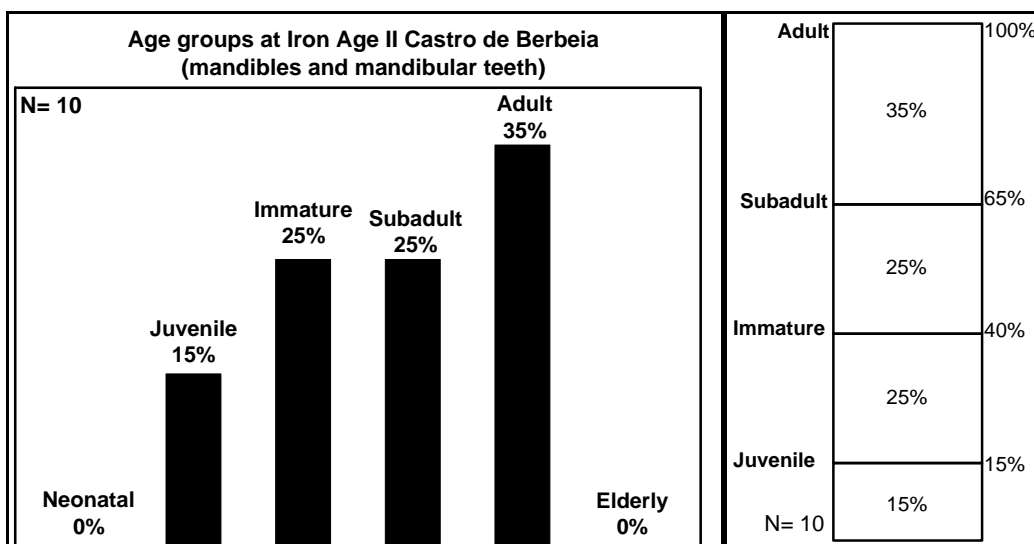


Figure 4.77: Age-at-death data for Iron Age II (5th century BC) Castro de Berbeia based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

From the assemblage of Santa Ana, an Iron Age site situated in the Logroño province at La Rioja, the few aged mandibles and loose teeth (N=18) indicate very few losses in the first year (6%), while most culling (52%) occurred in the

14-26 months interval. Furthermore, about a third of the population was culled in the 27-41 months interval and the presence of individuals older than 42 months is confirmed.

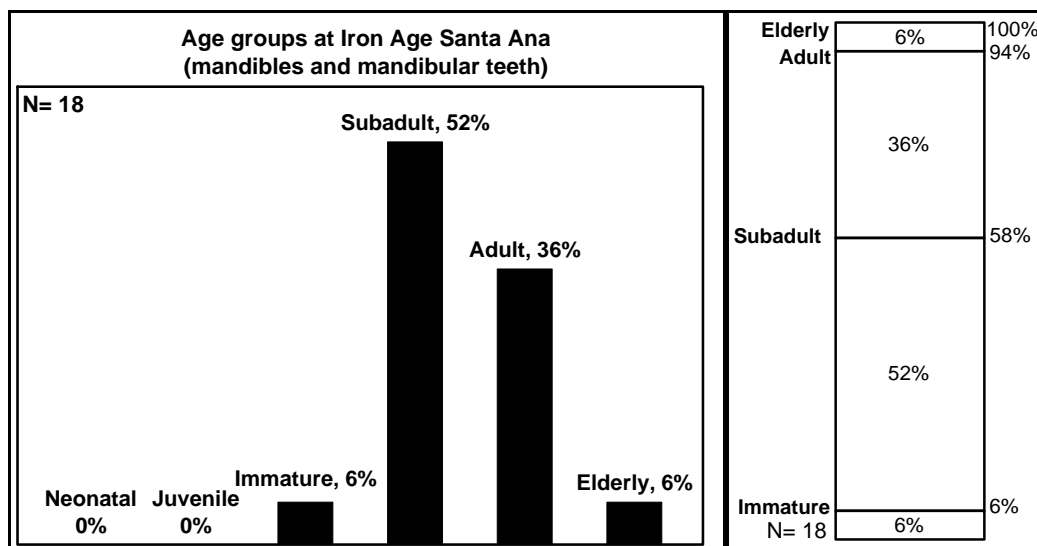


Figure 4.78: Age-at-death data for Iron Age Santa Ana based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

The assemblage of Iron Age I Castillar de Mendavia (Navarra) yielded a small sample (N=17) of mandibles and mandibular loose teeth. The results (figure 4.79) can only be commented in a general way, and they show 27% mortality in the first year, 35% in the second and 38% in the third and fourth years.

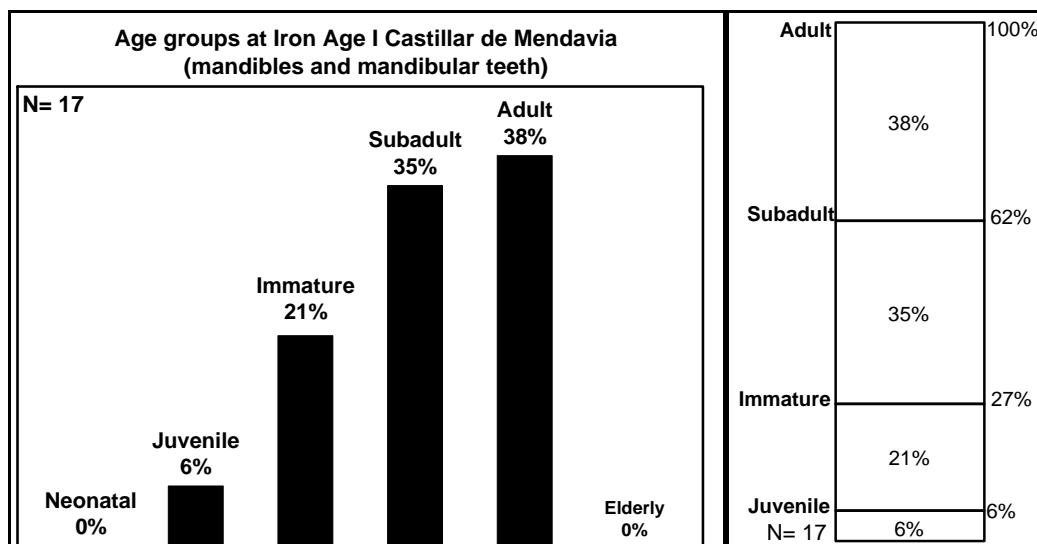


Figure 4.79: Age-at-death data for Iron Age I Castillar de Mendavia based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

Calle Puerto No10 (Huelva province, southwest Spain), dating between the 7th and the 4th centuries BC, is the last Iron Age assemblage subjected to ageing analyses and the only available from the southern half of Spain. Epiphyseal

fusion shows that almost a third of the pig population was slaughtered during the first year and another third in the 13-26 month interval (figure 4.80). Unfortunately, too few late-fusing elements were recorded to allow a reconstruction of the age profile beyond the age of 26 months and tooth eruption and wear data are too scarce to be presented.

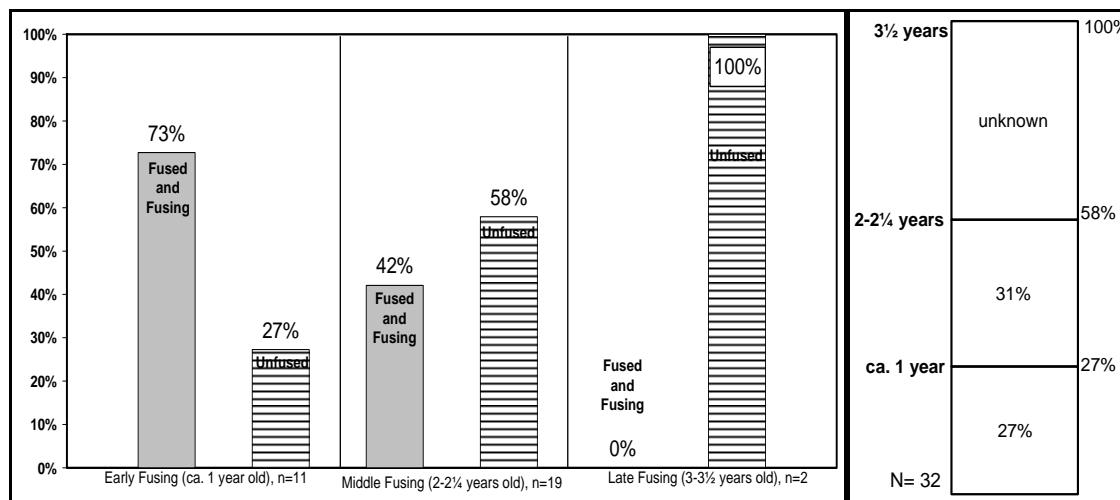


Figure 4.80: Age-at-death data for Iron Age (7th-4th centuries BC) Calle Puerto 10 based on tooth eruption and wear. Data are presented per age category (left) and in the form of a mortality bar (right).

To sum up, the two lines of ageing evidence presented in this section for Iron Age Spain show generally older age profiles compared to the Copper and Bronze Ages. In most Iron Age assemblages the majority of pigs were slaughtered in the second, third and fourth years of age. This pattern holds true for the Copper and Bronze Ages too. However, in the Iron Age the percentage of survival in the third and fourth year and beyond is clearly increased (also see figure 4.81). Despite that tooth eruption and wear data produced consistently younger age profiles, some Iron Age assemblages provided eruption and wear evidence that indicated the presence of small numbers of 'elderly' pigs in the population.

The beginning of this trend towards a progressively older pig herd can already be traced in some Neolithic assemblages, but it is more confidently identified in the Copper Age and consolidated in the Bronze Age. The patterns in the Iron Age profiles represent the culmination of this trend and suggest that by the end of the Iron Age, pig husbandry strategies were geared towards obtaining the maximum meat output from most of the pigs in the herd (figure 4.81).

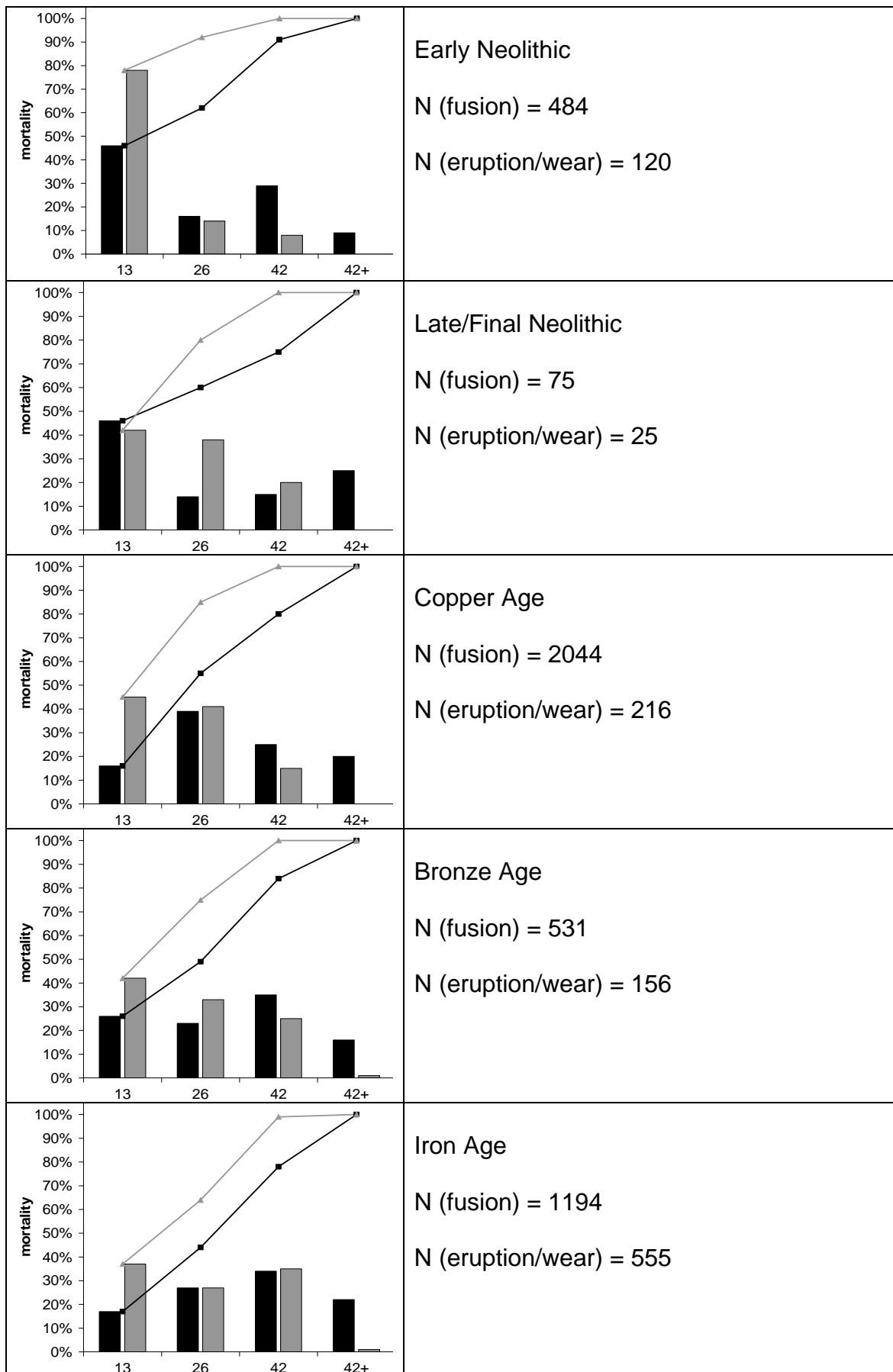


Figure 4.81: Age profiles based on pooled samples from each chronological period. The black colour represents epiphyseal fusion and the grey colour represents tooth eruption and wear. Bars show the mortality per age interval and the lines show the same data in a cumulative form. The numbers on the x axis represent age in months.

The age profiles of Iron Age pig populations revealed a chronological pattern, which shows that in the later phase of this period an increase in survival in the third, fourth years and beyond occurred. The largest assemblages with reliable samples from different phases of the Iron Age, such as La Hoya, Castros de Lastra and Soto de Medinilla, produced results which clearly show this tendency. Furthermore, the rest of the age profiles dating to the Iron Age II, such as those of Las Rabas, Castillo de Henayo and Castro de Berbeia, also exhibit lower mortality in the younger age intervals (roughly the first year) and higher in the older age intervals (especially third and fourth years). To obtain an overview of this trend, all epiphyseal fusion as well as tooth eruption and wear data from both Iron Age phases were pooled in order to produce overall age profiles for each phase (figure 4.82). Although the differences in the age profiles for the two phases are subtle, there is a tendency towards higher percentages of survival in the 26-41 and 42+ months intervals in the Iron Age II.

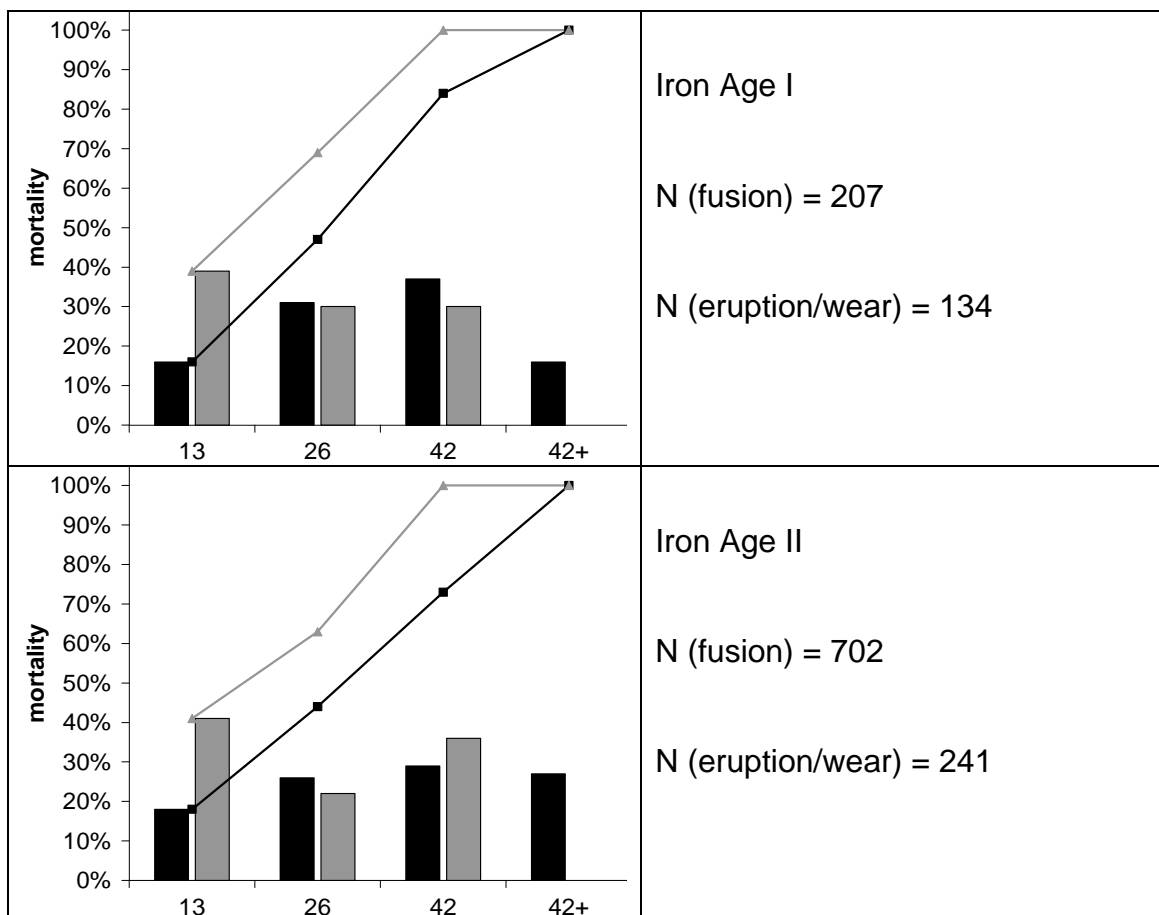


Figure 4.82: Age profiles based on pooled samples from Iron Age I and Iron Age II. The black colour represents epiphyseal fusion and the grey colour represents tooth eruption and wear. Bars show the mortality per age interval and the lines show the same data in a cumulative form. The numbers on the x axis represent age in months.

Also of particular interest is the tendency of tooth eruption and wear data to produce consistently younger age profiles compared with epiphyseal fusion – in terms of absolute age. Undoubtedly, the two lines of ageing evidence are closely related to the process of growth and ageing of animals, and hence the passage of time. However, they are also differently affected by other processes which make the task of establishing equivalences between them very difficult. The purpose of comparing the two ageing methods was not a detailed correlation but rather a combination of the information that they provide. This approach was chosen to ensure that possible biases acting on postcranial elements are more easily identified through the study of tooth eruption and wear and vice versa. The observation that the discrepancy between epiphyseal fusion and eruption and wear is quite consistent through time, suggests that it probably involves a bias acting uniformly in most areas and periods. The most likely bias that would have such a uniform effect on age profiles is the poor preservation of unfused postcranial elements. Furthermore, it is possible that preservation and recovery biases also affect – though to a lesser degree – the survival of teeth deriving from adult and elderly animals due to increased fragility when heavily worn. In some cases, heavily-worn teeth may even fall off the jaws.

4.3 Biometry

In chapter 3 the biometric analysis employed on pre-Neolithic and Neolithic dental and postcranial pig remains was presented, while this chapter deals with later prehistory (Copper, Bronze and Iron Age). The main aims of this analysis are to examine pig husbandry practices and wild boar hunting in the post-Neolithic periods, but also to enhance the resolution and interpretational value of the pre-Neolithic and Neolithic data through comparisons. In order to achieve an evolutionary perspective, some repetition in the presentation of data from earlier periods will be inevitable.

4.3.1 Biometry of postcranial elements

Mirroring the structure applied in chapter 3, the evidence is presented first in the form of scatterplots followed by log ratio histograms within each chronological period. Before presenting any specific biometrical analysis, summary statistics of postcranial measurements are provided and briefly discussed (table 4.2).

Although presented separately in chapter 3, pre-Neolithic and Neolithic periods are included here as well to provide a complete statistical overview of the data from all periods.

Table 4.2: Number (N), minimum, maximum, mean and coefficient of variation (V) for postcranial measurements of pre-Neolithic, Neolithic and post-Neolithic chronology. Only fully fused specimens were included.

Pre-Neolithic					
	N	Minimum	Maximum	Mean	V
Astragalus GLI	8	44.3	50.2	47.7	4.4
Astragalus GLm	6	39.5	46.1	42.8	5.9
Early Neolithic					
	N	Minimum	Maximum	Mean	V
Astragalus GLI	30	37.6	53.4	45.9	8.7
Astragalus GLm	33	34.7	47.4	41.2	8.0
Humerus BT	8	31.9	41.5	36.7	8.2
Humerus HTC	9	20.1	24.9	22.7	8.0
Tibia BdP	7	30.9	43.1	38.2	11.2
Tibia Dd	7	25.4	34.5	31.1	10.3
Calcaneum GL	5	84.6	101.9	94.3	6.9
Calcaneum GD	5	29.5	37.4	34.4	8.6
Late/Final Neolithic					
	N	Minimum	Maximum	Mean	V
Astragalus GLI	7	37.5	43.5	40.7	4.5
Astragalus GLm	7	35.3	38.7	37.1	3.1
Copper Age					
	N	Minimum	Maximum	Mean	V
Astragalus GLI	64	34.9	51.3	40.2	7.6
Astragalus GLm	63	31.5	45.1	36.8	7.4
Humerus BT	24	26.3	39.2	30.5	9.9
Humerus HTC	29	15.7	23.5	18.2	9.7
Tibia BdP	22	26.0	36.4	28.3	7.8
Tibia Dd	23	22.3	33.3	24.7	8.9
Calcaneum GL	12	65.4	97.0	77.1	10.9
Calcaneum GD	10	25.7	37.3	28.1	12.2
Bronze Age					
	N	Minimum	Maximum	Mean	V
Astragalus GLI	27	36.5	49.6	42.2	8.5
Astragalus GLm	25	33.3	45.0	38.3	8.2
Humerus BT	20	25.5	38.5	30.4	11.3
Humerus HTC	20	14.6	24.1	18.9	14.0
Tibia BdP	5	28.2	38.9	33.6	12.7
Tibia Dd	5	24.8	30.6	26.8	9.2
Calcaneum GD	5	29.0	37.0	32.8	10.9
Iron Age					
	N	Minimum	Maximum	Mean	V
Astragalus GLI	41	37.6	44.6	40.2	4.1
Astragalus GLm	55	32.3	39.7	35.8	5.0
Humerus BT	30	26.3	32.7	28.5	5.2
Humerus HTC	32	15.8	19.5	17.5	5.8
Tibia BdP	13	26.8	37.2	29.6	10.1
Tibia Dd	15	22.4	31.0	24.9	9.0
Calcaneum GL	6	69.4	104.9	89.1	19.4
Calcaneum GD	6	25.6	40.9	31.8	19.9

The trend towards smaller size identified in chapter 3 continues in the Copper Age as the means of all measurements are clearly lower than in the Early or Late/Final Neolithic. The means of measurements in the Bronze Age are still clearly smaller than their Early Neolithic but larger than their Late/Final Neolithic counterparts. In the Iron Age, a pronounced size reduction is recorded in comparison to all earlier periods.

4.3.1.1 Copper Age

The analysis of Copper Age biometric data is of particular interest in order to follow the evolution of pig size and to some extent, shape, in Spain. In contrast to preceding periods, larger samples are available, which have the potential, through comparison, to shed light on the Neolithic and pre-Neolithic data too.

In addition to the graphical exploration of size differences in postcranial elements presented below, the data are further analysed by using Kruskal-Wallis followed by Mann-Whitney tests. Statistically significant size differences between any of the periods could be found for all measurements (all Kruskal-Wallis tests $p < 0.004$, with the exception of calcaneum greatest length $p=0.06$). The non-significant result for the calcaneum measurement might be related to that sample being the smallest included in the analysis. Mann-Whitney tests were used to follow up all remaining significant results, excluding samples containing fewer than five specimens. Results involving the Copper Age sample are presented in table 4.3 but are commented in an element by element fashion in combination with the scatterplots. However, before delving into the presentation of biometric data, it is important to note that almost all Copper Age postcranial elements are very highly significantly smaller than their pre-Neolithic and Early Neolithic counterparts. The differences to the Late/Final Neolithic and later periods are either statistically insignificant - or noticeably less significant than the size differences compared to the pre-Neolithic and Early Neolithic periods.

Table 4.3: Significance (two-tailed) of size differences in pig postcranial measurements between Copper Age and the rest of the prehistoric periods, calculated with Mann-Whitney tests. Only samples with a minimum of five or more measurements were subjected to testing; green: very highly significant; blue: highly significant; yellow: significant.

	GLI	GLm	BT	HTC	BdP	Dd	CaIGD
Pre-Neolithic / Copper Age	<0.001	<0.001					
Early Neolithic / Copper Age	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.014
Late-Final Neolithic / Copper Age	0.316	0.389					
Copper Age / Bronze Age	0.010	0.029	0.517	0.189	0.008	0.036	0.020
Copper Age / Iron Age	0.326	0.088	0.005	0.082	0.124	0.929	0.128

The most abundant element is, as usual, the astragalus and in figure 4.83 the greatest lateral and medial lengths of all Copper Age specimens are plotted with the pre-Neolithic, Early Neolithic and Late/Final Neolithic specimens, which were already presented in chapter 3. The scatterplot reveals an interesting contrast between Copper Age and pre- and Neolithic pigs. Most Copper Age measurements cluster in the lower part of the distribution. They generally tend to be smaller than most pre-Neolithic and Early Neolithic measurements, although a considerable overlap exists. This size decrease from Early Neolithic to Copper Age specimens is very highly significant, while Late/Final Neolithic and Copper Age specimens do not differ significantly (table 4.3). Additionally, there are two Copper Age outliers in the upper part of the distribution together with some of the Early Neolithic and most of the pre-Neolithic specimens. Late/Final Neolithic measurements, though few, exhibit a similar distribution to the Copper Age measurements with most specimens plotting in the lower part. The relatively clear-cut pattern produced by the Copper Age and Late/Final Neolithic measurements is somehow blurred by most Early Neolithic measurements which create an extensive area of overlap. A small gap in the distribution at around GLm=42mm is perceivable and this may help discriminating between small domestic and large wild forms in the Late/Final Neolithic and the Copper Age. Considering that three of the pre-Neolithic specimens (presumably wild) plot in the smaller group, the gap is less likely to be a convincing threshold between populations in the Early Neolithic. In general, it should be kept in mind that only the astragalus measurements were included in the analysis.

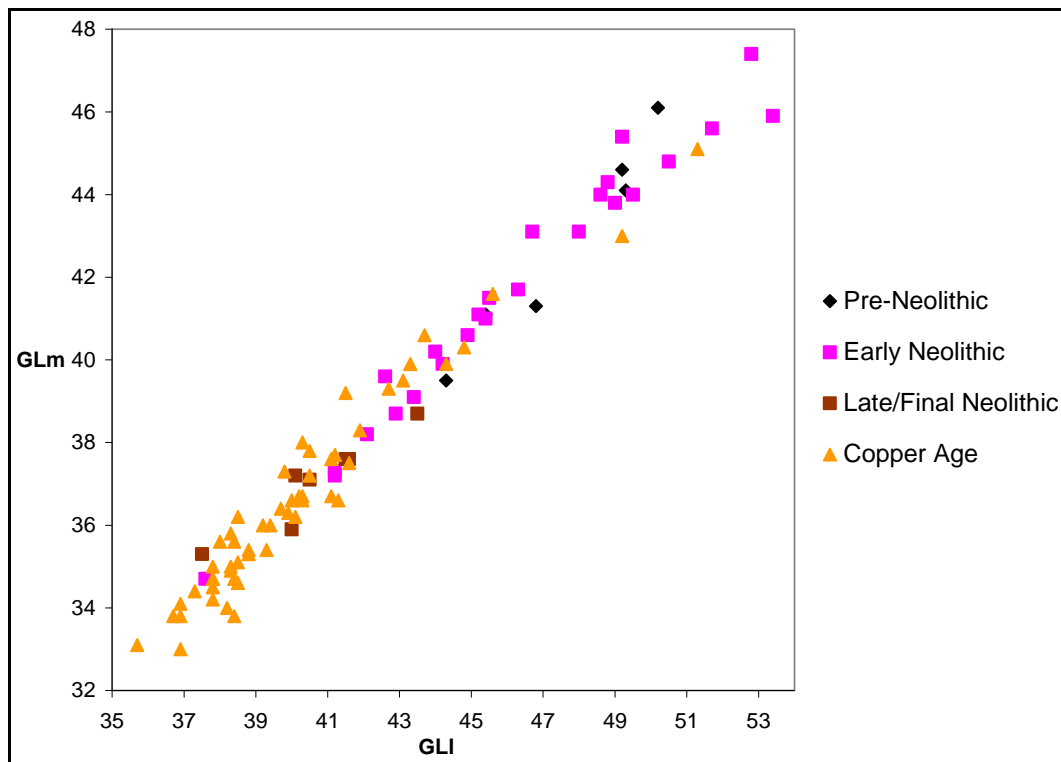


Figure 4.83: Scatterplot of astragalus greatest lateral x greatest medial lengths from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Light and porous specimens are excluded. Measurements in mm.

After the astragalus, the most commonly measured element in Copper Age assemblages was the distal humerus. The data are plotted in figure 4.84 with all Early Neolithic and Late/Final Neolithic specimens (no measurements from pre-Neolithic humeri were available). The scatterplot (figure 4.84) exhibits a similar pattern to that of the astragalus. The vast majority of Copper Age specimens and the Late/Final Neolithic specimen, plot in the lower left part of the distribution with a couple of Copper Age outliers plotting in the upper right part together with most of the Early Neolithic specimens. As for the astragalus, the majority of Copper Age specimens are clearly – and very highly significantly (table 4.3) - smaller than the Early Neolithic specimens, though some large outliers are present.

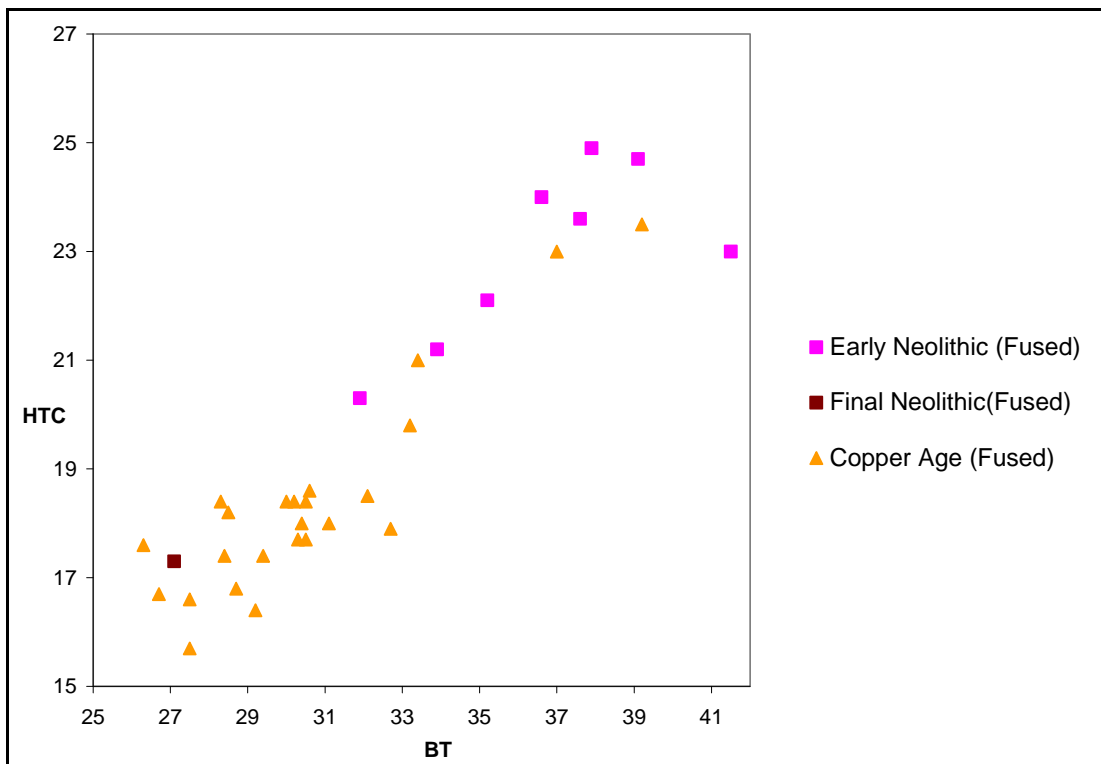


Figure 4.84: Scatterplot of humerus width of trochlea x minimum diameter of trochlea from combined samples of Early Neolithic, Final Neolithic and Copper Age chronology. Measurements in mm.

The distal tibia is the only other postcranial element that, due to the availability of measurements, can be compared with pre-Neolithic and Neolithic specimens. Once again, the scatterplot (figure 4.85) confirms the pattern established by the astragalus and humerus measurements, according to which Copper Age specimens are much smaller than the Early Neolithic and pre-Neolithic specimens (very highly significantly in statistical terms; table 4.3), with the exception of few large outliers. Since no fused distal tibiae were available for the pre-Neolithic, fusing specimens were also plotted; even those are significantly larger than most Copper Age specimens. This is not surprising as the distal tibia has been proven to be subject to limited post-fusion growth (Albarella and Payne 2005: 595). Although the two clusters are clear-cut, their distinction should not be over-emphasised due to the relatively small sample size.

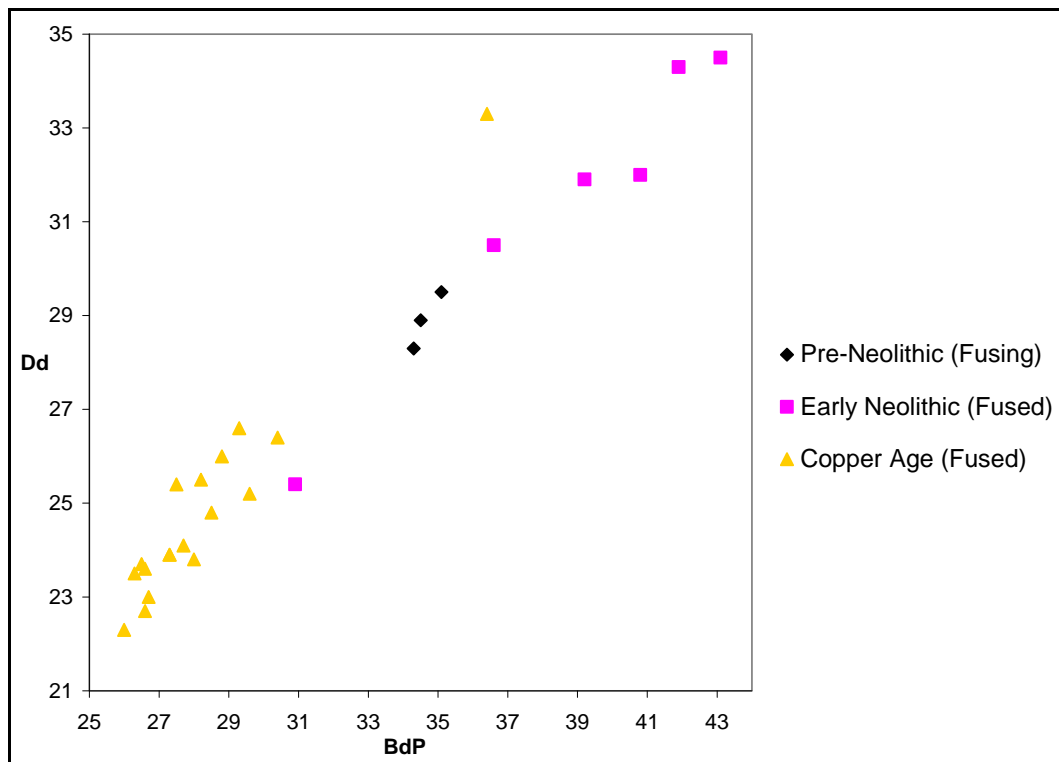


Figure 4.85: Scatterplot of tibia distal width x depth of the distal end from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Only pre-Neolithic ‘fusing’ specimens are included. Measurements in mm.

In summary, the comparison of Copper Age with earlier material has established some important biometric differences between samples of different chronologies. In order to examine possible variations in size between Copper Age pig populations, astragalus measurements are also compared by site (figure 4.86). The distribution does not exhibit any particular pattern, although this issue cannot be addressed adequately due to the scarcity of specimens from most Copper Age sites, except Valencina de la Concepción and Los Millares. If the two clearly larger outliers (from Valencina) are excluded, the vast majority of Copper Age specimens plot in the central and lower parts of the distribution and appear to be of generally similar size. Tibia, humerus and calcaneum measurements were also analysed and produced similar results, but with smaller available samples.

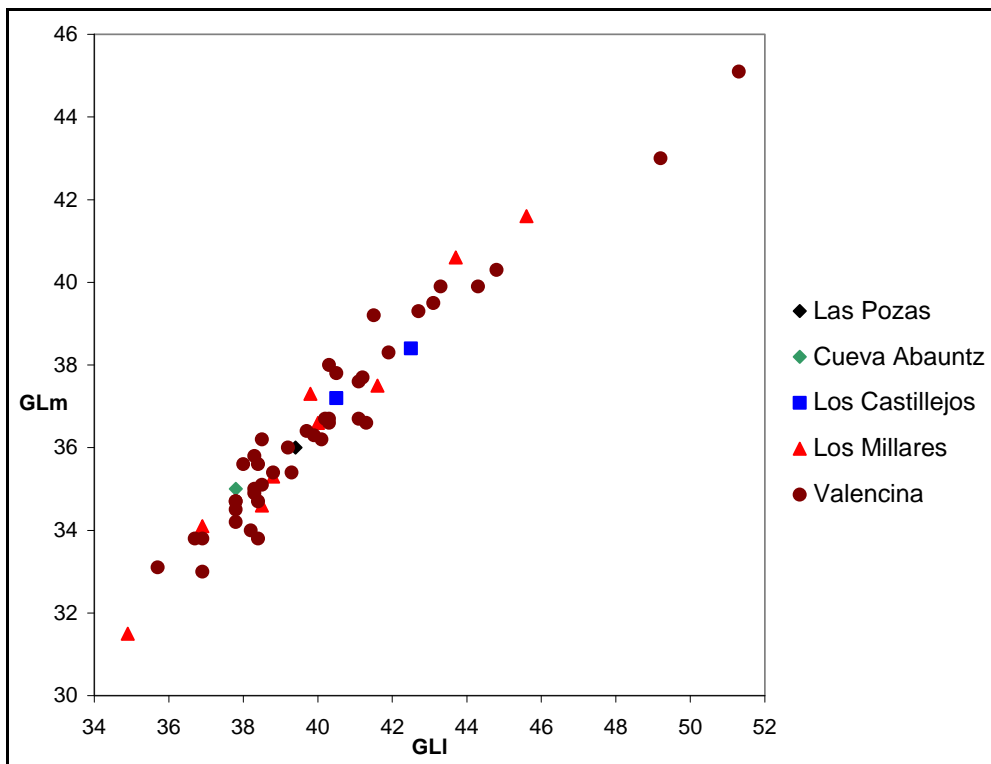


Figure 4.86: Scatterplot of astragalus greatest lateral x greatest medial lengths from all the recorded Copper Age assemblages. Measurements in mm.

In addition to the scatterplots, log ratio histograms with all the Copper Age sites have been produced. The histograms include all recorded postcranial measurements, with the exception of the heavily age-dependent length of the scapula neck (Payne and Bull 1988; Rowley-Conwy 2001). This approach allows us to increase sample size, though somewhat at the expense of resolution (see section 2.1.4).

The histograms in figure 4.87 offer an overview of the postcranial size of Copper Age pigs in relation to their pre-Neolithic, Early Neolithic and Late/Final Neolithic counterparts. The histograms are, as expected, consistent with the scatterplots, and also the statistical tests of significance in size differences (table 4.3). As shown in chapter 3, pre-Neolithic pigs are the largest and the Early Neolithic pigs are on average only slightly smaller, although some significantly larger as well as smaller specimens are present in the sample (the larger range is most likely to be a consequence of the large sample size). The small Late/Final Neolithic sample reveals a considerably smaller postcranial size, while the large Copper Age sample reveals that by the 3rd millennium cal. BC further size reduction in postcranial size occurred. As also shown by the relevant scatterplots, a ‘tail’ of larger measurements to the right side of the,

otherwise normal distribution in the Copper Age histogram is reflecting the presence of few animals which are even larger than the average size of their pre-Neolithic and Early Neolithic counterparts.

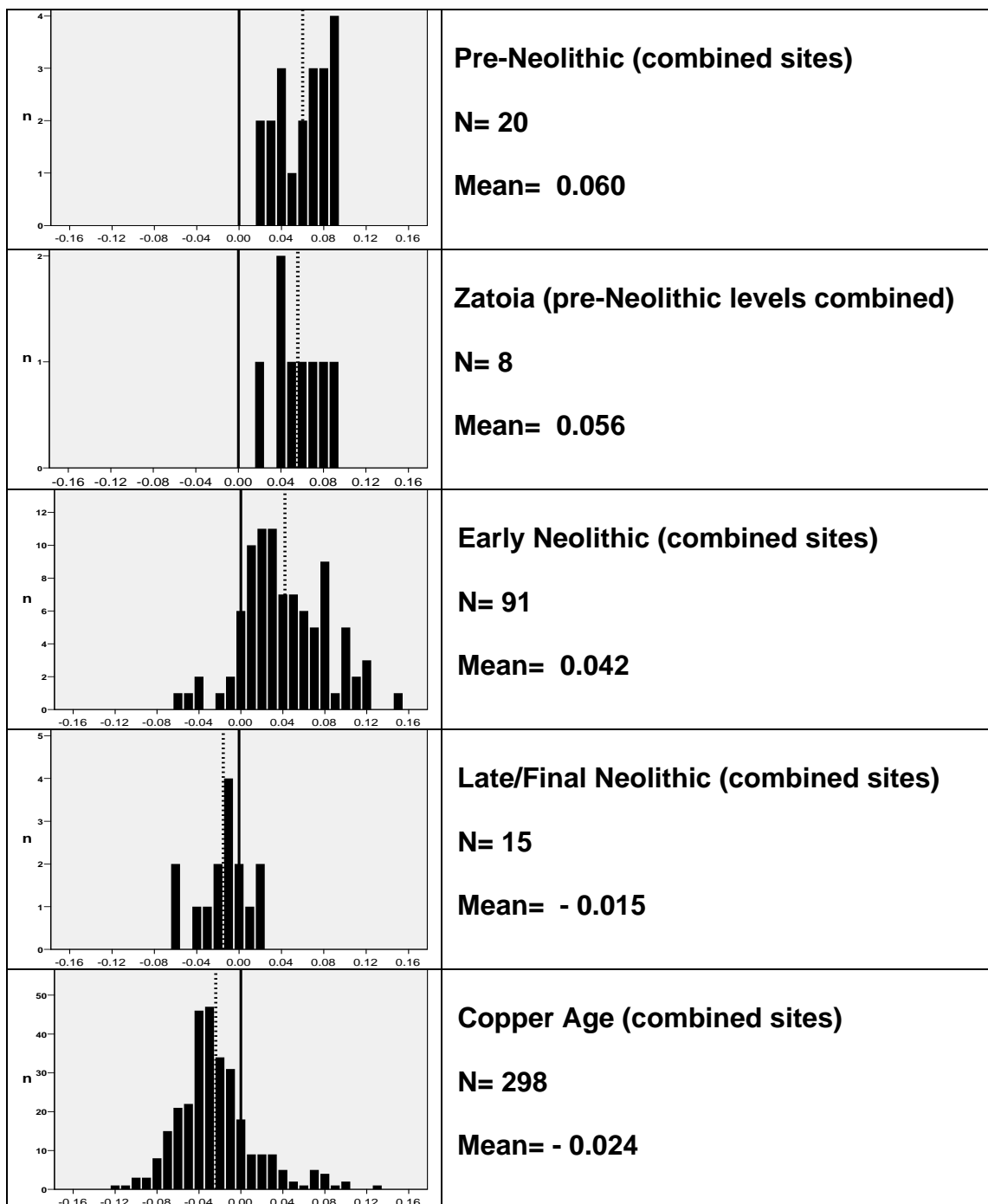


Figure 4.87: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Only fused specimens are plotted. The dotted line represents the mean value.

To examine possible differences between Copper Age populations, a stack of histograms with all Copper Age measurements per site is presented in figure 4.88. Only sites or levels that yielded five or more measurements are included in the analysis, although the measurements of Copper Age sites with less than five measured fused elements are included in the general Copper Age sample at the bottom of the stack. According to the histograms, Copper Age pigs had a consistently similar postcranial size without any marked differences between sites. The common geographic origin of the Copper Age assemblages (only Andalusian sites) may account, at least partly, for the uniformity in size. The only observable pattern, which can only be taken as tentative due to the small size of the samples involved, is a possible gradual size decrease at the site of Los Castillejos (first three histograms from the top) from the Final Neolithic to the Copper Age. In line with the scatterplots, a 'tail' of larger-sized individuals is visible, especially in the large samples such as Valencina, Los Millares and the general Copper Age sample.

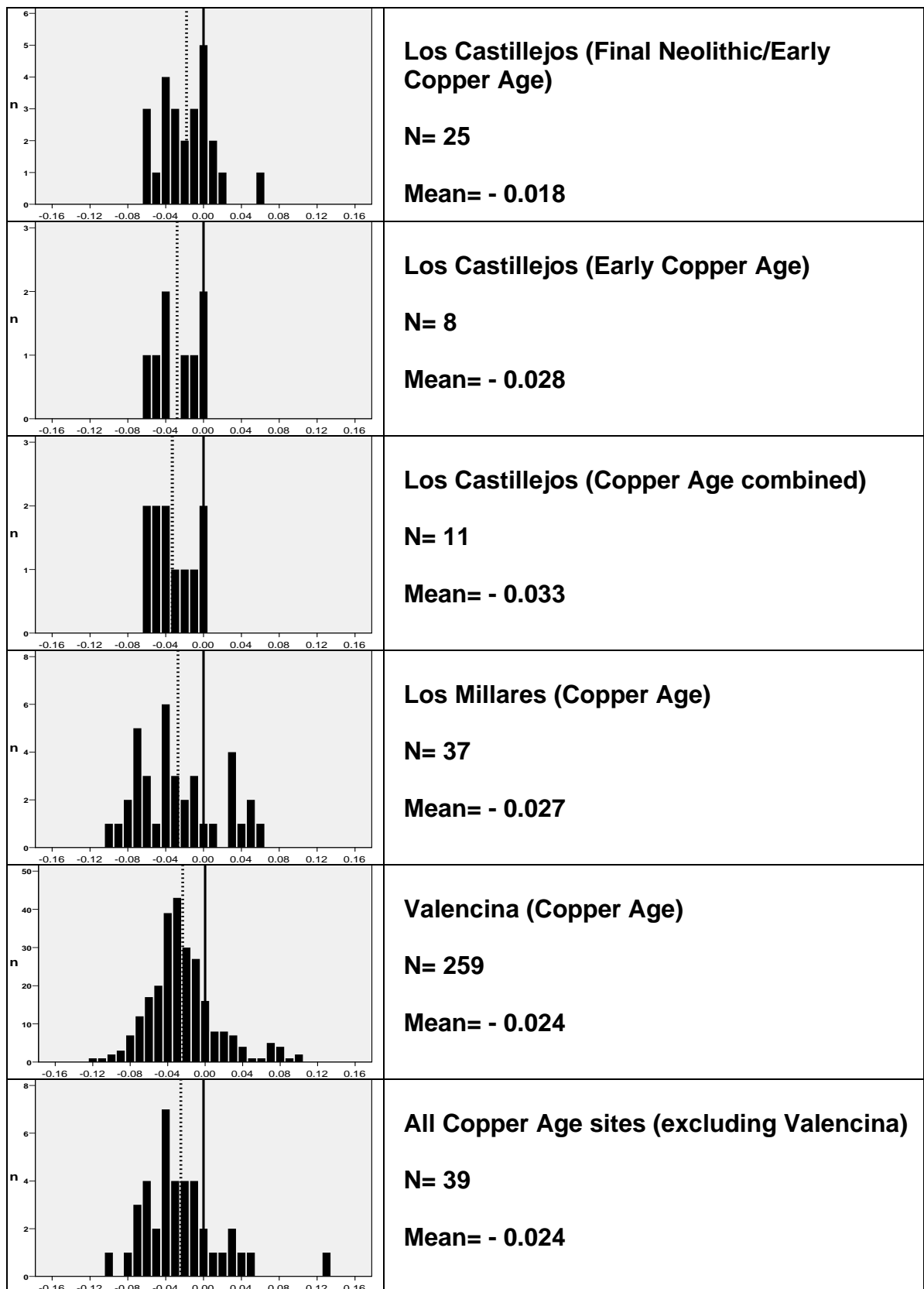


Figure 4.88: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) from Copper Age sites with the combined Copper Age sample (excluding Valencina). Only fused specimens are plotted. The dotted line represents the mean value.

4.3.1.1.1 Postcranial bones, age and sex structure-Copper Age

Many zooarchaeological studies have emphasised that age and sex should be taken into account in the interpretation of biometric data (e.g. Payne and Bull 1988 for pigs but also Zeder 2001 for caprines), especially when detailed comparisons are attempted. Hence, the presented biometric data on postcranial elements should also be interpreted based on sex and age data of Copper Age pig populations presented in the previous sections of this chapter.

The age and sex data for the Early Neolithic (chapter 3) have indicated an almost equal representation of the two sexes - with only hints of a female majority at some sites – and rather young age profiles. Copper Age data show a female majority, though not an overwhelming one. Since female pigs are generally smaller than males, a reduction in overall postcranial size should be visible between the Neolithic and the Copper Age if all other factors remain the same. In fact, Copper Age postcranial size is indeed smaller than in the Neolithic although size reduction is so extensive, that it is unlikely that it could be entirely attributed to the slight female majority. Biometrically, this size decrease is obvious in the measurements of all postcranial elements without any pattern that could be correlated with sexually dimorphic bones (e.g. the humerus). The older age profile of Copper Age pig populations should have contributed towards a larger size, since at least some postcranial elements continue to grow after epiphyseal fusion, even though slightly. Considering all these parameters, we can be fairly confident that the size decrease observed on postcranial bones is genuine.

The integration of age and sex data with biometry rules out some of the factors potentially contributing to biometric changes. As it has been discussed above, the size difference between the Copper Age and earlier periods can be justifiably attributed to morphological changes that have occurred on pig populations. Hence, the pattern for Copper Age in the histograms – predominately small-sized with a ‘tail’ of few large outliers (figure 4.87) – could only be interpreted as consisting predominately of domestic pigs (smaller-sized overwhelming majority) and a few wild pigs (large-sized few outliers). This interpretation is also supported by the biometric patterns of different postcranial

measurements, such as the relatively age- and sex-independent astragalus and tibia as well as the age- and sex- dependent humerus (*cf.* Albarella and Payne 2005: 598). Despite the seemingly straightforward interpretation, the picture is far from fully elucidated. Even if we accept that by the Copper Age domestic pigs were on average smaller than wild pigs, it is still not possible with the current data to differentiate every single specimen or determine the exact degree of size overlap between them.

4.3.1.2 Bronze Age

The analysis of postcranial data of Bronze Age chronology is expected to offer an overview of pig size and shape in the 2nd millennium cal. BC. The presentation of Bronze Age in relation with earlier data has the potential to provide insights into the evolution of pig size until the Bronze Age.

In addition to the graphical exploration of biometry in postcranial elements, presented below, Bronze Age data were also analysed by using Kruskal-Wallis followed by Mann-Whitney tests. Statistically significant size differences between any of the periods could be found for all measurements (all Kruskal-Wallis tests $p < 0.004$, with the exception of calcaneum greatest length $p=0.06$). The non-significant result for the calcaneum measurement might be related to that sample being the smallest included in the analysis. Mann-Whitney tests were used to follow up all remaining significant results, excluding samples containing fewer than five specimens. Results involving the Bronze Age sample are presented in table 4.4 but are commented on in combination with the scatterplots of each postcranial element. On a general level, the statistical results for Bronze Age measurements partly deviate from those observed in Copper Age data. As in the Copper Age, Bronze Age postcranial measurements are significantly smaller than those from the pre-Neolithic and Early Neolithic. However, some measurements (e.g. tibia BdP and calcaneum GD) are statistically not significantly smaller. The size difference between Bronze Age and Late/Final Neolithic astragali is not statistically significant. Most postcranial elements are significantly larger in the Bronze than the Copper Age (astragalus, tibia and calcaneum) and some of the Iron Age (astragalus and humerus). The Bronze Age is the only period in the whole prehistoric sequence, in which a

statistically significant size increase occurred compared both to its immediately earlier (Copper Age) and immediately later (Iron Age) period. Overall, the postcranial size of Bronze Age pigs exhibits significant differences, both with earlier and later periods, though it differs more significantly from earlier than later periods.

Table 4.4: Significance (two-tailed) of size differences in pig postcranial measurements between Bronze Age and the rest of the prehistoric periods, calculated with Mann-Whitney tests. Only samples with a minimum of five or more measurements were subjected to testing; green: very highly significant; blue: highly significant; yellow: significant.

	GLI	GLm	BT	HTC	BdP	Dd	CalGD
Pre-Neolithic / Bronze Age	0.001	0.006					
Early Neolithic / Bronze Age	0.001	0.002	0.001	0.001	0.062	0.042	0.602
Late-Final Neolithic / Bronze Age	0.418	0.508					
Copper Age / Bronze Age	0.010	0.029	0.517	0.189	0.008	0.036	0.020
Bronze Age / Iron Age	0.021	0.001	0.061	0.028	0.068	0.054	0.360

In figure 4.89 the measurements of all Bronze Age astragali are plotted with specimens of pre-Neolithic and Neolithic chronology. As for the Copper Age, most Bronze Age specimens plot in the lower part of the distribution. Although there is considerable overlap mainly with the Early Neolithic specimens, Bronze Age specimens tend to be smaller than their pre-Neolithic and Early Neolithic counterparts. Moreover, there are three large Bronze Age outliers plotting in the upper part of the distribution with some of the Early Neolithic and most of the pre-Neolithic measurements. This pattern is also in accordance with the high coefficient of variation in Bronze Age pig measurements (table 4.2), which is similar to the Early Neolithic. The relatively clear-cut pattern produced by the Bronze Age and Late/Final Neolithic measurements is somehow blurred by few Early Neolithic measurements which cover the area of overlap in the central part of the distribution. The rest of the Early Neolithic measurements is almost evenly distributed in the lower left and upper right parts of the distribution. Another characteristic of Bronze Age astragali is that they are – statistically (table 4.4) – significantly different from all the rest of the periods, except the Late/Final Neolithic (possibly due to the very small Late/Final Neolithic sample). They are smaller than the pre-Neolithic and Early Neolithic but larger than Copper and Iron Age specimens. Since astragali provided the largest samples, they consequently provide the most significant results.

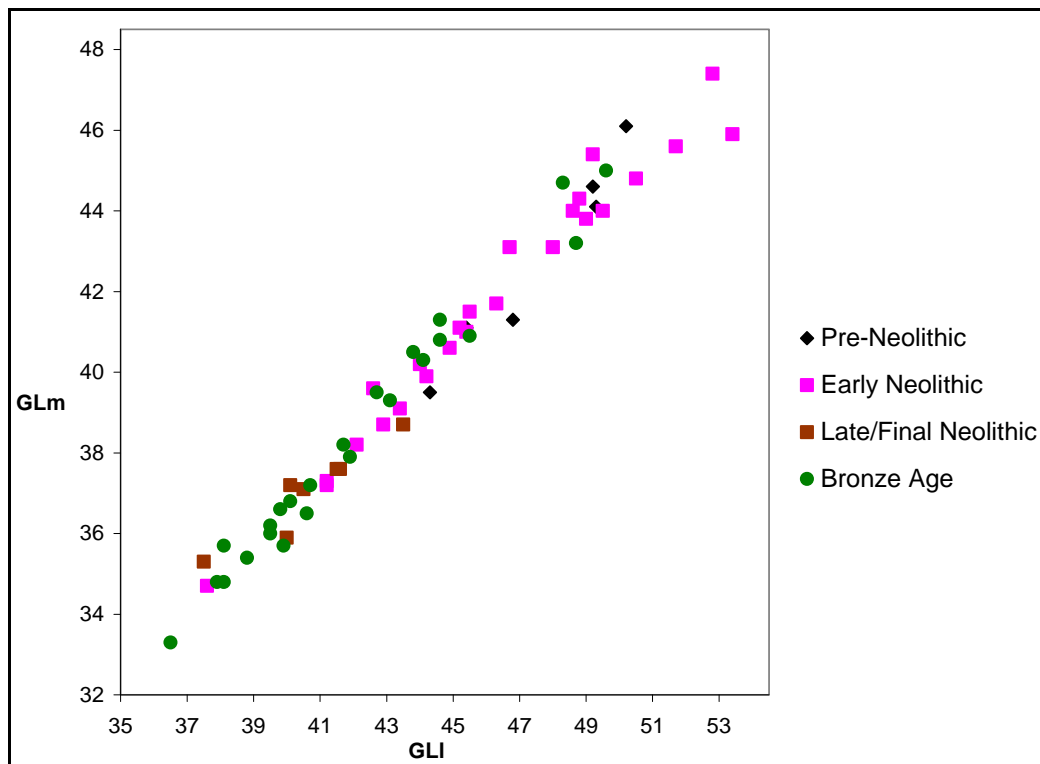


Figure 4.89: Scatterplot of astragalus greatest lateral x greatest medial lengths from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Light and porous specimens are excluded. Measurements in mm.

After the astragalus, the most commonly measured element in the Bronze Age assemblages was the humerus. Bronze Age specimens are plotted in figure 4.90 with Early Neolithic and Copper Age specimens, whereas no pre-Neolithic data were available. The vast majority of Bronze Age specimens, in a strikingly similar fashion to the Copper Age, plot in the lower part of the distribution, apart from a few outliers plotting in the upper part with the largest Early Neolithic specimens. As for the astragalus - and, in fact, even more so - Bronze Age humeri are in general much smaller than in the Early Neolithic. Overall, the picture is almost identical to that observed for the Copper Age. Unlike the astragalus, Bronze Age humeri are more similar to their other post-Neolithic (Copper and Iron Age) counterparts (table 4.4). Nevertheless, as the scatterplots suggest and the Mann-Whitney tests confirm, Bronze Age humeri were very highly significantly smaller than their Early Neolithic counterparts.

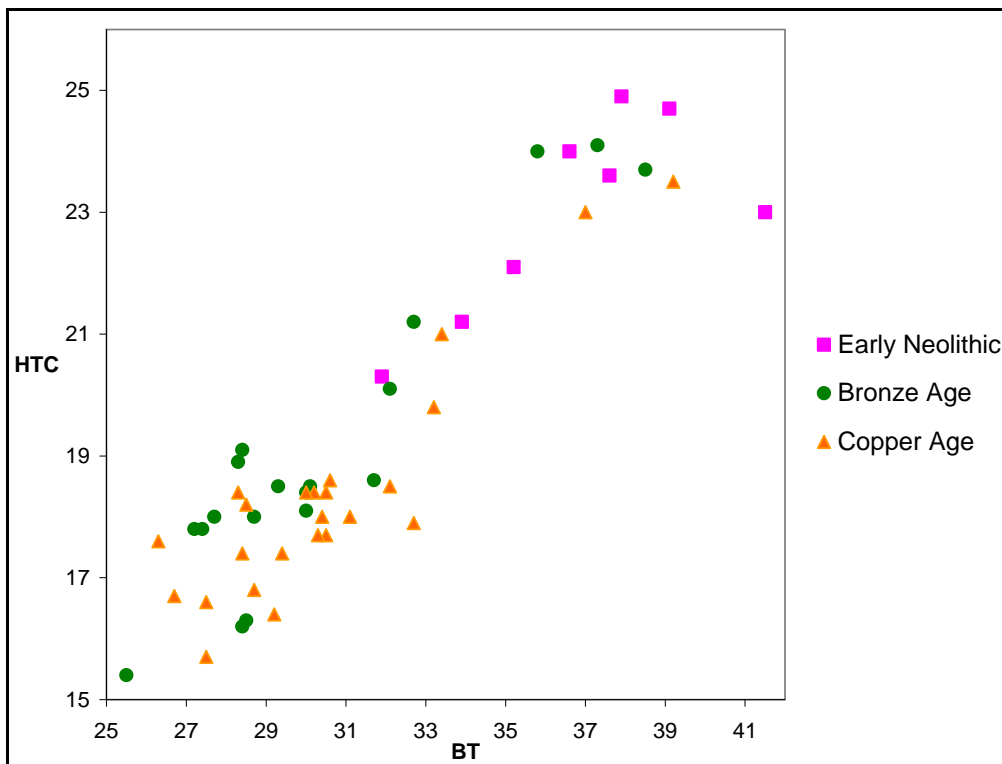


Figure 4.90: Scatterplot of humerus width of trochlea x minimum diameter of trochlea from combined samples of Early Neolithic, Copper and Bronze Age chronology. Only fully fused specimens are plotted. Measurements in mm.

The comparison of Bronze Age with earlier material provided useful information about the postcranial size of pigs in the 2nd millennium cal. BC in Spain. Unfortunately, the amount of Bronze Age individual measurements is insufficient for making site by site comparisons. However, this analysis will be undertaken with the use of log ratio histograms, in which samples are larger due to the pooling of measurements of different elements.

Before attempting any inter-site comparison, it is interesting to compare the general size of Bronze Age pigs with that of their Copper Age, Neolithic and pre-Neolithic counterparts. The histograms (figure 4.91) are, as expected, consistent with the results presented in the form of scatterplots but some additional overall trends can be observed. Since the evolution of postcranial pig size until the Copper Age has already been described in section 4.3.1.1, only the Bronze Age histogram at the base of the stack is described here and compared with the rest.

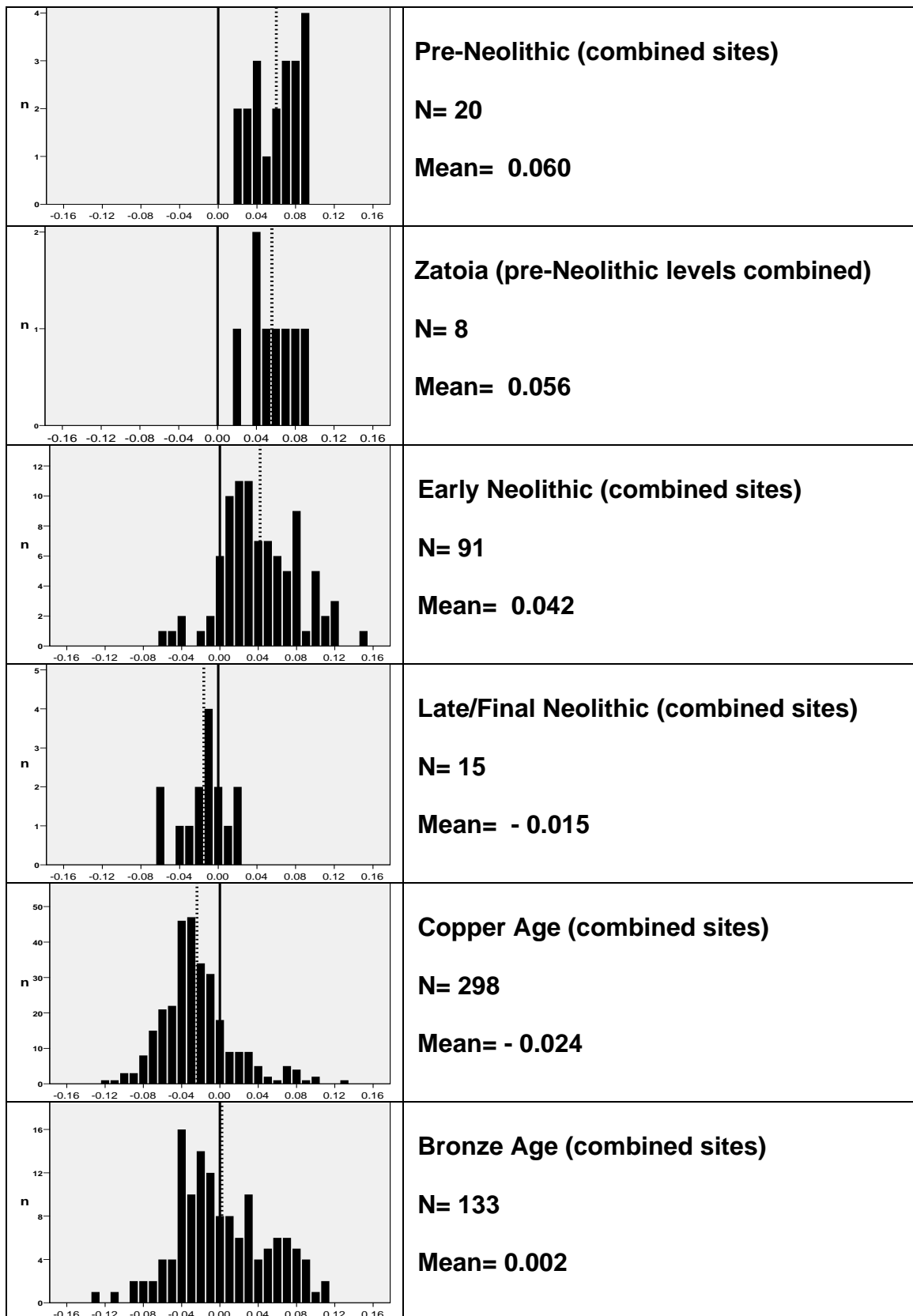


Figure 4.91: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Only fused specimens are plotted. The dotted line represents the mean value.

As already indicated by the distributions of individual Bronze Age specimens, the combined Bronze Age sample exhibits a tendency towards a bimodal distribution, with some overlap between the two modes. The 'tail' of larger measurements observed to the right of the, otherwise normal, distribution in the Copper Age sample, becomes more important in the Bronze Age. This reflects the presence of a proportionately more numerous population of larger animals. Most measurements in the right (larger-sized) mode are even larger than pre-Neolithic and Early Neolithic average size. As a result, the mean size of the Bronze Age pigs appears increased compared to that of the preceding Copper and Late/Final Neolithic pigs, though it still remains considerably smaller than the Early Neolithic and pre-Neolithic size. The peak on the left (smaller-sized) part of the distribution is the dominant one and indicates a size quite similar to that of Copper Age specimens. This pattern in the distribution of Bronze Age measurements may also be responsible for the increased coefficient of variation (table 4.2) and the increased frequency of statistically significant differences in some postcranial measurements between Bronze Age and the other two post-Neolithic periods (table 4.4).

To examine possible differences between sites, measurements from individual Bronze Age assemblages - with more than five available measurements - are presented in figure 4.92. Measurements from the smallest datasets are nevertheless included in the general Bronze Age sample at the bottom of the stack. In the absence of large Bronze Age samples, no geographic, chronological or other patterns can be reliably detected. However, some of the histograms show a tendency towards bimodality, although the proportions of the two modes vary per assemblage. For example, the distributions of Acequión and Cerro de Encina have a dominant peak on the left (smaller-sized) part of the distribution with very few specimens on the right (larger-sized) part, while exactly the opposite is observed for Morra de Quintanar and Bastida de Totana. Monte Aguilar and La Hoya exhibit an intermediate pattern, according to which the vast majority of measurements occupy the intermediate area approximately in the middle of the histogram. The only common characteristic that the latter two sites share is that they are situated further north (Monte Aguilar in Navarra and La Hoya in the Basque Country) than the rest of the sites, which are situated in southeast and south-central Spain.

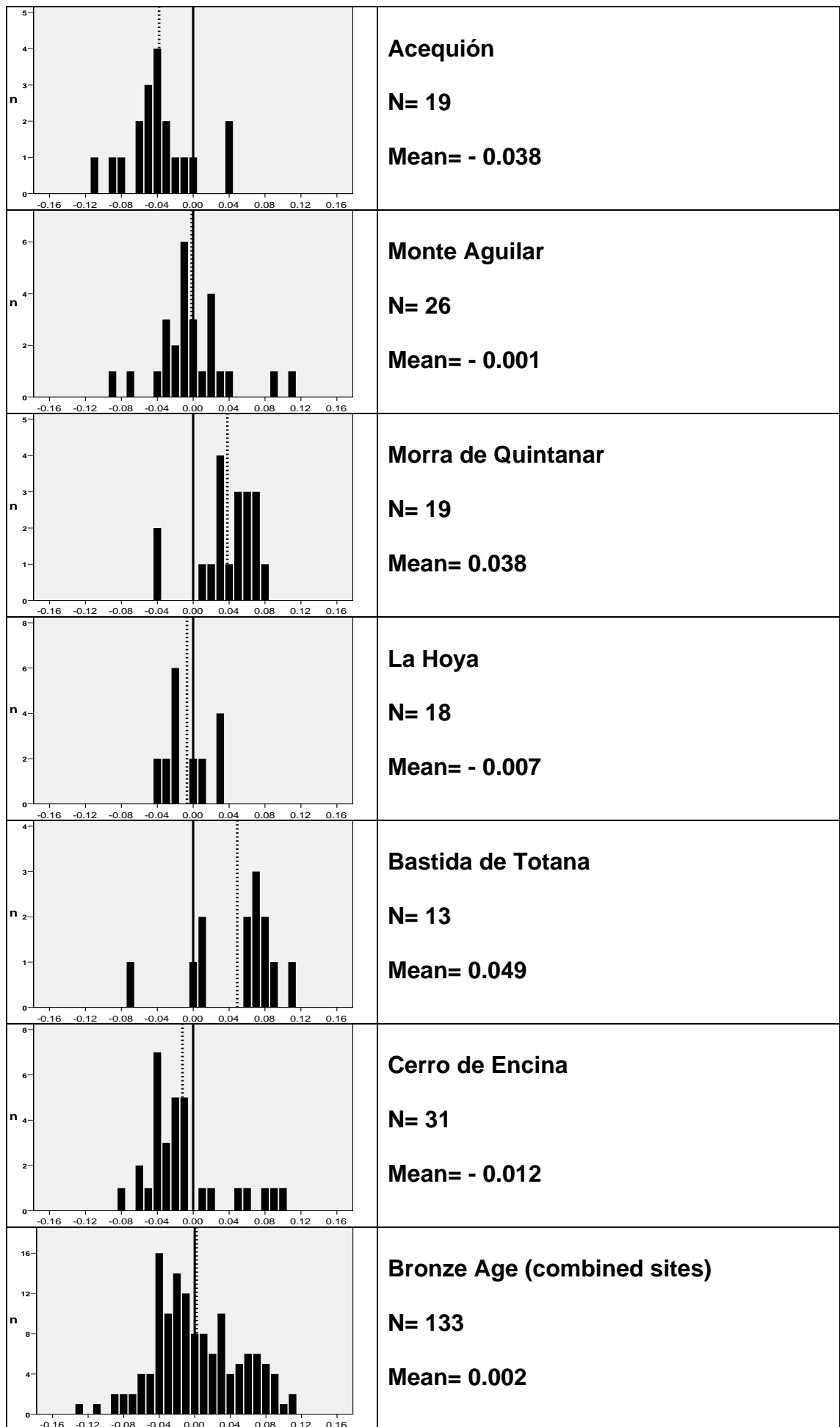


Figure 4.92: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) from Bronze Age sites with the combined Bronze Age sample. Only fused specimens are plotted. The dotted line represents the mean value.

Therefore, the pattern for the Bronze Age appears to be much more diversified than the rather homogenous picture of the Copper Age, which was to a certain extent due to the restricted geographical origin of Copper Age samples.

4.3.1.2.1 Postcranial bones, age and sex structure-Bronze Age

Before moving to the presentation of Iron Age postcranial biometry it is interesting to attempt a preliminary integration of Bronze Age biometric patterns with the age and sex profile of pig populations. The age and sex data for the Bronze Age indicate similar trends to those of the Copper Age, i.e. narrow female majority and increased mortality later than the first year. In comparison to the preceding Copper Age, Bronze Age also exhibits more variability in age and sex profiles. Taking into account, however, that samples are rather small and derive from almost all parts of Spain – in contrast to all Copper Age samples deriving from Andalusia – this variability may be partly justified by the diversity of environments from which the assemblages derive.

Among the few differences between Copper and Bronze Age pig age and sex structures are the slightly higher male percentages and the slightly older age profiles in the later period. Assuming that these small differences affected biometry to some degree, then postcranial size should be larger than in the Copper Age. Bronze Age postcranial size is indeed larger but there are no clear indications that this is related to sex and age. If this was the case, then the assemblages with higher male percentages and older age profile should also exhibit the largest postcranial size. For some assemblages such a tendency exists (e.g. Morra de Quintanar) but for others (e.g. Acequión, Monte Aguilar) - some of which come from the same geographic area (Acequión) – this is not the case. Hence, the causes of the overall larger postcranial size in the Bronze Age should be sought in other factors, whether wholly or partially. A strong candidate to explain the biometric patterns is an increased contribution of wild boar bones in the assemblages. This hypothesis cannot be tested to be proved right or wrong with certainty. However, it is supported by the pattern in the overall Bronze Age histogram (figure 4.91) which illustrates how the ‘tail’ of larger individuals in the Copper Age has grown in size to become a secondary

mode next to – and overlapping with - the primary mode of the majority of smaller-sized individuals.

Other possible factors that cannot be excluded, but unfortunately can neither be examined in detail, are climatic change and regional differences in husbandry strategies that resulted in increased morphological variability in pigs. As far as the former is concerned the sparse palaeoclimatic information for Spain suggest a drop of temperature (*cf.* Cuenca-Bescós et al 2009: 953; Fábregas et al 2003: 865, table 1) for part of the Bronze Age but evidence is insufficient to establish a reliable palaeoclimatic framework for prehistoric Iberia. Regarding husbandry strategies, the observed biometric diversity could be used in support of increased diversity in husbandry practices resulting in morphological diversity. There is, after all, evidence of settlement expansion and diversification in many Iberian regions during the Bronze Age, which is also reflected in indicators of forest clearance, increased erosion, soil disturbance and fire (e.g. Butzer 2005: 1791, fig 3; Chapman 2003: 131-46; Stevenson 2000: 607). Thus, it is likely that many factors contributed to the observed biometric patterns, the most important of which is deemed to be an increase in wild boar percentages in the Bronze assemblages included in this study.

4.3.1.3 Iron Age

The analysis of postcranial data from the last of the prehistoric periods, the Iron Age, is expected not only to provide an overview of pig size during that period but also to contribute the concluding part in the evolution of pig postcranial size in Spanish prehistory. Represented by abundant remains, the Iron Age has the potential to offer a higher resolution and further elucidate the postcranial size of preceding pig populations, through comparisons.

Beyond the graphical exploration of biometry in postcranial elements, presented below, Iron Age data were also analysed by using Kruskal-Wallis followed by Mann-Whitney tests. Statistically significant size differences between any of the periods could be found for all measurements (all Kruskal-Wallis tests $p < 0.004$, with the exception of calcaneum greatest length $p=0.06$). Mann-Whitney tests were used to follow up all remaining significant results, excluding samples

containing fewer than five specimens. Results involving the Iron Age sample are presented in table 4.5 and commented on in combination with the scatterplots for each anatomical element.

The general pattern observed in the Mann-Whitney results is that Iron Age pig bones are very highly significantly smaller compared to those of pre-Neolithic and Early Neolithic periods, and more similar to those of the Late/Final Neolithic, Copper and Bronze Ages. Judging also from the results of all earlier periods, the astragalus seems to be the element for which the most significant size changes are visible. This can be explained by the fact that it provides the largest sample size and therefore – given a genuine change in size - is more likely to produce significant differences. Combining the Mann-Whitney results of all prehistoric periods until the Iron Age, there is an overall pattern towards significantly smaller size, starting in Late/Final Neolithic and continuing through post-Neolithic periods.

Table 4.5: Significance (two-tailed) of size differences in pig postcranial measurements between Iron Age and the rest of the prehistoric periods, calculated with Mann-Whitney tests. Only samples with a minimum of five or more measurements were subjected to testing; green: very highly significant; blue: highly significant; yellow: significant.

	GLI	GLm	BT	HTC	BdP	Dd	CaIGD
Pre-Neolithic / Iron Age	0.001	0.001					
Early Neolithic / Iron Age	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.360
Late-Final Neolithic / Iron Age	0.320	0.060					
Copper Age / Iron Age	0.326	0.088	0.005	0.082	0.124	0.929	0.128
Bronze Age / Iron Age	0.021	0.001	0.061	0.028	0.068	0.054	0.360

Starting with the most abundant element, the astragalus, in figure 4.93 the measurements of all Iron Age specimens are plotted with the pre-Neolithic and Neolithic specimens. All Iron Age specimens are clustered in the lower left part of the distribution. Of all post-Neolithic periods, Iron Age is the only one for which no overlap is observed with the few available pre-Neolithic measurements, and little overlap with the Early Neolithic measurements. This observation is also supported statistically, as Iron Age astragali are very highly significantly smaller than pre-Neolithic and Early Neolithic size (table 4.5). Despite being smaller on average, Iron Age astragali are not statistically different from their Late/Final Neolithic counterparts.

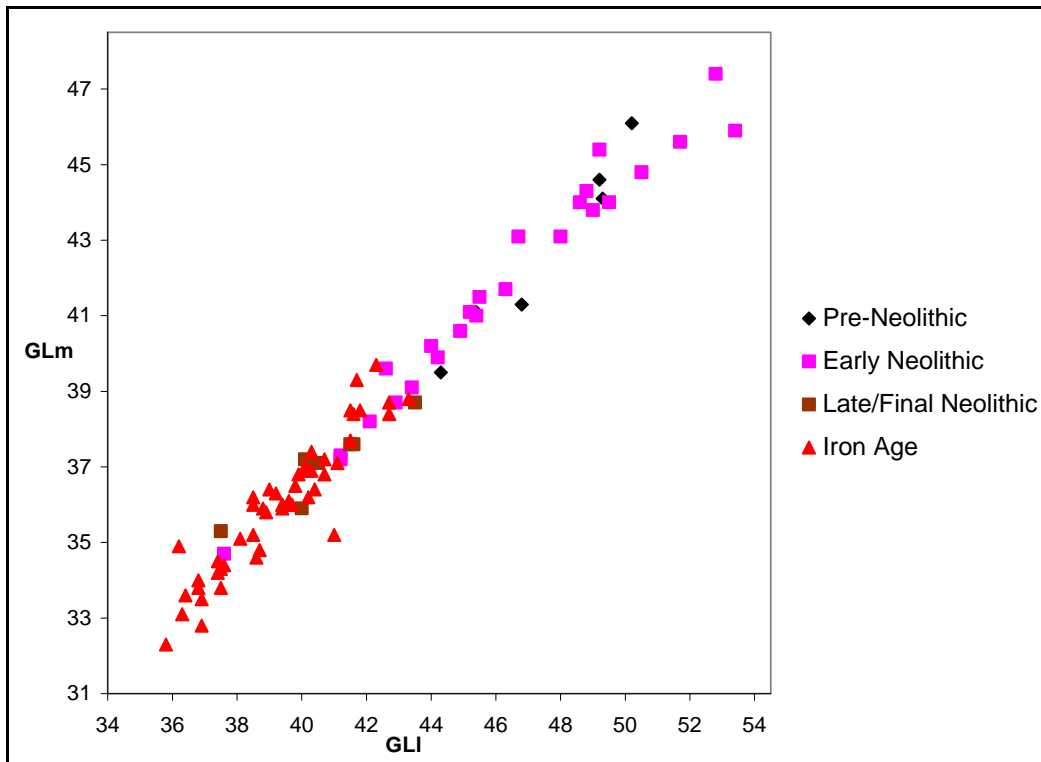


Figure 4.93: Scatterplot of astragalus greatest lateral x greatest medial lengths from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Light and porous specimens are excluded. Measurements in mm.

In figure 4.94 measurements of all Iron Age astragali are plotted with the Copper and Bronze Age specimens. In general, there is extensive overlap between the measurements of the three post-Neolithic prehistoric periods, which is also supported by the restricted or no statistical significance of the difference between the Iron Age and the other two post-Neolithic periods. However, Iron Age pigs appear to be of more homogeneous size and on average smaller than their predecessors (see descriptive statistics, table 4.2). Unlike the previous periods they do not include any large outliers, at least in astragalus specimens.

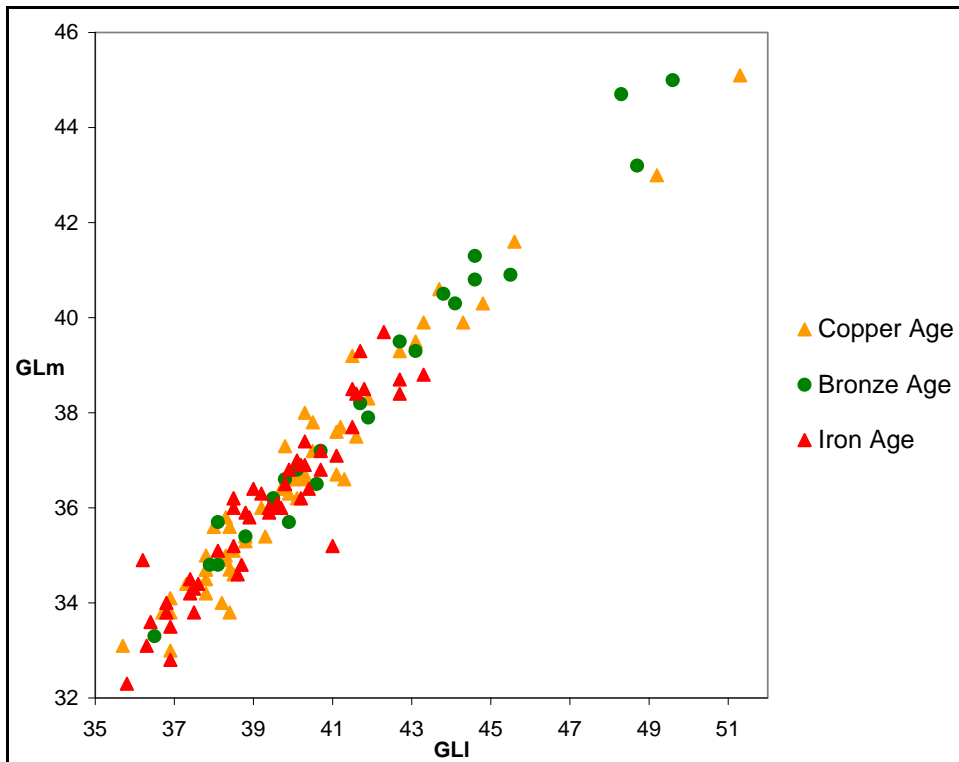


Figure 4.94: Scatterplot of astragalus greatest lateral x greatest medial lengths from combined samples of the three post-Neolithic periods (Copper, Bronze and Iron Age). Light and porous specimens are excluded. Measurements in mm.

In figure 4.95 Iron Age distal humeri are plotted with those of Copper, Bronze and Early Neolithic date. As for the astragalus, Iron Age specimens plot in a relatively tight cluster in the lower left part of the distribution, and are smaller than almost all Early Neolithic specimens. Statistically, this difference is very highly significant (table 4.5). There is extensive overlap between Iron Age and Copper and Bronze Age specimens, apart from the few large Copper and Bronze Age outliers. In general, Iron Age size appears homogeneously small, which is also reflected in the low coefficient of variation of most measurements (table 4.2).

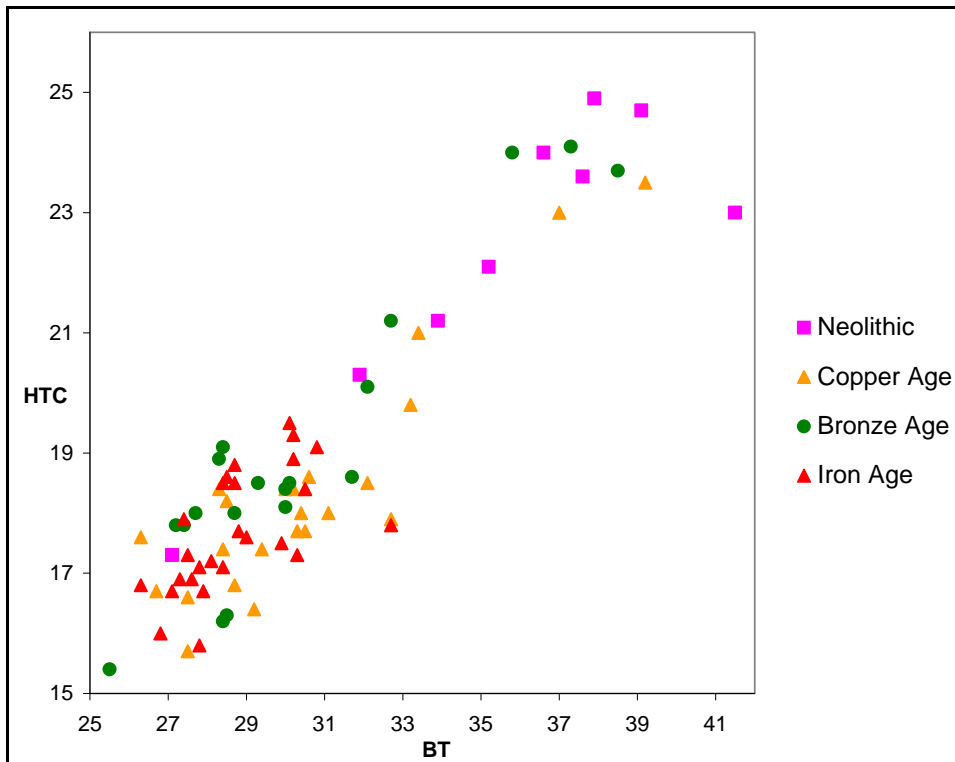


Figure 4.95: Scatterplot of humerus width of trochlea x minimum diameter of trochlea from combined samples of Early Neolithic, Copper, Bronze and Iron Age chronology. Only fully fused specimens are plotted. Measurements in mm.

The pattern exhibited by the astragalus and humerus Iron Age measurements is by and large similar to that found for distal tibia (figure 4.96) and calcaneum (figure 4.97). In both elements, the vast majority of Iron Age specimens are confined in the lower left part of the distribution. However, unlike the astragalus and humerus, tibia and calcaneum reveal the presence of some large outliers. This is a feature reminiscent of the Copper and Bronze Age scatterplots for most postcranial elements. In the case of the calcaneum, the two outliers exceed in size all their earlier counterparts, including the largest Early Neolithic specimens.

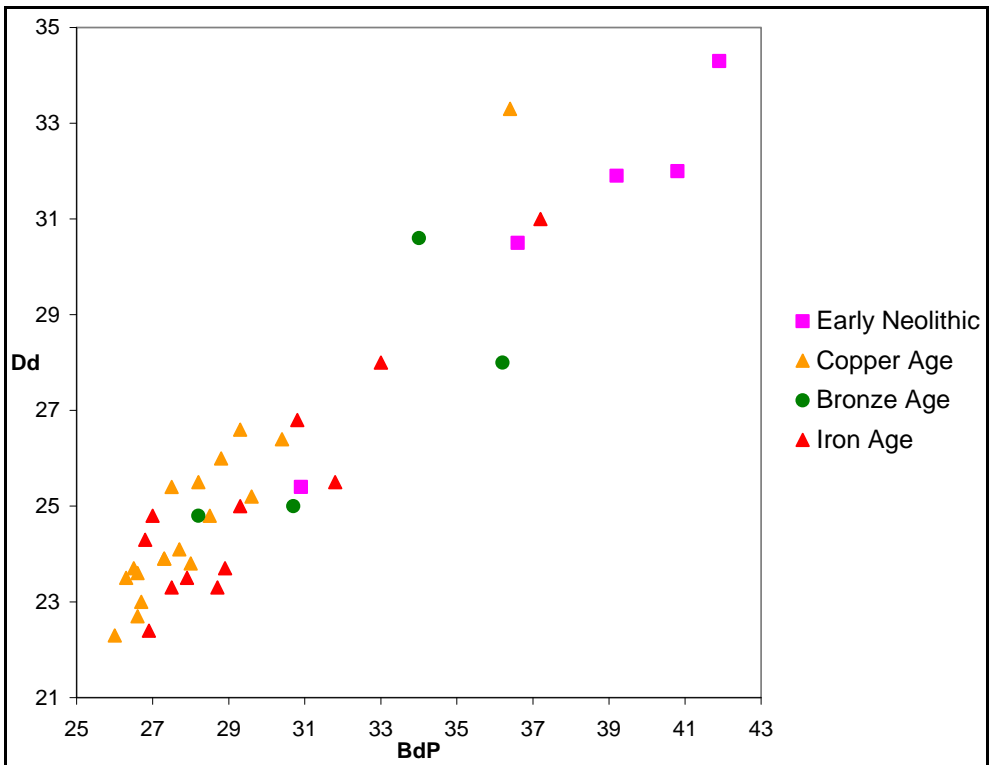


Figure 4.96: Scatterplot of tibia distal width x depth of the distal end from combined samples of pre-Neolithic, Early Neolithic, Copper, Bronze and Iron Age chronology. Only fully fused specimens are plotted. Measurements in mm.

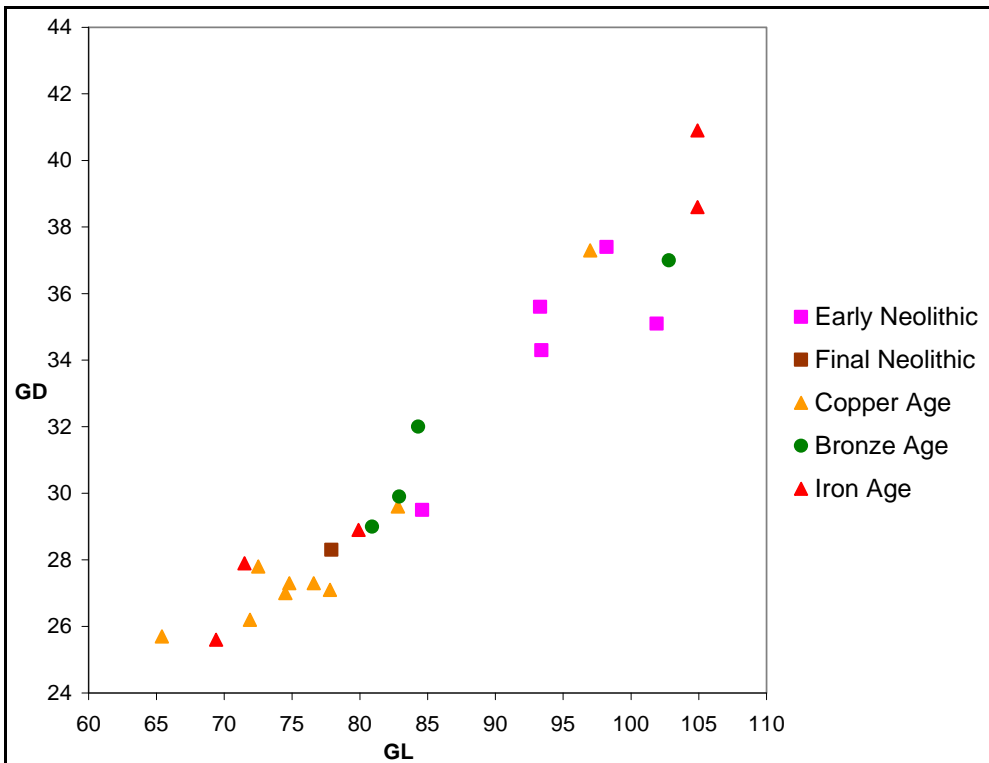


Figure 4.97: Scatterplot of calcaneum greatest length x greatest depth from combined samples of Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Only fused specimens are plotted. Measurements in mm.

To obtain a general picture of postcranial pig size in the Iron Age by comparing it with preceding periods, log ratio histograms with the measurements of fused specimens were produced (figure 4.98). Histograms provide a relatively low-resolution but at the same time useful overview of the evolution of postcranial pig size in Spain throughout the prehistoric period. The limited size reduction attested for the Early Neolithic becomes much more pronounced by the end of the Neolithic period. In the Copper Age, further size decrease is recorded, while a 'tail' of large measurements persists. In the Bronze Age, the majority of specimens maintain a similar size to that of the Copper Age but the 'tail' of larger specimens becomes more prominent and raises the average mean size of Bronze Age pigs. In the Iron Age, specimens are of smaller average size, although very few, particularly large specimens plot separately from the normally distributed majority. In the course of five millennia of Spanish prehistory, the postcranial size of pigs appears to have been reducing until it reached a point in the Iron Age when there is little size overlap with Early Neolithic and almost none with pre-Neolithic pigs. This is reflected in the Mann-Whitney tests, which confirm very highly significant size differences between Iron Age and Early Neolithic pig postcranial remains for all elements tested, except the calcaneum GD (table 4.5). A small number of Iron Age specimens reveal the existence of some individuals that are as large as their largest Early Neolithic and pre-Neolithic counterparts.

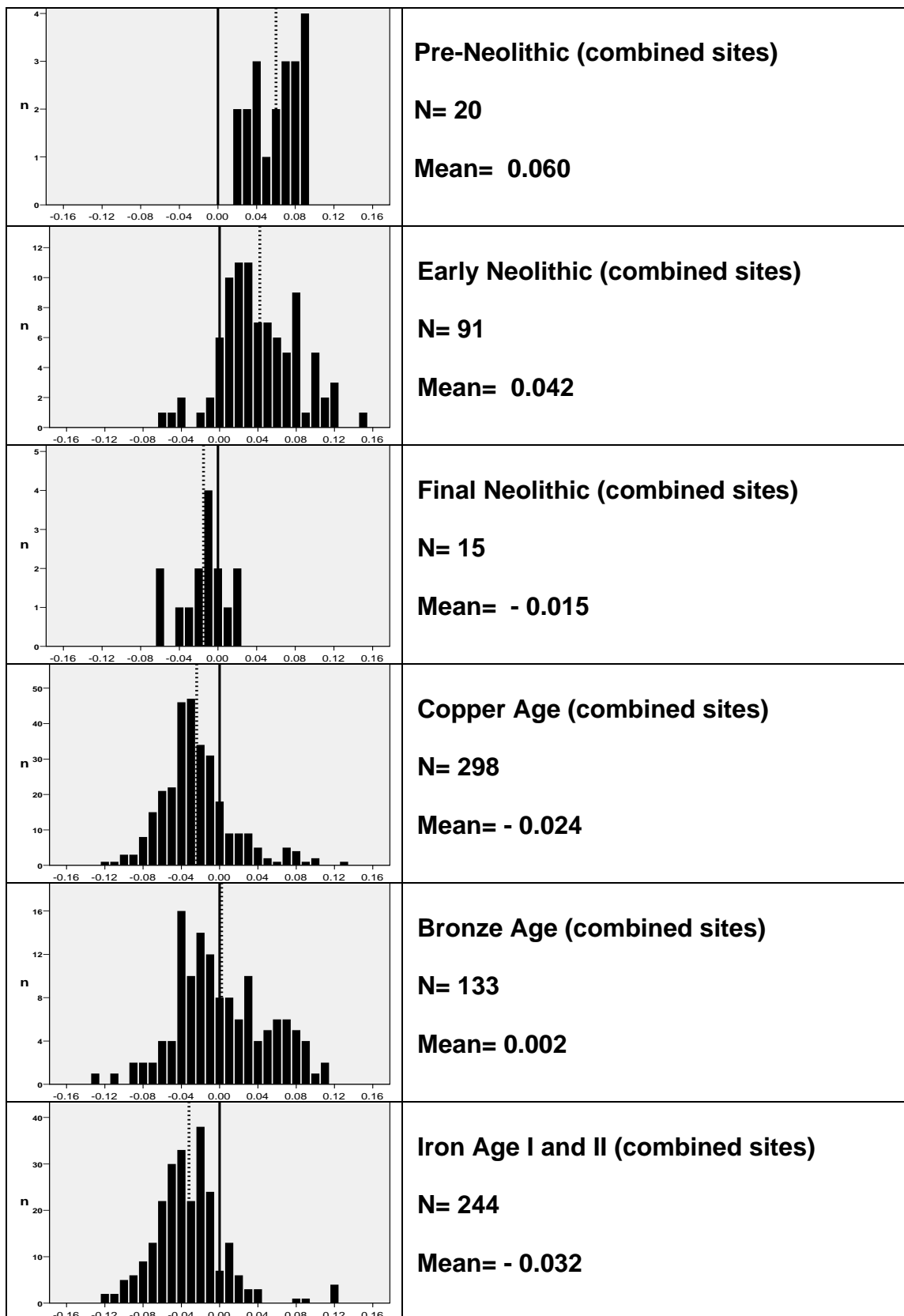


Figure 4.98: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Only fused specimens are plotted. The dotted line represents the mean value.

To examine possible differences between Iron Age sites, site-specific histograms with more than five available measurements are presented in figure 4.99. As done for earlier periods, measurements of Iron Age assemblages with less than five measurements are included in the combined Iron Age samples. The vast majority of Iron Age samples derive from northern Spain, mainly the Basque Country, Navarra, Cantabria and the northern central *meseta*. In cases where no important differences between the two phases of the Iron Age (i.e. Iron Age I and Iron Age II) were observed, measurements were pooled to increase sample size. Although no major differences between Iron Age populations can be observed in the histograms (figure 4.99), some trends deserve commenting. Beyond the general similarity in size of most Iron Age pig populations, the presence of a few clearly larger individuals to the right of the normally distributed majority is noteworthy in the two largest samples of La Hoya and Castros de Lastra; both are located in the Basque province of Álava. The measurements from the only southern Spanish (Andalusia), Calle Puerto 10, appear to be on average larger in size than the sites from northern Spain. This should be interpreted with caution due to the small sample size from this site. Another site that presents a tendency towards larger average size is Peñas de Oro, also from Álava. Beyond the possibility of this being an artefact of the small sample size, there may be a chronological reason for the observed pattern due to the mixed nature of the sample which also includes Final Bronze Age material. Finally, the smallest size is observed at the chronologically most recent sample from the Cantabrian site of Las Rabas.

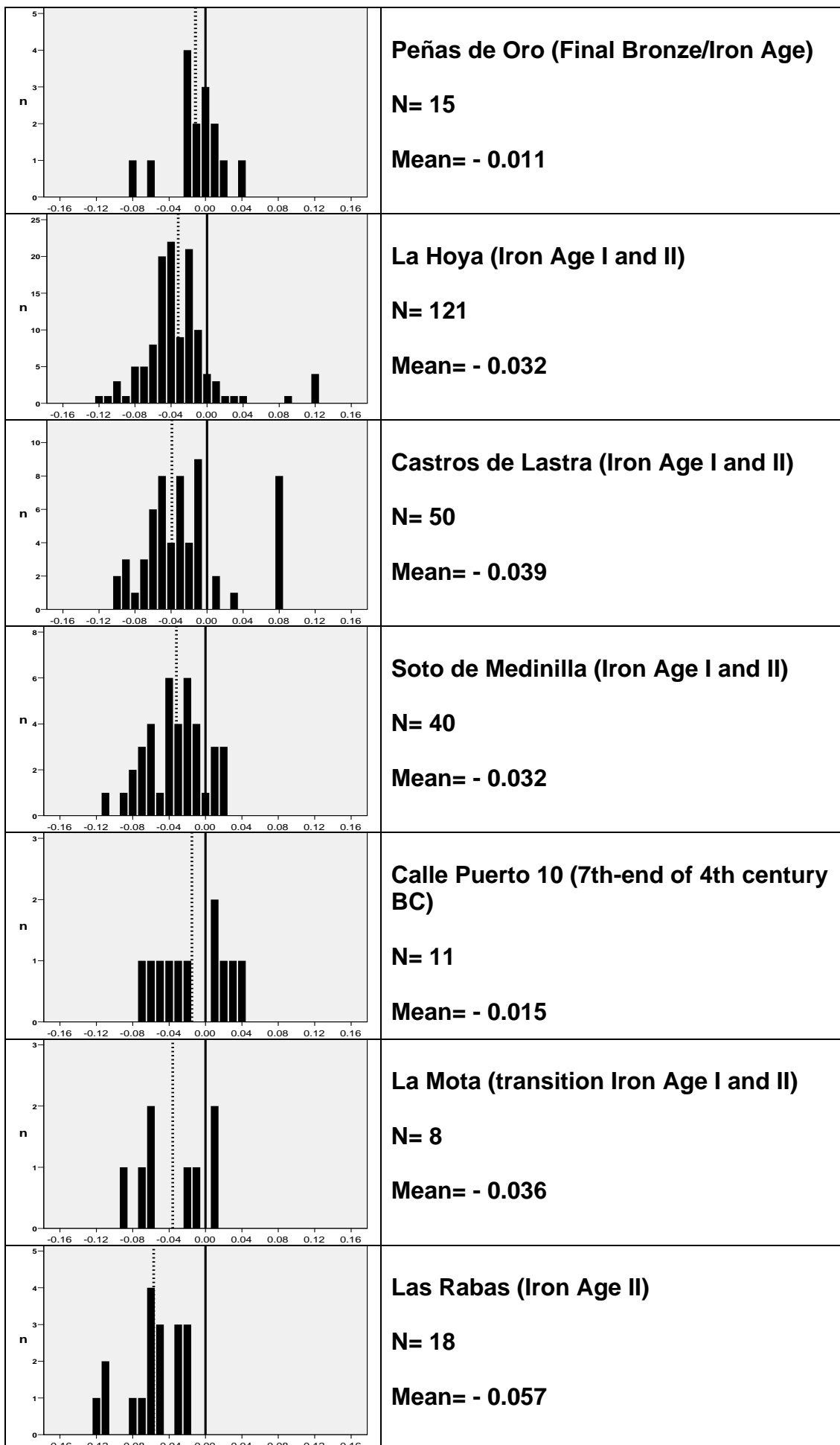


Figure 4.99: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) from different Iron Age sites. Only fused specimens are plotted. The dotted line represents the mean value.

The comparison between the two phases of the Iron Age (figure 4.100) shows a decrease in the average size of pigs from the earlier (I) to the later (II) Iron Age. Another difference between the two samples is that all large outliers belong to the Iron Age II sample. Despite the overlap in postcranial size between the two subperiods, the smaller average size of Iron II pigs is also exhibited by the measurements of specific anatomical elements. The astragalus measurements show extensive overlap but a trend towards smaller size in Iron Age II is discernible (figure 4.101). The size difference between the two phases is even clearer in the humerus (figure 4.102) where the overlap is limited, although this may be partly due to small sample sizes and higher female percentages in the Iron Age II. Though not presented with the rest of the Mann-Whitney tests, Iron Age II humeri (BT measurement) were found to be significantly smaller than their Iron I counterparts ($p=0.048$), while both astragalus measurements did not show any significant differences ($p>0.05$).

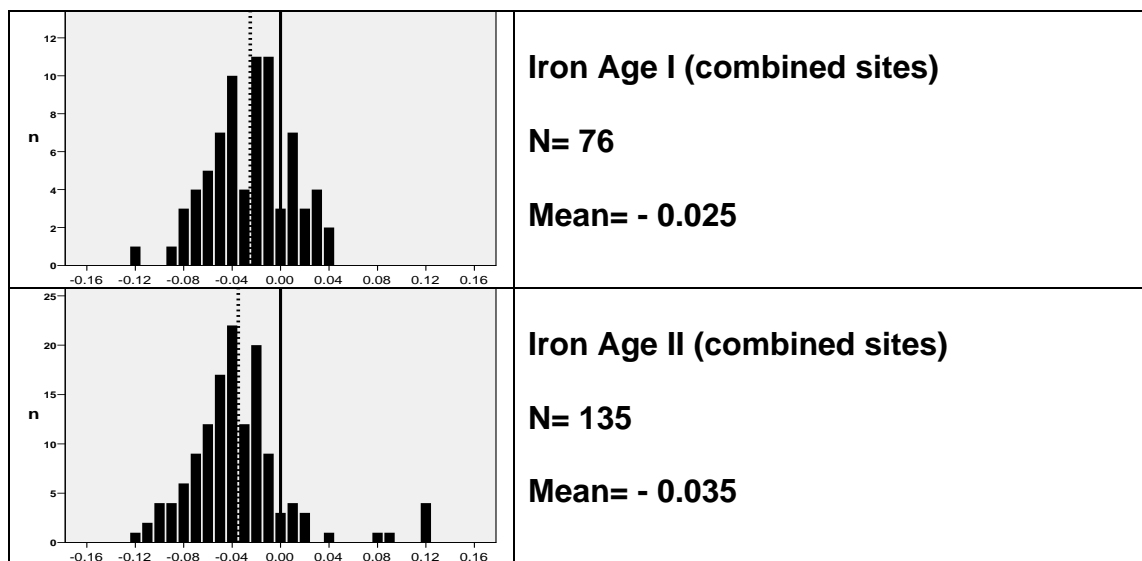


Figure 4.100: Log ratio histograms comparing pig postcranial measurements (excluding the length of scapula neck) from the combined samples of Iron Age I and Iron Age II. Only fused specimens are plotted. The dotted line represents the mean value.

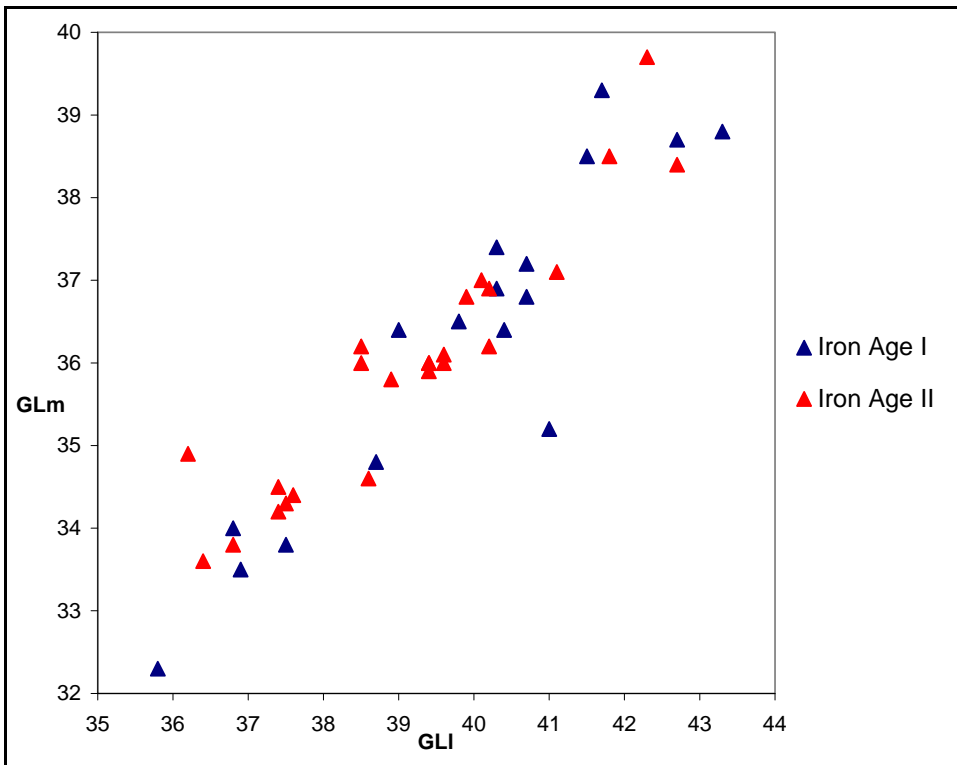


Figure 4.101: Scatterplot of astragalus greatest lateral x greatest medial lengths from the combined samples of Iron Age I and Iron Age II. Light and porous specimens are excluded. Measurements in mm.

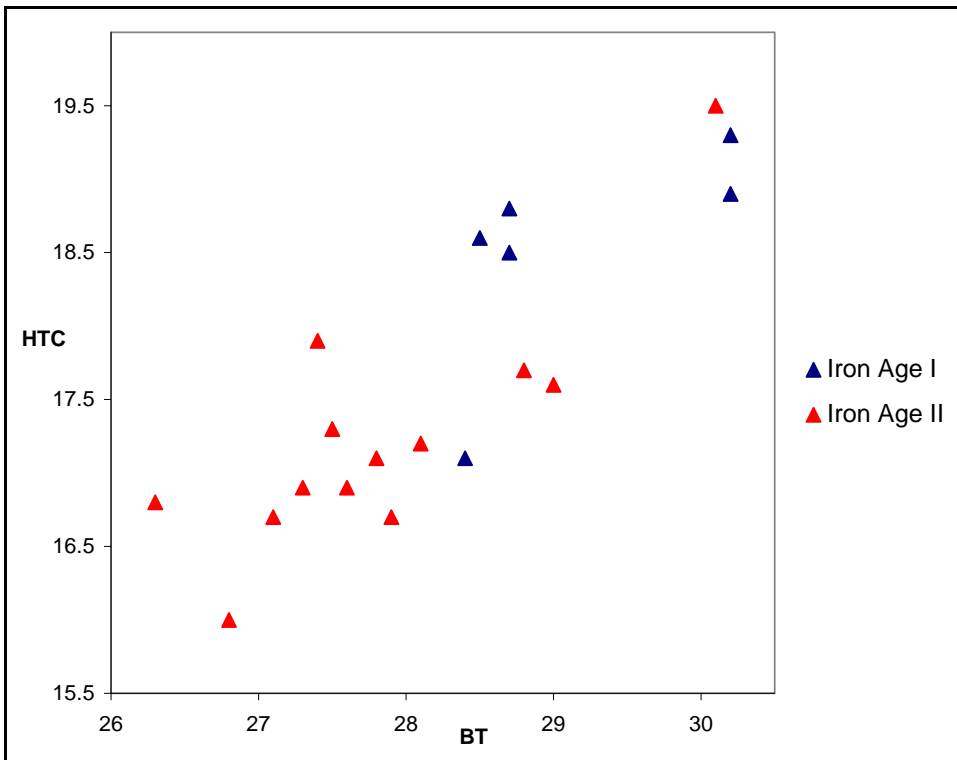


Figure 4.102: Scatterplot of humerus width of trochlea x minimum diameter of trochlea from the combined samples of Iron Age I and Iron Age II. Only fused specimens are plotted. Measurements in mm.

The only site that allowed the analysis of chronologically successive samples is La Hoya. In figure 4.103, the Middle/Final Bronze Age, Iron Age I and Iron Age II samples from La Hoya are compared. Although the Bronze Age sample is rather small, it indicates that in this period pigs were on average larger than in the Iron Age. Some further size decrease is visible between the first and second Iron Age phase.

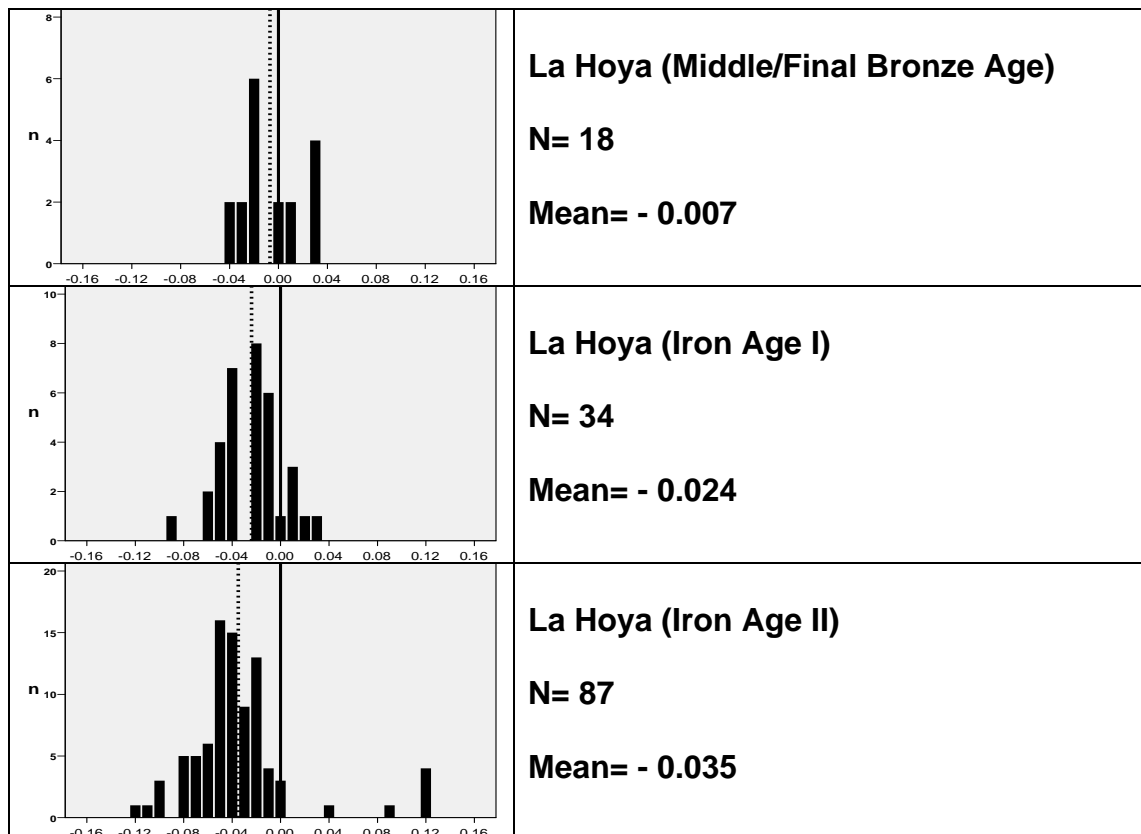


Figure 4.103: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) from three chronologically successive samples recovered at the site of La Hoya (Middle/Final Bronze Age-Iron I-Iron II). Only fused specimens are plotted. The dotted line represents the mean value.

4.3.1.2.1 Postcranial bones, age and sex profile-Iron Age

The Iron Age is perhaps the most suitable period to integrate age and sex and biometric data due to the availability of large and reliable samples, not only for the whole period but also for its two sub-phases and in some cases even for individual sites. Age and sex data revealed clear tendencies that differentiate Iron Age from earlier periods. Sex ratios have never indicated a female majority in a clearer way than in the Iron Age with ratios of 5-6:1 in some assemblages. Iron Age populations were also significantly older than earlier ones with very low

mortality in the first year and high survival beyond the second (almost 60% based on epiphyseal fusion, see figure 4.81).

Biometrically, Iron Age pigs had the smallest average postcranial size in Spanish prehistory. It is most likely that the overwhelming female majority has, at least to some extent, contributed to the small postcranial size. It does not seem to be sufficient to explain it entirely though. The majority of Iron Age pigs were slaughtered when older than 26 months (based on epiphyseal fusion), and this would allow time for some post-fusion growth on some bones. Since most of the older animals are clearly females, the age factor would partly counter the smaller female size, though not entirely as sexual dimorphism is a more significant factor in size variation than post-fusion growth. However, if we also take into account the relatively sex-independent tooth measurements (see section 4.3.2.3 below) which exhibit a strong tendency towards smaller size, then a genuine general size decrease is the most likely explanation.

Within the Iron Age, biometry has suggested a further size decrease on postcranial elements in Iron Age II. This slight decrease is most probably also genuine and cannot be attributed to increased female majority or older age profiles. Sex ratios for most Iron Age assemblages were calculated based on mixed samples of general Iron Age chronology and the few assemblages that have large enough samples for each Iron Age phase offered inconclusive results. At La Hoya for example, there is a more ample female majority in Iron Age II (compare figures 4.14 and 4.15) but the opposite could be observed for Castros de Lastra (compare figures 4.17 and 4.18), a site in the same region as La Hoya (Álava). Age profiles could not be held responsible for the size decrease as Iron Age II data indicated an overall older age profile. Another indication of the size decrease in pig postcranial bones is provided by multi-period assemblages such as that of La Hoya, which clearly illustrates a gradual size decrease from the Middle/Final Bronze Age to Iron Age I and further decrease in Iron Age II (figure 4.103), despite the slight fluctuation of age and sex profiles in each of the three periods.

4.3.2 Tooth Biometry

In this section the analysis conducted on pig teeth of Copper, Bronze and Iron Age chronology are presented in the form of scatterplots and histograms, and subsequently discussed. Before graphically presenting any biometric analyses, summary statistics for all recorded mandibular (table 4.6) and maxillary (table 4.7) teeth of post-Neolithic (i.e. Copper, Bronze and Iron Age) date are presented in the following two tables and the general patterns are highlighted here.

Table 4.6: Number (N), minimum, maximum, mean and coefficient of variation (V) for mandibular measurements of Copper, Bronze and Iron Age chronology.

Copper Age					
	N	Minimum	Maximum	Mean	V
dP4L	32	15.9	19.9	17.3	4.8
dP4WP	44	7.5	10.0	8.5	5.5
M1L	51	13.5	16.2	15.0	4.9
M1WA	75	8.2	11.1	9.8	5.6
M1WP	63	9.2	12.5	10.5	6.2
M2L	63	17.3	21.1	19.1	5.0
M2WA	66	11.9	14.8	13.1	5.4
M2WP	57	12.0	14.9	13.4	5.2
M3L	26	28.4	35.2	31.6	5.6
M3WA	30	14.7	16.9	15.6	4.7
M3WC	29	14.0	16.6	14.8	4.3
M3WP	19	10.7	13.9	11.5	7.4
Bronze Age					
	N	Minimum	Maximum	Mean	V
dP4L	28	16.0	18.2	17.1	3.4
dP4WP	38	7.6	9.2	8.5	4.1
M1L	58	13.4	16.9	14.8	4.9
M1WA	69	8.9	11.4	10.0	5.3
M1WP	70	9.5	12.0	10.6	5.2
M2L	34	16.6	22.0	18.9	6.9
M2WA	43	11.0	15.7	12.9	7.4
M2WP	45	11.3	15.9	13.4	7.3
M3L	23	26.5	41.7	33.3	10.7
M3WA	30	12.9	19.4	15.2	8.1
M3WC	33	13.2	18.6	14.6	8.3
M3WP	19	9.6	13.3	10.9	8.0
Iron Age I & II					
	N	Minimum	Maximum	Mean	V
dP4L	115	15.1	18.8	17.0	4.2
dP4WP	150	6.8	9.8	8.2	4.9
M1L	136	12.8	16.3	14.8	4.7
M1WA	235	8.3	12.4	9.7	5.9
M1WP	226	8.9	13.0	10.2	5.4
M2L	120	15.7	20.6	18.3	5.2
M2WA	205	10.8	16.4	12.6	6.1
M2WP	204	11.1	16.6	13.0	6.2
M3L	104	22.7	43.3	31.2	10.6
M3WA	168	11.6	20.5	14.6	7.2
M3WC	157	11.4	18.5	14.0	7.6
M3WP	88	7.7	14.8	10.4	12.1

Table 4.7: Number (N), minimum, maximum, mean and coefficient of variation (V) for maxillary measurements of Copper, Bronze and Iron Age chronology.

Copper Age					
	N	Minimum	Maximum	Mean	V
dP4L	20	11.3	15.0	12.5	6.9
dP4WP	19	9.6	11.9	10.7	6.2
M1L	62	13.2	16.4	14.8	5.3
M1WA	77	11.9	15.1	13.1	4.9
M1WP	74	10.9	15.3	13.0	5.0
M2L	58	16.8	22.3	18.6	6.6
M2WA	62	14.0	18.0	16.1	4.9
M2WP	51	13.7	17.0	15.5	4.5
M3L	36	28.0	34.4	31.0	5.7
M3WA	40	15.2	19.4	17.5	5.8
M3WC	35	13.2	17.0	14.9	5.9
M3WP	25	9.1	12.1	10.8	6.8
Bronze Age					
	N	Minimum	Maximum	Mean	V
dP4L	22	11.6	12.9	12.3	3.2
dP4WP	36	9.1	11.2	10.3	4.5
M1L	42	12.8	16.0	14.2	4.6
M1WA	67	11.4	14.5	12.9	5.1
M1WP	60	9.9	14.1	12.7	6.0
M2L	32	16.4	23.6	18.5	7.6
M2WA	56	13.2	19.1	15.9	6.8
M2WP	47	13.6	19.4	15.6	6.7
M3L	12	27.1	33.2	29.9	6.1
M3WA	19	15.3	22.1	18.2	8.8
M3WC	13	10.2	17.5	15.0	12.1
M3WP	8	9.4	13.3	10.6	12.8
Iron Age I & II					
	N	Minimum	Maximum	Mean	V
dP4L	59	11.2	13.2	12.3	3.7
dP4WP	73	9.3	11.5	10.4	4.2
M1L	76	12.7	17.2	14.3	5.5
M1WA	182	11.1	15.0	12.8	5.2
M1WP	171	10.9	14.1	12.8	5.1
M2L	122	14.5	22.5	17.7	7.0
M2WA	173	11.7	19.2	15.5	6.5
M2WP	178	11.1	17.4	15.0	6.1
M3L	103	18.1	40.0	28.9	9.6
M3WA	156	14.1	21.5	17.1	6.0
M3WC	114	12.3	18.0	14.8	6.7
M3WP	44	8.3	14.4	10.1	10.5

Compared to the pre-Neolithic and Early Neolithic measurements (chapter 3, tables 3.11 and 3.12), post-Neolithic measurements have a smaller mean as well as smaller minimum and maximum values in most measurements and periods. From the post-Neolithic periods, average tooth size was largest in the Bronze Age, followed by Copper and Iron Age. A pattern that appears repetitively through periods is the tendency for higher coefficients of variation in

second and third molar measurements. The identification of this increased variability in the size of teeth situated at the end of the tooth row is important as it strongly suggests that they are more sensitive indicators of size changes caused by human or natural agents.

4.3.2.1 Copper Age

As mentioned for postcranial data, the analysis of Copper Age data is crucial in order to follow the biometric evolution of pig size in post-Neolithic times in Spain. The analysis employed on tooth measurements from Copper Age assemblages mainly aims at examining biometric patterns within and between sites, as well as comparing the Copper Age with earlier periods. Moreover, the relation between postcranial and dental size is also addressed in this section.

In addition to the graphical exploration of tooth size in the Copper Age presented below, the data were further analysed by using Kruskal-Wallis followed by Mann-Whitney tests. Statistically significant size differences between any of the periods could be found for all – mandibular and maxillary - tooth measurements (all Kruskal-Wallis tests $p < 0.009$). Mann-Whitney tests were used to follow up this finding, again excluding samples containing less than five specimens. All analyses that included Copper Age data are presented in table 4.8 but commented on separately for each tooth in combination with the relevant scatterplots.

Table 4.8: Significance (two-tailed) of size differences in pig tooth measurements between Copper Age and the rest of the prehistoric periods, calculated with Mann-Whitney tests. Only samples with a minimum of five or more measurements were subjected to testing; green: very highly significant; blue: highly significant; yellow: significant.

MANDIBULAR												
	dP4L	dP4WP	M1L	M1WA	M1WP	M2L	M2WA	M2WP	M3L	M3WA	M3WC	M3WP
Pre-Neolithic / Copper Age	0.286	0.045	0.046	0.237	0.048	N/A	N/A	0.003	N/A	N/A	0.001	N/A
Early Neolithic / Copper Age	0.004	0.002	<0.001	<0.001	<0.001	0.002	<0.001	0.015	0.002	0.393	0.718	0.117
Late-Final Neolithic / Copper Age	0.755	0.067	0.466	0.013	0.038	0.193	0.361	0.028	N/A	<0.001	<0.001	<0.001
Copper Age / Bronze Age	0.361	0.634	0.376	0.086	0.639	0.213	0.194	0.625	0.054	0.010	0.055	0.039
Copper Age / Iron Age	0.022	<0.001	0.109	0.074	0.00	<0.001	<0.001	<0.001	0.449	<0.001	<0.001	<0.001
MAXILLARY												
	dP4L	dP4WP	M1L	M1WA	M1WP	M2L	M2WA	M2WP	M3L	M3WA	M3WC	M3WP
Pre-Neolithic / Copper Age	0.066	0.612	N/A	0.438	0.360	0.007	0.087	0.148	N/A	0.014	0.002	N/A
Early Neolithic / Copper Age	0.012	0.268	0.361	<0.001	0.001	0.083	0.001	0.013	0.001	<0.001	0.104	0.522
Late-Final Neolithic / Copper Age	N/A	N/A	0.845	0.639	0.551	0.491	0.456	0.169	N/A	0.203	N/A	N/A
Copper Age / Bronze Age	0.587	0.059	<0.001	0.211	0.026	0.555	0.281	0.717	0.068	0.087	0.280	0.222
Copper Age / Iron Age	0.254	0.104	0.001	0.003	0.013	<0.001	<0.001	<0.001	<0.001	0.050	0.759	0.001

In figures 4.104 and 4.105 the mandibular and maxillary measurements (crown length x posterior cusp width) of fourth deciduous premolar from pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age sites are presented. Both the mandibular and maxillary measurements show extensive overlap between Copper Age and earlier specimens, though a general tendency towards smaller size is evident for the Copper Age. This is especially visible in the lower left part of the mandibular and maxillary scatters, which are occupied by a few small-sized Copper Age and Late/Final Neolithic specimens. It is also worth noticing that some of the largest specimens in the scatterplots are also of Copper Age chronology. The impression of extensive overlap in dP4 size given by scatterplots is also reflected in statistics. Mann-Whitney tests showed that the least statistically significant size differences between Copper Age material and other periods are recorded for the dP4 measurements (table 4.8).

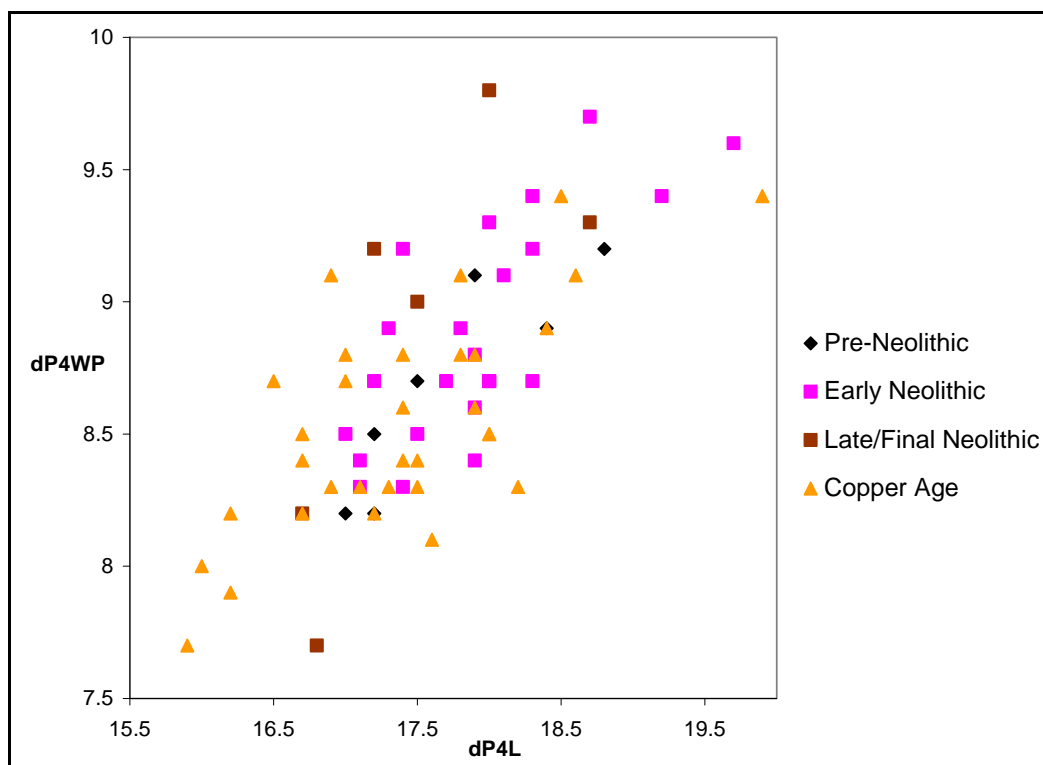


Figure 4.104: Scatterplot of crown length x posterior cusp width of mandibular fourth deciduous premolar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

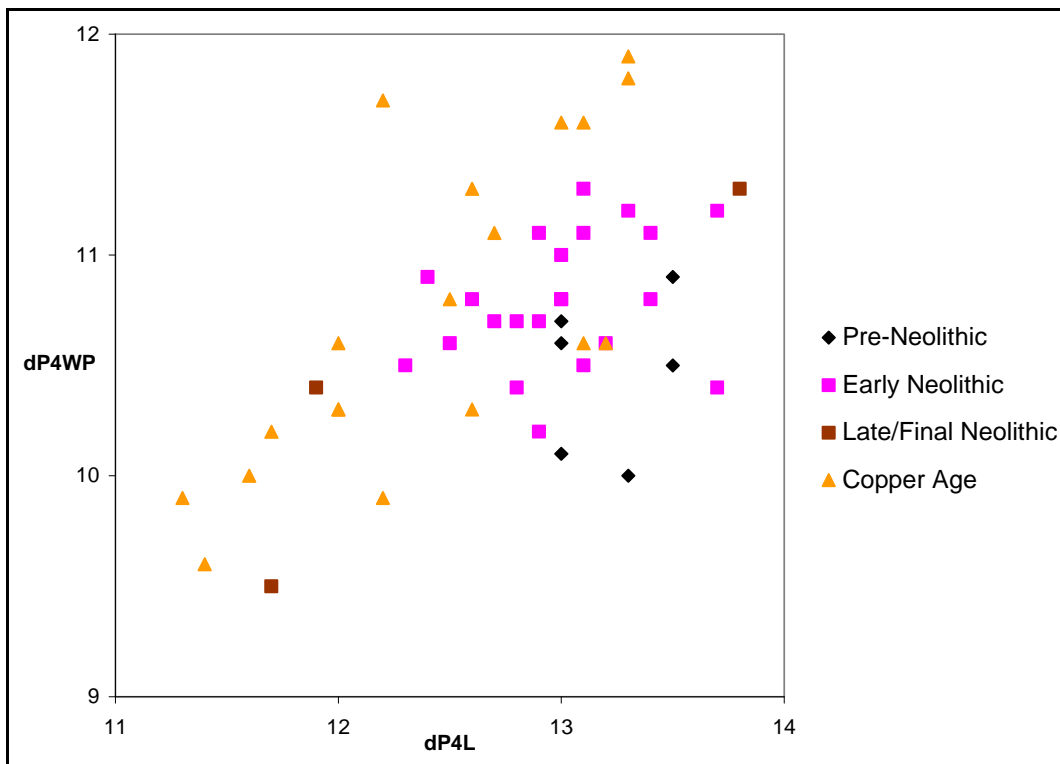


Figure 4.105: Scatterplot of crown length x posterior cusp width of maxillary fourth deciduous premolar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

In the following two scatterplots the crown length x anterior cusp width of mandibular (figure 4.106) and maxillary (figure 4.107) first molars are presented. The pattern is very similar to that of the dP4. The only notable difference is a tendency towards less size overlap between the Late/Final Neolithic and Copper Age specimens on the one hand, and the Early Neolithic and pre-Neolithic on the other. This is supported by many very highly significant Mann-Whitney results comparing Copper Age and Early Neolithic first molars (table 4.8). In the maxillary measurements (figure 4.107) a few particularly large Late/Final Neolithic and Copper Age outliers can be seen. Maxillary first molars – in fact, maxillary teeth in general – show less variability, expressed as increased overlap in scatterplots and reduced statistical significance of differences between samples (table 4.8).

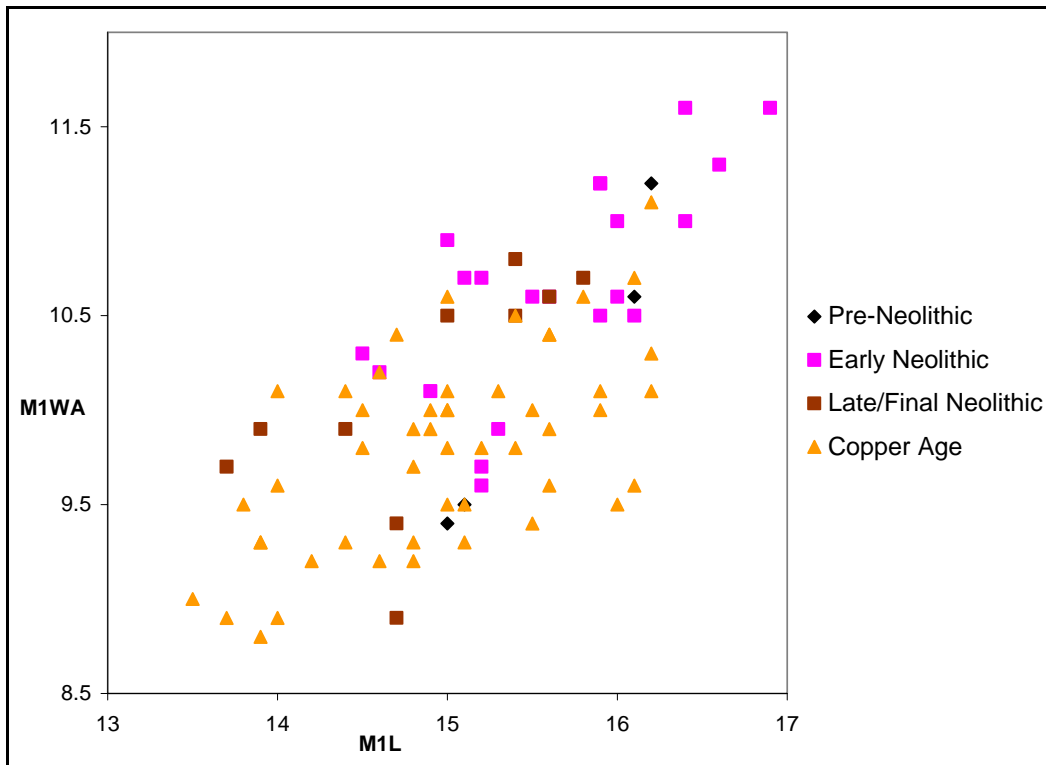


Figure 4.106: Scatterplot of crown length x anterior cusp width of mandibular permanent first molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

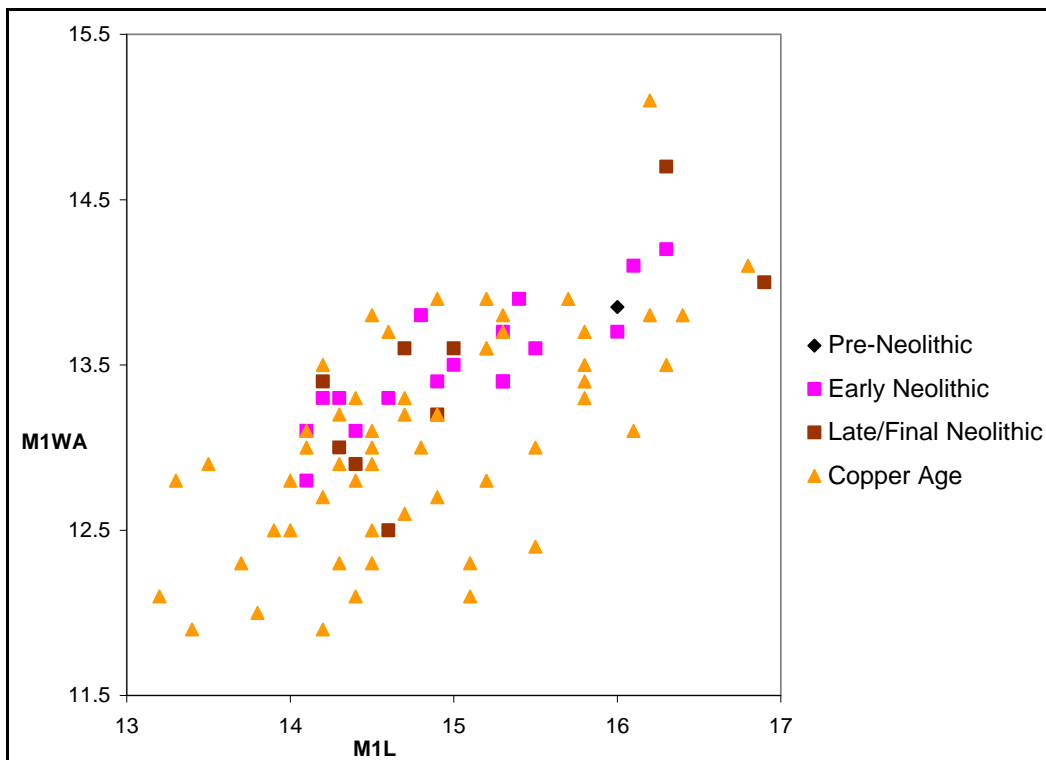


Figure 4.107: Scatterplot of crown length x anterior cusp width of maxillary permanent first molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

The anterior x posterior width of mandibular (figure 4.108) and maxillary (figure 4.109) first molars was also analysed. Essentially, the pattern is the same as that exhibited by the crown length x anterior width measurements, although in this case the sample is larger, and hence more reliable. Beyond the extensive overlap, which is still less than in the case of dP4 measurements, the tendency of Late/Final Neolithic and Copper Age specimens towards smaller size is easily discernible. The size of the few outliers from the same periods is as large as or larger than that of pre-Neolithic and Early Neolithic specimens. Another interesting pattern is that the Late/Final Neolithic specimens are of intermediate size between Early Neolithic and Copper Age specimens, although this is not easily discernible because the distributions of these periods exhibit extensive overlap and create a continuum of sizes.

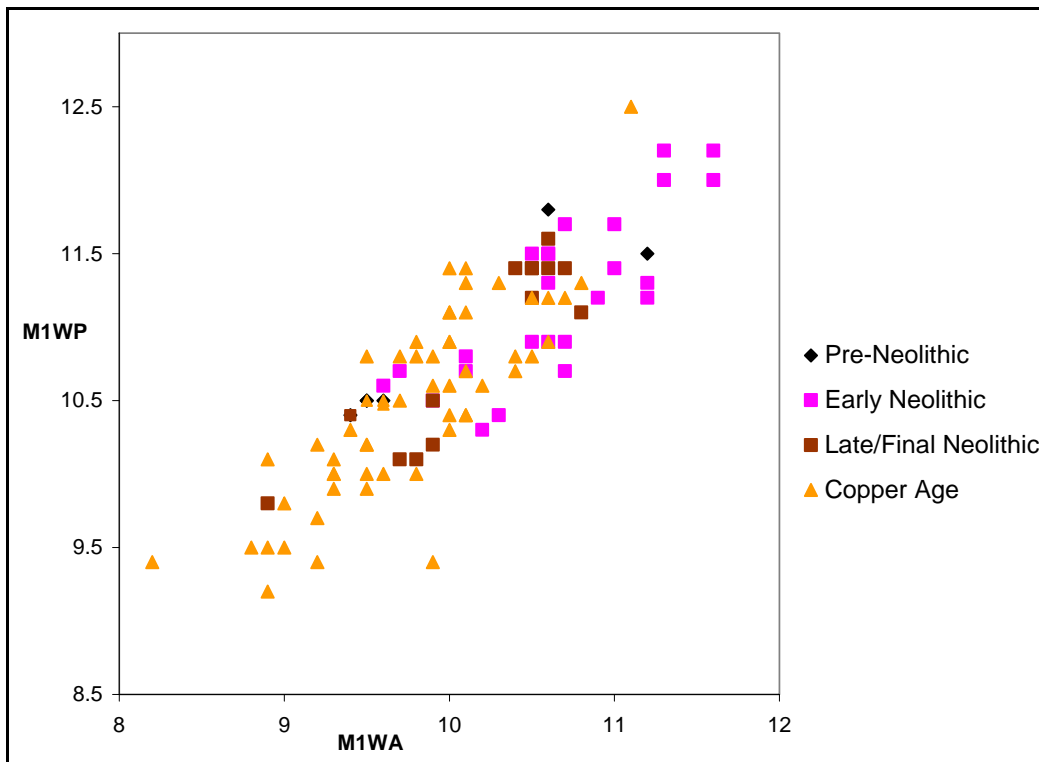


Figure 4.108: Scatterplot of anterior x posterior cusp width of mandibular permanent first molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

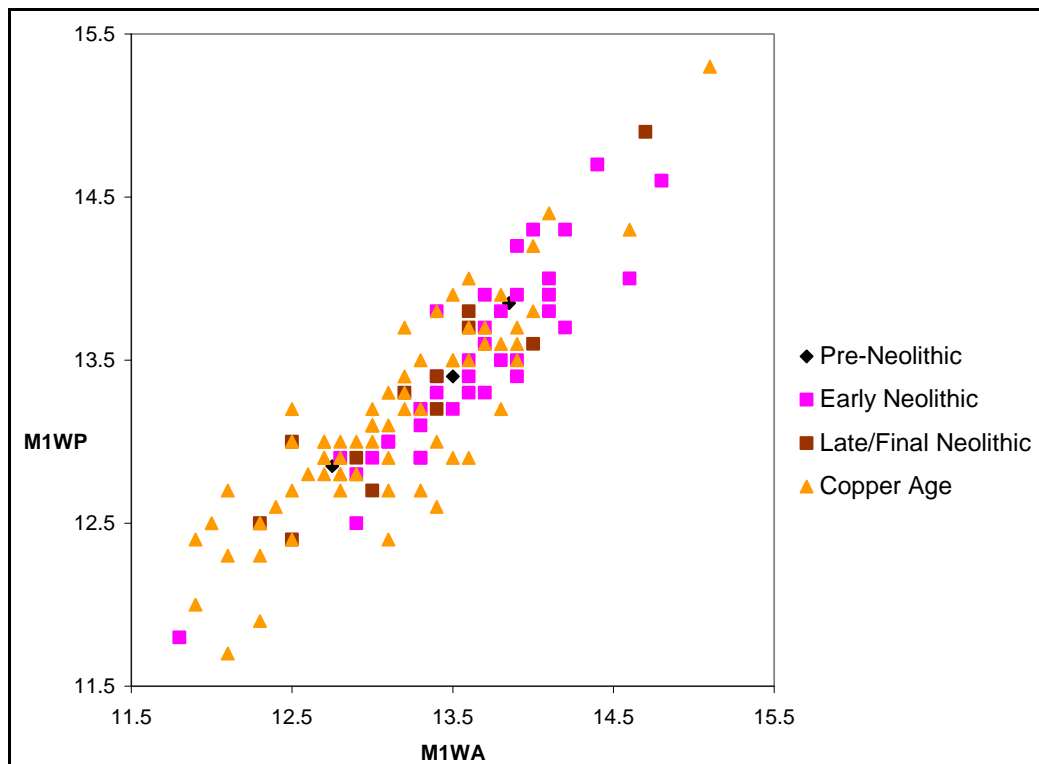


Figure 4.109: Scatterplot of anterior x posterior cusp width of maxillary permanent first molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

The anterior x posterior width of mandibular (figure 4.110) and maxillary (figure 4.111) second molars show many similarities but also some differences when compared with dP4 and M1. In the mandibular measurements, the majority of Copper Age, Late/Final Neolithic and a few Early Neolithic specimens plot in the central and lower left part of the distribution, while the upper right part of the distribution is occupied by the pre-Neolithic, the majority of Early Neolithic, three Late/Final Neolithic, and some Copper Age specimens. In general, no Early Neolithic specimen approaches a size as small as the smallest Final/Late Neolithic and Copper Age specimens (see also the statistically significant difference between Copper Age and Early Neolithic specimens; table 4.8). In the maxillary measurements (figure 4.111), a denser concentration of specimens in the central part of the scatterplot represents the only difference to the mandibular measurements, although generally the patterns are very similar.

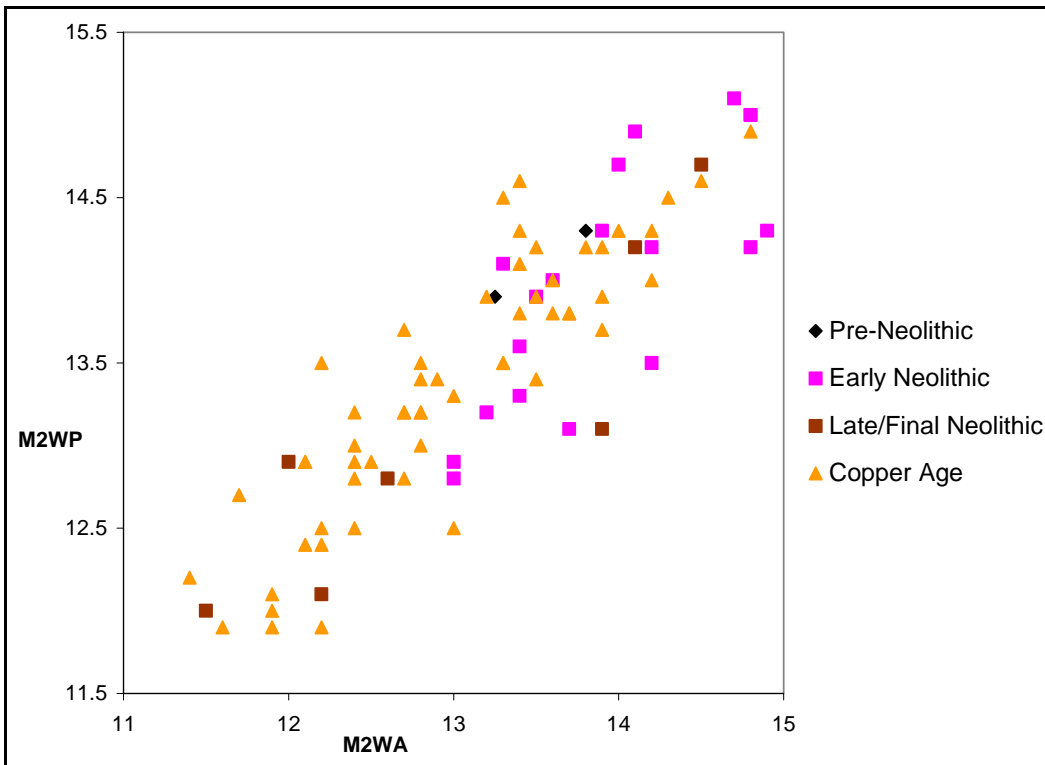


Figure 4.110: Scatterplot of anterior x posterior cusp width of mandibular permanent second molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

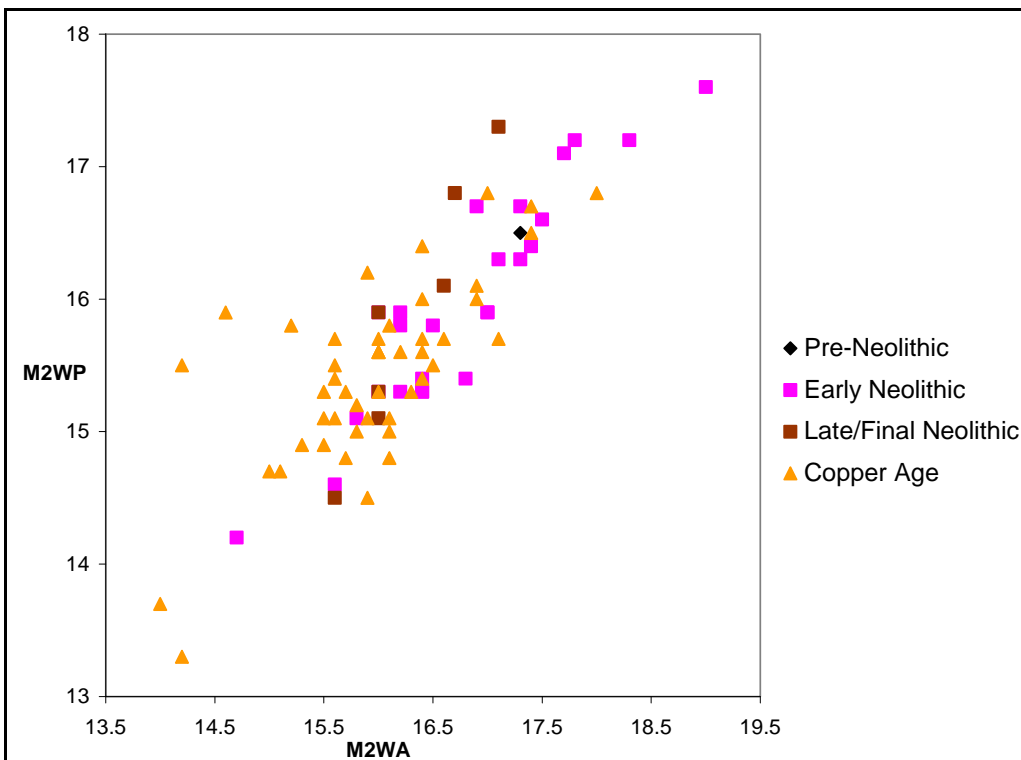


Figure 4.111: Scatterplot of anterior x posterior cusp width of maxillary permanent second molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

The following two scatterplots show the crown length x anterior cusp width of mandibular (figure 4.112) and maxillary (figure 4.113) third molars. As it is visible from the scatterplot, the Neolithic and pre-Neolithic samples are tiny and thus any comparisons between those and the Copper Age sample should be made with caution. The tendency for reduced overlap between pre-Neolithic and later specimens, that had been observed to gradually increase from the dP4 to the second molar, appears intensified for the third molar. In the scatterplots, the Late/Final Neolithic and Copper Age specimens occupy the central and lower left parts of the distribution with some overlap with the smallest Early Neolithic specimens. The upper right part, with considerable size difference, is occupied by the few pre-Neolithic specimens available and the occasional Early Neolithic outlier.

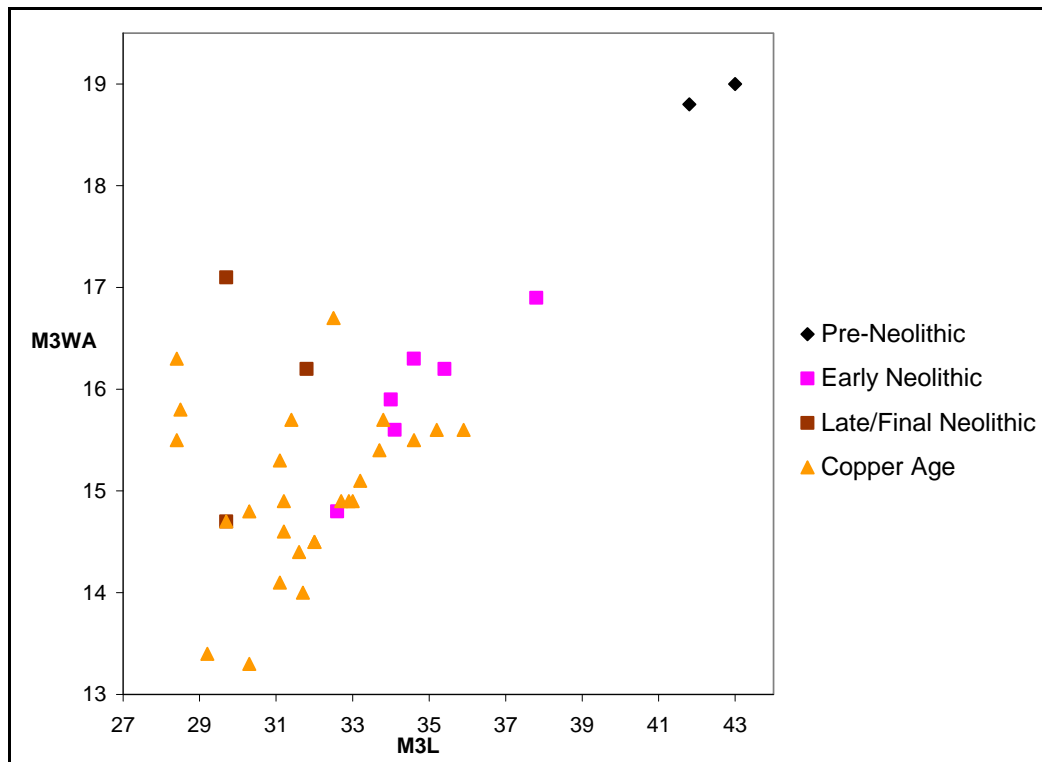


Figure 4.112: Scatterplot of crown length x anterior cusp width of mandibular permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

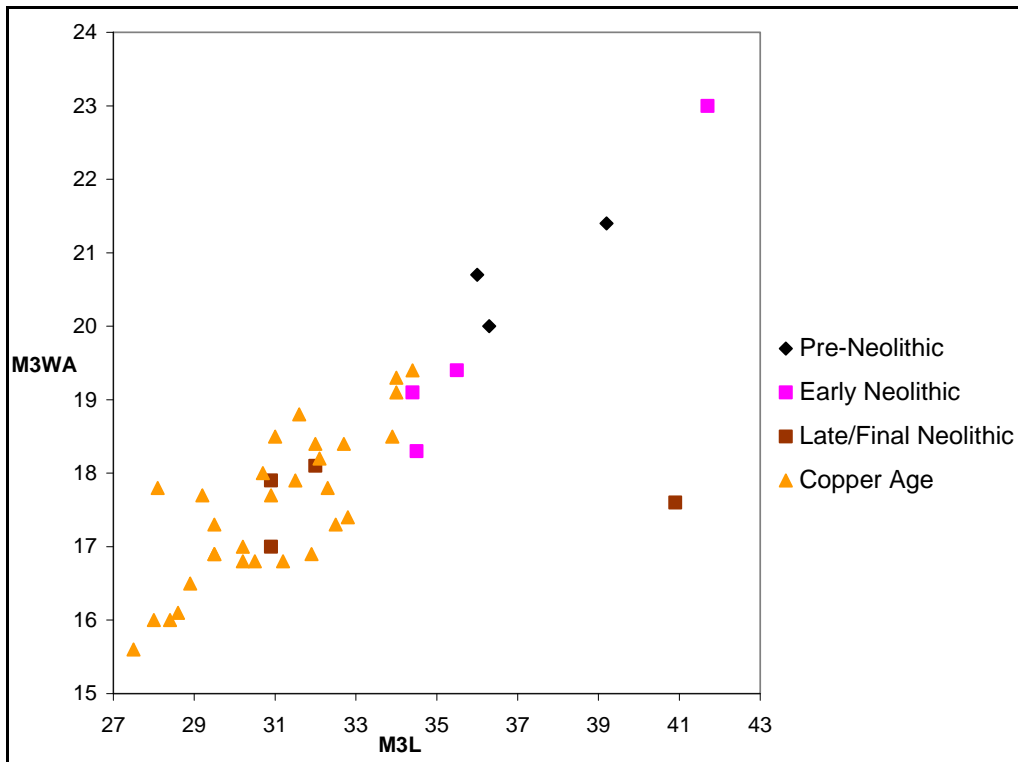


Figure 4.113: Scatterplot of crown length x anterior cusp width of maxillary permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

The anterior cusp x central cusp width of mandibular and maxillary third molars is presented in figures 4.114 and 4.115 respectively. Overall, the picture is similar to that of the crown length x anterior cusp width. Pre-Neolithic specimens plot separately from the rest in the upper right part, with the exception of a maxillary specimen that plots in the central part of the scatterplot. In mandibular measurements, Early Neolithic specimens overlap entirely with the middle and upper part of the Late/Final Neolithic and Copper Age distributions (also see the insignificant differences in their measurements, table 4.8). Noteworthy appears the presence of two particularly small Early Neolithic specimens in maxillary measurements and of an Early Neolithic specimen that is of similar size to the largest pre-Neolithic specimens.

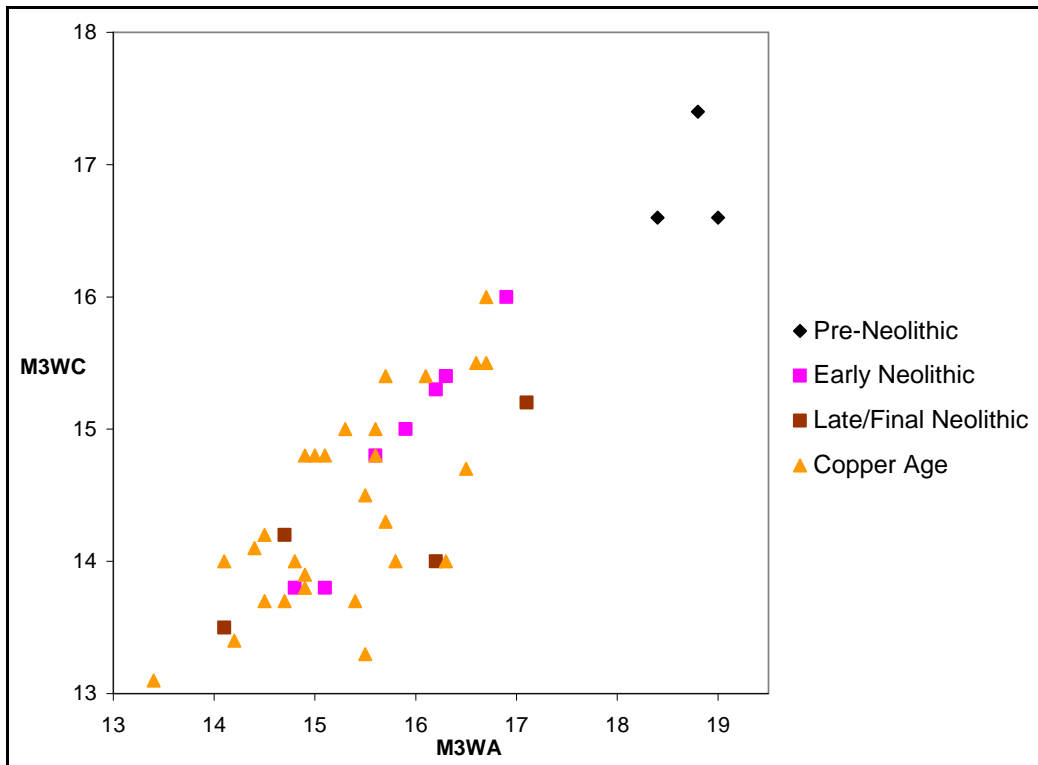


Figure 4.114: Scatterplot of anterior cusp x central cusp width of mandibular permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

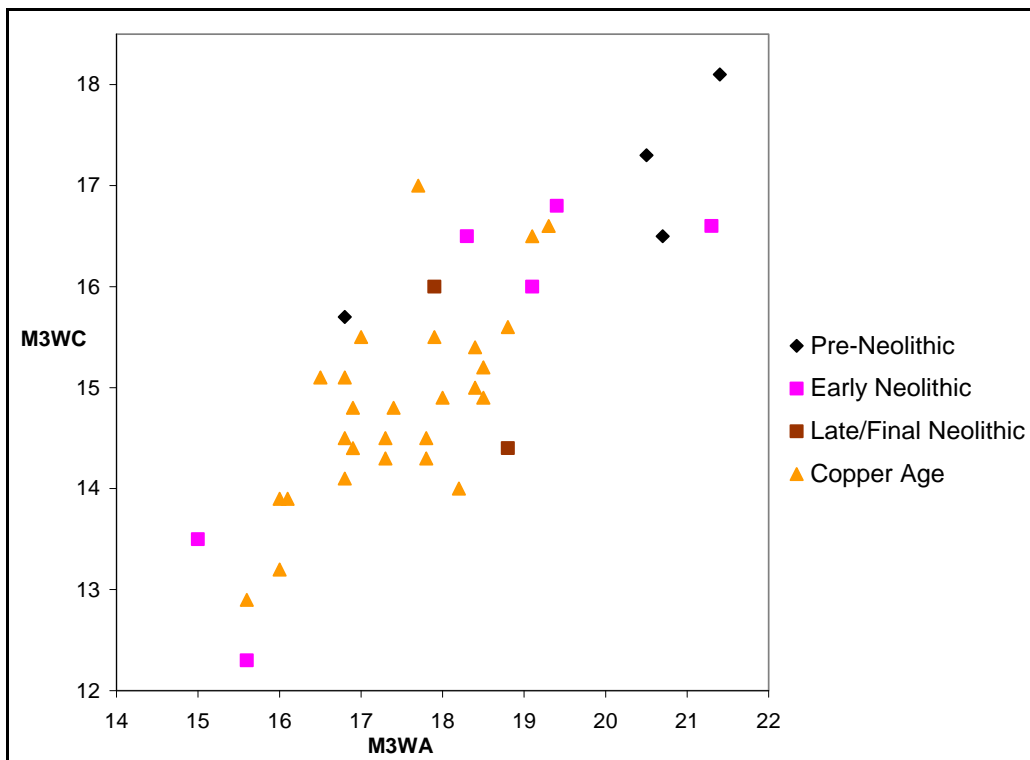


Figure 4.115: Scatterplot of anterior cusp x central cusp width of maxillary permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology. Measurements in mm.

As done for pre- and Neolithic specimens (chapter 3), Copper Age third molars were also analysed by using a shape index (ratio between length and anterior and central widths). Copper Age mandibular third molars (figure 4.116) show considerable variability in shape but most have a shape that is very similar – or at least approaching - the shape of Early Neolithic specimens. In accordance to this, the differences in third molar measurements between Copper Age and Early Neolithic specimens were found to be statistically insignificant (table 4.8). However, size and shape are not necessarily correlated since specimens that are clustered together based on their shape, differ significantly in size. The pattern produced by maxillary specimens is similar to that of the mandibular specimens (figure 4.117), though most Copper Age specimens plot anywhere between the only Late/Final Neolithic specimen and the three Early Neolithic ones.

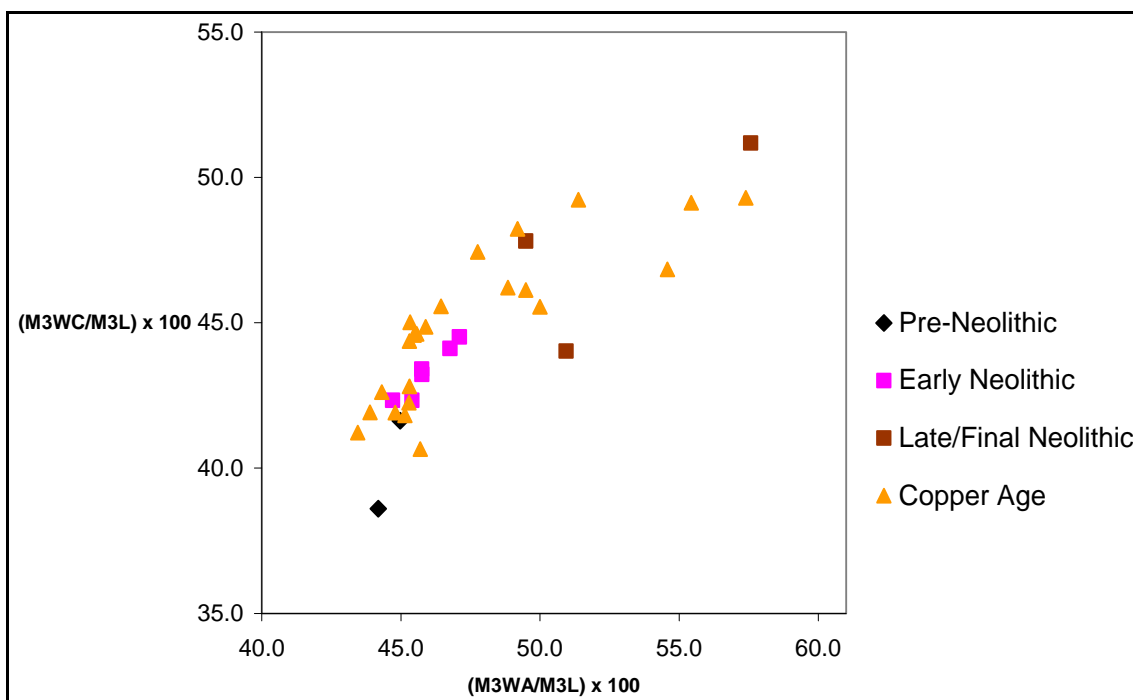


Figure 4.116: Ratio between width and length of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age lower third molars.

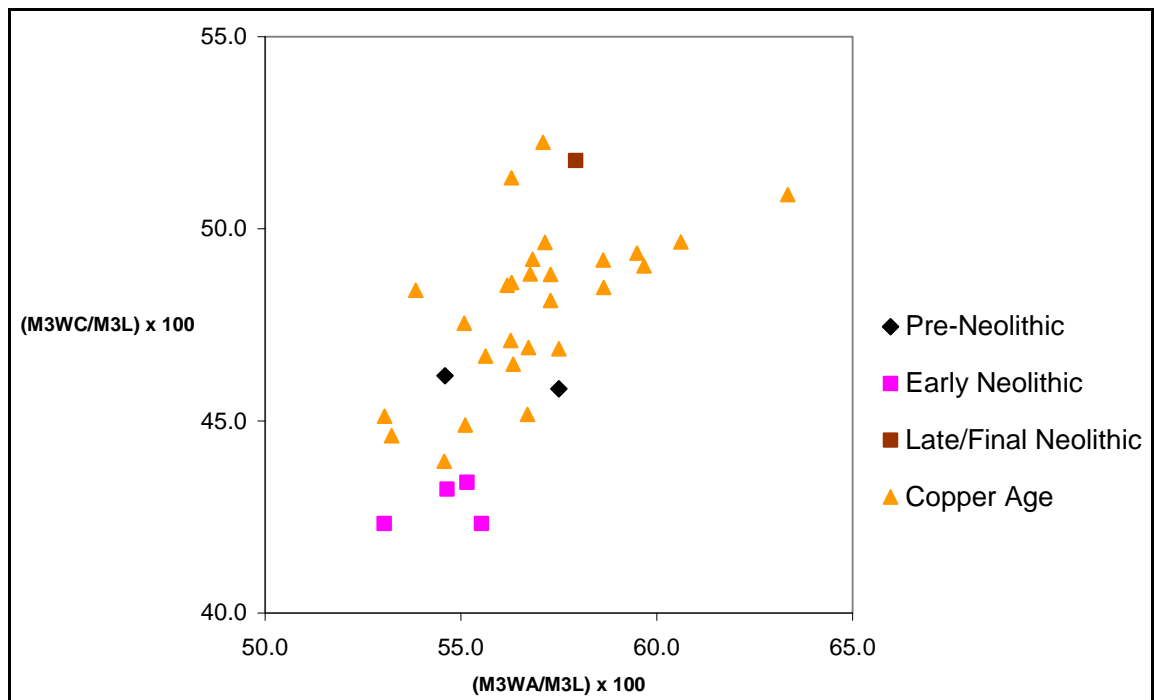


Figure 4.117: Ratio between width and length of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age upper third molars.

In addition to the scatterplots, log ratio histograms with all Copper Age assemblages were produced. Before presenting any histograms, it is important to state that all crown lengths of molars and the fourth deciduous premolar are excluded from the analysis because they were taken in a different way than the measurements of the standard population (Late Neolithic Durrington Walls, England). Although this has been found not to affect the third molar measurement, this has also been excluded for the sake of consistency.

In general, more pig assemblages are represented in the histograms than in scatterplots and a more general picture, though at lower resolution, becomes available. Before exploring any inter-site differences in tooth size during the Copper Age, it is useful to compare the tooth size of Copper Age pigs as a combined sample, with earlier periods. The histograms (figure 4.118) are, as expected, consistent with the results presented in scatterplots. As shown in chapter 3, pre-Neolithic pigs were on average the largest, followed closely by the Early Neolithic pigs, which were on average slightly smaller than their pre-Neolithic counterparts. Final/Late Neolithic tooth size is clearly smaller than the pre-Neolithic and Early Neolithic size, while a further size decrease is evident in the Copper Age. Compared to the histograms produced for postcranial measurements (figure 4.87), there is more size overlap in tooth size throughout

the analysed chronological span. Although the overall tendencies in the evolution of size are the same between postcranial and dental elements, size reduction is less pronounced in dental elements and, as a result, more overlap between periods occurs. This is also reflected in the increased statistical significance of postcranial measurements when compared with other periods (e.g. Early Neolithic/Copper Age, table 4.8).

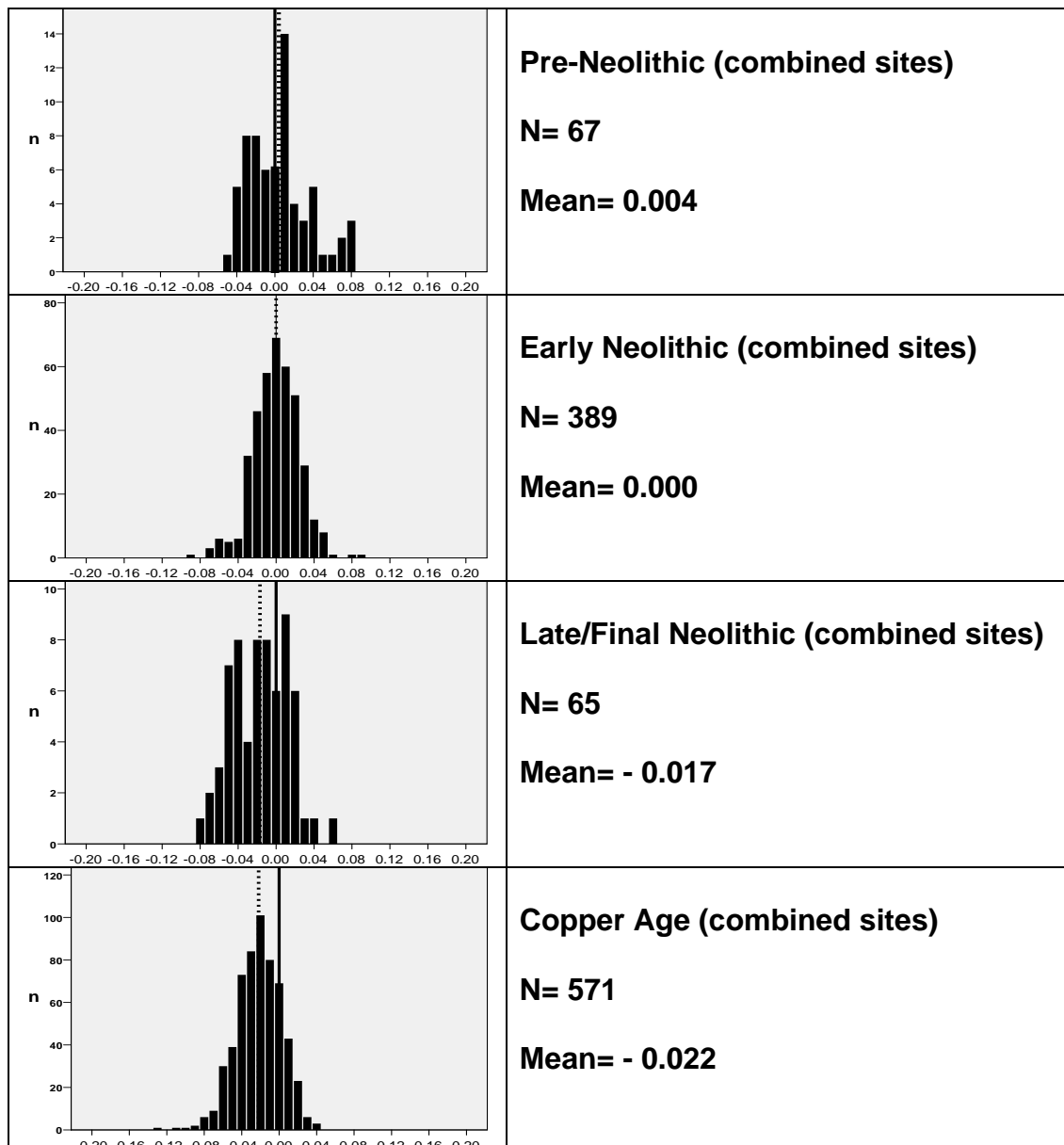


Figure 4.118: Log ratio histograms comparing pig tooth measurements from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Copper Age chronology.

Another difference is that the ‘tail’ of larger specimens, visible in the postcranial Copper Age distribution, is absent from the distribution of dental measurements. The chronological comparison of pig size can be more effectively analysed when both bone and tooth trends are compared. Both show that during the

Early Neolithic there was some size decrease in comparison to the pre-Neolithic. The first sharp decrease occurred between the early part (end of 6th millennium cal. BC) and the end of the Neolithic period (end of 4th millennium cal. BC). The second size decrease occurred between the Late/Final Neolithic and the Copper Age, although it was not as pronounced as the first one.

To examine possible differences between Copper Age sites, a stack of histograms with all Copper Age tooth measurements per site is presented in figure 4.119. Only sites or levels that yielded more than five measurements are included in the analysis, although measurements from Copper Age assemblages with less than five tooth measurements are included in the general Copper Age samples at the bottom of the stack. According to the histograms, Copper Age pig populations had a similar tooth size with only slight variations between assemblages. The most significant difference is the larger size of the pigs of Valencina de la Concepción, which also dominates the cumulative Copper Age sample when included (see bottom three histograms). The smallest size is exhibited by the site of Las Pozas followed by Los Millares. Of similar size are the Early Copper Age pigs from Los Castillejos, which appear to have a slightly smaller size than the mixed sample of Final Neolithic/Early Copper Age from the same site.

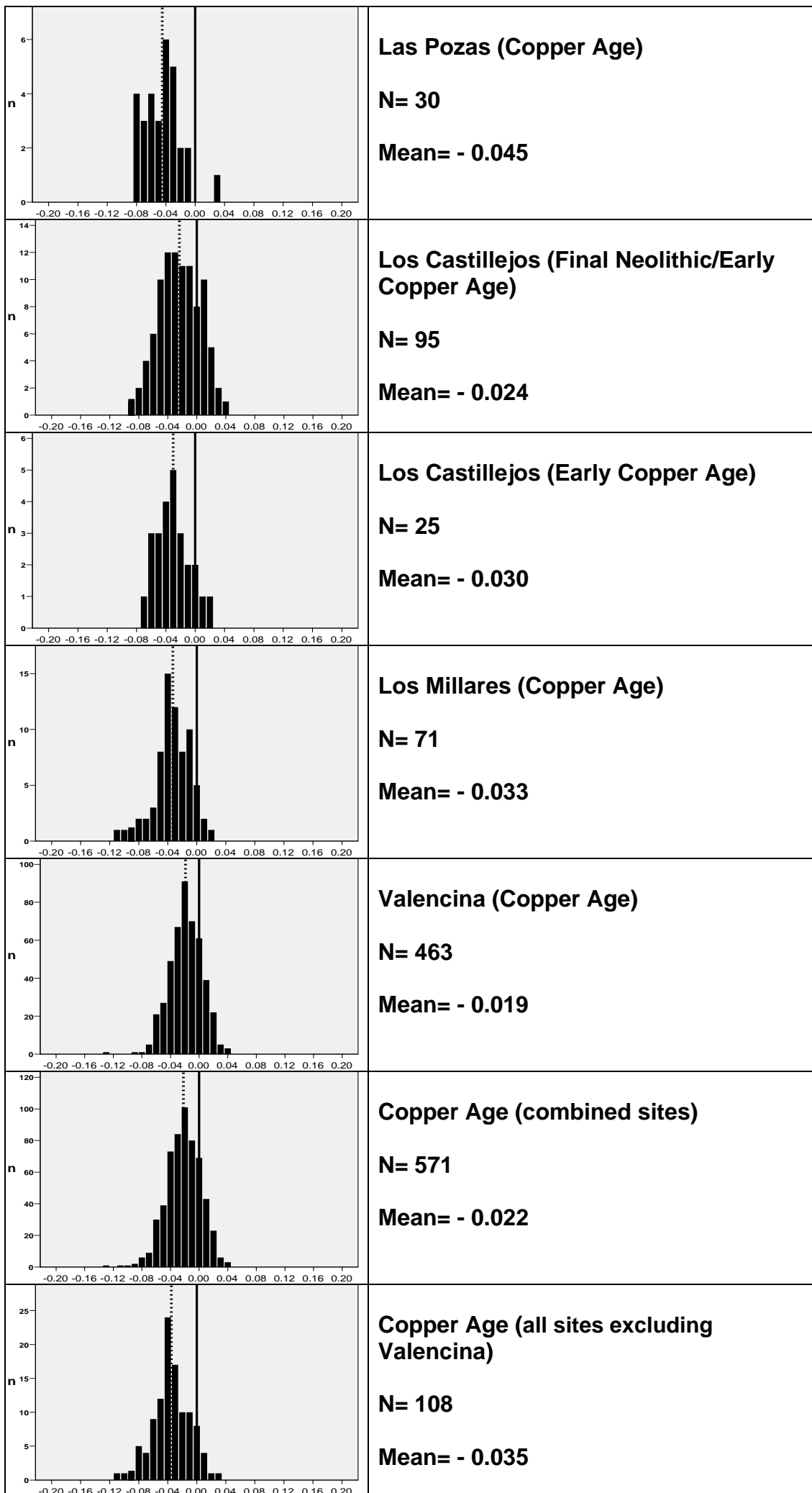


Figure 4.119: Log ratio histograms comparing pig tooth measurements from Copper Age sites with the combined Copper Age sample.

4.3.2.1.1 Dental size, age and sex profile-Copper Age

Dental size – especially width measurements – is probably the least age- and sex-dependent metric characteristic in pigs (Albarella and Payne 2005; Payne and Bull 1988). This means that comparisons between periods can be more directly interpreted as a consequence of genuine genetic differences or similarities between populations. Age and sex factors are ever-present but have a limited influence. Since tooth size is also less dependent on environmental factors, a greater size overlap - than for bones - between periods is expected. This is indeed supported by the scatterplots and histograms presented in the section above. Nonetheless, tooth size is clearly smaller in the Copper Age than in the Early Neolithic. The histograms actually suggest that a major decrease in tooth size had already occurred before the end of the Neolithic period (figure 4.118). Since it is expressed on tooth widths too, it constitutes a strong indication that it represents a genuine size decrease, rather than merely a product of a change in sex and/or age profiles.

4.3.2.2 Bronze Age

The analysis of Bronze Age data is important in order to follow the fluctuations in pig size over time. The comparison of Bronze Age data with those from earlier periods can provide us with a useful diachronic perspective (also see tables 4.6 and 4.7 for descriptive statistics). Furthermore, the comparison between the patterns produced by the analysis on dental and postcranial elements from the same period is important.

Before the graphical exploration of tooth size in the Bronze Age presented below, the data were further analysed by using Kruskal-Wallis followed by Mann-Whitney tests. Statistically significant size differences between any of the periods could be found for all – mandibular and maxillary - tooth measurements (all Kruskal-Wallis tests $p < 0.009$). Mann-Whitney tests were used to follow up this finding, excluding samples containing less than five specimens. All analyses including Bronze Age data are presented in table 4.9, but are commented on separately for each tooth in combination with the relevant scatterplots.

Table 4.9: Significance (two-tailed) of size differences in pig tooth measurements between Bronze Age and the rest of the prehistoric periods, calculated with Mann-Whitney tests. Only samples with a minimum of five or more measurements were subjected to testing; green: very highly significant; blue: highly significant; yellow: significant.

MANDIBULAR												
	dP4L	dP4WP	M1L	M1WA	M1WP	M2L	M2WA	M2WP	M3L	M3WA	M3WC	M3WP
Pre-Neolithic / Bronze Age	0.086	0.049*	0.020*	0.756	0.049*	N/A	N/A	0.011*	N/A	N/A	0.003**	N/A
Early Neolithic / Bronze Age	<0.001***	0.004**	<0.001***	<0.001***	<0.001***	0.002**	<0.001***	0.014*	0.162	0.042*	0.345	0.025*
Late-Final Neolithic / Bronze Age	0.385	0.042*	0.948	0.047*	0.094	0.391	0.769	0.099	N/A	0.011*	0.006**	0.008**
Copper Age / Bronze Age	0.361	0.634	0.376	0.086	0.639	0.213	0.194	0.625	0.054	0.010**	0.055	0.039*
Bronze Age / Iron Age	0.235	<0.001***	0.668	<0.001***	<0.001***	0.078	0.038*	0.008**	0.007**	0.012*	0.009**	0.021*
MAXILLARY												
	dP4L	dP4WP	M1L	M1WA	M1WP	M2L	M2WA	M2WP	M3L	M3WA	M3WC	M3WP
Pre-Neolithic / Bronze Age	0.006**	0.292	N/A	0.216	0.070	0.005**	0.055	0.206	N/A	0.174	0.038*	N/A
Early Neolithic / Bronze Age	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	0.030*	<0.001***	0.058	0.001***	0.034*	0.278	0.487
Late-Final Neolithic / Bronze Age	N/A	N/A	0.011*	0.229	0.066	0.787	0.199	0.266	N/A	0.899	N/A	N/A
Copper Age / Bronze Age	0.587	0.059	<0.001***	0.211	0.026*	0.555	0.281	0.717	0.068	0.087	0.280	0.222
Bronze Age / Iron Age	0.762	0.369	0.366	0.217	0.626	0.007**	0.015*	<0.001***	0.156	0.001***	0.172	0.439

In figures 4.120 and 4.121 the mandibular and maxillary measurements of fourth deciduous premolars from pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age sites are presented. Copper Age specimens are deliberately plotted in order to expose their close similarity to Bronze Age specimens, which is confirmed statistically by Mann-Whitney tests (table 4.9). Although the mandibular measurements show extensive overlap between the Bronze Age, Neolithic and pre-Neolithic populations, the overlap is much more restricted in the case of maxillary teeth. In fact, in maxillary specimens there is almost no overlap between Bronze Age and pre-Neolithic dP4 size and little overlap with the Early Neolithic. Statistically, Bronze Age fourth deciduous premolars are more similar to the post-Neolithic periods (Copper and Iron Age) and differ from their Early Neolithic and pre-Neolithic counterparts (table 4.9).

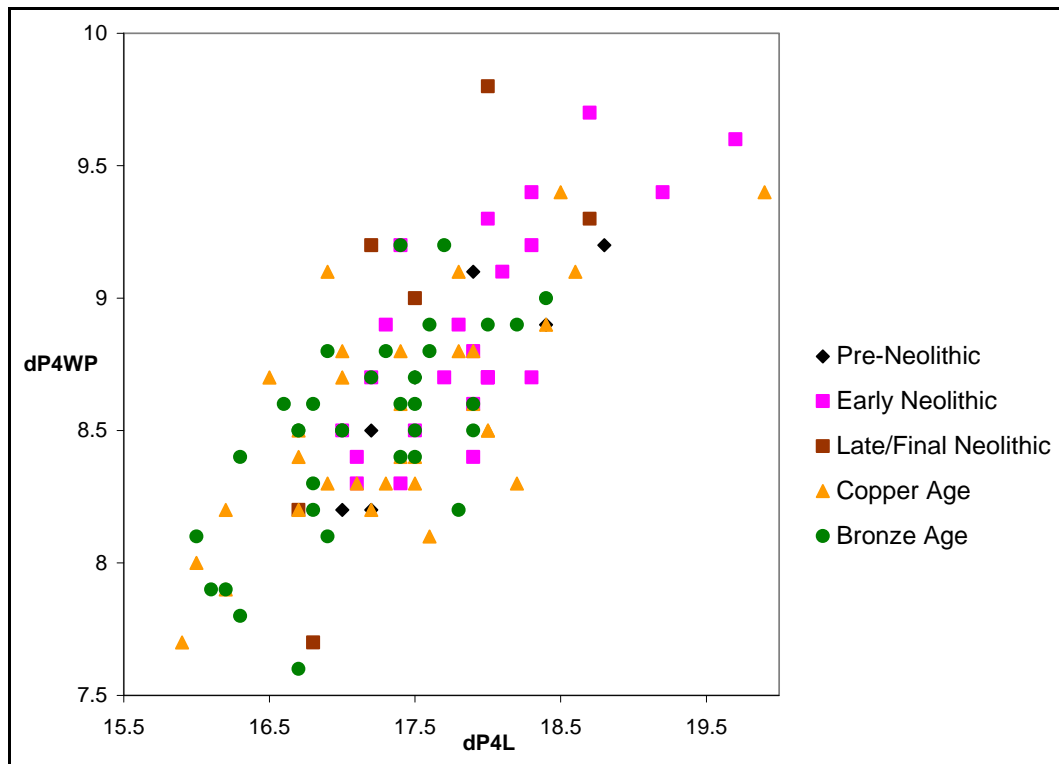


Figure 4.120: Scatterplot of crown length x posterior cusp width of mandibular fourth deciduous premolar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

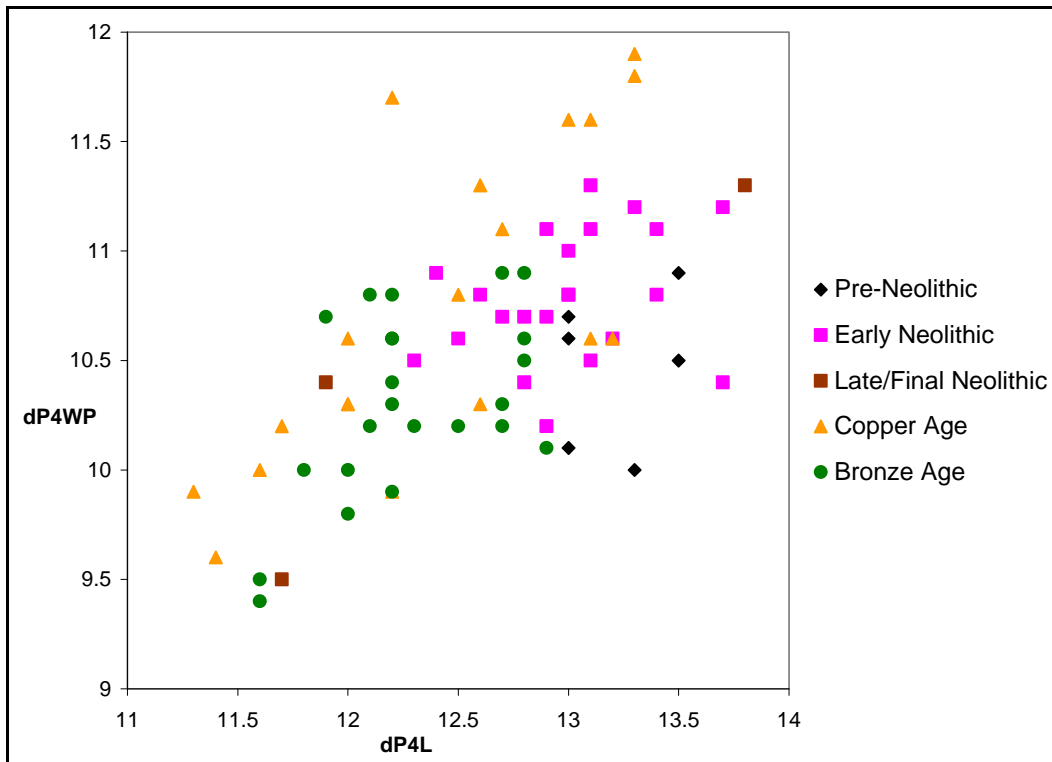


Figure 4.121: Scatterplot of crown length x posterior cusp width of maxillary fourth deciduous premolar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

In the following two scatterplots measurements of mandibular (figure 4.122) and maxillary (figure 4.123) first molars are presented. The pattern is similar to that of the dP4 with only one difference visible in both diagrams. There is a tendency towards less overlap between the Late/Final Neolithic, Copper and Bronze Age specimens on one hand, and the Early Neolithic and pre-Neolithic on the other hand (see also table table 4.9 for Mann-Whitney tests on significance of differences between Bronze Age and other periods). While a few particularly large Late/Final Neolithic, Copper and Bronze Age outliers plot in the upper right part of the distribution, the vast majority is distributed in the central and lower left parts of the scatter indicating the presence of a majority of smaller-sized individuals.

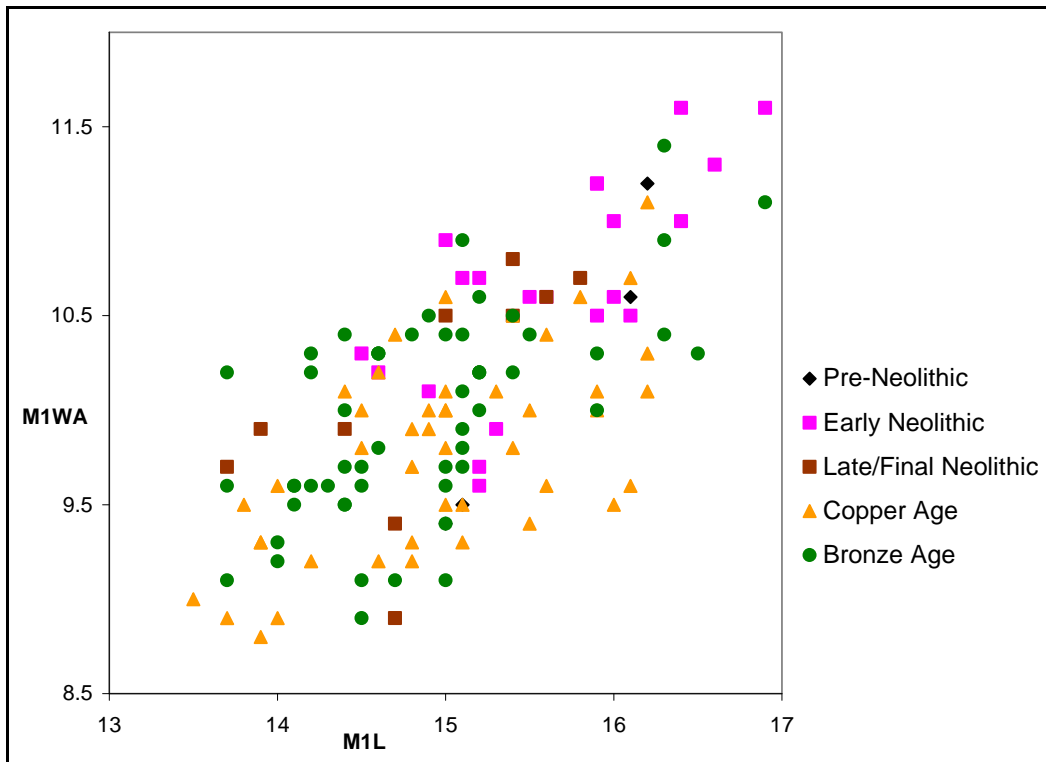


Figure 4.122: Scatterplot of crown length x anterior cusp width of mandibular permanent first molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

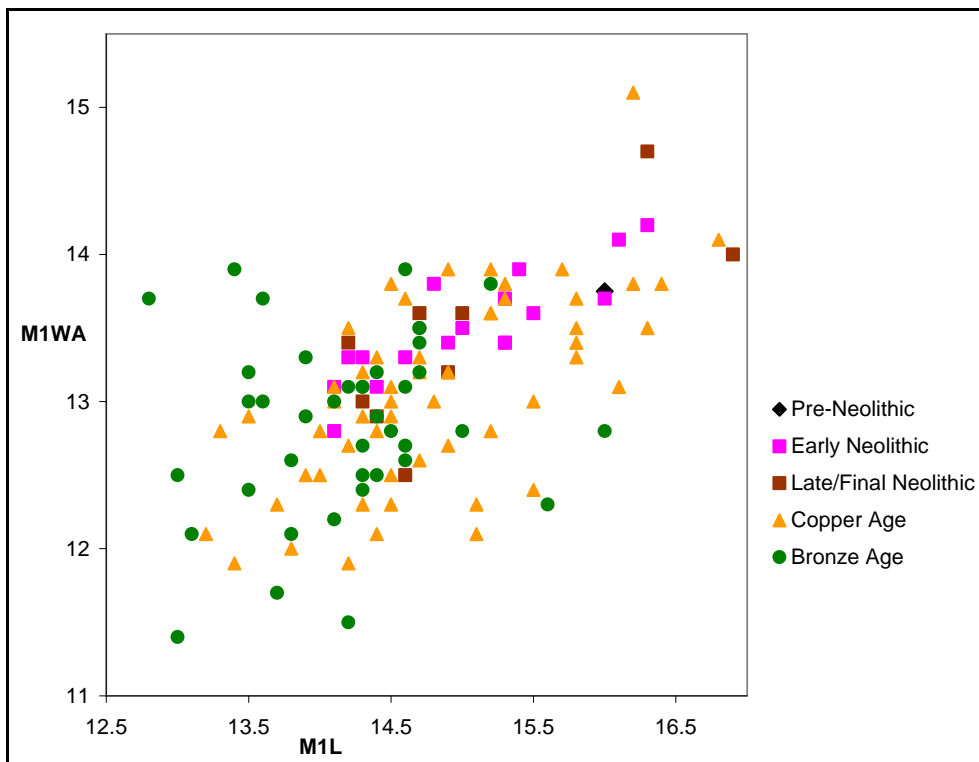


Figure 4.123: Scatterplot of crown length x anterior cusp width of maxillary permanent first molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

The anterior x posterior width of mandibular (figure 4.124) and maxillary (figure 4.125) second molars was analysed as well. In both, the central part of the

distribution is densely occupied by Bronze, Copper, Late/Final Neolithic and Early Neolithic specimens, while the lower part of the distribution almost exclusively by Late/Final Neolithic, Copper and Bronze Age specimens. The upper right part of the distribution is occupied by a few Late/Final Neolithic and Bronze Age outliers and the larger Early Neolithic specimens. Statistically, this pattern is supported by Mann-Whitney tests, which showed that Bronze Age second molars are significantly different from their pre-Neolithic and Early Neolithic but not from their Copper Age and Late/Final Neolithic counterparts (table 4.9).

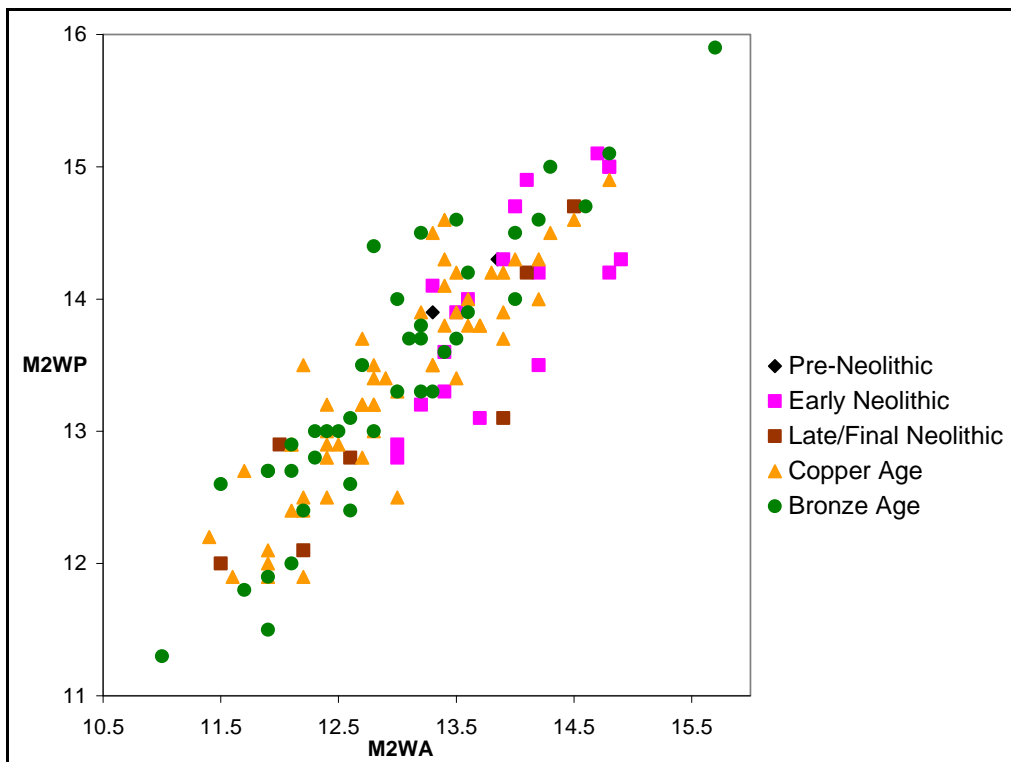


Figure 4.124: Scatterplot of anterior x posterior cusp width of mandibular permanent second molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

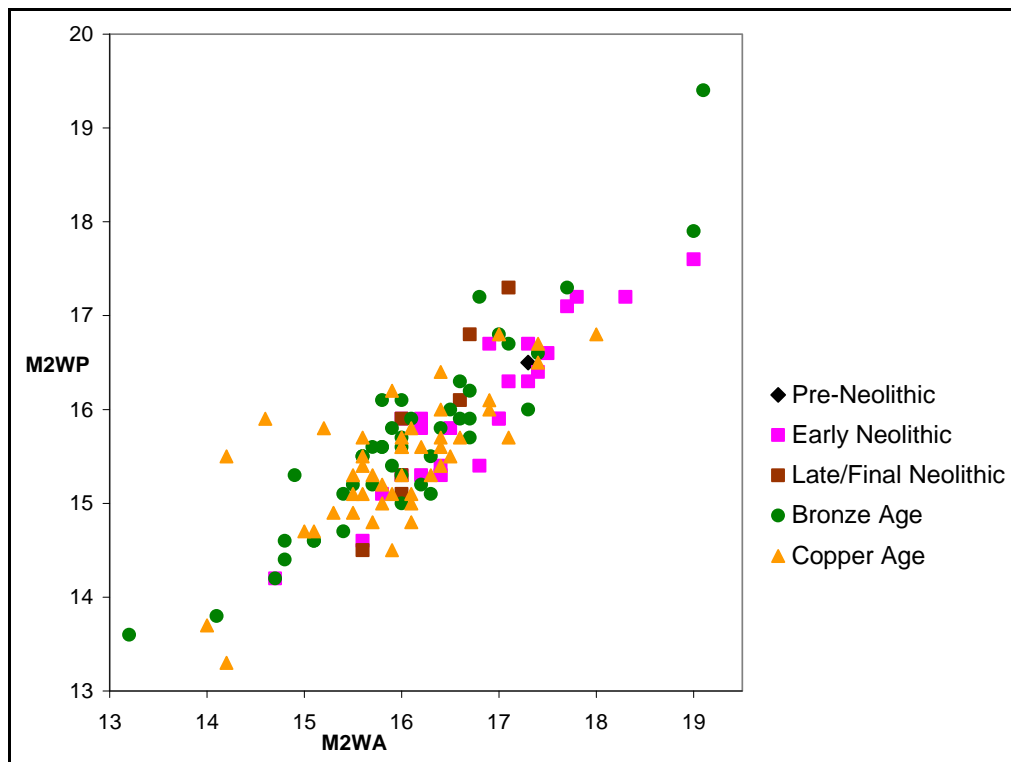


Figure 4.125: Scatterplot of anterior x posterior cusp width of maxillary permanent second molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

The crown length x anterior cusp width of mandibular (figure 4.126) and maxillary (figure 4.127) third molars are presented in the following two scatterplots. The Neolithic and pre-Neolithic samples are tiny but useful. The tendency for reduced overlap between the pre-Neolithic and later specimens, which had been observed to gradually increase from the dP4 to the second molar, appears quite intensified for the third molar. The Late/Final Neolithic, Copper and Bronze Age specimens occupy the central and lower left parts of the distribution with some overlap with the smallest Early Neolithic specimens, while the upper right part, with considerable size difference, is occupied by the few recorded pre-Neolithic specimens and the occasional Early Neolithic and Bronze Age outlier.

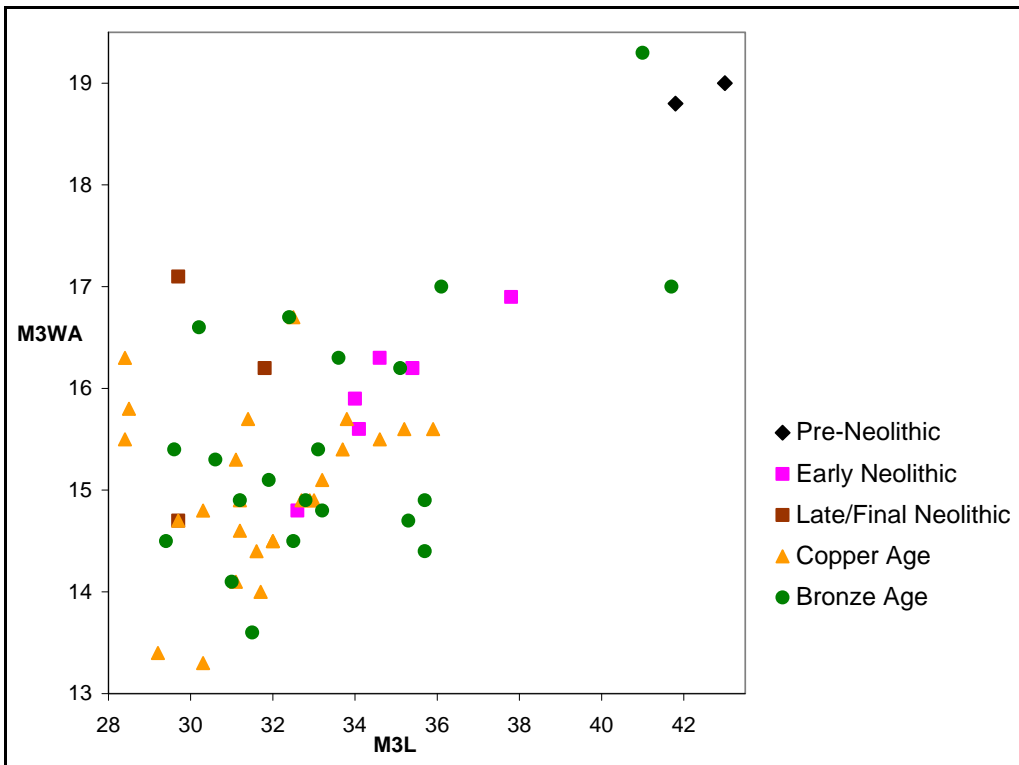


Figure 4.126: Scatterplot of crown length x anterior cusp width of mandibular permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

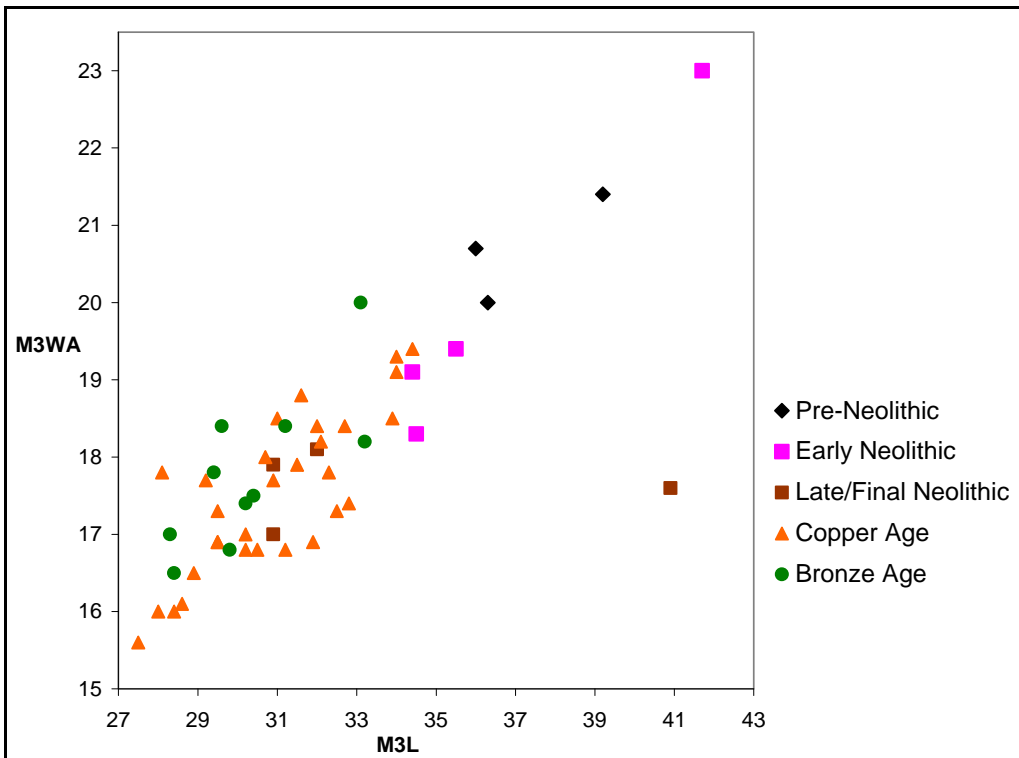


Figure 4.127: Scatterplot of crown length x anterior cusp width of maxillary permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

The anterior cusp x central cusp width of mandibular and maxillary third molars is presented in figures 4.128 and 4.129 respectively. Overall, the pattern is

similar to the crown length x anterior cusp width measurements, with the pre-Neolithic specimens plotting separately from the rest in the upper right corner of the distribution. The only exception is a maxillary specimen which plots in the central part of the distribution. The Early Neolithic specimens, especially their mandibular measurements, overlap completely with the middle and upper part of the distribution of Late/Final Neolithic, Copper and Bronze Age specimens. Also interesting is that a few Bronze Age specimens and an Early Neolithic maxillary specimen are as large as or larger than the pre-Neolithic specimens.

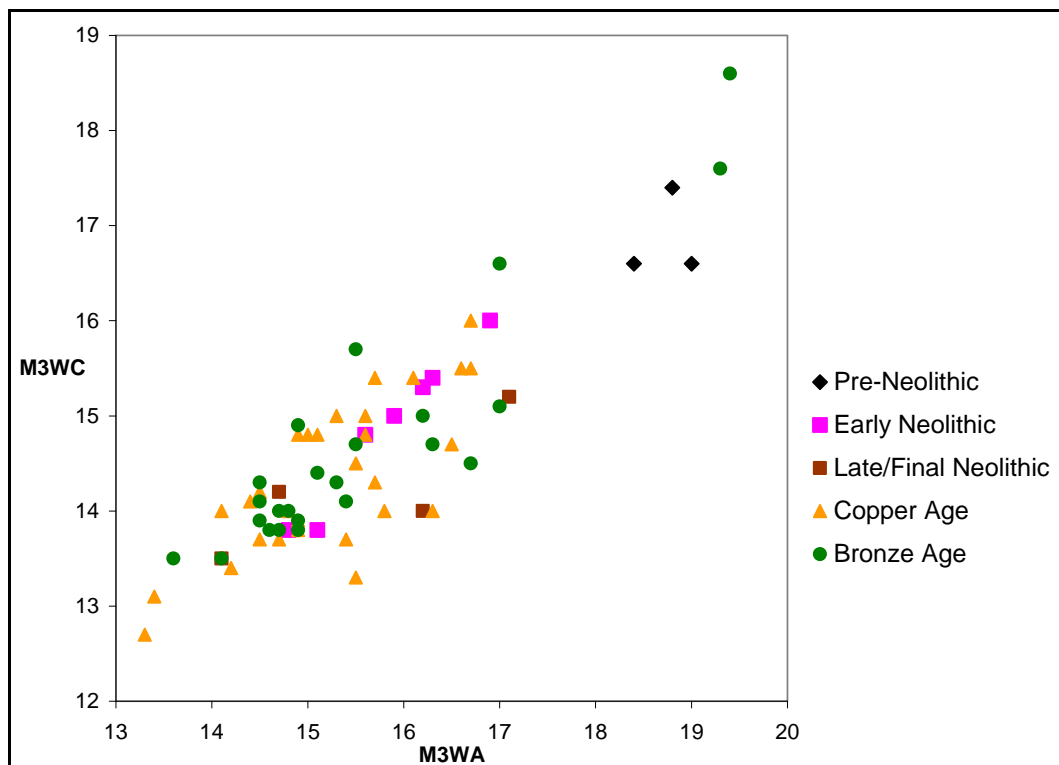


Figure 4.128: Scatterplot of anterior cusp x central cusp width of mandibular permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

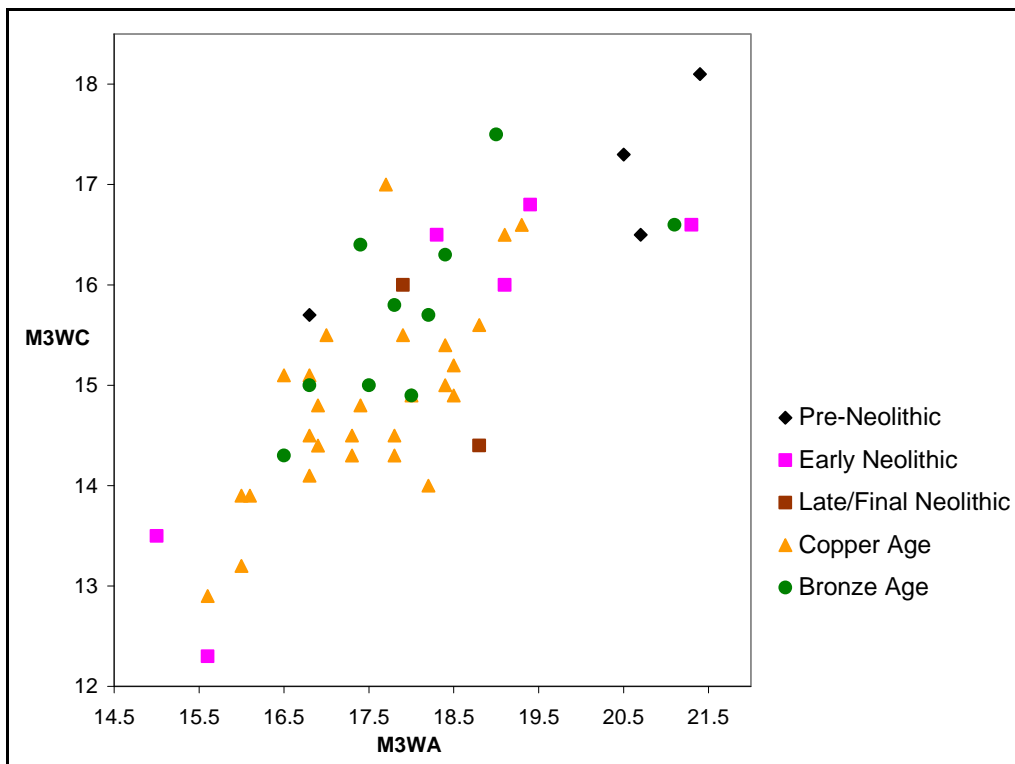


Figure 4.129: Scatterplot of anterior cusp x central cusp width of maxillary permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology. Measurements in mm.

Besides the size of third molars, also their shape in the Bronze Age is compared with earlier periods with the help of a size index. Most Bronze Age mandibular third molars have a similar shape to Early Neolithic and the majority of Copper Age specimens (figure 4.130). However, there are also a few specimens that are longer/thinner and few that are shorter/broader. The graph of maxillary third molars deviates from this picture (figure 4.131) as it shows a clear trend towards similar shape in the Late/Final Neolithic and post-Neolithic periods (Bronze and Copper Age), which differs from that of the Early Neolithic and pre-Neolithic specimens. Nevertheless, there are some post-Neolithic specimens that have a shape similar to that of Early and pre-Neolithic specimens. As noted for the Copper Age, the large-sized outliers do not necessarily correspond to the shape outliers; the size outliers are distributed in different areas of the shape scatterplot without any particular pattern. For this reason there is no need to differentiate them visually from the rest.

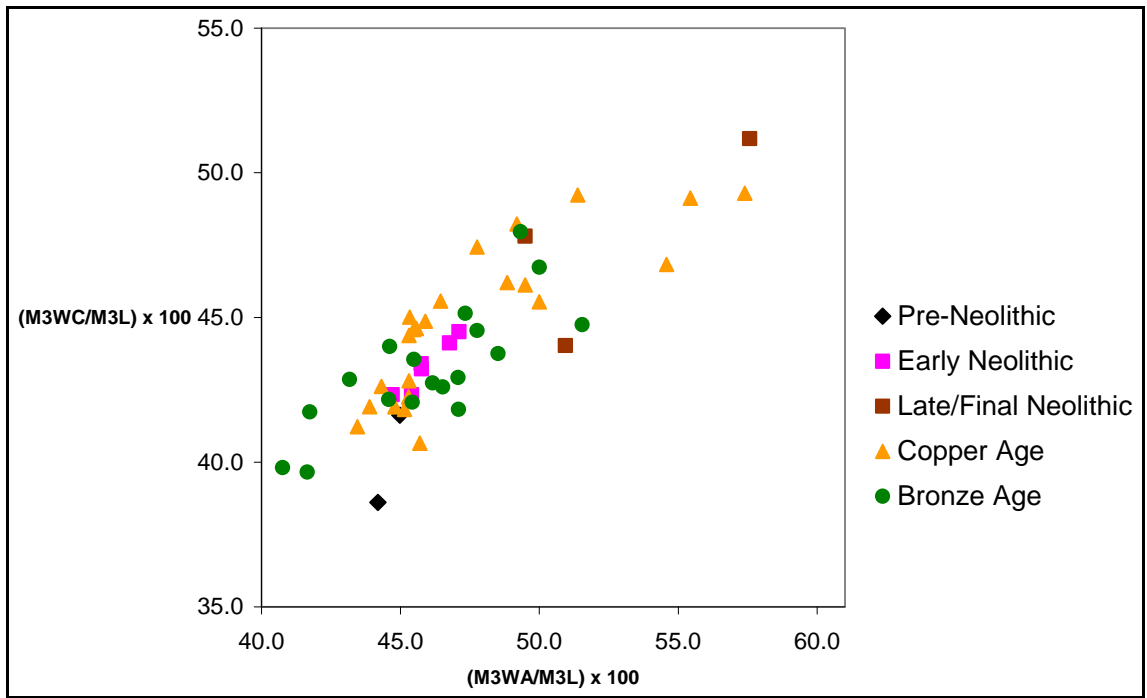


Figure 4.130: Ratio between width and length of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age lower third molars.

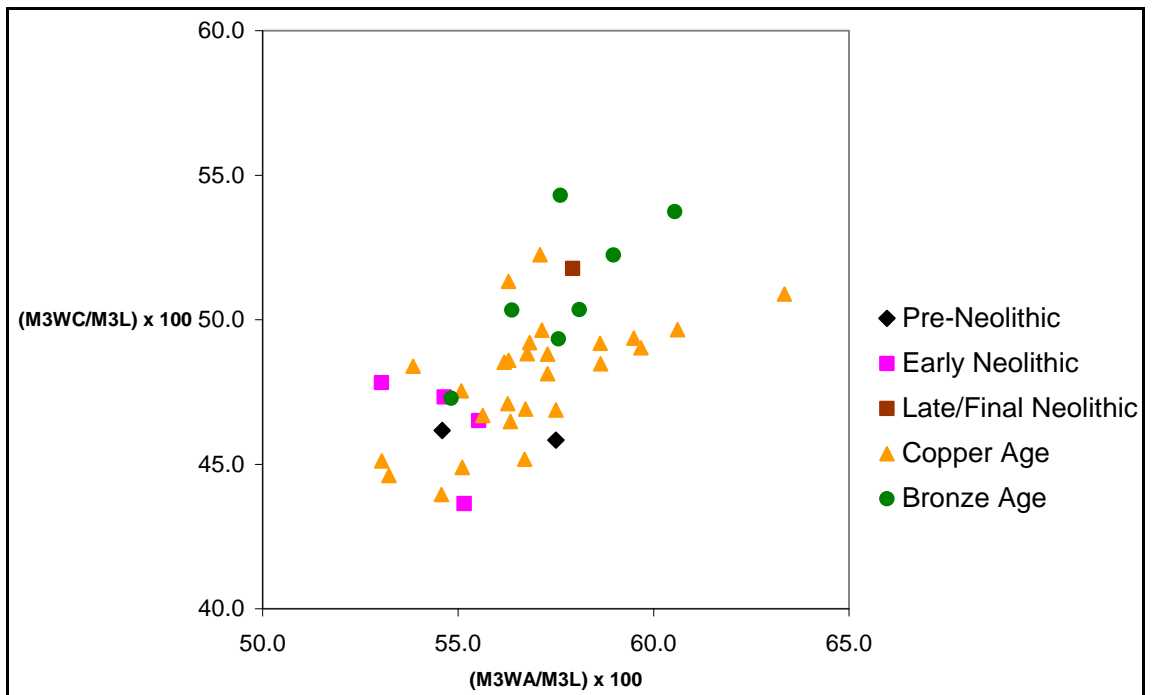


Figure 4.131: Ratio between width and length of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age upper third molars.

In addition to the scatterplots, log ratio histograms with all the Bronze Age assemblages have been produced. Before exploring any inter-site differences in tooth size in the Bronze Age, it would be interesting to compare the tooth size of the combined Bronze Age sample with earlier periods. The histograms in figure 4.132 show that tooth size in the Bronze Age is quite similar to the Copper Age and Late/Final Neolithic. In contrast to the increase of postcranial size in the Bronze Age (figure 4.91), tooth size remains similar to that of the Copper Age.

This discrepancy between postcranial and tooth size in the Bronze Age is intriguing and will be addressed during the interpretation stage. Another difference is that the 'tail' of larger individuals observed in postcranial measurements is less pronounced in tooth measurements, which also holds true for the Copper Age sample.

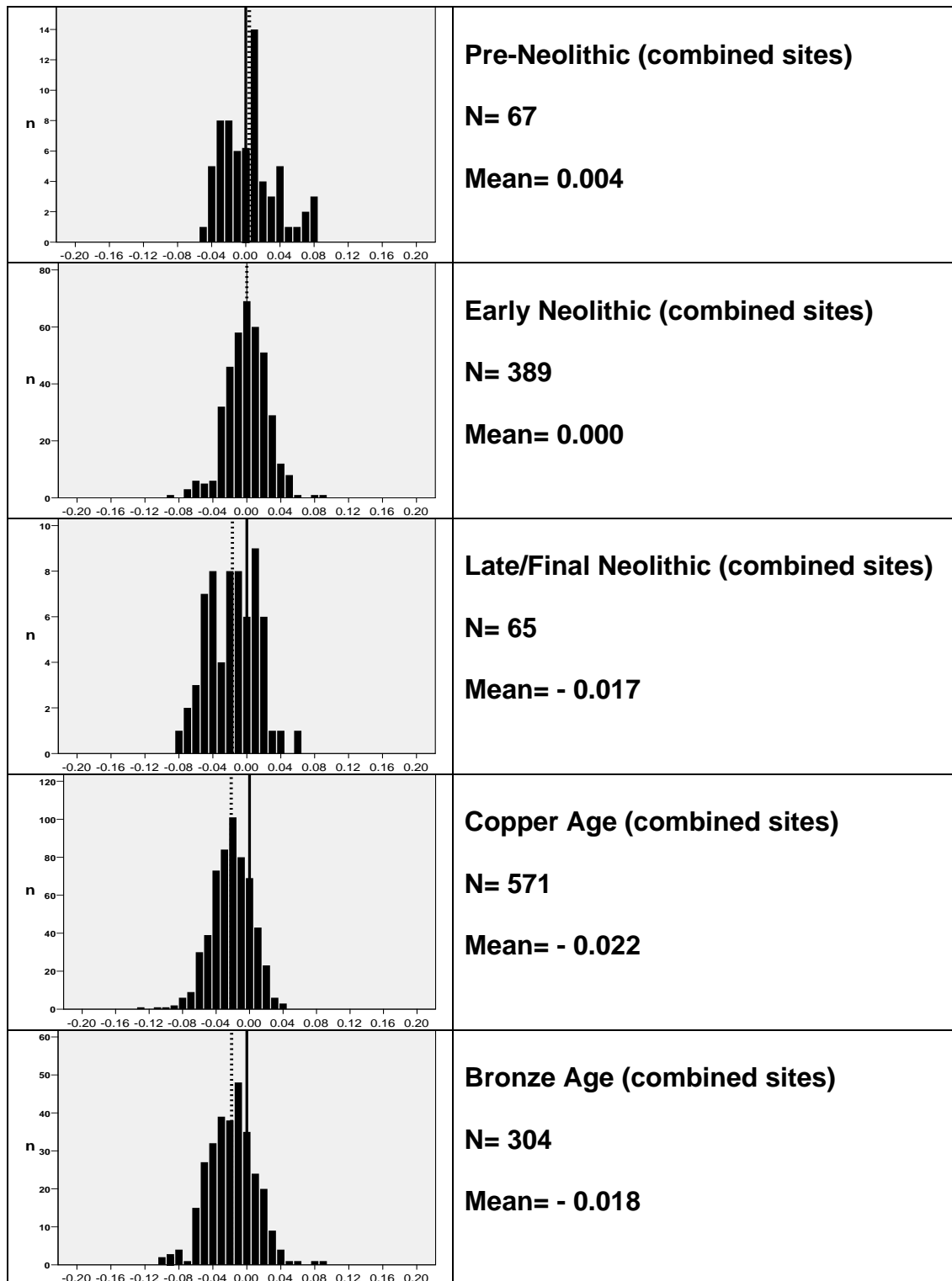


Figure 4.132: Log ratio histograms comparing pig tooth measurements from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper and Bronze Age chronology.

To examine possible differences between Bronze Age assemblages, a stack of histograms with all measurements per site is presented in figure 4.133. Again, only sites or levels that yielded more than five measurements are included in the analysis, although measurements from other Bronze Age assemblages, with less than five recorded measurements, are included in the general Bronze Age sample at the bottom of the stack. In some of the largest samples, such as those of Cerro de Encina and Morra de Quintanar, there is greater size variation. However, the largest single Bronze Age assemblage (Acequión) exhibits not only the smallest average size but also the most uniform tooth size. Compared to the Copper Age, Bronze Age assemblages are of similar average size with the largest – in terms of tooth size - Copper Age population of Valencina de la Concepción. Bronze Age assemblages also exhibit greater variability in size which may be attributed to chronological differences, although other factors, such as environmental ones, cannot be excluded. When compared to their respective postcranial histograms (figure 4.92), some assemblages (e.g. Morra de Quintanar and Acequión) exhibit a proportionately smaller tooth size. In general, tooth size in the Bronze Age is more uniform, while postcranial size is much more diverse within and amongst assemblages. The relationship between dental and postcranial size per period is further discussed later in this chapter.

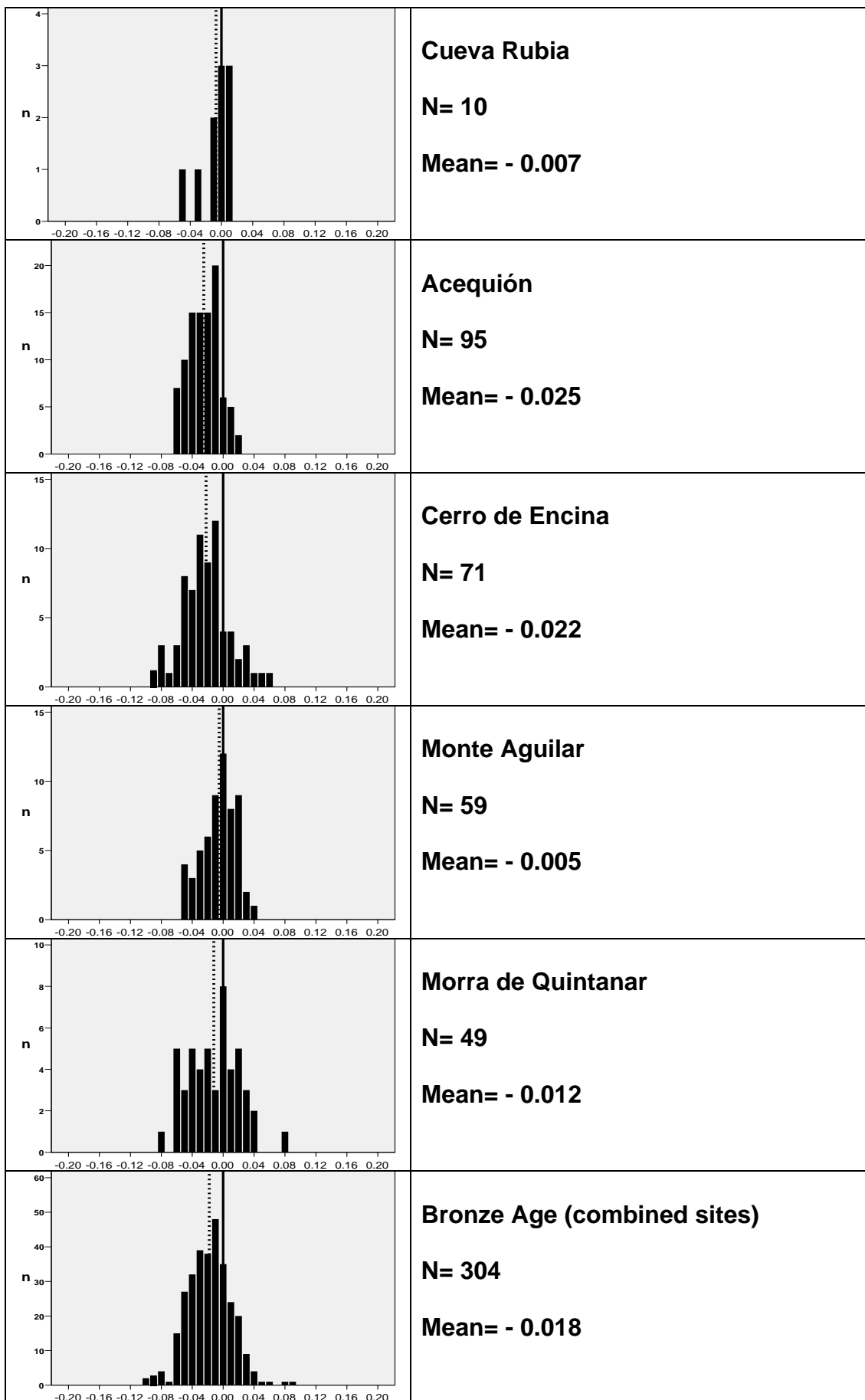


Figure 4.133: Log ratio histograms comparing pig tooth measurements from Bronze Age sites with the combined Bronze Age sample.

4.3.2.2.1 Dental size, age and sex profile-Bronze Age

Overall, Bronze Age tooth size is slightly larger than in the Copper Age, though only very few measurements differ significantly in statistical terms (table 4.9). Average tooth size in the Bronze Age is nevertheless noticeably smaller than in the Early Neolithic but fairly similar to that of the small Late/Final Neolithic sample. Bronze Age sex profiles showed only a slight overall female majority – though in some assemblages there is a male majority. Age profiles revealed an older average age than in the Copper Age. However, assemblages with higher male percentages and older age profiles (e.g. Monte Aguilar and Morra de Quintanar) tend to exhibit larger tooth size. As mentioned in this and previous chapters, dental size – especially width measurements, which were exclusively used in the histograms – is a relatively age- and sex-independent metric characteristic in pigs (Albarella and Payne 2005; Payne and Bull 1988). This along with the lack of plasticity in teeth could be - at least partly - responsible for the increased size overlap observed in teeth compared to bones.

Taking into account all the above, the evidence may in theory point out towards a sex-induced size increase. The higher increase in postcranial bone size could be explained with their greater sex dimorphism. The distribution of postcranial bone size is, however, not consistent with this suggestion as the measurements do not plot according to two possible sex modes. They rather include a tail of larger measurements that is more likely to belong to wild boar, including male individuals too. This tail is not visible in the tooth plots, and this may be due to a number of factors that may in fact act in combination:

- As in Italy (Albarella et al 2006b) domestic and wild boar populations are, dimensionally more clearly differentiated based on postcranial bones rather than teeth. Therefore, what becomes a tail in postcranial bones only represents an element of the main distribution in teeth.
- Some of the assemblages that include wild boar specimens may in fact not contain their teeth, as wild boar heads might have been left or processed at the kill site.
- In the absence of wild boar heads on site, the larger tooth size is entirely dependent on the larger number of males, but the difference between sexes is small and does not generate a bimodal distribution.

The finding that bones of pigs in sites with larger tooth size and higher male percentages, also present larger postcranial size (at least Monte Aguilar and

Morra de Quintanar where all three lines of evidence can be followed) strengthens the interpretation of an increased wild component, a product of wild pig hunting. The male majority in those Bronze Age assemblages could be explained on the basis of the behaviour of young male wild pigs. Young male wild pigs tend to break from their matriarchal sounder to form bachelor groups and thus, become more vulnerable (*cf.* Spitz 1989 cited in Fernández-Llario and Mateos-Quesada: 147). It is thus more likely that those male individuals which are more mobile, but also relatively inexperienced in avoiding people and their hunting techniques, will 'trespass' farming land and/or fall prey to human hunters. Moreover, when a male wild pig reaches four or five years old, is in a position to claim his own territory and the sounder(s) of females included in that territory. It is possible that this second 'transitional' phase may pose greater-than-normal danger.

4.3.2.3 *Iron Age*

The tooth data from the Iron Age provide the concluding chapter in the story of the evolution of pig size in Spanish prehistory. The Iron Age material is abundant and has the potential to offer a higher resolution on pig tooth size in this period. It can also further elucidate the situation for earlier periods through comparisons. Furthermore, the comparison between patterns produced by tooth and postcranial measurements offers useful insights in biometry and hence, management of Iron Age, as well as earlier pig populations.

Besides the biometric analyses presented below, Iron Age tooth measurements were analysed statistically by using Kruskal-Wallis followed by Mann-Whitney tests. Statistically significant size differences between any of the periods could be found for all – mandibular and maxillary - tooth measurements (all Kruskal-Wallis tests $p < 0.009$). As before, Mann-Whitney tests were used to follow up this finding, excluding samples containing less than five specimens. All analyses including Iron Age data are presented in table 4.10 and are commented on separately for each tooth in combination with the relevant scatterplots.

Table 4.10: Significance (two-tailed) of size differences in pig tooth measurements between Iron Age and the rest of the prehistoric periods, calculated with Mann-Whitney tests. Only samples with a minimum of five or more measurements were subjected to testing; green: very highly significant; blue: highly significant; yellow: significant.

MANDIBULAR												
	dP4L	dP4WP	M1L	M1WA	M1WP	M2L	M2WA	M2WP	M3L	M3WA	M3WC	M3WP
Pre-Neolithic / Iron Age	0.040*	0.003**	0.020*	0.105	0.003**	N/A	N/A	0.002**	N/A	N/A	0.003**	N/A
Early Neolithic / Iron Age	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	0.001***	0.001***	0.016*	0.002**
Late-Final Neolithic / Iron Age	0.137	0.001***	0.903	0.001***	<0.001***	0.939	0.654	0.276	N/A	0.370	0.293	0.379
Copper Age / Iron Age	0.022*	<0.001***	0.109	0.074	0.001***	<0.001***	<0.001***	<0.001***	0.449	<0.001***	<0.001***	<0.001***
Bronze Age / Iron Age	0.235	<0.001***	0.668	<0.001***	<0.001***	0.078	0.038*	0.008**	0.007**	0.012*	0.009**	0.021*
MAXILLARY												
	dP4L	dP4WP	M1L	M1WA	M1WP	M2L	M2WA	M2WP	M3L	M3WA	M3WC	M3WP
Pre-Neolithic / Iron Age	0.003**	0.556	N/A	0.082	0.094	<0.001***	0.011*	0.012*	N/A	0.002**	0.001***	N/A
Early Neolithic / Iron Age	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	0.045*	0.060
Late-Final Neolithic / Iron Age	N/A	N/A	0.040*	0.056	0.074	0.184	0.016*	0.008*	N/A	0.026*	N/A	N/A
Copper Age / Iron Age	0.254	0.104	0.001***	0.003**	0.013*	<0.001***	<0.001***	<0.001***	<0.001***	0.050*	0.759	0.001***
Bronze Age / Iron Age	0.762	0.369	0.366	0.217	0.626	0.007**	0.015*	<0.001***	0.156	0.001***	0.172	0.439

In figures 4.134 and 4.135 the mandibular and maxillary measurements of fourth deciduous premolar from pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age assemblages are presented. Overall, there is extensive size overlap between the different periods, although some general trends can be identified. In the mandibular measurements (figure 4.134), Iron Age specimens are of similar size to their Copper and Bronze Age counterparts. They mainly occupy the central and lower left parts of the distribution, while the pre-Neolithic and Early Neolithic specimens cluster in the central and upper right parts of the distribution with few Late/Final Neolithic and post-Neolithic outliers. The same pattern can be observed in the maxillary measurements (figure 4.135) with slightly less overlap between periods (also see table 4.10).

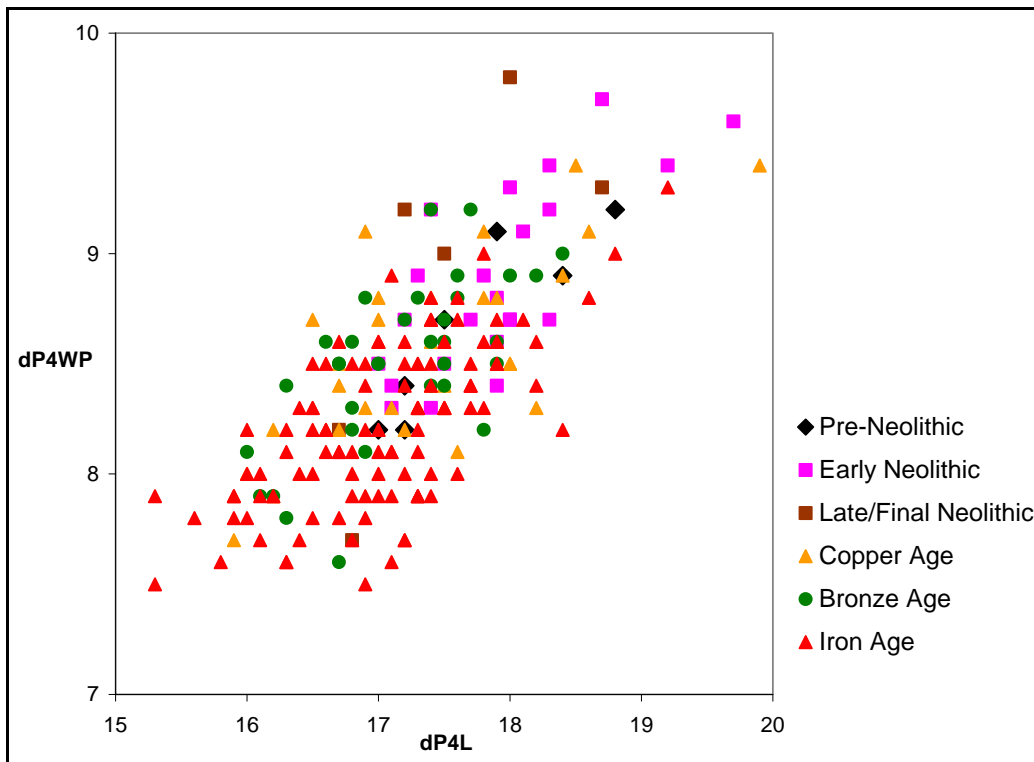


Figure 4.134: Scatterplot of crown length x posterior cusp width of mandibular fourth deciduous premolar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Measurements in mm.

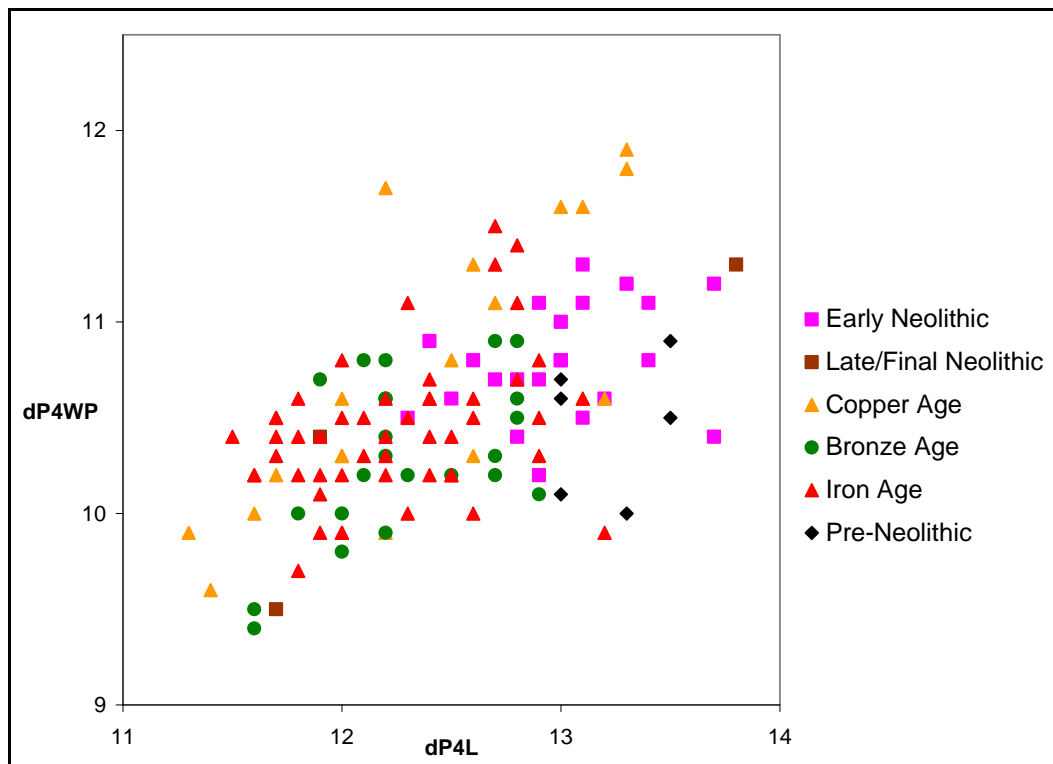


Figure 4.135: Scatterplot of crown length x posterior cusp width of maxillary fourth deciduous premolar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Measurements in mm.

In the following two scatterplots the crown length x anterior cusp width of mandibular (figure 4.136) and maxillary (figure 4.137) first molars is presented. The picture here is very similar to that of the dP4 with the only difference, visible in mandibular and maxillary first molars, being the tendency towards less size overlap between the Late/Final Neolithic and post-Neolithic on one hand, and the Early Neolithic and pre-Neolithic on the other. In the Iron Age there is tendency towards an even smaller size – in many cases statistically significant (table 4.10) - compared to the Bronze and Copper Age. The smallest individuals are dated to the Iron Age, while the few large Iron Age individuals are at least as large as the Early Neolithic individuals.

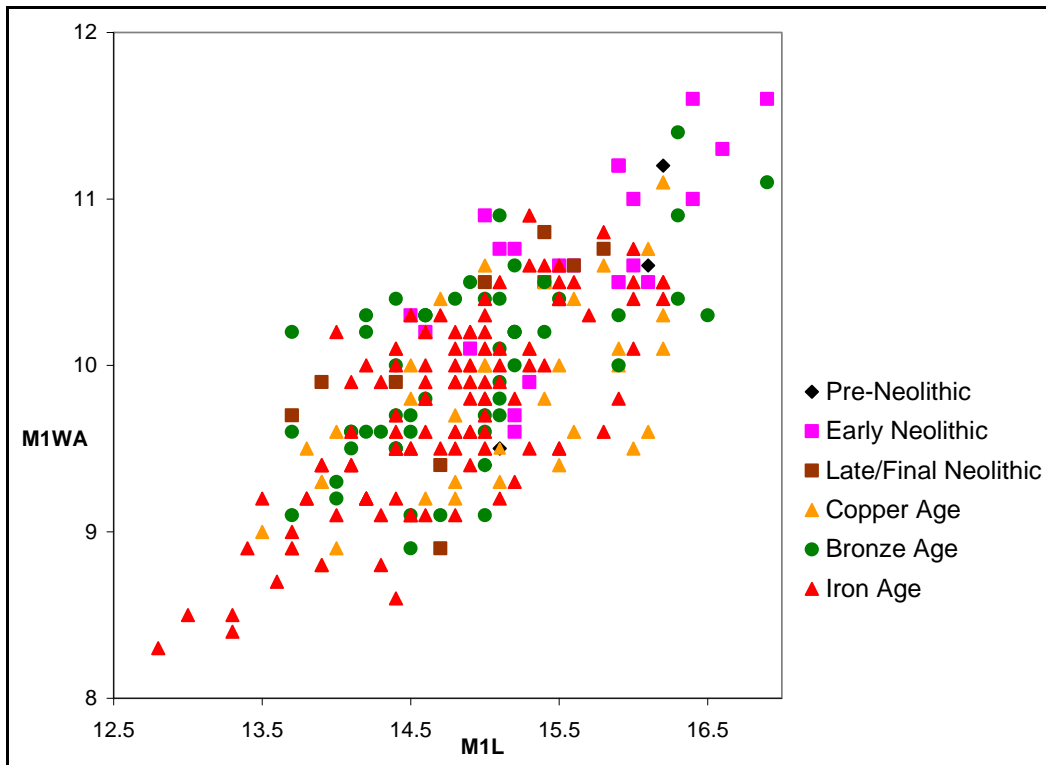


Figure 4.136: Scatterplot of crown length x anterior cusp width of mandibular permanent first molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Measurements in mm.

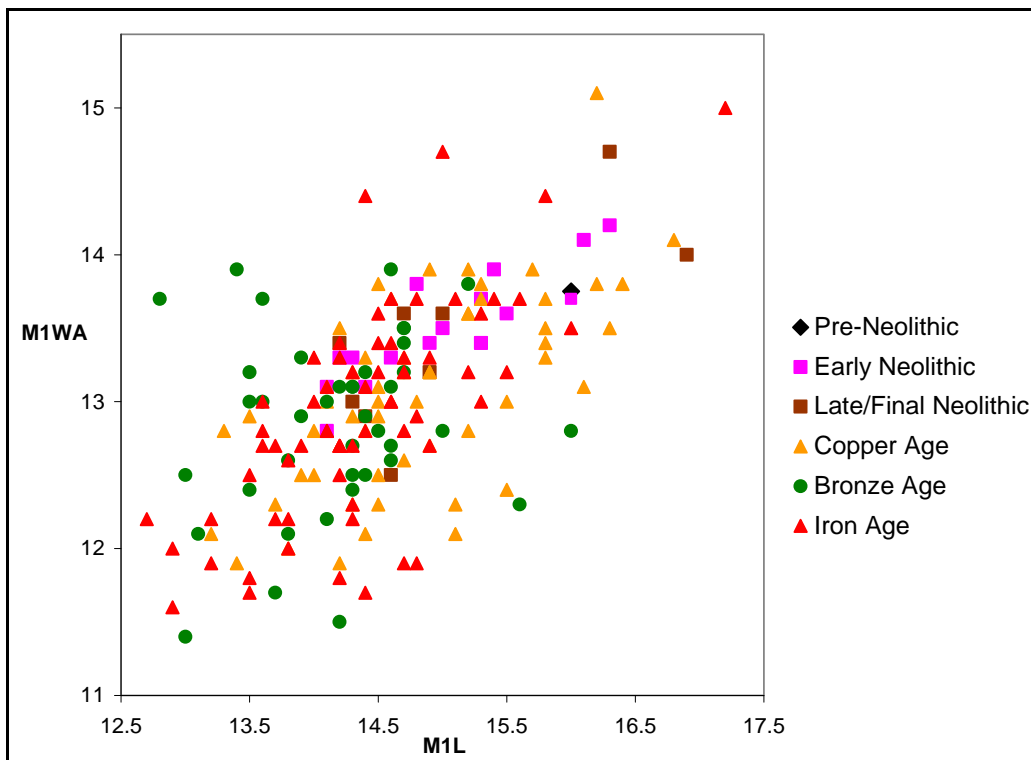


Figure 4.137: Scatterplot of crown length x anterior cusp width of maxillary permanent first molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Measurements in mm.

The crown length x anterior cusp width of mandibular (figure 4.138) and maxillary (figure 4.139) second molars is presented in the following two figures. The picture is similar to that described for the dP4 and M1, although with better-defined groups. The central part of the scatterplots presents the densest concentration of specimens, consisting of some Early Neolithic, most Late/Final Neolithic, and the majority of post-Neolithic specimens. The pre-Neolithic, many Early Neolithic and few outliers from later prehistoric periods constitute the group of larger specimens in the upper right part of the scatterplot. Moreover, few Iron Age specimens on the lower left part of the scatterplots is considerably smaller-sized than all earlier populations. The small size of Iron Age second molars is confirmed statistically as most second molar measurements were classified as significantly smaller by the Mann-Whitney tests (table 4.10).

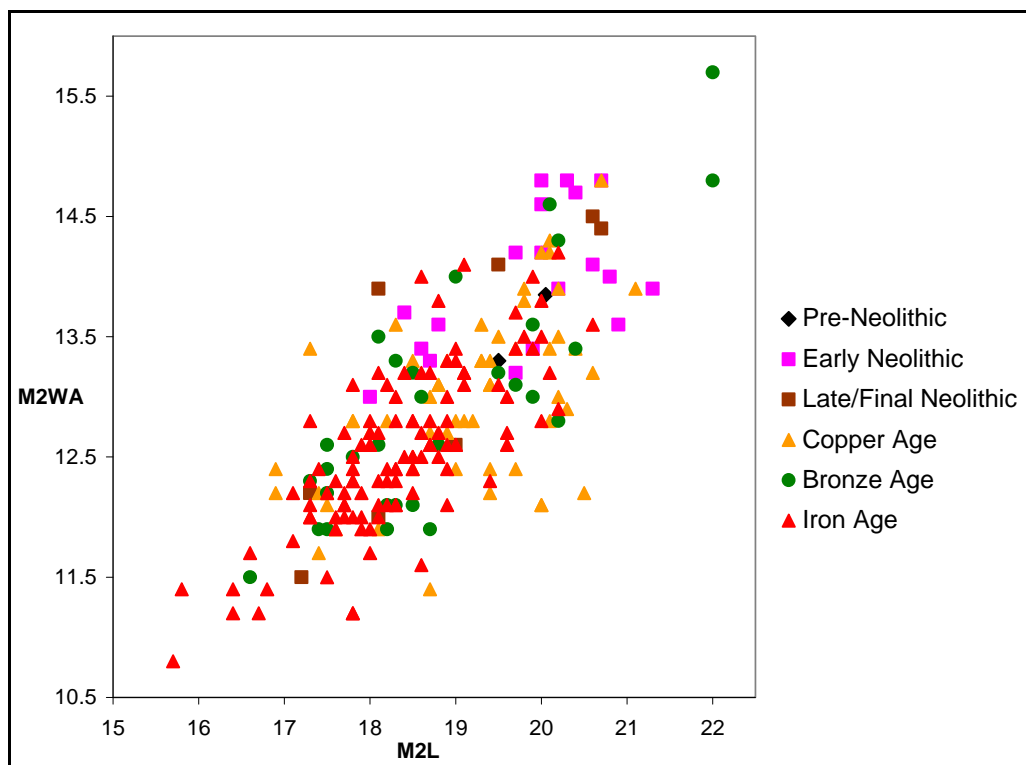


Figure 4.138: Scatterplot of crown length x anterior cusp width of mandibular permanent second molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Measurements in mm.

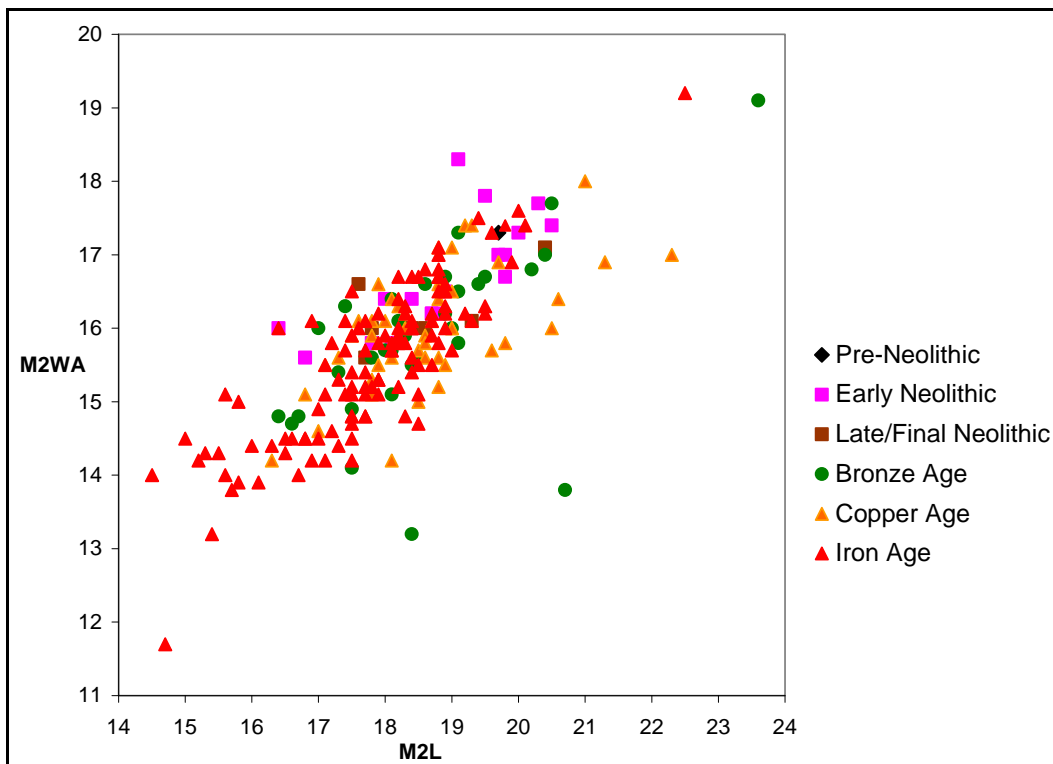


Figure 4.139: Scatterplot of crown length x anterior cusp width of maxillary permanent second molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Measurements in mm.

In the following two scatterplots the crown length x anterior cusp width of mandibular (figure 4.140) and maxillary (figure 4.141) third molars is presented. Overall, the same trends as those described for the other teeth hold true for the crown length x anterior cusp width of the third molar, although some patterns appear sharper than in other teeth. Most Iron Age specimens are concentrated in the central part of the scatterplot, though a few particularly large specimens exhibit a size as large as, or even larger, than all earlier ones. Additionally, a good number of particularly small Iron Age specimens in the lower part of the scatterplot show a size strikingly smaller than that of preceding periods. This size difference, illustrated here metrically, is so sharp that it has also been observed visually and photographed during recording. Figure 4.142 shows the particularly short mandibular third molar on the right in comparison to a 'normal'-looking third molar. The fact that this specimen does not represent an isolated case is interesting because it constitutes a differentiating factor between Iron Age and earlier populations. Overall, Iron Age third molar measurements – perhaps together with those of the second molar – were significantly smaller than almost all earlier prehistoric periods (table 4.10).

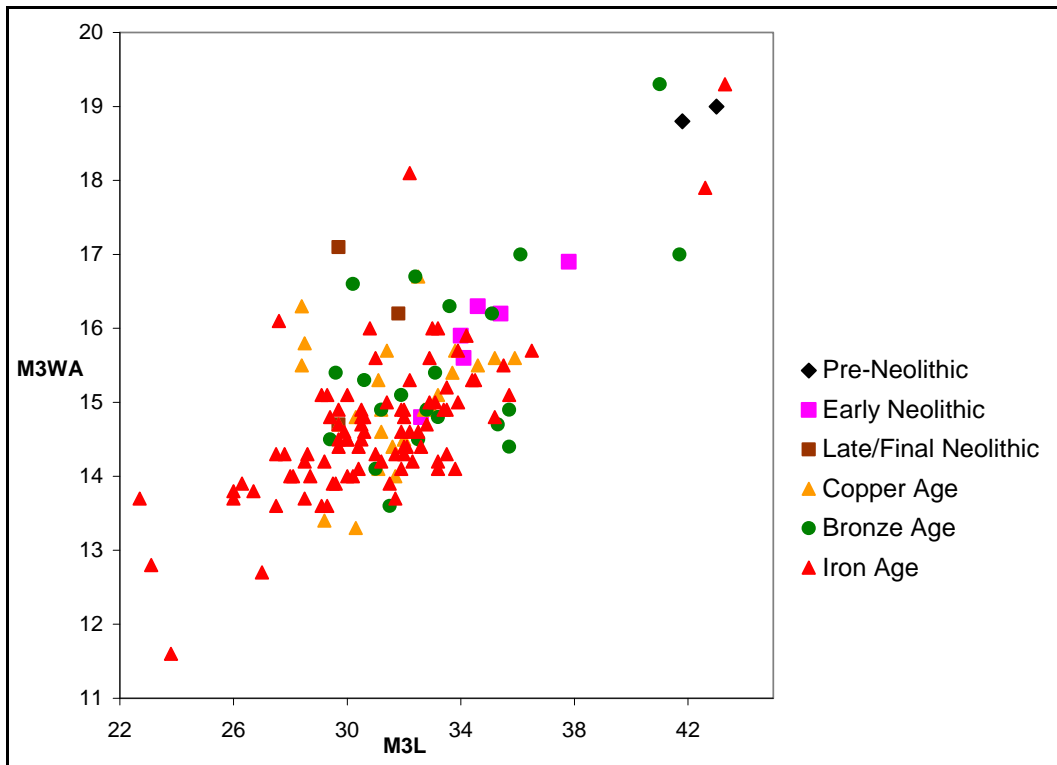


Figure 4.140: Scatterplot of crown length x anterior cusp width of mandibular permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Measurements in mm.

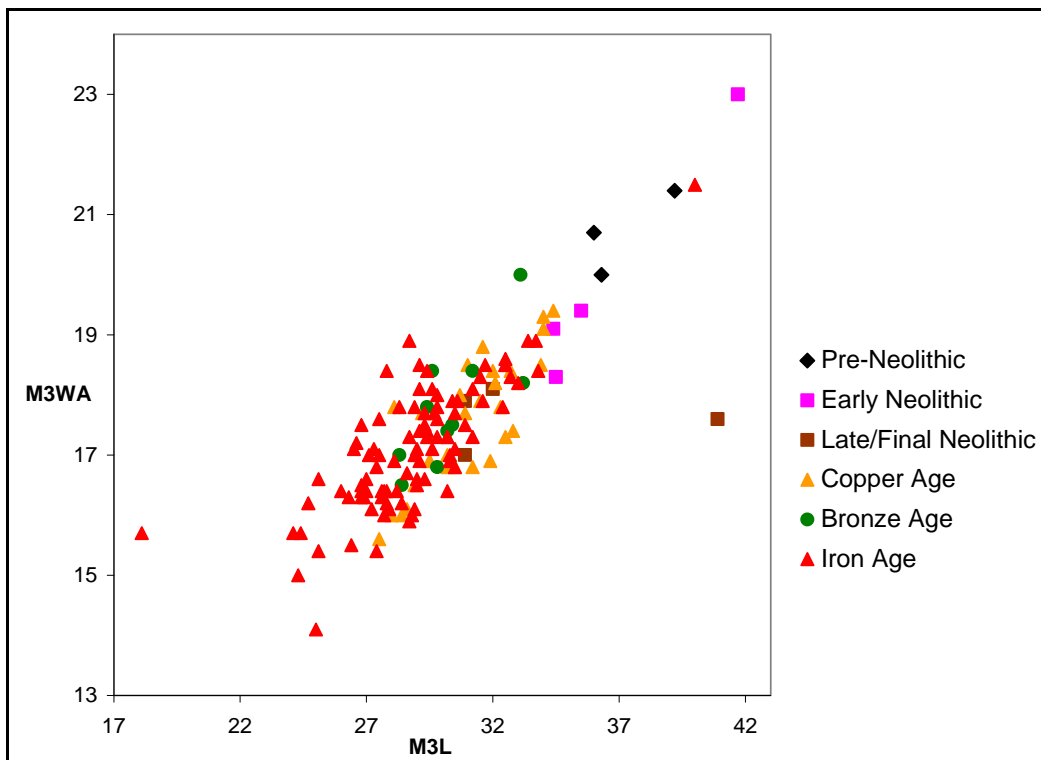


Figure 4.141: Scatterplot of crown length x anterior cusp width of maxillary permanent third molar from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology. Measurements in mm.



Figure 4.142: Photograph comparing a ‘normal’-looking mandibular third molar with a particularly shortened specimen. Several such shortened third molars were recorded and are visible near the lower left corner of the scatterplot in figure 4.140.

The shape of Iron Age third molars was also analysed using the same shape index as for all earlier periods. In the following two figures (4.143 and 4.144), Copper and Bronze Age specimens have been omitted to increase the clarity of Iron Age specimens. However, pre- and Neolithic specimens are plotted to provide a measure of comparison with all shape scatterplots presented in previous subsections. Iron Age mandibular third molars show considerable variability in shape (figure 4.143). The vast majority of Iron Age mandibular third molars plot in the lower left part, with and around the Early Neolithic specimens. This has also been observed for most Copper and Bronze Age specimens. However, the scatterplot suggests the presence of a quite different type of shape of the third molar. The specimens plotting in the upper right part of the distribution are extremely short and broad, relatively speaking. An example of such a type of mandibular third molar – with an almost vestigial third cusp – can be seen in figure 4.142 above. As for the previous periods and rather surprisingly, the shape of maxillary third molars is not exactly mirroring that of the mandibular (figure 4.144). The overall pattern is similar but in maxillary teeth a sharper shape differentiation is observed between Iron Age specimens on the one hand and the pre-Neolithic and Early Neolithic ones on the other hand.

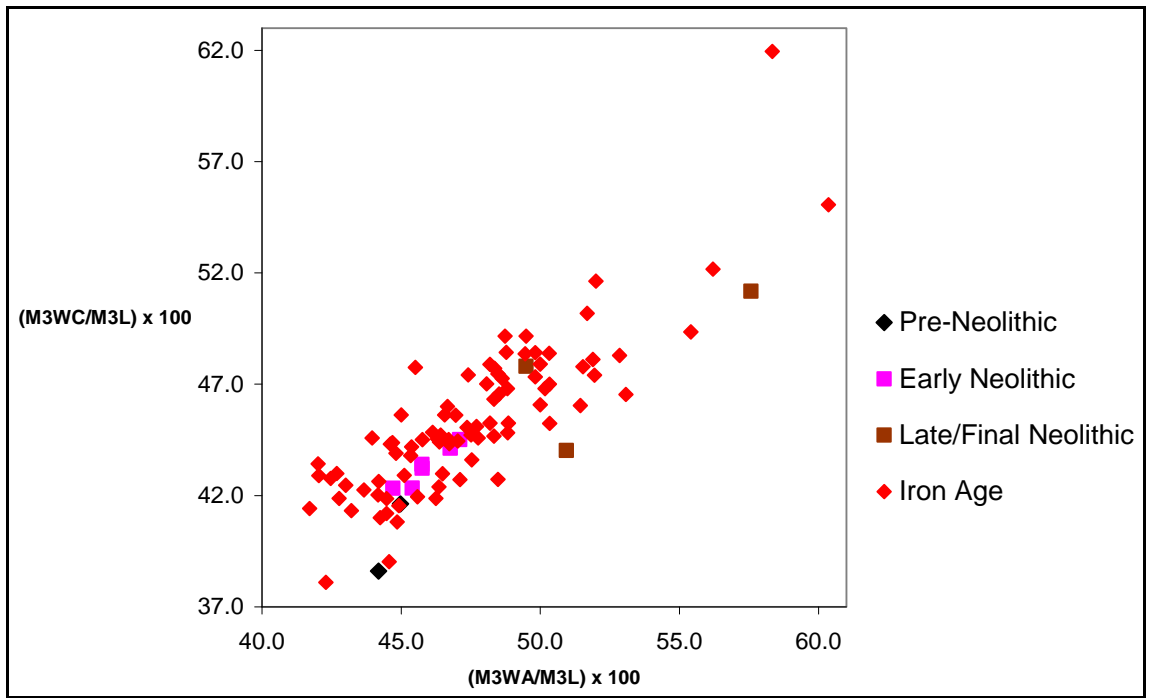


Figure 4.143: Ratio between width and length of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Iron Age lower third molars.

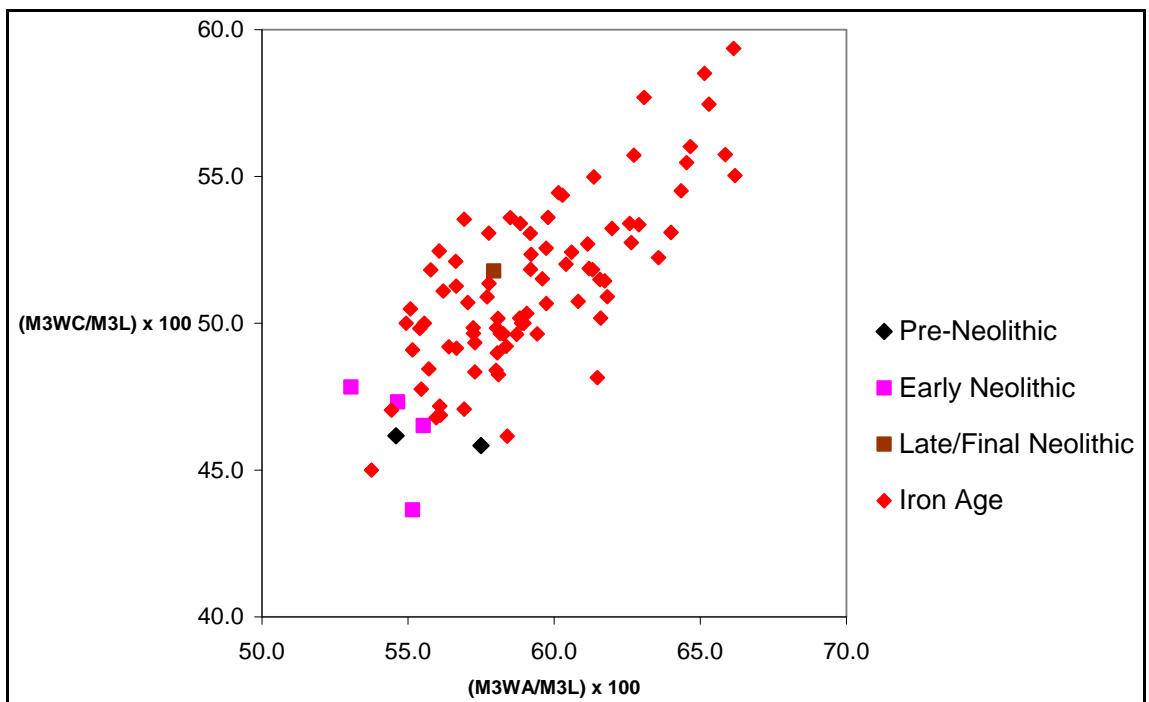


Figure 4.144: Ratio between width and length of pre-Neolithic, Early Neolithic, Late/Final Neolithic and Iron Age upper third molars.

In addition to the scatterplots, log ratio histograms with Iron Age measurements were produced. Before exploring any inter-site differences in tooth size during the Iron Age, figure 4.145 provides a general indication of tooth size in the Iron Age, as a combined sample, through comparisons with earlier periods.

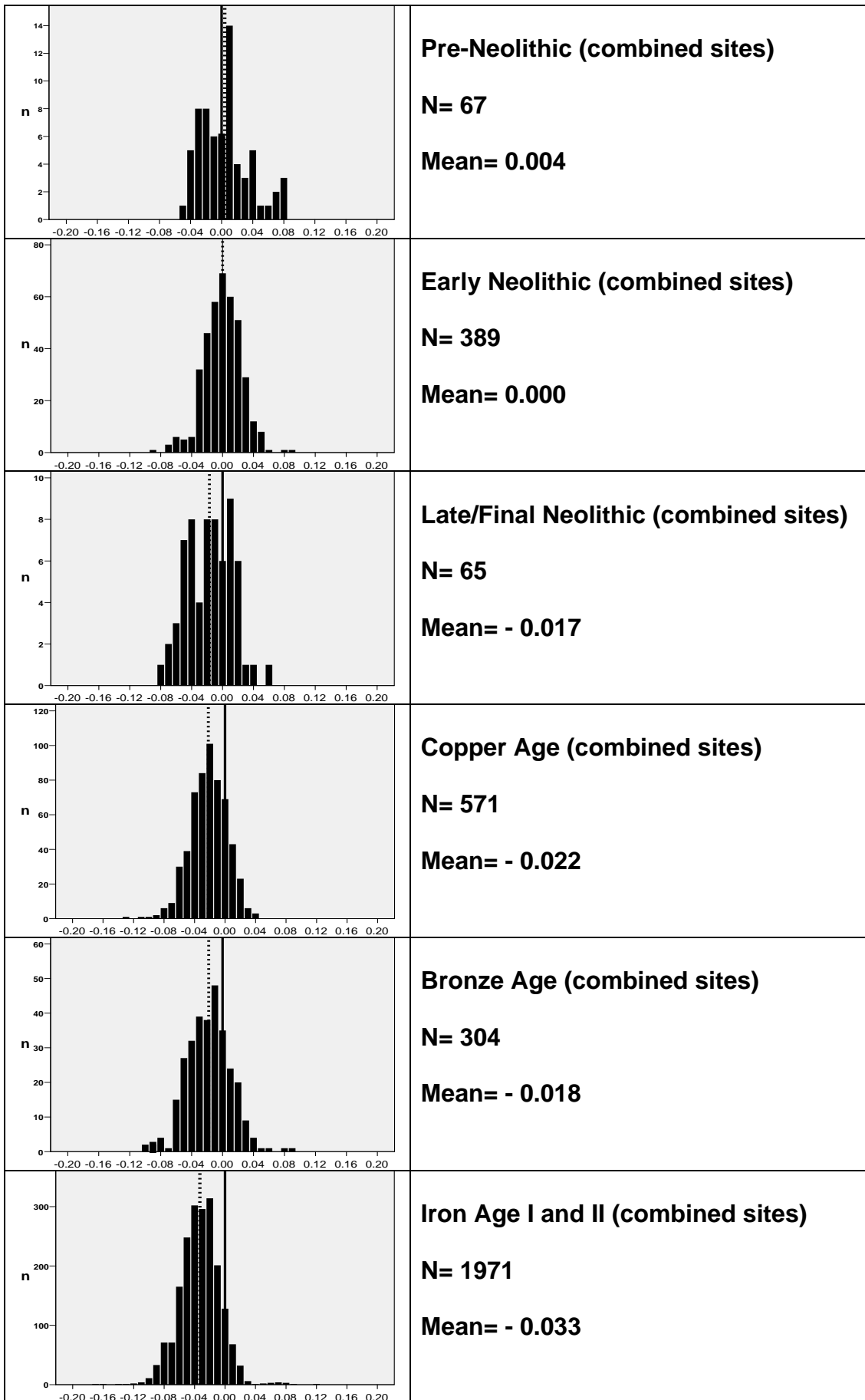


Figure 4.145: Log ratio histograms comparing pig tooth measurements from combined samples of pre-Neolithic, Early Neolithic, Late/Final Neolithic, Copper, Bronze and Iron Age chronology.

As also shown by the scatterplots presented above, the histograms indicate a further size decrease in the Iron Age. On average, this size decrease, also paralleled by a decrease in postcranial size (see figure 4.98), is of similar magnitude as the first major size decrease observed between the Early and Late/Final Neolithic period. Moreover, it is statistically significant for most tooth measurements (table 4.10). The Iron Age distribution is similar in form to the Bronze and Copper Age distributions, in the sense that it is also characterised by a dominant peak and a few smaller and larger outliers. Also important is the observation that Late/Final Neolithic, Copper and Iron Age samples exhibit a proportionate relationship between postcranial and dental size (compare figures 4.98 and 4.145). In the Early Neolithic and the Bronze Age, a discrepancy is observed between postcranial and dental size, with the former being proportionately larger than the latter. In both cases, a sharper size decrease can be observed in the immediately subsequent period.

In order to detect possible differences in tooth size between sites, measurements from all Iron Age I assemblages (generally 800-500 BC) are presented in figure 4.146. There are no significant differences in size between the presented assemblages. We must consider a geographical bias though, as all sites are situated in northern or northern-central Spain. Most populations exhibit a dental size averaging near a log ratio value of -0.030, with the exceptions of Campa Torres showing a smaller size, and La Mota a larger size.

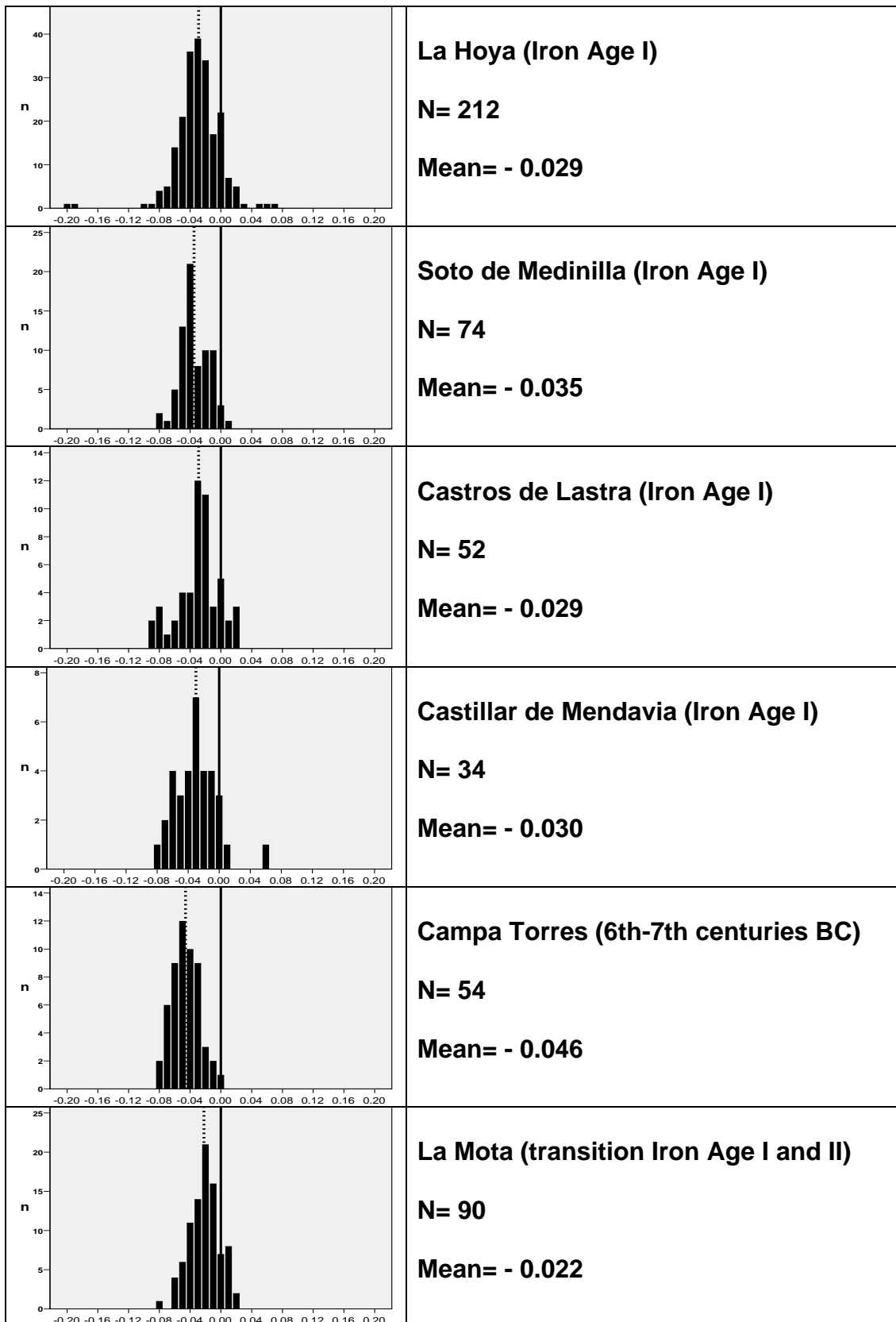


Figure 4.146: Log ratio histograms comparing pig tooth measurements from different Iron Age I sites.

Assemblages dating to the Iron Age II (generally 500-Roman conquest) have a smaller average size but also more diversity between populations compared to

Iron Age I. From the four assemblages of the Basque province of Álava (La Hoya, Castros de Lastra, Castillo de Henayo and Castro de Berbeia), Castro de Berbeia has the largest tooth size - although that sample is the smallest - and Castros de Lastra the largest (figure 4.147). At Soto de Medinilla - on the northern central plateau - size is intermediate between Castros de Lastra and Castro de Berbeia.

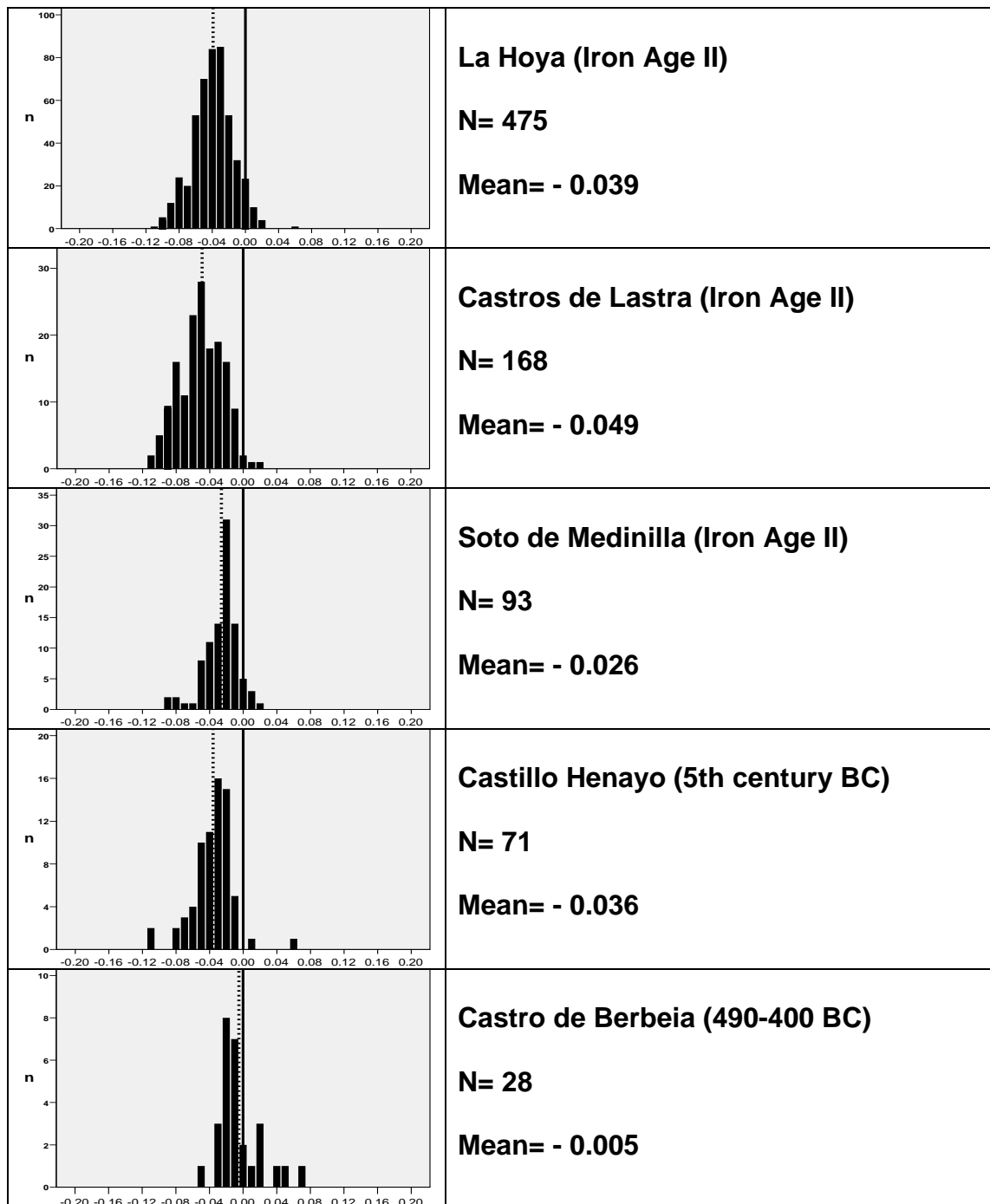


Figure 4.147: Log ratio histograms comparing pig tooth measurements from different Iron Age II sites.

Some multi-period sites, such as La Hoya and Castros de Lastra, allow a closer examination of fluctuations in tooth size through time. The three, chronologically successive (Middle/Final Bronze Age - Iron Age I - Iron Age II) samples from La Hoya (figure 4.148) show tooth size fluctuations. The Iron Age II sample presents the smallest size but also the least variability, lacking the few larger and smaller outliers observed in the Middle/Final Bronze and Iron Age I samples. Tooth measurements provide evidence for a gradual size decrease at La Hoya in the 1st millennium BC, also evident in postcranial measurements (figure 4.103). As for other periods, changes are sharper in postcranial than dental elements.

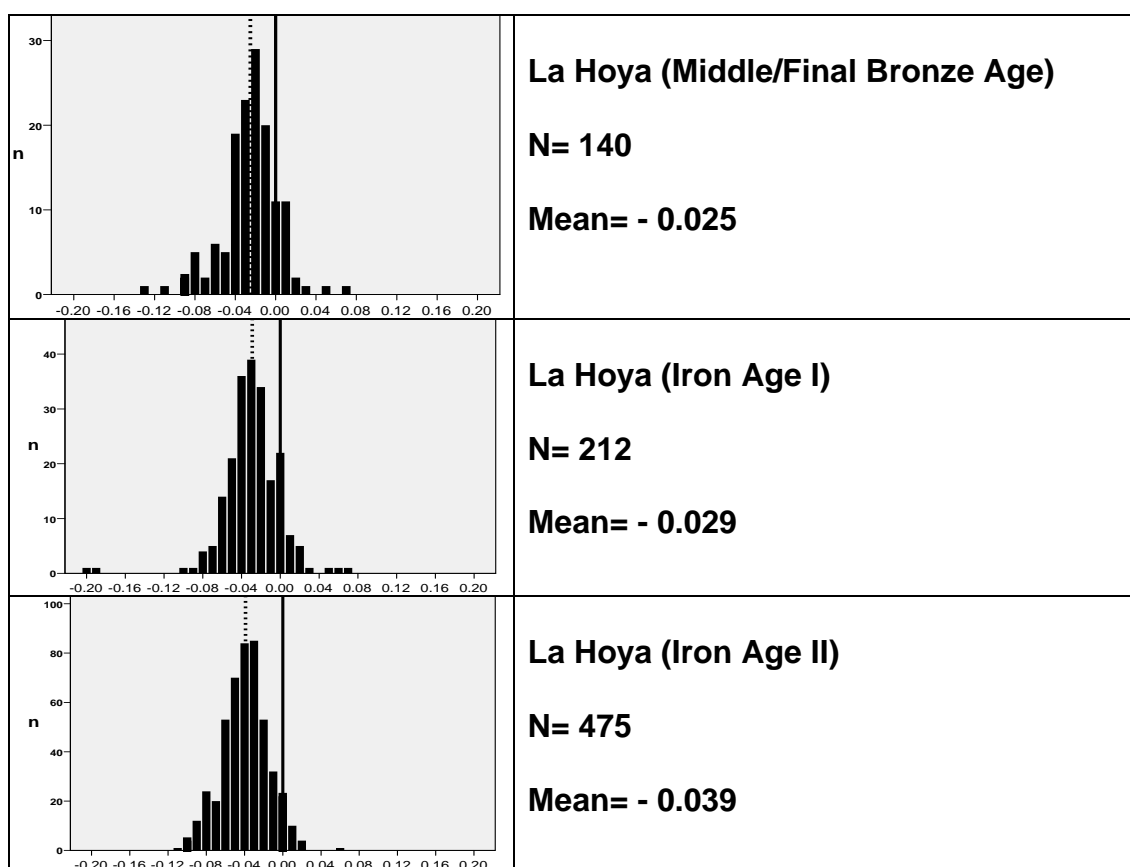


Figure 4.148: Log ratio histograms comparing pig tooth measurements from three chronologically successive samples recovered at the site of La Hoya (Middle/Final Bronze Age-Iron I-Iron II).

An almost identical trend in the changes of tooth size is observed in the sequence from Castros de Lastra (Bronze Age – Iron Age I – Iron Age II, figure 4.149). The tendency towards smaller size observed at La Hoya is more clearly expressed in this case, with the most significant decrease taking place between the Iron Age I and II. The Iron Age I average size is only slightly smaller than in the Bronze Age, but in Iron Age II there is a genuine size shift to a smaller size

and, for the first time in the chronological span under study, almost the entirety of measurements plot to the left of the standard value.

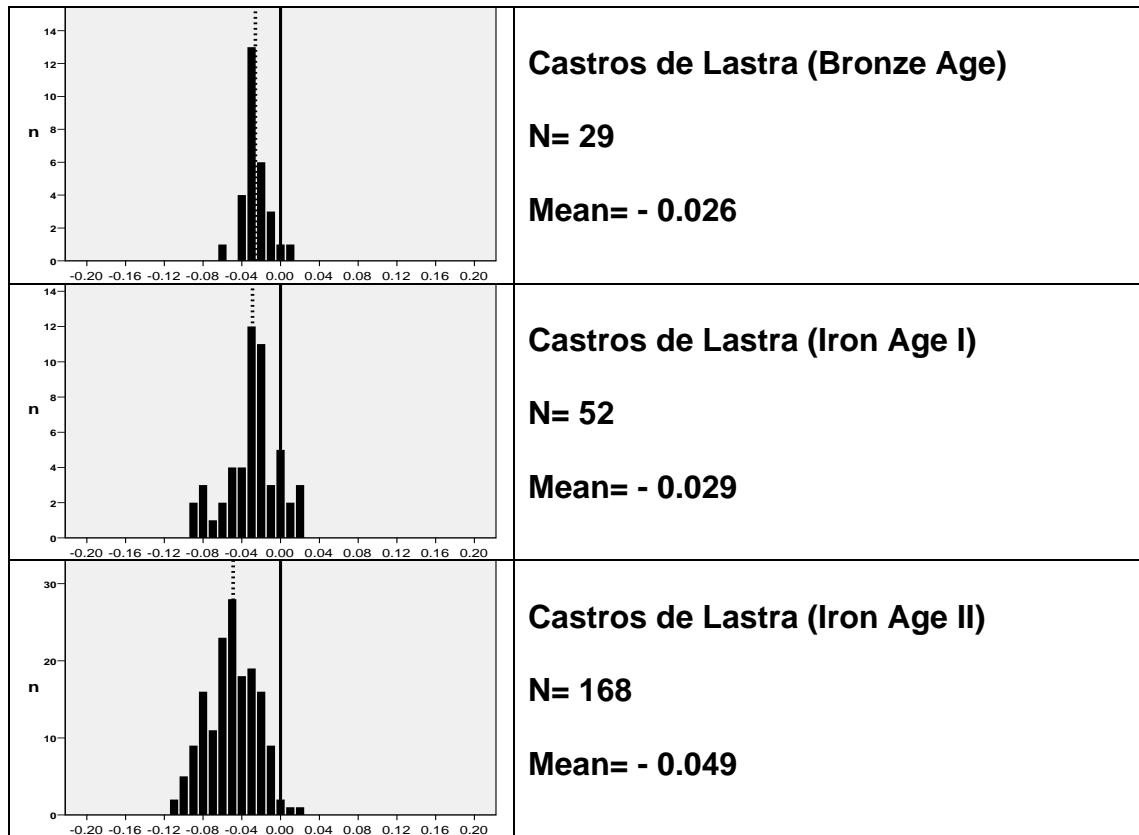


Figure 4.149: Log ratio histograms comparing pig tooth measurements from three chronologically successive samples recovered at the site of Castros de Lastra (Bronze Age-Iron I-Iron II).

4.3.2.3.1 Dental size, age and sex profile-Iron Age

Dental size in the Iron Age is the smallest recorded in the entire prehistoric sequence included in this study. In addition, the oldest age profiles and the most pronounced female majority in the entire sequence were recorded in this period. As mentioned before, tooth size is relatively free of age and sex biases – especially the widths. Although the larger number of females certainly represents a contributing factor, the substantial size decrease in both teeth and bones is probably indicative of a genuine size diminution of Iron Age pigs. Statistical tests also confirm this significant size decrease (table 4.10). Furthermore, shape analysis reveals a distinct shape – shorter and broader – for Iron Age pigs. Compared to the majority of Early Neolithic and all pre-Neolithic assemblages, the Iron Age assemblages reflect an unmistakably domestic character. The vast majority of smaller-sized pigs were domestic, and their age and sex structures were heavily manipulated by humans. The

occasional larger specimen is likely to be a reminder of the marginal character of wild boar hunting. Although the comparison between the Iron Age and the beginnings of pig domestication in Spain reveals sharp contrasts in size and age/sex structures, the intermediate periods (Copper and Bronze Ages) show that this process was gradual and subject to some fluctuations. It also occurred over a very long period of time as morphological changes related to an increasingly tighter domestication control were still occurring in the Iron Age. More specific issues relevant to the domestication of pigs in Spain are discussed later in this chapter and in the discussion (chapter 7).

4.4 Linear enamel hypoplasia

In order to obtain some measure of the health condition of the analysed pig populations, linear enamel hypoplasia (LEH) (Dobney and Ervynck 2000; section 2.1.2.2 in chapter 2) has been consistently recorded on mandibular molars. The results are presented here for all prehistoric periods, including the Neolithic and pre-Neolithic material. Although only teeth with well-preserved enamel surface were included in the calculations to minimise the risk of LEH being overlooked, possible biases may be present in the calculations. The most obvious and important is the reduction of the enamel surface with wear and hence, the increased possibility of LEH line(s) being worn away with the enamel. Dobney and Ervynck (2000: 601-02) demonstrated that this bias only has a minor effect on the produced patterns for the assemblages they analysed but this age-related bias should be nevertheless kept in mind when interpreting LEH results in general.

Figure 4.150 shows the chronological fluctuations of LEH presence (independently of the number of lines) on each of the three permanent mandibular molars. Although the pre-Neolithic sample is tiny and the Neolithic one rather small, there is a clear tendency for an increase in the occurrence of LEH from the Neolithic to the Copper Age, at least for the first and third molars, while for the second molar it remains stable. A general observation is that LEH is present on 25-40% of the second and third molars after the Neolithic, while the first molar appears to be less affected and the occurrence of LEH on this tooth is consistently between 5% and 10%. Keeping in mind the possible age-related bias, the observed pattern may have been affected to some degree by

the age profile of each period. However, the overall pattern is so clear that we can be fairly confident that it is not a product of a strong age-related bias. Assuming that the age bias had some effect on the pattern, there are two useful comments to be made when we consider the age profiles of specific periods. First, the absence of LEH on Neolithic third molars may be affected by the fact that very few have been recorded due to the very low percentages of individuals old enough to have erupted third molars (figure 4.81). Second, the age-related bias may be partly responsible for the slight decrease in LEH percentages during the Iron Age, a period for which survival beyond the second year – based on tooth eruption and wear (figure 4.81) – was at its highest recorded percentage in the entire Spanish prehistory.

Taking into account that crown formation occurs successively on the three molars, it is possible to speculate about the causes of LEH formation at specific stages in an animal's life. For example, the occurrence of LEH lines on the first molar - onset of crown formation *in utero* and lasting for 2-3 months (McCance et al 1961: 220, table 6) - can be related to physiological stress occurring early in an animal's life, especially birth and weaning (Dobney and Ervynck 2000: 603). LEH on the second molar – its crown formation lasting approximately from the third to the seventh month (McCance et al 1961: 220, table 6) – has been related to the dietary challenges of the first winter for young pigs (Dobney and Ervynck 2000: 603). Finally, LEH on the third molar - its crown formation lasting approximately from the third in well-nourished pigs (tenth-eleventh for undernourished) to the thirteenth month (and later than the fifteenth month for undernourished animals) (McCance et al 1961: 220, table 6) – has also been related to seasonal food scarcity (mainly during winter) but also mating activity of pigs (Dobney and Ervynck 2000: 604).

Another factor contributing to the high LEH frequency on the second and third molars, in contrast to the low frequency on the first molar, is inevitably the duration of crown formation for each tooth. The results support this hypothesis by showing that the tooth with the longest crown formation time (i.e. the third molar) also exhibits the highest LEH frequencies. The tooth with shortest crown formation time (i.e. the first molar) exhibits the lowest LEH frequencies (also see Dobney and Ervynck 2000: 602, fig 5). The inconsistency of this order during

the Neolithic may be explained by the very small number of third molars recorded for that period. The fact that the results show a dramatic increase of post-weaning physical stress on pigs in post-Neolithic periods (recorded on second and third molars) may be related to human intervention in many parameters of a pig's life cycle. On the contrary, the observation that LEH frequencies on the first molar remain more stable and generally low may be attributed to processes that can be characterised as 'default' events (birth and weaning) in every animal's life.

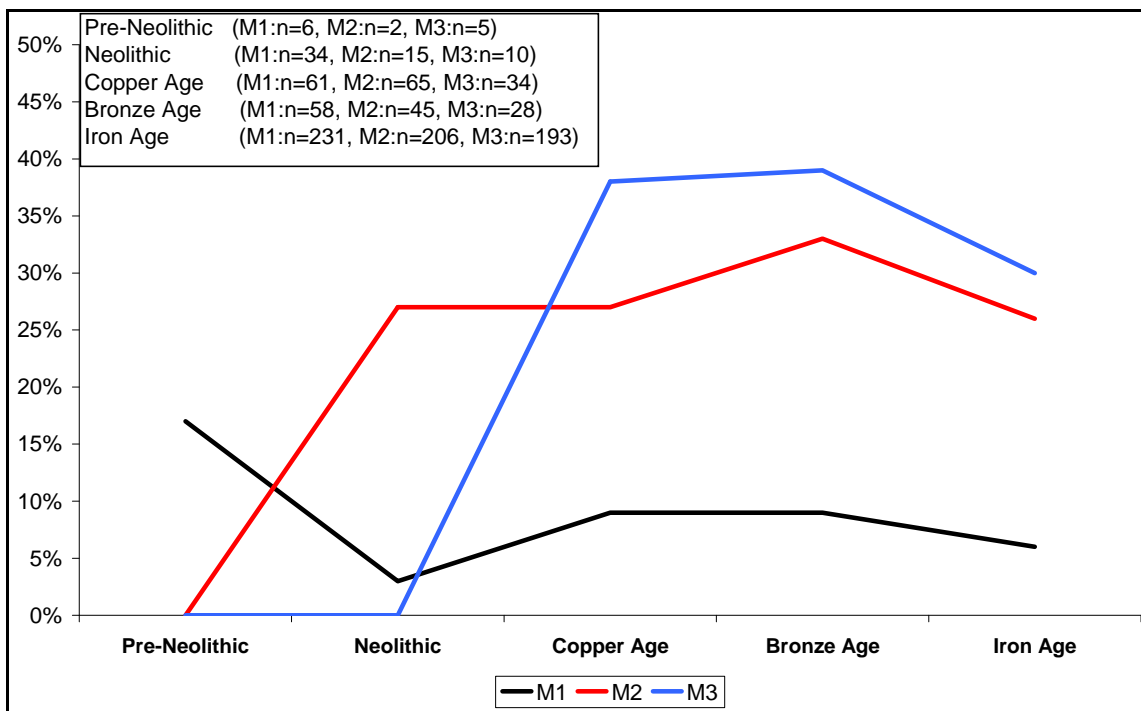


Figure 4.150: LEH presence on each mandibular molar through Spanish prehistory.

In order to examine how single LEH affected each mandibular molar, its frequency is plotted per chronological period (figure 4.151). The general pattern is almost identical to the one presented in figure 4.150 above, with the exception of a small decrease in its occurrence on the second molar from the Neolithic to the Copper Age. This shows that a single LEH line is more frequent than multiple lines and affects significant percentages of pig populations, especially in post-Neolithic periods. It is also visible on the graph that the fluctuations of single LEH percentages follow the same direction in all three molars from the Copper Age onwards, which may be interpreted as an indication that pigs experienced some physiological stress during the stages of

their lives in which crown formation of each molar was taking place (approximately from birth until early in the second year).

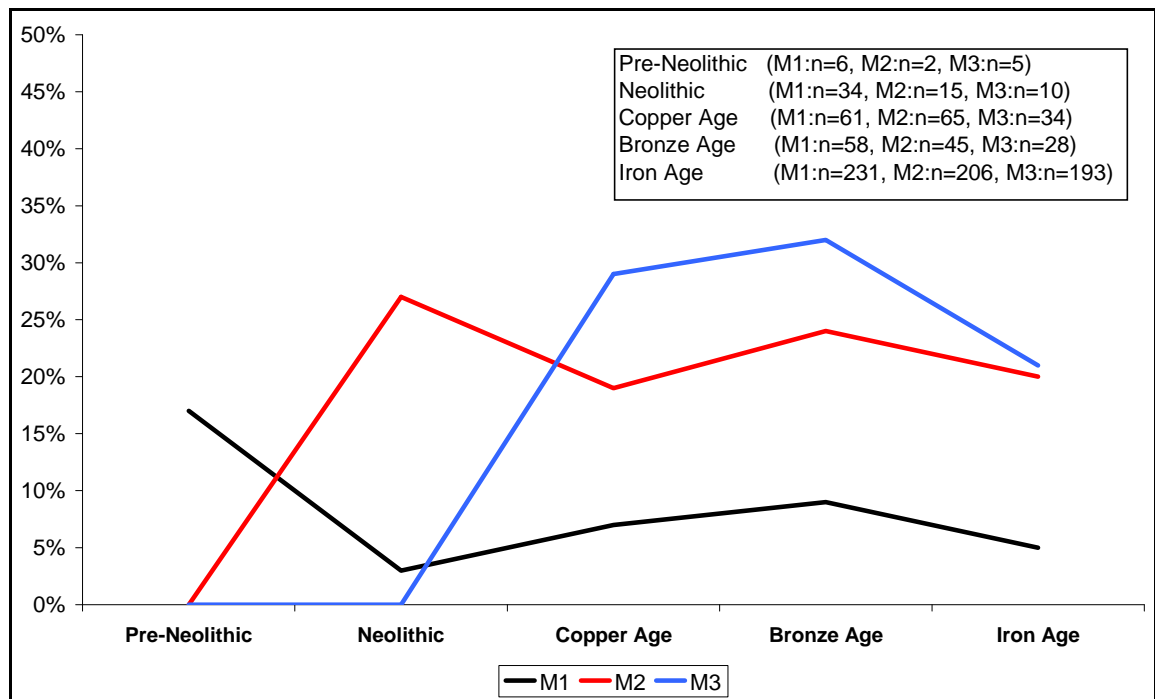


Figure 4.151: Single LEH line presence on each mandibular molar during Spanish prehistory.

In order to detect possible differences in the intensity of LEH through time, the occurrence of two or more LEH lines is plotted for each molar (figure 4.152). The pattern has similarities but also differences when compared with single LEH (figure 4.151). Firstly, multiple LEH lines occur only from the Copper Age onwards. Secondly, the first molar exhibits consistently low and the second and third consistently high multiple line percentages in post-Neolithic periods, as it was the case for single LEH. Thirdly, in contrast to single LEH lines, the occurrence of multiple lines does not decline between the Bronze and Iron Ages for the first and third molars. The overall pattern can be defined as 5-10% frequency for second and third molars and 0-2% for the first molar. This is in general agreement with the trends in figures 4.150 and 4.151 for increased LEH in post-Neolithic periods.

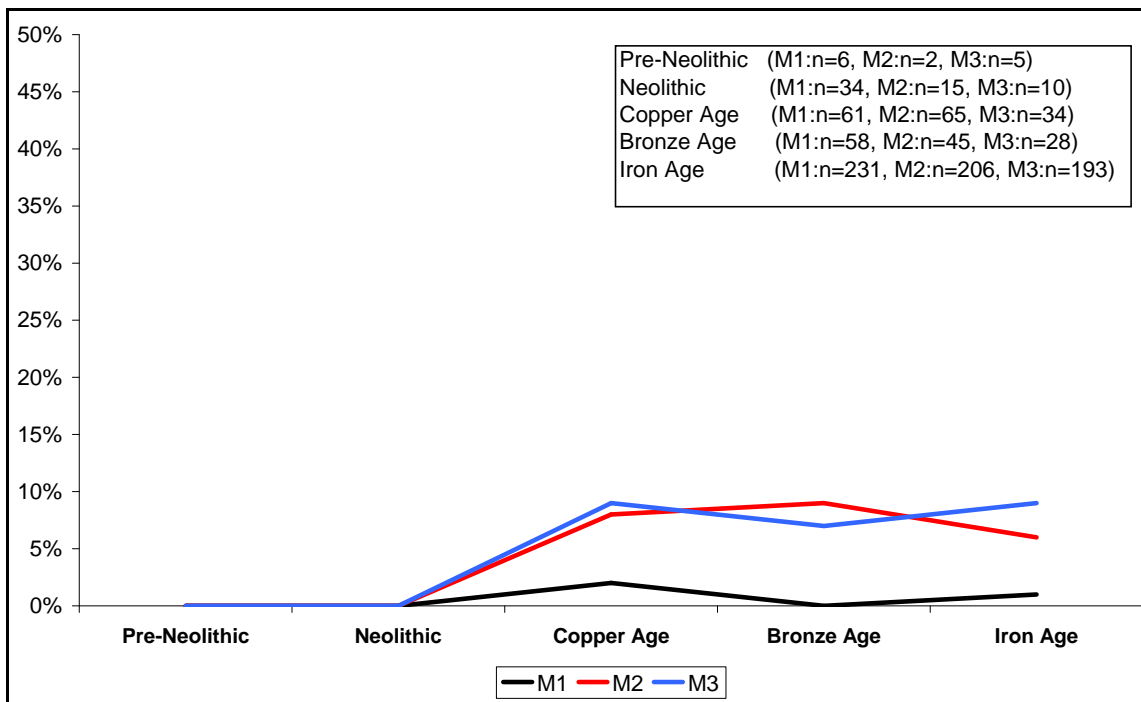


Figure 4.152: Double (or more) LEH line presence on each mandibular molar during Spanish prehistory.

When the LEH results are integrated with the other lines of evidence (biometry, ageing and sexing), interesting patterns emerge. The increase in the occurrence of LEH coincides with the decrease in size (biometry), the increase in survival beyond the first year (ageing) and the establishment of a female majority (sexing). There are several factors that can explain this co-occurrence and all may be directly or indirectly related to the husbandry practices in each period. LEH is a naturally occurring condition related to physical stress such as farrowing, malnutrition and disease (Dobney and Ervynck 2000) and that is why the fluctuations in its frequency may be related to the management of pigs by humans. The increase of LEH frequencies (one or more lines) in post-Neolithic periods and the fact that it coincides with the biometric, ageing and sexing patterns described above, can be taken as additional evidence for intensification in pig husbandry. Intensification is understood as tighter confinement of animals and greater degree of manipulation of their age and sex structure. Such husbandry strategies not only would cause size diminution due to a physical – and hence genetic – separation of the domestic from the larger-sized wild stock, but are also more likely to deteriorate many aspects of a pig's existence such as hygiene, aggression, seasonal malnutrition, increased pressure for farrowing, psychological stress and disease.

4.5 Summary

In order to obtain an overview and compare size fluctuations in bones and teeth occurring in post-Neolithic periods (*ca.* 3rd-1st millennia cal. BC), a graph based on the log ratio mean values of all recorded measurements (figure 4.153) has been produced. For comparative purposes, the values of the Neolithic and pre-Neolithic periods are included in the figure. The relationship between postcranial and dental elements has sporadically been discussed earlier in this chapter, but figure 4.153 allows the examination of this relationship in a more synthetic way. According to the diagram, pigs had relatively larger bones than teeth in pre-Neolithic and Early Neolithic times, though both decreased in size in the Early Neolithic (bones more than teeth). The most notable reduction in both bones and teeth occurred between the 6th and the 4th/beginning of 3rd millennium cal. BC. This clearly affected postcranial more than dental size. By the end of the 4th millennium, bone and tooth size became proportionate to that of the standard British Late Neolithic population. In the 3rd millennium cal. BC (*cf.* Copper Age), the proportions between postcranial and dental size remain the same as in the 4th millennium BC and the standard population (also 3rd millennium cal. BC Durrington Walls, England). However, the size decreased further.

In the 2nd millennium cal. BC (*cf.* Bronze Age), the proportions between bone and tooth size changed, compared to the previous two millennia. A sharper increase occurred in postcranial size, while dental size increased only slightly. This intriguing pattern was identified both in scatterplots and histograms and there are many candidate factors that could have contributed to it, such as sex and age profiles, management and domestic/wild contribution to the assemblages. Bronze Age sex structures, compared to the Copper Age, show a higher percentage of males. This would contribute to an overall larger postcranial size due to the more acute sexual dimorphism in postcranial, than dental elements. In addition, the Bronze Age exhibited higher survival rates into older age intervals, which is another factor that could have contributed to some increase in postcranial size due to some further growth of some postcranial elements even after epiphyseal fusion. Another possibility is that proportionately more wild boar is included in Bronze Age than Copper Age assemblages, which would explain a larger postcranial, but not necessarily dental size. Even if we

accept that wild pigs had larger bones than teeth as it was the case in pre-Neolithic periods, the presence of few particularly large tooth measurements in the Bronze Age is enough to prove the presence of individuals with very large teeth. Assuming that large-sized bones and teeth belonged to wild individuals, the above-mentioned pattern could be the result of hunters leaving wild pig skulls off site. It has also been shown in this chapter and chapter 3 that tooth size is more conservative and extensive overlaps in size occur between periods. The patterns in the biometry of Bronze Age pigs revealed an increased number of large-boned individuals in the assemblages, visible in the scatterplots as large outliers and in the histograms as a secondary mode to the right of smaller-sized majority. With the available data it cannot be determined whether the larger specimens belong to large domestic males or wild boar, but the most realistic scenario is that all the above-mentioned factors contributed, perhaps to different degrees, to this pattern.

In the 1st millennium cal. BC (*cf.* Iron Age), the proportions between postcranial and dental size are restored to those of the 3rd and 4th millennia. In the same period, the smallest size in Spanish prehistory - both postcranial and dental - is recorded. Sex ratios showed an overwhelming majority of females in the Iron Age and this could have contributed to an overall smaller size. However, a size decrease of this magnitude – the sharpest size decrease since the Neolithic - cannot be explained solely by an increase in females. It is more likely that a genuine size decrease occurred in the 1st millennium cal. BC. This is supported by the considerable size decrease observed on the relatively sex-independent tooth widths (figure 1.145) and some of the least age- and sex-dependent postcranial elements such as the distal tibia (figure 4.96).

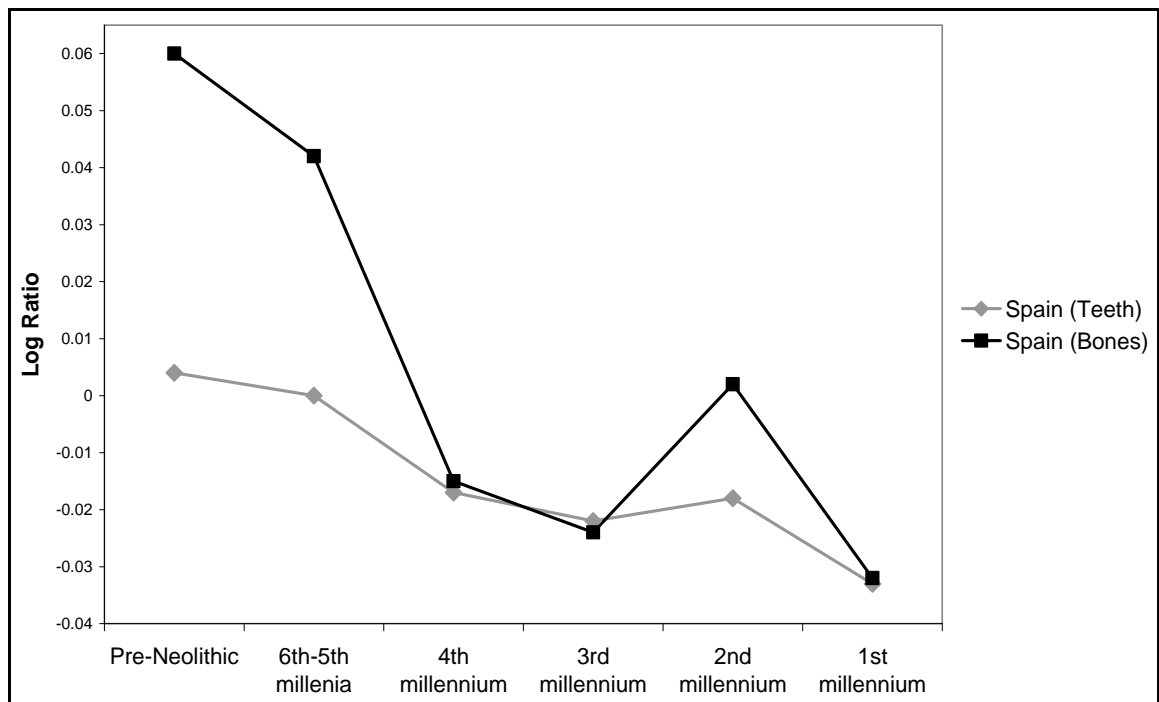


Figure 4.153: Graph illustrating the relationship between bone and tooth size through Spanish prehistory (ca. 10th-1st millennium cal. BC) based on the mean log ratio values of all recorded measurements (excluding the length of scapula neck for postcranial).

This chapter continued from where the previous has stopped. In general, the Copper Age can be seen in continuity with the trends that had already been identified for the Neolithic in chapter 3. All lines of evidence point to the same direction, namely that in the Copper Age, the overwhelming majority of pig remains belonged to domestic animals. Hints of a female majority in some Neolithic assemblages become more clearly established in the Copper Age. Furthermore, the reduction in mortality during the first year indicates a more efficient management of pig herds which targeted higher weight yields. An additional indication of tighter control and increased physical stress on domestic pigs is provided by the sharp increase of LEH occurrence on the permanent molars from the Neolithic to the Copper Age. The biometry of Copper Age pigs fits well with the rest of the evidence, by showing a majority of small-sized pigs and very few particularly large individuals, likely to be wild boar. This pattern, in combination with the rest of the evidence for a tighter control of pig herds, suggests that by the 3rd millennium cal. BC domestic pigs were by and large genetically isolated from the wild boar, to the point that the two populations are morphometrically distinguishable, or at least much more so than in previous periods. The particularly large size of some Copper Age specimens suggests that wild boar size may have even slightly increased from the Neolithic to the

Copper Age. Due to the small number of presumed wild boar specimens this should be regarded as a tentative suggestion and the clearer size differentiation between domestic and wild stock is mainly due to a size decrease in domestic pigs rather than an increase in wild boar size. All Copper Age assemblages present a similar pattern, with a rather uniform size of the domestic populations and the occurrence of occasional distinctively larger individuals. However, it is possible that the geographical bias of the Copper Age sample (the overwhelming majority derives from Andalusian sites) may have contributed to the observed uniformity in size and biometric patterns.

In the Bronze Age, extensive similarities with the Copper Age but also some interesting differences are noticeable, which highlight the dynamic nature of the human-pig relationship. The majority of Bronze Age pigs were of a similar size to those of the Copper Age and similar age profiles, with low mortality in the first year and high in the second and third. The sex structure also shows an overall majority of female pigs and hypoplasia frequency remains relatively stable. Beyond these similarities, there are some intriguing differences between Copper and Bronze Age pig populations. Biometry has shown that in the Bronze Age there were proportionately more larger-boned individuals in pig assemblages than the Copper Age. Another difference is that, despite the overall female majority, there are proportionately more male animals represented in Bronze than in Copper Age assemblages.

The integration of all the lines of zooarchaeological evidence presented in this chapter supports a scenario according to which in the Bronze Age pig husbandry was, as in the Copper Age, much more important than wild boar hunting. Domestic populations were managed under a well-established system without extensive interaction with wild populations. However, the increased presence of very large specimens suggests that wild boar hunting increased in importance in the Bronze Age. The particularly large size of some of these animals may suggest an increase in wild boar size. With the available data this increase in wild boar size cannot be chronologically specified but it is nevertheless an important piece of information for the evolution of wild boar size in Iberia. It is actually paralleled by data from other European countries such as Italy (Albarella et al 2006b).

The Iron Age data presented in this chapter reveal further changes in the interactions between humans and pigs. Biometry showed that the overwhelming majority of pig remains in Iron Age pig populations belonged to domestic animals, the size of which was the smallest recorded in the entire Spanish prehistory. Besides the important size diminution, there are more indications of intensification of pig husbandry practices in Iron Age Spain. The female majority recorded in earlier millennia becomes absolutely dominant in the Iron Age, reaching a ratio of 5-6:1 in some assemblages. Age profiles of Iron Age pig populations, though similar to those of Copper and Bronze Age populations, show even higher survival rates into the third and fourth years. All these results strongly indicate a system of husbandry that is based on sound knowledge of how to exploit a pig herd effectively. In this system sows were probably carefully selected and used for reproduction for at least three years, while much fewer males were kept beyond the end of the second year. The implementation of such a system must have required a considerable amount of time and organisation, as well as good knowledge of the animal's physical and behavioural characteristics.

Chapter 5. Comparisons of Spanish data with other European countries

In chapters 3 and 4, biometric analyses on pig remains from Spain recorded for this project have been presented. In chapter 3, the presentation of pre-Neolithic and Neolithic measurements provided a picture of pig postcranial and dental size that offered insights in the origins of pig domestication in Spain. In chapter 4 the evolution of pig size has been followed through later prehistory (Copper, Bronze and Iron Ages) and this allowed the identification of patterns in pig size, providing useful evidence for the evolution of pig domestication after the Neolithic. In this chapter, the material from Spain collected by the author is put in a wider geographical context through comparisons with measurements collected by colleagues from sites in neighbouring Portugal and France, but also Italy and Britain (see figure 5.1). Such comparisons have the potential to reveal overall trends in pig size in different countries and provide a larger regional scale of reference to the patterns identified for Spain in chapters 3 and 4. The chronological focus of the comparisons is the pre-Neolithic and Neolithic because of their potential to reveal the origins of pig domestication and complement the relatively limited Spanish data from these periods. The geographic focus remains on Spain, the subject of this work, with data from other countries used on a comparative basis, rather than as independent lines of inquiry.

The measurements from Portuguese sites (11-15 in figure 5.1) were collected by Simon Davis and Umberto Albarella. They derive from three Mesolithic (Cabeço da Arruda, Cabeço do Pez and Moita do Sebastião) and two Chalcolithic (Zambujal and Leceia) sites and are published in Albarella et al (2005). The measurements from the only available French site (27 in figure 5.1), Roucadour (Middle Neolithic), were collected by Umberto Albarella, though the assemblage was originally studied by Lesur et al (2001). The measurements from Italy, also collected by Umberto Albarella, derive from 11 sites (16-26 in figure 5.1, published in Albarella et al 2006b) – Grotta della Madonna (Upper Palaeolithic-Middle Bronze Age), Palidoro (Upper Palaeolithic), Arene Candide (Upper Palaeolithic), Grotta Romanelli (Upper Palaeolithic), Grotta dell'Uzzo (Mesolithic-Neolithic), La Marmotta (Early Neolithic), Favella (Early Neolithic),

Masseria Candelaro (Middle Neolithic), Torre Mordillo (Middle-Late Bronze Age), La Starza (Middle Bronze Age), and Concordia Sagittaria (Late Bronze Age). British data were mainly collected by Sarah Viner for her PhD project and derive from 10 sites (1-10 in figure 5.1) – Faraday Road (Mesolithic), Star Carr (Mesolithic), Thatcham (Mesolithic), Victoria Park (Mesolithic), Marsh Benham (Mesolithic), Goldcliff (Mesolithic), Wawcott XV (Mesolithic), Hambledon Hill (Early Neolithic), and Runnymede Bridge (Middle Neolithic). Data from Late Neolithic Durrington Walls were mainly collected by Umberto Albarella, but they also represent part of Sarah Viner’s thesis. The geographical distribution of the Spanish sites (see figures 3.1 and 4.1 in chapters 3 and 4) is deliberately omitted from the map because it would make the figure overcrowded and less clear.

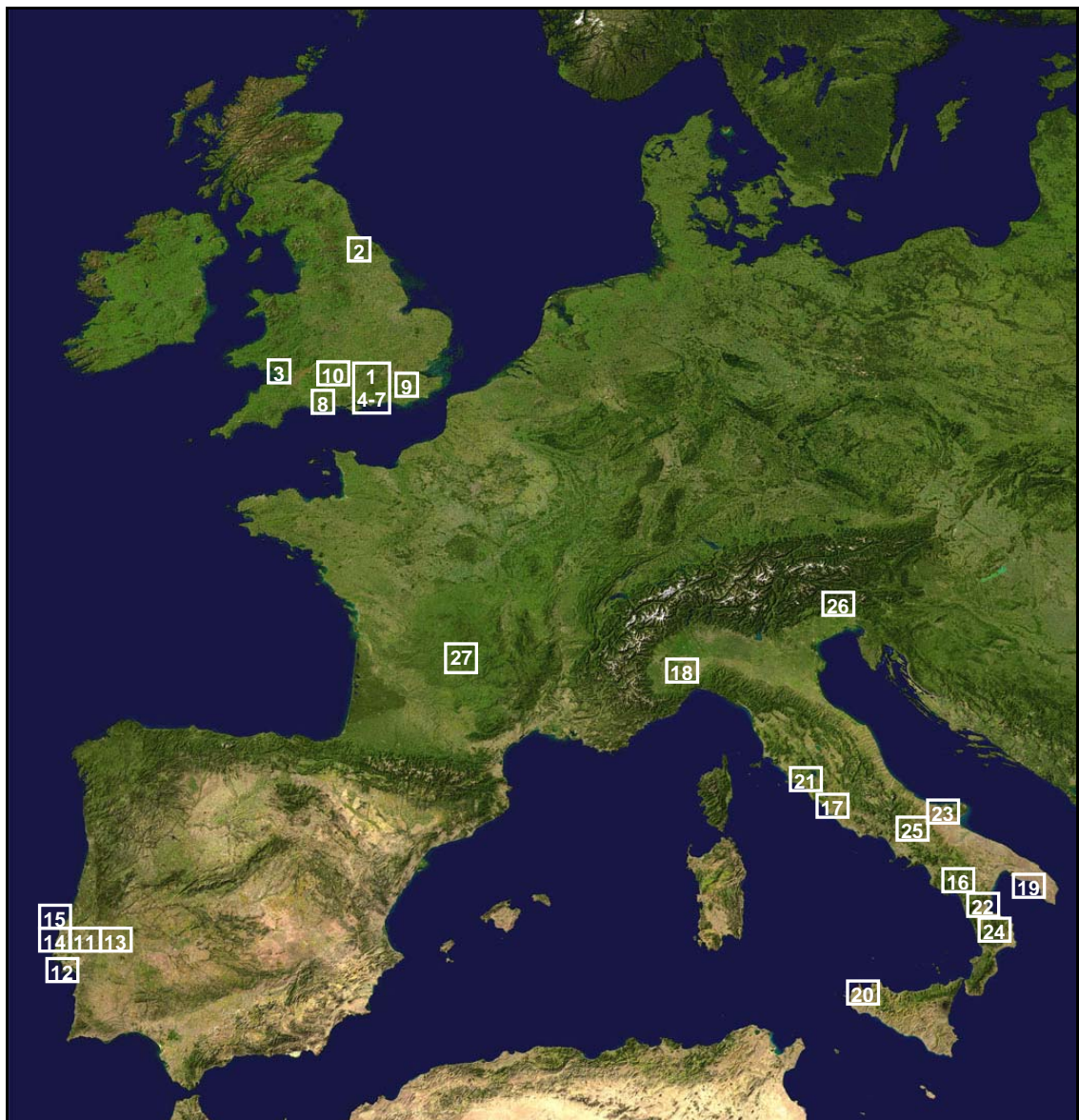


Figure 5.1: Geophysical map of central and western Europe indicating the location of all non-Spanish sites included in the analyses. See table 5.1 below for a list of the sites shown on the map.

Table 5.1: Overview of non-Spanish assemblages included in the analyses presented in this chapter. Sites are listed per country and in approximate chronological order.

	Site	Chronology
1	Wawcott XV, Berkshire, England	Mesolithic
2	Star Carr, North Yorkshire, England	Mesolithic
3	Goldcliff, Newport, South Wales, England	Mesolithic
4	Faraday Road, Newbury, Berkshire, England	Mesolithic
5	Thatcham, Berkshire, England	Mesolithic
6	Victoria Park, Newbury, Berkshire, England	Mesolithic
7	Marsh Benham, Newbury, Berkshire, England	Mesolithic
8	Hambledon Hill, Blandford Forum, Dorset, England	Early Neolithic
9	Runnymede Bridge, Egham, Surrey, England	Early-Middle Neolithic
10	Durrington Walls, Wiltshire, England	Late Neolithic
11	Cabeço da Arruda, Muge, Portugal	Mesolithic
12	Cabeço do Pez, Sado estuary, Portugal	Mesolithic
13	Moita do São Sebastião, Muge, Portugal	Mesolithic
14	Zambujal, Portugal	Chalcolithic
15	Leceia, Oeiras, Portugal	Chalcolithic
16	Grotta della Madonna, Calabria, southern Italy	Upper Palaeolithic-Middle Bronze Age
17	Palidoro, Latium, central Italy	Upper Palaeolithic
18	Arene Candide, Liguria, northern Italy	Upper Palaeolithic
19	Grotta Romanelli, Lecce, Apulia, southern Italy	Upper Palaeolithic
20	Grotta dell'Uzzo, Sicily, Italy	Mesolithic-Neolithic
21	La Marmotta, Latium, central Italy	Early Neolithic
22	Favella della Corte, Cosenza, southern Italy	Early Neolithic
23	Masseria Candelaro, Apulia, southern Italy	Middle Neolithic
24	Torre Mordillo, Calabria, southern Italy	Middle-Late Bronze Age
25	La Starza, Campania, southern Italy	Middle Bronze Age
26	Concordia Sagittaria, Veneto, northeast Italy	Late Bronze Age
27	Roucadour, Themines, Quercy, Lot, France	Middle Neolithic

The colleagues that recorded the assemblages mentioned above took most measurements in the same way as the author. Measurements cannot be considered to have the same degree of consistency as when they are taken by the same individual, but the adoption of the same recording protocol ensures a sufficient degree of comparability. To increase comparability, the crown lengths of teeth were excluded from the analysis because the author took those measurements in a slightly different way than the colleagues who recorded the rest of the assemblages. Additionally, the crown length of teeth is more age-related than widths and hence, biased biometric patterns may be created due to possible age-related variation in assemblages.

5.1 Biometry

The results presented in this section focus on the biometry of pre-Neolithic and Neolithic periods, but they extend to later prehistory where data are available. The aim of the biometric comparison between Spanish pigs and their Portuguese, French, Italian and British counterparts is to explore size variation among roughly contemporary populations, and interpret them on the basis of geographic, environmental, cultural or other factors.

5.1.1 Biometry of postcranial elements

In this section the analysis of postcranial measurements is presented and described in chronological order, although assemblages from other periods are used for comparative purposes in some cases (e.g. post-Neolithic assemblages are compared with those from the Neolithic and pre-Neolithic). The analysis is presented mainly in the form of scatterplots and log ratio histograms.

In figure 5.2, the measurements of all pre-Neolithic and Neolithic distal humeri from Spain, Portugal, Italy, and Britain are plotted. In the scatterplot, the central and upper right parts of the distribution are occupied by the Italian Palaeolithic, Mesolithic and Early Neolithic, the French Middle Neolithic and many of the Spanish Early Neolithic specimens. The largest British Mesolithic and Neolithic as well as the largest Portuguese Mesolithic specimens plot in the central part of the distribution, together with two Spanish Early Neolithic specimens. In the lower left of the distribution, most of the British Neolithic with some British and Portuguese Mesolithic specimens plot with a Spanish Early Neolithic specimen. Despite some overlap between the different chrono-geographical samples, the most discernible pattern in the distribution is that Portuguese Mesolithic and British - both Mesolithic and Neolithic pigs - were generally smaller than their Spanish Early Neolithic, Italian Palaeolithic, Mesolithic and Early Neolithic, and French Middle Neolithic counterparts (the last being certainly wild boar and therefore not representative of the French Neolithic domestic population; see Lesur et al 2001). The three smallest Italian Mesolithic specimens derive from the assemblage of Grotta dell'Uzzo in Sicily. Hence, a mild insular dwarfism may explain their smaller size compared to the rest of the Italian specimens. In fact, they plot in the same area as the Mesolithic specimens from Portugal and

Britain, as well as the Neolithic specimens from Britain and few Early Neolithic specimens from Spain. Also noteworthy is the particularly large size of some of the Neolithic specimens from Spain, Italy, and France, which are larger than all pre-Neolithic specimens; except two Italian Mesolithic specimens. Lastly, it is worth mentioning that most of the British Neolithic specimens plotting in the lower left part of the distribution derive from the Late Neolithic assemblage of Durrington Walls, which is chronologically analogous to the Copper Age/Chalcolithic in Iberia (i.e. 3rd millennium cal. BC). Despite the substantial overlap between groups, regional and chronological patterns emerge from this plot. The broad distribution of the Spanish Early Neolithic specimens, ranging from the centre to the top of the distribution, confirms the view that these animals probably represent a combination of domestic and wild forms. The five largest specimens are from the sites that have been suggested to have a larger wild component (Cova Fosca and Cueva Chaves), while the three smaller are from sites that are likely to have leaned more towards a productive economy (Cueva de la Vaquera and La Draga). The absence of particularly small specimens is probably an indication of a still early stage of the domestication process – in parallel with what has also been seen in Italy (Albarella et al 2006b).

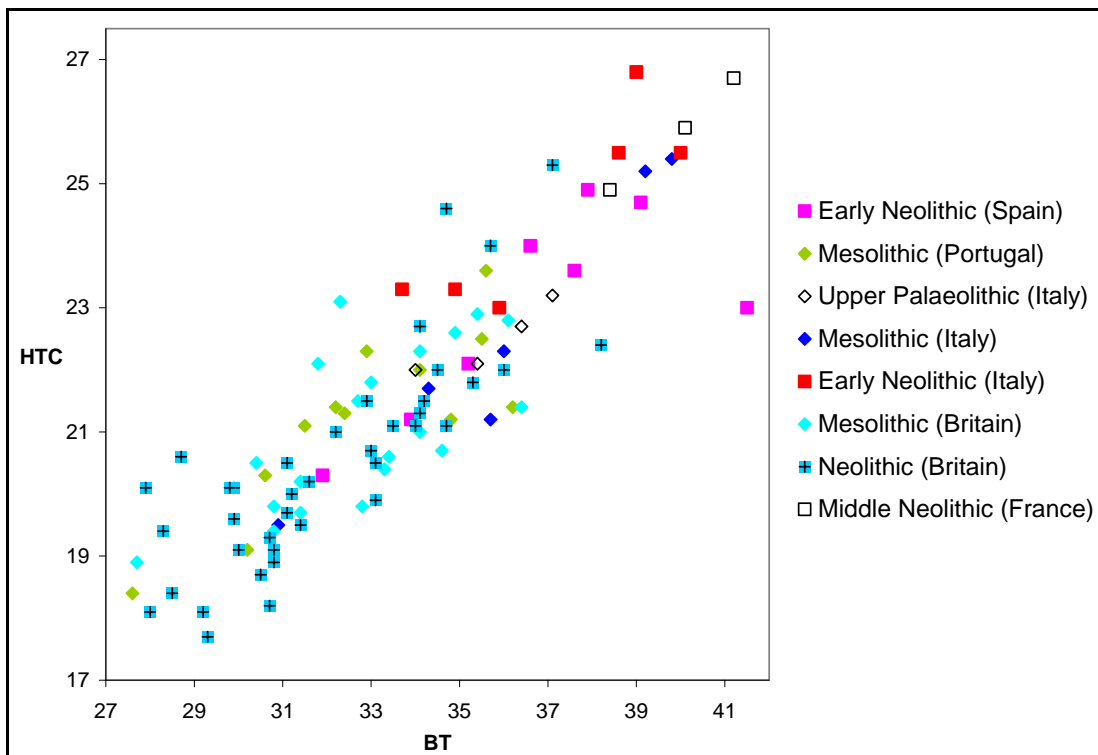


Figure 5.2: Scatterplot of humerus width of trochlea x minimum diameter of trochlea from pre-Neolithic and Neolithic samples from Spain, Portugal, France, Italy and Britain. Only fully fused specimens are plotted. Measurements in mm.

In figure 5.3, the distal humerus measurements of Copper and Bronze Age pigs from Spain, Portugal and Italy are plotted together with the Spanish Early Neolithic specimens. The inclusion of the Spanish Early Neolithic specimens serves as a measure of comparison to the pre-Neolithic and Neolithic results presented in figure 5.2. The picture here is clearer than the one for the pre-Neolithic and Neolithic specimens. The vast majority of post-Neolithic specimens plot in the lower left part of the distribution, while a group of few measurements from each period plot separately in the upper right part of the scatterplot, with most of the Spanish Early Neolithic specimens. Noteworthy is the similarity in humerus size between the contemporaneous Spanish Copper and Portuguese Chalcolithic pigs, as well as between those and their Bronze Age counterparts from Spain and Italy. The domestication-induced size reduction of post-Neolithic Spanish pigs seems to have led to animals of comparable dimensions to the late prehistoric pigs from Portugal and Italy. The largest Spanish specimens – presumably wild boar – are also consistent with large outliers from Chalcolithic Portugal.

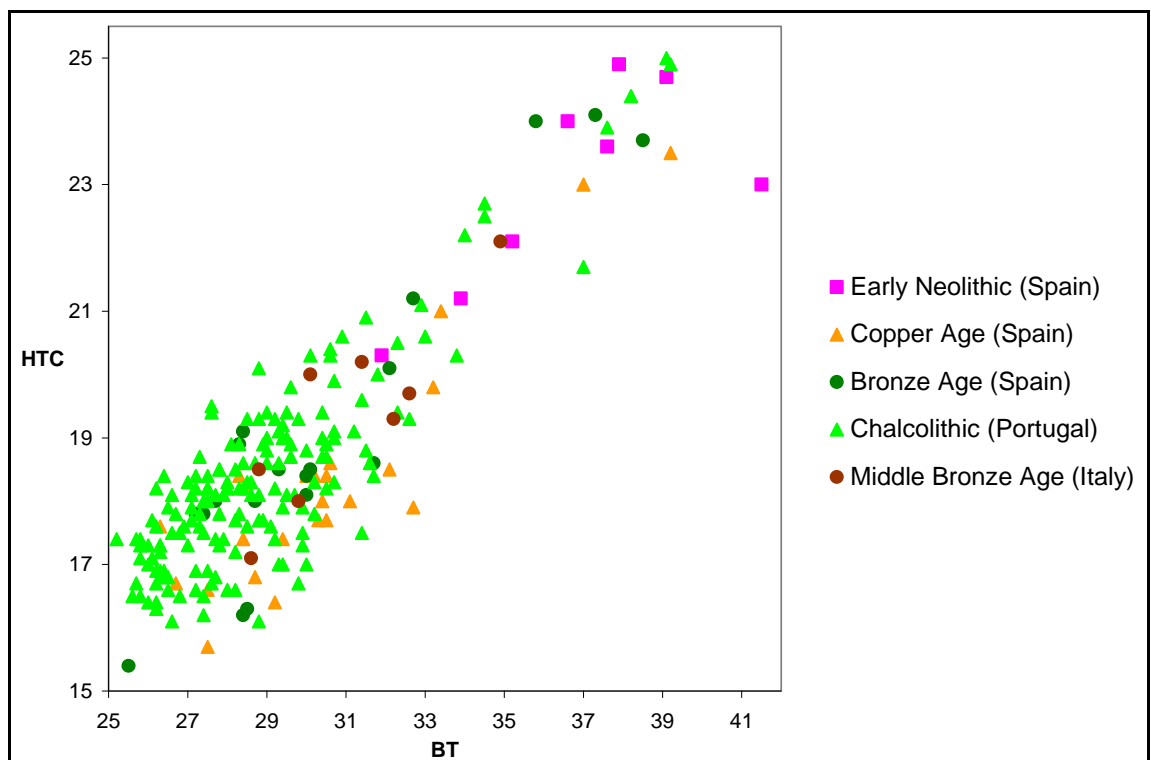


Figure 5.3: Scatterplot of humerus width of trochlea x minimum diameter of trochlea from post-Neolithic and Neolithic samples from Spain, Portugal and Italy. Only fully fused specimens are plotted. Measurements in mm.

All the available calcaneum measurements from all countries (except Portugal) and chronological periods are plotted in figure 5.4. Before presenting the results

it is worth mentioning that, as it was the case for the humerus, the two smallest Italian Mesolithic and the smallest Neolithic specimens derive from Grotta dell'Uzzo in Sicily, while the group of British Neolithic specimens plotting in the lower left part of the distribution derive from Late Neolithic (3rd millennium cal. BC) Durrington Walls. The dominant pattern in figure 5.4 is that pre-Neolithic and Neolithic specimens, being considerably larger, plot in the upper right part, while the bulk of post-Neolithic specimens plot in the lower left with few large outliers. Compared to the results on humerus, the calcaneum measurements exhibit a similar pattern. The smallest specimen is from La Draga and almost certainly represents a fully domesticated pig.

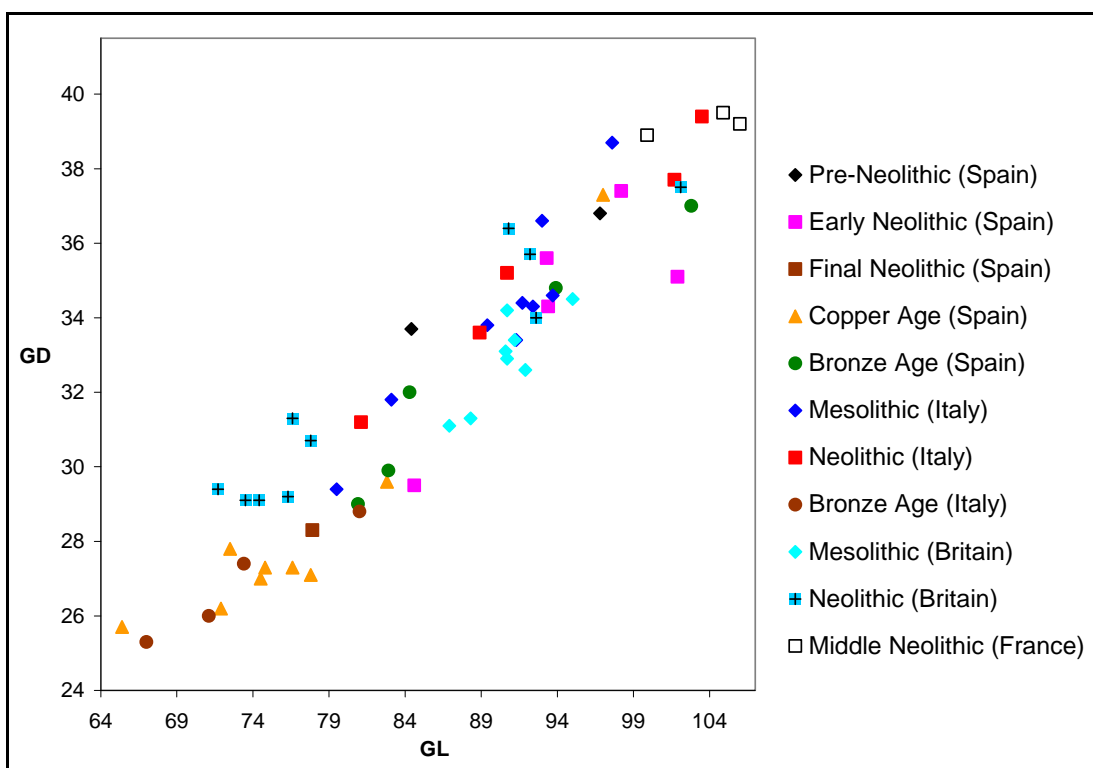


Figure 5.4: Scatterplot of calcaneum greatest length x greatest depth from pre- Neolithic, Neolithic and post-Neolithic and samples from Spain, Portugal, France, Italy and Britain. Only fully fused specimens are plotted. Measurements in mm.

As done for the humerus measurements, distal tibia measurements are also plotted in two scatterplots to avoid overcrowding and achieve better visibility. In figure 5.5, pre-Neolithic and Neolithic specimens are plotted, while all post-Neolithic specimens are plotted with the Spanish Early Neolithic specimens in figure 5.6 for comparative purposes. In the scatterplot showing the pre-Neolithic and Neolithic measurements (figure 5.5) only the largest Italian Neolithic specimen is not from Grotta dell'Uzzo in Sicily, while the smallest Italian

Mesolithic measurement is the only one available from Grotta dell'Uzzo. The significantly smaller size of pigs from Grotta dell'Uzzo (both during the Mesolithic and Neolithic) compared to the rest of the Italian specimens of same chronology is once more confirmed. Most French Middle Neolithic specimens are of similar size to the Italian Upper Palaeolithic and most of the British and Italian Mesolithic specimens. In addition to these, there are also few Italian, British and Spanish Neolithic specimens in the central part of the scatterplot. Concerning the British Neolithic material, the vast majority of specimens plotting in the lower left part of the distribution derive from Late Neolithic (or 3rd millennium cal. BC) Durrington Walls, while most of the larger specimens derive from Early Neolithic Hambledon Hill and Middle Neolithic Runnymede Bridge. Even more distinctively than for humerus and calcaneum, figure 5.5 reveals a very small Early Neolithic Spanish pig (from La Draga), of a size which seems to be hardly compatible with wild boar and compares well with some of the small Sicilian Neolithic specimens. The five much larger specimens are from Cova Fosca and Cueva Chaves.

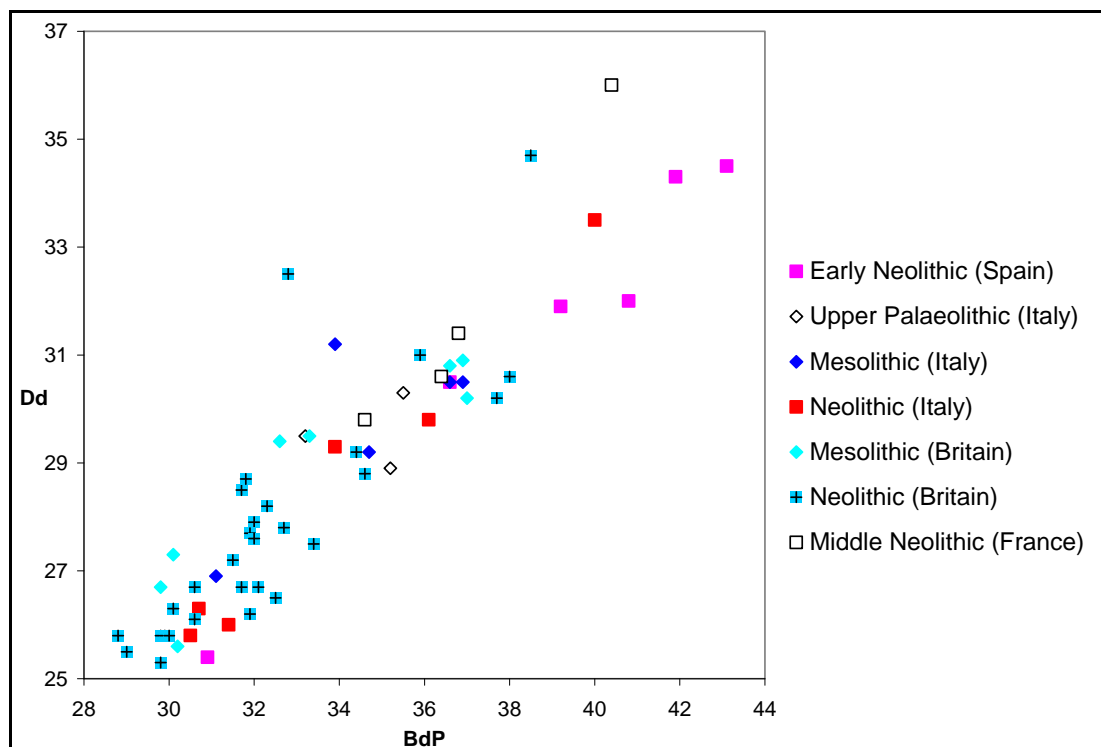


Figure 5.5: Scatterplot of tibia distal width x depth of the distal end from pre-Neolithic and Neolithic samples from Spain, France, Italy and Britain. Only fully fused specimens are plotted. Measurements in mm.

According to figure 5.6, a size reduction during post-Neolithic periods is also identified for the tibia, as for the humerus and the calcaneum. The vast majority

of Spanish and Portuguese Copper (or Chalcolithic) specimens are of smaller size than most Spanish Early Neolithic specimens, with the exception of the one small individual from La Draga. Again, late prehistoric Spanish pigs are compatible in size with those from Portugal and Italy.

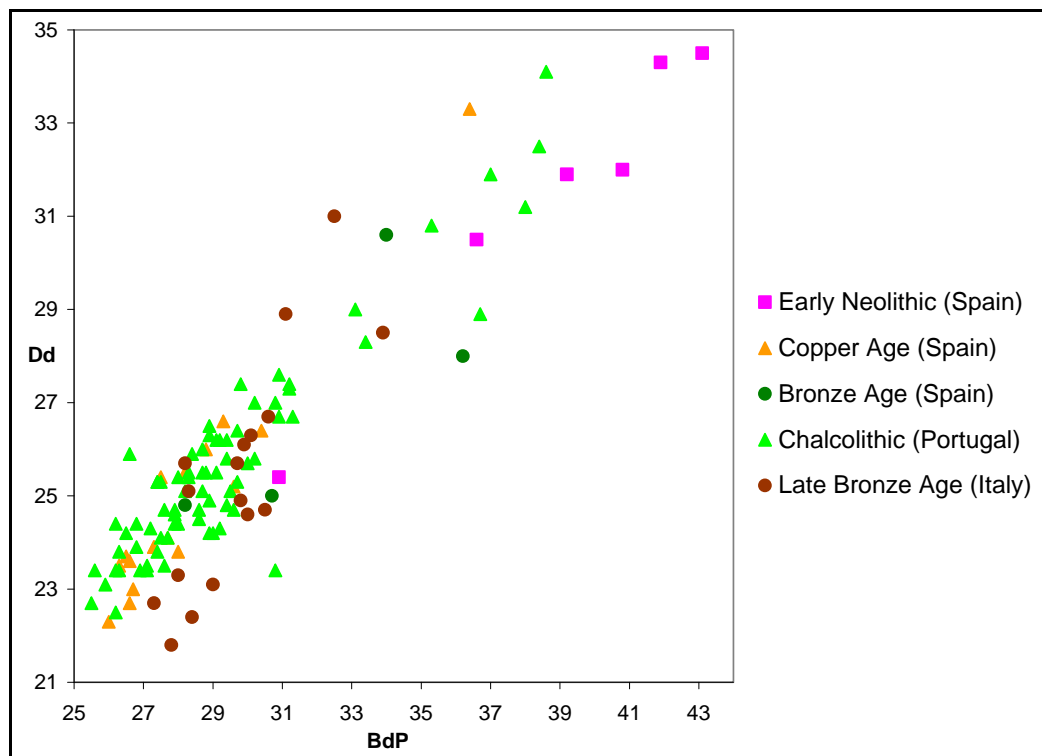


Figure 5.6: Scatterplot of tibia distal width x depth of the distal end from Neolithic and post-Neolithic samples from Spain, Portugal and Italy. Only fully fused specimens are plotted. Measurements in mm.

In figure 5.7, the astragalus measurements from pre-Neolithic, Neolithic and some post-Neolithic Spanish and British assemblages are plotted (Portugal and Italy are not plotted because only the greatest lateral lengths were available). Astragalus is usually the most commonly measured element due to its good preservation properties (cubic shape and high density) and the well-defined measurements. The astragalus does not fuse with any epiphysis. Thus, in order to reduce the age bias, all light and porous astragali have been excluded from the analysis. According to the scatterplot below, in both Spain and Britain there is a tendency towards two groupings of measurements during the Early Neolithic; one larger plotting in the upper right part and one smaller plotting mainly in the central and lower left part of the scatterplot. Both Spanish and British pre-Neolithic specimens tend to plot in the central part of the distribution. The roughly contemporaneous (3rd millennium BC) British Late Neolithic and

Spanish Copper Age specimens overlap in size, though the Spanish specimens are distinctively smaller. Excluding a few large outliers, British and Spanish 3rd millennium pigs are generally smaller than their pre- and earlier Neolithic counterparts and are occupying the central and lower left part of the scatterplot. Perhaps the most important observation in this comparison is that the Spanish Early Neolithic specimens are more diversified than the – chronologically later – British Early Neolithic specimens. The great mixing of locations, populations and perhaps also domestication origins that we have suggested to characterise the Spanish Early Neolithic is not entirely mirrored in Britain, where the domestication process may have taken a different route.

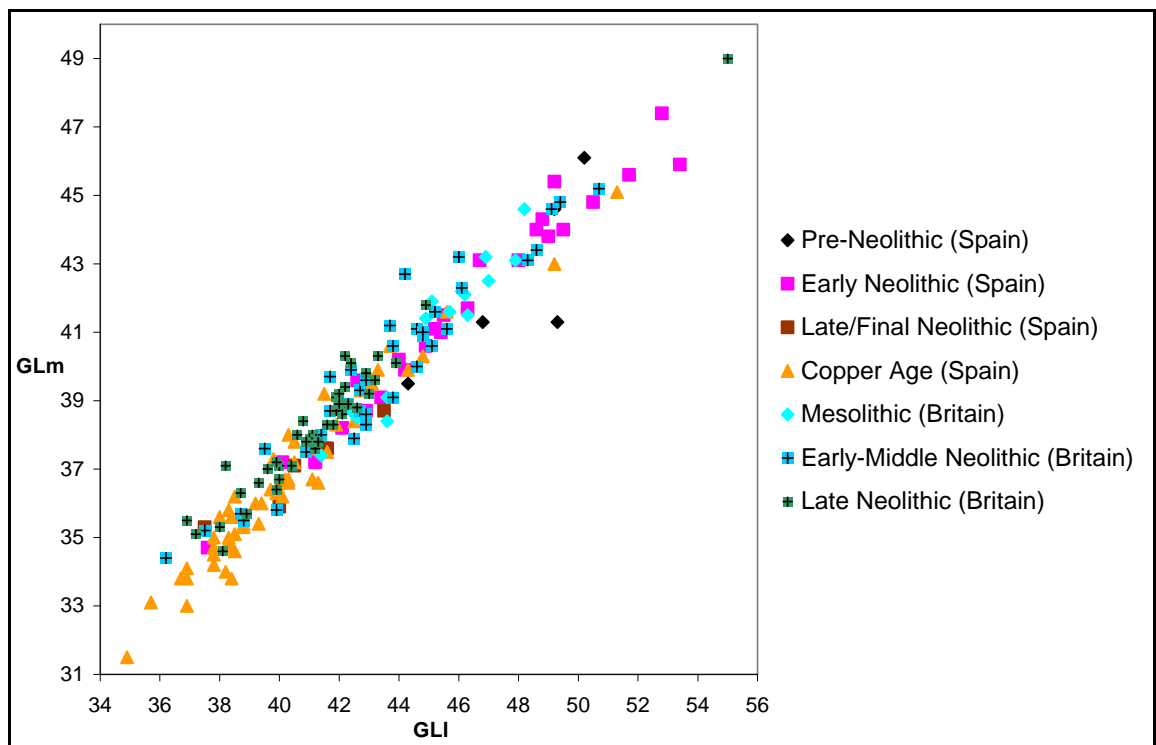


Figure 5.7: Scatterplot of astragalus greatest lateral x greatest medial lengths from pre- Neolithic, Neolithic and post-Neolithic and samples from Spain and Britain. Measurements in mm.

Additional to the scatterplots, log ratio histograms have been produced to compare the postcranial size of pigs in Spain, Portugal, Italy, France, and Britain during pre-Neolithic, Neolithic and post-Neolithic periods (figures 5.8, 5.9, 5.10, and 5.11). Although the specimens in the scatterplots are also included in the histograms, they are still worth presenting in this form because all recorded postcranial measurements, excluding the heavily age-dependent length of the scapula neck (Payne and Bull 1988; Rowley-Conwy 2001), are included in the analysis. As a result, more individuals are represented in the

histograms than in scatterplots and a more general picture becomes available, though at a lower resolution.

The histograms in figure 5.8 offer an overview of the postcranial size of pre-Neolithic, Neolithic and Copper/Chalcolithic pigs in the Iberian peninsula (Spain and Portugal). The histograms are generally consistent with the results presented in the form of scatterplots. The Spanish pre-Neolithic specimens are larger than the Portuguese Mesolithic specimens. However, it is important to stress that the two samples are not directly comparable because the majority of Spanish specimens are of Palaeolithic chronology and from the northernmost regions of Spain, while the Portuguese specimens derive from Mesolithic sites in central Portugal. The fact that the Palaeolithic was a colder period than the Mesolithic and northern Spain is a colder region than central Portugal indicates that the size difference is mainly due to a climatic difference (Bergmann 1847). The Portuguese Mesolithic specimens are also, on average, smaller than the Spanish Early Neolithic specimens, which are likely to include a substantial wild component. Unfortunately, no Portuguese Neolithic data were available, but the Chalcolithic data reveal a dramatic reduction in postcranial size, probably occurring at some point in the Neolithic period. Noteworthy is the very comparable distribution of Spanish and Portuguese 3rd millennium (Copper/Chalcolithic) measurements. Their means are the same and so is the pattern in their distribution, which is characterised by a unimodally distributed large group (presumably domestic pigs) and a 'tail' of larger individuals (presumably wild boar). In Spain, size reduction dates back to the later part of the Neolithic period or even earlier in some region, as the Late/Final Neolithic pigs are almost as small as their Chalcolithic counterparts.

The histograms in figure 5.9 offer an overview of the postcranial size of pre-Neolithic and Neolithic pigs in Spain, Italy, and France. The Spanish pre-Neolithic pigs have a similar size to that of their Italian Upper Palaeolithic and Mesolithic counterparts. During the Neolithic, an increased diversity in postcranial size can be observed in both Spain and Italy. In general, the average size of Early Neolithic pigs in Spain and Italy is smaller, though only slightly, than that of their pre-Neolithic counterparts. Compared to pre-Neolithic pigs, significantly larger and significantly smaller specimens can be found in the

Neolithic material. By far the largest postcranial size is that of the pigs from Middle Neolithic Roucadour. At that site, only wild fauna has been identified (Lesur et al 2001) and it is considered a certainty that all pig remains belong to the wild form. This impressively larger size of wild boar during the Middle Neolithic can only be partly explained by environmental conditions and it provides further support for the hypothesis of a size increase in wild boar during the Neolithic. Noteworthy is the similarity between the Italian and Spanish situations with limited size decrease but increased variation between the pre-Neolithic and the Neolithic.

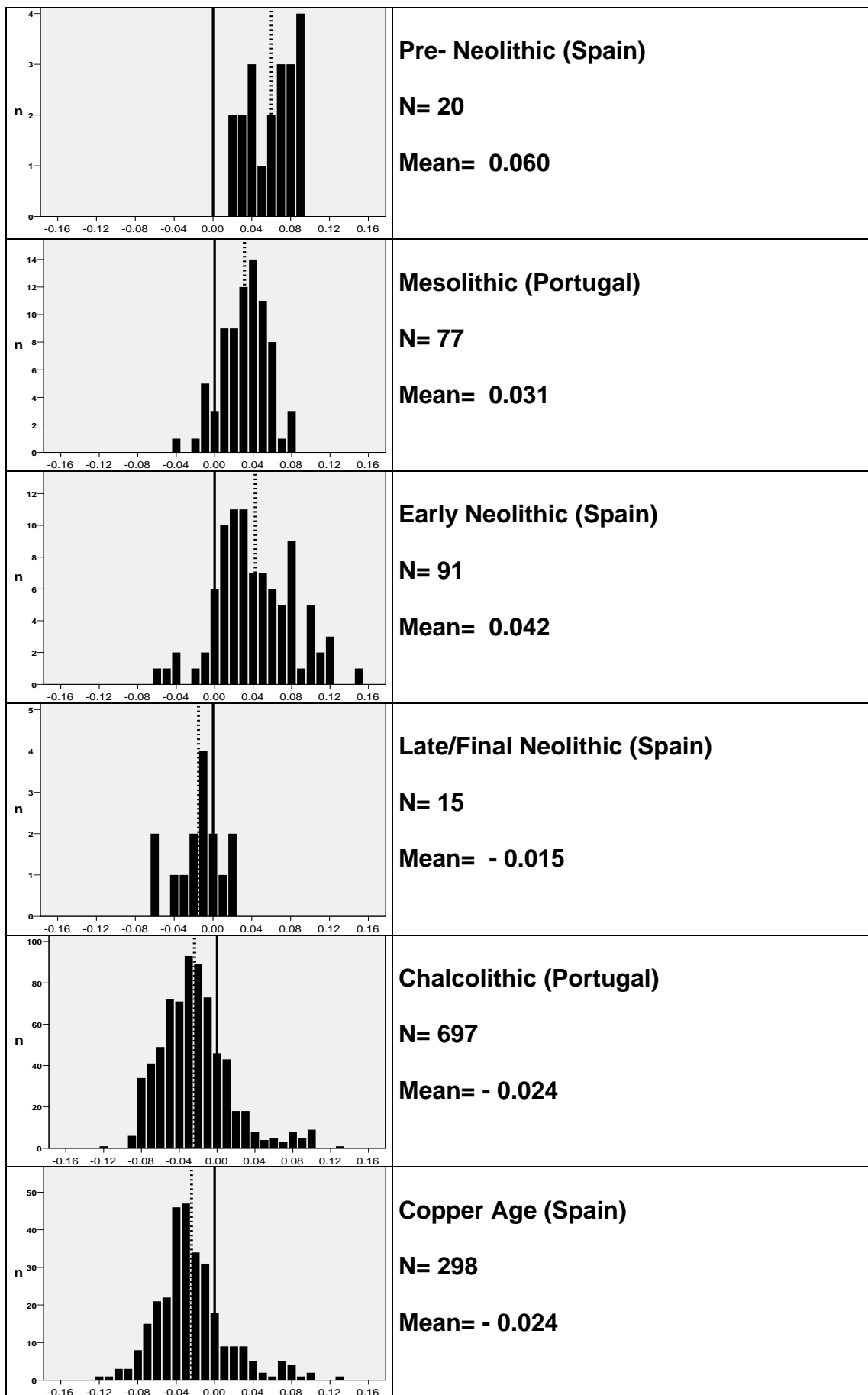


Figure 5.8: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) of Spanish and Portuguese specimens of pre-Neolithic, Neolithic and post-Neolithic chronology. Only fused specimens are plotted. The dotted line represents the mean value.

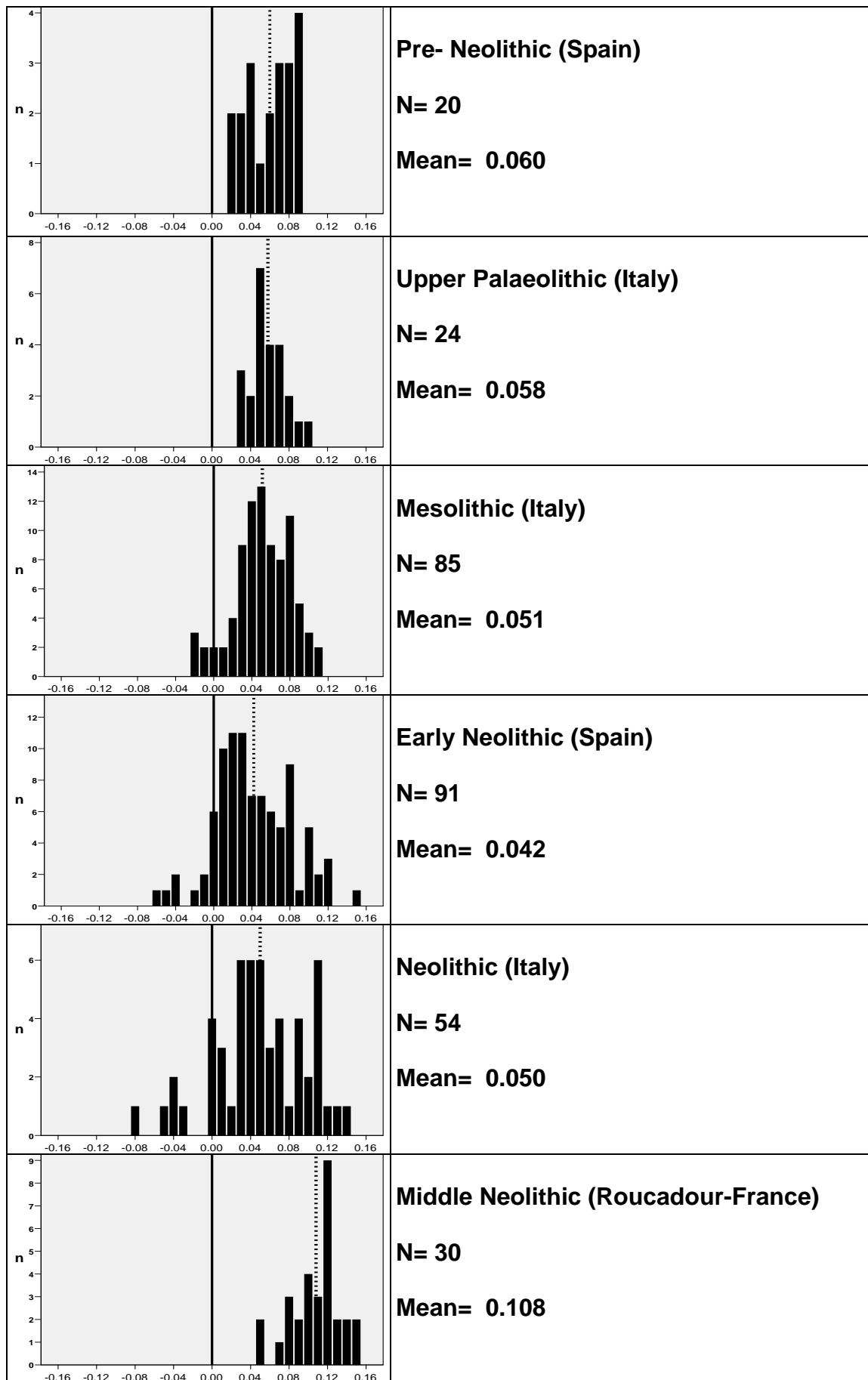


Figure 5.9: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) of Spanish, Italian and French specimens of pre-Neolithic and Neolithic chronology. Only fused specimens are plotted. The dotted line represents the mean value.

The histograms in figure 5.10 offer an overview of the postcranial size of pre-Neolithic and Neolithic pigs in Spain and Britain. Spanish pre-Neolithic and Early Neolithic pigs are on average larger than their British counterparts, although, as in the comparison with Portugal, the greater component of Upper Palaeolithic specimens in Spain may explain the observed size difference. Furthermore, the postcranial size of Spanish and British Early Neolithic pigs is decreased in comparison to their pre-Neolithic size. By the end of the Neolithic period, pig postcranial size in Spain and Britain is significantly reduced and generally similar. It is also important though to bear in mind that the chronology of the British Early Neolithic sites (Runnymede has been characterised as Middle Neolithic in the past, e.g. Serjeantson 2006) included in the comparison is later (4th-3rd millennia cal. BC) than that of the Spanish Early Neolithic sites (6th-4th millennia cal. BC).

The histograms in figure 5.11 offer an overview of the postcranial size of Neolithic and post-Neolithic pigs in Spain, Portugal, Italy, and Britain. During the 3rd millennium (roughly equivalent to the Copper Age in Spain, the Chalcolithic in Portugal and the Late Neolithic in Britain), pig postcranial size is similar in Spain and Portugal but larger in Britain. In all cases, it is significantly smaller than in the Early Neolithic. The smaller size of the Spanish and Portuguese 3rd millennium pigs may be related to a longer and/or more intense domestication process in comparison to Britain. Apart from the absolute size difference, the overall shape of the distribution in Spain, Portugal and Britain is very similar; with a majority of smaller-sized individuals and a 'tail' of few larger-sized individuals plotting to the right part of an otherwise normal distribution. This tail is particularly scanty in Late Neolithic Britain, where wild boar appears to be something of a rarity (Albarella and Payne 2005). The individuals represented in the 'tail' are as large as the pre-Neolithic and the largest Early Neolithic pigs.

During the Bronze Age in Spain a general size increase is observed, which can be explained by the greater number of measurements in what was described as 'tail' in the Copper Age material. Most of the Bronze Age measurements are still similar to those of the Copper Age but the 'tail' of the Bronze Age contains enough measurements to justify a characterisation of the distribution as approaching bimodal, with considerable overlap between the two modes. In

Italy, though we are lacking Copper Age data, a significant size decrease in postcranial size is observable when Bronze Age (figure 5.11) is compared with Neolithic material (figure 5.10). The size of Italian Bronze Age pigs is quite similar to that of their Spanish counterparts. However, the distribution of Italian Bronze Age measurements is somehow more reminiscent of the Copper Age/Chalcolithic distributions in having a 'tail' and not a second mode consisting of larger measurements. In other words, wild boar hunting played a lesser role in Italy than it did in Spain, at least concerning the sites included in the analysis.

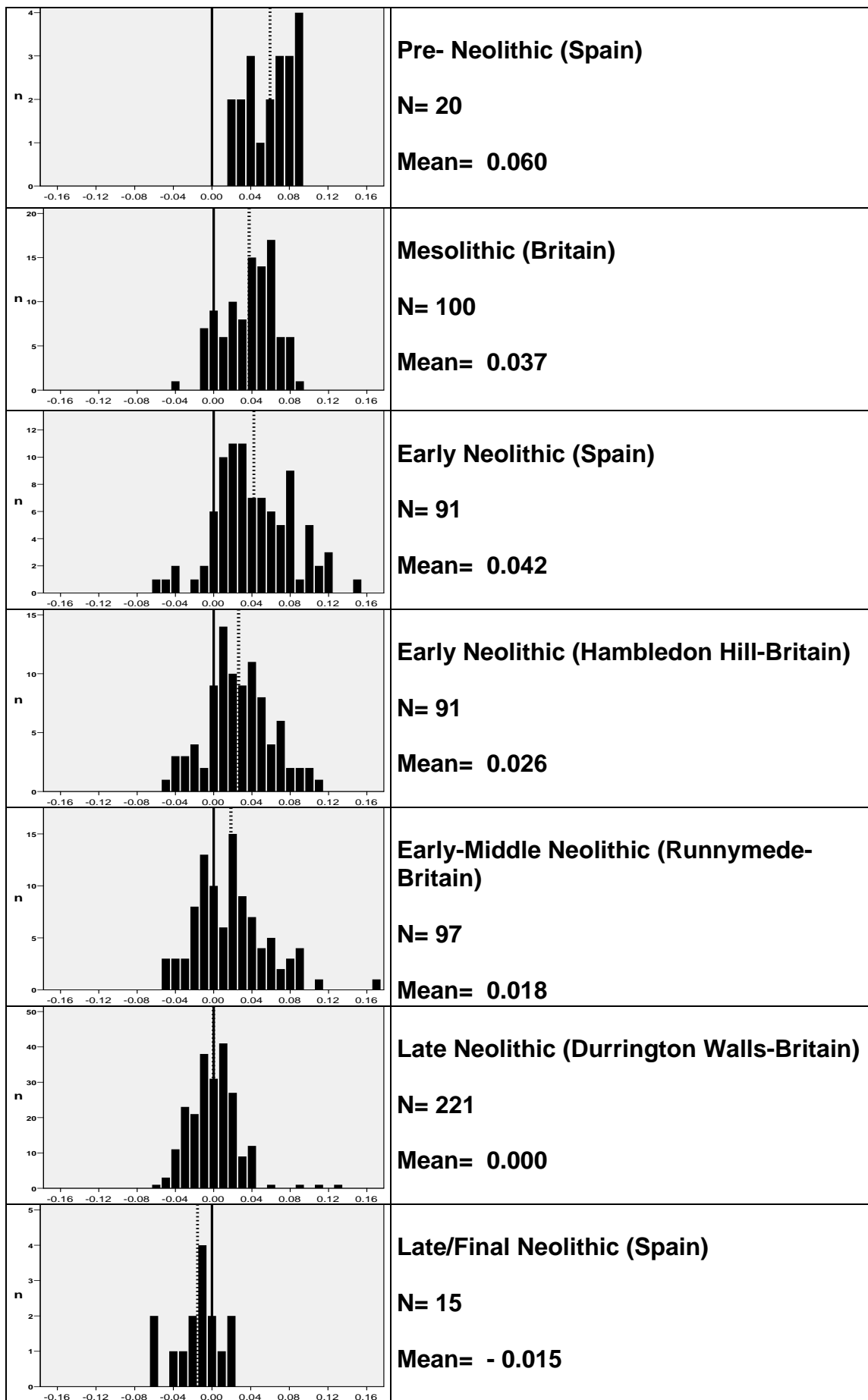


Figure 5.10: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) of Spanish and British specimens of pre-Neolithic and Neolithic chronology. Only fused specimens are plotted. The dotted line represents the mean value.

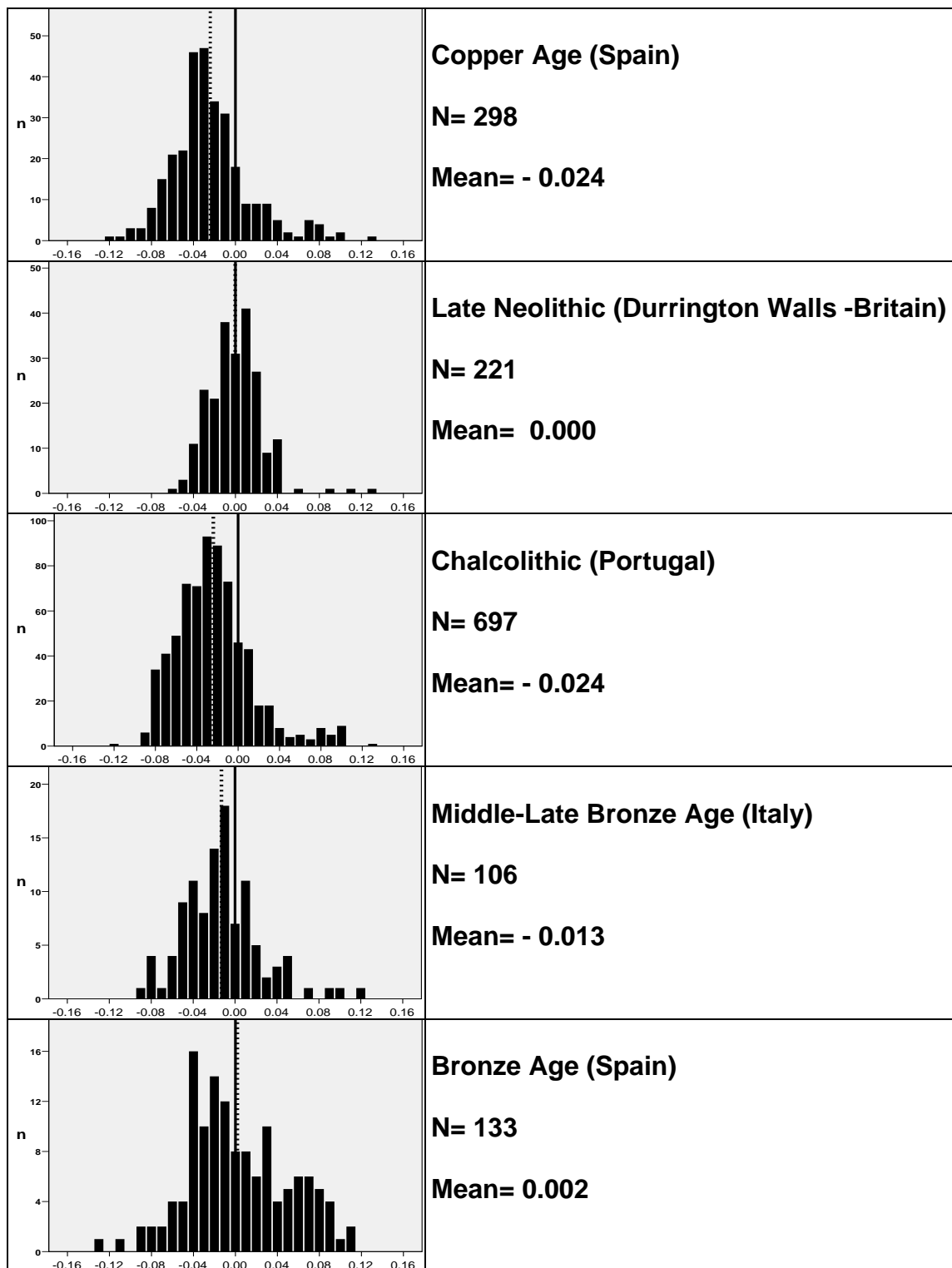


Figure 5.11: Log ratio histograms comparing pig postcranial measurements (excluding the length of the scapula neck) of Spanish, Portuguese, Italian and British specimens of Neolithic and post-Neolithic chronology. Only fused specimens are plotted. The dotted line represents the mean value.

5.1.2 Tooth Biometry

In this section the analysis conducted on pig teeth is presented and described in chronological order, although in some cases populations from other periods are included for comparative purposes (e.g. a post-Neolithic population is compared

with Neolithic and pre-Neolithic populations). The analysis is carried out mainly in the form of scatterplots and log ratio histograms. As for the postcranial data, the analysis of Spanish, Portuguese, Italian, and British tooth data is of particular interest in order to assess the level of size variation in pig populations at a European level. Furthermore, the comparison of tooth and postcranial measurements has the potential to offer additional information on the morphology of pigs in different countries and chronological periods.

In the following two figures, measurements from Spanish, Portuguese, Italian, and British assemblages of pre-Neolithic (figure 5.12) and Neolithic (figure 5.13) chronology are plotted. Portuguese pre-Neolithic specimens (figure 5.12) are on average the smallest, while Italian and British are the largest. The Spanish sample is unfortunately very small and rather inconsistent, with three specimens plotting at the very bottom of the distribution. The smallest of the Italian Mesolithic specimens all derive from Grotta dell'Uzzo, also mentioned for the postcranial measurements as a site with distinctly smaller-sized pigs. In the Neolithic (figure 5.13), a common tendency for greater size diversity is observed, which can be partly explained by the greater number of recorded specimens. In Spain, Portugal, Italy and Britain, there are some smaller and some larger Neolithic specimens than their pre-Neolithic predecessors.

In figure 5.14 the mandibular first molar measurements of post-Neolithic specimens from Spain, Portugal and Italy are compared with those of Spanish Early Neolithic specimens. The inclusion of the latter serves as a measure of comparison with the results presented in figure 5.13. In post-Neolithic periods, more than half of the specimens from Spain, Portugal and Italy are smaller than the smallest Spanish Early Neolithic specimens, despite the still significant overlap. There are, however, some Spanish (Copper) and Portuguese (Chalcolithic) specimens that are as large as their largest Early Neolithic counterparts.

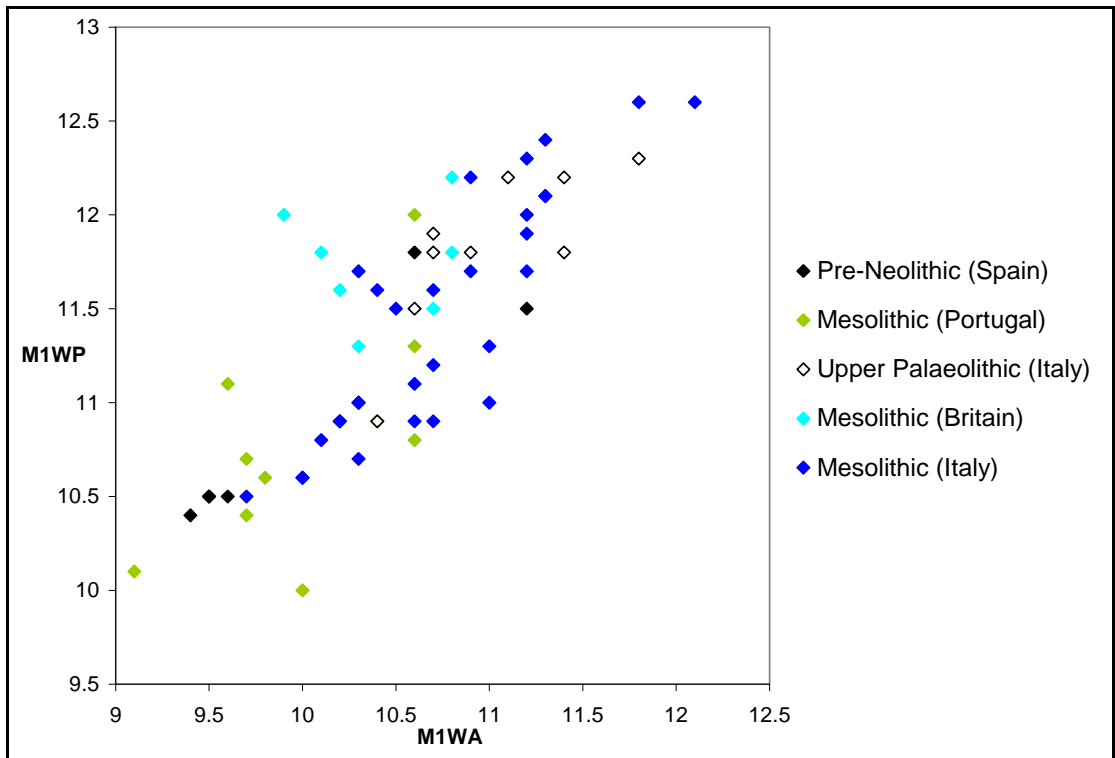


Figure 5.12: Scatterplot of anterior x posterior cusp width of mandibular permanent first molar from combined samples of pre-Neolithic chronology from Spain, Portugal, Italy and Britain. Measurements in mm.

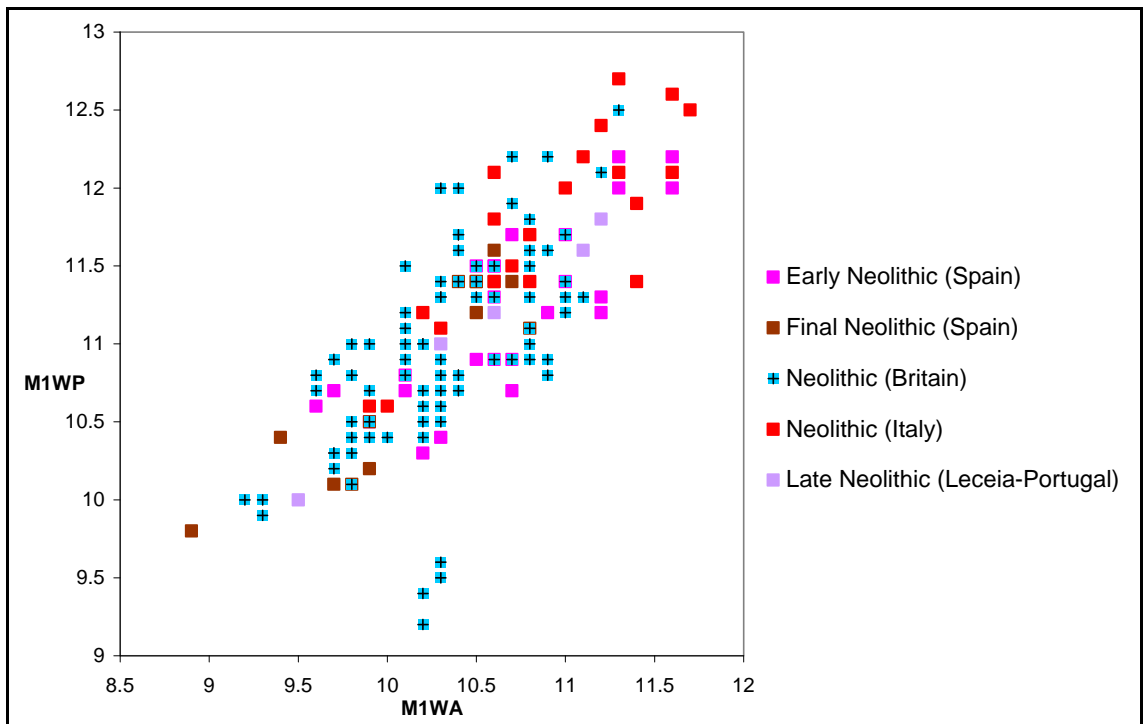


Figure 5.13: Scatterplot of anterior x posterior cusp width of mandibular permanent first molar from combined samples of Neolithic chronology from Spain, Portugal, Italy and Britain. Measurements in mm.

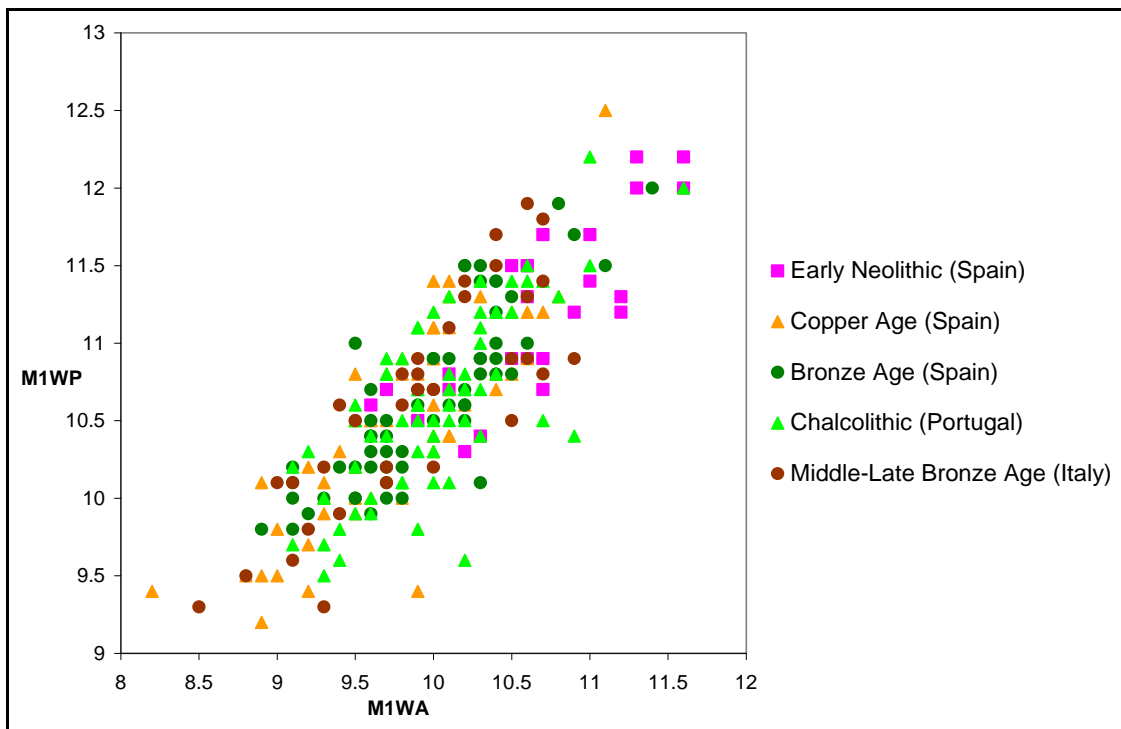


Figure 5.14: Scatterplot of anterior x posterior cusp width of mandibular permanent first molar from combined samples of post-Neolithic chronology from Spain, Portugal, Italy and Britain. The Early Neolithic Spanish sample is also included for comparative purposes. Measurements in mm.

In the following two figures, the width measurements of mandibular second molars are presented. All measurements derive from Spanish, Portuguese, Italian, and British assemblages of pre-Neolithic (figure 5.15) and Neolithic (figure 5.16) chronology. In general, these results are very similar to those produced for the first molar. For this reason, their description will concentrate on the few differences. Second molar measurements exhibit less overlap between the pre-Neolithic and Neolithic specimens. During the pre-Neolithic periods (figure 5.15), Spanish and Portuguese specimens are still on average the smallest. They plot next to a couple of small British Mesolithic specimens and the, particularly small, Italian Mesolithic specimens from Grotta dell’Uzzo. During the Neolithic (figure 5.16), there is broad size diversity in Spain with the scarce pre-Neolithic specimens plotting almost exactly in the middle of the distribution of Early Neolithic specimens. In Portugal, there are few Neolithic specimens, all of Late Neolithic chronology, but it is worth mentioning that two of them are smaller and one is larger than most Mesolithic specimens. In Italy, there is a tendency towards larger size during the Neolithic but there are also some specimens that are clearly smaller than their pre-Neolithic counterparts. In Britain, Neolithic specimens are clearly smaller than the Mesolithic, with the exception of two small Mesolithic specimens. Available only in Spain, Portugal

and Britain, Late Neolithic data tend to plot at the lower left end of the distribution with some large outliers at the opposite end of the distribution. For the British material this pattern is not as clear because the specimens from Late Neolithic Durrington Walls are pooled with the rest of the Neolithic specimens. However, the vast majority of the British Neolithic specimens that plot in the lower left part of the distribution derive from Durrington Walls. Also, Durrington Walls, despite being categorised as a Late Neolithic site in Britain, is chronologically later than the Late/Final Neolithic in Iberia and more compatible with the Copper Age or Chalcolithic period in Iberia (*cf.* 3rd millennium cal. BC).

In figure 5.17 the mandibular second molar widths of post-Neolithic specimens from Spain, Portugal and Italy are compared with those of Spanish Early Neolithic specimens as a measure of comparison with the results presented in figure 5.16. For the second molar there is less overlap between the post-Neolithic and the Spanish Early Neolithic than for the first molar. Around three quarters of the post-Neolithic specimens from Spain, Portugal and Italy are smaller than most Spanish Early Neolithic specimens. However, there are some Spanish (Copper Age), Portuguese (Chalcolithic) and Italian (Bronze Age) specimens that are as large as, and some even larger than, the largest Spanish Early Neolithic counterparts.

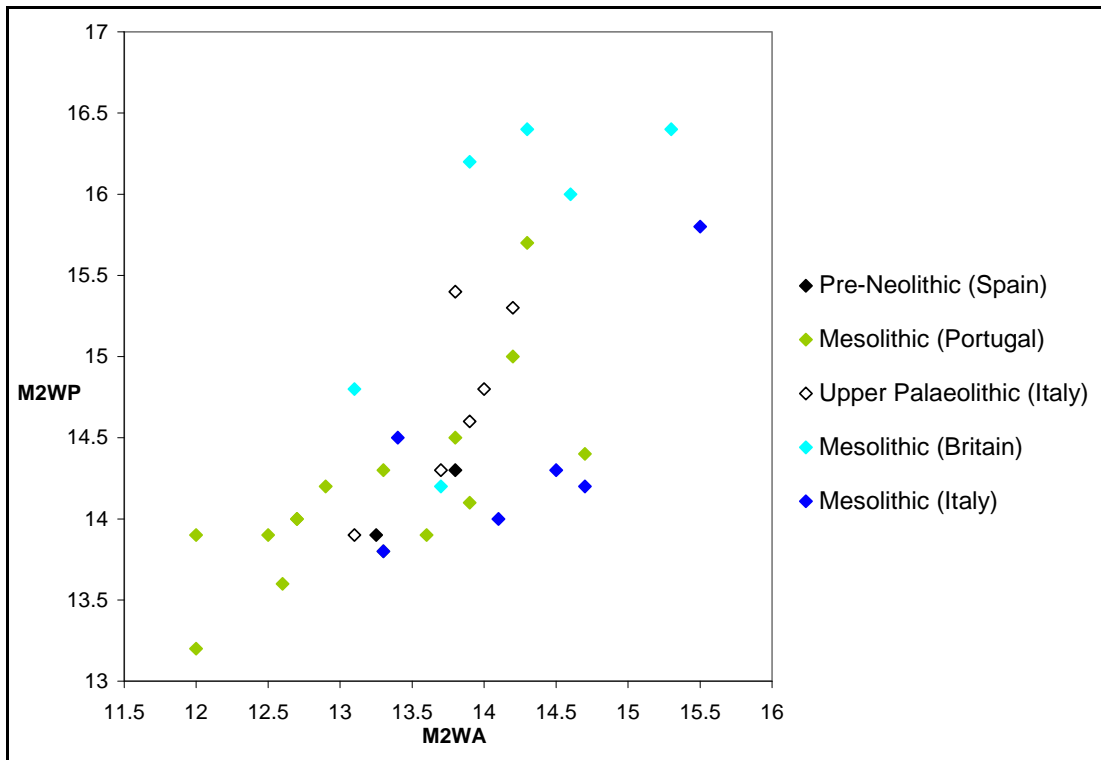


Figure 5.15: Scatterplot of anterior x posterior cusp width of mandibular permanent second molar from combined samples of pre-Neolithic chronology from Spain, Portugal, Italy and Britain. Measurements in mm.

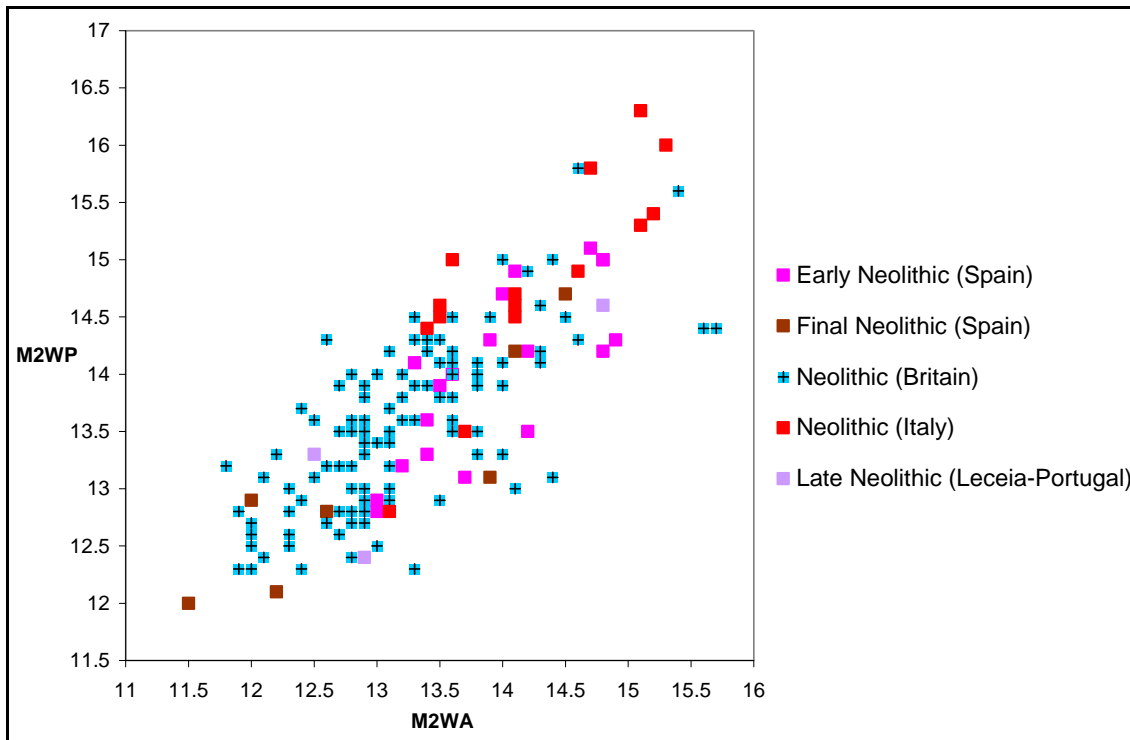


Figure 5.16: Scatterplot of anterior x posterior cusp width of mandibular permanent second molar from combined samples of Neolithic chronology from Spain, Portugal, Italy and Britain. Measurements in mm.

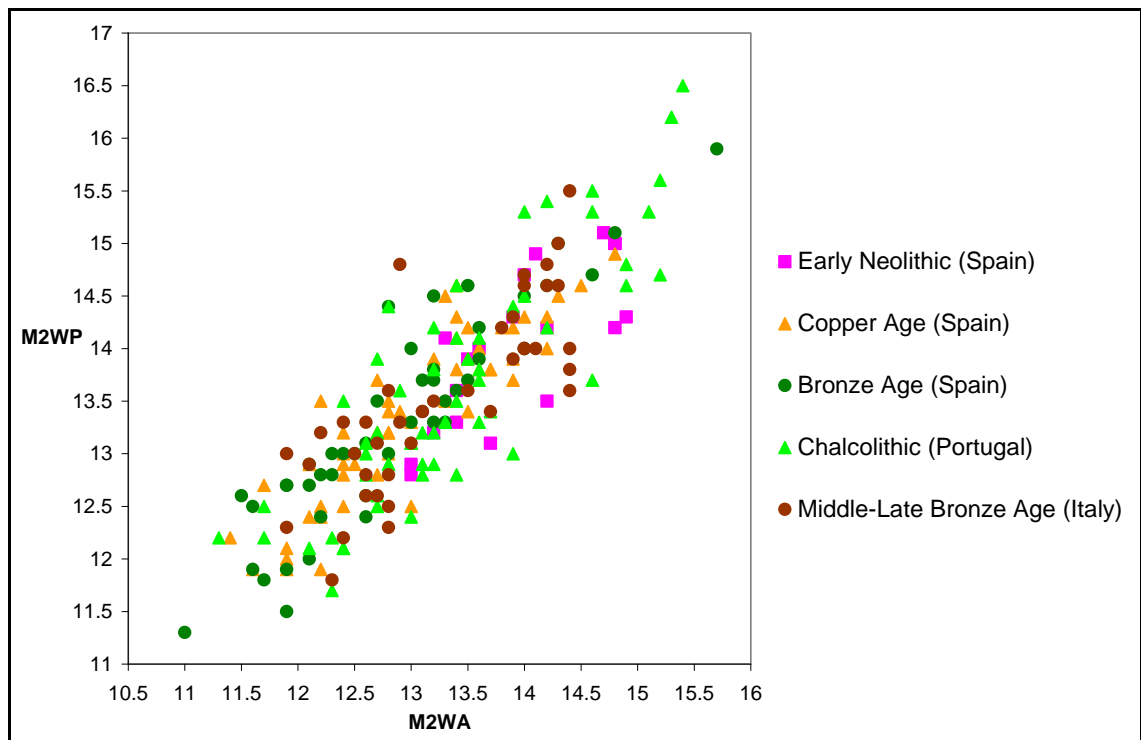


Figure 5.17: Scatterplot of anterior x posterior cusp width of mandibular permanent second molar from combined samples of post-Neolithic chronology from Spain, Portugal, Italy and Britain. The Early Neolithic Spanish sample is also included for comparative purposes. Measurements in mm.

In figure 5.18 widths of mandibular third molars are presented. All measurements derive from Spanish, Portuguese, Italian and British assemblages of pre-Neolithic (figure 5.19) and Neolithic (figure 5.20) chronology. As for the rest of the teeth, some of the samples are small and hence, caution is required in their interpretation. To some extent, the third molar widths results are similar to those of the first and second molar widths. Among the similarities are: the small size of Portuguese Mesolithic specimens, the similar size of pre-Neolithic and Neolithic Italian specimens, and the larger size of British Mesolithic compared to Neolithic specimens. However, in some other aspects the results of the third molar differ from those of the first and second molars. More specifically, there is no size overlap between Spanish pre-Neolithic and Neolithic specimens but this could be an artefact of the small sample sizes involved. The only two available Spanish pre-Neolithic specimens are much larger than their Portuguese Mesolithic counterparts. Although impossible to confirm with the present data, if this pattern is real and not an artefact of the small sample sizes, it may be explained by the chronological difference between the samples - the Spanish data being of Palaeolithic and the Portuguese of Mesolithic chronology.

In figure 5.21 the mandibular third molar measurements of post-Neolithic specimens from Spain, Portugal and Italy are compared with those of Spanish Early Neolithic specimens as a comparison with the results presented in figure 5.18. The pattern for the third molar is different than that described in figures 5.14 and 5.17 for the first and second molar respectively. In the case of the third molar, the Spanish Early Neolithic measurements are as small as the majority of post-Neolithic measurements, while in the first two molars there was a tendency towards larger size. In addition to this observation, there is a good number of post-Neolithic specimens, especially Spanish (Copper Age) and Portuguese (Chalcolithic), that are significantly larger than the largest Spanish Early Neolithic counterparts.

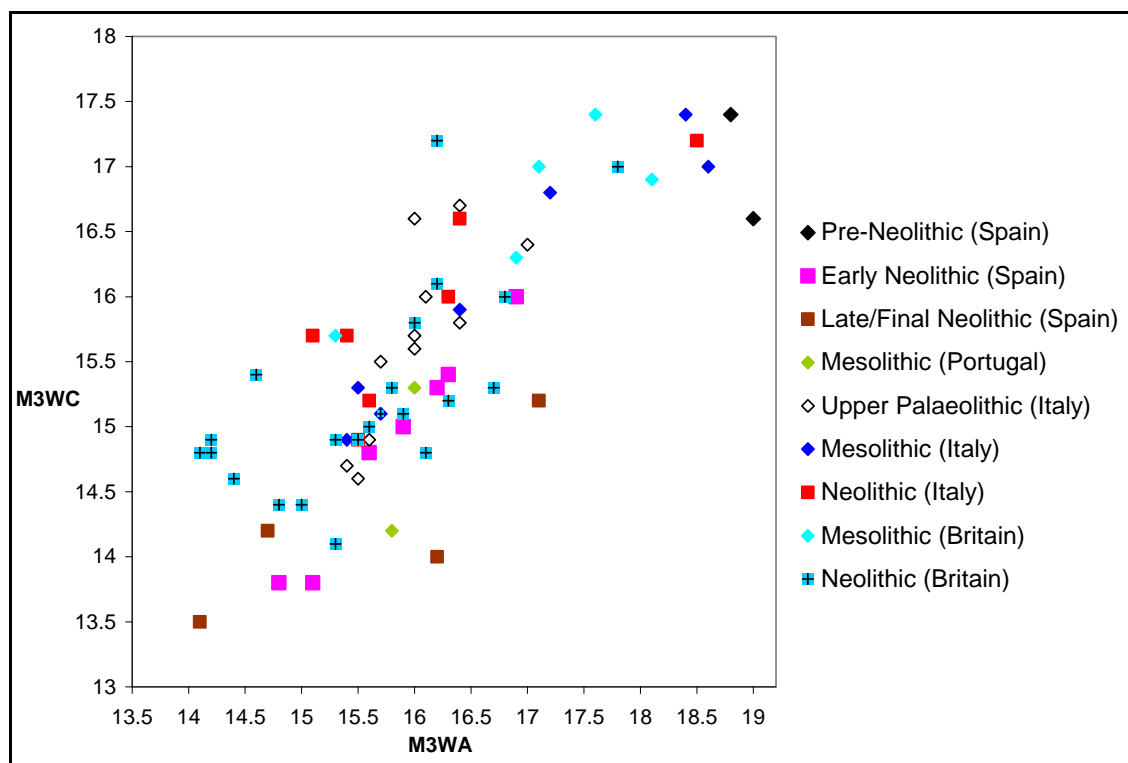


Figure 5.18: Scatterplot of anterior x central cusp width of mandibular permanent third molar from combined samples of pre-Neolithic, Early and Late/Final Neolithic chronology from Spain, Portugal, Italy and Britain. Measurements in mm.

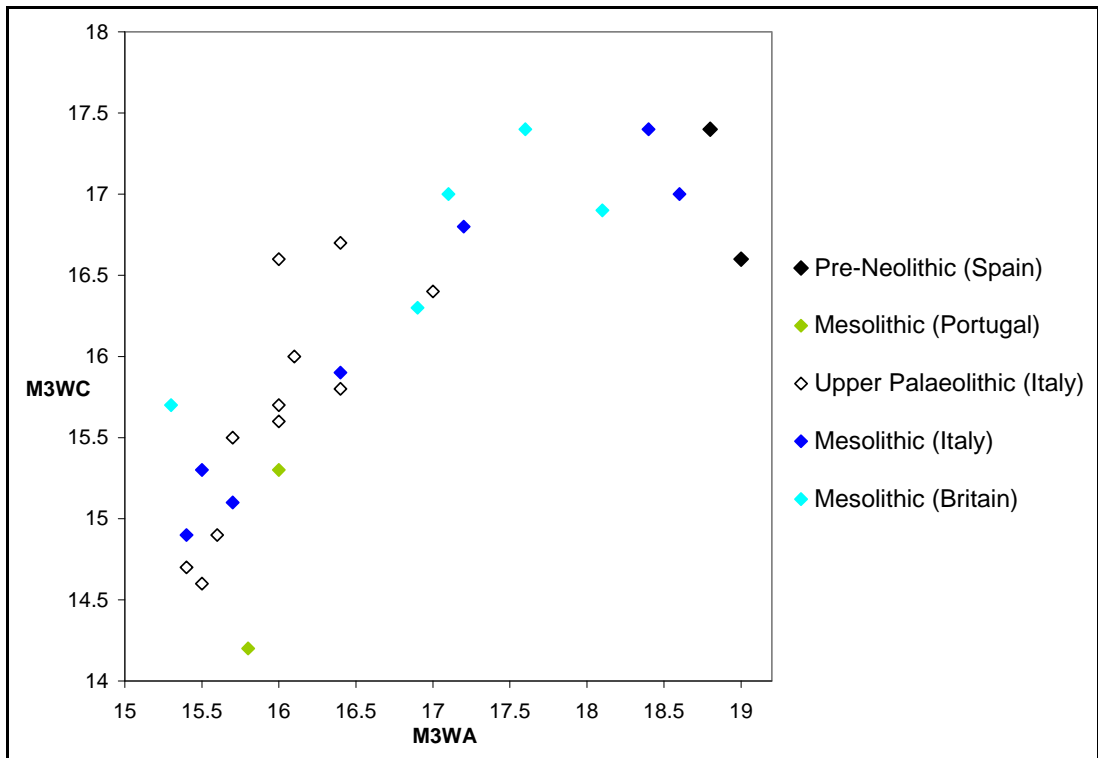


Figure 5.19: Scatterplot of anterior x central cusp width of mandibular permanent third molar from combined samples of pre-Neolithic chronology from Spain, Portugal, Italy and Britain. Measurements in mm.

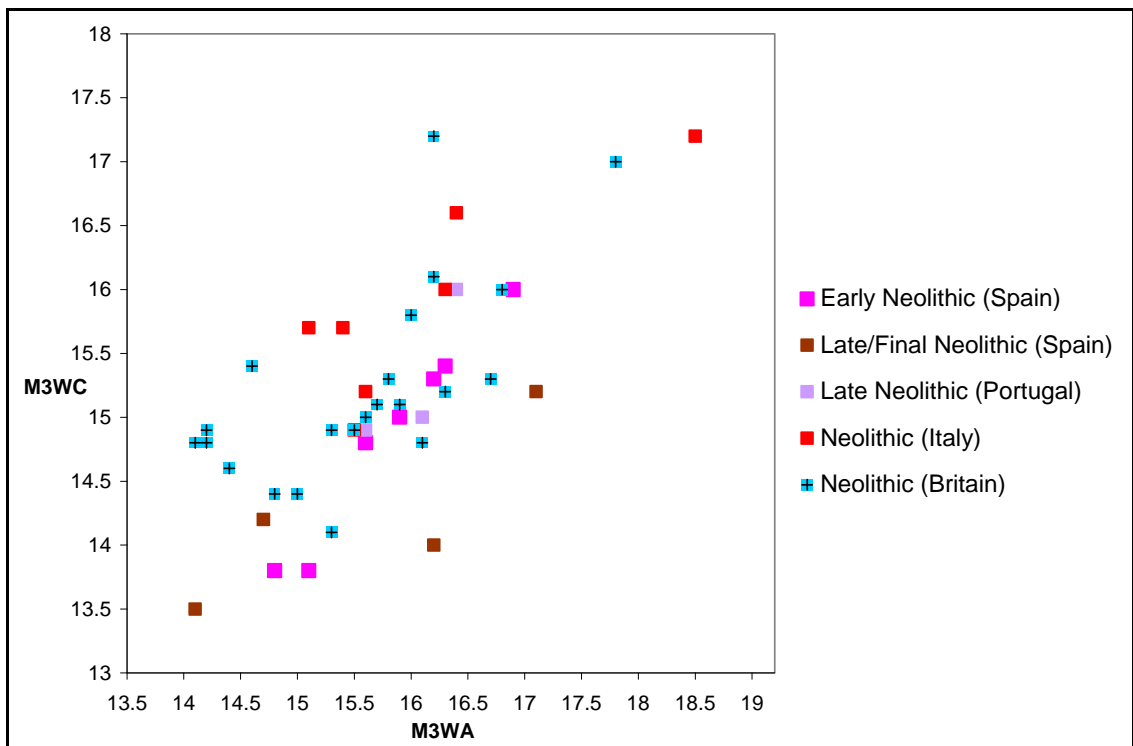


Figure 5.20: Scatterplot of anterior x central cusp width of mandibular permanent third molar from combined samples of Neolithic chronology from Spain, Portugal, Italy and Britain. Measurements in mm.

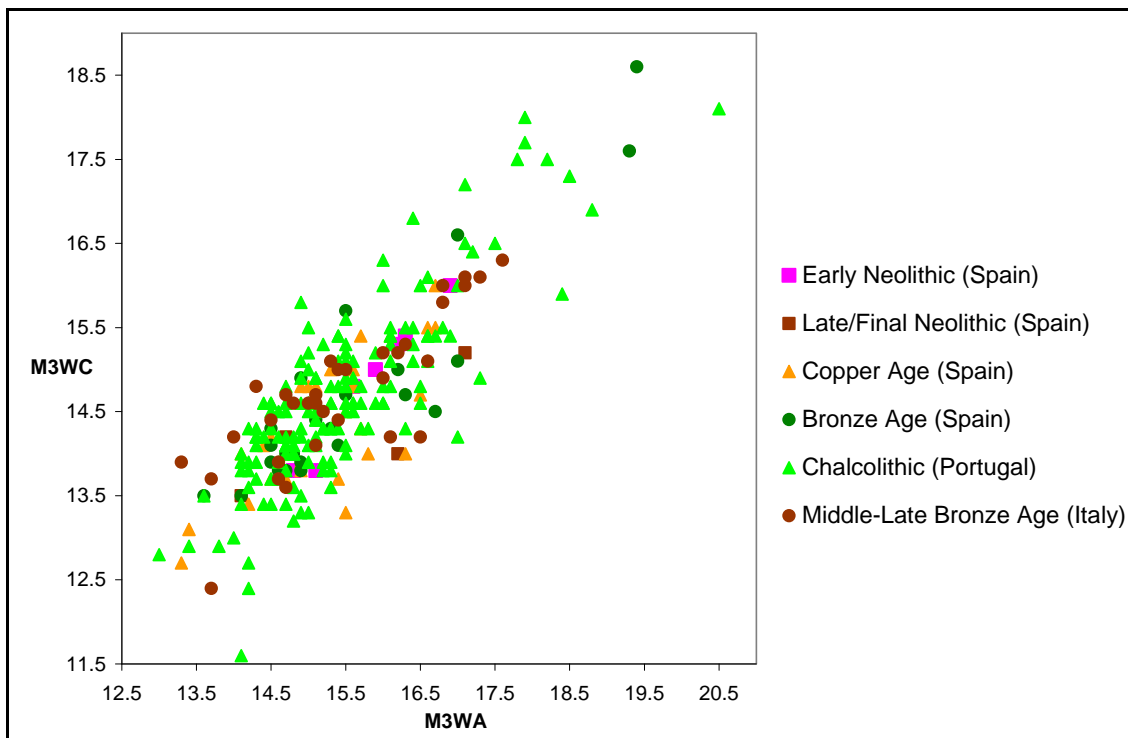


Figure 5.21: Scatterplot of anterior x central cusp width of mandibular permanent third molar from combined samples of post-Neolithic chronology from Spain, Portugal, Italy and Britain. The Early Neolithic Spanish sample is also included for comparative purposes. Measurements in mm.

The comparisons between measurements of the three permanent mandibular molars revealed that, despite the similarities, there are considerable differences in size fluctuations between periods and geographical areas. Even if it can be reasonably assumed that all molars were subjected to the same conditions - natural or anthropic - there seem to be differences in their adaptation to those conditions. The first molar measurements behave in a quite similar way to those of the second molar, but the third molar measurements, for some countries and periods, do not conform with the patterns observed for the first two molars. The general patterns of the first two molars are:

- Iberian pre-Neolithic and Italian Mesolithic (Grotta dell'Uzzo) specimens tend to be smaller compared to the Italian Upper Palaeolithic (excluding Grotta dell'Uzzo) and British Mesolithic specimens
- Spanish Early Neolithic specimens show a broad range of sizes, as do the Italian Neolithic specimens, with some specimens being larger and some smaller than their pre-Neolithic counterparts
- In Britain, a reduction in size occurred after the Mesolithic making the Neolithic specimens smaller

- Late/Final Neolithic specimens from Iberia are considerably smaller than their Early Neolithic and pre-Neolithic counterparts, excluding few equally large or larger outliers
- In post-Neolithic periods, the majority of specimens from Iberia and Italy are clearly and significantly smaller than their Early Neolithic and pre-Neolithic counterparts. Although not separately plotted, the same holds true for the roughly contemporaneous (3rd millennium) assemblage of Late Neolithic Durrington Walls in Britain

The patterns exhibited by the third molar measurements that deviate from the patterns described above are:

- Pre-Neolithic samples are very small but they show that the Spanish pre-Neolithic, as well as the British and Italian (excluding Grotta dell'Uzzo) Mesolithic specimens are the largest, while the Italian Palaeolithic and Mesolithic from Grotta dell'Uzzo, and the Portuguese Mesolithic are the smallest specimens
- Spanish Early Neolithic specimens are significantly reduced in size compared to their predecessors and have a size similar to that of the Late/Final Neolithic and post-Neolithic specimens
- The size of the largest post-Neolithic third molars from Spain is significantly larger than the Early Neolithic and even larger than the pre-Neolithic size

Additionally to the scatterplots, log ratio histograms have been produced to compare the tooth size of pigs in Spain, Portugal, Italy, France and Britain during pre-Neolithic, Neolithic and post-Neolithic periods (figures 5.22, 5.23, 5.24 and 5.25). As for scatterplots, all crown lengths are excluded from the analyses to increase comparability with the data collected by other researchers and avoid age-related patterns.

The histograms in figure 5.22 offer an overview of tooth size in pre-Neolithic, Neolithic and Copper Age/Chalcolithic Spain and Portugal. The Spanish pre-Neolithic - mostly Palaeolithic - specimens are slightly larger than the Portuguese Mesolithic specimens, which are also marginally smaller than the Spanish Early Neolithic specimens. The Spanish Final Neolithic specimens

have a clearly reduced size compared to their Early Neolithic counterparts. No Portuguese Neolithic data were available, but the Chalcolithic data reveal a slight reduction in tooth size, probably occurring at some point during the Neolithic period. The Spanish Final Neolithic and Copper Age specimens are on average slightly smaller than the Portuguese Chalcolithic, possibly as a consequence of the lack of a large 'tail' in the Spanish sample.

The histograms in figure 5.23 present the tooth size of pre-Neolithic and Neolithic pigs in Spain and Italy. The Spanish pre-Neolithic pigs are clearly smaller in tooth size than their Italian counterparts, both Palaeolithic and Mesolithic. During the Early Neolithic in Spain and the Neolithic in Italy, the means of all measurements remain fairly similar to those of pre-Neolithic specimens but, especially in Spain, the distribution is broader, at least partly as a consequence of the larger sample. In Spain, only by the Final Neolithic a notable size reduction occurs.

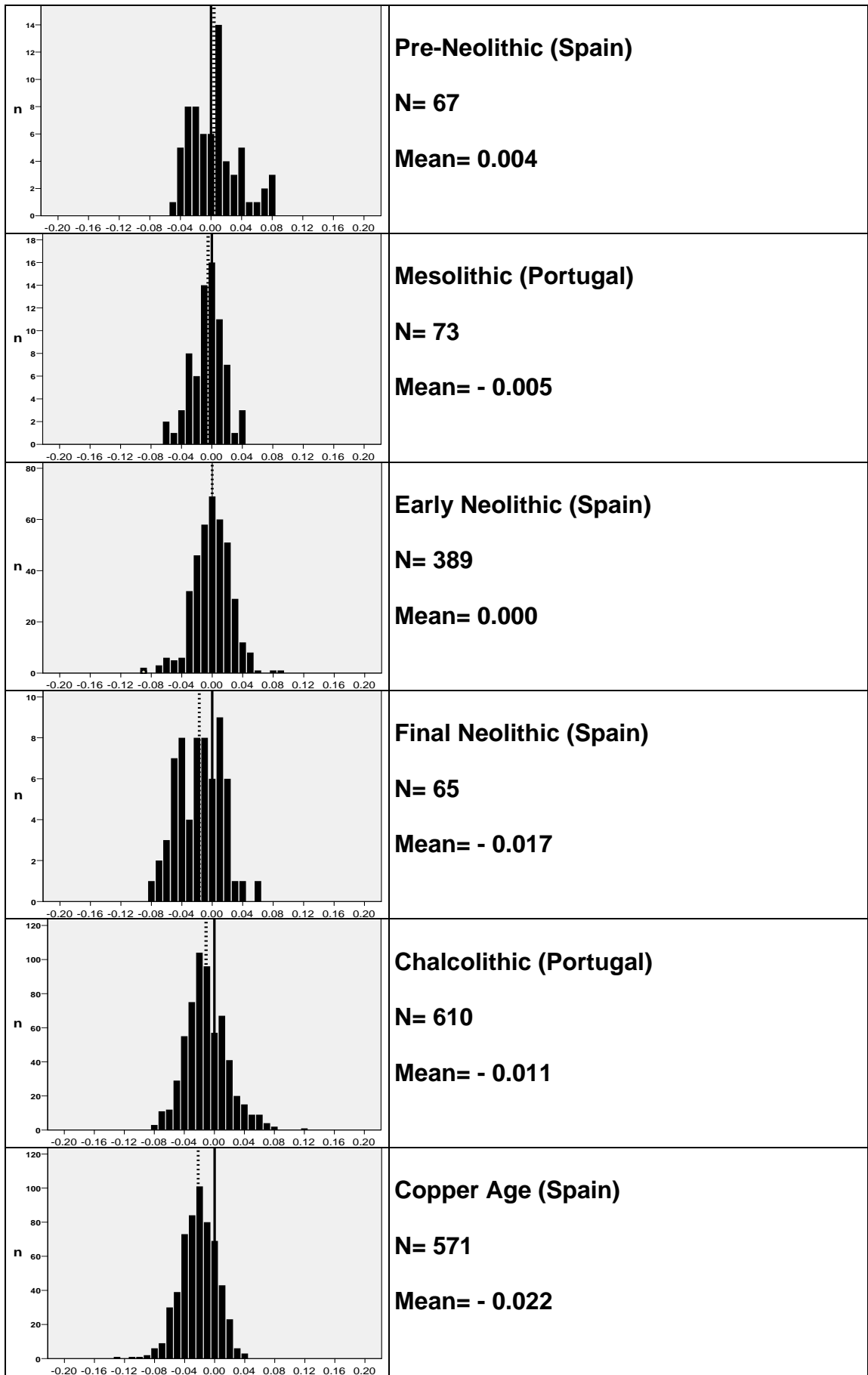


Figure 5.22: Log ratio histograms comparing pig tooth measurements of Spanish and Portuguese specimens of pre-Neolithic, Neolithic and post-Neolithic chronology.

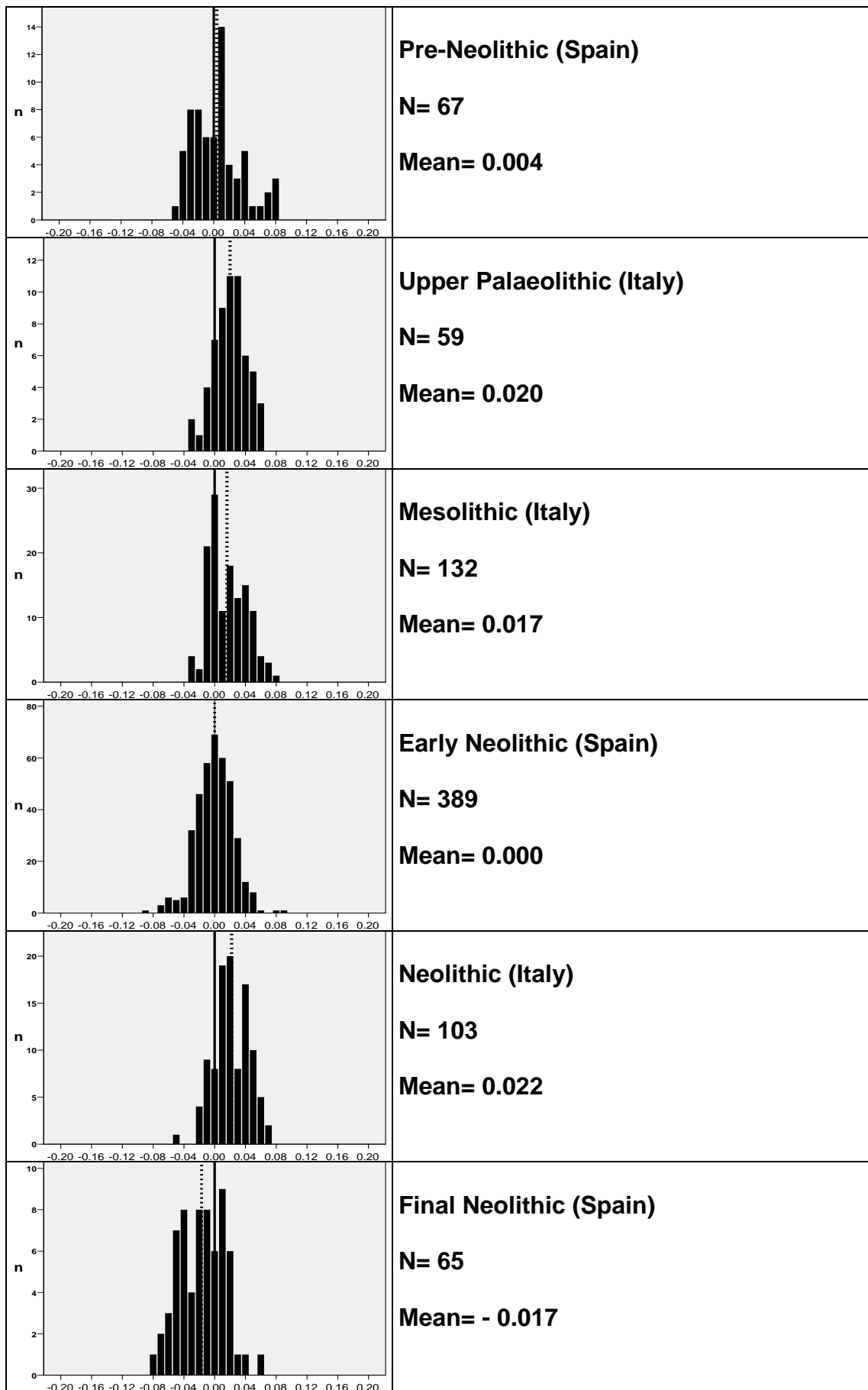


Figure 5.23: Log ratio histograms comparing pig tooth measurements of Spanish and Italian specimens of pre-Neolithic and Neolithic chronology.

The histograms in figure 5.24 offer an overview of the tooth size of pre-Neolithic and Neolithic pigs in Spain and Britain. Contrary to the postcranial measurements, the teeth of Spanish pre-Neolithic pigs are smaller than those of British Mesolithic pigs. The Spanish Early Neolithic and British Early-Middle Neolithic have a fairly similar mean tooth size. These periods are not strictly contemporaneous (some Spanish Early Neolithic sites included in the analysis are at least a millennium earlier than the British Early-Middle Neolithic sites) but they are compared here to examine the evolution of biometric patterns in the two areas. The distributions of measurements differ. In the British distribution there is a 'tail' of larger individuals, while in the Spanish distribution there is a more prominent 'tail' of smaller individuals and a less prominent 'tail' of larger individuals. By the Final Neolithic, in Spain tooth size is clearly reduced but for Britain size reduction is barely visible in the distribution of Late Neolithic Durrington Walls (a site of later chronology than the Spanish Final Neolithic). It is interesting that the general trend towards a reduction of dental size during the Neolithic is mirrored in the postcranial measurements but size reduction was much sharper than in dental elements.

The histograms in figure 5.25 offer an overview of tooth size in Spain, Portugal, Italy and Britain during the 3rd and 2nd millennia cal. BC. During the 3rd millennium (roughly equivalent to the Copper Age in Spain, the Chalcolithic in Portugal, and the Late Neolithic in Britain), the Spanish pigs had the smallest size, followed by the Portuguese and British pigs. It has been well-established by all results presented in this section that the size of Spanish pigs reduced dramatically from the Early Neolithic onwards. The result of this trend is that by the 3rd millennium, Spanish pigs were on average smaller, both in postcranial and dental size, than their Portuguese and especially their British counterparts.

During the 2nd millennium (Bronze Age), Spanish and Italian pigs had a similar tooth size, which was intermediate between that of Spanish and Portuguese pigs. In Italy, though we are lacking Copper Age data, a significant size reduction becomes apparent when Bronze Age size is compared with the Neolithic.

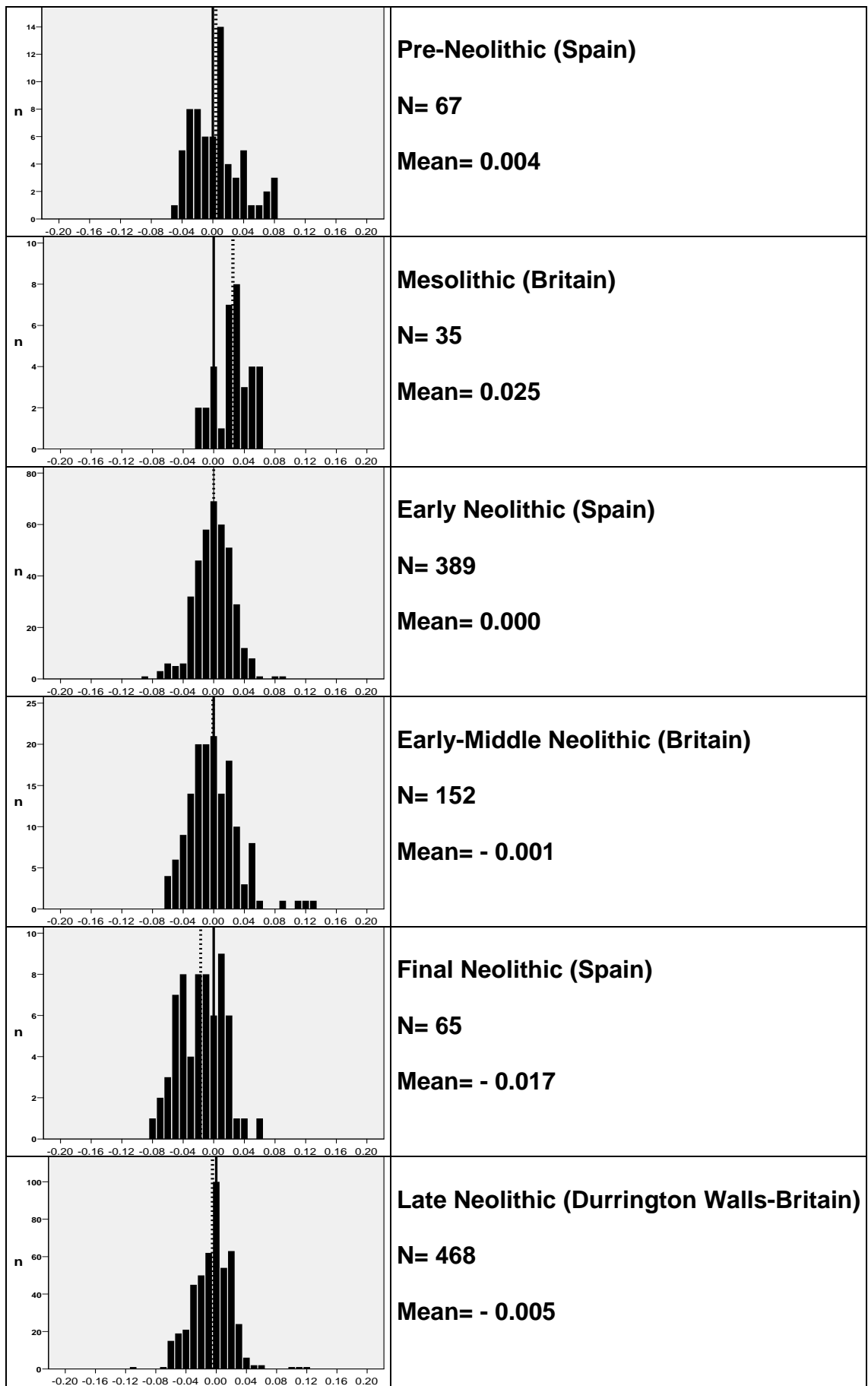


Figure 5.24: Log ratio histograms comparing pig tooth measurements of Spanish and British specimens of pre-Neolithic and Neolithic chronology.

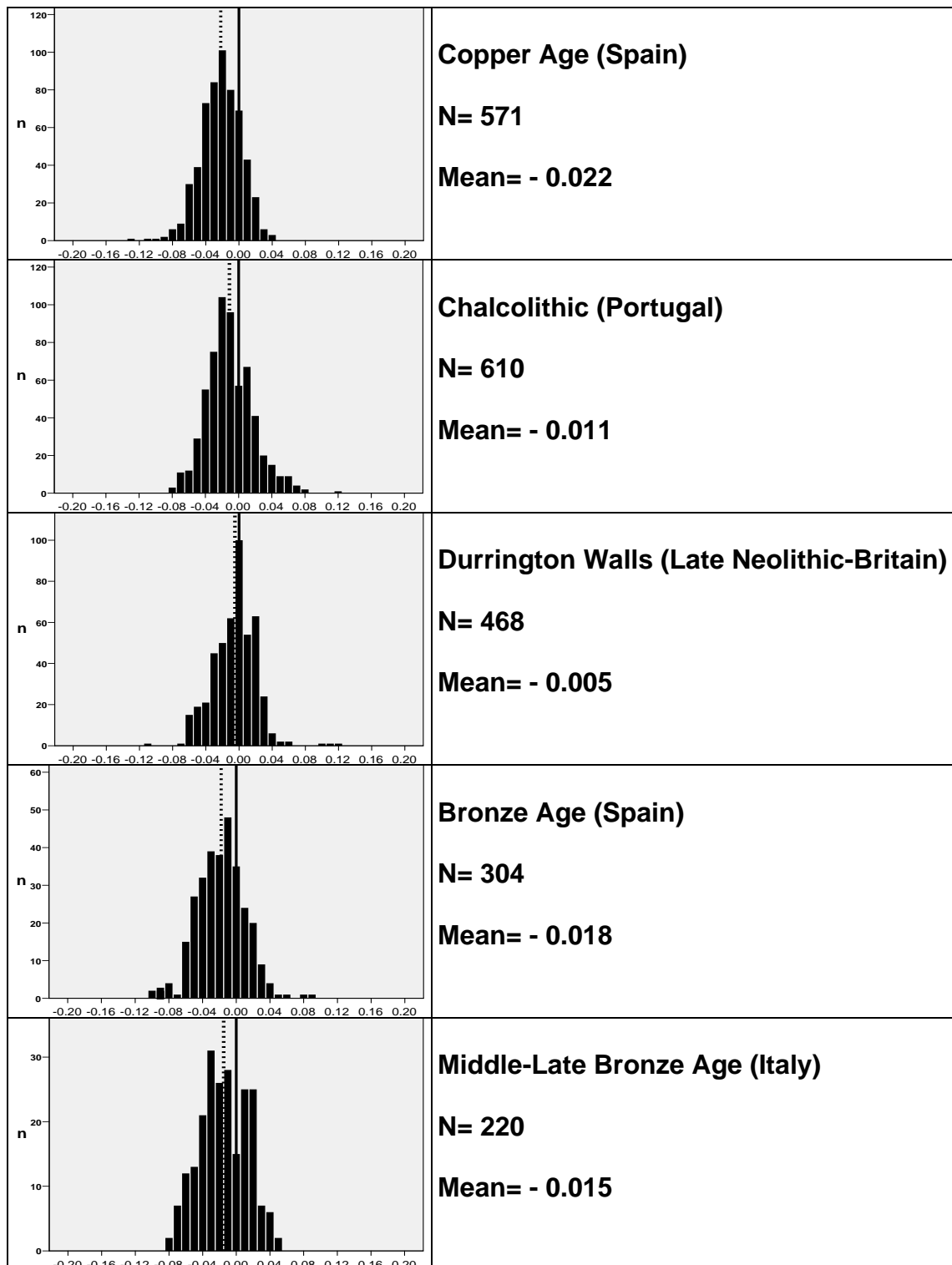


Figure 4.25: Log ratio histograms comparing pig tooth measurements of Spanish, Portuguese, Italian and British specimens of Neolithic and post-Neolithic chronology.

5.1.3 Postcranial-dental size comparison

In order to obtain an overview and compare size fluctuations in bones and teeth occurring before, during, and after the Neolithic, various graphs based on the log ratio mean values of all recorded measurements were produced (figures 5.26-5.31). Although the relationship between postcranial and dental elements

has been sporadically discussed earlier in this chapter, the graphs illustrate this relationship in a summarised form. The relationship between postcranial and dental size is explored first country by country for Spain, Portugal, Italy and Britain. Subsequently, all countries are compared, separately for postcranial and dental size.

5.1.3.1 Spain

Since the relationship between postcranial and dental size for Spain has been extensively presented in chapters 3 and 4 (figures 3.36 and 4.153) it will only be summarised in this section. According to figure 5.26, pigs in Spain had consistently larger bones than teeth (in comparison to the standard) during the pre-Neolithic and Early Neolithic periods. The clear reduction in both bone and tooth size in the Early Neolithic affected bones much more than teeth. The sharpest size decrease in bones and teeth occurred from the Early to the Late Neolithic (6th-4th millennium/beginning of 3rd millennium cal. BC). In the 4th millennium cal. BC, bone and tooth sizes became proportionate to those of the standard population (Durrington Walls, Britain) and at the same time rather different from earlier forms. In the Copper Age (ca. 3rd millennium cal. BC) the proportions remained the same but further size reduction occurred; though not as sharp as in the Neolithic. During the Bronze Age (ca. 2nd millennium cal. BC), there is a slight increase in dental and a significant increase in postcranial size. This increase of average size in the Bronze Age is almost certainly due to an increase in the hunting of the larger-sized wild boar and not a genuine increase in the size of domestic pigs. In the Iron Age (ca. 1st millennium cal. BC), bone and tooth sizes were proportionate once more, as in the Late Neolithic, Copper, and possibly Bronze Age, at least concerning domestic pigs. Compared to all their predecessors, the Iron Age pigs were clearly the smallest in Spanish prehistory. In summary, this diagram shows that Spanish domestic pigs, at least from the Late Neolithic onwards, had a similar tooth:bone size ratio to Late Neolithic domestic pigs from Britain. Wild boar, however, had much larger bones than teeth and this affects the value not only for the pre-Neolithic but also for the 6th-5th and 2nd millennia, which include a rather substantial wild boar component (clearly defined for the Bronze Age, and much more difficult to pinpoint in the Early Neolithic).

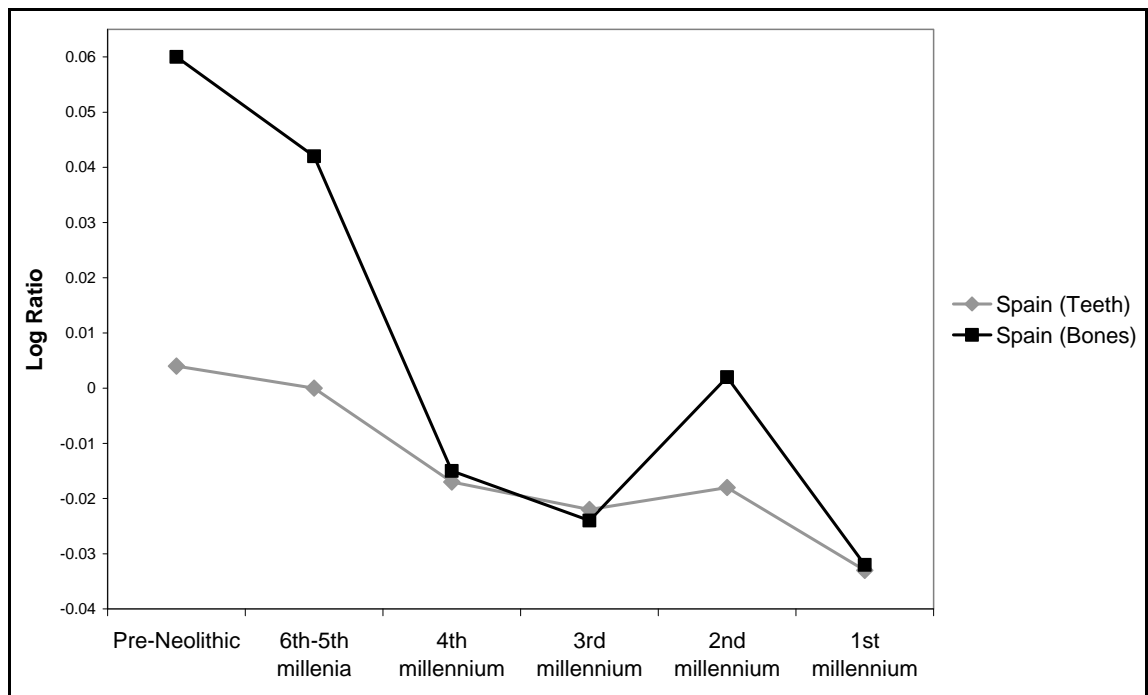


Figure 5.26: Graph illustrating the relationship between bone and tooth size through Spanish prehistory (ca. 10th-1st millennium cal. BC) based on the mean log ratio values of all recorded measurements (excluding the length of scapula neck for postcranial).

5.1.3.2 Portugal

For Portugal, data are only available for two periods, the pre-Neolithic (Mesolithic) and Copper Age (ca. 3rd millennium cal. BC). Figure 5.27 shows that significant size reduction(s) occurred in the four millennia from the Mesolithic to the Copper Age, but this was much sharper in bones than teeth. The situation is therefore similar to Spain, with domestic pigs having proportionately smaller bones. In Portugal, however, the difference is even more marked with Chalcolithic pigs having bones that are proportionately smaller even than the British Late Neolithic standard.

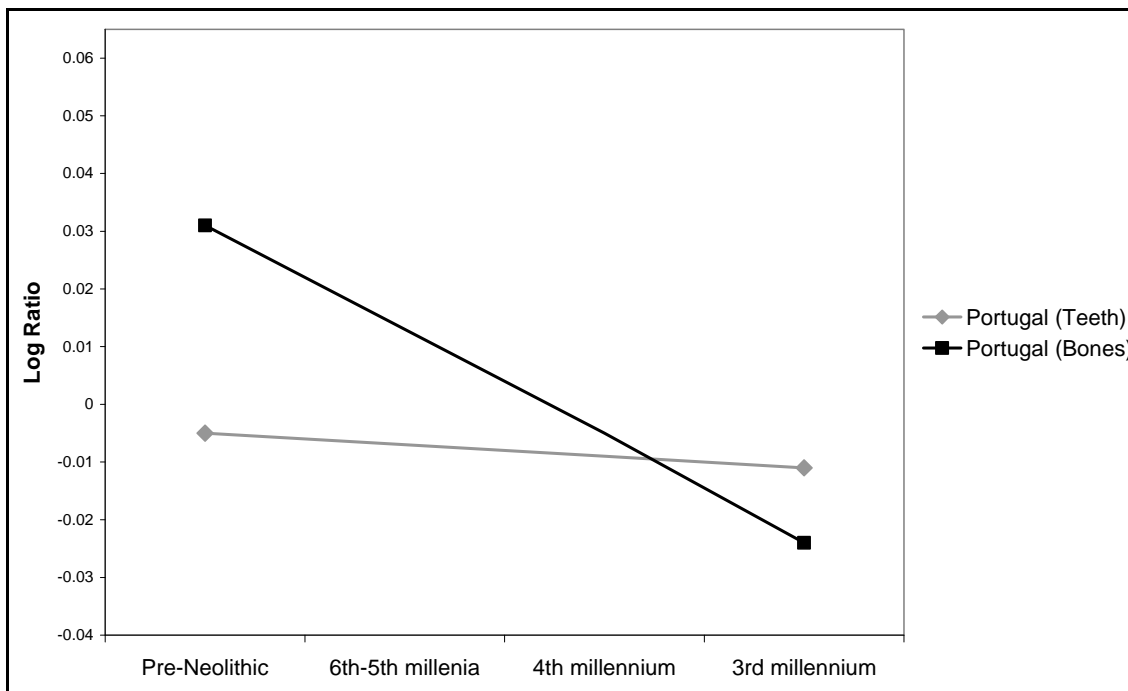


Figure 5.27: Graph illustrating the relationship between bone and tooth size for the Mesolithic and the Chalcolithic periods (*ca.* 7th-3rd millennia cal. BC) in Portugal, based on the mean log ratio values of all recorded measurements (excluding the length of scapula neck for postcranial).

5.1.3.3 Italy

For Italy, data are available for the pre-Neolithic (Palaeolithic and Mesolithic), the Early Neolithic (*ca.* 6th-5th millennia cal. BC), and the Bronze Age (*ca.* 2nd millennium cal. BC). Unlike the situation in Spain, figure 5.28 shows that in Italy the postcranial size reduced only marginally and the dental size even increased slightly from the pre-Neolithic to the Early Neolithic. If we assume that the sample of Italian Neolithic pigs includes both smaller-sized domestic and larger-sized wild animals, the produced pattern can be explained either by an increase in size of wild boar and/or a strong genetic contribution of the local wild boar to the Neolithic domestic stock. Without sufficient data for the later Neolithic and Copper Age, the next period for which data are available is the Bronze Age. As it was the case in Spain from the Late Neolithic onwards, during the Bronze Age in Italy the relation between the postcranial and dental size is proportionate to that of the standard population, resulting from a sharper size decrease in postcranial than dental elements. Overall, the size of Bronze Age Italian pigs is significantly reduced from that of their Early Neolithic and pre-Neolithic counterparts.

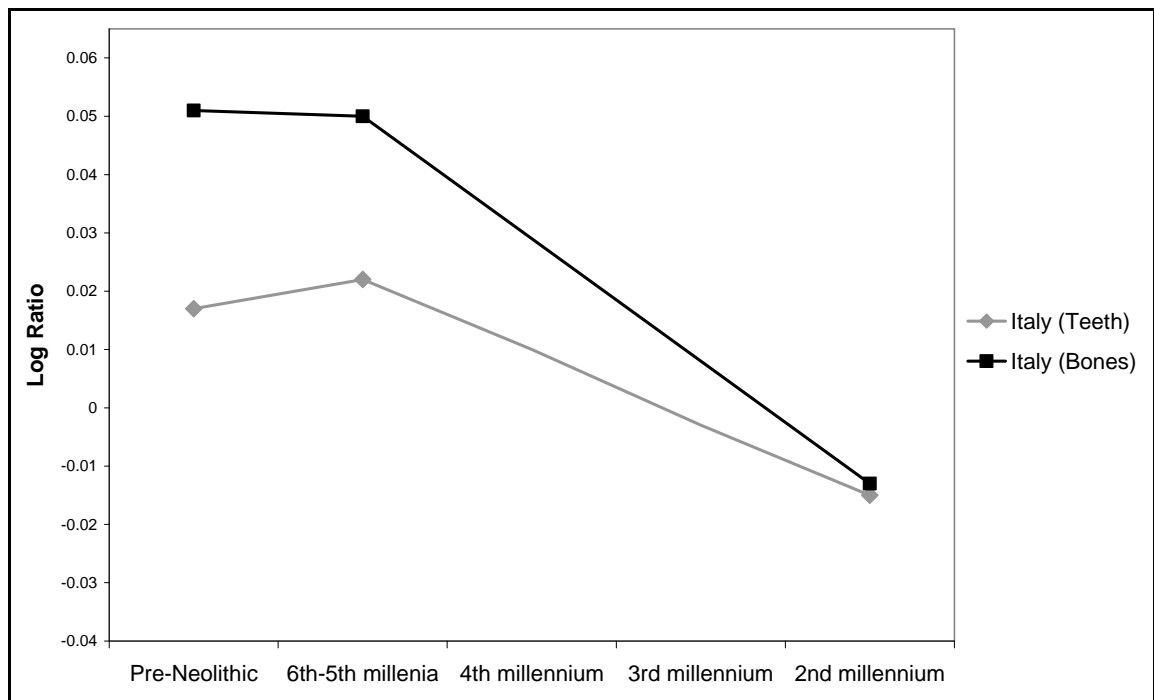


Figure 5.28: Graph illustrating the relationship between bone and tooth size for the pre-Neolithic, Neolithic and Bronze Age (*ca.* 10th-2nd millennia cal. BC) in Italy, based on the mean log ratio values of all recorded measurements (excluding the length of scapula neck for postcranial).

5.1.3.4 Britain

For Britain, data are available (figure 5.29) for the pre-Neolithic (Mesolithic), the Early Neolithic (assemblage of Hambledon Hill-*ca.* late 5th millennium cal. BC), Early-Middle Neolithic (assemblage of Runnymede Bridge-*ca.* late 4th and first half of 3rd millennium cal. BC), and the Late Neolithic (assemblage of Durrington Walls-*ca.* 3rd millennium cal. BC). As in other countries, in pre-Neolithic Britain pigs had relatively larger bones than teeth. In the Early and Middle Neolithic, a size reduction in both bones and teeth took place; as it was the case in Spain, Italy and probably Portugal. Unlike the other countries though, in Early-Middle Neolithic Britain the size reduction affected teeth slightly more than bones. In the Late Neolithic in Britain, which was roughly contemporary with the Copper Age in Iberia, postcranial size reduced further while tooth size increased. As a result, the bone:tooth size ratio of British Late Neolithic pigs (which represents the used standard) is similar to that exhibited by Spanish post-Neolithic and Italian Bronze Age samples.

The difference in the behaviour of dental size between Britain, and Spain and Italy from the pre-Neolithic to the Neolithic is intriguing. As is well-documented, bones are more plastic than teeth and hence, exhibit sharper size changes as a

response to environmental stimuli (Payne and Bull 1988). It was argued earlier that local wild populations, at least in Spain and Italy, probably contributed genetically to the Early Neolithic domestic stock and that is why they exhibit a similar tooth size to that of the pre-Neolithic wild boar. In Britain, the sharp reduction in dental size suggests a greater contribution of genetically distinct, introduced domestic stock. A genetic contribution of local wild boar to the Neolithic domestic stock cannot be excluded, but it was probably limited. In the archaeological record of Britain, there is a chronological gap of up to one millennium between the latest Mesolithic and the earliest Neolithic (Albarella and Pirnie, in prep). During that period, either the tooth size of the local wild boar had changed dramatically or – more likely - a domestic form of pig with smaller tooth size was introduced. Of course, these interpretations of Spanish, Italian and British data are based only on biometry only.

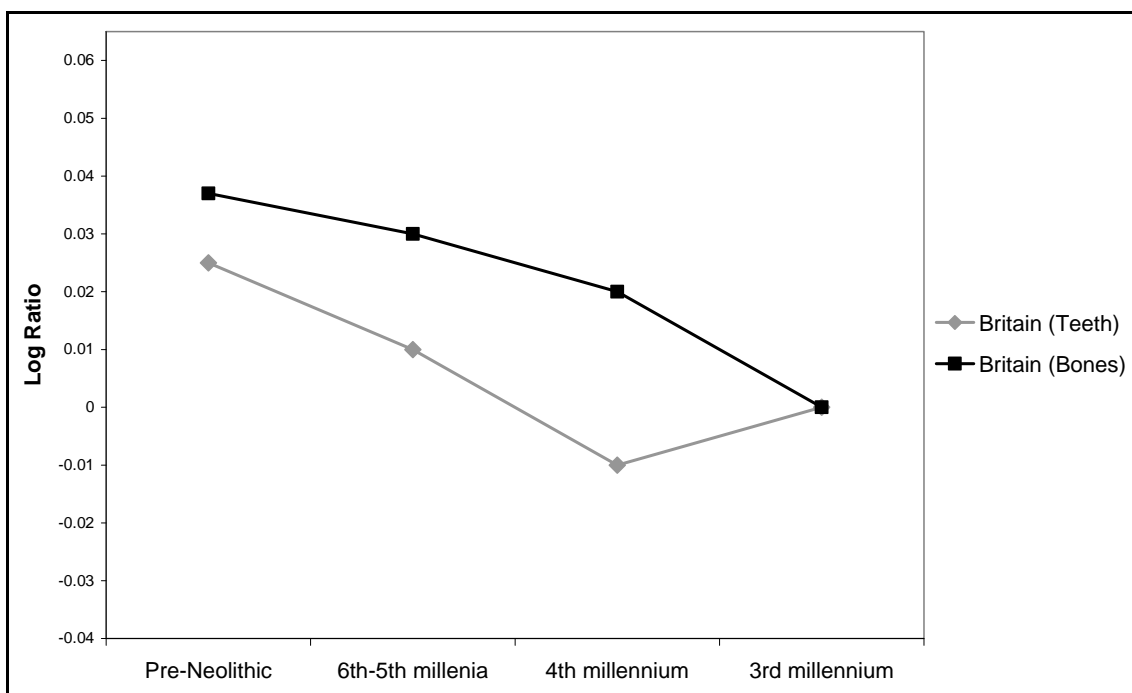


Figure 5.29: Graph illustrating the relationship between bone and tooth size for the Mesolithic and the Neolithic (ca. 7th-3rd millennia cal. BC) in Britain, based on the mean log ratio values of all recorded measurements (excluding the length of scapula neck for postcranial).

In addition to the presentation of measurements country by country, the postcranial (figure 5.30) and dental (figure 5.31) data are presented separately, for all countries.

In figure 5.30 the postcranial size of Spanish, Portuguese, Italian and British pigs of different periods is compared. In pre-Neolithic periods, the Spanish wild

boar was the largest, followed closely by the Italian. The British wild boar is similar in postcranial size to the Portuguese, but both are clearly smaller than their Spanish and Italian counterparts. Chronology is quite broad in the pre-Neolithic samples because they include both Mesolithic and Upper Palaeolithic specimens and this may partly contribute to the described pattern. The two samples exhibiting the largest postcranial size, i.e. Spanish and Italian, also include specimens of Upper Palaeolithic chronology, while the British and Portuguese specimens are all of Mesolithic chronology.

In the 6th-5th millennia cal. BC (*cf.* Early Neolithic), there are samples available from Spain, Italy and Britain. In all three countries, a size reduction took place but the least affected sample is the Italian one which is on average the largest but still similar to the Spanish. Postcranial size reduction can be characterised as sharp in Spain, moderate in Britain, and almost none in Italy. For the 4th millennium cal. BC data are available from Spain (Late/Final Neolithic sample) and Britain (Middle Neolithic assemblage from Runnymede Bridge). In Spain, the postcranial size of pigs decreased sharply, while in Britain size decreased moderately.

For the 3rd millennium cal. BC, data are available from Spain (Copper Age), Portugal (Chalcolithic), and Britain (Late Neolithic assemblage of Durrington Walls). The trend towards a postcranial size reduction, noted in the preceding period, continues into the 3rd millennium cal. BC in both Spain and Britain, though in absolute size the British pig is clearly larger than the Spanish. It is interesting that, despite the Spanish pre-Neolithic wild boar being the largest of the four countries analysed, by the 3rd millennium the Spanish pig was the smallest, having the same size as the Portuguese. For the 2nd millennium cal. BC (Bronze Age), the data from Spain indicate a size increase which makes it larger than the only other available Bronze Age sample from Italy. The sequence ends in the 1st millennium, during which the smallest postcranial size of all analysed samples is recorded in Spain, though there are no data of similar chronology from the rest of the countries.

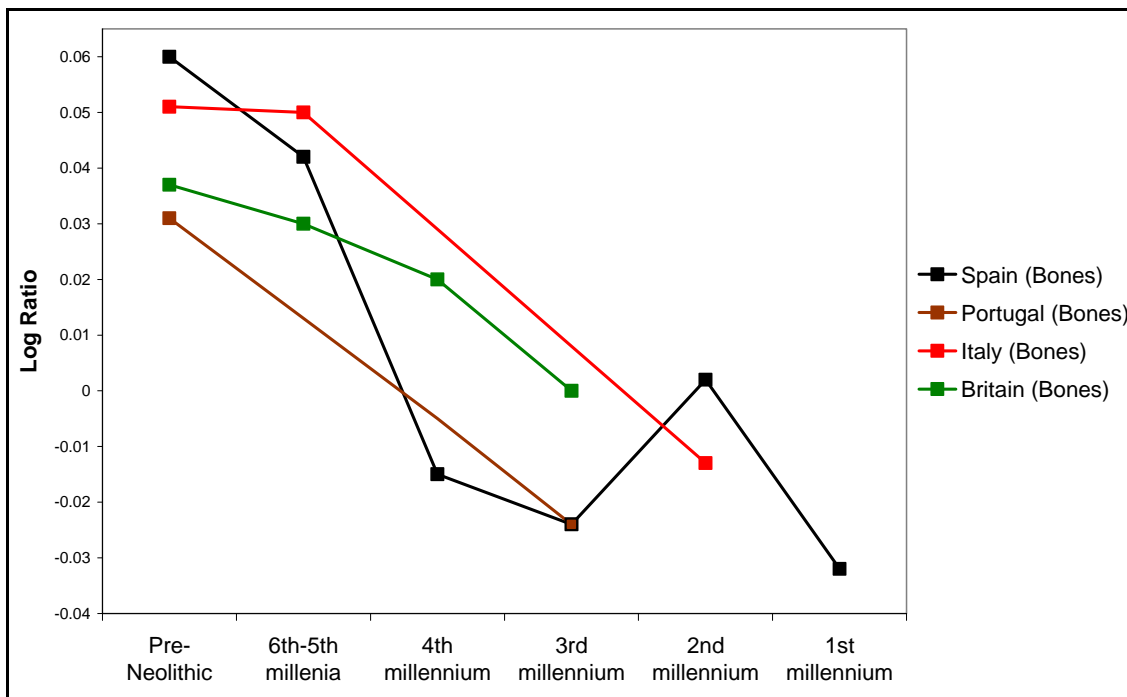


Figure 5.30: Graph comparing bone size in Spain, Portugal, Italy and Britain through prehistory (ca. 10th-1st millennium cal. BC) based on the mean log ratio values of all recorded measurements (excluding the length of scapula neck).

In figure 5.31, the dental size of Spanish, Portuguese, Italian, and British pigs of different periods is compared. In pre-Neolithic periods, British wild boar exhibits the largest tooth size, followed closely by the Italian, while the Spanish is even smaller. The smallest tooth size is that of the Portuguese Mesolithic wild boar. Unlike the pattern in postcranial size, the pattern in dental size appears related to geographic latitude, with the northernmost areas exhibiting larger size; although Spain and Italy have extensive overlap in geographic latitude. Recent research on modern wild boar in Europe has demonstrated that today there is not only a south-north but also a west-east size gradient (Albarella et al 2009; Genov 1999; Magnell 2004). Such a gradient is not as clearly manifested in postcranial size but this may be explained, at least partly, by the fact that the specimens of Palaeolithic chronology in the Spanish and Italian pre-Neolithic samples were on average larger than the Mesolithic specimens in postcranial, but not in tooth size. It can be argued that a larger body volume would be a favourable adaptation to the - colder than Mesolithic - Upper Palaeolithic climate (Price 1987). Especially the Spanish sample is mostly constituted by specimens from the northernmost part of Spain and from mountainous cave sites.

In the Early Neolithic period (6th-5th millennia cal. BC), the decrease in dental size in Britain is striking, while the slight size increase in Italy is also noteworthy. In Spain, there was a moderate size reduction, while for Portugal no data are available. In terms of tooth size, the Italian Neolithic pigs are the largest and the Spanish the smallest. As it has been mentioned earlier, in Spain and Italy the size change from the pre-Neolithic to the Neolithic is not great, which may imply a genetic relation with pre-Neolithic populations or - less likely - the import of domestic stock with similar dental size to that of the pre-Neolithic populations. In Britain on the other hand, despite the chronological hiatus between the Mesolithic and the Neolithic, such a sharp size change is difficult to accommodate with environmental factors; it is thus more probable that a genetically distinct domestic stock of pig had been introduced in Britain sometime in the 5th millennium cal. BC. However, caution is needed in the interpretation of the British Neolithic samples (Early, Middle and Late Neolithic sample) because each period is represented by a single site, which may not be entirely representative of the situation in the country as a whole.

In the 4th millennium cal. BC (Late/Final Neolithic for Spain and Middle Neolithic for Britain), a very sharp decrease in dental size is recorded. In Spain this sharp decrease in dental size is mirrored by a sharp decrease in postcranial size. Together they raise the possibility of intensification in pig husbandry and/or introduction of a smaller-sized domestic stock. In Britain, the data derive from a single site (Runnymede Bridge) and also indicate a sharp size decrease in dental but a more moderate one in postcranial size. If it is assumed that the Early and Middle Neolithic populations were typical of their periods, it is difficult to explain why dental size should decrease so much, while postcranial size only a little. Thus, it appears valid to raise the possibility of further introductions of domestic pigs with different bone:tooth size ratio.

In the 3rd millennium cal. BC, British pigs had the largest dental size, Spanish the smallest and Portuguese were of an intermediate size. The Spanish size decreased moderately from the end of the Neolithic to the Copper Age, the Portuguese also moderately compared to the Mesolithic size, while the British size increased compared to the Middle Neolithic (4th millennium cal. BC) specimens. In the 2nd millennium cal. BC (Bronze Age in Spain and Italy), the

dental size of Spanish pigs increased slightly and was very similar to that of their counterparts in Italy. Lastly, another sharp decrease, also mirrored in postcranial size, is evident from the Spanish Iron Age sample (1st millennium cal. BC). This sharp decrease at the end of the prehistoric era in Spain, combined with other lines of evidence such as the overwhelming majority of females and an increase in pathologies during the Iron Age, constitutes strong evidence for intensification in pig husbandry.

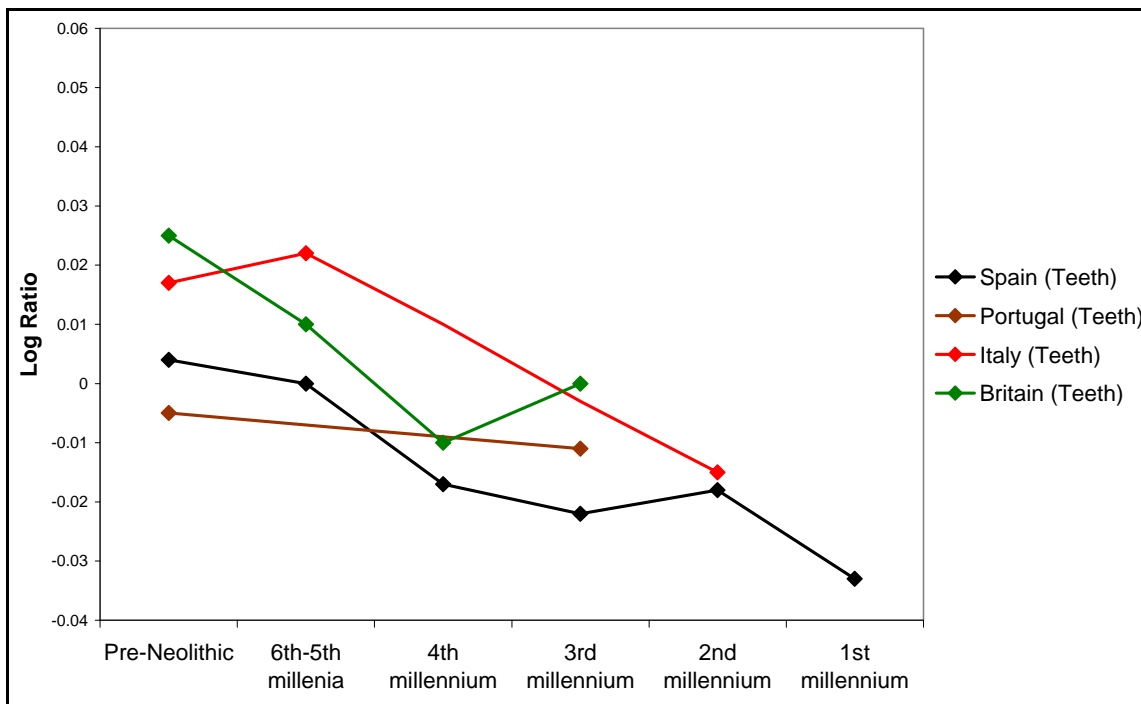


Figure 5.31: Graph comparing tooth size in Spain, Portugal, Italy and Britain through prehistory (ca. 10th-1st millennium cal. BC) based on the mean log ratio values of all recorded measurements.

5.2 Summary

In this chapter, postcranial and dental metrical data from Portugal, France (only postcranial), Italy, and Britain were presented with the aim of integrating them with Spanish data, which is the focus of this study. For reasons of clarity in the graphs, but also because a more general view was sought (i.e., on a continental scale), resolution in the analysis was low, both in terms of chronology and in the composition of the samples. Nevertheless, important inferences regarding how pig size varied during the origins and evolution of pig domestication were made possible.

In chapters 3 and 4 the issues of the origins (chapter 3) and evolution (chapter 4) of pig domestication in Spain were addressed. The results certainly still leave many questions unanswered but, at the same time, they allow for a well-informed discussion of domestication patterns as they are based on the largest volume of biometric, sexing, ageing, and pathological data collected and analysed up to date in Spain. In this chapter, the comparison with biometric data from four other European countries provides the opportunity to interpret the Spanish trends within a broader geographic context. The results bring to the surface similarities but also differences between Spain and the four other countries. Therefore, they contribute to our understanding of the complexity of a phenomenon that clearly cannot be reduced to a simplistic dichotomy between local and introduced domestication.

Our knowledge of the fluctuation of wild boar size in pre-Neolithic periods is limited over most of Europe. This makes the interpretation of Neolithic data and the detection of the domestication process even more challenging. For pre-Neolithic Europe, the results suggest that during the Palaeolithic, possibly due to lower temperatures (Price 1987), wild boar postcranial size was larger than during the warmer Mesolithic. This scenario is supported by the larger postcranial size of Palaeolithic wild boar in Spain and Italy compared to the Mesolithic wild boar from Portugal and Britain. The fact that tooth measurements do not follow exactly the pattern of postcranial measurements may be explained by two reasons: first, the genetic differences between populations adapted to different environmental conditions and second, the conservatism of teeth towards size change (Payne and Bull 1988).

The Neolithic period is the chronological focus of this study and the analysis in this chapter offers new insights into how pig domestication was initiated in Europe. On the most general (continental) level, the diversity in size between Neolithic samples from different countries as well as the differences in the relationship between postcranial and dental size support a scenario of diversity in the way pig domestication was introduced in Europe. There is no uniformity of size and changes are neither unidirectional nor homogenous across Europe. In Spain, for which more data have been analysed and a higher resolution is available, it is also clear that there are important differences between regions

and even individual sites. Despite such diversity, the importance of common elements, such as the overall size reduction after the Mesolithic should not be underestimated.

Particularly interesting for the aims of this project is the reduction in postcranial size from the pre-Neolithic to the Early Neolithic and further reduction during the course of the Neolithic in Spain, Italy, and Britain. The same trend is visible in dental data, except for Italy where a small size increase is observed in the Early Neolithic. In order to make the best out of the comparison of Spanish data with those from other countries it is essential to realise that different scales of analysis illuminate different facets of pig domestication. On the continental level, the common trend for size reduction in all countries during the Neolithic is most likely reflecting the presence of smaller-sized domestic pigs – irrespective of the source and intensity of this innovation. On the country level, the differences in absolute postcranial and/or dental size, as well as its fluctuations during the Neolithic probably reflect the different trajectories which pig domestication took in each country. The main patterns emerging from the inter-country comparisons for the Early Neolithic period is the similarity between Spain and Italy, and the difference to Britain in the biometry of their pig populations.

To conclude, the results presented in this chapter provide support for the following scenarios:

- In Spain, Portugal, France, and Italy, wild boar size possibly increased during the Neolithic and/or post-Neolithic periods
- Pig size – especially of postcranial bones – decreased during the Neolithic in Spain, Italy, Britain, and probably Portugal. In Spain and Italy, the average size of Early Neolithic pigs is similar to that of their pre-Neolithic periods, which may suggest a genetic affinity between the local wild boar and the first domestic pigs. In Britain, the sharp tooth size decrease supports more a scenario of extensive introduction of domestic pigs and limited genetic exchange with the local wild boar.
- By the end of the Neolithic (4th millennium cal. BC), in Italy and Spain, and possibly Portugal, the genetic separation between wild

and domestic pigs was such that wild and domestic pigs are morphologically distinguishable, at least on a population level

- Combined with the results described and discussed in chapters 3 and 4, the results from the other countries provide further support for the presence of domestic pigs in Early Neolithic (6th-5th millennia cal. BC) Spain. In post-Neolithic times, pig husbandry probably intensified.

Chapter 6. Traditional pig husbandry in southwest Iberia: results, discussion and conclusions

In this chapter the results obtained from the analysis of the collected ethnoarchaeological data are presented and described. As mentioned in chapter 2, the ethnoarchaeological data were collected in May 2008 through interviews – based on a questionnaire - with 11 pig breeders (nine in Extremadura, Spain; two in Alentejo, Portugal) of the traditional Iberian breed (Appendix 3), and a veterinarian of the AECERIBER (Association of Spanish breeders of the Iberian pig breed) (Appendix 4). Personal observations and photographic documentation of the pigs and their environment also contribute to the body of data presented and discussed in this chapter. The data provide information on many aspects of pig husbandry, most of which are of relevance to the interpretation of archaeological faunal assemblages. These aspects mainly concern: the physical and behavioural characteristics of the Iberian pig, the practical aspects of traditional pig husbandry and the natural, cultural and economic contexts in which Iberian pigs are managed today. Although a large volume of information has been collected, only the aspects most relevant to archaeology, as well as some general characteristics of the natural environment and the pigs, are presented in this chapter. Where available and relevant, data from other sources – mainly from literature produced by AECERIBER – are also presented. The presentation of the data is followed by a discussion of their archaeological relevance and value as analogies that may facilitate our understanding of pig husbandry in the past.

6.1 Ethnoarchaeology of pig husbandry in southwest Iberia: results

In the following sections the results of the ethnoarchaeological component of this project are presented thematically.

6.1.1 The *dehesa*

In the autonomous community of Extremadura (Spain) and neighbouring areas in Spain and Portugal, the traditional Iberian pig is still managed extensively in a

semi-human-made environment called *dehesa*, a rather loose term which in Extremadura means an oak forest of varying density (figures 6.1-3) with an understorey of herbaceous species and sparse shrubs (Harrison 1996; Joffre et al 1988, 1999; López et al 2007; Martín and Fernández 2006; Parsons 1962). According to the calculations of the Spanish ministry of agriculture (Rueda and Diéguez 2007: 48-49) the *dehesa* covers around 23.5% of Spanish territory or 3.151.000 ha (a large part of Extremadura and Andalusia and to a lesser degree Castilla y León and Castilla La Mancha). This environment is defined as semi-human-made because its plant community consists of local plants which are encouraged to thrive, while other plants are suppressed and kept under control.



Figure 6.1: Dehesa with high-density oak forest.



Figure 6.2: Dehesa with oak forest of medium-to-high density.



Figure 6.3: Dehesa with low-density oak forest

Although the coverage in oak - predominately holm oak (*Quercus ilex*) but also cork oak (*Quercus suber*), Portuguese or Lusitanian oak (*Quercus faginea*) and Pyrenean oak (*Quercus pyrenaica*) - varies considerably (e.g. Parsons 1962: 219, fig 2), in all recorded cases average oak density is well above 10 trees/ha, which is the lowest accepted by the Spanish Ministry of Agriculture (MAPA 2007: 8). AECERIBER calculates an average of 40-50 adult trees/ha for the Spanish dehesas, with a tree coverage that ranges within 5-20% of the surface of areas designated as dehesas (Rueda and Diéguez 2007: 47). Other tree species grow in the dehesa (e.g. olive in lower and chestnut in higher altitudes), though in lower numbers.

The semi-human-made nature of the dehesa can be appreciated by comparing figure 6.4, showing the dense shrub coverage of a dehesa abandoned for only two years, with figures 6.1-3, showing actively managed dehesas, with their much sparser vegetation cover, especially in shrubs that would restrict animal movements and access to fallen acorns. The inclination of the terrain varies significantly from area to area, but also within the same property, ranging from an almost level terrain to steep slopes (see figures 6.1-3). The extensive pig husbandry systems are perfectly adapted to these variations, as the animals exploit all parts of these environments. At the beginning of the acorn season (*montanera*) in autumn, pigs are driven to feed on acorns in the most remote, steep and low oak-density areas of each property, but by the end of the acorn season, when they are fatter and more selective in their taste, they feed on flatter terrain where oaks are usually more productive and their acorns of higher quality. This strategy is an ingenious way to make the best out of the environment, not only avoiding damaging it but even improving its productivity.

The dehesa's most important product, the acorn of oak species, ripens and falls from November to February. Acorn production is calculated at 8-20 kg per tree and 200-800 kg/ha per year (Rueda and Diéguez 2007: 58). Although much less frequently, the fruits of other tree species, such as olives, chestnuts and figs, are exploited by pigs, wherever available. In the dehesa, pigs also take advantage of the lush (under normal rainfall conditions) grass, usually available to them from September to May. Being a monogastric animal, the pig cannot extract energy from grasses as efficiently as the ruminants do, and prefers

consuming them in winter and autumn, before their content in indigestible woody cell walls increases by late spring/early summer. Dehesas produce 3500-12000 kg/ha per year of different grasses and other edible annual plants (Rueda and Diéguez 2007: 51). Pigs in dehesas also exploit the seasonally-available residual seeds and stubble from the occasional cultivated cereal plot and vegetable garden. As a successful opportunist and omnivore, the Iberian pig also consumes small animals (e.g. worms, snails, reptiles etc), though this is not estimated to play any major role in its diet (Rueda and Diéguez 2007: 50; also Herrero et al 2006: 247 report approximately 3.5% of animal matter in the stomach contents of wild boars in the Middle Ebro Valley).



Figure 6.4: Dehesa abandoned for two years.

6.1.2 The Iberian pig

The Iberian breed of domestic pig is one of the few traditional breeds of pig that still thrive and resist the threat of being replaced by improved breeds. It is also one of the few European pig breeds that has remained genetically unaffected by the introgression of Chinese domestic pigs, which altered to a varying degree (15-56%) the genetic - and consequently phenotypic, behavioural and

reproductive - characteristics of the most commonly exploited breeds of Europe (Alves et al 2003; Clop et al 2004). The European pig breeds are often divided into two main types, the Celtic and the Mediterranean or Iberian. The origin and persistence of each of these types is an extremely complex issue not addressed here. In Iberia, a widespread extinction of most Celtic breeds took place in the 20th century due to their substitution and crossing with improved breeds from other European countries and Asia. Two examples of the Celtic type in the Iberian Peninsula are the now extinct, *porc catalá* in Catalonia (Parés et al 2006: 67-69) and the *chato vitoriano* in the Basque Country (Barandiarán and Manterola 2000: 154). Traditionally, and until recently, the 'border' between the Iberian and Celtic types of pig was roughly from Galicia in the northwest to Valencia on the Mediterranean coast (Parés et al 2006: map, 66). The main differences between these two types are more visible on the head. Iberian pigs are dolichocephalic, long-snouted, and with large, narrow and horizontal ears, while Celtic pigs are brachycephalic, short-snouted, and with wide, floppy ears (Parés et al 2006: 66).

The survival of the Iberian breed has been achieved through a combination of factors such as genetic isolation in the past, government intervention, increased economic interest for its products, an increased scientific interest in the dehesa as an example of successful sustainable development and other factors (Marcos 1984; Rueda and Diéguez 2007; Vargas and Aparicio 2001). Within the Iberian breed there is a number of formally accepted *estirpes* or 'lineages', such as the *Retinto*, the *Entrepelado*, the *Torbiscal* and the *Lampião* (see Rueda and Diéguez 2007: 20-21 for description and photographs of the Iberian 'lineages'), although they are frequently crossed, especially the *Retinto* with the *Entrepelado*. The vast majority of the interviewed breeders owned pigs that are crossings between *Retinto* and *Entrepelado* (figure 6.5 a and b), but pure *Lampião* (figure 6.5 c) and *Torbiscal* (figure 6.5 d) were also kept. It is important to mention that traditionally the *Lampião* lineages were more employed in valleys, while the *Entrepelado* lineages in more mountainous areas. Some breeders also keep crosses – mostly males - of Iberian and Duroc-Jersey breeds (figure 6.5 e and f).

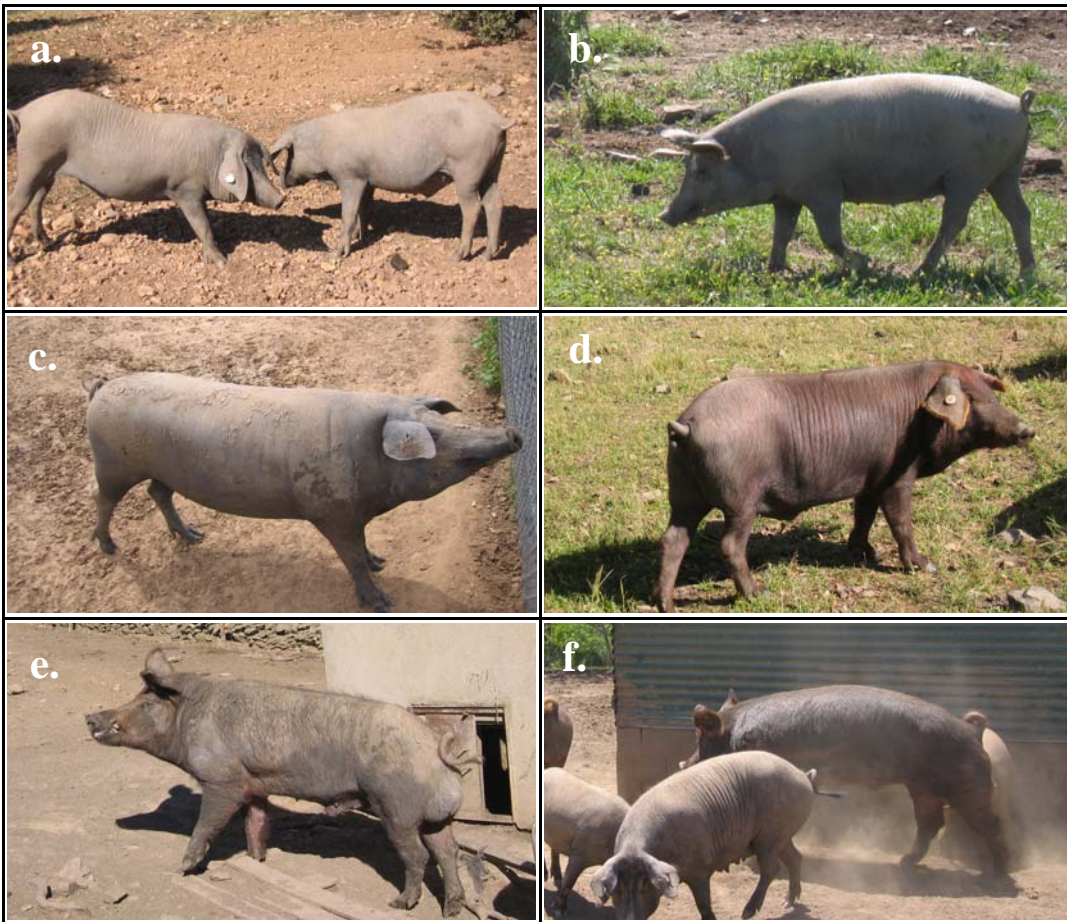


Figure 6.5: a. Retinto-Entrepelado, b. Retinto-Entrepelado, c. Lampiño, d. Torbiscal, e. 50% Iberian/50% Duroc-Jersey, f. Duroc-Jersey.

Since the purpose of this study is not a detailed description of the 10 or more different Iberian pig 'lineages' (Pardo et al 1998), only the general physical characteristics common to all or most Iberian pigs are presented here. The Iberian pig is considered as one of the surviving traditional pig breeds in Europe. The term 'traditional' implies physical characteristics which distinguish the pure Iberian pig from other more improved or allochthonous breeds. These can be summarised as follows:

- The trunk is relatively narrow and long with a slight arching of the rib case. The neck is short with a laterally compressed appearance and a dewlap which varies in size depending on the weight of the animal (figure 6.5 a-d).
- The coat is sparse or absent and skin colour is predominately dark, usually black, grey or dark reddish brown (figure 6.5 a-d).
- The upper front limb does not have a distinctive shape, while the lower half is slender and somehow pointy, ending in a dark-coloured hoof. The hind limb tends to be slightly longer than the front and better-defined

against the trunk of the animal (figure 6.5 a-d). Generally adapted to a free way of life, the Iberian pig has relatively slender bones which are well suited to covering considerable distances and performing on rough or steep terrain.

- Tails are only slightly curly but there are many pigs with straight or almost-straight tails (figure 6.6).



Figure 6.6: Iberian pigs with almost straight tails.

- Ears are large but narrow and are hanging horizontally over the eyes. The head is rather small but narrow and proportionately elongated, also due to the long and straight (or subconcave) snout (figure 6.7 a-b). Crossings between Iberian and Duroc-Jersey pigs have considerably shorter, broader and more concave skull profiles, more cylindrical trunks, curlier tails and denser, though still sparse, coat (figure 6.7 c-d).

It is important to mention that the Iberian pig is distinctive not only in its physical appearance but also in its behaviour and general adaptation to the dehesa environment. Through interviews and personal observations it became clear that these pigs are very alert and skilled creatures which can successfully fend for themselves in finding food, shelter and escape danger. The author has personally observed that the free-range pigs maintain the instinct of fleeing, activated when approached by someone unfamiliar to them (figure 6.8).



Figure 6.7: a-b. Pure Iberian, c-d. 50% Iberian/50% Duroc-Jersey.



Figure 6.8: Pure Iberian free-range pigs keeping a safe distance and observing an unfamiliar person (author) walking towards them.

Breeders also informed me that during the acorn season, when free-range Iberian pigs are entirely self-sufficient in their feeding habits, they behave even

more as wild animals and avoid human presence as much as they can. However, as opportunists, when they sense a certain degree of safety their intense curiosity urges them to examine any new object in their territory. These behavioural characteristics, common in omnivorous animals, constitute an important aspect of their success in making the best out of the environment in which they live. Some of the interviewed breeders mentioned that in the past they experimented with improved pig breeds in the dehesa with disastrous results. The Large White breed did particularly badly in coping with the same management regime as the Iberian pigs, as they failed to gain sufficient weight, developed foot pathologies and even skin cancer (to which they must have been particularly sensitive because of their light-coloured skin). Most breeders stressed how clever and alert their pigs are and some even regarded the white breeds of pigs to be 'lazy' and 'stupid'.

6.1.3 Herd size and composition

At the time of the interviews in May 2008 all breeders mentioned that herd size fluctuates considerably in the course of the year but also from year to year. The fluctuations between years are influenced mostly by market forces and life circumstances of each breeder while the fluctuations within a year seem to be the norm in pig herds and depend on factors such as single or double farrowing per reproductive female, seasonality in slaughtering, and the sale or purchase of piglets. The total number of pigs (table 6.1) in each herd at the time of the interviews ranged from 200 to 2700 (including pure Iberian, crossings with Duroc-Jersey and pure Duroc-Jersey). Generally the size of the herds can be characterised as medium to large and this is reflected by the fact that all breeders do it for a living and see it as a serious business and not as a hobby or part-time economic activity. At the time of the visit many breeders expressed their deep concern for the future of their profession due to sharp worldwide increase in cereal prices. Because of this, pig breeders with extensive land plots are more likely to survive because they depend less on bought cereals and legumes to feed their herds.

Table 6.1: Herd size per breeder at the time of the interviews (May 2008).

Breeder	1	2	3	4	5	6	7	8	9	10	11
Herd's total	200	481	2000	965	380-390	1900-2000	450	2500-2700	800	1350	610

A more stable index of a herd's size within a year is the number of reproductive pigs kept (table 6.2). Breeder 2 has no reproductive animals because he is letting his land and labour to AECERIBER, which provides him with castrated males in order to create a uniform group to conduct experiments concerning diet, well-being and other aspects of an Iberian pig's life. The rest of the breeders own reproductive herds of 43 to 355 individuals but most fall within the 50-150 range. The reproductive herd is of particular zooarchaeological interest because it also reveals the proportions of male to female reproductive pigs in each herd. As expected, and confirmed by the breeders, proportions of males and females are approximately equal at birth. While the vast majority of piglets – males and females - are castrated and destined to be fattened for slaughtering, sex ratios (table 6.2) are a result of each breeder's management strategy. Despite some variation in the percentages, in most herds males are approximately 7-10% of the reproductive population. Breeders 1, 4, and 11 kept more males than the rest but in general reproductive males rarely exceed 20%. Breeder 1 represents a special case because his farm is managed by the provincial administration of Badajoz and practices observed there may therefore have been influenced by factors independent of the breeder's will. The interviewed AECERIBER veterinarian (Appendix 4) also mentioned that male percentages are usually around 8-10%.

Table 6.2: Numbers of reproductive males and females per herd (above). Percentage of males per herd (below), calculated as a percentage of the total of reproductive pigs (males and females).

Breeder		1	2	3	4	5	6	7	8	9	10	11
Reproductive pigs	♀	50	castrated ♂ only	230	80	70	180	40	325	120	145	50
	♂	8-10		18	16-21	6	15	3	30	13	11	10
Male %		14-17%	-----	7%	17-21%	8%	8%	7%	9%	10%	7%	17%

The age profile of each herd at the time of the interview varied considerably for the same reasons mentioned for herd size fluctuations. Age cohorts and their numbers varied greatly from herd to herd and for this reason only the percentage of adults (reproductive individuals) against 'juveniles' (the rest of the herd destined for slaughtering) and other general information are presented here (table 6.3). Excluding breeders 1 and 2, whose decisions on pig husbandry may be influenced by other agents, the percentage of adult pigs is relatively stable across herds, ranging between 10% and 20%. The remaining 80-90% of

the pigs was exclusively made of one-year-olds or younger at the time of the interviews. Large herds tend to produce a new generation of piglets every two months by dividing their reproductive females into two, three or even four breeding groups, while smaller herds tend to have fewer breeding slots.

Table 6.3: Percentage of adults per herd at the time of the interviews (May 2008), calculated as a percentage of the total of each herd.

Breeder	1	2	3	4	5	6	7	8	9	10	11
Adult %	29-30%	-----	12%	10%	20%	10%	10%	14%	17%	12%	10%

6.1.4 Wild boar and domestic pig populations

Wild boar is ubiquitous in all areas, both Extremadura (Spain) and Alentejo (Portugal), where the interviewed pig breeders operate. All breeders mentioned that wild boar is present around their estates but only rarely they manage to overcome the walled or fenced land parcels reserved for the domestic pigs. The term *dehesa* derives from the Latin *defensa* (Harrison 1996; López Sáez 2007) and the *dehesa* is indeed well-defended against wild boar, although the meaning of this term in the past as well as today has much broader connotations.

The only breeder to own a wild boar was n. 11, who kept a wild sow. This man is a devoted hunter and he captured this female as a piglet after her mother fled frightened by dogs and hunters. In the past he also owned a male wild boar but under no circumstances wild animals are allowed to interbreed with his domestic herd, and are rather kept as a rarity or curiosity. Most breeders mentioned that whenever a wild boar trespasses their properties, it is likely to be shot because interbreeding is highly undesirable. Nowadays, reproductive males and females are kept within smaller enclosures under tighter inspection and it is therefore unlikely that they will come into contact with wild boar.

All breeders listed the transmission of disease (brucellosis was frequently mentioned) as the main reason for the tight control, especially of reproductive females. In the rare occurrence of interbreeding, all hybrid piglets are invariably slaughtered because they are considered to have no market value since ‘they have a lot of bone and no meat’, as most breeders mentioned. This opinion somehow echoes the suggestion that ancient pig breeders favoured flesh rather

than skeletal mass in their selection schemes (Lasota-Moskalewska et al (1987). Breeder 6 mentioned that two years ago his herd was 5000 strong but he had to reduce it drastically due to a brucellosis outbreak, attributed to the local wild boar.

The extreme current hostility towards the wild boar genetically isolates genetically the wild and domestic populations effectively. Nevertheless, breeders 4 and 10, both with a long family tradition in pig breeding, mentioned that interbreeding occurred much more frequently in the past. Breeders were not specifically asked about the occurrence of interbreeding in the past and it can be assumed that more breeders, especially those with a long family tradition in this profession, would confirm that even in the recent past pig husbandry was loose enough to allow some interbreeding between wild and domestic populations. Properties were also walled in the past, though not as diligently and systematically as today.

Another interesting piece of information concerning the wild boar was provided by breeder 9, who mentioned that there are currently two types of wild boar in the area. A smaller type of local origin and a larger type imported from northern Europe (Germany was mentioned) in order to satisfy the increasingly profitable recreational hunting industry.

6.1.5 Castration

Castration is a surgical procedure that removes parts of the reproductive system of an animal - usually testicles for males and ovaries for females – rendering the animal incapable of reproduction. In pigs this is performed mostly on males to suppress aggressiveness and avoid the notoriously unpleasant boar taint - caused by the presence of a pheromonal steroid (androstenone) and a fermentation product of L-tryptophan (skatole) (Lundström et al 2009: 1498).

In the area under study, all breeders consistently claimed that all their males and females are castrated, excluding those animals reserved for reproductive purposes. Males are generally castrated before weaning, but breeders 3, 7 and

8 castrate them at the time of weaning, as they routinely do with females. The rest of the breeders castrates males between one week and two months old, but most within the first month. Overall they tend to castrate the females at a later age than the males, with the exception of the three cases mentioned above. The reason for this was provided by breeder 9 who explained that this choice is due to the anatomical differences between sexes. The male reproductive organs are externally visible since birth and can easily be mutilated at a fairly early age, while in the earliest stages of life the female reproductive organs are insufficiently developed to be easily detected. Breeder 9 added that the right weight for a female to be castrated is 30-35 kg. If castration is attempted earlier, an additional incision to search for the ovaries is necessary, a process that is more painful, dangerous and time-consuming. In the *Manual of the Iberian pig* (Rueda and Diéguez 2007: table 10, 70) is mentioned that castration age is related to the husbandry regime. According to the manual, free-range Iberian males are castrated at 8-12 weeks and the females at 4-5 months, while the intensively managed Iberian males are castrated at 7-8 days and the females at 4-5 weeks. The white pig breeds exploited in the most restricted regime are not castrated since they are slaughtered at 24-25 weeks and thus before they develop any undesirable taint.

Castration does not cause any significant loss of pigs, as all breeders mentioned that only very rarely a pig may die from an infection caused by it. In addition, nowadays the health condition of pigs is significantly supported by veterinary inspections, modern medicine, vaccinations etc.

6.1.6 Birth season and conditions

The veterinarian from AECERIBER mentioned that there is an overall preference for births in spring and autumn (Appendix 4). More than half of the breeders, usually those with the largest herds, have two to four (usually three) groups of females that farrow twice per year (Appendix 3). In this way there are births all year round. Breeder 1 mentioned that births occur anytime, although too cold and too hot weather should be avoided. The rest of the breeders expressed their preference for births to concentrate in spring and autumn (sometimes starting from August).

The conditions in which pigs give birth vary from breeder to breeder but pigs are everywhere provided with some sort of human-made shelter. Breeder 11 was the only one who mentioned that there are some births in completely natural conditions in the shrubs but they are quite rare and piglets are quickly transported to a safer location. More modern breeders, usually with more than 1000 pigs, provide specialised buildings for their pigs to breed in a highly controlled and safe environment (figure 6.9). In the case of breeder 6, each breeding position even had its own heating system (figure 6.9, lower right photograph).

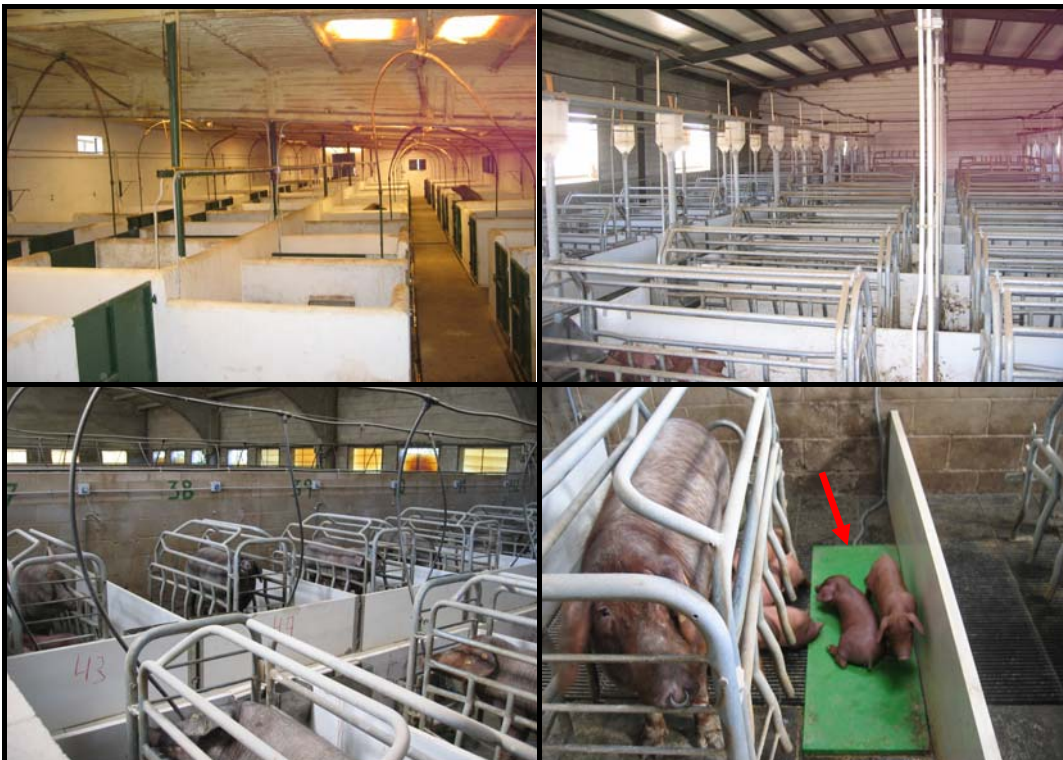


Figure 6.9: Specialised facilities for pigs to breed in a highly controlled and safe environment. Some even have heating systems for the piglets (see arrow in lower left photograph).

However, most of the interviewed breeders (7 out of 11) provide outdoor tent-shaped shelters (usually made of metal) called ‘camping’, which are usually fenced individually or into groups (figure 6.10). Despite being outdoors, ‘camping’ provides sufficient protection for breeding females and their piglets until they are weaned, usually within two months.

‘Camping’ is more than just a safe place to give birth and raise piglets; it is a simple, yet ingenious, system that also provides comfort, secured nutrition and

even a mechanism that accelerates weaning. Comfort is provided with a layer of straw which is regularly replaced to avoid increased wetness (e.g. figure 6.10, lower right photograph) and in some cases straw is placed on the roof for greater insulation from heat or cold (figure 6.10, upper right photograph). Integrated in the 'camping' structure is a separate feeding spot for the piglets to which the sow has no access (figure 6.11). In this way, the piglets are encouraged to gradually feed on their own avoiding the possibility that food intended for them is eaten by their mother. Breeders have every reason to encourage early weaning and they are usually proud of achieving it; early weaning means fast-growing piglets and healthier sows made available again for breeding at an earlier date.



Figure 6.10: These outdoor shelters called 'camping' provide a safe breeding environment for pigs. Some are fenced in groups (upper two photographs) and some are fenced individually (lower two photographs). Some are even provided with extra insulation in the form of straw (see upper right photograph). In most cases, the floor is covered with straw to provide comfort and warmth.



Figure 6.11: Separate feeding spots, integrated in the ‘camping’ system, only accessible to the piglets to accelerate weaning.

In addition to discussing the present-day situation, some breeders provided interesting information about pig *parideras* (breeding spots) in the past and they were kind enough to show me these places, some of which may be so old that should attract archaeological attention. Breeder 6 showed me a building that was still in use in the earlier part of the 20th century, which provided several breeding positions for pigs (figure 6.12, left photograph). Next to the old *paridera* there was a small stone-built hut in which the *porquero* (pig herder) lived for parts of the year to attend the herd and especially the breeding sows (figure 6.12, right photograph).



Figure 6.12: *Parideras* or sheltered breeding spots for pigs (left) and the ruins of the stone hut of the *porquero* or pig breeder (right).

The most surprising and archaeologically interesting *parideras* were presented to me by breeder 11. Within his property there is a hillock with few old stone-built *parideras* but the breeder, who has spent all his life (aged 54 in 2008) in the area, claimed that they had not been in use for more than 50 years and probably ceased being used before the beginning of 20th century (figure 6.13). In many cases natural granitic boulders, ubiquitous in Extremadura, were

incorporated in the construction of pig *parideras* to save stone and labour (figure 6.13, bottom photographs).



Figure 6.13: Stone-built *parideras* or breeding spots, possibly dating earlier than the 20th century. Granitic boulders are incorporated in the structure, saving useful smaller stones and labour.

6.1.7 Purchase/exchange of animals

Most of the interviewed breeders are regularly purchasing pigs - mostly males but occasionally also females - to 'change the blood' as they characteristically say (table 6.4). All breeders seem to recognise the benefits of enriching the genetic diversity of the herd. Breeder 1 for example mentioned that, although he has not bought any pigs so far, he is planning to do so in the near future, since his herd is relatively small. The rest of the breeders (4, 6 and 9), who claimed that they do not need to buy any animals, justified their strategy with the fact that their herd is large and genetically diverse and allows them to run their own selection schemes. Many of the breeders of Extremadura and Alentejo participate in annual *ferias* (fairs), where the best Iberian pigs are awarded prizes and deals are made between breeders to buy, sell or exchange pigs.

Table 6.4: Frequency of pig purchases to enrich the genetic diversity of the herd. Breeder 2 is not included because he only buys piglets to raise them.

Breeder	1	3	4	5	6	7	8	9	10	11
Herd size	200	2000+	965	380-390	1900-2000	450	2500-2700	800	1350	610
Purchase	Not until now	A male every 1-2 years	No	Yes (4 males last year)	No	Usually males (rarely females)	Males every few years	Not any more	2 males every 2 years	All males and occasionally females

6.1.8 Slaughtering practices and age-at-death

The veterinarian provided an overall picture concerning the issues related to the slaughter of pigs in Extremadura. The majority of free-range pigs are slaughtered in December and January with a focus around the Christmas season, although this continues until March when the acorn season ends. Actually the law forbids the slaughter of acorn-fattened pigs before the 15th of December or after the 15th of April. Semi-free-range pigs are fattened intensively on provided food and are thus independent from the seasonal availability of acorns. For this reason, pigs managed in this way are slaughtered all year round, although many breeders mentioned that summer is avoided because pigs loose weight due to lack of appetite and slaughterhouses are closed in August. On the other hand, free-range pigs follow a more conservative diet until autumn (usually those who are 12 months old or older) when they start feeding on acorns to reach their slaughtering weight.

Concerning the age-at-death, the veterinarian informed me that the law dictates that no free-range pig is slaughtered before 14 months of age and that the vast majority is slaughtered later than that. For semi-free-range and intensively managed pigs the youngest permitted age is 10 months (see Appendices 3 and 4 for definitions of 'free-range' and 'semi-free-range' systems). The age-at-death of free-range pigs ranges from 14 to 24 months old, while for semi-free-range pigs from 12 to 14 months, with the vast majority slaughtered at 12 months (table 6.5). The veterinarian, as well as all breeders, mentioned that pigs are usually driven into a smaller enclosure the day before slaughter and into a truck on slaughter day.

Table 6.5: Age-at-death of ‘semi-free-range’ (upper row) and ‘free-range’ (lower row) pigs per breeder. See also Appendices 3 and 4 for definitions of ‘free-range’ and ‘semi-free-range’ systems.

		1	2	3	4	5	6	7	8	9	10	11
Age at slaughter (months)	Semi-free-range	12	14	12	13-14	N/A	N/A	14	12	12	12-13	12-13
	Free-range	15-16	24	16-20	16-18	18-24	16-18	16-22	15	14-20	17-18	14-16

Some breeders also provided information concerning the slaughtering age of reproductive pigs. Breeder 3 informed me that usually the first pregnancy of his reproductive females occurs at 12-14 months of age and that they are slaughtered after producing 8-10 litters (i.e., by then they are four or five years old). His reproductive males start fertilising females at two years of age and they are slaughtered at 6-7 years of age. Breeder 5 mentioned that his reproductive females breed for the first time at two years of age and he does not keep them for more than four years (i.e. until they are six years old). Breeder 9 revealed a reproductive life that begins and ends at a younger age. His females enter reproductive life at just one year of age and are replaced (probably slaughtered) after 6-7 litters, while his males, also beginning at one year, are slaughtered at four years of age, which is consistent with the age when a female will have farrowed about 6-7 times.

6.1.9 Home range, control and movements

All interviewed breeders own at least one herd that is managed in a free-range husbandry regime and most also own herds that are managed more intensively in some sort of semi-free-range regime, which varies significantly from herd to herd. It is a general rule that free-range herds are kept in larger land parcels than semi-free-range herds, although a clear line can not be drawn between the two systems due to the existence of intermediate strategies (for all classifications see MAPA 2007: 11-12 and Rueda and Diéguez 2007: 45-70).

The veterinarian informed me that in Extremadura, due to historical reasons, there is a tendency towards rather large land properties and this favoured the survival of extensive pig husbandry practices. This information is confirmed by the collected data (see Appendix 3), which indicate that the smallest properties are 150 ha and the largest 1000 ha. It is important to stress that not all the land

is used as pig pasture, as other animals, mainly sheep, cattle and horses, are also kept. In addition, each property is divided into smaller land parcels, usually fenced by a stone wall or a metal fence. The size of individual land parcels also varies significantly (1-100 ha). Semi-free-range pigs are usually managed in small land parcels rarely exceeding 3 ha, while free-range pigs are released in larger land parcels of up to 100 ha, and are usually moved from parcel to parcel during the acorn season. Reproductive males and females are part of this regime, but they are normally kept in much smaller and well-protected enclosures at the administrative centre of each property.

All breeders consistently stated that pigs normally prefer to spend their days and nights outdoors and only some breeders provide them with shelter in case of unusually cold weather. The veterinarian and the breeders stressed that Iberian pigs are clever animals that know how to find suitable spots to rest and feed. At nights they usually sleep in groups and tend to use the same spot called *cama* (bed), which over time ends up devoid of stones and vegetation and develops into a comfortable layer of softened fine soil (figure 6.14).



Figure 6.14: *Camas* (beds) are preferable resting and sleeping spots for pigs (left photograph). With use over time they become devoid of stones and vegetation, with a layer of soft soil remaining (right photograph).

Due to the subdivision of all properties in smaller land parcels, the large economic importance of the pigs and the legal obligations of the breeders, even free-range pigs cannot roam outside their fenced or walled land parcel. Within the parcel, however, pigs do not require any special attention and are usually inspected once a day during feeding time. Pigs are well aware that food is supplied, usually in the morning, and are already at the designated feeding spot when the breeder arrives with their food. During feeding, pigs are easily

inspected for illness or injuries, though such inspections are more demanding during the acorn season when pigs are more dispersed and are not fed by humans. After feeding, free-range pigs continue roaming and feeding with whatever else they can find, usually different plant species. In many properties there are artificial water reservoirs that pigs especially like and visit regularly (figure 6.15). Overall, breeders confirmed that the Iberian pigs are quite at home in the dehesa environment and little or no control is needed, excluding the closely inspected breeding sows and their piglets.



Figure 6.15: Examples of artificial water reservoirs available to pigs.

Some breeders commented that in the recent past the use of dehesas was more diverse. Breeder 10 for example, stated that the countryside was much more populated than today and people were occupied with a greater diversity of activities such as agriculture, animal husbandry (other than pigs, e.g. cattle, sheep, rabbits, etc.), collection of wild foodstuff (e.g. asparagus, mushrooms, truffles, pine kernels, chestnuts and even acorns). Despite the impression given by all breeders that keeping pigs is nowadays easy and does not require the involvement of many people, breeder 4 informed me that pig husbandry was conducted in a less systematic and less organised way in the past. In such more traditional systems of pig husbandry, reproduction was not so tightly controlled. As a result, litters were born more randomly through the year and interbreeding with wild pigs was much more probable than today, but still undesirable and infrequent.

6.1.10 Capture

The issue of capturing the pigs has been briefly addressed in the paragraph relevant to the slaughter of the pigs. Generally, this aspect of pig husbandry in

Extremadura is quite modernised and little variability is observed. All breeders found it quite amusing that such a question was even posed and replied that pigs are simply loaded on a truck from a small enclosure. However, the fact that they all recognised the need to herd the pigs into a smaller enclosure prior to slaughter is important in itself because it highlights the difficulty of capturing a free-range pig in a large land parcel, especially after it has fed independently on acorns for two to four months. In addition to capturing the pigs for slaughter, often breeders need to handle them for vaccination purposes, general inspection of their health condition, placement of ear tags, etc. For these purposes, most breeders use specially constructed narrow corridors (made of metal, concrete or stone) in order to achieve control over the pig and significantly restrict its mobility (e.g. figure 6.16).



Figure 6.16: Narrow corridors are used to restrict the pig’s mobility to allow inspection, vaccination, placement of ear tags, etc.

6.1.11 Diet

As in other aspects of pig husbandry in Extremadura and Alentejo, there is also considerable variation in the diet of domestic pigs depending on their management regime. All interviewed breeders kept at least one pig herd under a free-range regime and most also kept at least a herd fattened exclusively or predominately on supplied food (referred to as semi-free-range in Appendix 3, where more specific information can be found).

The Spanish ministry of Agriculture issues norms which assign different labels on Iberian pig products mainly according to the diet of the pigs and the environment in which they feed (MAPA 2007: 11-12). The first category is called ‘acorn-fattened’ and it includes all pigs that immediately prior to their slaughter

were feeding exclusively on acorns, grass and other resources of the *dehesa*, without access to any provided food. Another requirement for this label is that the weight of the animals when entering the oak forest should be 92-115 kg. In addition, pigs should start feeding in the oak forest between the 1st of October and the 15th of December and stay in it for at least 60 days. The minimum gained weight during that period is set at 46 kg and the minimum age-at-death at 14 months.

There are three more categories, defined mostly by the type of diet. One of these applies to products from pigs that were fed on acorns for some of the time but their diet was supplemented with additional food (ground legumes and cereals) to achieve the desired weight. A third category does not require any reliance on natural food and it is accepted that pigs are fattened exclusively on provided food, though the population density should be of no more than 15 pigs/ha and the minimum age-at-death is set to 12 months. Even within this category the amount of space available to the pigs differs significantly from farm to farm. For the purposes of this study the first label is defined as free-range and the second and third label as semi-free-range, being aware of the great variability in the diet and space available to pigs of the latter two groups.

The fourth category is essentially the most intensive, with pigs kept in restricted space, fattened on provided food and slaughtered at a minimum age of 10 months. Little information has been collected concerning this type of intensive husbandry due to its limited relevance to archaeological issues, and hence it is not described further. The husbandry scenario that is more likely to be comparable to the archaeological past is the one represented by exclusively acorn-fattened pigs. For this reason the other husbandry regimes will only be described in terms of their deviations from the free-range status.

When asked about the diet of their free-range pigs, the pig breeders and the veterinarian described it on a seasonal basis and in a consistent way (table 6.6). In autumn and winter free-range pigs feed exclusively on wild resources, mainly acorns but also other edible plants and small animals found in the *dehesa*. In spring, pigs continue to forage in the oak forest consuming mostly plants but their diet is supplemented by provided food in the form of ground

cereals and legumes. Due to the high prices of cereals, one breeder was feeding his pigs with olive pulp, a by-product of olive oil production, and claimed that after laboratory tests, the fat produced by pigs with the consumption of olive pulp was found to be of similar quality as the fat produced with the consumption of acorns. Another breeder is cultivating rye and *triticale* (a hybrid between wheat and barley) and allows his pigs to enter the cereal fields and eat the ears, while the straw is consumed by his sheep. The rest of the breeders buy ground cereals and legumes to feed their pigs. Concerning the diet of domestic pigs in the past, the AECERIBER veterinarian mentioned that in Extremadura, pigs were also feeding on figs, which are abundant in parts of the region.

Table 6.6: Summary of the diet of free-range Iberian pigs, described on a seasonal basis.

	Autumn - Winter	Spring	Summer
Diet	Mainly acorns (also grass, other plant species, worms, snails, and other edible items found in the forest)	Grass and other edible items from the forest, supplemented by provided food, usually consisted of ground cereals and legumes	Provided food is of primary importance due to the lack of naturally available food

Semi-free-range herds are fed with more provided food and have less access to naturally-obtained foodstuff. Some herds are raised and fattened exclusively on ground cereals and legumes, while others occasionally pasture in the oak forest, although their final fattening is based on provided cereals and legumes.

6.1.12 Weight

The weight-at-slaughter of Iberian pigs is influenced by the physical characteristics of the breed, market demand, diet and environmental conditions. The veterinarian of AECERIBER informed me that the law dictates that no free-range Iberian pig is slaughtered at a weight less than 108 kg, while the average weight per herd – of animals destined for slaughtering must be 117 kg or more. She added that in reality, most breeders slaughter their pigs at around 140-155 kg. When asked about the weight of their animals, most breeders based their answers on the adult weight (i.e. including only their males and females kept for reproduction), though one breeder dealt with the weight-at-slaughter, while two others provided information on both (Appendix 3). According to most breeders, excluding breeder 1 who supplied a common weight range for both sexes, adult

males are heavier than adult females, though the difference varies from herd to herd (table 6.7).

According to the breeders, the adult weight of reproductive Iberian pigs (some males are genetically up to 50% Duroc-Jersey), is 115-200 kg for females and 135-250 kg for males. Weight-at-slaughter also varies considerably, ranging from 120 to 180 kg (table 6.7), though breeder 7 mentioned that currently there is market pressure towards lower weights because big heavy hams are more difficult to sell than small light ones.

Table 6.7: Weight of male and female reproductive Iberian pigs (upper row) and weight-at-slaughter of non-reproductive Iberian pigs (lower row). Many of the males are genetically 50% Duroc-Jersey.

Breeder		1	2	3	4	5	6	7	8	9	10	11
Reproductive pigs weight (kg)	♀	100-150		115-130	135-150	115	180-200	145	150	150	-----	130-140
	♂	100-150	---	150-170	155-160	170	200-250	165-175	170-180	180	-----	150-160
Weight-at-slaughter (kg)		-----	---	-----	-----	-----	-----	170	-----	180	120-150	-----

In addition to this general picture, breeders highlighted a number of other interesting points. Breeder 3 mentioned that Duroc-Jersey males can reach a weight of 200 kg, while his Iberian males do not exceed 170 kg. He added that ‘you do not want them to be fat, just healthy’, which was repeated by breeder 7, who added that there is a tendency of pigs to gain some weight with age (e.g. a three-year-old female will probably be lighter than a five-year-old). Breeder 5 attributed the relatively low weight of his reproductive females to the fact that they are still young and not fully adult (only two years old). Breeder 11 claimed that the exact weight depends on the ‘line’ from which a specific animal descends (implying genetic attributes) and the ‘taste’ of the breeder (e.g. he prefers them a bit fatter than other breeders). Contradicting breeders 5 and 7, in a hypothetical question comparing the weight of a two-year-old male with a four-year-old male, breeder 11 replied that there would be no difference because by two years the animal is an adult and weight does not change much from that point onwards unless the breeder consciously fattens the pig. Another general comment was that some breeders claimed that a great difference in weight between reproductive males and females is undesirable because, in that case, females have to bear excessive weight and additional stress during the reproductive action.

6.1.13 Damage

Most land parcels available to pigs in Extremadura and Alentejo do not include any agricultural land and hence the issue of damage caused by the uprooting and feeding activities of pigs is not a major concern to local breeders. Most interviewed breeders mentioned that pigs do not cause any permanent damage, except when kept in small enclosures. Breeder 6 cultivates some cereals in his property but they are destined for pig consumption. Breeders 7 and 8 stated that the only type of damage caused by pigs is the occasional destruction of fences and walls surrounding the land parcels. Breeder 7 also mentioned that without snout rings pigs would damage the forest more due to their uprooting activity, while breeder 8 mentioned that pigs do 'lift' some soil but the available area is large enough to allow the natural recovery of the vegetation. Indeed most breeders (except two) applied snout rings on some or all of their pigs, despite the absence of cultivations (figure 6.17). The main reasons for this practice appear to be the restriction of damage to local vegetation (especially when kept in smaller enclosures) and the prevention of pigs digging their way out of fenced or walled areas.



Figure 6.17: Examples of snout rings applied on Iberian pigs to restrain them from destructive soil lifting and uprooting activity.

6.1.14 Products

Cured and fresh meats are the only products of the Iberian pig. All breeders sell all their animals alive, to be slaughtered at modern slaughterhouses, with the exception of those few pigs that are slaughtered by some of the breeders for family consumption. Current laws do not allow the slaughtering of pigs without official papers issued by a veterinarian and for this reason household slaughtering is not so common nowadays but still exists, at least in

Extremadura. The most famous of the Iberian pig products is the ham but a great variety of other cured meat products (e.g. *lomo*, *chorizo*, etc.) is also prepared through the processing of other parts of the pig's carcass. Breeder 7 informed me that the main reason that Duroc-Jersey is crossed with pure Iberian is to combine the desired characteristics of the Iberian pig (e.g. intramuscular fat and good adaptation to the dehesa environment) with those of Duroc-Jersey (e.g. less subcutaneous fat, bigger musculature and hence more meat). The production of cured meat from Iberian pigs is nowadays a large-scale enterprise, well-integrated in the free market system. Some of the breeders own shares in companies that cure meat (see figure 6.18 for an example of a modern cellar of ham processing), which is subsequently sold to providers in Spain and abroad.



Figure 6.18: Example of a modern large-scale facility (cellar) for ham drying.

6.2 Ethnoarchaeology of pig husbandry in the Mediterranean: zooarchaeological implications

In the previous sections of this chapter, the recorded information relevant to the husbandry system of the Iberian pig in Extremadura (Spain) and Alentejo

(Portugal) has been presented. Most of the presented data are archaeologically relevant because they concern aspects that are routinely recorded by zooarchaeologists such as age-at-death and sex ratios. Beyond these, the ethnoarchaeological study presented here generated a wealth of data (e.g. on ethology, diet, morphology of soft tissues, castration, etc) that is difficult to compare with archaeological data, but still useful in making well-informed and environmentally relevant hypotheses about pig husbandry in the past. In this subsection, the ethnoarchaeological data are synthesised thematically to render them more directly useful for the interpretation of zooarchaeological data. Where available, data collected by colleagues in Spain or other relevant geographic areas in Europe, mainly Sardinia, Corsica and Greece, are integrated in the discussion.

6.2.1 Morphology

No biometric measurements of pigs were taken during this study. Such an undertaking would have been impossible with the available time and resources. Consequently, any zooarchaeological inferences based on data collected during this study, as well as their comparison with other geographic areas, will inevitably remain on a general level.

As mentioned earlier in this chapter, in the Iberian Peninsula, pig breeds are divided into two morphologically distinct 'trunks', the Iberian and the Celtic (e.g. Parés et al 2006: 66-67). In the literature there is considerable confusion around the origin of these two 'trunks'. Hernandez et al (1996; 2001) mention that the Iberian breeds derive from *Sus mediterraneus* and the Celtic from *Sus scrofa*; Marcos (1984) claims that the Iberian pig is the product of crossings between *Sus scrofa ferus* and *Sus scrofa mediterraneus*; Toro et al (2000) mention that the Iberian pig derives from the subspecies *Sus scrofa meridionalis*. Groves' phylogenetic scheme for wild pig subspecies (1981; 2007) is currently the most widely-accepted and according to it, northeast Iberia is occupied by the subspecies *Sus scrofa scrofa* (the typical but variable in size wild pig of mainland Europe; also known as *Sus scrofa castilianus* in Spain) and southwest Iberia by *Sus scrofa meridionalis* (significantly smaller-sized than *castilianus*; also known in Spain as *Sus scrofa baeticus*). Assuming that this division held

true in the past and the distribution of the subspecies was similar to the modern, then it is possible to suggest that the traditional domestic breeds of southwest Iberia were more genetically related or crossed with *Sus scrofa meridionalis* (or its ancestors), while the Celtic breeds of the northeast were more related with *Sus scrofa scrofa*.

The opinions on the origin of the Iberian pig are many but of limited archaeological use. These two trunks are further divided into many *estirpes*, a Spanish term used to describe the different 'lineages' within the two 'trunks' (see section 6.1.2 above). A direct comparison of any modern pig breed ('trunk' or *estirpe*) with zooarchaeological data is currently difficult as it would require a detailed biometrical study of numerous modern specimens and the availability of large archaeological pig assemblages from different areas and periods of Iberia. Nevertheless, any knowledge on the morphology and ethology of the traditional unimproved breeds of Mediterranean Europe – where most have been extinct, marginalised, or altered through crossings – is useful to zooarchaeologists who are constantly seeking to improve the relevance and quality of their inferences on past pig husbandry in Mediterranean areas.

The general characteristics of the Iberian pig are well-known (e.g. Hernández et al 1996: 3-4; Parés et al 2006: 66; Rueda and Diéguez 2007: 18) and have also been described in section 6.1.2 above. For this reason in this section they will be mentioned only in relation to their relevance in the interpretation of past pig husbandry.

It is a common observation in Iberia, but also in Sardinia, Corsica and Greece, that traditional breeds of pigs are quite different from the more modern improved breeds. From the photographs published by Albarella et al (2007: e.g. fig 16.4, 291 and fig 16.7, 293), the Sardinian and Corsican breeds appear to be somewhat leaner than the Iberian, especially the Sardinian unimproved breed. Nevertheless, there are many common characteristics that differentiate these traditional forms from the improved breeds. The most striking differences are: the proportionately longer and straighter snout (e.g. figure 6.7 a-b, above), contrasting with the shorter and concave snouts of improved breeds (e.g. Porter 1993, figs in pages 31-41); the straight or almost-straight tails (e.g. figure 6.6,

above), contrasting with the characteristic curly tails of most improved breeds (e.g. Porter 1993, figs in pages 31-41); the generally leaner bodies and thinner and somewhat pointier lower legs (e.g. figure 6.5., above, and Albarella et al 2007, fig 16.4, 291), contrasting the heavier and rounder trunk, but also the broader and proportionately shorter legs (e.g. Porter 1993, figs in pages 31-41), necessary to support the much higher average weight of improved breeds. The traditional pig breeds in Greece share similar characteristics to the Spanish, Sardinian and Corsican traditional breeds (Halstead and Isaakidou in press).

The comparison between traditional and improved breeds shows that the former deviate less from the morphology of wild pigs. The reasons for this are genetic and consequently related to adaptation. The extensive nature of traditional pig husbandry is more likely to allow some genetic exchange with local wild boars, although this is changing today in Iberia and to a lesser degree in Sardinia and Corsica, due to more effective enclosure of pig foraging areas and immediate elimination of hybrids (see above and Albarella et al 2007). In Greece conversely, interbreeding has been increasing due to a more relaxed control over free-roaming domestic pigs, since they can no longer damage the, now abandoned, cultivations (Halstead and Isaakidou in press). Even in the absence of interbreeding, wild-like physical characteristics may be retained because they enable pigs to move, forage and fend for themselves successfully in the specific environment they are kept. Indeed, most pig breeders in Iberia and in Sardinia and Corsica stressed that their pigs are independent, inquisitive and physically very competent animals, contrasting them with larger improved breeds that were characterised as less active, less alert and generally failed to adapt in the same environment by developing mobility- and skin-related health problems.

The zooarchaeological implications of observations on the physical differences between pigs are many. First, genetic isolation and adaptations to different environmental settings and husbandry conditions, result in different phenotypes. Most of these phenotypes are difficult to detect archaeologically but it is important to identify the trends related to certain types of husbandry. This enables better-informed interpretations of archaeological biometric data. The persistence of longer snouts in traditional pig breeds exploited in extensive systems and the pronounced shortening of the snout in improved breeds

exploited intensively appear to be the most promising trend. There is the potential of biometrical detection of such trends in teeth, the dimensions of which (especially the length) would be expected to decrease as the snout shortens through time, hence reducing available space in the jaw. In such an event, previous studies (e.g. Albarella and Davis 1994: 17) have shown that the further back in the jaw the sharper the effect of size reduction. Such trends have already been identified in chapters 3 and 4 for Spanish prehistoric pigs, the biometrical analysis of which strongly supports a sharper decrease in the second and third molar, especially evident in post-Neolithic populations. In Early Neolithic pigs, only the third molar showed considerable deviation from the pre-Neolithic, presumably wild pig, size (figures 3.29 and 3.30). In the Iron Age, a new type of extremely shortened third molar – with the third cusp being vestigial – makes its appearance (figures 4.140-142).

6.2.2 Age and sex structures

Other issues of zooarchaeological interest - and also detectable in archaeological remains – are represented by the age and sex structures of pig populations.

In Iberia, free-range pigs are slaughtered at an older age (usually 16-24 months) than intensively managed pigs (around one year). The age-at-slaughter of the majority of free-range pigs (table 6.5) is compatible with the high mortality percentages in the second and third years observed in post-Neolithic assemblages, contrasting the much younger Early Neolithic age structure and the intermediate Late/Final Neolithic age structure (chapter 4, figure 4.81). However, even post-Neolithic data suggest generally older and less uniform age structures than modern pig herds, an observation that is rather expected if we take into account modern technology, breed improvements, market demand, availability of food and other factors that did not affect pig husbandry in the past. In Sardinia and Corsica (Albarella et al 2007), where free-range pig husbandry is small-scale and less systematic, age-at-slaughter varies more than in Iberia. This is probably due to the fact that in Iberia, though free-range and extensive, pig husbandry is practiced on a large-scale, to satisfy the national and international market demand rather than the local needs of a household or a

village. In Greece, age-at-slaughter is quite variable but it appears to be dependent on the scale of exploitation (Halstead and Isaakidou in press). In general, the typical household pig is slaughtered at around a year old, while pigs managed in larger free-range herds fattened on naturally available food, tend to be slaughtered at a later age. In Iberia, Sardinia, Portugal and Greece, reproductive sows are usually kept at least until four or five years old, while in Greece there is a tendency to slaughter reproductive males at two or three years of age to prevent them from reaching a weight that would be too much for sows to bear (Halstead and Isaakidou in press).

Sex structures recorded in ethnoarchaeological studies are difficult to compare with relevant archaeological data because they are based on different sources. In modern herds, sex structures of pig herds are provided by their owners who define the sex of each animal based on the morphology of the reproductive organs, while archaeological sex structures are based on the morphology of permanent canines and their alveoli. This would not be a big problem if all pigs survived for longer than two or three years to ensure that permanent canines were sufficiently erupted to be unmistakably identified as male or female. Also, the effects of castration on the morphology, eruption age and eruption speed are unknown. Most of the pigs kept for reproduction reach an age at which permanent canines are sufficiently (in males) or fully (in females) erupted. The tendencies in ancient sex structures are more likely to approach the composition of the reproductive herd than that of the animals destined for fattening and slaughter. Even bearing in mind that husbandry conditions may have been different in the past, comparisons between ancient and modern sex structures can be fruitful.

The interviews and observations carried out during this study revealed, a ratio of males to females around 1:10 (table 6.2). In contrast, in Sardinia and Corsica the small-scale character of pig husbandry causes more variability in male:female ratios, usually resulting in higher male percentages but with a permanent female majority (Albarella et al 2007). Similar tendencies have been observed in Greece (Halstead and Isaakidou in press), with small-scale pig husbandry tending towards a more equal representation of sexes, while larger-scale pig husbandry tending towards a 1:10 female majority. This pattern is

intriguing as it suggests that larger herds may be characterised by higher female percentages and a greater uniformity in sex structure. However, it should be noted that uniformity and rationality aiming at maximising economic profit are also related to the degree of economic dependence on pig husbandry, as well as other factors that may have been absent or very different in past societies (e.g. market pressures and veterinary support).

In the Spanish assemblages included in this study, there is a clear tendency towards an increase of females from the Early Neolithic onwards (chapters 3 and 4). Under the light of the presented ethnoarchaeological data, the pattern observed in archaeological assemblages could be viewed as a trend towards larger-scale pig husbandry in post-Neolithic periods, which may in turn have induced more rationality and uniformity to the system. The culmination of this tendency can be observed in the age structures of Iron Age assemblages (chapter 4), in which sex ratios are approaching the modern traditional ones. On the contrary, the tendency for more equal representation of the two sexes in earlier periods - e.g. Bronze Age but especially the Neolithic – could be explained, at least partly, by a less systematic, small-scale exploitation of pigs and also a greater contribution of wild boar hunting - especially if hunting strategies were equally targeting males and females, or even more males than females.

6.2.3 Biological status and management

An important issue that the work of colleagues in Sardinia and Corsica highlighted (Albarella et al 2007: 305) is the dichotomous way in which zooarchaeologists often deal with pig remains by attempting to divide them into wild or domestic. Currently, almost no interbreeding occurs between domestic and wild pigs in Iberia, and the same is true for Sardinia and Corsica. Most of the reasons for the current avoidance of interbreeding are very recent. Strict policies against the spread of diseases, efficient land enclosure and conscious avoidance of wild boar morphological and behavioural traits, are among the main reasons for this relatively recent phenomenon. However, in all these areas pig breeders with a long family tradition in the profession stated that this was not the case in the past, mainly because the control of animals and their

reproductive activity was more relaxed. As mentioned above, in Greece the tendency for interbreeding with wild boar has recently even increased (Halstead and Isaakidou in press).

The zooarchaeological implications of the observations made above are important. First, the absolute genetic separation of free-range pigs in Iberia and other areas must be a recent phenomenon and it is likely that in the past interbreeding was more frequent, although its exact frequency per period is a very difficult issue to address. Second, it cannot be excluded that in the past interbreeding may have even been desirable, as it is the case in modern-day New Guinea for example (Rappaport 1984: 70). Such a strategy maintains the morphological similarity between domestic and wild stock, although it does not stop people from perceiving the managed pigs as 'domestic' and the non-managed as 'wild'. The opposite of such strategy (i.e. the avoidance of interbreeding with wild boar) might have been sought in the past too to improve the flesh:bone mass ratio of domestic pigs (*cf.* Lasota-Moskalewska 1987). Third, the chances of genetic divergence between domestic and wild populations depend on the type of husbandry. For instance, an extensive system of pig husbandry is likely to allow more frequent interbreeding, while a more stationary style of husbandry is likely to genetically isolate the domestic stock, unless interbreeding occurs deliberately. Pig breeders draw a clear-cut distinction between domestic and wild stock nowadays and they stated that in the recent past this was still the case. This does not offer any practical help in the analysis of zooarchaeological data but it does help us realise that people who manage animals and spend even a little time and effort to manage them, quickly perceive them as domestic and differentiate them from the wild stock. However, the biological distance between domestic and wild stock is not necessarily clear-cut and depends on the type of management. Fourth, the reverse tendency from Iberia was observed in parts of Greece (i.e. more interbreeding between wild and domestic pigs occurring recently). This is a crucial observation as it shows that morphological change due to domestication is not necessarily linear because pig husbandry is interwoven with other economic activities (e.g. crop cultivation, tree orchards, other animal species, etc.) which change through time and cause changes to the other components of a given system. For example, a shift of economic interest away from crop

cultivation or a shift towards cultivation of specific tree species (e.g. apples, olives, figs, etc) may trigger a more relaxed control over domestic pigs which in turn may result in increased interbreeding between wild and domestic animals.

6.2.4 Castration

In Iberia all pigs destined for fattening – male or female - are castrated (see above for Extremadura and Alentejo but also Barandiarán and Manterola 2000: 326, for the Basque Country, and Santamariña 1985: 307, for Galicia). In Sardinia and Corsica (Albarella et al 2007) most males - and sometimes the females – are castrated. In Europe today approximately 80% of all slaughtered male pigs are castrated, while female castration is much more restricted (Fredriksen et al 2009). The castration of pigs is an issue that is not as frequently discussed in zooarchaeology as, for example, the castration of cattle or sheep. The main reasons are both methodological (i.e. lack of tools for its detection) and interpretative (i.e. castration does not change the fact that pigs are exploited only for their primary products). However, the issue of pig castration may be useful in addressing strategies of pig husbandry in the past, which can be many and varied, though all aiming the procurement of the same product – meat.

The main culinary reason for castration is to avoid the notoriously undesirable boar taint but the reasons related to pig husbandry are even more important archaeologically. Behaviourally, castrated males are less aggressive, more manageable and generally more suitable as members of a large herd. The physical effects of castration are not well known but in case there are observable morphological or biometrical changes on any postcranial or dental elements, the development of methodological tools for their detection would offer new interesting insights in the pig-human relationship. It would be interesting to know whether people in the past similarly disliked boar taint (we can be almost certain about it) and whether male only or also female pigs were castrated. This issue also affects the chances of interbreeding between domestic and wild pigs. Unfortunately, if we take into account the considerable size overlap between male and female, as well as between wild and domestic pigs, it seems that, for the time being, castration in pigs cannot be addressed

zooarchaeologically. Perhaps future research on this should concentrate on the morphology and/or biometry of specific postcranial and/or dental elements that are fully developed in the first or early second year, since castrated individuals are normally slaughtered at a younger age than reproductive individuals.

6.2.5 Genetic viability of herds and avoidance of inbreeding

The negative effects of inbreeding are well-known for all mammalian species (e.g. Keller and Waller 2002) and pig is no exception to this rule (e.g. Köck et al 2009). Vital characteristics for a healthy and productive domestic pig population such as litter size, survival rate, weight, *libido*, disease frequency and growth rate, are negatively affected by inbreeding. Pig herds in Iberia are considered as medium or large and breeders are perfectly aware of the danger of inbreeding. To avoid it, almost all breeders purchase reproductive pigs from other breeders. It can be assumed that in the past too pig breeders must have noticed the obvious negative effects of inbreeding and tried to find remedies for them.

Zooarchaeologically, this assumption has important implications related to issues of scale, but also of the effects of potential strategies against inbreeding. In terms of scale, if a domestic pig population is to retain its productivity and viability in the long term, its genetic pool has to be sufficiently diverse (i.e. hundreds or even thousands of pigs). In many cases in the past - as in many cases of traditional pig breeders in Sardinia and Corsica today (Albarella et al 2007) - the pig herd of a breeder or even the collective herd of a small village could not have had sufficient genetic diversity. This must have exerted strong pressure on pig breeders, as it does today, to cross their pigs with those of other members of their community and even with those from neighbouring communities. An alternative strategy, not practiced today in Europe but still practiced in New Guinea (Rappaport 1984: 70), would be to cross domestic with wild individuals, either by capturing wild individuals or allowing wild boars to mount domestic sows, thus combining the domestic with the potentially infinite genetic diversity of wild populations. According to the former scenario, the collective genetic pool of a domestic population is kept separate from that of wild populations, while according to the latter scenario the domestic genetic

pool is an extension of that of wild populations. In both cases the desirable avoidance of the detrimental inbreeding effects is achieved but the resulting morphology of domestic pigs would be different. Genetic relation to local wild stock would maintain morphological similarity, while genetic isolation would promote morphological divergence between the two stocks. In reality, the situation in the past, assuming that free-range pig husbandry was practiced, could have been anywhere between the two scenaria described above but it is nevertheless important to keep these considerations in mind when interpreting zooarchaeological data on pigs.

6.2.6 Seasonality

Seasonality in births and age-at-slaughter is an important issue of pig husbandry and is justifiably frequently addressed by zooarchaeologists. In Iberia, birth season is extremely variable and pigs can farrow potentially anytime of the year. Each reproductive sow normally farrows twice a year and, much more rarely, three times. However, the breeders in Iberia expressed an overall preference for spring and autumn births to avoid extreme heat and cold but also to increase the chances of specific birth slots to reach the desired weight-at-slaughter by exploiting the *montanera* (acorn season) from October to February. The small-scale pig breeders of Sardinia and Corsica (Albarella et al 2007) are not exercising as tight a control on the birth slots as in Iberia, and this is also reflected in the more variable, and generally older, age-at-slaughter. The zooarchaeological implications for the observed patterns are important and they increase our awareness on issues of seasonality, scale and general pig husbandry practice.

The most important zooarchaeological implication is that in Mediterranean regions with mild climate, births of domestic pigs can not be assumed to occur only in spring. Assuming a preference for slaughtering during the acorn season in the past, then it is expected that age structures of past populations may indicate only a slight or even no preference for autumn/winter slaughtering. The differences observed in the control level of birth and slaughter seasons between Sardinia and Corsica on one hand (Albarella et al 2007) and Iberia on the other also depend on the degree of integration in the national and international

market environment. However, it is still true that small-scale systems of pig husbandry, free from extra-communal economic pressures, are likely to produce more variable age structures than large-scale systems geared towards satisfying a large market beyond the local community level. Despite the considerable variability in the birth and slaughter season of pigs in the Mediterranean the overall trend for increased births in spring – and to a lesser degree autumn – and increased slaughtering in autumn and winter still hold true due to factors such as climate and food availability, that most probably were also active in the past. However, it is also important to be cautious in applying indiscriminately these patterns in the interpretation of all past populations because human interference can create systems of pig husbandry that are to a greater or lesser degree independent from climatic conditions and seasonally available natural food resources.

6.3 Conclusions

The ethnoarchaeology of traditional pig husbandry in modern Spain generated valuable knowledge on the morphology, age/sex profiles, seasonality, scale, genetic viability of herds and general management. The information on many of these aspects is used in the interpretation of patterns in the zooarchaeological data, but it is also useful to any zooarchaeologist and ethnographer studying pigs; for this reason the conclusions of the ethnoarchaeological component are summarised below:

a) Morphology

- i) Traditional breeds deviate less than improved breeds from the morphology of wild pigs (proportionately longer and straighter snout, straight tails, leaner bodies, pointier legs).
- ii) Extensive systems of pig husbandry are more likely to promote interbreeding – to varying degrees – and thus affect the morphology of domestic pigs in the aspects listed in point (i) – among others.
- iii) Even in the absence of interbreeding, wild-like characteristics and behaviour may be retained because they enable pigs to move, forage and fend for themselves successfully in specific environments.

iv) Generally, genetic isolation and adaptations to different environmental settings and husbandry conditions, result in different phenotypes and ultimately to domestication and creation of breeds.

b) Age and sex structures

i) Uniformity in age and sex structures is characteristic of medium- or large-scale pig husbandry practices that aim at maximising the meat output of the managed herds.

ii) The age-at-slaughter of free-range pig herds strongly suggests high mortality in the second and third years of age, at least in the surviving traditional Iberian breeds of pig.

iii) The tendencies in ancient sex structures are more likely to approach the composition of the reproductive herd and not that of the animals destined for fattening and slaughter. Scale of husbandry is also likely to affect sex ratios, with a tendency for more equal representation in small-scale and a stronger female majority in large-scale.

c) Biological status and management

i) The absolute genetic separation of domestic and wild pigs appears to be a very recent phenomenon and it is likely that in the past interbreeding was more frequent. It cannot be excluded that in the past interbreeding may have even been desirable.

ii) Irrespective of biological/genetic status, humans tend to perceive as 'domestic' any animal on the rearing and protection of which they have spent even a minimal amount of time and effort.

iii) The chances of genetic/morphological divergence between domestic and wild populations depend on the type of husbandry (extensive systems-more frequent interbreeding; stationary husbandry-genetic isolation). The evolution of pig domestication is not linear and the opposite tendencies can occur, i.e. genetic/morphological convergence between domestic and wild populations.

d) Seasonality

i) Birth season is extremely variable in Mediterranean areas and pigs can farrow potentially anytime of the year. Each reproductive sow normally farrows twice a year and, much more rarely, three times. However, breeders in Iberia show preference for spring and autumn births to avoid extreme heat and cold but also to increase the

- chances of specific birth slots to reach the desired weight-at-slaughter by exploiting the acorn season from October to February.
- ii) Small-scale systems of pig husbandry, free from extra-communal economic pressures, are likely to produce more variable age structures than large-scale systems geared towards satisfying large markets.
 - iii) In Mediterranean areas there is an overall trend for increased births in spring – and to a lesser degree autumn – and increased slaughtering in autumn and winter. This seasonality is based on factors such as climate and food availability, which probably were also active in the past.

Chapter 7. The origins and evolution of pig husbandry in prehistoric Spain: discussion, future directions and conclusions

As stated in the Introduction (chapter 1), one of the main aims of this project is to investigate the origins of pig domestication in Spain, and place it in the context of other relevant European areas – more specifically Portugal, Italy, France and Britain - for which data were made available. The analysis of pre-Neolithic and Neolithic data from Spain (presented in chapter 3) and other countries (presented in chapter 5) was aimed at detecting possible changes in the size, shape, sex profiles, age structure and pathology of pig populations across these periods. The assumption on which this investigation is based is that as part of the domestication process – whether it involved introduction of animals or local domestication - humans manipulated all or some of the above-mentioned characteristics of the animals. Hence, the detection of such potential changes and the discussion of whether or not, and to what extent, they occurred naturally or were induced by humans assumes a central position in the discussion of the origins of pig domestication in Spain. Other lines of archaeological evidence, as well as ethnoarchaeological analogies, are also integrated in the discussion on the origins and evolution of pig domestication.

The pursuit of the origins of pig domestication is complemented – but also aided - by another important aim, namely its subsequent evolution in later prehistory (i.e. Copper, Bronze and Iron Ages), which also constitutes an important research aim. Despite the tendency in archaeology to give particular emphasis to the ‘origins’ of things and processes, the evolution of pig domestication is equally important, not only because it helps us to understand the context of the ‘origins’, but also because it provides original knowledge about past human societies. As well as for Neolithic and pre-Neolithic periods, where available, data from other countries and other lines of archaeological and ethnoarchaeological evidence are also incorporated in the discussion of pig husbandry in Copper, Bronze and Iron Age Spain.

The findings of the ethnoarchaeological component of this project (chapter 6) represent a useful interpretative tool to address all stated aims of this research and are thus integrated in the discussion of zooarchaeological and archaeological data.

7.1 Pig domestication: the origins

7.1.1 Spanish wild boar

Many Spanish colleagues (e.g. Arturo Morales, pers. comm. January 2009) consider the scarcity of pre-Neolithic data as the main hurdle towards our understanding of the characteristics and history of the Spanish wild boar. The site of Zatoia – with a wild boar proportion of the fauna in Magdalenian and Epipalaeolithic levels ranging between 16% and 18% (Altuna and Mariezkurrena 2001a) – represents one of the few cases in which pre-Neolithic animal bone assemblages are not entirely dominated by deer, ibex, chamois and horse – depending on the surrounding landscape and vegetation. In the Epipalaeolithic/Mesolithic there is, however, an overall increase of wild boar (and roe deer) frequencies mainly at the expense of horse, ibex and red deer, though this last species remained predominant in most assemblages. This trend probably continued into the early stages of the Neolithic, as indicated by the marked preference (60% of the whole assemblage) for wild boar hunting by the inhabitants of Zatoia (Altuna and Mariezkurrena 2009: 144, table 8). Though sparse, wild boar data from pre-Neolithic periods are valuable as a comparison with assemblages of later date, as they represent a baseline to be compared with later, domestic and wild, pigs.

Irrespective of precise geographical origins, the domestic pig of Europe derives from the Eurasian wild boar. Thus, it is necessary to throw some light – as much as allowed by the data – on the history of the wild boar in Spain and other countries before delving into any discussion on the appearance of the domestic form. Due to the pooling of several millennia to increase the size of the Spanish pre-Neolithic sample, resolution has been inevitably low but some patterns are sufficiently reliable to be discussed and provide the opportunity to raise some working hypotheses for future research.

Almost all pre-Neolithic biometric data derive from the northern part of Spain (mainly Cantabria, the Basque Country and Navarra) and include anything from Mousterian to Epipalaeolithic/Mesolithic chronology. The crude chronology of the sample and the geographic bias favouring northern Spain is acknowledged but the patterns emerging from the comparison between pre-Neolithic and later data cannot be ignored. Another important parameter when assessing wild boar size in pre-Neolithic Europe is the comparison between populations in Spain and other neighbouring or nearby areas (see chapter 5 for a detailed discussion of biometric patterns in Spain, Portugal, Italy, Britain and France).

The hypothesis of a size increase of the wild boar in the Neolithic is supported by some Early Neolithic postcranial specimens - mainly from Cueva Chaves and Cova Fosca (figure 3.22) but even from the later Sant Pau (figure 3.16) - which are larger than the largest pre-Neolithic measurements. This may not constitute sufficient evidence to confirm a size increase but, the extremely large size recorded for wild boar at the Middle Neolithic southern French site of Roucadour (figure 5.9) is, in this respect, interesting and relevant. In addition, the 'tail' of large measurements in post-Neolithic periods (figure 4.98), interpreted to belong to wild boar, confirms that later prehistoric Spanish wild boar could reach a size for which we have no record in the pre-Neolithic period. It is difficult to establish when this size increase occurred or track its speed and exact geographic extent, but it must have occurred sometime in the course of the Neolithic. Similar patterns in the evolution of wild boar postcranial size have been observed in Portugal (Albarella et al 2005), Italy (Albarella et al 2006b; chapter 5) and other European countries (Albarella et al 2009). Dental size does not appear to have been equally affected by this process and showed very limited or no fluctuations.

The wild boar size increase cannot be explained by the rising temperatures of the early Holocene - which would have rather contributed towards the opposite trend. It is more likely that the expansion of deciduous forests over most of Spain (*cf.* Burjachs and Riera 1996 for the Mediterranean facade; García-Amorena et al 2008 for the northern coast; Pantaleón-Cano et al 1999 for the southeast; Stevenson 2000 for east-central Spain; Zapata 2006 for the northeast) - the optimal habitat for wild boar – contributed to this phenomenon.

Aura et al (2002: 223) mention that the increase of wild boar and roe deer populations in the Valencian region at the beginning of the Holocene is more likely to be a result of increased humidity than increased temperature. A relaxation in hunting pressure, due to the availability of domestic animals and an increase in wild populations, constitutes another possible explanation for a size increase in wild boar, as has already been argued for the increase of red deer size in post-Mesolithic Portugal (Davis 2006). Site-specific studies and regional zooarchaeological syntheses carried out by colleagues in northern Spain provide undisputable evidence for increased numbers of wild boar towards the end of the Palaeolithic and during the Epipalaeolithic/Mesolithic periods (e.g. Altuna 1980: 70, 1986: 618, 1990: 237-39; Castaños 2006: 5). With the onset of the climatic amelioration of the early Holocene, the hunting of wild boar increased in importance for human communities. Whereas in earlier times the species played an insignificant role for hunter-gatherer groups, by the Mesolithic/Epipalaeolithic it had become ever-present and a prey of major importance.

Whatever the reasons are for the probable size increase recorded in wild boar remains, its identification has direct consequences in our efforts to detect the appearance of a biometrically distinguishable domestic pig in Spain. It alerts us to the fact that pre-Neolithic wild boar size constitutes a baseline to start from but it does not necessarily remain fixed through space and time.

Beyond biometry, even less is known about the age and sex structure of pre-Neolithic hunted wild boar populations. The scarce data from Spain suggest a high occurrence of relatively young individuals (0-2 years old) and an approximately equal representation of males and females among the hunted wild pigs. These age and sex patterns cannot be considered as representative of all pre-Neolithic assemblages but rather as the only available indication we have in the data analysed for this project. Fluctuations in sex and age structures of pre-Neolithic pig populations and their relationship with intensified wild boar hunting represent a useful topic for future exploration. When better sex and age data become available, hopefully accompanied by better chronological and geographical resolution, biometry will also acquire a new potential. The study of wild boar morphological changes occurring at the threshold between the last

glaciation and the Holocene climatic maximum represents a particularly important subject that requires further evidence and investigation. When this issue is resolved, we will be in a much better position to address changes associated with domestication.

7.1.2 First domestic pigs

The quest for the detection of the first domestic pig is a notoriously difficult task and in the past biometry was the most common – if not the only – methodological tool employed to distinguish the domestic from the wild form. It still is the most robust tool we have easily and cheaply available to address this issue, but other lines of evidence can contribute to make biometrical patterns clearer and more reliable. Nevertheless, we must also consider the possibility that – due to interbreeding between domestic and wild forms, and/or the early stage of the domestication process - the presence of domestic animals can be obscured by their biometrical similarity with their wild counterparts (e.g. Zeder 2001 for wild/domestic goat). For this project, a holistic approach has been adopted through the combination of various lines of evidence (i.e. biometry, sex and age structure, species composition of assemblages, pathology and general archaeological context). In this way, a more reliable and better-informed discussion on the origins of pig domestication in Spain can be achieved than when any one of the lines of evidence is examined separately.

In chapter 3 the pre-Neolithic data were compared with those of the Neolithic (Early and Late/Final) revealing a number of interesting patterns. On average, Early Neolithic pigs in Spain were smaller – clearly in postcranial and marginally in dental elements - than their pre-Neolithic counterparts. A major element of biometrical variation is represented by the relationship between bone and tooth size and its fluctuations through time. The interplay between the two lines of biometrical evidence supports a picture of diversity, which is also confirmed by other aspects of Early Neolithic pig populations such as age and sex structures (see chapter 3). Though many possible scenarios of tooth/bone size ratio can be envisaged, three basic patterns have been identified:

- Postcranial and dental size are both on average similar or only slightly smaller than pre-Neolithic wild boar (e.g. Cova Fosca and Cueva Chaves)
- Postcranial size is clearly smaller than pre-Neolithic wild boar but dental size is only slightly smaller (e.g. La Draga and Cueva de la Vaquera)
- Postcranial and dental size are both clearly smaller than in pre-Neolithic times (e.g. Sant Pau; though at this site the postcranial evidence is very limited)

The three scenaria described above are not exhaustive, and should not be viewed as three different models of interaction between pigs and humans – as other so far unrecorded situations may have occurred. Nevertheless the three scenaria mentioned above (and described in greater detail in chapter 3), are those from which we have available evidence and they highlight different trajectories that pig domestication – and consequently neolithisation – may have taken in a relatively restricted geographical area. Of course, the recorded biometrical patterns are also dependent on the chronology of each assemblage, differences in wild/domestic frequencies, the local environment and the socioeconomic context. Whatever the contributing factors, it is clear that in different parts of Early Neolithic Spain variable conditions of pig exploitation occurred, and these cannot be entirely described through the use of ‘traditional’ biometric thresholds which hypothetically separate wild and domestic pigs. This is particularly the case when the analysis involves comparisons between areas that are environmentally, climatically and geologically very different.

Despite the extensive size overlap between pre- and Early Neolithic pigs, biometrically distinct (i.e. clearly smaller) specimens have been identified in most Early Neolithic sites. At open-air settlements (almost invariably situated in lowland or coastal areas) such as La Draga and Sant Pau, but also at the cave-site of La Vaquera, the majority of pig remains is of a considerably smaller size than pre-Neolithic pigs. Conversely, Early Neolithic pig remains from cave sites (most of which are situated in mountainous areas and at a considerable distance from the coast) tend to derive from larger animals, more similar to their pre-Neolithic predecessors. The most straightforward, but also rather superficial, interpretation of this pattern would be that it reflects a dual lifestyle

mode, with lowland open-air settlements engaging in productive activities such as husbandry and farming, and cave-dwellers still relying on hunting and gathering. However, the rest of the zooarchaeological and archaeological evidence suggests a more complex development of pig domestication in Spain, which is part of a highly articulated neolithisation process during the 6th and 5th millennia cal. BC.

At sites such as Cova Fosca and Cueva Chaves, where biometry is insufficient to resolve the problem of the domestic or wild status of the pigs, other lines of evidence, such as species composition, age and sex structure, and archaeological context provide crucial additional information. For example, the presence of other domestic animals such as sheep, goat and cattle at Cueva Chaves provides incontrovertible evidence of husbandry practices and therefore of the occurrence of a farming community in which the presence of domestic pigs would make perfect sense. Conversely, at Cova Fosca the fauna is entirely composed of wild species and as such the occurrence of domestic pigs would be at odds with what seems to be an entirely hunter-gatherer lifestyle. At Cueva Chaves the presence of perinatal pig remains and a slight adult female majority provide further support to the hypothesis that domestic pigs occurred on site. The cave's stratigraphy also excludes a scenario of an uninterrupted occupation by hunter-gatherer groups, since a stalagmitic layer separates the pre-Neolithic levels - with exclusively wild fauna – from the Early Neolithic (Castaños 2004). The comparison between different lines of evidence from the sites of Cova Fosca and Cueva Chaves highlights how difficult and misleading the detection of pig domestication can be without the integration of different lines of evidence.

Despite the difficulty in attributing individual specimens to domestic or wild pigs, the presence of domestic pigs in Early Neolithic Spain is almost beyond question. Hence, previous suggestions by colleagues working in Spain (e.g. Altuna 1980; Boessneck and von den Driesch 1980; Castaños 1986, 2004; Morales and Riquelme 2004; Morales and Martín 1998; Saña 2000) that domestic pigs were present in Spain since the Early Neolithic or at least the 6th millennium cal. BC are confirmed by this study, despite some objection concerning the timing of such appearance (Rowley-Conwy 1995a, 1995b). This is, however, only one aspect of a much more complex story in which different

regions, sites, and possibly human groups exploited pigs in a diversity of ways. It is, in fact, exactly this diversity that represents the defining characteristic of the Early Neolithic, rather than a homogenous switch from one style of life to another.

The diversity that we witness in the Early Neolithic makes it difficult to provide a single explanation for how pig domestication initiated in Spain. However, a number of trends associated with various chronological, environmental and socioeconomic attributes can be identified and are summarised below:

- **Chronology.** Within the Early Neolithic there is a chronological trend towards an increase in the size distinction between domestic and wild pigs (e.g. compare Sant Pau and Cueva de la Vaquera with Cueva Chaves in figure 3.16). This is possibly a result of a trend towards tighter control of the animals, leading to greater genetic separation between domestic and wild populations. The introduction of new morphological types of domestic pigs in the course of the Early Neolithic cannot be incontrovertibly demonstrated but the presence of some clearly smaller pigs provides some support to the introduction scenario (e.g. figure 3.15 for postcranial and 3.28 for teeth).
- **Site-type.** This is related with the environment, landscape and fauna at specific sites in Spain (*cf.* Altuna and Mariezkurrena 2009: 155-156). The trend concerning these attributes is that cave sites in mountainous forested areas tend to have higher percentages of wild fauna (or even exclusively wild fauna as at Cova Fosca). In such sites (e.g. Cueva Chaves), pigs generally are of similar morphology to the pre-Neolithic wild boar and very rarely a line can be drawn between wild and domestic suid remains, unless other types of evidence are taken into account. At the opposite end are lowland, open-air sites (such as La Draga) with a definite 'domestic' character. This is translated into an overwhelming majority of domestic fauna and an overall focus on productive activities rather than hunting and gathering. These are the sites that yielded clear evidence for the presence of morphologically distinct pigs, which are here interpreted as domestic.

- **Material culture.** Sites (e.g. La Draga) with rich and diverse material culture, such as relatively elaborate housing structures, increased storage capacity, a broad array of specialised tools (usually directly related to agricultural activities), and extensive use of ceramics (sometimes with evidence for its local production), tend to yield clear evidence for the presence of domestic pigs. On the contrary, sites with poor – both in absolute numbers and diversity – material culture tend to yield more disputable or no evidence for the presence of domestic pigs. An example of the latter type is Cueva Chaves with its much more restricted - compared to the roughly contemporaneous La Draga – material culture. Cova Fosca yielded even poorer material evidence of a neolithic way of life. The only evidence at Cova Fosca is represented by ceramic and even for that serious doubts about its stratigraphic attribution have been raised (e.g. Zilhão 2001). The cave-site of La Vaquera provided evidence that seems to be intermediate between the open-air sites and the two caves mentioned above.
- **Biological resources.** Sites with evidence of a heavy reliance on the hunting of wild animals and gathering of wild plants are much less likely to yield clear evidence of the occurrence of domestic pigs too. Such sites (e.g. Cova Fosca and Cueva Chaves) show limited or no reliance on domestic pigs. At the opposite end - of what was in reality a continuum of different degrees of reliance on ‘wild’ and ‘domestic’ resources - are sites such as La Draga, which showed clear evidence for an almost absolute reliance on productive economic activities such as cereal and pulse cultivation and animal husbandry of several domestic species (amongst which the domestic pig played an important role).

In the context described above, a Neolithic ‘package’ may well have existed, though it probably did not spread simultaneously across Spain. Some aspects of the ‘package’ such as domestic sheep and goats, and cereal cultivation, not only were introduced already in their domestic form to Spain, but were also accompanied by well-developed management practices (Zapata et al 2004, 2005). Some similarities in material culture (Cava 2000) and agricultural management (Stika 2005) with areas of southern France (Schuhmacher 1996; Zapata et al 2004) suggest a trans-Pyrenean or coastal/maritime route or both,

at least for some of the Neolithic innovations. In addition, we should always keep in mind that possible influences from northern Africa cannot be evaluated due to a poor archaeological record in those regions and a eurocentric approach to Spanish archaeology.

Many factors, which could account for the observed diversity in the timing and intensity of the use of Neolithic innovations, are mentioned in the literature and briefly summarised above. The presence of morphologically distinguishable domestic pigs in the Early Neolithic is confirmed, at least in parts of the country but whether domestication took place locally or domestic pigs were introduced from neighbouring areas cannot be presently determined due to lack of multi-period assemblages – preferably including Mesolithic and Neolithic levels - which would enable us to address this issue in greater detail. Pig husbandry, as well as the importance of wild boar hunting, varied not only from region to region, but also from site to site. An example of intra-regional difference is represented by the sites of Cova Fosca (Llorente 2007), with its predominant hunting economy, and La Draga (Saña 2000), which clearly had a developed food production economy. Yet the two sites lie in roughly the same geographic region and overlap chronologically with each other.

The relative importance of hunting and husbandry is not the only element of variation in the exploitation of pigs at different sites, as the intensity in management of domestic pigs varied too. For example, the biometric data from La Draga show reduced postcranial size, compared to teeth, which could be interpreted as the result of a tighter control of the domestic herd and a gradual morphological deviation from the wild form. Such morphological changes would be, as in the case of La Draga, first visible on bones and then teeth, due to the plasticity of bones and the conservatism of teeth against environmental stimuli. In contrast, the pig population of Cueva Chaves, here interpreted as predominantly domestic, is more distinguishable by its age and sex profile rather than its biometry. This picture of diversity in the relationships between pigs and humans during the Early Neolithic contrasts with the relatively rapid spread of other neolithic innovations such as cereal cultivation and sheep/goat husbandry in eastern and southern Spain (Zapata et al 2005) but does not contradict it. There is no reason why some of the Neolithic innovations,

especially those involving exotic animal and plant species, could not have been implemented more rapidly and homogeneously whereas others reflected more closely local environments and pre-existing cultural traditions (Zvelebil 1995).

From the interpretation and discussion of the analysed data it is evident that the resolution they offer for the time being is crude. Nonetheless, the evidence presented here still offers significant insights in the chronology, speed, geographic origin and direction of the pig domestication process in Spain. This should facilitate, and hopefully provoke, a more detailed reconstruction of how pig domestication articulated with the process of neolithisation in Spain.

7.1.3 Integrating zooarchaeology and ethnoarchaeology: the origins of pig domestication

Integrated with the purely archaeological approach, the results of the ethnoarchaeological component of this project provide relevant analogies to some of the issues that early pig herders must have also faced in Early Neolithic Spain. The perception of a pig – and every animal species in general – as ‘wild’ or ‘domestic’ by humans is clearly dichotomous, as the traditional pig breeders of Spain (chapter 6), and Sardinia and Corsica (Albarella et al 2006c, 2007) have stated. Though this statement is relatively vague and Neolithic people in Spain did not necessarily think in exactly the same way, it seems to be the most likely way to view pigs irrespective of their morphology. It is quite probable that, like today, people in the past too considered as ‘domestic’ any animal for the rearing of which they had invested labour and time. This way of viewing animals does not seem to be affected by the morphology of the animals involved. Specifically for pigs, anything between identical-to-wild-boar morphology to clearly distinct from it, would most likely be perceived as a ‘domestic’ animal, if some time was invested in its rearing. This view offers little practical help in detecting the origins of pig domestication but it does alert us to the fact that the morphology of animals is to a certain extent irrelevant to their perception as ‘wild’ or ‘domestic’. The definition of a ‘domestic’ pig in this project is based exactly on the above-described perception. This contradicts many of the traditional zooarchaeological definitions of what a ‘domestic’ animal is and it makes the task of identifying early domesticates even more challenging. In

some cases, we may just have to admit that with the currently available methodological toolset, it is not possible to detect the presence of domestic animals, even if they occurred and were perceived as such.

Another issue on which ethnoarchaeology has raised our awareness is that of the potential interbreeding between wild and domestic pigs. Pig breeders in Spain and other Mediterranean areas (see chapter 6) consistently state that such mixing is nowadays undesirable, but at the same time they are aware that it occurred on a regular basis in the past. This has important implications for our understanding of the origins and evolution of pig domestication. It is evident that we should not think of the pigs of the past in terms of present-day animals whose movements are severely restricted. It is most likely that these animals were relatively free to move around substantially thus increasing the chance of meeting their wild counterparts, and eventually mating with them; even the possibility of deliberate interbreeding cannot be excluded. Assuming – as also supported by the available archaeological record – that, at the onset of the Neolithic, human communities were relatively sparse, small-sized and still relying to varying degrees on wild resources, interbreeding between domestic pigs and wild boar must have been almost impossible to prevent. In fact interviews with pig breeders indicate that this was the case even a few decades ago – let alone in early prehistory. In addition we must consider that interbreeding may have the positive role of avoiding inbreeding. Inbreeding is a constant concern of pig breeders, even in cases – such as in modern Extremadura (see chapter 6, section 6.2.5) - where hundreds of pigs are kept. In the Early Neolithic, herds were inevitably small and hence the need to find ways to avoid the detrimental effects of inbreeding must have been pressing and the obvious two ways were: a) interbreeding with wild boar, and b) exchange of pigs between communities.

Since past interbreeding between wild and domestic pigs was inevitable, the question that we should try to tackle is therefore not whether it occurred or not but rather how frequently it happened and how desirable it was for the herders. The biometric data so far presented provide support to a scenario of some interbreeding between domestic pigs and wild boar in Early Neolithic Spain. We have for instance seen that at Cueva Chaves the two populations could not all

be distinguished, despite the likelihood that both forms occurred. It is still very difficult to distinguish whether domestic pigs were introduced, locally domesticated or both, but if frequent interbreeding occurred, then any introductions would be obscured by subsequent dilution in the richer and more extensive genetic pool of the local wild boar. The morphological similarity between pre-Neolithic and Early Neolithic pigs in most tooth measurements is a particularly strong indication of genetic affinity, unless we advocate the rather unlikely introduction of a new type of domestic pig that had – by pure chance – the same tooth size as the pre-Neolithic Spanish wild boar. On the other hand, even in tooth measurements - especially those of the third molar – there are indications for a shortening of the snout, which is considered as one of the first and typical effects of domestication (see figure 3.29). The shape of Early Neolithic third molars also shows some signs of deviation from the pre-Neolithic standard (see figure 3.31). Although interbreeding certainly occurred the fact that a slow morphological differentiation between domestic and wild forms started emerging indicates that the two populations became gradually more separate from each other – whether by deliberate choice or not is hard to say.

The ethnographic work in Spain has also provided an idea of how a local wild boar can practically be domesticated or incorporated in an already established domestic herd. One of the Spanish pig breeders who – like his Early Neolithic ancestors – is also a hunter, stated that wild boar hunting frequently produces orphaned or abandoned piglets which are easily raised by humans. The specific breeder does not promote interbreeding between any of the captured wild piglets and his domestic pigs but this cannot be ruled out for the past, as he mentioned medical controls and a low meat:bone ratio in wild boar (and consequently hybrids) as the only reasons to avoid interbreeding.

7.1.4 The end of the Neolithic period: consolidation of pig domestication

The data from the Late/Final Neolithic period or roughly the 4th millennium cal. BC are almost as scarce as those from pre-Neolithic periods. Nevertheless, their analysis and discussion in chapter 3 has revealed clear patterns that do not allow for much doubt about the trajectory that pig domestication took in

Spain. This does not mean that pig domestication evolved in a linear and uniform way across the country, but rather that tendencies were common in different areas.

In the Early Neolithic we have seen a great diversity of situations, but at the same time definite indications for the onset of pig domestication, at least in Catalonia, the Ebro basin and the *meseta*, and most probably in the Valencian Country and Andalusia. In the Late/Final Neolithic, sharp changes were recorded in all lines of zooarchaeological but also archaeological evidence. Zooarchaeologically, major changes in the biometry and age/sex structure of pig populations occurred, all of which point towards a consolidation of pig husbandry and a sharp demise of the importance of wild boar hunting.

Late/Final Neolithic pigs are on average clearly smaller than in the preceding period, both in postcranial (e.g. figure 3.21) and dental (e.g. figure 3.33) measurements. These smaller - presumably domestic - pigs can be, by this time, much more clearly distinguished at a population level from the much rarer wild boar. This biometric pattern is accompanied by a sharp increase in the average age-at-slaughter, compared with the Early Neolithic (figure 4.81). In addition, during the Late/Final Neolithic, a heavy reliance on domestic animal species – already identified in some Early Neolithic sites – appears to be the norm. Concerning pigs, this is reflected in the biometric patterns with the bulk of measurements – both postcranial and dental - being significantly smaller than those of earlier periods (e.g. tables 3.10 and 3.13), while large outliers – presumably belonging to wild boar - are rare.

The definite zooarchaeological evidence for an increased divergence between domestic and wild pigs, as well as the demise of the importance of wild boar hunting, are in accordance with the rest of the archaeology. Cave sites are much rarer in the Late/Final Neolithic than earlier, while open-air settlements are the norm. Moreover, there is widespread evidence for the diffusion of the typical Neolithic innovations (ceramics, cereals, pulses, domestic animals, sedentism, etc) across the entire Iberian peninsula (*cf.* Arias 1999; Arias et al 1999; Ribé et al 1997).

In pigs, another important difference between the Late/Final Neolithic and earlier periods is the relationship between postcranial and dental size (figure 3.36). A much sharper size reduction in postcranial – than dental - elements resulted in pigs that have more or less the same bone:tooth proportions as the domestic pigs of Durrington Walls in England (used as the standard for the log ratio histograms throughout this study). As it has been stated several times in previous chapters, this pattern is in accordance with the fact that teeth are much more stable and respond much more conservatively to environmental stimuli, whether those are the result of human management or environmental change.

Unquestionably a larger dataset for the Late/Final Neolithic would have provided the opportunity to refine substantially the resolution of our understanding of pig husbandry in this period. Nevertheless, the most important feature of this period is the occurrence of an unmistakable signature of predominately domestic pig populations, not just in one region but all over Spain. The available data, albeit limited, also allow us to claim that the domestic animals had diverged much more from the wild form, both in terms of absolute size and postcranial:dental proportions.

7.2 Pig domestication: post-Neolithic evolution

As mentioned several times, this project focuses on the understanding of the onset of pig domestication in Iberia but is equally interested in following the evolution of this practice throughout prehistory (i.e. until the Iron Age and before the Roman conquest). This broad chronological approach permits to investigate how pig husbandry was shaped by - and in turn shaped – the important sociopolitical, technological, economic and environmental developments that occurred in Spain during the Neolithic as well as the Copper, Bronze and Iron Ages. There has been a tendency in zooarchaeology to focus on the origins of animal domestication and to relegate the role of animal husbandry in post-Neolithic times to a matter of secondary importance. In this study, however, pig domestication is seen as an ongoing process, from its origins to the end of prehistory, with each period providing equally interesting insights and original knowledge on the dynamic relationship between pigs and humans.

7.2.1 Copper Age

The Copper Age is an intriguing period in Spanish archaeology. It constitutes the continuation of the Neolithic and has a particularly rich archaeological record, which has attracted intense research interest from Spain and abroad. The defining characteristic of this period and one of its most intensively studied aspects is the appearance and rapid development of metallurgy, particularly in the regions of Andalusia and Almeria, where extensive and world-famous settlements such as Los Millares, Valencina de la Concepción and Los Castillejos have been excavated. The bulk of the Copper Age material included in this study derives from those sites.

On the basis of the results presented in chapter 4, but also the rest of the Spanish zooarchaeological literature (e.g. Fábregas et al 2003: 868; Morales 1992; Peters and von den Driesch 1990; Ziegler 1990), it is evident that in the Copper Age interactions between wild boar populations and human communities (either in the form of hunting or interbreeding with managed pig herds) were limited. This trend was most probably established before the end of the Neolithic but in the Copper Age we have more and larger assemblages pointing in the same direction.

On average, Copper Age pigs were significantly smaller than in the Early Neolithic, both in postcranial (table 4.3) and dental (table 4.8) size. A small proportion of wild boar remains can, however, also be found in this period (figure 4.86 and 4.87), which suggests a likely opportunistic exploitation of these animals by Copper Age people. The rather distinct large size of some specimens suggests limited mixing of wild and domestic pigs in this period. The suggested increase of wild boar size during the Neolithic is supported by Copper Age data too since the few large outliers are usually as large or even larger than those from pre-Neolithic times. The age and sex structures of Copper Age populations - with a clear female majority and consistently high mortality in the second year - also point towards domestic rather than wild or mixed pig populations. The high frequencies of linear enamel hypoplasia on Copper Age pig teeth (figures 4.150 and 4.152) constitutes another differentiating factor, pointing in the direction of predominately domestic populations managed more intensively than in the Early Neolithic.

Beyond the obvious biometric differences between Copper Age and Early Neolithic pigs, interesting patterns emerge when some of the measurements are viewed individually. For example, there is a clear trend for sharper reduction in teeth further back in the jaw (mostly the third and to a lesser extent the second molar). Based on the biometric patterns, it seems that processes initiated in the Early Neolithic (e.g. clearly distinguishable reduction only in third molars) continued in the Copper Age. This suggests a gradual but steady process of genetic separation between wild and domestic stocks. In this process, postcranial size must have been much more directly affected, as it is more influenced by the environmental restrictions and the usually worsening living conditions of domestic life, while tooth size was slowly but steadily adapting to the reduced size of the jaw.

This pattern identified in Spain is similar to that from neighbouring Portugal in both postcranial (figure 5.11) and dental measurements (figure 5.22). The biometric similarity over large geographic areas – whether within Spain, Portugal, or both - suggests an increased uniformity in the morphology of Iberian domestic pigs and also a certain homogeneity in the size of the Iberian wild boar. This is at least the case for the southern half of the peninsula from where almost all Copper Age assemblages derive. These characteristics are indicative of consolidated productive economies with heavy reliance on domestic resources and an opportunistic interaction with wild boar populations.

The above-described zooarchaeological data are in perfect agreement with other archaeological lines of evidence. The relatively well-studied Copper Age settlements of south, southeast, southwest, and – lately - central Iberia are in sharp contrast with the picture highlighted earlier for the Early Neolithic sites. The overwhelming majority of Copper Age sites are open-air and with confirmed year-round habitation, communal infrastructure, evidence for long-distance contacts and trade, and indicators of social stratification. These characteristics of Copper Age sites, help explain the genetic separation and hence the morphological deviation between domestic and wild pigs. In the archaeological context briefly outlined above, it can be relatively easily envisaged why and how the morphology of domestic pigs was shaped in the way presented in this chapter.

Many Copper Age settlements were fortified or built in naturally defended locations, a characteristic that may have contributed to restricted mobility for pigs, especially where they were kept close to the nuclei of settlements. Moreover, due to intense mining and metallurgical activities in the Pyrite Belt of southern Spain (Nocete et al 2005), there is strong evidence for serious environmental degradation – in the form of deforestation, erosion and contamination – around the Copper Age sites of that area (also Kunst 1995 for Portugal). Even if we cannot be sure about the degree of degradation at each site, it is likely that this contributed – to varying degrees – to the reduction of wild boar populations in the vicinity of human settlements and to the lack of suitable vegetation for a free-range style of pig husbandry.

The specialization and large scale of metallurgical activities in southern Spanish sites such as Valencina de la Concepción (by far the largest Copper Age assemblage recorded for this project) is also expected to have exercised pressure for an increase in specialization and scale in animal husbandry. The pressure to increase numbers and productivity in domestic pig herds was a major factor that shaped the style of husbandry. For example, the increased – compared to the Early Neolithic - survival in the first year and the establishment of an adult female majority may constitute expressions of efforts to make the most out of pig herds. This incipient intensification provides an additional explanation for the further size diminution, which may be – at least partly – attributed to a worsening of the living conditions of pigs and a restriction of interbreeding with the wild boar. This suggestion is also supported by an increase in tooth developmental defects (figure 4.152).

7.2.2 Bronze Age

Although there are fewer data for the Bronze than the Copper Age, the assemblages used as part of this thesis cover a wider geographical area and are therefore more representative of the country as a whole. The discussion of the data for this period (chapter 4) provided useful insights into pig husbandry strategies as well as the hunting of wild boar in the 2nd millennium cal. BC. In the preceding Copper Age pig remains were almost exclusively represented by the domestic form. A relatively clear morphological domestic/wild separation

occurred and age/sex structures were suggestive of intentional efforts to increase productivity. In chapter 4 we have seen that Bronze Age data exhibited both similarities and differences with Copper Age patterns, which is interesting to assess in their wider zooarchaeological and archaeological contexts.

The data analysed in chapter 4 highlighted a picture of diversity in the pig-human relationship during the Bronze Age. This diversity is, however, different from the one identified for the Early Neolithic. Unlike the Early Neolithic, in the Bronze Age there is no doubt that domestic pigs predominate and that productive economies were firmly established all over Spain, even in the areas of the Atlantic coast, where development was delayed in the Neolithic and Copper Age. However, in the Bronze Age there is increased diversity in the age/sex structure of pig populations and a deviation from the strongly unimodal biometric distribution of Copper Age assemblages.

The main aspect of diversity in the human-pig relationship is the fluctuating – and overall increased - percentage of wild boar remains in Bronze Age assemblages. This is reflected in the biometric patterns which exhibit an almost bimodal distribution – with overlap - of postcranial measurements (figure 4.91) and a bone:tooth size ratio that deviates from that of the Copper Age, the Late/Final Neolithic and the Durrington Walls standard (figure 4.153). The relationship between postcranial and dental size is reminiscent of the Early Neolithic and pre-Neolithic periods, when wild boar was much more frequently exploited. Other general aspects that deviate from the preceding Copper Age are the older age profiles (figure 4.81) and the increased male percentages (section 4.1.2) in Bronze Age pig assemblages.

The Bronze Age data are intriguing, mainly because they highlight the non-linear evolution of the pig-human relationship. Despite pig husbandry was already firmly established and assumed a dominant role compared to wild boar hunting since the Copper Age, Bronze Age assemblages show a considerable increase in wild boar hunting. This increase is not necessarily – and most probably is not - related to the style of husbandry of domestic herds. The size of domestic pigs is still the same – or quite similar – to that of the Copper Age, with the only difference that the few larger-boned specimens of the Copper Age

become much more frequent in the Bronze Age. It is therefore the higher frequency of wild boar that separates the Bronze from the Copper Age, rather than a major change in pig husbandry. Differences in age (more old animals) and sex (more males) can also be explained with a higher proportion of wild boar in the assemblages.

I have also postulated (chapter 4) that in this period wild boar may have slightly increased in size and not just in frequency. An increase in wild boar body size during prehistory has also been identified in Italy (Albarella et al 2006b) and may be attributed to an increase in moisture and food availability in Spain during the 2nd millennium cal. BC (*cf.* Chapman 1990: 108-109, 139). We must, however, consider that this increase in moisture was not universal within Spain. In addition, the Copper Age and Bronze Age sites are not entirely comparable in terms of their geographic distribution, with the latter stretching out more in areas with wetter climate and hence with capacity for larger and healthier wild boar populations. Future research will therefore need to ascertain whether the increase in wild boar size in Spain is an artefact of the uneven geographic coverage in different periods or it represents a genuine overall increase in the body size of the species across the country. Currently, the knowledge that similar patterns of body size increase have been identified in other European areas makes the latter hypothesis more likely.

Though the Bronze Age exhibits considerable cultural diversity in Spain, there are some general trends that hold true, either all over the country or over large sections of it, that could explain the biometric, age and sex patterns described above. First of all it is necessary to consider that the Copper Age dataset is dominated by the large assemblage of Valencina de la Concepción and is generally biased towards southern Spain, while Bronze Age data are more likely to reflect the naturally occurring diversity in both wild and domestic pig populations across Spain. In addition, the observed biometric diversity within the predominant 'domestic' mode could be used to support a scenario of increased diversity in husbandry practices resulting in morphological diversity (see figures 4.92 and 4.133 for a site-by-site breakdown of the Bronze Age histograms). There is, after all, evidence of settlement expansion and diversification in many Iberian regions during the Bronze Age, which is also

reflected in indicators of forest clearance, increased erosion, soil disturbance and fire (e.g. Butzer 2005: 1791, fig 3; Chapman 2003: 131-46; Stevenson 2000: 607).

There are also various cultural, demographic and economic factors that may have contributed to the zooarchaeological patterns observed for the Bronze Age. In most areas, there was a change – rather than continuation - of site locations in the Bronze Age and a trend towards greater concern for defence (Díaz-Andreu 1995). The habitation of new locations may have increased the chance of contacts with previously isolated wild boar populations. The demography and the economic model in many areas may have also contributed to the ‘conflict’ between wild boar and humans. Significant increase in human populations has been suggested for the Bronze Age (Chapman 1990; Diaz-Andreu 1995), which may be partly responsible for an increase in economic importance of the more predictable arboriculture (vine, olive, fruits). In turn, this may have encouraged the use of horses and cattle (e.g. Chapman 1990: 117-118; Muñoz 2000: 251) for transportation and traction in order to increase productivity and facilitate the exploitation of areas further away from the main nuclei of human settlements (Harrison 1985; 1995). This new reality in many areas possibly contributed to increase the frequency of wild boar-human encounters. The increase in coverage and/or diversity of agricultural activities offered feeding opportunities that wild boar may have found irresistible and easier to exploit than fields close to the settlements. The more the agricultural land expanded, the more likely it was to approach areas where wild boar populations lived, but also the more difficult it became to effectively protect the fields. Especially in the case of arboriculture, it may have even been desirable for wild boars to be attracted by fallen fruits and be hunted as an additional bonus. In these circumstances, solitary males may have been more vulnerable - especially during the first year after they had broken off their mother’s sounder - than sounders consisted of experienced adult females and their young. This scenario would provide an explanation for the predominance of males in some assemblages.

In central and southern Iberia since the Early Bronze – and across the peninsula by the end of the period – there are strong indications for important

changes in material culture, social structure and beliefs, which could have affected human-animal relations. Many archaeologists (e.g. Chapman 1990, 2003, 2008; Diaz-Andreu 1995) have identified increased social stratification and complexity, such as individual (instead of collective) burial or cremation, drinking vessels such as *copas* (chalices) and increased frequency (e.g. generalisation and normalisation in production of bronze artefacts) and diversity (e.g. use of silver) of metallurgy, etc, (also see Kunst 1995 for social complexity since the Copper Age). All these could not have been directly relevant to pig husbandry nor to the increase of wild boar hunting. However, the scenario is open that in these social circumstances the dangerous activity of wild boar hunting – especially of males - may have been another opportunity for an individual to climb up the social ladder or maintain a high position. This could – at least partly – explain the high frequencies of male canines, which could have been perceived as trophies of bravery.

7.2.3 Iron Age

The Iron Age is the most recent and best documented period discussed in this project. The dataset includes a bias towards the Basque Country but most areas of Spain are represented, as well as a variety of cultural and chronological units. In the Iron Age pig husbandry assumed a clear and undisputable domestic character and never before the morphology of domestic pigs was more distinct from that of the wild boar. Although undisputable characteristics of domestic pig herds have been identified in the Late/Final Neolithic, Copper and Bronze Ages, the same trends in biometry and sex/age structures became intensified in the Iron Age.

In contrast with the preceding period, in the Iron Age wild boar hunting represented a very marginal activity. Biometrical indications for the presence of the wild boar are constantly scarce and this probably reflects the overall limited economic importance of hunting, as other wild species are also poorly represented in Iron Age assemblages (e.g. Altuna 1980: 40, fig 8; Iborra 2004: 379-398; Liesau 1998: 78, fig 34). This should not be taken as an indication that the wild boar had become rare, but simply that its hunting was not pursued with any regularity. However, at Iron Age La Hoya (Basque Country) the social and

symbolic importance of hunted animals may have been disproportionately greater than their economic value. For example, deer antlers recovered at this site were found incorporated in the outer face of the wall protecting the settlement and may have had a symbolic protective role (Llanos 1990: 176). In addition, a wild boar mandible – recognized as such by its enormous size – was identified by the author as a potential trophy, due to the presence of a perforation on the *ramus* of the mandible possibly to facilitate its display.

The most important Iron Age developments in the pig-human relationship concern the style of husbandry, which has similarities but also important differences compared to the other two post-Neolithic periods. The main common characteristic is that, as in all periods after the Early Neolithic, pig husbandry assumes a dominant role over wild boar hunting and this domestic majority can be morphologically identified, at least at a population level. The biometric patterns of the Iron Age (chapter 4) showed an overwhelming majority of smaller-sized individuals and very few large outliers.

In addition, the Iron Age results suggest important developments that highlight the dynamic character of pig husbandry after its initial appearance in the Neolithic. In this period domestic pigs decreased further in size thus indicating that animal domestication is an ongoing process and humans are capable of inducing important – and archaeologically visible – morphological changes not only during its initial phase but also at any point during the evolution of the process. Tiny pigs, smaller than ever recorded in prehistoric Spain, and pig assemblages characterised by clearly defined trends in sex and age structure typify this period. More specifically, an overwhelming female majority indicates a high level of manipulation of the herd structure. The age composition of the herds was also highly controlled by humans and geared towards maximizing meat yields.

All these characteristics indicate intensification in pig husbandry. The term 'intensification' in this context is perceived as a conscious economic strategy geared towards increasing the calorific output. Such an aim could have been achieved only through a profound knowledge of pig biology, long-term observations of genetically-determined individual attributes and integration with

other economic and social parameters. All these characteristics seem to have been fulfilled in Iron Age Spain. On the other hand, all these indications are more compatible with a sedentary style of pig husbandry and possibly a worsening of the pigs' living and dietary conditions, which would explain the marked body size diminution. The introduction from other areas of a smaller-sized type of pig in the Iron Age is unlikely, as the change is not abrupt but rather the result of a gradual and steady pattern of body size diminution, which started in the Neolithic (e.g. figures 4.103 and 4.148).

During the Iron Age, pig husbandry probably assumed its highest economic importance, at least in some areas of Spain (e.g. Iborra 2004: 344-45), though it was generally of secondary importance to cattle husbandry in the north and sheep/goat husbandry in the south. Another interesting characteristic of Iron Age domestic pigs is their general homogenous size across the country, which hints at the possibility that the style of husbandry in different parts of the country, from the Atlantic coast to the Mediterranean, was similar or at least less diversified than in previous periods. If spatially no size differences could be detected, temporally, a size decrease can be identified within the Iron Age, as pigs from the later part of the period are generally smaller than those from the earlier (e.g. figure 4.100).

The geographic homogeneity of pig husbandry may seem surprising when we consider the remarkable cultural diversity that characterised Spain according to other lines of archaeological and literary evidence. This has led to the identification of distinct Iberian 'ethnic' groups, such as the 'Cantabrians' and the 'Vettones' in the north, and Phoenician and Greek colonies or influences in the south. Yet, pig exploitation appears as a relatively constant and uniformly exercised economic activity which was shared by the different cultural groups.

7.2.4 Integrating zooarchaeology and ethnoarchaeology: the evolution of pig domestication in post-Neolithic periods

The ethnoarchaeological findings described and discussed in chapter 6 are especially relevant to our understanding of later prehistoric husbandry. In fact,

some of the husbandry trends identified in prehistory can still be identified today, though they usually occur in a more intensified form.

The tendency towards a decrease in the importance of wild boar hunting for subsistence in post-Neolithic Spain has reached its climax today. Wild boar hunting is widely practiced in modern Spain but it has a recreational rather than economic character. The element of prestige attached to wild boar hunting that has been suggested for the Bronze and Iron Age does, however, persist today. Some of the modern pig breeders do indeed often display heads of hunted male wild boars and sets of male canines in their houses – a continuation perhaps of a long standing practice.

The increasing majority of females kept in pig herds, which culminates in the 5-6:1 female:male ratio that we have found in the Iron Age, is broadly consistent with modern traditional practices. Modern breeders in fact tend to encourage an even higher female:male ratio, which suggests that the trend did not stop with the end of the Iron Age.

As with sex ratios, age profiles in post-Neolithic periods show a clear tendency towards a restriction of losses in the first year and a concentration of slaughtering in the second and third years, while a significant – but still small - number of pigs reached full adulthood. This tendency can be broadly related to the strategies of modern pig breeders in southwest Iberia, who have managed – with their sound husbandry knowledge, veterinary help and improvement of living conditions – to minimise losses of young pigs and developed the ability to cull their pigs at about two years of age. The higher percentages of third-year-olds in post-Neolithic assemblages might be the combined result of slower-developing primitive breeds, a more slack style of husbandry and the admixture – to varying degrees – of wild boar remains in the samples.

Another point of relevance in the comparison between post-Neolithic pig husbandry and that documented for modern southeast Iberia is that of the interbreeding between wild and domestic stocks. It has been discussed before that it must have been almost impossible for Early Neolithic breeders to prevent some or even extensive interbreeding between their domestic pigs and the local

wild boar. This may have even been desirable. However, in post-Neolithic times, a gradual size diminution of the domestic stock suggests a progressive increase of the genetic separation between the two forms. Today there is strict separation between domestic and wild animals, as the interbreeding is regarded to be undesirable. Biometric patterns for the Copper, Bronze and Iron Age, indicate that a similar opinion may have been held by herders of the past. Moreover, it can be argued that with the demographic increase, the increase in the density of settlements and the intensification of husbandry that took place in post-Neolithic Spain, interbreeding may have become unnecessary, since there was enough genetic diversity in the domestic pool. Free from this necessity, post-Neolithic pig breeders probably started developing their individual or regional selection schemes to achieve those characteristics they desired for their pigs.

A possible difference between early and post-Neolithic pig husbandry is the compatibility of pig husbandry with other economic activities, especially agriculture. In post-Neolithic times there is strong evidence towards an expansion of agriculture, both in area coverage and diversity of exploited plant species. In modern Iberia, pigs are kept free-range partly because there are no cultivations in the same land plots and still the pig breeders apply snout rings on their pigs to reduce the amount of soil disturbance, but mostly to exclude the possibility of the pigs digging their way out of walled or fenced plots. It is possible that the restriction of mobility in post-Neolithic pig herds is related to this aspect of pig behaviour, which would also restrict the chances of interbreeding with their wild relatives.

7.3 Weaknesses, strengths and future directions

7.3.1 Weaknesses

One of the challenges faced by this thesis work has been the lack of comparable projects in the same geographic area. On the one hand this contributes to make this project particularly innovative, on the other it does not provide it with the opportunity to rely on a substantial body of comparative data.

As a consequence many of the questions that have been raised could not be resolved, or at least not completely so.

In addition, there are gaps and shortcomings in the distribution, quality and accessibility of zooarchaeological data from Spain. Geographical and chronological biases have been acknowledged throughout this thesis, but unquestionably some have severely impeded our level of understanding of the zooarchaeological evidence. The inadequacy of pre-Neolithic data – in terms of overall quantity, as well as geographic and chronological coverage and resolution - represents a particularly serious issue. The inevitable pooling of several millennia and the lack of pre-Neolithic data from central and southern Spain prevented addressing crucial issues such as the effect of environmental and climatic changes on wild boar populations (e.g. glacial vs. post-glacial populations), as well as capturing the natural variability of wild boar populations in a country as environmentally diverse as Spain.

In the Early Neolithic there are similar problems, but less severely so. However, the importance of the period in relation to the origins of pig domestication renders the existence of geographic and chronological biases particularly lamentable. Ideally the research questions should have been tackled by analysing a larger number of sites that covered the Mesolithic/Neolithic transition, or at least by comparing Late Mesolithic and Early Neolithic sites located in the same area.

Another problem has been the lack of financial resources, which would have allowed paying for radiocarbon dating of targeted pig remains. This would have enabled the direct dating of Early Neolithic specimens that appear to be distinctively small and are therefore likely candidates as early representatives of a new and morphologically distinct type of pig in Spain. This would have also provided greater chronological resolution to some assemblages, important for such a critical period for the appearance of domestic animals.

7.3.2 Strengths

Despite these weaknesses, this project has also provided the opportunity to generate scientifically sound results, as well as the production of original knowledge on many zooarchaeological and archaeological issues.

For the first time the study of pig exploitation in prehistoric Spain has been approached at a broad chronological and geographical scale. As a consequence, by far the largest volume of data on Spanish prehistoric pigs has been accumulated. This dataset has allowed the results to be investigated at a regional level, therefore addressing the issue of pig domestication in a holistic manner. In the past, for practical and political reasons, only a few studies have been given the opportunity to address zooarchaeological issues that 'trespass' more than one or two autonomous communities.

This study has also benefited from the application of a well and successfully tested methodological approach. Biometry is not a novel technique *per se* but the measurements recorded for this project have been carefully selected from various sources in order to achieve a suite that offered the opportunity to address different aspects of pig morphology and reliably evaluate the main factors affecting measured postcranial and dental elements. In addition all the data presented in this project were collected by the same operator, thus enhancing their consistency and comparability. Concerning the age profiles of populations, standard methods have been applied but also an attempt has been made to correlate – in terms of absolute age - epiphyseal fusion with dental eruption. Sex identifications and the recording of dental defects, also provided useful results, integrated with the other lines of evidence. The application of the log ratio technique – among other more straightforward methods - in the analyses of the recorded data, proved to be very useful since it increased sample sizes and their comparability.

The ethnoarchaeological component of the project has proved to be even more fruitful than initially anticipated. The combination of ethnoarchaeology with zooarchaeology is commonly used but in this case the environmental and geographic relevance was high and the results offered numerous opportunities for the establishment of analogies with the past.

The research environment in which this project was carried out at the Department of Archaeology of the University of Sheffield greatly facilitated and enhanced positively the results of the project. Many colleagues with very relevant research interests contributed valuable knowledge, data and bibliography to the current project. It was particularly useful and rewarding to have the constant opportunity to have the results of the project scrutinised by a research team that has familiarity and expertise with both the methodological approach and the research questions.

7.3.3 Future directions

This project has addressed many zooarchaeological issues relevant to pig domestication, but, as is usually the case in archaeology, few have been fully resolved, some have been taken forward and many more have been identified as in need to be addressed by future research.

An issue that could have not been sufficiently explored is the detection and reliable evaluation of regional variability in the biometry of wild boar and domestic pig. This requires an approach that involves the study of sufficient numbers of pig remains from targeted environmental/climatic and cultural units in Spain. This is challenging because it should include abundant and chronologically well defined samples, which are currently insufficiently available. The intense archaeological activity that has taken place in Spain in the last decade, and which will hopefully continue in the future, could, however, contribute to make such an enterprise possible in the near future.

Another topic on which we still know very little and that should be explored further concerns the creation and extinction of local breeds of domestic pig, as well as the possible introduction of breeds from other parts of the world. In this project, hints of possible differentiation of breeds have been identified for the Iron Age. Such an undertaking is extremely difficult due to the expected size and morphological overlap between such breeds, as well as the wild boar. However, additional methodological tools with a potential to tackle this issue may include genetics, geometric morphometrics (e.g. Bignon et al 2005), shape indices such as those used for third molars in this project, as well as auxiliary

methods that will be developed in the future. Ethnography has shown how important the choice of specific animal breeds is to humans, not only in terms of animal adaptation, behaviour and differential economic exploitation, but also of cultural identity. Thus, being able to identify pig breeds in the archaeological record will be a fascinating development, which will add a huge amount of useful archaeological information.

Many more methodological tools were not included in the current project, mainly for practical and financial reasons. However, in future projects relevant to pig domestication in Spain, methods such as genetic analysis, radiocarbon dating, isotopic analysis, microwear analysis and others, may provide a huge potential in enhancing, taking forward, or even contradicting the results of the current project. Such developments not only are already feasible but the need for them to be carried out is pressing.

As a chronological expansion to this project, it would be very interesting to explore changes in pig husbandry that may have occurred in the Roman period. The advent of Romans in Hispania affected many aspects of the social, economic and cultural life of the Iberian tribes and it would be very interesting to investigate if and in what ways pig husbandry was affected in different areas.

Many ideas for future work are stemming from the ethnoarchaeological component of this project. Ethnoarchaeological work focusing on traditional pig husbandry in Europe has proved to be a very fertile area of research and there are many issues that could be explored further in the future. For instance, it would be interesting to compare biometrically different traditional breeds of pig in order to evaluate the potential of distinguishing them in the archaeological record. Even if such a project does not yield satisfactory results in distinguishing different breeds, it will produce a high resolution – in terms of age, sex, breed, castration, nutrition, etc - biometric database, which can be used in exploring the relationship between biometry and other attributes.

7.4 Conclusions

In this final section the main conclusions drawn in previous sections will be summarised.

1) The presence of domestic pigs in most areas of Spain since the Early Neolithic or at least the 6th millennium cal. BC is confirmed. This suggestion had been made before on a site by site basis but this can now be observed at a larger scale and using several different lines of evidence.

2) The Iberian wild boar - through interbreeding and/or direct domestication - affected the morphology and size of the first domestic pigs in Spain. The extent to which it occurred varied from site to site depending on factors that were probably unique to each site. There is a tendency for more resemblance between domestic and wild pigs in dental than postcranial size. Also there is a tendency for clearer genetic separation between domestic and wild populations at open-air sites with better-developed productive economies usually situated in lowland or coastal areas.

3) During the process of neolithisation in Spain a 'package' may well have existed, though this did not seem to spread simultaneously and uniformly. Some aspects of the 'package' such as domestic sheep and goats, and cereal cultivation, not only were introduced already in their domestic form to Spain, but were also accompanied by well-developed management practices. However, the degree of reliance on domestic resources varied significantly, and was affected by environmental, climatic and possibly cultural attributes. Pig husbandry seems to be a highly variable component of the neolithisation process.

4) As a consequence of such variability we can confidently suggest that at Early Neolithic sites we witness relationships between humans and pigs that range between full predation at one extreme and rather developed husbandry at the other. Local and introduced domestication probably both played a role, thus confirming the results of the ancient genetic evidence for other European areas.

5) By the end of the Neolithic there are indications that the small, morphologically distinct domestic pigs, which were present only at some Early Neolithic sites, had become common. This process was accompanied by the also widespread, but not necessarily passive adoption of innovations such as agriculture, a sedentary way of life, and almost exclusively domestic animal economies.

6) By the Copper Age, productive economies were firmly established with considerable reliance on domestic pigs and only the occasional exploitation of wild boar populations. At least in the south and southeast of Spain, the restricted interaction with the wild boar - either in the form of hunting or interbreeding with domestic pigs – seems to be related with environmental and economic reasons. The exploitation of domestic pigs is clearly reflected in their reduced size, a predominance of females, a reduction of first year mortality and the increase in the occurrence of tooth developmental defects. Uniformity in pig husbandry over extensive regions of the Iberian peninsula is reflected in the biometric similarity between Spanish and Portuguese pigs.

7) In the Bronze Age there are no indications for any significant changes in the exploitation of domestic pig herds, but important changes occurred in the interactions with wild boar populations. Wild boar hunting – especially of male animals - became more substantial, probably because of a combination of environmental, economic and social reasons. The importance of each of those factors varied from site to site and will need to be better evaluated in the future.

8) Further intensification in pig husbandry was recorded in the Iron Age. A sharp size decrease occurred in this period and in conjunction with the establishment of an overwhelming female majority and age profiles aimed at maximising meat output. Shortly before the Roman conquest, pig domestication was more established and intensified than ever all over Spain, while wild boar hunting was of marginal economic importance though possibly of greater social and symbolic importance.

Pigs and humans have been interacting in the Iberian peninsula probably since the appearance of both species in that geographic context. With the

unprecedented increase in numbers of both pigs and humans over the last ten millennia their relationship changed dramatically. Initially, pigs constituted an important prey for humans. Later on, this relationship evolved into a mutual dependence for food with advantages and disadvantages for both partners. The pig – irrespective of the exact status of its relationship with humans – was and still is of paramount importance for many human societies. Despite that, our knowledge of its past – which is to a significant degree our own past - remains incomplete and hopefully attractive to future research. Beyond its scientific value, this project has also enabled me to meet the world of pigs in a profound way and appreciate them for what they really are. I was positively surprised to find out that my impression of pigs before the undertaking of the project was to a great degree negatively biased from long-established misconceptions passed from generation to generation. Mainly through the ethnoarchaeological component of the project, I was given an opportunity that I wish everyone had to gain insights into the physical and behavioural characteristics of this animal, as well as its intelligence and complexity of its psychology. Many would find it provoking or insulting to the human species to state that we are very similar to pigs but for me it is just the plain truth and certainly nothing I would be ashamed of.

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Appendices

Appendix 1. Database fields and codes

Database fields

An electronic database containing the raw data is provided on the enclosed CD (see inside back cover). The measurement GLI is recorded under the heading GL. DC, BdP and GD are recorded in the DC column. In the two columns below, database fields are presented in the form of a list, accompanied by a short description:

Rec Num: Record number	GLI: Lateral length
Site Name	Glm: Medial length
Location	X/N: Maxilla (X) or mandible (N)
Box Number	J/L: Jaw (J) or loose tooth (L)
Ctx Num: Context number	C: Canine
Bone Num: Bone number	dP4: dP4 wear stage
Phase	dP4L: dP4 length
Dating	dP4WP: dP4 posterior cusp width
El: Element	P4: P4 wear stage
Taxon	M1: M1 wear stage
Fus prox: Fusion proximal	M1L: M1 length
Fus dist: Fusion distal	M1WA: M1 anterior cusp width
BFcr: Width of cranial articular surface	M1WP: M1 posterior cusp width
SLC: Width of collum	M1hyp: M1 hypoplasia
BT: Width of trochlea	M2: M2 wear stage
HTC: Minimum diameter of trochlea	M2L: M2 length
GL: Greatest length	M2WA: M2 anterior cusp width
LAR: Diameter of acetabulum	M2WP: M2 posterior cusp width
DCP: Depth of the caput femoris	M2hyp: M2 hypoplasia
Dd: Depth of the distal end	M3: M3 wear stage
	M3L: M3 length

M3WA: M3 anterior cusp width
M3WC: M3 central cusp width
M3WP: M3 posterior cusp width
M3hyp: M3 hypoplasia
M12: M1 or M2
M12L: M1 or M2 length

M12WA: M1 or M2 anterior cusp width
M12WP: M1 or M2 posterior cusp width
M12hyp: M12 hypoplasia
Mand H: Mandible height
Comments

Codes

Postcranial Bones

at - atlas	othfe - proximal femur only
sc - scapula	ti - tibia
hu - humerus	othti - proximal tibia only
othu - proximal humerus only	as - astragalus
ra - radius	ca - calcaneum
othra - proximal radius only	mtiii - 3 rd metatarsal
mciii - 3 rd metacarpal	mtiv - 4 th metatarsal
mciv - 4 th metacarpal	p1 - 1 st phalanx
pe - pelvis	p2 - 2 nd phalanx
fe - femur	oth - specify element in comment

Teeth

l - loose tooth
j - jaw
x - maxilla
n - mandible
u - unknown

For the dP4, M1, M2, M3, M12 (M1 or M2) wear stages follow Grant (1982).

Presence/absence is indicated by using the codes:

p - present
'blank' - absent

Taxon (as classified by the previous investigator of the material and not by us)

w - wild

d - domestic

'blank' – unknown

Fusion

f - fused

g - fusing

h - fused or fusing

ud - unfused diaphysis

ue - unfused epiphysis

ux - unfused, both diaphysis and epiphysis present

Sexing

f - female

m - male

af - female alveolus

am - male alveolus

'blank' – absent

11) Are they born in the sty or in the wild? If in the sty, after how long do they move out? *Nacen en el establo o en campo abierto? Si en el establo cuanto tiempo permanecen antes de salir?*

12) Do you purchase any pigs to increase the size of your herd? *Compra ejemplares para aumentar la cabaña (piara)?*

13) At what age do you slaughter your pigs? *En que edad se sacrifican los cerdos?*

14) Is there a favourite slaughter season? If so, why? *Tiene una epoca preferente de matanza? En caso afirmativo, porque?*

15) Do you slaughter the pigs yourself or are they sent to the slaughterhouse? *Se sacrifican los cerdos en un matadero o lo hacen ustedes?*

16) How large is their home-range? *Que tamaño tiene su area de forrajeo?*

17) Do they go back to the sty for the night? *Pernoctan en el establo?*

18) Do they use any other natural or human-made shelters ? *Hacen uso de refugios naturales o artificiales?*

19) Where do they spend the day and how closely controlled do they need to be? *Donde pasan el dia y que necesidad de vigilancia estrecha precisan?*

20) How do you call/catch them for slaughtering? *Como se capturan a la hora de la matanza?*

21) What do they eat? Are there any seasonal variations? *Que comen? Hay variaciones estacionales?*

22) What is their average weight as adults? *Cual es el peso medio de adulto?*

23) Are there any cases of crossings with wild boars? *Hay cruces con jabalies?*

24) How often do animals disappear? *Con que frecuencia se producen desapariciones (perdidas)?*

25) Do they cause any damage? *Causan daños?*

26) Do you sell the meat you produce? If so, how? *Vende la carne que produce? De que modo?*

27) Which are the other products of economic value apart from the meat? How do you use them? *Que otros productos de interés comercializa además de la carne? Que usos tiene?*

28) Other comments

Appendix 3. Summary table of ethnoarchaeological data

Region	Badajoz, Extremadura, Spain	Olivenza, Badajoz, Extremadura, Spain	Jerez de los Caballeros, Badajoz, Extremadura, Spain	Ahillones, Badajoz, Extremadura, Spain	Burguillos, Badajoz, Extremadura, Spain	La Parra, Badajoz, Extremadura, Spain	Tentudía, Badajoz, Extremadura, Spain	Safara, Moura, Alentejo, Portugal	Campo Maior, Alentejo, Portugal	Jerez de los Caballeros, Badajoz, Extremadura, Spain	Fregenal, Badajoz, Extremadura, Spain	
Breeder	1	2	3	4	5	6	7	8	9	10	11	
Pig breeding experience	20 years	20 years	Family tradition. In large scale for the 3-4 years	All his life (family tradition)	10 years	Since 1956 (52 years)	15 years	Family tradition but him the last 10 years	Family tradition but him the last 7 years	Family tradition but him the last 23 years	All his life (family tradition). He was born in the estate	
Herd size	200	481	2000+	965 approximately	380-390	1900-2000	450 approximately	2500-2700	800 approximately	1350	610	
Husbandry regime*	Semi-free-range and free-range (majority)	Semi-free-range and free-range (majority)	Semi-free-range and free-range	Semi-free-range and free-range	Free-range	Semi-free-range and free-range (majority)	Semi-free-range and free-range (majority)	Semi-free-range (majority) and free-range	Semi-free-range and free-range	Intensively managed (majority) and free-range	Semi-free-range and free-range	
Breed	Pure Iberian (Lampião)	Pure Iberian (Entrepelado, Retinto, Lampião)	Pure Iberian (Lampião), Pure Duroc-Jersey, mixed (50% Iberian-50% Duroc-Jersey)	Pure Iberian (Retinto)	Pure Iberian (mixture of Retinto and Entrepelado)	Pure Iberian (Torbiscal and <i>Tornela</i> , a crossing of Torbiscal and Negro Lampião produced and owned by this man. <i>Tor-ne-la</i> comes from TOR-biscal+NE-gro LA-mpião)	Pure Iberian and mixed (75% Iberian and 25% Duroc-Jersey)	Majority of pure Iberian (Retinto) and some mixed (50% Iberian and 50% Duroc-Jersey)	Pure Iberian (mixture of Retinto and Entrepelado)	Vast majority of pure Iberian (Retinto) and few Duroc-Jersey	75% Iberian (Retinto) and 25% Duroc-Jersey	
Sex	♀	50	No reproductive pigs (castrated males only)	230 (226 pure Iberian, 4 Duroc-Jersey)	80	70	180	40 (pure Iberian)	325 (few Duroc-Jersey, majority is pure Iberian)	120	145 (140 pure Iberian, 5 Duroc-Jersey)	50
	♂	8-10		18 (6 pure Iberian, 12 Duroc-Jersey)	16-21	6	15	3 (2 Duroc-Jersey, 1 pure Iberian)	30 (few Duroc-Jersey, majority is pure Iberian)	13	11 (10 pure Iberian, 1 Duroc-Jersey)	10 (50% Iberian and 50% Duroc-Jersey)
Age profile at the time of interview	4 and 6 months: Majority Adults (3 years old or older): 60 Yearlings: few	Yearlings (born previous April/May): 240 7 month-olds: 241	2.5-3 months: 340 4-5 months: 520 6 months: 330 7-8 months: 330 Yearlings: 520 Adults: 248	6-7 months: 120 Neonatal-1 month: 500 Yearlings: 245 Adults: 96-101	1 month: 200 4 months: 108 Adults: 76	Neonatal-1 month: 550 4 months: 400 8 months: 800 Adults: 195	1-2 months: 100 7 months: 200 Yearlings: 100 Adults: 43	2 months: 500 4 months: 350 6 months: 300 8 months: 400 11 months: 500 Yearlings: 300 Adults: 355	4 months: 150 6 months: 150 8 months: 150 10 months: 20-60 Yearlings: 20-60 Adults: 133	8 months: 200 Yearlings: 150 Adults: 156 Age of 100 intensively bred pigs: unknown	6-7 months: 400 10-11 months: 150 Adults: 60	

Wild Boar (ubiquitous)	No	No	No	No	No	No	No	No	No	No	1 female (captured as a piglet during a hunting day). In the past he owned a male too.
Crosses with wild boar	Unwanted. Accidentally occurred once in the past	Unwanted. Never occurred.	Unwanted. Never occurred.	Unwanted. Never recently but occurred in the past	Unwanted. Never occurred.	Unwanted. Never occurred.	Unwanted. Never occurred.	Unwanted. Never occurred.	Unwanted. Never occurred.	Unwanted. Never occurred recently. In the past it used to occur.	Unwanted. Never occurred.
Castration	All males castrated at less than 1 month old	All males (1 week old) and females (unknown age) are castrated	All males (1 week old) and females (after weaning) are castrated	All males and females are castrated at 3 months of age	Males (1-2 months old) and females (unknown age) are castrated	All males (less than 1 month old) and females (unknown age) are castrated	All males and females are castrated upon weaning (2 months old)	All males and females are castrated upon weaning (4-5 months old)	All males (before weaning) and females (later than males) are castrated	All males (1 month old) and females (unknown age) are castrated	All males (1-2 months old) and females (2-3 months old) are castrated
Birth season	Anytime but too cold (winter) and too hot (June-July) periods are avoided	April-May and September-October	6 slots all year round (3 groups of females x twice a year)	Semi-free-range: April-May Free-range: October	6 slots all year round (3 groups of females x twice a year)	4 slots: Winter: Semi-free-range Spring: free-range Summer: free-range Autumn: free-range	Normally 2 birth slots: March-April and August-September	There are 6 slots all year round (3 groups of females x twice a year)	There are 6 slots all year round (3 groups of females x twice a year)	There are 8 slots all year round (4 groups of females x twice a year)	Stall-fed: January-February Free-range: August-September
Where are the litters born?	Born and remain indoors for 40-45 days	Outdoors in 'camping'**	Born and remain indoors for 35 days	Outdoors in 'camping'**	Outdoors in 'camping'**	Indoors	Outdoors in 'camping'** but indoors in extreme cold	Outdoors in 'camping'**	Outdoors in 'camping'**	Indoors	Outdoors in 'camping'** (rare and accidental births in nature)
Purchase of animals	Never but about to introduce another type of Iberian breed	Recommended to avoid reproductive problems and malformations	Every 1-2 years buys a male	No	Generally yes (last year he bought 4 males)	No	Usually some males, and rarely females, every 4-5 years	Usually some males every few years	Only at the beginning but not any more	Two males every two years	He buys all his males every year and occasionally some females
Age at slaughter	Semi-free range: 12 months Free-range: 15-16 months	Semi-free range: 14 months Free-range: 2 years	Semi-free range: 12 months Free-range: 16-20 months	Semi-free range: 13-14 months Free-range: 16-18 months	Free-range: 18-24 months	Free-range: 16-18 months	Semi-free range: 14 months Free-range: 16-22 months	Semi-free range: 12 months Free-range: 15 months	Semi-free range: 12 months Free-range: 14-20 months	Intensively managed: 12-13 months Free-range: 17-18 months	Semi-free range: 12-13 months Free-range: 14-16 months
Slaughter season	Nowadays, stall-fed pigs are slaughtered all year round but the acorn-fattened pigs predominately in January and February	All year round but summer is the worst time because pigs loose a lot of weight	Semi-free-range pigs slaughtered all year round (except August when slaughterhouse is closed) but free-range pigs as soon as possible after the acorn period	Semi-free-range pigs slaughtered all year round (avoiding summer) but free-range pigs mainly January-February	January is the slaughtering peak because it is the end of the 'montanera'	Mid-December to mid-March and has to be done as soon as possible because they loose weight and the desired acorn taste	Semi-free-range pigs slaughtered all year round but the free-range pigs in January-February (and less in March)	Stall-fed pigs are slaughtered all year round (except July-August) but the acorn-fattened pigs in January-March)	Stall-fed pigs are slaughtered all year round (avoiding July-August) but the acorn-fattened pigs in January-February	Stall-fed pigs are slaughtered all year (mostly September-February and avoiding summer) but the acorn-fattened pigs from mid-January onwards	Stall-fed pigs are slaughtered all year round (avoiding July-August) but the acorn-fattened pigs when at their optimum weight (somewhere from December to March)

Home range (free-range)	Farm is 626 ha. Pigs have 35 ha (divided in parcels of 2-8 ha). During acorn season they are in 70 ha	Whole farm is 300 ha. Pigs use 150 ha (divided in two parcels of approximately 70 ha each)	500 ha divided in 4-5 parcels of more than 100 ha each	640 ha divided in 5-6 parcels of more than 100 ha each	150 ha divided in 10 parcels of 15 ha each	844 ha divided approximately in 47 parcels of approximately 20 ha each	180 ha (not continuous land) divided in 24 parcels ranging from 1 to 15 ha each	200 ha (2 parcels x 50 ha, 1x26 ha, 1x14 ha, 1x10 ha, 1x8 ha and several small of 1-3 ha each)	215 ha (divided in parcels of 10-15 ha each)	1x70 ha (divided in 6x12-24 ha each) and 1x80 ha (divided in 4x20 ha each)	1000 (divided in parcels of 10-50 ha each, most are 30-40 ha)
Daily movements (excluding reproductive and very young individuals)	They tend to prefer the provided human-made shelter	They spend all their time outdoors where they also sleep in cleared spots called 'camas'= beds (in extreme cold access is allowed in man-made shelters)	The free-range always prefer to sleep outdoors even if man-made shelter is provided (even in bad weather)	Day and night outdoors. If it is cold they find a naturally sheltered area and if it is too hot they find oak shade or use the stream to cool down	Outdoors all the time	They are independent choosing where to be or sleep. They do not mind the cold but they mind the water and they move more when it is wet in order to find a good place	Outdoors day and night. In extreme cold they use some shacks but it is dangerous for young pigs due to temperature difference. Better to get them used outdoors	The ones that are fattened on provided food remain in small areas while the ones destined to be acorn-fattened roam freely in larger fenced areas	Outdoors all the time (that is what they prefer) but if weather gets bad they use the 'camping'	Sometimes they sleep indoors but they usually prefer to spend the day and sleep outdoors	Depending on the season. In winter they prefer a roofed area but in warmer months (most of the year) they sleep outdoors
Level of Control***	Little (only to feed)	Little (only to feed during which they are also inspected for health problems)	No need for control but occasionally the 2-3 employees walk around to inspect for ill animals	Little (only to feed during which they are also inspected for health problems)	Little (during feeding or during inspection of the fences)	They do not need control as the system is self-regulating with well-divided land parcels	Very little beyond feeding	Little (usually during feeding)	One person suffices to feed and inspect them (increased vigilance during births)	Little (usually they are checked during feeding and then they are roaming outdoors to complete their diet)	Little (only during feeding). If some are missing their sleeping spots are checked (ill animals usually remain there)
Capture for slaughter	Herded into a truck	Herded into a truck (kept in small land parcels 1-2 days before)	Herded into a truck	Herded into a truck	Corralled and herded into a truck 'like sheep', also attracted by food	Corralled and herded into a truck	Corralled using food as bait and herded into a truck	Easily herded into a truck	Corralled and herded into a truck	Corralled and herded into a truck	Corralled and herded into a truck
Diet (free-range)	Autumn-Winter: acorns and grass Spring: grass and provided food Summer: provided food	Predominately provided food, except during Autumn-Winter (acorn season)	Autumn-Winter: acorns (also grass, worms, snails) Spring: grass and provided food Summer: provided food	Autumn-Winter: mainly acorns (also grass, worms, snails etc) Spring: grass and provided food Summer: provided food	Autumn-Winter: mainly acorns (also grass, worms, snails) Spring: grass and provided food Summer: provided food	Autumn-Winter: mainly acorns (but also grass, worms, snails) Spring: grass and provided food Summer: <i>triticale</i> ears and provided food	Autumn-Winter: mainly acorns (also grass, worms, snails) Spring: grass and provided food Summer: provided food	Autumn-Winter: mainly acorns Spring: grass and provided food Summer: provided food	Predominately provided food, except during Autumn-Winter (acorn season)	Autumn-Winter: mainly acorns (also grass and other forest foodstuff) Spring: grass and provided food Summer: provided food	Autumn-Winter: mainly acorns (also grass and other forest foodstuff) Spring: grass and provided food Summer: provided food

Adult weight (reproductive pigs unless otherwise indicated)	100-150 Kg (mentioned no significant difference between males and females)	unknown	Female ('not fat, just healthy'): 115-130Kg Male: 150-170 Kg, although Duroc reaches 200Kg	Female: 135-150 Kg Male: 155-160Kg)	Female:115Kg (they are relatively young, 2 years old) Male:170 Kg	Female: 180-200 Kg Male:200-250 Kg	Females: 145Kg Male:165-175Kg Ideal culling weight: 170 Kg	Female: 150 Kg Male: 170-180 Kg	Female: 150 Kg Male: 180 Kg Slaughtering weight: 180 Kg	Slaughtering weight: 120-150 Kg	Female: 130-140 Kg Male:150-160 Kg Slaughtering weight: 150-160 (free-range) and 160-170 (semi-free-range)
Losses	Every couple of years a couple of piglets are stolen. 1 in 200 females dies from castration	Extremely rare (when it happens it means they are stolen)	Nobody has ever stolen a pig of his	No losses. In cases of heavy rain, some pigs may enter another parcel but are easily recovered	No losses. No pig is stolen due to the remote location of the farm	1-2 times a year a few animals (mostly piglets) are stolen	Extremely rare (when it happens it means they are stolen)	Very rarely	4-5 stolen piglets per year, during an annual fiesta at the village	Some (1%) during acorn season by escaping the fenced area (difficult to recover)	1-2 pigs get stolen each year. Even fattened pigs have been stolen
Agricultural damage	No damage (snout ring on all or most pigs)	There is nothing to damage (snout ring on all or most pigs)	No damage (no snout ring noticed but not all pigs were present)	No damage (snout ring on all or most pigs)	No damage (snout ring on all or most pigs)	No damage (snout ring on all or most pigs)	No cultivation. Pigs will destroy parts of oak forest without snout rings. Occasionally demolish some walls and fences	They 'lift' soil but there is enough space so soil recovers (no snout ring). Sometimes they destroy fences	No damage (some worn snout rings, some not)	No damage (snout ring on all or most pigs)	Only when in restricted areas. Without snout rings they cause more damage (some worn snout rings, some not)
Products	Meat (mostly dried hams, and other types of cured meat) and some piglets to other farms	Sells live animals	Sells live animals. 3-4 pigs/year for family needs. Some piglets as presents to employees	Sells live animals	Sells live animals	Sells live animals	Sells live animals	Family business sells live animals but also process cured meat (butcher shop and cellars)	Sells live animals	Sells live animals	Sells live animals. 3 pigs per year for family consumption

*There is great variety of husbandry regimes, especially in the amount of time that the pigs spend outdoors, the available area and the amount of provided food. Within the term 'free-range' there is everything between year-round free-range to acorn-fattened pigs (that are foraging outdoors during their last 3-6 months of life). 'Semi-free-range' includes pigs which are raised and fattened with provided food, kept in man-made shelter and have restricted outdoor area (which varies to a great degree from crowded enclosures to larger land parcels, very rarely exceeding 3 ha). 'Intensively managed' includes pigs that are born and fattened in specialised indoor spaces with minimal space and exclusively provided food. Much more refined is the classification of the Spanish Ministry of Agriculture which defines the norms of different pig husbandry regimes (MAPA 2007: 11)

**Specially constructed tent-shaped shelters (usually from metal and rarely plastic, see figure 6.10)

*** All interviewed farmers own well-fenced properties and it is extremely rare for any pig to manage to escape. The same difficulty and frequency is observed for wild boars attempting to enter in these properties. Also, in free-range husbandry the level of control fluctuates seasonally due to fluctuations in food availability in the oak forest (e.g. much more food is provided during summer and none during autumn and winter)

Appendix 4. Summary table of interview with AECERIBER veterinarian (Zafra, Extremadura, Spain)

Pig breeding experience	The majority of pig breeders in Extremadura have been doing it forever. Only some industrial producers are new in the field and they see it as just another investment
Herd size	Depends what we are counting. Reproductive females range from 30-100 and males are 8-10% of the female total. The size of the herd is fluctuating because the females will normally farrow twice a year. For example, a herd with 100 reproductive females and 8 males will produce about 2000 new pigs in a year.
Husbandry regime	All kinds, from intensive to fully free-range husbandry regimes can be found among the breeders in Extremadura.
Breed	AECERIBER works for the protection of the Iberian 'trunk' of pig breeds. They work with the Iberian <i>Retinto</i> and <i>Entrepelado</i> (they are nowadays relatively abundant) , as well as with rarer 'lineages' of the Iberian 'trunk' such as the <i>Manchado de Jabugo</i> , the <i>Torbiscal</i> and the <i>Lampiño</i> (they are under special protection due to scarcity). It is important to keep in mind that a significant number of Iberian pigs are to a small degree crossed with Duroc-Jersey pigs (mostly reproductive males), although 50% is the lowest accepted percentage of pure Iberian genes for a pig to be classified as Iberian (there are different degrees of purity)
Sex	Usually males are 8-10% of the reproductive population
Age profile	Breeding seasons are ideally one in Spring and one in Autumn. The slot born in Spring will be perfectly ready to go on ' <i>montanera</i> ' (acorn-feeding season) next Autumn
Wild Boar (ubiquitous in the area)	Normally no breeder likes any wild boar nearby
Crosses with wild boar	They are generally rare and unwanted. The piglets resulting from such crossings are called ' <i>rayones</i> ' (i.e. 'striped') because their striped (wild-boar-like) appearance
Castration	Males are castrated at an early age (certainly earlier than 6 months). Even if a breeder did not castrate his males, he would not tell because it is considered bad for the taste of the meat and for the animal's well-being
Birth season	Normally Spring and Autumn
Where are the litters born?	It depends. There are various systems. The most modern is that of specialised buildings (some even with heating) but they are few. There are also some breeders who have more basic buildings (e.g. without heating). Finally, there are breeders (the majority) who use specially constructed tent-shaped shelters (usually from metal and rarely plastic) called 'camping'
Purchase of animals	Some yes and some no. If they can avoid it they will not buy. Some, more devoted breeders, carefully select their best pigs to improve their stock
Age at slaughter	Semi-free range and/or intensive: the law sets the 10 months as the minimum age of slaughter Free-range: the law says that they have to be at least 14 months old but the vast majority are older than that
Slaughter season	The majority, at least in Extremadura, are slaughtered in December-January, with a focus around the Christmas season, although this continues until March. The law forbids the slaughter of acorn-fattened pigs after the 15 th of April or before the 15 th of December
Home range (free-range)	In Extremadura, there is a tendency for large land parcels due to a history of big land-owners. Other areas of Spain, due to historical reasons, could not develop or maintain similar systems of extensive pig husbandry.
Daily movements	Normally they spend days and nights outdoors. Only some breeders provide them with shelter in case of extreme weather. They are clever animals and always able to find the best location for them. They usually sleep in groups and use the same spot (called ' <i>cama</i> '=bed), which over time ends up devoid of large stones and vegetation with a comfortable layer of softened fine soil
Level of Control	Most breeders have their estates subdivided in smaller (but still quite extensive) land parcels in which pigs require minimal attention and control. Normally they are inspected only once a day during feeding, while the reproductive females are more closely inspected during pregnancy and until the piglets are weaned
Capture for slaughter	The day before slaughtering they herd them into a smaller enclosure and the next day they are loaded on a truck
Diet (only free-range pigs considered)	Autumn-Winter: acorns, grass and whatever else they can find by grazing and browsing in the oak forest. Reproductive pigs are fed with <i>pienso</i> (generic term for different mixtures of cereals, legumes and other types of food) and are discouraged from eating acorns because the pigs intended for slaughtering have priority. Spring: grass and other foodstuff they can find from the <i>dehesa</i> (oak forest) but their diet is complemented by <i>pienso</i> . Summer: <i>pienso</i> becomes of greater importance for the pig's nutrition due to a scarcity of naturally available food. August is the peak of this scarcity of natural food

Adult weight	The law dictates that no free-range Iberian pig is slaughtered at a weight less than 108 kg, while the average weight of any herd destined for slaughtering must be 117 kg or more. In reality, most breeders slaughter their pigs at around 140-155 kg
Losses	Rare. Because of their high economic value, strict measures are taken by the breeders to keep losses to a minimum. It is a huge responsibility if an animal escapes and e.g. causes a road accident, and in such a case the owner of the pig would face serious charges at court
Agricultural damage	They do not cause much damage because of the strictly enclosed land parcels in which pigs are kept
Products	All producers sell live animals to slaughterhouses and companies which process them into cured meat (mostly) but also fresh meat. They weigh the animals and they make deals for a price per ' <i>arroba</i> ' (Spanish measure of weight equivalent to 11.5 kg, at least in Extremadura). Some breeders slaughter a pig or two for their own consumption but this is not done on a large scale. The laws have become strict and you have to obtain permission (subject to veterinary checks) to slaughter a pig